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 3 ft 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.

Figure 1. A 6-year old bur oak (*Quercus macrocarpa*) with 15-cm (6-inch) stem diameter. Production included 3 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 constricts all roots with a diameter of 5/64 inch. At the end of the third growing season seedlings had stem diameters of 6 to 7 cm (2.3 to 2.8 inch). Trees were pulled from the soil, the knit fabric removed and all were replanted on 3-m (10-ft) centers and grown 3 more years. Trees were never staked nor irrigated during the last 3 years in the field, but were fertilized according to soil test (Whitcomb 2001). Six years from planting and harvesting, the largest root on any of the 36 trees was 2.5 cm (1 inch) in diameter at the outer face of the root ball.

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 nutrients to leaves 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 (Fig. 1). Such desirable root systems can be created consistently by air-root-pruning

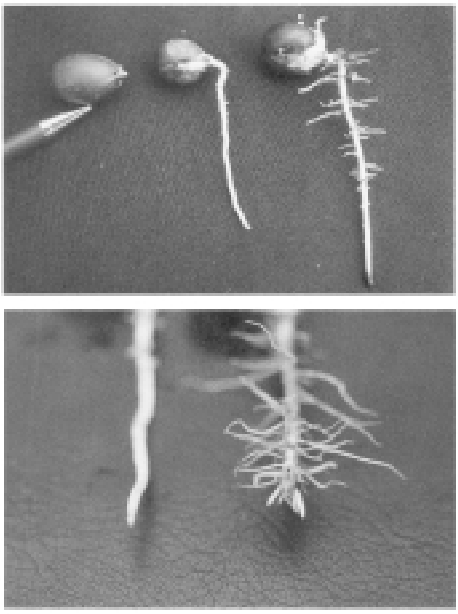

Figure 2. (Above) A shumard oak (*Quercus shumardii*) seed at left at the earliest visible stage of germination. The seed at center germinated 3 days earlier than the seed to the left. The seed at right germinated 4 days earlier than the seed to the far left. The seedling to the right has experienced air-pruning of its tap root at 10.2 cm (4 inches); note the darkened tip of the tap root, the production of secondary horizontal roots and emergence or the primary shoot.

(Below) Seven days after germination, a non-air-pruned shumard oak seed extends to a depth of 22.9 cm (9 inches). There are few secondary roots near. In contrast, the tip of the air-pruned taproot is restricted to a depth of 10.2 cm (4 inch) and has subsequently produced horizontal roots above the point of air-pruning that were not evident on Day 4. In addition, four branch roots have been produced just behind the point of pruning of the taproot. These secondary roots are larger in diameter and will reestablish a multiple —taproot if left unchecked. It is only after air-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.

(dehydration pruning) the tip of the taproot approximately 10 cm (4 inch) below the seed. This stimulates secondary branch root formation along the entire short taproot (Fig. 2). 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.

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

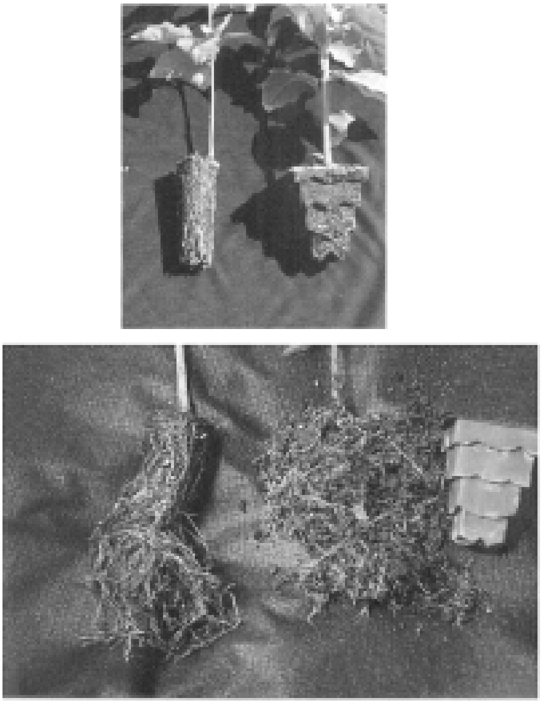

Figure 3. (Above) Roots extend in the direction they were oriented in their liner containers, respectively, a plug and RootMaker® seedling container system, from left to right.

(Below) The shumard oak seedlings were transplanted from, respectively, the plug and RootMaker® seedling containers into 3-gal containers, and then removed after 3 weeks to observe root development. All roots in the plug container grew downward (left). Seedlings produced in RootMaker® propagation containers have roots extending in all directions because of the air-pruning on the sides and bottom of the container (right).

containers deflect all secondary branch roots down, leaving few, if any, roots to grow horizontal following transplanting. 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-pruned roots at several levels on the sides as well as at the bottom. The original RootMaker® design was an injection molded container 6.4 cm x 6.4 cm × 10.2 cm (2.5 inches × 2.5 inches × 4 inches) with a series of saw-tooth-like ledges and openings in the sides and four bottom openings for air-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 straight down (Fig. 3). 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 (Fig. 4) (Whitcomb, 2001).

CONCLUSIONS

With timely air-pruning of seedling roots that include provisions for continued horizontal root development, trees can be consistently produced with compact fibrous root systems whether container or field grown. Trees grown this way require little if any staking (Whitcomb, 2001), establish more quickly following transplanting with greater small root production. Furthermore, root diameter is controlled

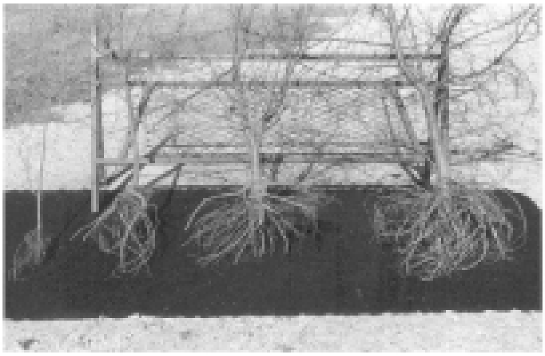

Figure 4. The lacebark elm (*Ulmus parvifolia*) seedling at right was grown under conditions that stimulated optimum horizontal root development. The three seedlings to the left were grown under conditions less favorable to the stimulation of horizontal secondary roots. All four trees are the same age and following the early seedling stage were grown for 2 years under identical conditions in the field. Results from extensive studies support the desirability of having many roots form at the base of the stem and allowed to grow in all directions, rather than producing just a few larger roots.

(restricted), thus avoiding potential landscape problems. For those still thinking that a taproot is necessary, consider which is stronger, a single steel rod or a multistrand cable of the same diameter. Remember, it is not how much real estate is moved as the rootball, but rather what is IN the real estate.

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Micropropagation of Sweet Viburnum (*Viburnum odoratissimum*)©

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INTRODUCTION

Sweet viburnum (*Viburnum odoratissimum*, Ker-Gawl.), an evergreen shrub native from Japan and the Himalayas, is widely used in Florida landscapes as a foundation plant for large buildings, borders and hedges (Dehgan, 1998). Because of its fast growth and prompt response to nitrogen fertilization, sweet viburnum is being used as a model plant to study root and shoot growth cycles and nitrogen nutrition (Martins et al., unpublished data). However, the use of non-clonal material leads to asynchronous flushes among plants. This problem has been reported not only on sweet viburnum but also on cacao (Greathouse et al. 1971), lychee (Marler and Willis, 1996), and oak (Borchert, 1975). Borchert (1973) suggested the use of clonal material to overcome this problem.

Sweet viburnum can be vegetatively propagated by cuttings (Dehgan, 1998), however, in vitro propagation (micropropagation) techniques could be applied to produce physiological uniform clonal plants in a relatively short time period. Nobre et al. (2000) developed a successful protocol for in vitro propagation of *V. tinus*, a Mediterranean viburnum species, however, there is no report of in vitro propagation of *V. odoratissimum*.

Another advantage of using in vitro plants in growth flush studies is that shoot or root flushes can be easily controlled using appropriate growth regulators, therefore, facilitating studies of the effects of growth flushes on nutrient uptake. The objective of this study was to determine the feasibility of developing a protocol for the in vitro propagation of *V. odoratissimum* not only to be used as an aid in studying growth cycles and nutrient uptake, but also to be used in commercial propagation.