Growth and Development of Shoot and Root Pruned Yellow-Poplar Seedlings on Two Sites

Keeping proper shoot-root ratio is important factor in maintaining early height growth

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Yellow-poplar *(Liriodendron tulipifera L.),* one of our major hardwood species, attains its greatest growth on well-drained bottomlands and coves, but these sites also support the greatest amount of competing vegetation. Several studies (2, 4, 8) have shown that yellow-poplar does not do well with overstory competition. In attempting to improve survival and competitive ability of yellow-poplar planted seedlings, Sluder (1964) found that root pruning increased root weight and fibrosity but not survival, and Thor (1965) found an increase in root branching with no effect on survival. However, Linstrom, *et al.* (1955) noted an increase in survival when seedling roots were pruned to 10 inches. A study at Clemson University (Bruner,' unpublished), on the other hand, showed a significant reduction in survival with increasing severity of root pruning. None of these workers found a correlation between shoot pruning and survival.

This study was established to determine whether a combination of shoot and root pruning would have a significant effect upon survival or growth of yellow-poplar seedlings during the first year after planting.

Materials and Methods

Two sites were selected in a cutover mixed-hardwood stand. One was a hill site on the upper part of a steep south-facing slope exposed to full sunlight. The second, a cove site, was shaded during part of the day by the adjacent stand. These sites had been clearcut recently but neither had ever been cultivated. Analysis of the Cecil sandy loam indicated excellent nutrient status for tree growth with 8 to 10 inches of topsoil.

The treatments included all combinations of four levels of both shoot and root pruning: (1) control (no pruning), (2) pruned to 20 cm, (3) pruned to 15 cm and (4) pruned to 10 cm. The 1-0 seedlings were selected to have a root collar diameter of 0.'-1.3 cm because it has been shown that seedlings with small root-collar diameters have poorer survival (3, 5). A randomized complete block design was used with six replications per site and 3 seedlings per plot for 288 seedlings on each site. They were planted in February at a spacing of 0.6 m by 0.6 m and hand cultivated to reduce competition.

Measurements made were: initial height, height growth, final height, dry shoot weight, dry root weight, diameter growth at the ground line and incident light levels. Other data recorded at the end of the growing season were shoot/root ratio, mean number of leaves, leaf surface area, and root surface area.

Height measurements were taken at 2-week intervals throughout the growing season which lasted into October because of the unusually wet and warm season. After growth ceased, all seedlings were dug by hand to determine root growth and weight. Root surface area was determined on one-third of the seedlings using absorption of $CaNO_2$, on the root surface (1). Dry weights are reported as ovendry (105 C for 24 hours).

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Figure 1.—Hill site.

Figure 2.—Cove site.

Results and Discussion

Shading apparently had a major effect on seedling growth (figures 1 and 2). Heights of seedlings on the

cove site, which received only 58 percent as much sunlight as the hill site, ranged from 53 to 64 cm less than that of seedlings on the hill site. The growth curves (figure 3) are for the best, poorest, and control treatments, and indicate a difference in the pattern of height growth caused by the shading. Seedlings on the hill site exhibited a typical sigmoidal growth curve, but those on the cove site exhibited a very flattened curve with a much reduced logarithmic phase.

Shoot pruning to 10 cm and root pruning to 20 cm gave both greater growth throughout the growing season and greater final heights than other treatments (Table 1), although the differences were not significantly greater than the controls. On the other hand, any combination of root pruning without shoot pruning had significantly less height growth on both sites compared to controls or combinations of shoot and root pruning.

Dry shoot weights followed the same pattern as height growth. Dry root weights (table 2) followed a similar pattern but only the more severe pruning treatments were significantly different.

These findings could be a significant factor in yellow-poplar propagation, because tree planting personnel tend to prune the root systems to "even them up", without any top pruning. Top pruning appears to have offset any damage caused by root pruning under these conditions.

There was no increase in root fibrosity, as measured by root surface area or visually, although such an increase has been reported by others (6, 7). There was, however, branching at the point of pruning. Seedling survival was not affected by the pruning, as it exceeded 90 percent in all treatments, probably because there was little moisture stress during the wet growing season.

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TABLE 1.—One year's height growth of yellow-poplar seedlings growing on two sites with various levels of shoot and root pruning.

Root (cm) \ Shoot (cm)	10	15	20	46	$\bar{X}$
Hill site					
10	82	75	80	72	77^{b}
15	97	65	81	71	78^{b}
20	111	91	103	78	95^{a}
32	107	72	90	93	91^{a}
$\bar{X}$	99^{a1}	76^{c}	88^{ab}	79^{bc}	
Cove site					
10	36	45	26	20	32^{b}
15	45	42	32	24	36^{ab}
20	46	47	39	20	38^{a}
35	43	39	31	38	38^{a}
$\bar{X}$	43^{a}	43^{a}	32^{b}	25^{c}	

[1] Means followed by the same letter are not significantly different at the 5 percent level by Duncan's Multiple Range Test.

TABLE 2.—Dry root weight (gms) of yellow-poplar seedlings after one growing season with various levels of shoot and root pruning.

Root (cm) \ Shoot (cm)	10	15	20	46	$\bar{X}$
Hill site					
10	30	36	29	27	30^{c}
15	39	30	33	42	36^{bc}
20	49	47	49	44	47^{a}
32	49	35	36	49	42^{ab}
$\bar{X}$	42^{a1}	37^{a}	37^{a}	41^{a}	
Cove site					
10	10	8	8	10	9^{b}
15	14	13	11	11	13^{a}
20	14	16	14	9	13^{a}
35	13	15	14	20	15^{a}
$\bar{X}$	13^{a}	13^{a}	12^{a}	13^{a}	

[1] Means followed by the same letter are not significantly different at the 5 percent level by Duncan's Multiple Range Test.

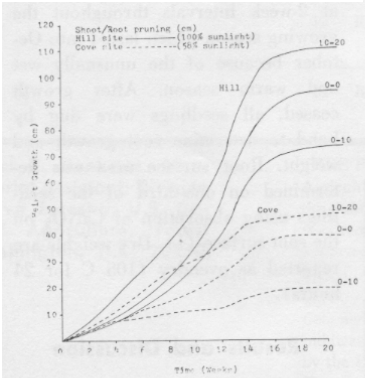

Figure 3.—Cumulative height growth with time for shoot-pruned and root-pruned yellow-poplar seedlings on two site.

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The pruning levels had no significant effect upon final shoot/root ratio, no significant effect upon diameter growth on either site, and no significant effect upon average leaf size or leaves per seedling.

It is evident from these results that proper ratios of shoot and root pruning have not caused a loss in height growth under these conditions. Yet, removal of the excess shoot and root material prior to seedling planting can improve uniformity of planting and facilitate handling, especially by mechanical planters.

If shoot and root pruning is feasible at the nursery, a reduction in shipping costs would also be possible. Thus if a proper balance in the shoot/root ratio is maintained when pruning, both a cost saving and performance increase may be possible.

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(Continued from page 11) around the micropyle was just as evident with the stones as with individual nutlets.

The results demonstrate the importance of a high-quality seed source. Greenleaf manzanita seed was considerably superior to pinemat seed. One source of greenleaf seed came from irrigated shrubs, which may have contributed to higher viability. Finding a good pinemat manzanita seed source is probably the greatest obstacle to successful germination.

Based on the data, it is likely that greenleaf manzanita can be germinated easily in the greenhouse with 1-0-50 percent success. Key factors in optimum germination are a good seed source, closely monitored scarification, removal of the carbon residue from the seedcoat after scarification, and adequate moisture during stratification.

Pinemat manzanita seed germinated poorly. Further testing is needed to provide guidelines for obtaining uniform, viable seed in the field and optimum stratification requirements.

TABLE 2.—Experiment 2. Germination of Arctostaphylos patula (*ARPA*) *and* Arctostaphylos nevadensis (*ARNE*)

Species	Seedling counts: Planting	10 da	14 da	21 da	28 da	35 da	42 da	%
No treatment								
ARPA LK-189	0	0	0	0	0	0	0	0.0
ARNE LK-212	0	0	0	0	0	0	0	0.0
ARNE LK-263	0	0	0	0	0	0	0	0.0
90 days stratification at 5.5°C								
ARPA LP-189	0	7	13	26	26	26	27	6.8
ARNE LK-212	0	0	1	1	1	1	1	0.3
ARNE LK-263	0	0	0	0	0	0	0	0.0
H_2SO_4 scarification, 90 days stratification at 5.5°C								
ARPA LK-189	50	60	79	136	157	168	174	43.5
ARNE LK-212	0	0	0	1	1	1	1	0.3
ARNE LK-263	0	1	1	1	1	1	0	0.3
H_2SO_4 scarification, 15 days stratification at 18-25°C, 75 days at 5.5°C								
ARPA LK-189	29	45	53	100	108	110	113	28.3
ARNE LK-212	0	5	5	4	4	4	4	1.3
ARNE LK-263	0	0	0	0	0	0	0	0.0
H_2SO_4 scarification, 30 days stratification at 18-25°C, 60 days at 5.5°C								
ARPA LK-189	0	12	18	62	64	64	64	16.0
ARNE LK-212	0	1	3	9	9	9	9	2.3
ARNE LK-263	0	1	2	2	3	3	3	0.8
H_2SO_4 scarification, 45 days stratification at 18-25°C, 45 days at 5.5°C								
ARPA LK-189	0	1	14	39	42	44	41	11.0
ARNE LK-212	0	0	0	0	0	0	0	0.0
ARNE LK-263	0	0	0	1	1	1	1	0.3
H_2SO_4 scarification, no stratification								
ARPA LK-189	0	0	0	0	0	0	0	0.0
ARNE LK-212	0	0	0	0	0	0	0	0.0
ARNE LK-263	0	0	0	0	0	0	0	0.0