THE EFFECTS OF DORMANT PRUNING TREATMENTS ON LEAF, SHOOT AND ROOT PRODUCTION FROM BARE-ROOT *MALUS SARGENTII*

by Philip S. Evans and James E. Klett

Abstract. The effects of dormant branch thinning and heading on leaf, shoot and root production were investigated for two-year-old, branched, bare-root trees of *Malus sargentii* (Sargent crabapple). Each pruning treatment removed 50% of branch length and number of buds. Thinning reduced leaf weight in the subsequent growing season, but heading did not. Compensatory increases in shoot growth from the retained branches were observed for both treatments. Treatments did not affect root weights or leaf:new root ratios. The usefulness of the shoot:root ratio as a measure of the balance between transpiration and root water absorption is discussed.

Pruning is often recommended at planting time for dormant, bare-root trees, in order to establish a more favorable shoot:root ratio (2, 15, 21). The reduction of the root system during harvest is thought to necessitate a proportional reduction in branch structure. The assumption is that dormant pruning will delay or reduce leaf area development in the following season. An implicit assumption is that root growth will be unaffected or increased by shoot pruning. Pruning is intended to reduce the shoot:root ratio and the probability of injurious water stress during establishment (7, 16). Watson and Himelick (26) estimated that for large caliper trees 98% of the soil volume containing the root system is removed by standard digging practices. No comparable information is available for small bare-root trees. Visual examination of the root system of a small tree suggests that the proportion of functional roots removed may be similar, since white, unsuberized roots are almost completely removed by harvest. A rule of thumb in the nursery business is to remove 30% of the shoot system of bare-root trees at planting time. If a balance between the loss of roots and shoots is desired, this would appear insufficient, considering the reduction in root mass and function.

Conflicting results have been reported as to pruning effects on tree survival and growth (7, 21, 23, 25). Few researchers have specifically measured the effects of pruning on leaf area development. Some workers (11, 18, 19) have shown that branch decapitation (heading back) reduced leaf area proportionately to the severity of pruning. Although these results support conventional practices, in most cases heading back of dormant branches has been shown to increase the number, rate of growth, or length of new shoots (1, 5, 14, 21). Although shoot growth is not a precise measure of leaf area development, these results indicate that leaf area may be increased by pruning. Previous research has also indicated that shoot pruning decreased root growth (8, 11, 14). Several workers have postulated a competitive inhibition of root growth by the rapid shoot growth response characteristic after heading back (8, 11, 27).

These results suggest that pruning may have an undesirable effect on shoot:root ratios of bare-root trees. However, most previous research only utilized dormant branch heading. Evidence exists that branch thinning might produce contrasting results. Although Plich et al reported that bud and new shoot thinning resulted in increased elongation of the remaining shoots (22), Maggs (18, 19) reported a reduced leaf area development by restricting the number of dormant buds allowed to develop. Other workers found no increase in the

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growth of leaders when current season's shoots were removed from trunks (10, 13). Such reports indicate that individual branch growth may be independent, and that increase in shoot growth may not be found in the branches after thinning. Thus leaf area development may be reduced in thinned trees. Although thinning of current season's shoots has resulted in a reduction in root development (10), dormant branch thinning may not have the same effect. The shoot:root ratio may then be reduced. To explore this possibility, a study was initiated to investigate and compare the effects of dormant branch thinning and heading on leaf, shoot, and root development from a tree species commercially planted bare-root.

Materials and Methods

Seventy-two 2-year-old, bare-root, branched (4-5′ grade) *Malus sargentii* (Sargent crabapple) were used in these experiments. Trees were held at 5°C for 12 days after arrival until planting on May 7, 1983. Trees were moistened daily while in storage. Although the root and shoot systems were quite uniform, trees were sorted by visual quality so that each treatment group would contain a representative sample of this variation.

Trees were planted in 40 liter (10 gal) pressed paper fiber containers. The growing medium was a mixture of clay loam, sphagnum peat moss, and coarse sand (2:1:1 by volume). The medium was steam pasturized and no fertilizer was added at planting time. The growing medium was irrigated as necessary to maintain moisture content near container capacity. Trees were widely spaced in a completely random design on a large asphalt pad, exposed to elevated radiation and temperature levels throughout the growing season. Sixty days after planting, the growing medium was top-dressed with Osmocote 14-14-14 at the recommended rate (14g) per pot. From that date until harvest, a soluble complete fertilizer (Peters 20-20-20) was injected at 200 ppm N into the irrigation system on alternate waterings.

Pruning treatments are shown diagrammatically in Fig. 1. One week after planting, all trees were pruned to remove broken branches and spurs. Twenty-four check trees received no further pruning. On each tree the uppermost branch was considered the leader and left unpruned. In order to reduce branch variability, a restriction was set on the length and crotch angle of lateral branches to be spared during thinning. Seven branches within these size restrictions were spared on each tree. The thinned treatment had all but these seven lateral branches removed. Branch length and number of buds per tree were reduced by approximately 50%. Trees in the thinned and headed treatment had all but the seven branches removed, and these seven were pruned to approximately half their length (Fig. 1). The thinned and headed treatment compared to the thinned (only) treatment reduced the branch length and number of buds by approximately 50%.

The effect of branch thinning was determined by comparing the thinned treatment with the control. The effect of branch heading was shown through comparison of the thinned and headed treatment with the thinned (only) trees. Applying the heading treatments to all branches and trees, rather than to just the spared branches, would have been inconsistent with industry practice and introduced additional variability.

Twelve trees from each treatment were harvested August 6, 1983, 90 days after planting. By this date all shoots had set terminal buds, and leaf expansion was complete. Our objective was to examine the shoot:root ratio upon full canopy development, but before additional root growth occurred. Shoots less than 2.5 cm were

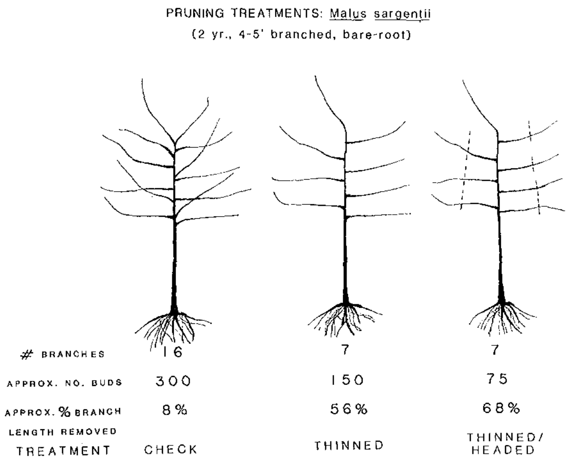

Fig. 1: Pruning treatments and the corresponding percentage of branch length removed. The number of branches and the approximate number of buds on each tree is also shown.

considered spurs. Spur and shoot leaves were collected separately. Spur and shoot numbers, average shoot length, and total shoot length were estimated from a representative sample of branches on each tree, using all 24 trees in each treatment. The growing medium was carefully loosened, shakened, and washed from the root system. New root growth was easily distinguishable from preexisting root stubs by color, and was collected separately. Leaf and root dry weights were determined after drying in a forced-air oven at 80 °C to constant weight.

Results and Discussion

A 31% reduction in leaf weight resulted from a 50% removal of branches and buds. Shoot development factors were investigated to clarify the sources of increased leaf development from the branches retained after thinning (Table 1). The percentage of buds which elongated was unaffected by thinning. No difference in spur leaf size or number, or shoot leaf size was found between treatments. However, a significant increase in average shoot length occurred on thinned trees. In addition, the observed increase in the proportion of shoots formed by elongating buds, although not statistically significant, contributed to increased leaf development. A concurrent experiment with thinning of *Prunus cerasifera* 'Newportii' (Newport plum) also identified increases in shoot length and the proportion of shoots formed in thinned trees (6). In that experiment the observed increase in shoot development from branches on thinned trees compensated completely for branch removal, and branch thinning did not reduce total leaf production. However, in the present experiment shoot growth increases compensated only partially for branch removal. For both species the expected independence between branches was not found.

Heading back did not reduce total leaf production (Table 2), in spite of a 50% reduction in branch length and number of buds. Significant increases in the proportion of shoots formed, average shoot length, and total shoot length were observed in headed trees, and compensated as above for branch length removal. An increase in the percentage of buds elongating was also found due to release from apical dominance. Only in this way did the heading response differ qualitatively from that of thinning.

Neither thinning nor heading affected root weights (Tables 1, 2). Although leaf weights were moderately well correlated with roots weights

Table 1. Effects of 50% bud removal by dormant branch thinning on leaf, root, and shoot development from bare-root *Malus sargentii*. Shoot data shown are mean values for lateral branches remaining on pruned trees.

	Treatment		
	Check (unpruned)	*Thinned*	*LDS 5%*[1]
Dry weights:			
Leaf (g)	41.2*	28.4	9.48
New root (g)	7.26	5.96	NS
Leaf:new root ratio:	6.20	4.98	NS
Shoot development factors:			
% Buds elongating	.552	.550	NS
Proportion of shoots formed	.083	.123	NS
Avg. shoot length (cm)	2.66	5.54*	2.27
Total shoot length (cm) per branch	6.54	11.3	NS[2]

1 A significant difference (at the 5% level of probability) between means in a row is indicated by an asterisk. The least significant difference for each comparison is shown at right, if applicable.
2 NS means non-significant.

Table 2. Effects of 50% bud removal by dormant branch heading on leaf, root, and shoot development from bare-root *Malus sargentii*. Shoot data shown are mean values for lateral branches remaining on pruned trees.

	Treatment		
	Check (thinned only)	*Headed and thinned*	*LSD 5%*[1]
Dry weights:			
Leaf (g)	28.4	30.9	NS[2]
New root (g)	5.96	6.26	NS
Leaf:new root ratio:	4.98	5.45	NS
Shoot development factors:			
% Buds elongating	.550	.711*	.107
Proportion of shoots formed	.123	.392*	.088
Avg. shoot length	5.54	12.9*	4.32
Total shoot length (cm) per branch	11.3	34.4*	10.4

1 A significant difference (at the 5% level of probability) between means in a row is indicated by an asterisk. The least significant difference for each comparison is shown at right, if applicable.
2 NS means non-significant.

(r=.68), the reduction in leaf weight due to thinning was not reflected in a decrease in root weights. Heading resulted in shoot growth increases but no inhibition of root growth as suggested by previous reports (8, 11, 14, 27). With the larger trees used here, stored carbohydrates and other growth substances may provide a reserve which buffers the competition between roots and shoots for these materials (9).

The shoot:root ratio is often calculated using total top and root weights (17). The percentage of woody tissue increases dramatically with tree size, and reduces the value of the shoot:root ratio as an indication of the relative size of surfaces for root water absorption and top transpiration. For bare-root trees the leaf:new root ratio may be more appropriate.

Leaf:new root ratios were variable within treatment groups and were unaffected by either pruning treatment (Tables 1, 2). However, the leaf:new root ratio was closely and inversely related to new root weights (Fig. 2). These results were also observed with *Prunus cerasifera* (6). Treatments promoting root regeneration (12, 20) may be effective in reducing the leaf:new root ratio. Post-harvest handling and storage effects on root regeneration also need further study.

It is possible that the shoot:root ratio may not effectively predict susceptibility to water stress. Richards (24) found in peach seedlings that root absorption efficiency increased with top:root ratios. Cripps (3) found an interaction between soil moisture conditions and the developing shoot:root ratio. Low soil moisture reduced shoot growth more than root growth, decreasing the shoot:root ratio. Under well-irrigated conditions the reverse was found. Preston (23) reported growth from unpruned trees planted with roots removed was equal to that from pruned trees planted with roots. Research with pine seedlings demonstrated a cyclic fluctuation in shoot:root ratio around a characteristic value as shoot and root growth flushed alternately (4). Shoot growth from *Malus* and other deciduous trees ceases early in the season, yet root growth continues throughout the year with adequate soil temperatures. Evidently, there is a range within which shoot:root ratio may vary without increasing the risk of water stress.

Even the leaf:new root ratio is not a direct measure of leaf:root balance. Leaf weight and leaf area may not always be highly correlated, and leaf area may not determine transpiration rates closely due to differences in leaf expansion and leaf exposure throughout a tree canopy. Variation in root weight/surface area relationships, and extensive suberization of tree roots may reduce the usefullness of root weight as a measure of absorption.

Experienced nurserymen have concluded that pruning enhances survival and growth of bare-root trees (7, Flemer, personal communication). Results here and elsewhere (1, 6, 25) suggest that pruning is of limited value for affecting the shoot:root balance of bare-root trees of commercial size. Beneficial effects of pruning on initial root production may exist. There may also be early-season interactions with water stress, other environmental factors, or pre-plant handling. Response differences between species have been noted (7). Research is needed to determine the conditions under which pruning is warranted for different species.

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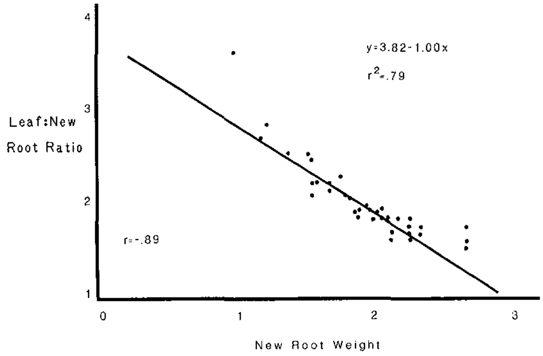

Fig. 2: Relationship between leaf:new root ratio and new root weight. Correlation and regression based on the natural logarithmic transformation of gram dry weights.

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ABSTRACT

DONALDSON, D.R., J.K. HASEY, and W.B. DAVIS. 1983. **Eucalyptus out-perform other species in salty, flooded soils.** California Agriculture 37(9 & 10): 20-21.

Landscape plants are often needed for difficult sites. To find plants that would grow in saline, frequently flooded soils, we evaluated 106 species on a nonirrigated floodplain underlain with salt water along the Napa River in northern California. The site was one of many established throughout the state for landscape tree evaluation. Of the 55 *Eucalyptus* species planted, 26 remain. Of the 51 other species, only 3 survived. *Eucalyptus* thus seems better able to tolerate difficult soil conditions. After eight to ten years of periodic flooding in saline soil and the 1976-77 drought, 17 *Eucalyptus* species had survived as acceptable landscape candidates. Acceptable species varied in shape and form from low-spreading to tall, skyline types, from dense to open branching habits, and from heavy to fine-textured foliage.