ROOTS FOR THE FUTURE

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We root cuttings routinely. We plant seeds, they germinate and develop roots. Everyone knows that roots are important, so why all the fuss about roots? It appears there are efficient and inefficient roots. There are aggressive roots that secure and establish the plant quickly and there are the ''welfare'' roots that wander aimlessly doing just enough to get by.

Conducting research is a bit like being a sleuth, in that you are always probing and looking for clues. There had been clues suggesting a variation in root efficiency, but they could not be confirmed. In the fall of 1985, a total of 720 trees were excavated to try to determine why some had grown well while others grew poorly. All of the trees (180 of each of four species) were the same age, had been grown the same way and on the same soil for two years. The procedure used was to sharpen the teeth and sides of a 24-inch backhoe bucket and dig every tree. Before all the trees were dug it was clear that a wide variation in root systems existed. But could the roots be correlated with the growth of the top? The answer was a dramatic, yes!

Every tree that had grown well had a very fibrous root system with many roots arising at the root/stem junction. Trees with a limited number of roots at this junction were always medium or small, even if those roots were well branched several inches from the stem. All trees with a poor root system were small (Figure 1).

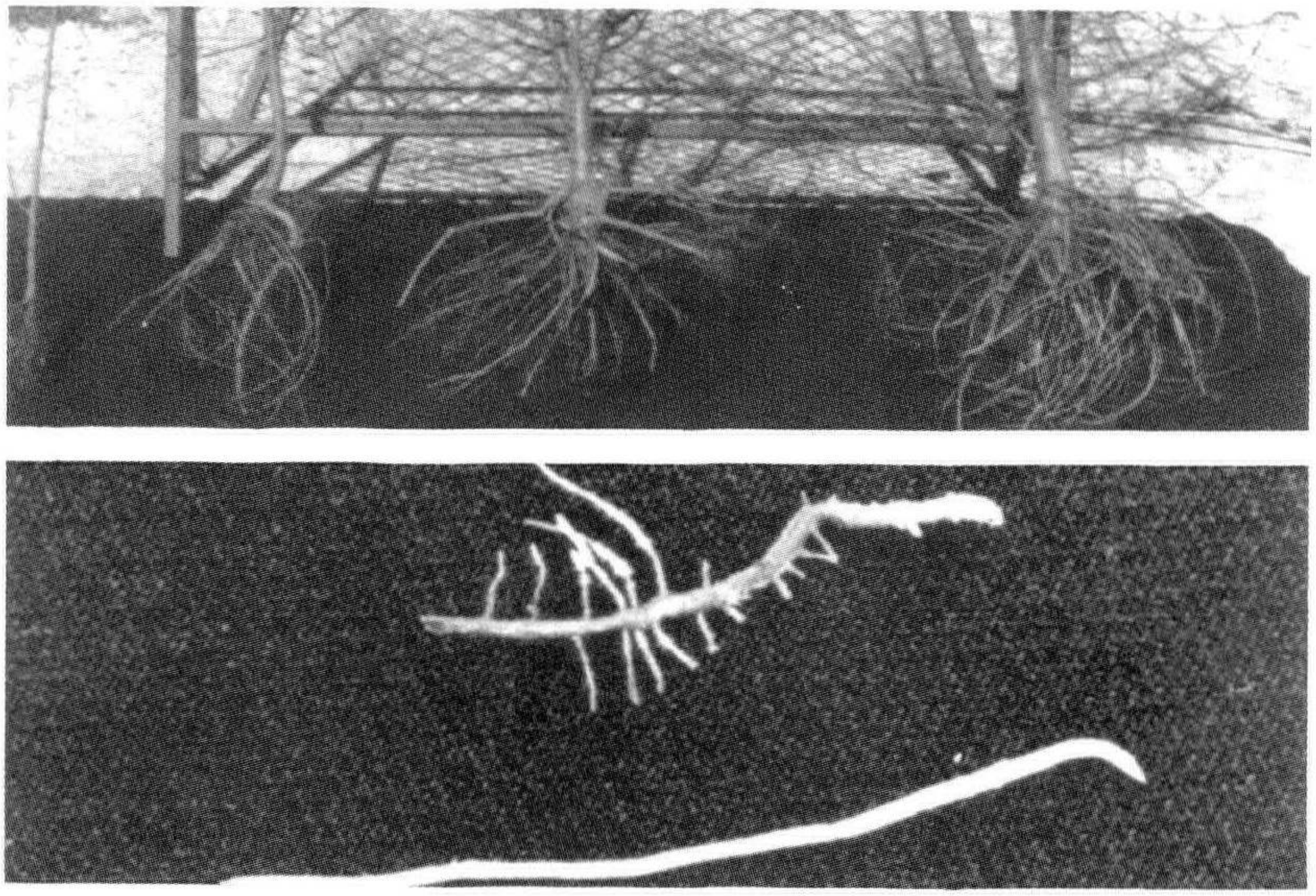
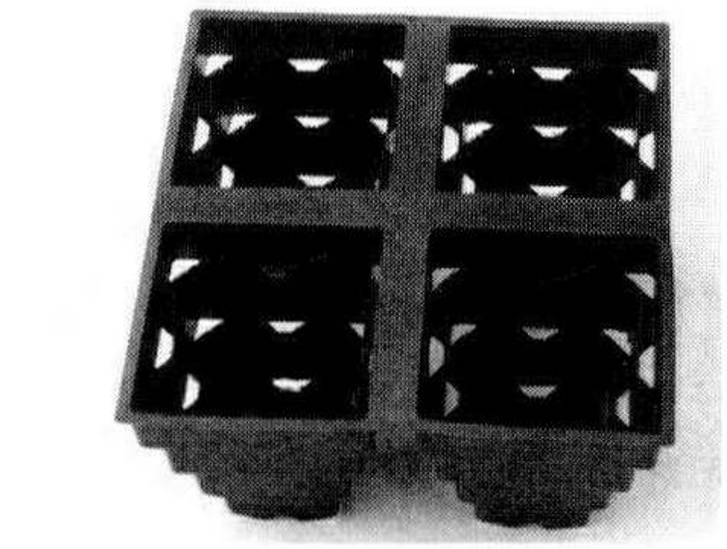


Figure 1. (Above) Roots of lacebark elm, *Ulmus parvifolia*, following two growing seasons in the field. Some of the trees had grown very little while others had reached 2.5-inch stem diameter. Every tree that had many secondary root rising from the base of the stem was a large tree. Trees with a few large roots that then branched, were always of moderate size. (Below) Aggressive roots (with branching) and welfare roots (no branching). When transplanting from a container into the field or landscape, the aggressive roots establish the tree and provide for its health.

This leads to the age-old question: Did the roots make the top grow or did the top make the roots grow? My present view is the roots enabled the top to grow. The roots originating at or near the root/stem junction were more efficient than roots originating further away. This led to the burning question, "If this observation is correct, how can it be utilized effectively?"

Beginning on January 6, 1986, a determined effort was begun to design a propagation container to force roots to develop at the key root/stem junction. A review of old research data and masses of photos suggested that 4 in. was the maximum depth for effective branch root stimulation as a result of air-root-pruning. One opening at the base of the container was unsatisfactory and led to a cluster of root tips. One day while "dreaming" during a coffee break, I looked up at the roof on our house. A north/south roof over the garage intersects with the east/west roof over the main house thus creating the sloping V. I climbed onto the roof and stood atop the intersecting roof lines. It would work for a bottom in a container, thus directing roots to four air-root-pruning holes and increasing the volume of mix at the bottom of the container. This same roof design also led to the sawtooth undulations in the side wall of what

is now known as the "RootMaker Propagation Container." Air-root-pruning can occur at the bottom of every tooth. The other key design aspect added later was an outward slope to the ledges created by the sawtooth undulations around the container (Figure 2).



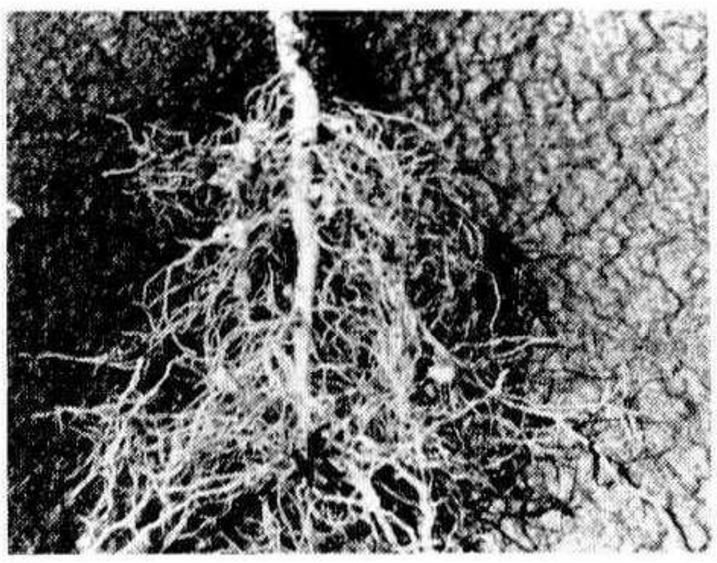


Figure 2. (Above) The Rootmaker propagation container is designed to air-prune the taproot of a seedling at a depth so that secondary roots will form back to the base of the stem. The secondary roots are then air-pruned on the sides of the containers to stimulate further root branching. The design of the container with 24 air-root-pruning openings prevents entanglement of the roots as occurs with conventional containers. Thus at transplanting, roots grow in many directions to quickly establish and anchor the plant. (Below) The tree seedling is a green ash, *Fraxinus pennsylvanica*, that had been grown in the container for three months.

When a seed or seedling is placed in this container, the taproot is directed into one of the four openings at the bottom. When the root tip is air-pruned, secondary roots form through the vertical length of the tap root, not just at the bottom. These secondary roots grow mostly horizontally and strike the side wall of the container where they are guided to one of 24 openings for air-pruning. This, in turn, stimulates tertiary branch roots and so on.

This container is designed to stimulate root branching and create a more efficient root system. With the air-pruning on the sides, the aimless "welfare" roots that typically circle conventional round containers and contribute little to plant health are eliminated.

This container has only been manufactured since January, 1989. Thus far it has worked well on seedlings of all test genera including *Carya* (pecan), *Quercus*, *Cercis*, *Platanus*, *Betula*, *Pinus*, *Pyrus*,

Myrica cerifera, and *Eucalyptus*. It may also be useful in the stimulation of roots on rooted cuttings, especially on those species that develop few secondary roots prior to transplanting.

It also appears that early root branching complements the further development of roots and tops. Thus, if a tree with many roots at the root/stem junction is placed in an in-ground fabric container, the resulting root multiplication and growth stimulation will proceed more rapidly than normal.

The influence of root system quality on plant growth also became clear while trying to solve problems with the old style (Root Control) fabric containers with the polyethylene bottoms. Some nurserymen would be happy with the ''bags'' while another, growing the same species, would report problems. The difference would be the branching of the root system on the original liner. It appears that if a tree has five major roots at the root/stem junction, each one will grow much larger in diameter and exert much more expansion pressure on the fabric compared to the roots on a tree with 25 or 50 major roots.

Another interesting aspect of root response resulted from a series of studies to try to determine if there is an optimum time or diameter to restrict a root. A series of different size holes were drilled in the bottom of small plastic ''funnels''. The funnels were positioned such that the tap root of a seedling would grow down and through the opening. If the root was not restricted by the plastic until it was about 3/16 in. in diameter, few secondary roots formed behind the restriction. In contrast, if the opening was about 2/16 in., the number of secondary roots increased by a factor of five to seven times.

We can now grow trees with more fibrous and compact root systems. These trees will perform better in restricted spaces in the landscapes of the future. How much better? No one knows. Will these trees be sufficiently well-anchored to remain upright and not pose a hazard? Thus far, trees grown with this type of root system have been more tolerant to wind than conventionally-grown trees. Circling roots, especially on trees and other species grown from seed, slow establishment, increase stress, shorten the life of the plant, and contribute to a host of related problems. We can do better and it is up to us as plant propagators to set the stage for other aspects of the nursery industry.

I believe that trees grown using techniques that stimulate efficient roots will grow faster, transplant easier, be healthier longer, and adapt better to restricted root spaces than trees grown conventionally. How fast will these changes occur? Very slowly, because, unfortunately, the more difficult thing to change is tradition.