EFFECTS OF CONTAINER SIZE ON WHITE PINE AND DOUGLAS-FIR SURVIVAL AND GROWTH IN NORTH IDAHO --Daniel L. Miller and Richard M. Schaefer III

ABSTRACT: This study was designed to determine the effect container size has on field survival and growth of western white pine (*Pinus monticola*) and Douglas-fir (*Pseudotsuga menziesii*). Between 1978 and 1982 field tests were installed in 13 plantations, and height growth and survival of styro-2, 4 and 8 seedlings were tracked for 2 to 5 years. Results indicate that styro-2 white pine survived as well as larger seedlings although height growth was slightly less. Greenhouse disease problems currently prevent growing operational quantities of styro-2 white pine, however. Styro-2 Douglas-fir performed as well as styro-4 seedlings on most sites. Styro-2 seedlings may be used on all but the driest Douglas-fir sites. In general, styro-8 seedlings were larger when planted and produced better height growth than styro-2 or 4 white pine and Douglas-fir seedlings. Increased survival and growth did not compensate for increased styro-8 production costs, however.

INTRODUCTTON

In a containerized seedling production greenhouse, container size affects both seedling size and production costs. Larger containers provide increased space for both shoots and roots. This will usually be reflected in seedling size. In general, larger containers produce taller seedlings with larger stem diameters than do smaller containers (Miller 1978). Seedling stem diameter at the soil line may be critical to seedling establishment. Smaller stems are more susceptible to girdling by high temperatures at the soil surface (Cleary and others 1978). Larger seedlings have more insulating tissue that shields sensitive cambial cells. This is especially important on hot dry sites.

Container size is also an important component of seedling cost. The cost of producing containerized seedlings is largely governed by seedling density. Growing more seedlings per square foot of greenhouse space reduces the fixed cost per seedling. For example, seedlings grown in styro-2 containers cost 36 percent less to grow than styro-4 seedlings (table 1). In addition to seedling production costs, survival and growth data are needed to determine which container size results in lowest cost per surviving, healthy seedling.

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Table 1.--Container size descriptions and production cost comparison

Container	Cavities/ Sq. Ft.	Cavity Size (cu.in.)	Cavity Depth (in.)	Percent Cost/M Change
Styro-2	96	2.5	4.5	-36
Styro-4	63	4.8	5.0	0
Styro-8	41	8.0	6.0	+149

This study was designed to determine the effects that container size has on field survival and growth of western white pine and Douglas-fir seedlings.

METHODS

Between 1978 and 1982 container size tests were installed in 13 plantations. These planting sites were selected to test the effects of north and south slopes (moister and drier sites) on survival and growth. White pine and Douglas-fir grown in styro-2, 4, and 8 containers were planted in 1978, 1979, and 1980. In 1980 only styro-2 and 4 containers were used for white pine.

Seedlings were grown one summer in the greenhouse. Seed was sown in March and height growth was completed in August. Seedlings were hardened off during the fall and shipped to cold storage in February. They were removed from storage and planted in May. Seedlings were held in the styroblocks until planted.

The 1978 and 1979 tests consisted of three blocks planted on each site for each species tested. Each block contained a row of 25 seedlings of each container size planted 2 feet apart with 2-3 feet between rows. Tests planted in 1980 and later consisted of four blocks of each species on each site. Each block was a row of 20 seedlings planted 4-6 feet apart with rows 6-10 feet apart. This wider spacing will allow tracking growth for more than 5 years before inter-tree competition becomes severe. Earlier tests were spaced tighter as significant survival differences were expected and uniformity of microsite was the major concern. All seedlings were dibble-planted. Initial height (the distance from the cotyledonary node to the base of the terminal bud or candle) was measured following planting. Subsequent annual height growth increments were measured and survival and injury recorded.

Frost and animal damage severely affected the Little Green Mtn. test. As a result, only second year data are reported. Similarly, second year results of the Shanghai 1978 test are reported for Douglas-fir and third year data for white pine.

Total height and survival data were analyzed by analysis of variance for each site separately. All animal-damaged seedlings (browsed, clipped) were eliminated from the analyses since the plots were not designed to accurately evaluate animal damage. Means were ranked using Duncan's multiple range test when significant treatment (container) differences were detected.

Where measured total heights were significantly different between container sizes, regression techniques were used to estimate the years required to reach 15 feet (4.5m) tall. Differences in years to 15 feet were assumed to indicate potential rotation length differences. This assumes that trees grown in different containers will all grow similarly after they reach 15 feet tall. By then only site quality and inter-tree competition should be limiting growth.

RESULTS AND DISCUSSION

Western White Pine

With the exception of Little Green Mountain, container size did not significantly affect survival (table 2). The styro-2 survival at Little Green Mtn. did not differ from styro-8 survival, but was significantly better than styro-4 survival. No reason for this difference is apparent. Survival was poor (48-49 percent) for both styro-2 and styro-4 containers at Robinson Creek. This test was planted on a southwest aspect where soil was thin and rocky. This was a relatively severe site, but the larger container size produced no increase in survival. All other sites produced survival in excess of 90 percent for all container sizes.

Based on plantation establishment costs of planting 500 seedlings per acre (1 235/ha), survival of styro-4 seedlings would have to be at least 20 percent higher than survival of styro-2 seedlings to justify planting the more expensive seedlings. If the expected survival difference is less than 20 percent, it costs less to plant additional styro-2 seedlings to compensate for mortality. If white pine survival was the only basis for selecting container size, the lack of significant differences would suggest that we should use styro-2 stock on all sites.

Total height varied significantly on several sites (table 2). Styro-2 seedlings were significantly shorter than styro-4 seedlings in the Breakfast Creek 1978 test. Height growth projections indicated that there will be no significant difference in estimated rotation age, however. Both styro-2 and styro-8 heights differed significantly from the styro-4 height in the Orogrande Creek 1979 test. Estimated rotation ages also differed; with the styro-2 trees taking 1 more year and the styro-8 trees 1 year less to reach maturity than the styro-4 trees. Economic analysis of planting cost and rotation length changes indicated no significant value difference at maturity. At the Robinson Ridge site, styro-8 seedlings were taller after 5 years and are estimated to take 1 less year to reach rotation than styro-4 seedlings. Increases styro-8 seedling production costs more than offset the economic advantage of a shorter rotation, however.

Styro-4 seedlings were significantly taller than styro-2 seedlings at Elk Creek, Potato Hill, and Stoney Creek after 3 years (table 2). These differences resulted in a rotation length change only at Potato Hill where styro-2 seedlings lengthened rotation by 1 year, but still increased plantation value slightly.

Douglas-fir

With the exception of the Little Green Mountain and Mt. Margaret sites, survival did not vary significantly by container size (table 3). Styro-2 survival at the Breakfast Creek 1979 site averaged 35 percent below that of styro-4 seedlings. A significant difference was not detected due to variation in survival between blocks on the site, however. Styro-2 survival was much lower on two blocks, but about equaled styro-4 survival on the third. Given this and the size of the difference, we should assume that there is an increased risk associated with planting styro-2 containers at Breakfast Creek and styro-4 seedlings should be selected. Based on plantation establishment costs and planting 400 Douglas-fir seedlings per acre (988/ha), styro-4 survival must exceed styro-2 survival by 14 percent to cover increased stock costs. If the expected difference is less than 14 percent, it costs less to plant more styro-2 seedlings to compensate for increased mortality. Similarly, planting styro-8 seedlings must increase survival by at least 15 percent over that of styro-4 seedlings to cover increased seedling production costs.

Based on survival differences, we should select styro-4 Douglas-fir over styro-2 seedlings only on dry sites with shallow or rocky soil such as Mt. Margaret where styro-4 containers increased survival by 22 percent. Styro-8 containers did not increase survival enough on any site to justify their use. Severe sites where styro-8 containers would prove beneficial are best planted to more drought-resistant species such as ponderosa pine.

Table 2.--White pine survival and total height by site and container size. Browsed and clipped seedlings were deleted from analyses. Figures within site followed by different letters are significantly different (α=.05). Figures not followed by letters do not differ significantly

Site	Year Planted	Slope/ Aspect	Site Index[1]	Precip. (in.)	Elev. (ft.)	Site Prep	Survival (%)			Total Height (in.)		
							Styro-2	Styro-4	Styro-8	Styro-2	Styro-4	Styro-8
							FIVE-YEAR DATA[2]					
Orogrande Cr.	1978	40/N	101	45	4000	Dozer	98	98	100	30 b	31 ab	33 a
Breakfast Cr.	1978	10/N	108	45	4200	Dozer	93	100	98	25 b	29 a	29 a
Orogrande Cr.	1979	20/NW	101	45	4200	Dozer	100	100	100	25 c	32 b	36 a
Shanghai	1979	25/S	67	40	4100	Dozer	95	91	97	22	22	25
Robinson Ridge	1979	40/N	86	45	3800	Burn	98	98	100	30 b	33 b	38 a
Breakfast Cr.	1979	30/S	90	45	4200	Dozer	98	98	97	26 b	27 ab	29 a
							THREE-YEAR DATA					
Shanghai	1978	25/SE	67	40	4200	Burn	91	92	94	10	11	11
Elk Cr.	1980	30/S	83	50	4000	Dozer	90	93	--	17 b	20 a	--
Potato Hill	1980	35/NW	79	45	4000	Dozer	98	99	--	17 b	21 a	--
Stoney Cr.	1980	65/NE	119	45	3000	Burn	99	100	--	16 b	20 a	--
Robinson Cr.	1980	20/SW	88	40	3500	Burn	49	48	--	7	8	--
							TWO-YEAR DATA					
Little Green Mtn.	1978	10/S	93	45	4700	Dozer	94 a	87 b	89 ab	5 b	7 a	6 ab

[1]@ 50 years breast height, calculated, not measured.
[2]Time since planting.

Table 3.--Douglas-fir survival and total height by site and container size. Browsed and clipped seedlings were deleted from analyses. Figures within site followed by different letters are significantly different (α=.05). Figures not followed by letters do not differ significantly

Site	Year Planted	Slope/ Aspect	Site Index[1]	Precip. (in.)	Elev. (ft.)	Site Prep	Survival (%)			Total Height (in.)		
							Styro-2	Styro-4	Styro-8	Styro-2	Styro-4	Styro-8
							FIVE-YEAR DATA[2]					
Orogrande Cr.	1978	40/N	101	45	4000	Dozer	100	100	100	41 b	43 b	48 a
Breakfast Cr.	1978	10/N	108	45	4200	Dozer	95	97	100	41 b	48 ab	53 a
Orogrande Cr.	1979	20/NW	101	45	4200	Dozer	98	98	100	34 b	34 b	44 a
Shanghai	1979	25/S	67	40	4100	Dozer	77	81	92	24 b	27 b	35 a
Robinson Ridge	1979	40/N	86	45	3800	Burn	100	93	97	33	33	36
Breakfast Cr.	1979	30/S	90	45	4200	Dozer	50	85	78	14 b	27 a	28 a
							THREE-YEAR DATA					
Elk Cr.	1980	30/S	83	50	4000	Dozer	100	94	96	22	22	24
Potato Hill	1980	35/NW	79	45	4000	Dozer	84	78	91	13 b	13 b	16 a
Stoney Cr.	1980	65/NE	119	45	3000	Burn	99	99	100	19 b	21 a	22 a
Robinson Cr.	1980	20/SW	88	40	3500	Burn	72	73	82	15	15	18
							TWO-YEAR DATA					
Shanghai	1978	25/SE	67	40	4200	Burn	86	87	100	15	14	18
Little Green Mtn.	1978	10/S	93	45	4700	Dozer	82 b	85 b	98 a	9 b	11 b	14 a
Mt. Margaret	1982	20/NE	87	40	3900	Dozer	52 b	74 a	77 a	5 b	12 a	12 a

[1]@ 50 years breast height, calculated, not measured.
[2]Time since planting.

Styro-2 seedlings produced significantly less height growth than styro-4 seedlings on only three sites (table 3). Styro-2 seedlings were 13 inches (32.5 cm) shorter than styro-4 seedlings at the Breakfast Creek (1979) site. This difference only lengthened the predicted rotation age by 1 year, but the less expensive seedlings offset the cost of the longer rotation. Survival differences would not favor planting styro-2 seedlings on this site, however. Three-year height differences at Stoney Cr. also resulted in a 1 year longer rotation for styro-2 seedlings. The 1 year height data from Mt. Margaret couldn't be analyzed for rotation length differences, but survival data. favored styro-4 seedlings.

Styro-8 seedlings were significantly taller than styro-4 seedlings on five test sites. Planting styro-8 rather than styro-4 seedlings on these sites shortened the predicted rotation length by 1 year, but resulted in reduced net present values due to higher seedling costs.

CLIMATIC CONDITIONS

Growing season precipitation during 3 of the 5 years that tests were planted was at least 25 percent above normal (table 4). Even in drier years, July or August precipitation was above normal. The increased precipitation may have reduced stress during the critical first year of seedling establishment. Had the climate been in a dry cycle, survival results may have differed slightly.

Table 4.--Growing season precipitation recorded at Pierce, Idaho (National Oceanic and Atmospheric Administration data)

Month	Normal Precip. (in.)[1]	Percent of Normal 1978	1979	1980	1981	1982
May	3.51	122	164	138	118	52
June	3.47	63	29	135	210	81
July	1.03	340	36	122	187	315
Aug.	1.14	219	135	128	50	65
Sept.	2.34	73	20	139	98	92
TOTAL	11.49	124	80	135	141	93

[1]Average of 1941-1970 precipitation.

GREENHOUSE PRODUCTION CONSIDERATIONS

Both species examined in this test have been produced in operational quantities in styro-4 containers. Styro-2 containers pose some operational concerns due to increased seedling density which reduces the amount of light available to the seedlings, increasing suppression problems. Suppressed seedlings generally won't reach plantable size in styro-2 containers. Also, the increased density retards foliage drying following irrigation. This, combined with dead needles that have died from shading, produce increased disease risks. The following comments address these and other concerns that make greenhouse production of styro-2 seedlings more difficult.

Western White Pine

We have not grown white pine on a production basis in styro-2 containers. Seedlings planted in these research tests were grown in less than a dozen blocks. This is not a large enough size to sample microclimate effects which influence disease occurrence in the greenhouse or to provide a large mass of densely grown seedlings which also affects disease impact. White pine has been operationally grown in styro-4A blocks. These have 87 cavities/ ft^2 compared to 96 cavities/ft^2 for styro-2 blocks. Observations based on styro-4A production are as follows:

1) Five percent were culled during pull-and-wrap operations due to poor caliper development.

2) Mortality increased an additional 5 percent due to botrytis (grey mold) infections. Usuall, the smaller codominant and intermediate seedlings were affected.

3) Styro-2 production could increase disease control chemical cost by $3/M over that for styro-4 production. Increased control activities still may not reduce disease incidence.

If these observations hold true for the denser styro-2 seedlings, then production costs could increase by 14 percent. This still leaves a 28 percent cost difference between styro-2 and 4 seedlings, however.

Douglas-fir

Large lots of Douglas-fir have been operationally grown in styro-2 containers. The following observations are based on this experience:

1) A 3-5 percent reduction in shippable (or plantable) seedlings results from the increased competition in styro-2 containers.

2) Styro-2 containers have not increased disease problems.

3) Styro-2 sowings use approximately 15-20 percent more seed than styro-4 sowing. Extra seed is used to ensure rapid and uniform germination in all cavities. Late germinating seedlings are often suppressed due to increased competition (seedling density) for light and may never reach plantable size.

CONCLUSIONS

Data from 11 sites indicate that planting styro-2 rather than styro-4 white pine will not result in reduced survival. Where 3- or 5-year total heights differed significantly, further analyses indicated that no practical differences existed between styro-2 and styro-4 seedling growth. Based on survival and growth data, white pine should be grown in styro-2 containers. Greenhouse problems may preclude styro-2 production, however. Increased risk of disease mortality must be evaluated before beginning large scale styro-2 production.

Douglas-fir survival data suggest that styro-4 containers may be needed only on the driest sites. Styro-2 seedling performance was excellent on moister sites. Height growth differences did not justify using larger containers. The slight increase in height and decrease in predicted rotation lengths produced by larger containers did not compensate for the increased seedling production costs.

Seedling root growth was not examined in this study. Although root development problems are not anticipated, examinations should be made to determine if root form problems may develop.

REFERENCES

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