results are compared to the critical concentration, the relative degree of deficiency for the crop can be estimated for the growing season just completed. Fig. 4 gives an application of this concept to the field experiments of Tyler *et al.* (5). They found that when no fertilizer was applied, the potato plants were K deficient at about 85 days after planting and hence the tuber yield was decreased. With the application of K in the field, all petiole values were above the critical level and hence no yield differences were observed.

In the use of plant analysis as a guide to crop production, Tyler *et al.* (5) recommended a declining critical level instead of a constant reference critical concentration (6). Their declining critical level concept can be illustrated from their field plot study where all the fertilizers were applied at the beginning of the season and only one sample is to be collected at early midseason for analysis from the growing crop. The results of this sampling anticipate the K supply to the plants and the yield of potato tubers at harvest. The accuracy with which this sampling anticipates the K value at harvest depends on the time of sampling and the rate of change of K in the plant to harvest. This rate of change of K in the plant to harvest depends on the weather and soil type, which cannot be predicted accurately by present technology. The average effects of climate can, however, be established by taking a series of plant samples from many fields for a reasonable number of seasons in a cropping area. If cropping practices, climate and soils are relatively constant, then a single sampling will have a high predicative value, but in non-uniform areas, the declining slope of critical values will change from season to season and from soil type to soil type and more samplings will therefore be necessary to establish the nutrient trends of the crop for the growing season. In essence, the 2 sampling programs are compatible and compliment each other.

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Staking and Pruning Young *Myoporum laetum* Trees

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Abstract. The ability of young *Myoporum laetum,* Forst. f. trees to stand by themselves was improved by neither staking nor pruning them during their first 2 years in the landscape. Omitting these practices resulted in: 1) larger trunks at the ground, 2) trunks with greater taper, and 3) shorter tops. Taper of the trunks increased as the trees became older.

Introduction

Since young trees in the landscape are often slow in being able to stand upright and are frequently deformed by wind, almost all young trees in California urban plantings are staked. However, staking appears to create as many problems as it overcomes. Trunk and limbs may be injured and made unattractive by rubbing against the stake, tree ties may girdle the trunk, and the entire top may be lost if the stake or ties break.

Leiser and Kemper (5) have shown that the stress per unit cross-sectional area of the trunk increases as the height of staking rises from the ground level to within 12–18 inches of the tree top. The main leader may be severely deformed as a young tree grows above the top of the stake.

Restricting the tree tops from swaying greatly impaired the ability of Monterey pine, *Pinus radiata,* to withstand the elements. Jacobs (3) guyed the trunks of 2 trees in each of 74 matched 3-tree sets of 16-year-old Monterey pine. In the first year after guying, trunk diameter increased 83% as much in guyed trees as in trees which were free to sway. By the fifteenth year, the guyed trees had made only 52% as much trunk growth as the free-swaying trees but grew taller. In the first wind after the guy wires were removed, all trees that had been guyed broke or blew over. None of the other trees was lost.

Leaving branches along the trunk has been recommended by many (1, 4, 7) to protect and speed development of the trunk.

Young landscape trees might withstand the elements and other hazards better if grown without staking or pruning. The response of an evergreen tree species to certain staking and pruning practices is reported here.

Materials and Methods

The experiment was located at a future park site in Fremont in the San Francisco Bay Area. During March through September, the prevailing winds average 9 to 10 mph from the west and north-west. Afternoon wind velocities of 15 to 25 mph are common.

The soil is described as Yolo clay loam to Yolo clay. It is compact, inclined to crack, and high in alkali. To provide surface drainage for planting, the soil was graded into 2′-high gentle-sloping ridges. Forty trees of *Myoporum laetum,* Forst. f. were planted on the ridges 20 ft apart in May 1965.

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Fig. 1. Myoporum trees after pruning at beginning of second growing season. Left – staked tree; laterals below 4′ removed. Right – unstaked tree; temporary laterals thinned and headed. Stripes on marker 1′.

The myoporum, a broad-leaved evergreen, was grown from cuttings in a nursery — 1 season in 1-gal cans and 1 year in 5-gal containers. At planting the trees averaged 290 cm tall, with a trunk diameter of 9.4 mm (70 mm²) at 15 cm and 8.5 mm (57 mm²) at 107 cm above the ground. The trees were trained to a single leader and continued to grow with an excurrent growth habit. The lowest branches were about 3 feet above the soil. In the nursery the trees had been tied with 5 or 6 plastic ties to 6′ stakes.

The staking and pruning treatments were established at planting. The trees were pruned, and each to be staked was tied with plastic tape to a 10′ 1 × 1″ guide stake which was fastened to 2 cross pieces supported by two 6′ 2 × 2″ redwood stakes planted with the tree 18–24″ into the soil (2), Fig. 1.

The pruning treatments were:

1) Unpruned, all branches left.
2) Permanent branches selected, and other (temporary) growth removed or headed at planting and at each dormant pruning thereafter.
   A) No pruning during the growing season.
   B) Temporary growth removed or headed as needed during the growing season.
3) Permanent branches selected, and laterals below 4′ removed at planting and each dormant pruning thereafter. Any developing shoots on the trunk were removed during the growing season.

Ten trees were used for each of the pruning treatments. Five trees in each pruning treatment were staked as described, and 5 were left unstaked except that during most of the first summer the unstaked trees were guyed with hemp rope to keep the root ball in the ground and the trunk upright. The 3 guys for each unstaked tree were looped around the trunk in the crotch of the first permanent branch, about 4′ above the ground. The trunk was free to flex above and below the guys. No problem of bark injury or girdling resulted from the guys.

Table 1. The influence of staking on the growth of young *Myoporum laetum* trees[x]. Fremont, 1965 and 1966.

	Treatments	
	Unstaked	Staked
Height:	mm	mm
Increase, 1965	243	358
Increase, 1966	177	253
Total Increase	420	611*
Trunk growth, Cross-sectional area:		
At 15 cm	mm²	mm²
Increase, 1965	283	255
Increase, 1966	744	494**
Total Increase	1,027	749**
At 107 cm	mm²	mm²
Increase, 1965	200	178
Increase, 1966	282	291
Total Increase	482	469
Trunk taper[y]:		
May 14, 1965	.0026	.0034
May 22, 1966	.0144	.0116
February 21, 1967	.0380	.0237**

[x]Each value the average of seven.
Comparing unstaked and staked values:
*Significantly different at 0.05 level.
**Significantly different at 0.01 level.
[y]Taper = (D-d)/1
D = diameter at 15 cm; d = diameter at 107 cm; 1 = 107 – 15 cm.

Wind was a severe problem, particularly with trees with as dense crowns as these. The bark of several staked trees was injured from rubbing against the stake. On several, the guide stake broke at the top of the crosspiece. In the second year, the guide stakes were replaced with heavier pieces — 2″ × 2″.

Many trees were vandalized, resulting in broken branches, damaged trunk bark, and broken stakes. At the end of the second year, 14 of the 40 trees had been eliminated from the experiment because of stake damage or vandalism. Of the remaining trees it was possible to compare the responses of 1) 7 pairs of staked and unstaked trees, and 2) 4 replicates of the 4 pruning treatments.

Results

Staking. The staked trees grew 50% more in height than the unstaked (Table 1), whether the unstaked trees were guyed as during the first season, or completely unstaked, as during the second year. The heads of the unstaked trees were above the guy and free to move.

The unstaked trees, however, increased more in trunk caliper 15 cm above the ground than the staked trees. In the first year, when the unstaked trees were guyed, the differences were small and not significant. In the second year, on a cross-sectional area basis, the unstaked trees grew 50% more in trunk area than the staked trees (Table 1).

At 107 cm above the ground, trunk growth did not appear to be affected by staking. Thus, the taper, the difference in the diameters at two points on the trunk divided by the distance between these points, was greater in the unstaked trees than in the staked, particularly at the end of the second year (Table 1).

Each of the differences in height, trunk area, and trunk taper brought about by leaving a tree less rigidly staked than is the normal practice, resulted in a tree better able to withstand a windy environment and other hazards where trunk strength and flexibility are important factors.

Pruning. The pruned trees grew taller than the unpruned trees (Table 2). A heavy bloom in the second year on the unpruned trees contributed to their slower growth. The variation within treatments was increased by vandalism.

Table 2. The influence of pruning on the growth of young *Myoporum laetum* trees. Fremont, 1965 and 1966.

	Treatments[x]			
Top of tree Laterals on trunk	Unpruned[y] Unpruned	Pruned[y] Headed	Pruned[y] Headed	Pruned[y] Removed
Dormant-pruned	No	Yes	Yes	Yes
Summer-pruned	No	No	Yes	Yes
Height:	mm	mm	mm	mm
Increase, 1965	175 a	428 b	558 b	270 ab
Increase, 1966	25 a	192 bc	162 b	265 c
Total Increase	200 a	620 b	720 b	535 b
Trunk growth, Cross-sectional area:				
At 15 cm	mm^2	mm^2	mm^2	mm^2
Area increase, 1965	383 a	274 b	266 b	283 b
Area increase, 1966	527	671	508	498
Total Increase	910 a	945 a	774 b	781 b
At 107 cm	mm^2	mm^2	mm^2	mm^2
Area increase, 1965	202	157	206	190
Area increase, 1966	200	292	260	276
Total Increase	402	449	466	466
Trunk taper[z]:				
May 14, 1965	.0026	.0024	.0034	.0034
May 22, 1966	.0181	.0146	.0103	.0103
February 21, 1967	.0371 a	.0354 a	.0242 b	.0242 b

[x]Top of tree is composed of scaffolds and other branches above 110 cm. Laterals on trunk are temporary branches below 110 cm.

[y]Averages (4 replicates) having different letters are significantly different at the 0.05 level of probability according to Duncan's multiple-range test.

[z]Taper = (D/d)/1; D = diameter at 15 cm; d = diameter at 107 cm; 1 = 107 − 15 cm.

The unpruned trees made 40% more trunk-area growth at 15 cm than the pruned trees the first year. By the end of the second growing season the trees with trunk laterals unpruned during the growing season had made about 20% more trunk-area growth than the trees with laterals headed or removed.

There is a suggestion that leaving branches unpruned along the trunk during the growing season favors growth of the lower trunk that is more rapid than if such laterals are headed or removed. The heavier flower crop in the second year on the unpruned trees could have caused the lesser trunk growth than in dormant-pruned trees with laterals not headed during the summer.

Although growth at the 107-cm height tended to be less for the unpruned trees than for trees pruned, the trend was not significant.

Taper was much greater on trunks with laterals unpruned during the growing season than on those with laterals headed or removed. This was to be expected, since trees with unpruned trunk laterals had the largest growth near the ground and the least at 107 cm.

Regardless of pruning or staking treatment, the trees had a marked and highly significant increase in taper in each of the 2 years.

Discussion

The results cast doubt on the wisdom of the method by which trees are usually trained (staked and pruned) in many landscapes. Trees that were unstaked and unpruned developed characteristics that made them better able to withstand wind: 1) larger trunk cross-section at the ground, 2) a trunk with greater taper, and 3) a shorter top. The latter 2 characteristics reduce the stress to which the roots and lower trunk would be subjected. These trees also would have a larger trunk, which would better withstand the forces to which the tops were subjected.

The myoporum trees were not noticeably deformed by wind. The trunks were as straight and upright in unstaked trees as in staked. Although the outside top shoots were somewhat shorter on the windward sides than on the leeward sides, staking or pruning did not seem to influence the amount of shoot growth into the wind.

Many trees, particularly those grown in containers spaced close together, cannot stand upright without support when first planted in the landscape. Even those that can may need support to keep the roots in the ground and the trunks upright. Yet, the results of this experiment and others (3, 5, 6) indicate that a tree will withstand the elements better if it is not staked. A subsequent paper will present information on nursery production practices for growing trees that are better able to stand without support.

Even so, some trees will need support. Such support should be flexible and as low as possible while still holding the top upright. Some thinning of the top will reduce wind resistance and top weight. Temporary branches along the trunk will increase the rate of trunk growth and protect it from injury.

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