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ROOT SYSTEM CONFIGURATION IS IMPORTANT TO LONG TREE LIFE

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Abstract. Circling roots can stunt growth or increase susceptibility to wind breakage and blowdown. The problem can be largely avoided by growing tree seedlings in containers with vertical ribs or grooves, without sharp horizontal corners, and with an egress hole at the bottom for air pruning roots. Root configuration control is standard forest nursery practice in 30- to 700-ml containers, but now has been demonstrated in 10-liter containers intended to produce potted trees for the retail market. Additional egress holes near the pot surface may correct insufficient root production of outplanted trees.

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Horticulturists have known for a long time that circling roots can stunt growth and increase susceptibility to wind breakage and blowdown. Whenever container trees or shrubs are outplanted, it is standard practice to dig a larger hole than the rootball and then straighten the roots before planting. Alternatively, the circling roots at the bottom are pruned off and shallow slices made in the sides of the rootball to cut circling roots and to stimulate development of new lateral roots.

What can happen if trees are allowed to grow to large size with roots circling the main axis has been vividly documented at the symposium: "Root Form of Planted Trees."[2]

As a tree seedling grows, root deformity develops in the following manner. Roots tend to grow in the same general direction until the growing tips strike an impenetrable object. When growing tips encounter the container wall, they turn and grow along it. If the container is circular, the roots may make one or more complete horizontal revolutions around the stem axis. After the tree is outplanted, the circling roots continue to grow in diameter until they contact the taproot, if there is one, or completely fill the volume they once surrounded (Figure 1).

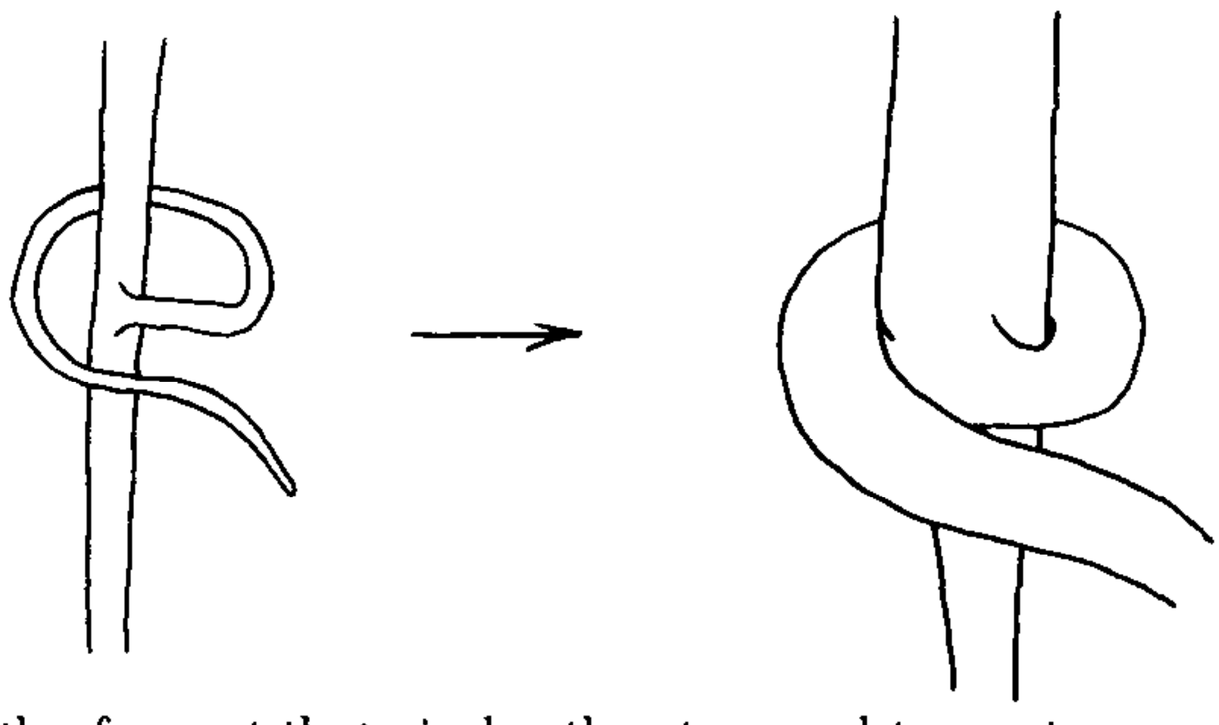

Figure 1. Growth of a root that circles the stem and taproot.

Sometimes the circling root may strangle the taproot, and the tree will become stunted or die. In other cases, the circling root grafts to the taproot and the tree continues to grow. The stem above the circling root continues to increase in diameter, but the taproot inside the circling root cannot increase in diameter. As a result, the core of vertical wood fiber of constant diameter is surrounded by an enlarging doughnut of horizontal fibers which do not increase in strength in proportion to the size of the above ground stem (Figure 2). Although fusion of the encircling root with the main stem and taproot appears complete and sturdy from the outside, a weak spot susceptible to

[2] Kinghorn, James, and Evert van Eerden (eds.) 1978. Root Form of Planted Trees. Pac. For. Res. Cent., 506 Burnside Rd., Victoria, B.C. V8Z 1M5 (in press). [Symposium held in Victoria, B.C., May 16,19, 1978.]

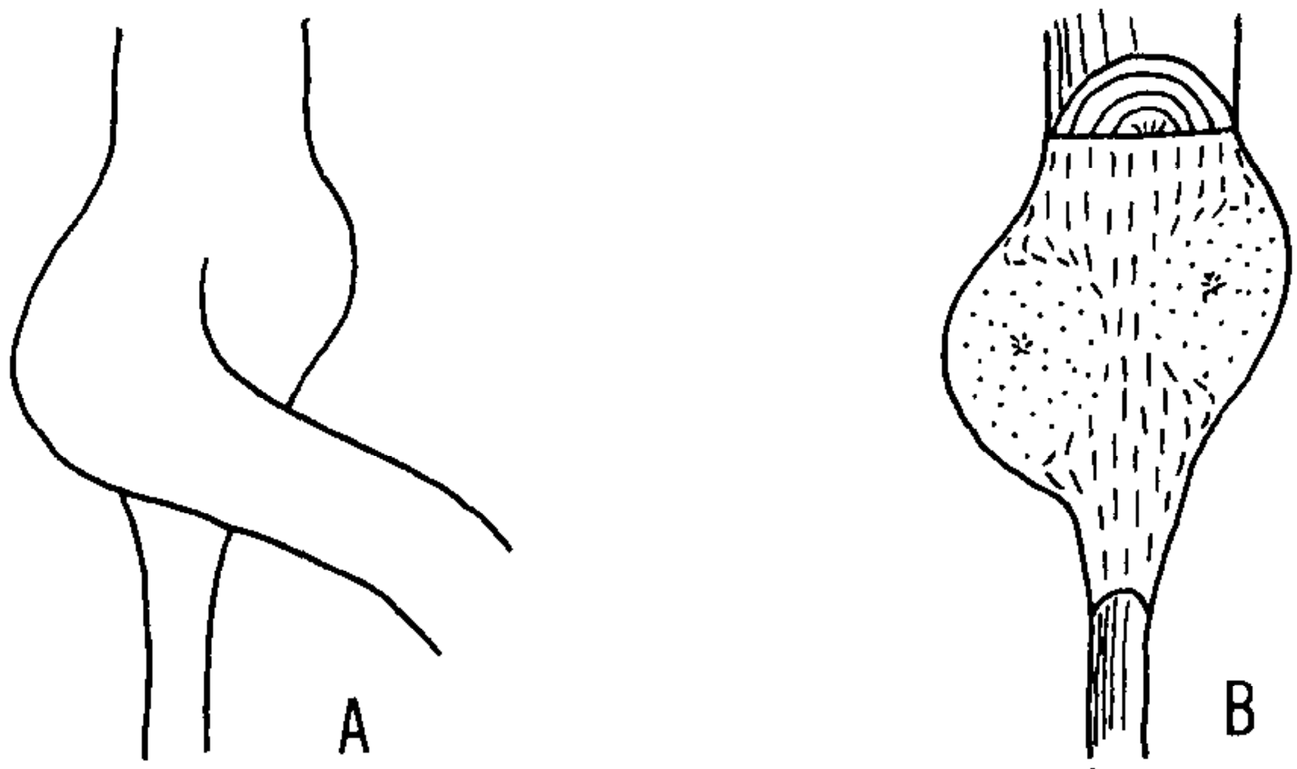

Figure 2. Further growth of a circled root may fuse it with the taproot. The graft may appear healed (A), but in cross-section (B) shows structural weakness. Dashes are vertical grain, and dots are horizontal grain.

wind breakage remains, right where the tree needs to be the strongest.

In addition, a balled root system tends to remain self-contained after outplanting. Few lateral roots emerge, and a taproot may not develop. The tree does not have adequate access to water and mineral nutrients and becomes stunted. The tree is also susceptible to windthrow, because it lacks surface lateral roots to adequately anchor it.

As mentioned, horticulturists have found ways to prevent these disasters, but foresters cannot afford the individual tree care needed. Instead, forest tree seedlings are grown in specially designed containers in such a way that most roots are oriented vertically and none circle horizontally. The seedlings are removed from the container and planted with the rootball intact. No extra large planting hole, or hand modification of the shape of the root system is needed.

How is this done? First, containers with impenetrable walls are made with vertical ribs or grooves. When lateral roots encounter them, the roots are directed downward and prevented from circling. Second, there are no sharp horizontal corners, as there are in conventional pots where the sides meet the bottom; instead, the container walls gently taper to the bottom. Such corners have the same root-directing properties as the vertical ribs or grooves, but cause the roots to circle. Third, the roots are directed to a relatively large egress hole at the bottom of the container. Roots must find a way out of the container, otherwise they either ball up or grow upwards again. Fourth, the containers rest on open benches or racks so that their egress holes are open to the air with enough ventilation so that the root tips desiccate and stop growing, a process called "air pruning". New root tips are then produced higher in the root ball.

Another way to keep the roots from balling up is to grow the seedlings in containers with walls permeable to roots or media blocks without any walls. If there is an air space between containers, the roots emerge from the sides and bottom, and they are air pruned. If the containers are adjacent and the roots pass from one container to the next, these roots will be broken when the containers are separated for planting. However, this is permissible only when the roots broken are small and unlignified, otherwise the seedling will be heavily damaged and much of the advantage of growing the seedling in a container is lost.

There is a wide variety of containers on the market for raising forest tree seedlings, but the largest of them is only about 700 ml. I have fabricated several prototypes of a 10-liter container which have all of the root control features described above for impenetrable wall containers. Ten-month-old seedlings of Scots pine and Siberian larch grown in 400-ml containers were transplanted into these 10-liter containers and grown for another season in the greenhouse. They are now 76 and 102 cm in height and 1.5 and 1.8 cm in caliper, respectively, and probably suitable for retail sale. Estimated production cost is about $3 per tree. It should be possible to simply lift these trees from their containers and plant them without having to manipulate or prune the root systems in any way. The trees should grow root systems that will not be defective; trees with intact root systems at outplanting should result in better top growth than from trees whose roots have been pruned. Vigorous top growth is something every buyer likes to see.

Does that mean we have in hand the ultimate tree growing container? No. The containers I have described have two deficiencies. Even with a large egress opening at the bottom, large numbers of root tips may accumulate, blocking the opening and reducing drainage. Waterlogging and root rot may result. The already large opening on many containers cannot be enlarged further without losing too much growing medium. Second, new root development after outplanting develops mostly from the air-pruned root tips at the bottom of the rootball. There are few laterals near the surface, which is likely to reduce the windfirmness of the tree (Figure 3).

We are currently testing the addition of holes or slits in the upper sides of containers to see if seedlings will produce growing points that will develop into surface laterals after outplanting (Figure 4). If they do, we may have solved the windfirmness problem. Also, fewer root tips may accumulate at the bottom, which should reduce obstruction of drainage. However, we have found already that more exposure of the rootball to air requires more careful control of humidity and air flow. It

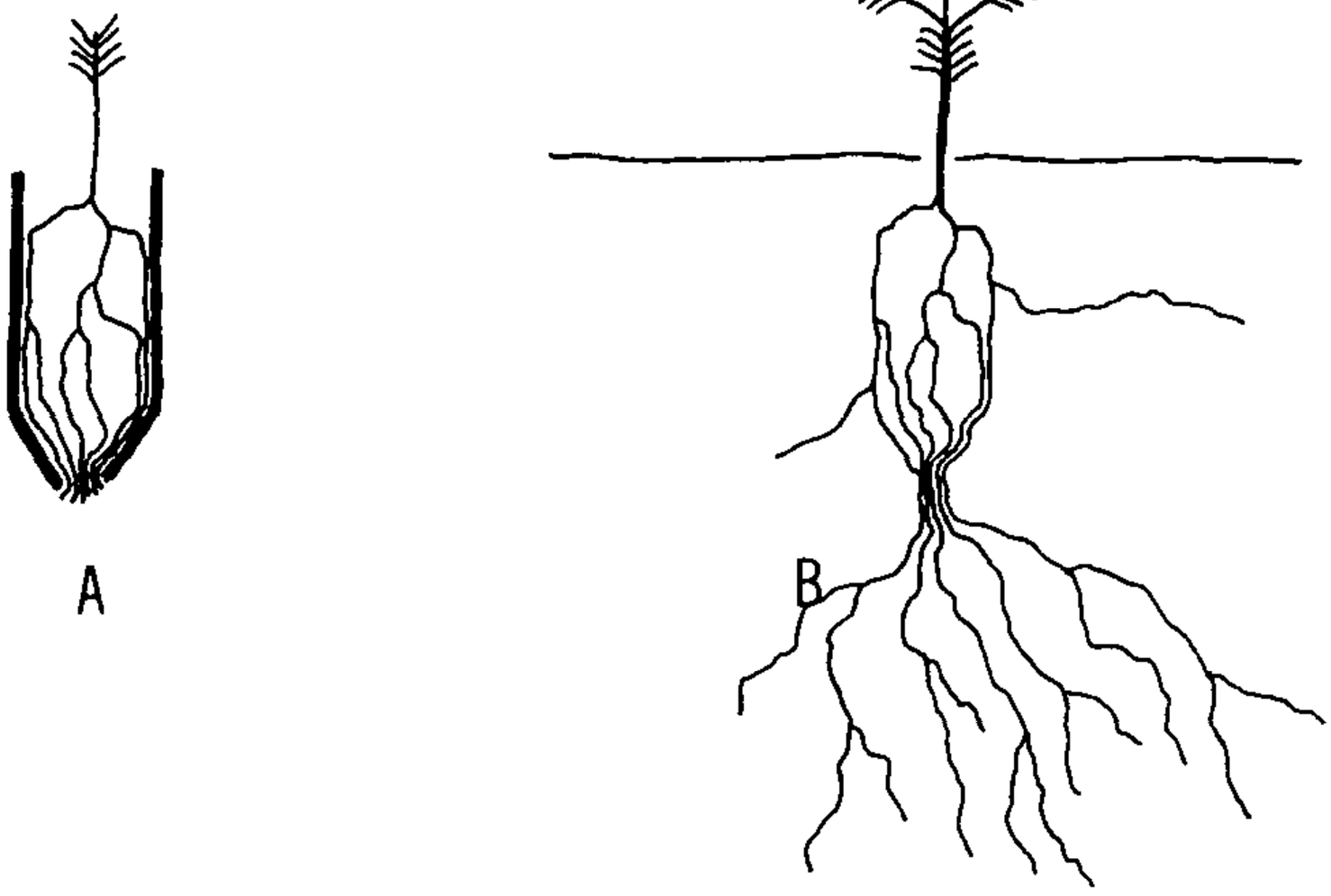

Figure 3. Root configuration commonly produced by currently used forest tree seedling containers (A) in the container, and (B) one season after outplanting.

will probably take another 2 years to work out the remainder of the problems with container design and greenhouse culture of the trees.

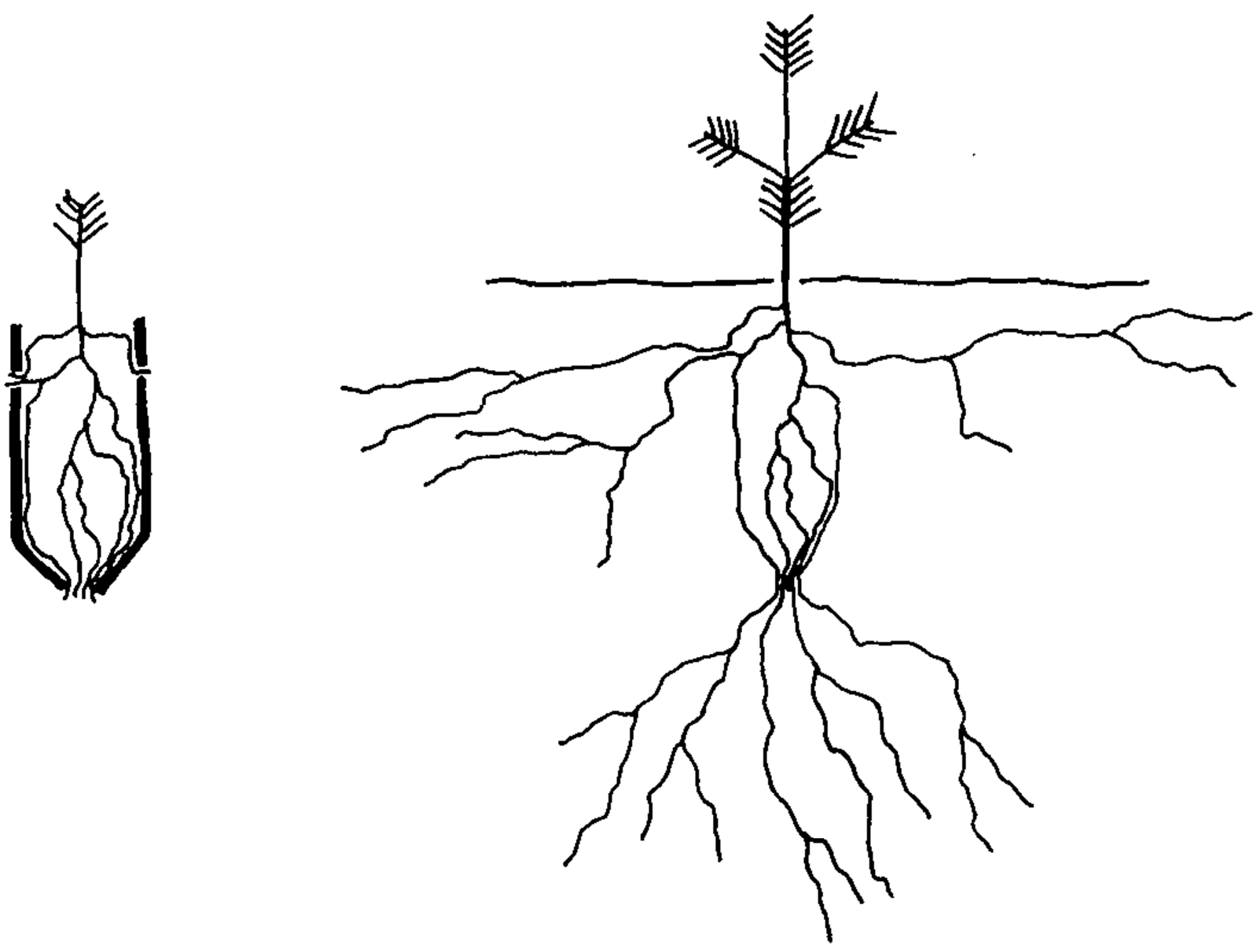

Figure 4. Anticipated root configuration to be produced by forest tree seedling containers with holes in the upper sides to promote growth of surface lateral roots.