EFFECTIVENESS OF METHODS USED TO REDUCE HARMFUL EFFECTS OF COMPACTED SOIL AROUND LANDSCAPE TREES

by Dennis R. Pittenger and Ted Stamen

Soil compaction is a serious problem for many established landscape trees because it reduces root growth and development (1, 9, 13). It occurs where foot, equipment or vehicular traffic repeatedly takes place especially when the soil is moist (10, 11). Compaction is particularly harmful when it occurs within 30 inches of the soil surface since this is the zone where most tree roots grow (4, 9).

Meaningful parameters for expressing compaction are penetrometer readings and bulk density determinations (1, 5, 8, 10, 11, 13). Soils with penetrometer values as low as 470 kPa reduced root growth of Austrian pine and Norway spruce seedlings (14) while soils with values of 2,500 kPa to 3,000 kPa stopped cotton and radiata pine growth (10, 12). The relationship of increased soil resistance to decreased root growth is linear in some instances (7). Bulk densities of 1.8 g/cm^3 were shown to stop root growth in conifers (14).

Soil moisture content and soil texture can greatly affect soil strength and influence root systems' response to compaction (8, 12, 14). Therefore, the most reliable comparisons of penetrometer readings are obtained when soils are at field capacity moisture content and are uniform loamy textured.

Compaction reduces aeration, infiltration and drainage in soils (2, 8, 10). It also increases the physical resistance (impedence) that roots must overcome in order to extend through the soil. Roots growing in compacted soil will be thicker and shorter with more lateral branching than those growing in uncompacted soil (4, 6, 7, 13). This increases the surface area of the root system per volume of soil at shallow depths (6) and increases the possibility of drought stress (5, 13). Extremely high levels of compaction can actually crush the fine, 1-2 mm diameter roots of trees (13). The typical symptoms of affected trees range from reduced growth to dieback in the crown and eventual death.

Remedies used to reduce the effects of compaction on root systems of established trees attempt to improve aeration and water movement in the surrounding soil. However, the research-based evidence to support these practices does not exist. Therefore, we initiated a study to evaluate the effectiveness of four commonly used methods in reducing the harmful effects of soil compaction around established landscape trees.

Methods and Materials

The study was conducted in a uniform block of 20 established Chinese wingnut trees *(Pterocarya stenoptera)* that had been serving as shade trees in a picnic ground for over ten years. Trees were spaced 6.1 x 9.1 meters apart in 5 rows to which a Latin square experimental design was applied. Irrigation was applied monthly with minisprinklers, and bare soil conditions were maintained with contact herbicides or hand cultivation. The irrigation schedule maintained soil moisture in the available range. Soil compaction in the planting was quantified with a recording penetrometer. The recording penetrometer was used because it accurately reflects soil strength, it is relatively quick and convenient for obtaining numerous samples over depth, and it has been correlated to root growth (10, 12). Values exceeding 2,500 kPa were consistently recorded at depths of 15 to 60 cm, but the trees appeared to be only slightly stressed in terms of overall vigor.

Analysis of the soil at the site revealed it to be a coarse sandy loam with a pH of 7.1 and soluble salts below 1.0 dS/m. Because the site possessed homogenous plant material and uniform loamy soil that was highly resistant to penetration, it was deemed ideal for use in the study.

In December of 1985 and January 1986, baseline soil penetration tests were performed using a recording penetrometer with a 9.15 mm diameter coneshaped tip and a probe length of 60 cm. Readings were recorded at distances of 5, 10 and 15 feet from the trunk in directions of east and west at each tree, and at distances of 5 and 10 feet in directions of north and south. Three penetrations were recorded at each distance. Soil moisture content was at field capacity at the time of testing. Readings were recorded to a depth of 60 cm or until penetration was no longer possible. Post-treatment penetrometer readings were obtained in the winter of 1988 to monitor any changes in soil strength with time.

Treatments were applied in March of 1986 and replicated 4 times with single trees serving as replicates. The treatments were: 1) 135 to 140, 5-cm holes created with a power auger and placed at a 60 degree angle to a depth of 45 cm. Holes were arranged in a spoke-fashion that formed 6 concentric circles 60 cm apart beginning 60 cm from the trunk. 2) Holes prepared as above then backfilled with a 1:1 mix of sand and milled fir bark. 3) Holes prepared with a high pressure water jet in the same fashion as treatment #1. 4) Two holes, 10 cm in diameter by 45 cm deep placed 180 degrees apart and 1.5 m from the trunk. Holes were lined with perforated PVC pipe backfilled with gravel. 5) Untreated control.

Baseline growth data of each tree were recorded in January 1986. Tree height, trunk circumference at 15 cm from the soil surface, and annual growth of 4 lateral shoots in the upper ⅓ of the canopy were the parameters measured. During the dormant season in 1987 and 1988, the same growth data were recorded for each tree.

Results and Discussion

A summary of the tree growth data collected during the study is presented in Table 1. Tree height was difficult to measure precisely and varied significantly among trees within a treatment. Trunk diameter and annual shoot growth more precisely reflect growth. There were no significant differences in tree growth responses among treatments during the two-year period. No treatment was beneficial to this tree species grown under these soil and irrigation conditions.

The results indicate that where soil moisture content is consistently maintained in the readily available range, trees can grow and develop satisfactorily in compacted sandy loam soil. When soils of this type are compacted, soil moisture may be a more limiting factor than soil aeration. These findings support conclusions inferred by Zisa, et al. (14) in their study with conifers in urban soils. They concluded that seedling trees could successfully grow in signficantly compacted soils provided soil moisture is readily available.

Extensive use of aeration treatments in compacted sites should not be applied until soil moisture conditions and irrigation practices are carefully evaluated. When landscape trees appear to be stressed by compacted soil, tree care professionals should first ensure that soil moisture content is consistently maintained in the available range. Aeration treatments may not be necessary unless trees do not respond favorably to improved soil moisture conditions or unless drainage below the root system is so impaired that the soil remains saturated for extended periods after rainfall or irrigation. These situations indicate that soil aeration is limiting and in need of improvement. There are no published data that show which aeration method is most effective however.

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Table 1. Mean tree growth responses*

Treatment	*Trunk diameter (cm)*				*Height (m)*				*Annual shoot growth (m)*			
	1986	1987	1988	86-88	1986	1987	1988	86-88	1986	1987	1988	86-88
Auger	26.31	28.78	30.73	4.42	11.25	11.68	11.35	0.10	1.19	0.82	1.21	2.03
Auger + backfill	27.38	30.84	33.58	6.20	11.19	11.88	12.00	0.81	1.42	0.88	1.39	2.27
Water jet	29.74	34.21	37.29	7.55	12.14	12.22	12.00	0.00	1.31	0.97	1.26	2.23
PVC + gravel	28.42	32.84	36.22	7.80	11.95	12.65	12.57	0.62	1.43	0.96	1.57	2.53
Control	28.50	31.72	34.29	5.79	11.81	12.03	12.02	0.21	1.12	0.90	1.20	2.10

*1986 measurements are baseline before treatments were applied.
F-test revealed differences among treatments were insignificant for $p > .05$.

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Riverside County Cooperative Extension
University of California
Batchelor Hall Extension
Riverside, California 92521

WARREN, KEITH. 1988. **Perfecting the crab.** Am. Nurseryman 168(7):77, 79-81.

Crab apples are nearing perfection. Advances in breeding and selection, coupled with careful research of disease resistance, have made these ornamentals more beautiful and problem-free than ever. The best cultivars now approach the theoretical "perfect" landscape tree—with one exception, suckers. With crab apples, the roots close to the soil surface tend to produce heavy sucker growth. And the more you cut them back, the more they seem to multiply. Suckers are not only unslightly, but they also limit the tree's use in landscapes where low maintenance is a prime criterion. Eliminating suckers may be the last frontier to conquer in perfecting the crab apple. To accomplish this, the industry needs to examine our current propagation techniques.

BALL, JOHN. 1988. **Roots, air and tree health.** Arbor Age 8(11):12-14.

Roots are often viewed as food-absorbing organs. Roots, as with all other living portions of the tree, do undergo a process called respiration. This process utilizes oxygen. Low oxygen conditions can prevent new roots from forming—and old roots from growing. Anything that reduces soil oxygen levels, such as pavement or soil compaction, can retard root growth. Regardless of how the nutrient is brought in contact with the root, the absorption of the nutrient into the root requires oxygen. The symptoms a tree expresses for low soil oxygen—off-color foliage and loss of vigor—are the same for low soil fertility. The tree does not have to utilize energy to absorb water. For the tree to survive, the roots must continue to grow, so that it can reach out to new supplies of water.