Seedling Development: The Critical First Days

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Introduction: Consider what happens in nature.

When a seed germinates in the wild, a strong primary or taproot plunges downward. The tip of the taproot has a strong apical dominance that suppresses secondary root branching in the same manner as the tip of a new shoot suppresses production of side branches. The objective of the taproot is to extend deeply to anchor the new plant and access moisture to avoid dehydration. The objective of the new shoot is to reach sufficient vertical height to access light to support leaf functions and to avoid being overshadowed by competing vegetation. A typical tree seedling top response is to develop few, if any, side branches until the leaves on the main stem are positioned in sunlight. Likewise, a typical response with the taproot is to produce few, if any, branch roots until the taproot has extended considerable distance, often three feet or more, and provisions for the plant have been secured. Since there are limited energy resources stored in the seed, the young plant proceeds most efficiently. Only after the taproot is secured and is providing water and nutrients and the new leaves are producing energy does appreciable secondary branching begin to occur both above and below ground.

Conditions in a Nursery.

Nursery conditions are very different, as moisture and nutrients are provided and weeds are controlled. **There is no need for a deep taproot; in fact in a nursery a deep taproot is a liability, not an asset**. This is because shallow horizontal roots are the prime providers of leaves with nutrients since they are in the zone of soil where both oxygen and nutrients are most plentiful. When root pruning occurs at the proper time and position, horizontal secondary roots are produced and it is highly desirable to maintain these roots in the horizontal position. Trees grown with such procedures produce roots radially as well a downward following transplanting, accelerating establishment, top growth and overall plant health (Figure 1). Trees that develop large numbers of roots at the root – stem juncture and along the vertical axis of a short taproot have consistently grown faster than trees with fewer roots arising from this point (Figure 2) (Whitcomb 2001). Such desirable root systems can be created consistently by air-root-pruning (dehydration pruning) the tip of the taproot approximately four inches below the seed. This stimulates secondary branch root formation along the entire short taproot (Figure 3). Pruning the taproot later will stimulate formation of secondary roots at the face of the point of pruning only, much like development of roots from the cut ends on a tree harvested balled-in-burlap, but never along the vertical axis of the taproot just below the soil surface. **There is but one opportunity to stimulate secondary branch roots at this critical junction. If it is missed, it is gone forever.** However, if provisions are made to stimulate secondary roots but no provision is made to keep them in that position, little is gained.

Figure 1. This bur oak, Quercus macrocarpa, tree is six years old and was approx. six inches in stem diameter 12 inches above the soil surface and was part of 36 trees in a study that all grew at a similar rate. The tree spent the first three months following germination in a RootMaker® propagation container that air-root-prunes both at the bottom and sides of the container. Seedlings were then planted in the field in fabric containers (grow-bags) made of a polyester knit fabric that constriction prunes all roots at a diameter of 5/64 inch and grown for 2.5 years. At the end of the third growing season following germination, the seedlings ranged from 2.25 to 2.75 inches in stem diameter. At that point, the trees were pulled from the soil with a nylon strap, the knit fabric was removed and all were replanted on 10-foot centers and allowed to grow three more years. The trees were never staked and were not irrigated during the last three years in the field, but were fertilized according to soil test (Whitcomb 2001). In mid March, six years from the time the seeds were planted, 36 trees were harvested using a 52-inch tree spade. Six trees were sacrificed in order to inspect root development. The largest root on any of the trees was one inch in diameter at the outer face of the root ball. The number of roots produced goes beyond any practical method of counting.

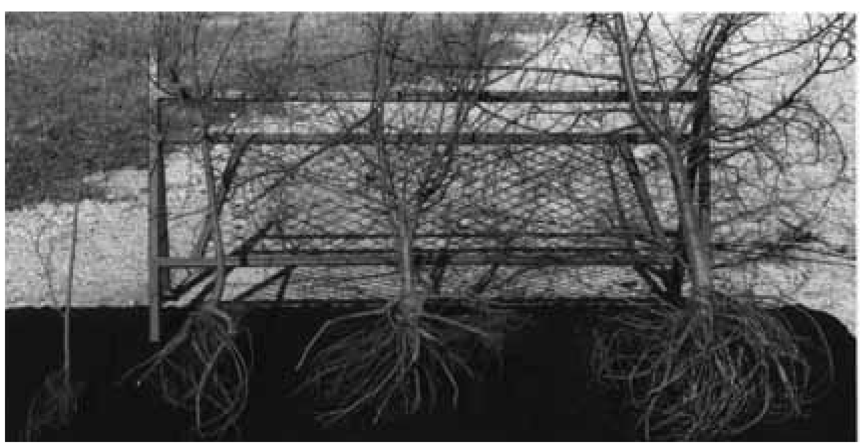

Figure 2. The lacebark elm, Ulmus parvifolia, seedling at right was grown under conditions that stimulated optimum horizontal root development. The three seedlings to the left were grown under conditions less and less favorable to the stimulation of horizontal secondary roots. Most striking of all is the fact that all four trees are the same age and following the early seedling stage were grown for two years under identical conditions in the field. Results from extensive studies leave no doubt as to the desirability of having many roots form at the base of the stem and allowed to grow in all directions as opposed to a few large ones.

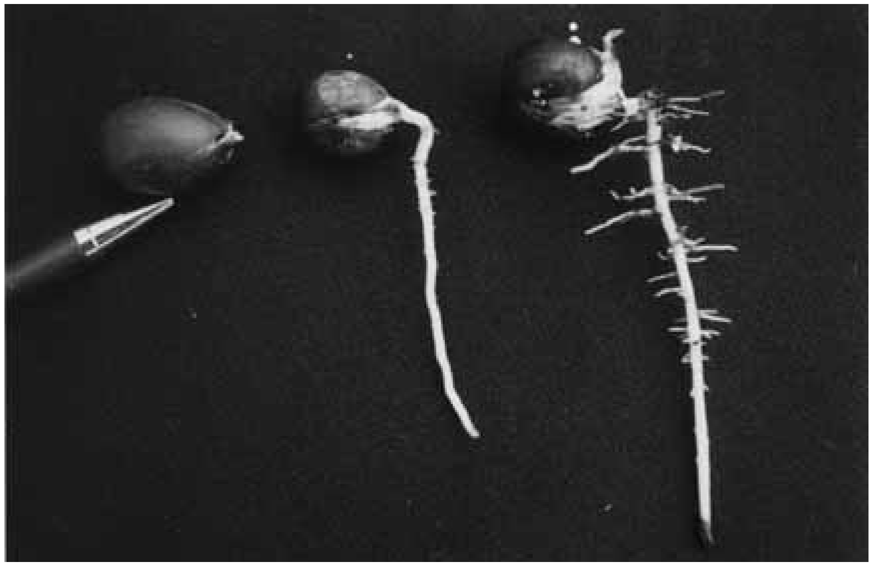

Figure 3. (Above) The shumard oak, Quercus shumardi, seed at left is in the earliest detectable stage of germination. The seed at center is three days older than the seed to the left. The seed at right is four days older than the seed to the far left. The seedling to the right has experienced air-root-pruning at a depth of four inches (note the darkened tip of the tap root) and has begun to produce secondary horizontal roots and the primary shoot is beginning to emerge and all after just four days.

(Below) After seven days, the shumard oak seed (above center) which was allowed to grow normally had extended to a depth of nine inches and the few secondary roots near the seed were no more developed than on day three (above). By contrast, the tip of the taproot that had been air-root-pruned at a depth of four inches had produced horizontal roots above the point of pruning that were not evident on day four. In addition, four branch roots have been produced just behind the point of pruning of the taproot. These secondary roots are larger in diameter than the others and will reestablish a multiple – taproot if left unchecked. It is only after air-root-pruning of these secondary and sometimes even tertiary attempts to reestablish a taproot that the horizontal secondary roots along the vertical axis of the taproot begin more rapid growth.

When air-root-pruning is accomplished at the proper time and depth, secondary roots originate positioned horizontal or slightly downward. The challenge has been to find a way to keep these roots growing horizontally (Harris 1967, Whitcomb 1988). In bottomless milk cartons, plastic tubes or sleeves and open bottom plug trays, there is no opportunity to maintain horizontal root growth. These types of containers deflect all secondary branch roots down, leaving few, if any, roots to grow horizontal following transplanting (Figure 4). Trees grown in plug or milk carton type containers and planted into larger containers promptly develop a complex mat of roots at the bottom and modest roots above. When trees grown in plugs or milk carton type containers are planted in the field, most roots extend downward, further reducing the amount of roots in the root ball when harvested balled-in-burlap or with tree spades (Klingaman and King, 1981).

Improved Container Technology.
In 1987 it occurred to me that the way to consistently improve root branching and horizontal root development was to create a seedling container that air-root-pruned at several levels on the sides as well as at the bottom. The original RootMaker® design was an injection molded container 2.5 X 2.5 X 4 inches deep with a series of saw tooth like ledges and openings in the sides and four bottom openings for air-root-pruning. RootMaker® II is a 32 cell tray that accomplishes the same results. Seeds planted in the RootMaker® propagation containers develop roots in all directions following transplanting, not just down (Figure 3).

Conclusions
With timely air-root-pruning of seedlings that include provisions for continued horizontal root development and continued provisions for horizontal root development, trees can be consistently produced with compact fibrous root systems whether grown in containers or field (Figure 5). Not only do trees grown this way require little if any staking (Whitcomb 2001), they establish more quickly following transplanting and with a vast array of small roots, no one root is likely to increase in diameter to the point of causing problems in the landscape as they age. For those still thinking that a taproot is necessary, consider which is stronger, a single steel rod or a multi-strand cable of the same diameter. Remember, it is not how much real estate moved as the root ball that is important, but rather what is IN the real estate.

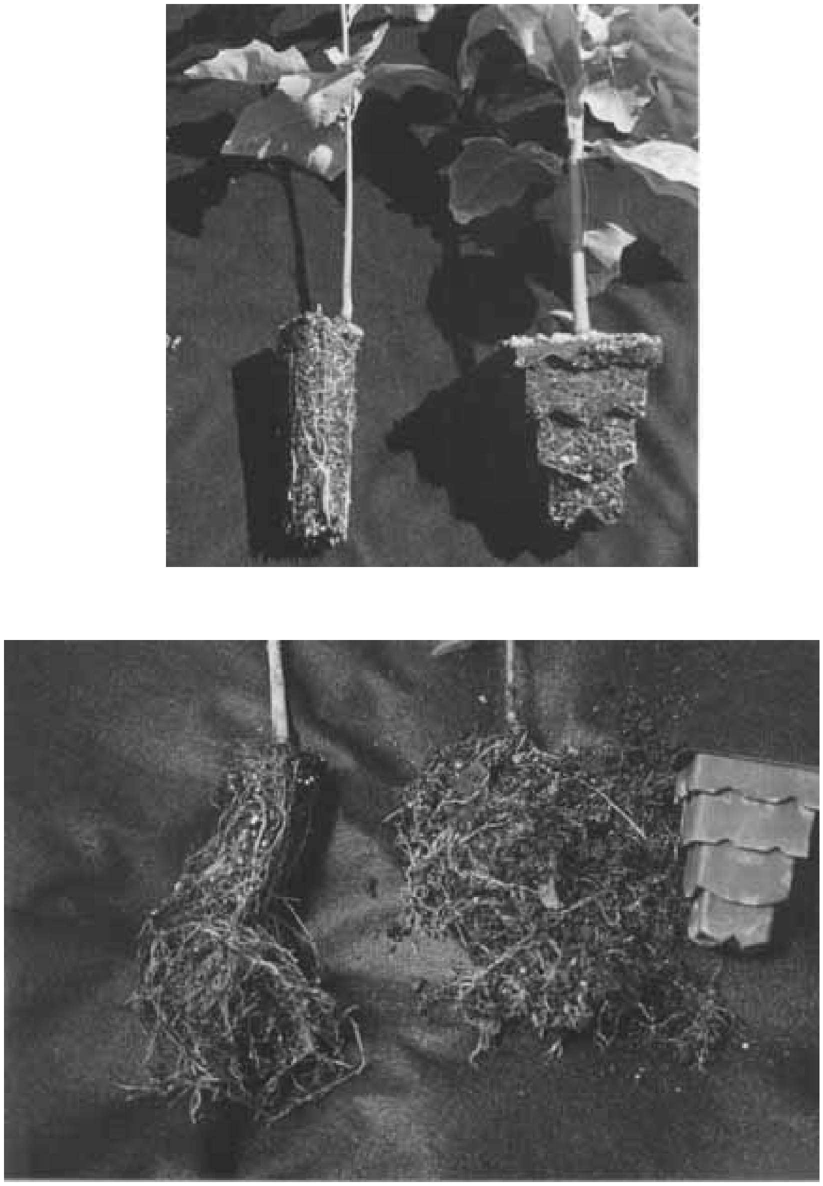

Figure 4. Following transplanting, roots extend in the direction they were oriented in the previous container. The shumard oak seedlings shown here were transplanted from the plug and RootMaker® seedling container into three-gallon containers, and then removed after three weeks to observe root development. In the case of the plug type containers, all of the roots grew downward (left). In the case of the RootMaker® propagation container with air-root-pruning on the sides as well as the bottom, roots extended in all directions (right).

Figure 5. The RootMaker® II design currently comes in a 32 cavity tray that fits a 10 X 20 flat. Air-root-pruning is accomplished by 4 openings at the bottom and 12 openings at the corners of ledges in the sidewall. Stimulation of root branching is similar to the original RootMaker® design but with greater space use efficiency and at about one half the cost.

Literature Cited

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