The Potential for Chemical Root Pruning in Container Nurseries

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INTRODUCTION

Deformed root systems of container-grown plants are a longstanding concern of nursery managers, landscapers, and foresters (Armstrong, 1951; Burdett, 1979). Kinked or circling roots can strangle the plant, impair long-term growth, lead to instability or toppling, and cause death. Halter et al.(1993) found a reduction in growth and an increase in root deformities in 11-year-old lodgepole pine, *Pinus contorta* ssp. *murrayana*, planted as container stock. Plants with deformed roots are more sensitive to environmental stress, such as drought, and to attack from insects and disease. Certain plants develop deformed roots rapidly, especially when they are grown in small containers.

Root systems become deformed when the growing root tips deflect off the smooth container wall, grow sideways, and accumulate on the periphery of the root ball. Harris (1967) suggested that if roots where encouraged to grow in the center of the medium, plants could remain in containers longer, before serious root circling occurred. Containers modified with vertically oriented ridges, ribs, or grooves intercept circling roots and direct them downwards. Containers designed to air prune roots, such as porous-walled containers, often promote fibrous roots on the periphery of the root ball (Privett, 1992). Another option is to coat the walls of the container with a chemical root-pruning agent (Landis et al., 1990). Every root tip that comes in contact with this chemical barrier is pruned and usually results in a fibrous root system with a greater number of roots in the upper portion of the container. A quality tree seedling is one with a large, fibrous root system with a large surface area for absorption of water and nutrients (Thompson, 1985).

HISTORY

Evaluation of chemical root-pruning agents to control root morphology began in the late 1960s. But almost 30 years before that, Leatherman (1939) used copper resinate to treat paper pots to prevent decomposition and found no indication of toxicity to tomato plants. In another early trial, cyclamen grown in clay pots dipped in copper naphthenate, for control of algal growth, had more extensive root growth within the medium than untreated clay pots (Stinson, 1956). After the Ontario

Department of Lands and Forests initiated a program to plant containerized seedlings, Saul (1968) demonstrated that roots could be confined to tubes if copper metal sheeting, copper-coated paper, or copper paints were used to line the flats holding the tubes. Later trials with woody landscape plants showed that root growth could be prevented near container walls treated with copper naphthenate or with copper sulfate (Furuta et al., 1972).

So began the search for chemical compounds to coat the inside walls of containers to prune root tips. Pellet et al. (1980) evaluated metal compounds containing cobalt, copper, manganese, nickel, silver, zinc, and others, and found that several of them effectively pruned roots. Several non-metal chemical compounds were also investigated for their root pruning potential: oryzalin (Surflan™, DowElanco) and indolebutyric acid (IBA) were also found to be effective in controlling root growth (McDonald et al., 1984; Ticknor, 1989). But the copper compounds, especially cupric carbonate, consistently gave excellent results for chemically pruning plant roots with no visual plant toxicity. Recently, cupric hydroxide has emerged as an alternative to cupric carbonate (Arnold, 1992).

EFFECTS ON ROOT GROWTH

Chemical root pruning modifies the root system of container-grown plants by reducing the elongation of roots and by promoting a more fibrous root system. Since root growth is influenced by the amount of auxin in the root tip, a dead or arrested root tip causes the root to branch. Early studies by Duncan and Ohlrogge (1958), reported the effects of fertilizer bands on root pruning in a production system. The first-order root tip was apparently killed when it contacted the fertilizer band and second-order roots developed. Second-order roots produced a large number of higher order roots, increasing the total number of root tips. Similar observations were made when cork oak, *Quercus suber*, acorns where sown in flats with a bottom layer of osmocote, treflan, or copper naphthenate-soaked perlite (Nussbaum, 1969). All three chemical layers prevented taproots from elongating through the treated layer and the seedlings had more secondary and tertiary roots.

Chemical root pruning is actually a mild form of copper toxicity. Although the physiology of copper toxicity is not thoroughly understood, copper is only negligibly translocated in the stem (Bennett, 1971). Symptoms of copper toxicity are stunted roots with blackened, thickened root tips, and reduced shoot growth and foliar chlorosis. Arnold and Struve (1989) found copper toxicity symptoms of green ash, *Fraxinus pennsylvanica,* only on root tips in contact with cupric carbonate-treated surfaces. In addition, they found that high copper concentrations were confined to the terminal 1.5 to 2.0 in. of the root. Whether or not a root tip will renew growth once removed from the copper treated zone depends on plant species and copper formulation and concentration (Arnold and Wilkerson, 1993).

APPLICATION TO CONTAINERS

Several nurseries have used homemade solutions to bind a chemical root- pruning agent to the container. Copper is applied to the inside of the containers using latex paint as the carrier and adhesive. Either cupric carbonate or cupric hydroxide is used at the rate of 100 g/liter of paint. While brush application is very time consuming, an airless sprayer can treat several thousand 2¼-in. liner containers in 1 h. Uniform coverage is more difficult with narrow, deep containers. How long the copper treatment remains effective depends on the thickness of the coating, type of adhesive, and the amount of wear or chipping.

Commercial products have recently become available for nursery use. Spin Out^{TM} (Griffin Corporation) is a liquid flowable product that has received registration for use on plastic nursery containers. In South Africa, Plazdip (Starke Ayres) is used extensively for producing containerized forest seedlings. Another product operationally used in forest nurseries, is the Trimroot Styroplug^{TM} (Beaver Plastics), that is a styrofoam container whose cavities are coated with cupric carbonate. Larger pre-treated containers for producing landscape plants may become available in the near future. Chemical root pruning agents are considered a plant growth regulator and must have EPA registration.

ENVIRONMENTAL AND SAFETY CONCERNS

Environmental issues regarding the use of chemical root-pruning products are very important concerns. Although copper is rapidly and strongly fixed in organic matter, the leaching potential has not been thoroughly studied in container nursery stock production. The current, federal, maximum, permissible contaminant level for copper is 1.0 mg/liter for water delivered to any user of a public water system (U.S. EPA, 1991). Cupric hydroxide is toxic to fish. When using copper-treated containers, irrigation tail-water that is stored and recycled should be monitored for levels of copper throughout the growing season. In addition, disposal and recycling of treated containers may be a concern.

Nurseries who use chemical root-pruning products must comply with local, state, and federal worker safety regulations. Health and safety issues focus on exposure during application of the product to containers and during handling of the treated containers. Nursery managers must consider: (1) maintaining material safety data sheets, (2) record keeping regulations,(3) appropriate protective clothing for applicators, (4) restricted-entry intervals, and (5) worker training.

NURSERY POTENTIAL

There is high interest and increased use of chemical root pruning in container nurseries. Nursery managers are finding that more plants pass the grading requirements and that markets are starting to demand fewer root deformities. For example, foresters in British Columbia, Canada, are requiring that lodgepole pine be grown in copper-treated blocks. Chemical root pruning of seedlings has become an established practice in South Africa.

More information is needed on phytotoxicity and on long-term outplanting performance of plants with chemically pruned roots. Potential benefits of a root system confined to the interior of the medium is improved tolerance to extreme medium temperatures. Roots should be more insulated from high temperature during the summer, and from low temperatures during the winter. Interior root tips are less subject to desiccation and to mechanical injury when transplanted. Crop water requirements and shelf life may also change due to the fibrous nature of chemically pruned root systems.

CONCLUSION AND RECOMMENDATIONS

Although the potential benefits of chemical root pruning are great, we advise nursery managers to proceed with caution. First, always do small trials when introducing a new plant species to copper-treated containers and watch for any phytotoxicity. Be aware that environmental and safety regulations regarding the use of chemical root-pruning agents could change, as it often does for pesticides and plant growth regulators. And finally, follow the latest research as it relates to nursery practices and outplanting performance.

LITERATURE CITED

Arnold, M.A. 1992. Timing, acclimation period, and cupric hydroxide concentration alter growth responses of the Ohio Production System. J. Environ. Hort. 10(2):114-117.

Arnold, M.A. and **D.K. Struve.** 1989. Cupric carbonate controls green ash root morphology and root growth. HortScience 24(2):262-264.

Arnold, M.A. and **D.C. Wilkerson.** 1993. Putting a different spin on container production. The Texas Nurseryman 24(9):54-58.

Armstrong, W. 1951. Root constriction of container-grown nursery stock. Comb. Proc. Intl. Plant Prop. Soc. 12:258-259.

Bennett, A.C. 1971. Toxic effects on root growth, p.675-677. In: E.W. Carson (ed). The plant root and its environment. University Press of Virginia, Charlottesville, Virginia.

Burdett, A.N. 1979. Juvenile instability in planted pines. Irish Forestry 36(1):36-47.

Duncan, W.G. and **A.J. Ohlrogge.** 1958. Principles of nutrient uptake from fertilizer bands. II. Root development in the band. Agron. J. 50:605-608.

Furuta, T, W.C. Humphrey, and **T. Mock.** 1972. Chemically controlling root growth in containers. California Agriculture, December 1972.

Halter, M.R., C.P. Chanway, and **G.J. Harper.** 1993. Growth reduction and root deformation of containerized lodgepole pine saplings 11 years after planting. Forest Ecol. and Management 56(1-4):131-146.

Harris, R.W. 1967. Factors influencing root development of container-grown trees. Proc. Intl. Shade Tree Conf. 43:304-314.

Landis, T.D., R.W. Tinus, S.E. McDonald, and **J.P. Barnett.** 1990. Containers and growing media, Vol. 2, The container tree nursery manual. Agric. Handbk. 674. Washington, D.C: U.S. Department of Agriculture, Forest Service.

Leatherman, M. 1939. The use of copper resinate as a treatment for paper pots. Proc. Amer. Soc. Hort. Sci. 37:951-955.

McDonald, S.E., R.W. Tinus, and **C.P.P. Reid.** 1984. Modification of ponderosa pine root systems in containers. J. Environ. Hort. 2(1):1-5.

Nussbaum, J.J. 1969. Chemical pinching for roots of container plants. Calif. Agric. 23(10):16-18.

Pellett H., M. Litzow, and **L. Mainquist.** 1980. Use of metal compounds as root pruning agents. HortScience 15(3):308-309.

Privett, D.W. and **R.L. Hummel.** 1992. Root and shoot growth of 'Coral Beauty' Cotoneaster and Leyland Cypress in porous and nonporous containers. J. Environ. Hort. 10(3):133-136.

Stinson, R.F. 1956. Algal growth and the performance of flowering plants in clay pots treated with copper naphthenate. Proc. Amer. Soc. Hort. Sci. 68:564-568.

Saul, G.H. 1968. Copper safely controls roots of tubed seedlings. Tree Planters Notes (USDA) 19:7-9.

Thompson, B.E. 1985. Seedling morphological evaluation—What you see is what you get, p. 59-71. In: M.L. Duryea, (ed.). Proceedings: Evaluating seedling quality: principles, procedures, and predictive abilities of major tests. Forest Research Laboratory, Oregon State University, Corvallis, Oregon.

Ticknor, R.L. 1989. Production of *Forsythia* plants for forcing. Comb. Proc. Intl. Plant Prop. Soc. 39:115-118.

U.S. Environmental Protection Agency. 1991. Drinking water regulations and health advisories—April 1993. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.