FIRST-LIFT PRUNING TIMES OF RADIATA PINE SEEDLINGS AND ROOTED CUTTINGS IN A SMALL CALIFORNIA EXPERIMENT*

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SYNOPSIS

Radiata pine trees of rooted-cutting and seedling origin were pruned to a height of 1.5 metres six years after planting. It was demonstrated that the pruning times for the trees grown from rooted cuttings were consistently and significantly less than for their seedling-origin relatives. Trees grown from cuttings had fewer and smaller branches, less taper, and smaller knotty cores.

BACKGROUND

Recent issues of this journal have presented a general argument for using rooted cuttings of radiata pine (Thulin and Faulds, 1968) and briefly discussed cuttings with respect to initial stocking and pruning (James *et al.*, 1970). A more general discussion of the advantages to be gained by coupling vegetative propagation of radiata pine with a genetic selection programme was presented by Libby *et al.*, 1972. Among those advantages, the following are germane to this paper: cuttings have greater within-clone uniformity in most (perhaps all) characteristics, fewer lower branches, smaller lower branches, and less stem taper than seedlings. Although cuttings from old radiata pine do not grow in height as fast as seedlings, cuttings from juvenile and adolescent radiata pine grow in height at about the same rate as seedlings.

If pruning is accepted as normal practice, perhaps the most meaningful single measure of lower branch characteristics is the time it takes to prune them. Three subexperiments of a California experiment containing seedlings and cuttings of radiata pine were in an area of high risk from vandalism and fire, and therefore an early low pruning was dictated. We decided to time the pruning operation on each tree, so that the apparent differences in branch characteristics of the seedlings and rooted cuttings would be quantified in a single measure — the time required to prune the tree to a specified height.

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THE EXPERIMENT

Controlled crosses of several radiata pines were made in 1963 and cones were harvested in 1965. The parent trees were selected so as to have a low probability of being related, but were otherwise unselected for any characteristic. In late 1965, cuttings were taken from the parent trees, and seeds from the controlled pollinations were germinated. In June and December, 1966, the seedlings and the rooted cuttings of their parents were planted at three locations in California. The most uniform of these sites was at Gill Tract, near Berkeley, and it was on this site that the initial pruning was conducted in late 1971.

Only the three families* listed in Table 1 were included in this initial pruning trial. The experiment had been planted as a randomized block layout for each family. In the first family, each block consisted of three trees — one rooted cutting from each parent (R1 and R10) and one seedling (1 × 10). The second family had two-tree blocks consisting of one cutting (R4) and one seedling (4 × 13). The third family consisted of one rooted cutting (R7) and one graft on a randomly selected rootstock (G7), both from parent tree 7, and one seedling (7 × 14), in each block. Note that parents 13 and 14 were not vegetatively propagated, as growth performance of such old clones was expected to be inferior to cuttings of adolescent clones, as well as to seedlings.

TABLE 1: LIST OF CUTTING AND SCION DONORS, AND SEEDLING PARENTAGE

Tree No.	*Age of Tree in 1965*	*Vegetative Propagation*	*Sexual Propagation*	*Seedling Family Designation*
1	Adolescent 14 yr	via cuttings	as cone parent	1 × 10
10	Adolescent 12 yr	via cuttings	as pollen parent	
4	Adolescent 11 yr	via cuttings	as cone parent	4 × 13
13	Mature 30+ yr	none	as pollen parent	
7	Adolescent 12 yr	via cuttings and grafts	as cone parent	7 × 14
14	Mature 30+ yr	none	as pollen parent	

*The term "family", as used in this paper, includes seedlings and the rooted cuttings (and in one case grafts) of one or both of the seedlings' parents, unless the context restricts the meaning to only full-sib seedlings.

A single worker pruned all trees in these three families. He had fair pruning experience (for a Californian), but did not know the biological details of the experiment, nor its purpose. Since the trees were randomized within blocks, the order of pruning when working down a row was random for grafts, cuttings and seedlings. Members of the first (R1, R10, 1 × 10) and second (R4, 4 × 13) families were contained in the same rows, and were thus pruned alternately during the same time span. The third family (R7, G7, 7 × 14) was some distance away, and was pruned as a unit.

All trees had been previously marked to a uniform height of 1.5 m above ground level. The worker used a pair of long-handled secateurs for most branches and a short-handled pruning saw for the larger branches. The timing operation was as follows: Turn on stop-watch. Observe tree. Penetrate branch canopy to stem. Prune off all branches between the ground and the 1.5 m mark. Return to data board and stop the stop-watch. Enter time on data sheet. Of these operations, only the return to the data board was probably similar for each tree.

After pruning, the tree heights and the diameters inside bark of the three largest pruned branches were measured. All stubs of branches that had been pruned, no matter what size, were counted. The diameters of the largest pruned whorls were measured, and bole diameters at one, two, and three metres height were taken to calculate bole taper.

RESULTS

In the 26 valid intra-block comparisons between a rooted cutting or graft and a seedling, the cutting or graft was pruned faster in 23 comparisons and the seedling was pruned faster in only 3 (Table 2). On the average it took only 42% and 47% as long to prune a rooted cutting from tree 1 or 10 as it did to prune one of their seedling offspring, 71% as long to prune a cutting from tree 4 as a seedling of 4 × 13, and 72% and 70% as long for a graft or cutting from tree 7 as a seedling of 7 × 14. The variability in pruning time (as expressed by the variance in Table 2) was, as expected, less between trees within a clone than between seedlings in a genetically segregating full-sib family.

As was obvious when it was decided to time the pruning operation, seedlings (Fig. 1) had more branches below 1.5 m, and their largest branches were bigger compared with vegetative propagules of their parents (Fig. 2; Table 3). (An apparent exception to this was the largest branches of the grafts. However, these large branches were generally below the graft union, and thus were really of seedling origin.) The greater number and diameter of seedling branches, plus their greater length and density (making the initial penetration of the branch canopy to the stem more difficult), probably account for most of the differences in pruning time between cuttings and seedlings.

FIG. 1: *Radiata pine seedling (1 × 10) with many long branches and a dense lower crown, making initial penetration of the branch canopy to the stem difficult.*

FIG. 2: *Radiata pine rooted cutting (R1), with few and short branches and an open lower crown, making initial penetration of the branch canopy to the stem relatively easy. Note, however, the crooked lower stem near the metre stick, and the whorls of low stem cones.*

TABLE 2: PRUNING TIMES IN MINUTES FOR SEEDLINGS, CUTTINGS AND GRAFTS

	Identity of Clones and Families							
Block	*R1*	*R10*	*1 × 10*	*R4*	*4 × 13*	*G7*	*R7*	*7 × 14*
1	0.91	1.51	2.26	1.70	1.84	—	1.17	1.05
2	1.50	0.78	3.21	2.78	2.24	1.61	2.04	1.85
3	1.92	1.36	2.21	1.84	2.59	—	1.21	2.51
4	0.82	1.44	2.65	1.45	3.34	1.12	1.34	1.79
5	0.82	1.52	5.10	2.79	3.65	1.43	1.22	2.29
6	—	1.30	1.53	1.10	—	2.14	1.63	2.74
Av.	1.19	1.32	2.83*	1.94	2.73	1.57	1.43	2.04
σ^2	0.25	0.08	1.55	0.49	0.57	0.15	0.12	0.37

R1 = Rooted cuttings of tree 1.
G7 = Grafts of tree 7.

The 1 × 10 and 4 × 13 families were planted in June, 1966. The 7 × 14 family was planted in December, 1966.

*The seedlings are significantly different from both the tree 10 and tree 1 cuttings at the 5% level.

Pooled data: Cuttings and grafts averaged 1.50 min per tree; seedlings averaged 2.52 min per tree. Pooled difference significant at 1% level.

In the 1 × 10 family, both parent clones have grown to identical average heights, and the seedlings average slightly more than one decimetre taller. Not having clones of both parents in families 4 × 13 and 7 × 14, meaningful height comparisons between rooted cuttings and seedlings are not pos-

:D BRANCH MEASUREMENTS OF CLONES AND FULL-SIB FAMILIES IN TABLE 1

					Pooled Data	
R4	*4 × 13*	*G7*	*R7*	*7 × 14*	*Grats and Cuttings*	*Seedlings*
44*	52	44	44	40	48.1	52.3
6.0**	7.5	5.5*	5.3	6.8	6.1**	8.6
3.3	4.8	3.5[1]	2.7*	3.6	2.8**	4.2
26	30	22	23	28	25.0[2]	29.9
9.8**	15.6	10.6	8.3	10.7	9.6**	13.8
0.77	0.72	0.72	0.75	0.59	0.77	0.69
0.50	0.51	0.49	0.53	0.35	0.69*	0.49

from seedlings at 5% level.
gs at the 1% level.
ıt the 1% level, but not significantly different from the seedlings.
ıce approaches 5% level of significance).
meter at 2 m height relative to the bole diameter at 1 m height and by the
ıeter at 1 m height. Statistical significance was assigned by testing the sign
rooted cutting (or graft) in each block, and assuming + and — differ-
distribution. For the 2m/1m taper, 15.5+ and 9.5— were observed
re observed ($P = 0.02$).
d t test. Pooled data tested by unpaired t test.

FIG. 3: *The first and fourth trees of the foreground row are (1 × 10) seedlings. Note the greater taper and more frequent branch stubs of these pruned seedlings, compared with the second and third trees in the row, which are rooted cuttings of clones* (*R10*) and (*R1*), *respectively.*

DISCUSSION

The phase change (Kozlowski, 1971, Chapter 3) from juvenile through adolescent to mature seems to occur most sharply between two and four metres height in California trees. If this is the general case, one would expect small average differences in pruning times between cuttings and seedlings at the second lift from two to four metres, and little or no average difference at the third lift to six metres. A recent comparison between grafted stock and normal seedlings at the N.Z. Forest Research Institute at Rotorua indicated, in fact, that the grafts had more branches per unit length in the region of the second lift than did seedlings (James *et al.*, 1970; W. R. J. Sutton, pers. comm.), and thus second-lift pruning times might favour seedlings.

The effect of the difference in taper may be important. Following low pruning and phase-change of the seedlings, later wood production of pruned seedlings and pruned cuttings may be similar or identical. No really good data on this point are yet available. But if this is true, then a less tapered butt log may be an advantage in favour of pruned cuttings, in terms of such variables as distribution of core wood and straightness of grain.

The size of the knotty core is considered to be very important in production of clearwood (James *et al.*, 1970). To compensate for an increase in knotty core diameter of 1 cm, the final diameter of the tree must be 2.5 cm larger. Thus, the large, consistent, and highly significant differences between cuttings and seedlings in diameter of pruned whorls (Table 3) are of significant economic importance if clearwood production is one of the goals of pruning.

This small experiment reports on real biological differences between cuttings taken from adolescent trees, and juvenile seedlings which contain some or all of the same genes. These biological differences are translated into a practical difference in the time it takes to low prune these trees. It suggests that some or all of the higher costs of raising rooted cuttings compared with seedlings may be recovered by savings in first-lift pruning costs. It further suggests, in a different vein, that pruning times might be part of the evaluation of clones which are candidates for production forestry plantings.

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REFERENCES

James, R. N.; Tustin, J. R.; Sutton, W. R., 1970: Forest Research Institute symposium on pruning and thinning. *N.Z. Jl For., 15:* 25-56.

Kozlowski, T. T., 1971: *Growth and Development of Trees. Vol. I. Seed Germination, Ontogeny, and Shoot Growth.* Academic Press, N.Y. and London. 443 pp.

Libby, W. J.; Brown, A. G.; Fielding, J. M., 1972: Effects of hedging radiata pine on production, rooting, and early growth of cuttings. *N.Z. Jl For. Sci., 2* (2): 263-83.

Thulin, I. J.; Faulds, T., 1968: The use of cuttings in the breeding and afforestation of *Pinus radiata. N.Z. Jl For., 13:* 66-77.