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# Effects of Container Size and Transplanting Date on the Growth of Tree Seedlings[1]

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## Abstract

Superior growth was obtained from deciduous and coniferous trees seeded into the largest volume propagation container. This effect remained evident through the second growing season for all species. In a second experiment, larger containers were in some cases better, but attempts to improve growth by means other than an increase in propagation volume proved futile. Earlier transplant dates were much less important than container size.

**Index words:** container volume, milk carton, paper pot, Nu-pots, air root pruning, deodar cedar, *Cedrus deodara,* loblolly pine, *Pinus taeda,* Japanese black pine, *P. thunbergi,* red pine, *P. resinosa,* Scotch pine, *P. sylvestris,* Afghan pine, *P. eldarica,* Chinese pistache, *Pistacia chinensis,* Shumard oak, *Quercus shumardi*

## Introduction

Studies of growth and development of seed-grown trees have shown that size of the propagation container can have a significant influence on subsequent growth (2). Davis and Whitcomb (2) showed that greater root growth could be obtained in 6.4 $cm^2$ (1-1/2 $in^2$) square bottomless milk cartons than in 3.8 $cm^2$ (1-1/2 $in^2$) and 5.1 $cm^2$ (2 $in^2$) containers. Hathaway and Whitcomb (4) showed that volume was important, with seedlings produced in half-pint milk cartons equal to seedlings produced in larger containers. Williams and Whitcomb (9) demonstrated that container volume and width were important, with wider containers promoting more seedling growth than narrow containers even when volumes were equal. Similar effects of volume upon tree seedling growth have been shown by Tinus and McDonald (6) and Wall and Whitcomb (7), and were cited by Carlson (1). Owston and Stein (5) noted that larger containers were better for all but slow growing tree seedlings.

Whitcomb, Storjohann and Gibson (8) noted early summer transplant dates were preferable for container grown deciduous tree seedlings. Transplant date had little effect on subsequent growth for slow growing conifers.

Gibson and Whitcomb (3) found that when tree seedlings were held 4 months or less, 7.0 $cm^2$ (2-3/4 $in^2$) milk cartons compared favorably with larger containers. If tree seedlings were held for 12 months prior to planting, larger size containers were better.

The following experiments were conducted to further evaluate the effect of size and design of tree seedling propagation containers on subsequent growth, to further evaluate the effects of transplant date, and to look for possible container size-transplant date interactions.

## Materials and Methods

*Experiment 1:* Seeds of 6 conifers, deodar cedar, *Cedrus deodara;* loblolly pine, *Pinus taeda;* Japanese black pine, *P. thunbergi;* red pine, *P. resinosa;* Scotch pine, *P. sylvestris;* and Afghan pine, *P. eldarica,* and 1 deciduous tree, Chinese pistache, *Pistacia chinesis,* were direct seeded into containers of 4 sizes, March 12, 1981. Seeds of a second deciduous tree, Shumard oak, *Quercus shumardi,* were first pre-germinated in moist peat moss and subsequently transplanted to the 4-sized containers on March 24, 1981.

The 4 propagation container sizes were: 1) unused half pint milk carton stock (a square sleeve) 7.0 $cm^2$, 682.6 $cm^3$ (3-2/4 $in^2$, 41 $in^3$); 2) 7.6 $cm^2$, 360.5 $cm^3$ (3 $in^2$ Nu-pot, 22 $in^3$); 3) 5.7 $cm^2$, 196.7 $cm^3$ (2-1/4 $in^2$ Nu-pot, 12 $in^3$); and 4) rounded paper pot approximately 2.6 cm in diameter (2 in), 147.5 $cm^3$ (9 $in^3$). A propagating medium of peat and perlite (1:1 by volume) containing 3.6 kg/$m^3$ (6 lbs/$yd^3$) of 18N-2.6P-9.9K fertilizer (18-6-12 Osmocote) and 0.6 kg/$m^3$ (1 lb/$yd^3$) Micromax micronutrients was used. All containers were bottomless and were placed on elevated wire mesh for air-root pruning in an unheated greenhouse designed to provide good air circulation.

There were 4 transplanting dates for the 2 deciduous trees: May 12, May 26, June 9, and June 23, 1981. The 6 conifers were transplanted on the 3 later dates. The deciduous trees were planted into 11.4 l (#3) white poly bags, the conifers into 3.8 l (#1) white poly bags. The medium was of bark, peat and sand (3:1:1 by volume) containing 8.3 kg/$m^3$ (14 lb/$yd^3$) of 17N-3.01P-9.96K fertilizer (17-7-12 Osmocote), 4.8 kg/$m^3$ (8 lbs/$yd^3$) dolomite and 0.9 kg/$m^3$ (1-1/2 lbs/$yd^3$) Micromax. The plants were placed on a container bed in full sun in a completely randomized block design by species with 6 uniform seedlings as replications of each container size for each transplanting date.

On August 14, 1981, height and caliper were recorded for the deciduous trees, and height and number of branches for the conifers. The first transplanting date of Shumard oak, Chinese pistache, deodar cedar and Afghan pine were transplanted to the field December 4, 1981. Plants from the latter 2 transplanting dates for deodar cedar and Afghan pine, along with plants from all 3 dates for the 5 remaining pines were overwintered in an unheated single layer poly greenhouse.

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All plants overwintered in the poly greenhouse were placed on a container bed for a second growing season. Scotch and red pines remained in the 3.8 l (#1) poly bags because of limited size. Japanese black pines were transplanted into 7.6 l (#2) plastic pots, and loblolly and Afghan pines and deodar cedar into 11.4 l (#3) poly bags. A mix of bark, peat and sand (3:1:1 by volume) containing 8.3 kg/m³ (14 lbs/yd³) of a 2:5 blend of 18-6-12 and 17-7-12 Osmocote, 3.6 kg/m³ (6 lbs/yd³) dolomite and 0.9 kg/m³ (1-1/2 lbs/yd³) Micromax micronutrients was used.

On August 2, 1982, height, caliper and number of branches were recorded for deodar cedar and loblolly and Japanese black pines, and height and number of branches for Scotch pine. For red and Afghan pines, height and number of branches, and height, caliper and number of branches, respectively, were recorded August 18.

No second-year measurements were taken on the field planted material due to winter damage.

*Experiment 2:* A second experiment was designed to further test whether superiority of milk-carton-grown seedlings was due to increased volume of propagation medium or to some design feature of the milk carton. Six container treatments were: 1) 7.6 cm² (3 in²) Nu-pots 380.5 cm³ (22 in³); 2) 7.6 cm² (3 in²) Nu-pots with side slits; 3) a milk carton constructed to have equal height and volume of the 7.6 cm² (3 in²) Nu-pots; 4) 5.7 cm² (2-1/4 in²) Nu-pots 196.7 cm³ (12 in³); 5) 5.7 cm² (2-1/4 in²) Nu-pots with side slits; and 6) a milk carton constructed to have equal height and volume of the 5.7 cm² (2-1/4 in²) Nu-pots. All containers were bottomless, and the same propagation medium and nutrients were used as in Experiment 1. Japanese black pine from seed directly sown on April 16 and Chinese pistache from pre-germinated seed started April 26 were used.

The Japanese black pines and Chinese pistache were transplanted on three dates (June 14, July 5, and July 26, 1982) into 3.8 l (#1) and 11.4 l (#3) white poly bags, respectively, using the same medium and nutrients as in Experiment 1. Six replications per container treatment were set by species on a container bed in full sun in a randomized block design. Transplanting dates for 1982 were June 14, July 5 and July 26, due to delayed production of seedlings, and a desire to transplant under less favorable conditions.

Height and number of branches for Japanese black pine were recorded on October 11, 1982. Chinese pistache height was recorded on October 22, 1982, and caliper on November 1, 1982.

## Results and Discussion

*Experiment 1:* Milk carton grown seedlings of all species were superior to those grown in the 3 smaller containers. Seedlings were taller, had thicker stems, and the conifers had more branches (Table 1).

A less dramatic result was noted with regard to transplant date. Height and caliper of shumard oak and height of deodar cedar was greatest when planted on the

**Table 1. Effect of container size on plant height and caliper or height and number of branches[z] (Experiment 1—1981).**

| | Container and Volume | | | |
|---|---|---|---|---|
| Species | Milk Carton (682.6cm³) | 3" Nu-pot (360.5cm³) | 2¼" Nu-pot (196.7cm³) | Paper pot (147.5cm³) |
| Chinese pistache | | | | |
| height[y] | 87.7b[x] | 67.9a | 68.3a | 59.0a |
| caliper | 1.10b | 0.71a | 0.68a | 0.60a |
| Shumard oak | | | | |
| height | 71.8b | 61.2a | 49.0a | 55.8a |
| caliper | 1.00b | 0.70a | 0.59a | 0.65a |
| Deodar cedar | | | | |
| height | 20.3b | 15.7a | 16.1a | 16.1a |
| no. branches | 21.1b | 6.9a | 6.8a | 6.8a |
| Loblolly pine | | | | |
| height | 36.2b | 24.4a | 25.4a | 22.2a |
| no. branches | 8.1b | 5.3a | 6.3a | 4.6a |
| Japanese black pine | | | | |
| height | 16.2b | 11.2a | 10.9a | 11.9a |
| no. branches | 3.3b | 1.4a | 2.3a | 2.2a |
| Red pine | | | | |
| height | 7.9b | 5.7a | 5.1a | 5.4a |
| no. branches | 2.8b | 1.7a | 1.1a | 1.6a |
| Scotch pine | | | | |
| height | 10.3b | 9.3a | 8.3a | 9.8a |
| no. branches | 3.9b | 3.2a | 2.9a | 3.3a |
| Afghan pine | | | | |
| height | 22.0b | 17.1a | 16.6a | 19.6a |
| no. branches | 22.1b | 8.9a | 10.1a | 11.4a |

[z]Means of 6 plants per 3 or 4 planting dates.

[y]All heights and calipers in centimeters (cm).

[x]Mean separation within rows followed by the same letter are not significantly different at the 1% level using Duncan's multiple range test.

**Table 2. Effect of transplanting date on plant height and caliper or height and number of branches[z] (Experiment 1—1981).**

| Species | Date | | | |
|---|---|---|---|---|
| | May 12 | May 26 | June 9 | June 23 |
| Chinese pistache | | | | |
| height[y] | 73.4a | 68.5a | 77.8b | 63.1a |
| caliper | 0.80a | 0.75a | 0.85a | 0.69a |
| Shumard oak | | | | |
| height | 71.8b[x] | 64.3a | 56.6a | 45.1a |
| caliper | 0.81b | 0.78a | 0.72a | 0.62a |
| Deodar cedar | | | | |
| height | —— | 19.6b | 16.4a | 15.1a |
| no. branches | —— | 10.9a | 10.5a | 9.8a |
| Loblolly pine | | | | |
| height | —— | 28.0a | 28.1a | 25.1a |
| no. branches | —— | 5.6a | 6.7a | 6.0a |
| Japanese black pine | | | | |
| height | —— | 14.3a | 10.6a | 12.8a |
| no. branches | —— | 2.6a | 2.1a | 2.2a |
| Red pine | | | | |
| height | —— | 5.6a | 6.4a | 6.1a |
| no. branches | —— | 1.7a | 2.1a | 1.6a |
| Scotch pine | | | | |
| height | —— | 9.8a | 9.8a | 8.7a |
| no. branches | —— | 4.0a | 3.3a | 2.8a |
| Afghan pine | | | | |
| height | —— | 18.6a | 20.9a | 16.9a |
| no. branches | —— | 14.6a | 13.5a | 11.3a |

[z]Mean of 6 plants per the 4 containers.

[y]All heights and calipers in centimeters (cm).

[x]Mean separation within rows followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

**Table 3. Effect of propagation container size on growth of tree seedlings 17 months after planting the seed and approximately 14 months following transplanting into a larger container (Experiment 1—1982).**

| Species | Container and Volume | | | |
|---|---|---|---|---|
| | Milk Carton (682.6cm³) | 3" Nu-pot (360.5cm³) | 2¼" Nu-pot (196.7cm³) | Paper pot (147.5cm³) |
| Deodar cedar | | | | |
| height[z] | 72.0b[y] | 62.8a | 61.7a | 61.8a |
| caliper | 1.5b | 1.26a | 1.26a | 1.20a |
| no. branches | 266.6b | 171.3a | 169.2a | 166.0a |
| Loblolly pine | | | | |
| height | 128.7b | 114.7a | 115.7a | 115.7a |
| caliper | 2.5b | 1.8a | 2.0a | 1.8a |
| no. branches | 47.7b | 33.2a | 36.3a | 29.1a |
| Japanese black pine | | | | |
| height | 70.8b | 59.8a | 62.8a | 58.6a |
| caliper | 1.6b | 1.2a | 1.3a | 1.3a |
| no. branches | 23.0b | 12.8a | 13.0a | 15.6a |
| Red pine | | | | |
| height | 26.8b | 16.4a | 15.5a | 16.7a |
| no. branches | 8.9b | 8.1b | 5.0a | 9.2b |
| Scotch pine | | | | |
| height | NS | NS | NS | NS |
| no. branches | 47.5b | 35.8ab | 30.3a | 38.5ab |
| Afghan pine | | | | |
| height | 82.1c | 67.8abc | 46.5a | 79.2bc |
| caliper | 1.72c | 1.20ab | 0.89a | 1.6bc |
| no. branches | 83.5b | 38.4a | 33.8a | 67.3b |

[z]Height and caliper in centimeters (cm).

[y]Mean separation within rows followed by the same letter are not significantly different at the 1% level using Duncan's multiple range test.

earliest date, while Chinese pistache were tallest when planted on the 3rd date (Table 2). The 5 species of pine were not affected by transplant date. No container size-transplant date interaction was observed.

The superior growth seen after the first growing season with the milk carton propagated trees was still evident after the second growing season (Table 3). In some cases plants in paper pot propagation containers (which were still intact after 18 months) produced growth nearly equal that of plants in milk cartons, despite a volume approximately 4 times smaller (Fig. 1). However, two undesirable situations were noted with paper pots: 1) the paper pots had not begun to deteriorate, thereby creating a future possibility of root restriction; and 2) stems of paper pot plants were considerably weaker than those of plants in other treatments.

Plants produced in 5.7 $cm^2$ (2-1/4 $in^2$) Nu-pots were the smallest, and many winter killed, particularly the slow growing red pine.

As with the first season's growth response, date of transplanting had less effect than propagation container size. Transplant date had less effect on the relatively slow growing conifers than for the fast growing deciduous trees. Again, there was no significant container size-transplant date interaction.

*Experiment 2:* No significant differences were found for Japanese black pines with regard to either container design or transplant date. Only for the faster growing Chinese pistache were differences significant for both container design and transplant date. Larger volume containers were generally better as were the earlier transplant dates (Table 4). No container design-transplant date interaction was significant for either species.

Fig. 1. ***Pinus sylvestris*, Scotch pine seedlings 18 months from seed planting date. Left to right, in milk carton, 3 $in^2$ Nu-pot, 2-1/4 $in^2$ Nu-pot and paper pot.**

## Significance to the Nursery Industry

Frequently the improved growth that is observed for container-grown plants from various experimental factors during the first year of plant growth is diminished in subsequent years. That was not the case in this study, and it is felt that the benefit seen in this experiment could be expected to continue into the future.

The fact that earlier transplant dates did not consistently have a positive effect on plant growth during either the first or second year suggests that, given an adequate volume of medium and nutrients during propagation, a healthy and vigorous tree seedling will transplant relatively well even under high summer temperatures.

**Table 4. Effect of container size and design on height and caliper of Chinese pistache[z] (Experiment 2—1982).**

| | Container | | | | | |
|---|---|---|---|---|---|---|
| **Growth Parameters** | **3" Nu-pot (680 $cm^3$)** | **3" Nu-pot with slits (680 $cm^3$)** | **3" Milk Carton (682.6 $cm^3$)** | **2¼" Nu-pot (196.7 $cm^3$)** | **2¼" Nu-pot with slits (196.7 $cm^3$)** | **2¼" Milk Carton (195 $cm^3$)** |
| Height[x] | 103.5ab[y] | 98.6a | 107.3b | 99.6a | 94.3a | 90.8a |
| Caliper | 1.4b | 1.4b | 1.4b | 1.2a | 1.2a | 1.2a |

[z]Means of 6 plants per 3 dates.

[y]Mean separation within rows followed by the same letter are not significantly different at the 1% level using Duncan's multiple range test.

[x]All heights and calipers in centimeters (cm).

**Table 5. Effect of transplanting date on height and caliper of Chinese pistache[z] (Experiment 2—1982).**

| | Date | | |
|---|---|---|---|
| | **June 14** | **July 5** | **July 26** |
| Height[x] | 100.6b[y] | 105.4b | 91.1a |
| Caliper | 1.5c | 1.4b | 1.1a |

[z]Means of 6 plants per 3 dates.

[y]Mean separation within rows followed by the same letter are not significantly different at the 1% level using Duncan's multiple range test.

[x]All heights and calipers in centimeters (cm).

Early transplanting will most often benefit fast growing deciduous trees and have a negligible effect on slower growing coniferous trees.

Because there was not a significant container size-transplant date interaction, it appears that early transplanting cannot overcome the restricted growth incurred by tree seedlings propagated in small containers.

Based on the results of these and previous studies, rapid growing tree seedlings can be expected to increase in size as container volume increases up to a volume of approximately 680.0 $cm^3$ (41 $in^3$). A bottomless container that permits air root pruning is recommended, and propagation container design similar to that of the unused half pint milk carton (41 $in^3$) should be further investigated.

## Literature Cited


1. Carlson, L.W. 1979. Guidelines for rearing containerized conifer seedlings in the Prairie Provinces. Northern For. Res. Ctr., Edmonton, Alberta, Canada. Information Report NOR-X-214:5.

2. Davis, R.E. and C.E. Whitcomb. 1975. Effects of propagation container size on development of high quality seedlings. Proc. Intern. Plant Prop. Soc. 25:251-257.

3. Gibson, J.D. and C.E. Whitcomb. 1980. Producing tree seedlings in square bottomless containers. Orn. South 2(5):12-15.

4. Hathaway, R.D. and C.E. Whitcomb. 1977. Propagation of *Quercus* seedlings in bottomless containers with Osmocote. J. Arboriculture 3:208-212.

5. Owston, P.W. and W.I. Stein. 1977. Production and use of container seedlings in the west. Proc. Intermountain Nurserymen's Association:117-125.

6. Tinus, R.W. and S.E. McDonald. 1979. How to grow tree seedlings in containers in greenhouses. Rocky Mtn. For. and Range Expt. Sta. General Technical Report RM-60, 256 p., Bottineaus, ND.

7. Wall, S. and C.E. Whitcomb. 1980. A comparison of commercial containers for growing tree seedlings. Okla. Agri. Expt. Sta. Res. Rpt. P-803:72-75.

8. Whitcomb, C.E., A. Storjohann and J. Gibson. 1977. Effects of time of transplanting container grown tree seedlings on subsequent growth and development. Okla. Agri. Expt. Sta. Res. Rpt. P-777: 37-39.

9. Williams, E. and C.E. Whitcomb. 1979. Effects of growing media and container design on growth of tree seedlings. Okla. Agri. Expt. Sta. Res. Rpt. P-791:40-43.




# Evaluation of Herbicides for Use in Closed Structures[1]


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## Abstract

The herbicides Hyvar X (bromacil) WP, Pramitol (prometon) 5 PS and WP, Princep (simazine) WP and Karmex (diuron) WP were each applied at 3 rates to soil in closed structures with test plants held above the soil. Karmex (diuron) at the 11.25, 22.5 and 45 kg ai/ha (10, 20 and 40 lbs aia) rate did not damage 3 test species. Hyvar X (bromacil) at the 17 kg ai/ha rate (15 lbs aia) may also be safe. Pramitol (prometone) 5 PS or WP and Princep (simazine) damaged most test plants.



**Index words:** greenhouse, volatile, Pennsylvania bittercress *(Cardamine pensylvanica* Muhl.), yellow wood sorrel *(Oxalis stricta* L.)


## Introduction

The control of weeds on the floors of greenhouses and overwintering structures that are either soil or gravel is a serious problem. Weeds like Pennsylvania bittercress *(Cardamine pensylvanica* Muhl.) and yellow wood sorrel *(Oxalis stricta* L.), have mechanisms for propelling the seed at maturity. Weeds may harbor disease organisms, insects, spiders, mites, and also give the nursery or greenhouse an unsightly appearance. Many herbicides cannot be used inside structures because of volatility or residual which may cause injury to crops, especially at high temperatures. There has been little research to show what herbicides may be used for weed control under greenhouse benches and in overwintering structures. Karmex (diuron) and Princep (simazine) have been mentioned in some greenhouse-related publications but with no supporting evidence. Burt (1) and Kearney *et al.* (4) have shown that triazine herbicides will volatilize under laboratory conditions, however, whether they volatilize from a soil surface has not been established. The objective of this study was to determine if certain herbicides could be safely used on the floor of a closed chamber as evaluated with sensitive species.

## Methods and Materials

Unvented chambers 92 $cm^3$ (3 $ft^3$) were constructed and covered with 4 mil polyethylene plastic and placed on the floor of a greenhouse equipped with fan-pad cooling (Fig. 1). Three 30.5 x 56 x 5.7 cm (12 x 22 x 2.2


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