CONTAINER SHAPE CONTROLS ROOT SYSTEM CONFIGURATION OF PONDEROSA PINE [1]

Harvey A. Hiatt and Richard W. Tinus [2]

Abstract.--A 2-year evaluation of root coiling of ponderosa pine grown in different containers showed there was some recovery after outplanting. Trees grown in containers with no walls had no more coiling than trees grown from seed in place, and seedlings grown in containers with vertical grooves had less coiling than ones grown in smooth-walled containers.

Containerized seedlings are being planted in increasing numbers because of better survival and superior initial growth rates (Tinus 1974), but containers can produce malformed root systems that cause slower growth and even death later in the tree's life (Donald 1968, Ben Salem 1971). Root strangulation can be avoided by judicious slicing of the root ball without losing all the benefits of a container-grown intact system (Ben Salem 1971, Harris et al. 1967, Stone and Norberg 1971), but this is not practical for mass plantings. Because of the large number of containerized seedlings that will be planted in the next few years, problems found with some containers must be corrected, or new containers should be designed that will produce a sound root system.

Our objectives were (a) to determine the effects of container size, shape, and growing time on root system configuration, and (b) to determine what happens to root configuration after outplanting.

MATERIALS AND METHODS

Sideboards and screenwire bottom were added to a 7.3 x 0.9 m greenhouse bench. The bench was then filled to about 28 cm with a mixture of a peat-perlite-vermiculite that was inoculated with forest duff containing mycorrhizal fungi. On February 2, 1972, the bench was divided into 15 x 15 cm areas, and ponderosa pine seed (Colestrip, Montana source) was planted. One seedling was established on each area. These seedlings were the "seed-in-place" trees against which all container-grown trees were compared. On the same date, 10 types of containers that were currently in wide use or that appeared promising were filled with peat, seeded, and placed in the same greenhouse.

For the first 4 weeks all seedlings were watered with rain water. Thereafter, they were watered with Hoagland's solution as needed. Greenhouse temperatures were maintained between 20 degrees and 30 degrees C with humidity between 50 and 90 percent. Both container-grown and seed-in-place trees were under the equivalent of a 24-hour day at all times. They received about 1,000 lux of incandescent and fluorescent light throughout the night for 1 minute out of 15. Seedlings were sampled and the "strangle angles" measured on May 12, September 1, and October 30, 1972. Strangle angle is the angle of rotation, in degrees, of a lateral root around the axis of the root system measured from where the root joins the taproot to the bottom of the container (Ben Salem 1971, fig. 1). For example, if a lateral root grows to the side of the container, then follows the container wall straight down to the bottom, its strangle angle is 0 degrees. But if a root follows the container wall half way around, it has a strangle angle of 180 degrees. Strangle angles may be clockwise, counterclockwise, or both on the same root. At each sampling date, 10 healthy trees were selected at random from each type of container. Strangle angles were measured on 5 trees and the other 5 were transplanted to random locations in the bench containing seed-in-place trees. Strangle angles were measured on 5 of the seed-in-place trees that were removed to make room for the transplants.

---

[1] Paper presented at North American Containerized Forest Tree Seedling Symposium, Denver Colorado, August 26-29, 1974.

[2] Forestry Research Technician and Principal Plant Physiologist, respectively, Shelterbelt Laboratory, Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Bottineau, North Dakota 58318.

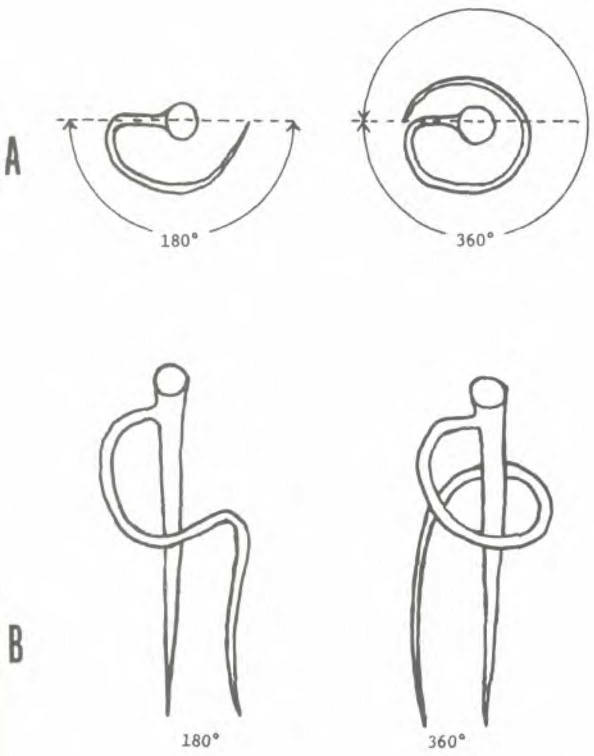

Figure 1.--Measurement of strangle angle: A, primary lateral as viewed from above; B, primary lateral, side view. (Adapted from Ben Salem 1971.)

Fourteen months after the last sampling date (about 2 years from seeding date) all trees were dug up and strangle angles were measured as before. The strangle-angle measurements were summarized as (a) total strangle angle per seedling; that is, the angles summed over all roots measured on an individual seedling, and (b) mean angle per root; that is, sum of angles on a seedling divided by number of roots. When a root had both clockwise and counterclockwise strangle angles, they were added.

RESULTS AND DISCUSSION

Figure 2 shows strangle angle per root for each container type tested. The left bar represents the mean strangle angle taken on the three sampling dates. The strangle angle per root increased slightly with time in the large book planter and the honeycomb, but remained nearly the same on all others. The right bar represents the strangle angle at the termination of the experiment. Strangle angle per root showed partial recovery after outplanting from book planters, sausages, honeycombs, and large plug molds. The containers are grouped according to strangle angle:

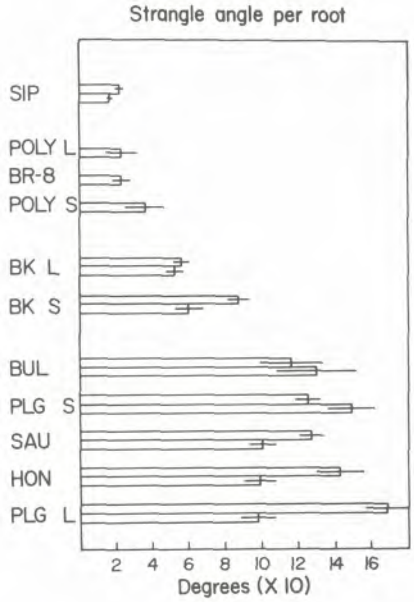

Figure 2.--Strangle angle per root for each container type tested at Shelterbelt Laboratory, Bottineau, N.D.

1. No containers: these were the seed-in-place trees used for comparison.

2. Containers with no walls: the container is the growing medium. These were the BR-83/ block and large and small blocks of an early version of the Polyloam block.

3. Containers with walls designed to control root configuration: these had vertical grooves or ridges, no horizontal corners, and a hole at the bottom. These were large and small 1970 model Spencer-Lemaire book planters.

4. Containers with smooth walls: there was no apparent attention to container configuration for control of root spiraling. These were large and small 1971 model plug mold, Walters bullet, Alberta sausage, and a honeycomb-shaped prototype of the large book planter.

Of the containers tested, those with no walls produced seedlings whose roots had no larger strangle angles than roots of seed-in-place trees. Containers designed to control root configuration produced roots with strangle angles larger than roots of seed-in-place trees, but smaller than roots of trees grown in con-

---

3/Trade names are used for brevity and specificity and do not imply endorsement by USDA.

tainers with smooth walls. This experiment shows that container shape does control root configuration. Strangle angle per root showed partial recovery after outplanting from some containers. However, the recovery was not as significant when comparing strangle angle per tree (fig. 3).

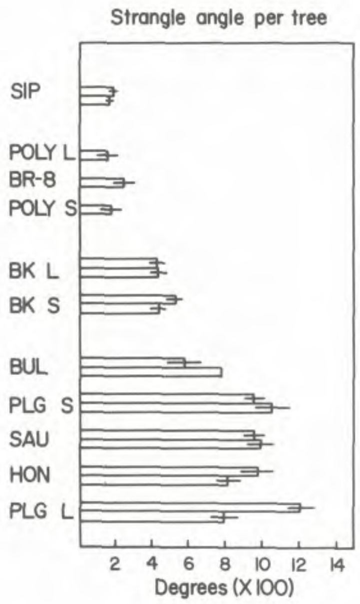

Figure 3.--Strangle angle per tree for each container type tested at Shelterbelt Laboratory, Bottineau, N.D.

In the 2 years it took to complete the study, new containers have been developed, and others have added vertical ridges. The upper laterals of ponderosa pine are usually the roots with the high strangle angles. It is especially important that these roots be directed to the bottom of the container and air pruned. The proper container for a large seedling for the Plains must be shaped to direct roots straight to the bottom. Ridges and grooves on the container sides seem to accomplish this. The opening in the bottom of the container is also important. When the root reaches the bottom, the tip should die, otherwise it may be deflected upward and coil in a vertical plane. If a properly shaped container is used for the proper length of time, a good root system can be developed on ponderosa pine. We still don't know, however, how much deformity a root system can have before growth is restricted or the structural support of the tree is weakened. A root study on much older and larger trees grown from containers is needed to answer these questions.

LITERATURE CITED

Ben Salem, B.
1971. Root strangulation: A neglected factor in container grown nursery stock. M.S. thesis in forestry, Univ. of Calif., Berkeley, 50 p.

Donald, D. G. M.
1968. Fundamental studies to improve nursery production of Pinus radiata and other pines. Annale Universiteit van Stellenbosch 43, Ser A(1), 180 p.

Harris, R. W., D. Long, and W. B. Davis.
1967. Root problems in nursery liner production. Calif. Agric. Ext. Serv. AXT-244, 4 p.

Stone, E. C., and E. A. Norberg.
1971. Modification of nursery climate to improve root growth capacity of ponderosa pine transplants. Am. Soc. Agric. Eng. Annu. Meet., Pullman, Wash., June 1971, Pap. 71-165, 7 p.

Tinus, R. W.
1971. Growing conifer seedlings in a controlled environment. Paper presented to the joint meeting of the Western For. Nurs. Counc. and the Intermt. Nurserymen's Assoc., Edmonton, Alberta, Can., Aug. 3, 1971, 16 p.

Tinus, R. W.
1974. Conifer seedling nursery in a greenhouse. J. Soil and Water Conserv. 29:122-125.

Question: Were there any differences in size after 2 years' growth between low-strangle-angle and high-strangle-angle seedlings?

Hiatt: No, we would have to look at root systems of trees outplanted for a longer length of time.

Question: Would not root fusion during the first decade of growth obliterate the "strangle angle" concern?

Hiatt: That may be quite true for some species, but many authors have reported cases where the roots grew into a ball, the structural support of the tree was weakened, and the trees blew down.

Question: What is your educated guess on long-term effects of root deformation?

Hiatt: It appears there may be no ill effects for some species, but we also know that other species, pines especially, are susceptible to blowdown, root rot and retarded growth, if they are planted with knotted roots. The effects may take a decade or more to show up. We do not know how much root deformation a tree can tolerate and still perform the way it should.