THE EFFECT OF ROOT PRUNING ON THE ROOT SYSTEM OF NURSERY TREES[1]

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Abstract. Pruning root systems of landscape-size Colorado blue spruce (*Picea pungens* Engelm.) root systems in the nursery, 5 years before transplanting, increased the number of roots and the amount of root surface area in the root ball. The total root surface area of the harvest-ready 2m tall trees was increased from 122,000 cm^2 to 245,000 cm^2. The root ball of the root-pruned trees contained approximately four times as much root surface area as trees that were not root-pruned. Root balls of root-pruned trees contained 11.8 percent of the whole root system compared to 5.8 percent in root balls of unpruned root systems. Sixty percent of the pruned root systems were inside the dripline compared to 40 percent of the unpruned root systems. The increased absorbing root surface transplanted with the pruned trees should help to increase survival and reduce transplanting shock.

Root pruning in the nursery to increase survival of transplanted shade trees has not been widely practiced in recent years. This is because there is perception that root pruning is not cost effective in improving survival and growth after transplanting. It has been calculated that less than 5 percent of the root system is moved with a typical nursery tree (11). Proper balance between the root system and the crown is necessary for optimum growth (2, 13). Minimizing the imbalance imposed by transplanting should increase survival and speed restoration of the root:crown ratio, resulting in vigorous growth. Since root pruning has the potential to confine the root system to a relatively small volume, there is tremendous promise for using it to increase the number of absorbing rootlets moved with the tree. More roots in the root ball should result in increased survival and vigor of transplanted trees. This, in turn, could make root pruning economically attractive.

When a root is severed, most of the subsequently regenerated roots originate from the callus tissue formed very near the cut end (2, 12). Therefore, root pruning several inches to the interior of the eventual root ball perimeter would insure inclusion of most of these regenerated roots in the final root ball.

Most previous studies on root pruning have been concerned with performance of small seedlings in the nursery following rootpruning and with the quality of seedling root systems. In the short term, root pruning generally induces water stress and reduced growth (4, 9). Long term growth is either unaffected (3, 4, 7, 9) or increased (1, 5, 8). Root pruning, combined with careful planting, results in less distortion of seedling roots (1, 5, 6). Little work has been done on the pruning of landscape-size stock to prepare the root system for transplanting to the landscape.

Methods

Colorado spruce (*Picea pungens*) obtained from two commercial nurseries near Portland, Oregon were studied. Plants from both sources were approximately 2m (6ft) tall at the time of harvesting in 1985. Trees from one source were transplanted within the nursery as 1m (3ft) tall plants with a 30cm (12in) root ball to root prune the plants. This took place while the plants were dormant, prior to the 1981 growing season. Since root-pruning temporarily slows growth, to obtain plants of equal size, 8-year-old unpruned plants and 10-year-old root-pruned plants were used.

Root distributions were determined by collecting a consecutive series of soil samples in a radial direction starting from the base of the trunk. A U-shaped pit was dug to expose a rectangular slab of soil 150cm (60in) long x 15cm (6in) wide x 46cm (18in) deep. The slab was divided into two rows (shallow and deep) of samples 10cm (4in) x 15cm (6in) x 23cm (9in), each placed into a separate plastic bag and transported to the laboratory. Each sample was soaked overnight and then washed free of soil. Fine roots (less than 5 mm diameter) were separated from larger roots and debris by hand and stored for measurement. Three root-pruned and three unpruned trees were

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sampled on one side that was isolated from the roots of other trees.

Three root-pruned trees and three unpruned trees were harvested with root balls 71cm (28in) diameter and 46cm (18in) deep for comparisons of roots contained within. The root balls were 10cm (4in) greater in diameter than those usually accepted as normal size by the nursery industry. These were washed free of soil in the field and the fine roots collected for measurement. The diameter of all severed roots greater than 5mm was measured on these root systems.

Surface area was used as the primary measurement of the fine root system. This was determined using a Decagon Devices, Inc. Delta-T Area Meter.

Results

The horizontal root distribution samples indicated that the pruned root system had a dense concentration of fine roots at the center, declining sharply outside of a 30cm (12in) radius, and continuing to decline at a slower rate out to the five-foot limit of the sampling area (Fig. 1). Although actual root density (measured as mm^2 surface area/cc soil) decreased with increasing distance from the trunk for both treatments, the soil volume available for root exploration increased as the square of the distance from the trunk. Horizontal distribution sample values were thus converted to estimate the total surface area of the root system (Fig. 2). For the unpruned tree, the area under the curve shows that 60 percent of the absorbing roots of the tree were beyond dripline. Root pruning altered this distribution somewhat, but still more than 40 percent of the root system was beyond of the dripline. Photographs of the distribution samples reassembled in their original orientation (Fig. 3) reinforce the data.

Size of the total root system. The size of the entire root system was calculated for both pruned and unpruned trees using the horizontal distribution data (Table 1). The total calculated average size of the pruned root system is 245,000 cm^2 (38,000 in^2) surface area. The unpruned trees had a surface area of only 122,000 cm^2 (19,000 in^2) surface area. This overall two-fold increase is not uniform throughout the entire root distribution. Within the root ball there was a 407% increase in root surface area (386% increase in dry wt.); outside the root ball area the increase was 180%. Surface area measurements of fine roots collected from root balls are in agreement with the estimated values, and show a four-fold increase in the surface area in the root balls of the root-pruned trees. Dry weight data confirmed (table 1) that this increase in root surface area

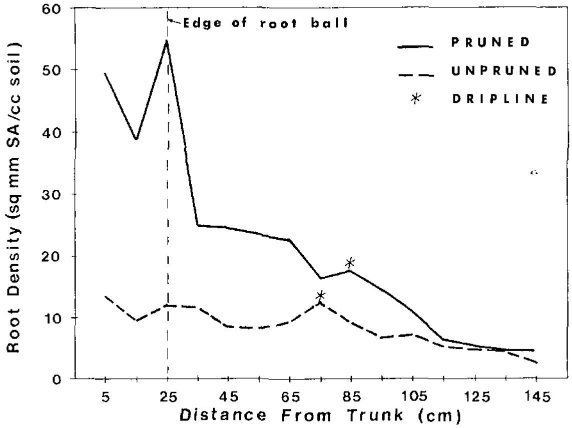

Figure 1. Horizontal distribution of pruned and unpruned root systems of Colorado blue spruce based on root density.

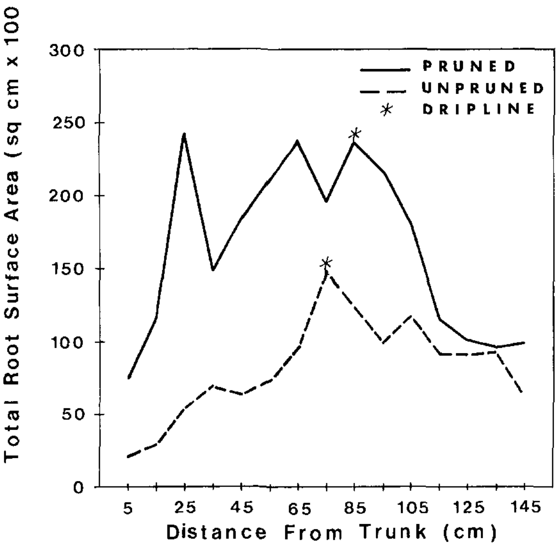

Figure 2. Horizontal distribution of pruned and unpruned root systems of Colorado blue spruce based on total amount of roots at each distance from the trunk. Sixty percent of the unpruned root system lies outside the dripline, compared to 40 percent of the pruned root system.

was traceable to increased tissue mass, rather than a change in root morphology (ie. increased branching).

A greater percentage of the entire root system was located in the root ball of the pruned trees than in unpruned trees. Using both the calculated surface area of the total root system and the actual measurements of roots in root balls, 11.8 percent of the root system was contained in the root ball of root-pruned trees compared to 5.8 percent for unpruned trees (Table 1). Simple volume calculations can be used to estimate the effect of size of the root ball on the amount of roots in it. Decreasing the ball size from that used in this study (70cm/28inch diameter) to ANSI standards (60cm/24inch diameter) will decrease the soil volume by approximately a third and decrease root surface area by a similar amount. Only 3.8 percent of the root system of an unpruned tree would be in an ANSI standard size ball.

Diameters of roots not considered fine roots (eg. those greater than 5mm diameter) severed during harvesting decreased from 9.0mm to 7.6mm as a result of root pruning. The average number of roots greater than 5mm increased from 14.3mm to 21.5mm as a result of root pruning.

Discussion

Root pruning can increase both the amount of root surface area and the percentage of the total root system in the root ball. In this study, the root ball was cut 20cm (8in) beyond the point of the root pruning, and a large portion of the regenerated roots was included in the root ball. Root pruning resulted in a four-fold increase in the amount of root surface area in the root ball. The percentage of the total root system harvested in the root ball was doubled. The data showed that the standard size root ball contained less than 4

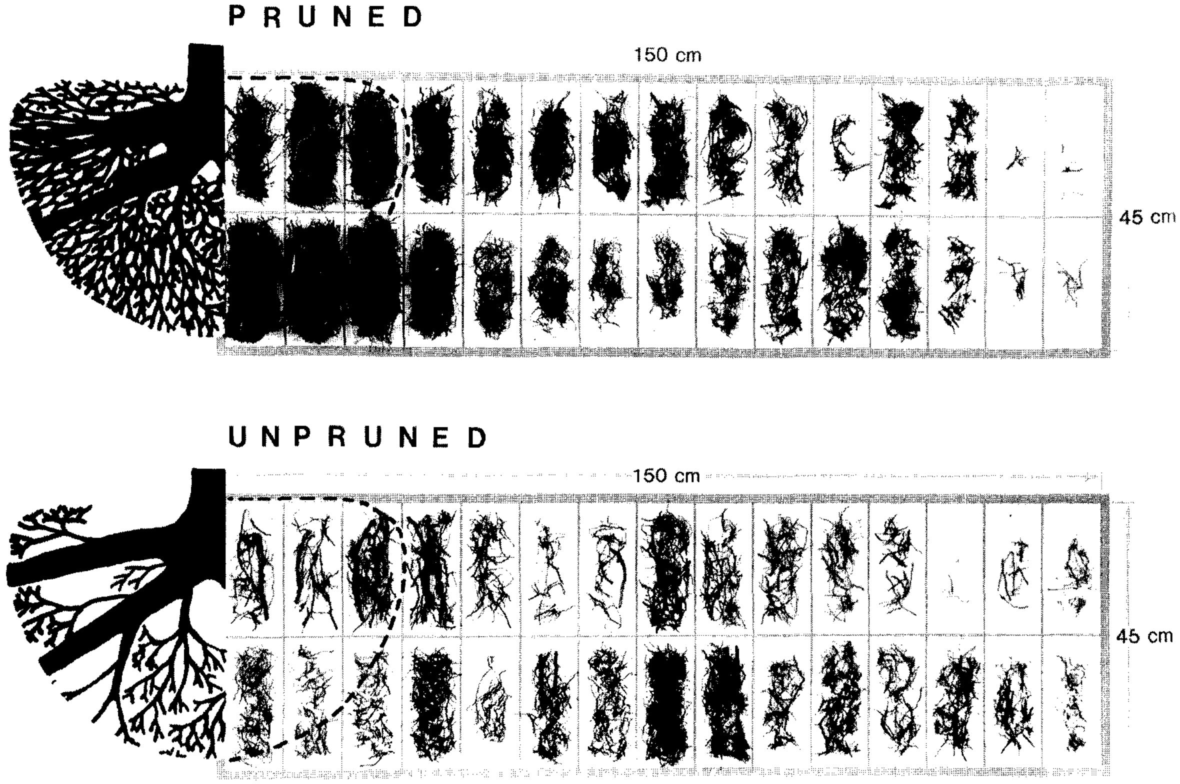

Fig. 3. Reconstruction of the root system distribution samples used in the study. Note the high concentration of roots in the root ball area on the pruned root system contrasted with the even density of roots over the entire spread of the unpruned root system.

percent of the root system, confirming an earlier prediction of less than 5 percent (11). Even the oversized root ball used in this study contained less than 6 percent of the root system.

There were five growing seasons between root pruning and harvesting for trees used in this study. The lateral spread of the pruned root system was similar to that of unpruned trees. If the interval had been shorter, the horizontal distribution of the root system would probably have been more restricted and an even greater percentage of the root system would have been included in the root ball.

Close examination of the pruned root systems revealed that many small roots regenerated from each severed root. On each severed root, usually one or two of these roots eventually became dominant and collectively developed into the replacement root system. Because of the long interval between pruning and harvesting, some of the small regenerated roots had already begun to deteriorate. Harvesting the trees when the number of these was the greatest, would have further increased root surface area and resulted in larger portion of the root system in the root ball. Additional research is required to determine the optimum interval between root pruning and harvest. However, an advantage of waiting as long as 5 years to harvest the trees is that the crowns are given ample time to regain vigor and become attractive.

The trees used in this study were actually transplanted in order to root prune them. The alternative would have been to sever the roots and leave them in place. Little is known about what effect the dead portion of the roots might have on the living root system when remaining in place. Most regenerated roots are produced near the cut surface and if the trees are not moved, the dead roots might physically impede the growth of new roots. However, roots often follow openings in the soil and if root decay were rapid, the new roots could possibly follow the channel created by the decayed roots. Nitrogen released from the decaying tissue might also benefit root growth. If a potential pathogen such as *Armillaria mellea* is involved in decay of the old roots, it could also invade the live root system. This fungus is known to attack stressed root systems (10) and a transplanted tree would be an ideal target. Symptoms of the disease might not become apparent until the trees were planted in the landscape. More research is needed in this area.

Care should be taken to insure that the root ball is of the proper size. A small difference in ball size, such as a decrease of two inches in the radius of the root ball, can reduce the soil volume and root surface area by a third, reducing the amount of roots transplanted with the tree. Similarly, if just the outer few inches of the root ball were allowed to dry out, a major portion of the root system could be lost. The impact on the plant might be severe since the ANSI standard root ball already contains less than 4% of the root system.

Root pruning reduced the average diameter of the severed roots larger than 5mm by 16 percent and increased the number of these roots by approximately half. Size of the severed root is related to the amount and speed of root regeneration (12). Smaller roots often regenerate roots more rapidly than larger roots. The effect of the decrease in root diameter and the large increase in number of these roots should be to enhance root regeneration. Additional research is underway to study this relationship.

Root pruning has the potential for increasing the amount of absorbing roots moved with transplanted trees. Since only a very small portion of the root system is moved in a standard sized root ball, a relatively small increase in surface area

Table 1. Root system characteristics of root pruned and unpruned Colorado spruce root systems.

	Pruned	Unpruned	Pruned: Unpruned
Total root system			
Surface area (cm^2)	244,957	122,434	2.00
Dry weight (g)	1,360	696	1.95
Roots in ball			
Surface area (cm^2)	29,009	7,116	4.07
Dry weight (g)	252	65	3.86
Percent of root system surface area included in root ball	11.8	5.8	2.03

could easily double or triple the absorbing root surface in the root ball. This would mean a greater capacity for water absorption and a potential for increased survival and reduced transplanting shock.

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Abstract

Shurtleff, M. C. and B. J. Jacobsen. 1986. **Iron chlorosis: its cause and control.** Arbor Age 6 (3): 12-14.

Chlorosis, a yellowing of the plant leaf due to a lack of chlorophyll may be caused by a variety of factors. Among the more common causes are compacted soils, poor drainage, alkaline soils and nutrient deficiencies. Probably the most common cause is iron chlorosis, where iron is unavailable to the plant. Iron (Fe) is an essential element for plant growth, it is required for the formation of chlorophyll, the green pigments that capture light to produce food for the plant. Iron is also necessary for the proper functioning of many plant enzyme systems that influence respiration and plant metabolism. Chlorosis may develop because of unfavorable conditions for the utilization of iron in the plant or in the soil. Under neutral or alkaline conditions at a soil reaction (pH) above 6.5 to 6.7 iron changes into insoluble forms and becomes unavailable for uptake and utilization by the plants. Iron chlorosis can be controlled when plants are supplied with available iron. The iron may be sprayed onto the chlorotic foliage, introduced into the trunk or added to the soil. The most lasting results are obtained through treating the soil.