Wound Compartmentalization in Cultivars of *Acer, Gleditsia,* and Other Genera[1]

Frank S. Santamour, Jr.[2]
U.S. National Arboretum
Agricultural Research Service
U.S. Department of Agriculture
Washington, D.C. 20002

Abstract

Results of studies on a broad range of plant material (20 cultivars in 7 genera) suggest that most, if not all, landscape tree cultivars that have been successfully commercially propagated by budding or grafting are strong wound compartmentalizers. All of the cultivars tested with chisel wounds on mature trees or young plants exhibited strong wound compartmentalization that prevented wood discoloration from occurring in tissue internal to the wound zone. These included red maple cultivars 'Armstrong,' 'Autumn Flame,' 'Bowhall,' 'Gerling,' 'October Glory,' 'Red Sunset,' 'Scarlet Sentinel,' 'Tilford,' 'V.J. Drake,' and 'Wageri'; Norway maple 'Emerald Queen'; silver maple 'Silver Queen'; honeylocust 'Majestic,' 'Skyline,' and 'Sunburst'; ginkgo 'Pendula'; Callery pear 'Bradford'; green ash 'Marshall Seedless'; American linden 'Nova'; and 'Regent' scholartree.

Index words: maple, honeylocust, landscape trees, graft compatibility

Introduction

Ever since it was suggested and proved that the wound compartmentalization response in trees was under genetic control (3, 6), there has been interest in determining the compartmentalization potential of cultivars currently in the nursery trade. However, such studies have been delayed by insufficient knowledge of adequate testing procedures, varying concepts of significant compartmentalization response, the availability of potentially expendable plant material, and the time necessary for experimentation.

Two recent studies are of interest in this regard. Gallagher and Sydnor (1) reported significant variation in rate of closure of drill wounds among a number of red maple (*Acer rubrum* L.) cultivars. Previous work (3, 6, 7) has shown that wound closure was not correlated with the internal compartmentalization of discolored tissue in the wood. Later, Gallagher and Sydnor (2) ranked these same cultivars according to the vertical extent of trunk xylem discoloration as determined by electrical resistance measurements made with the wire probe of a Shigometer[3] or by actual observation on wounded and dissected branches. They established categories of "weak compartmentalizers" and "superior cultivars" on these bases.

According to the CODIT (Compartmentalization Of Decay In Trees) model (5), there are 3 "wall" systems present in a tree at the time of wounding. Wall 1, which resists vertical spread of wound-induced discoloration, is the weakest of these, and can be visualized as being composed of the transverse top and bottom walls of cells above and below the wound. In virtually all wounds there is some vertical wood discoloration beyond the original wound zone. Wall 2, which resists inward spread, can be thought of as the tangential walls of cells laid down in the annual growth rings resulting from cambial activity. Wall 2 is stronger than Wall 1, but not as strong as Wall 3, which resists lateral spread and can be considered as the radial walls of cells that constitute the xylem rays. These "walls" are not walls in the true sense, but merely represent cell types that differ in their morphology, physiology, and position and that may constitute roughly the "boundaries" of certain patterns of wound-induced wood discoloration.

Since there is always a wound-induced breach of Wall 1, and very few trees that we have studied showed a breach of Wall 3, we have concentrated on Wall 2 compartmentalization as being the most significant criterion for the selection of landscape trees that could best withstand repeated trunk wounds and resist potentially dangerous wood decay. Also, in contrast to many other researchers, we have usually used chisel wounds rather than drill wounds. Weak compartmentalization following a chisel wound results in a wedge-shaped pattern of wood discoloration. Chisel wounds provide a well-defined internal wound "edge," and can be made shallow enough so that there usually will be sufficient xylem internal to the wound for the wedge of discoloration to develop even on young trees. One potential problem with drill wounds is that they frequently are made deep enough to penetrate the central core of bacterial wetwood (in *Gleditsia, Ulmus, Populus)* or true colored heartwood (in *Quercus, Prunus).* In both types of wood, Wall 2 compartmentalization is difficult to visualize. In trees with internal wetwood, the release and subsequent movement of bacteria caused by the drill wound can also influence the interpretation of the nature and extent of discoloration attributed to the "failure" of Walls 1 and 3.

Thus, in this paper, we are concerned only with Wall 2 compartmentalization. The discolored area caused by wounding in "strong" compartmentalizers would be limited virtually to the original wound zone. "Weak"

[1]Received for publication March 14, 1984; in revised form June 26, 1984. Research partially supported by a grant from the Horticultural Research Institute, Inc.

[2]Research Geneticist, U.S. National Arboretum.

[3]Osmose Wood Preserving Co. of America, Buffalo, N.Y, Mention of a particular product should not be taken as an endorsement by the Agricultural Research Service or the U.S. Department of Agriculture.

compartmentalizers would show a wedge of discolored wood, in cross section, tapering from the original wound zone to the pith. Any tree with at least one wound showing this discolored wedge is a genetically weak compartmentalizer.

Materials and Methods

Preliminary studies of the efficacy of using the twisted wire probe of the Shigometer on October 12, 1979, were made on red maple trees that had been wounded in 1974, but had not been felled for examination in 1978 (3). Predictions on compartmentalization were based on the drop in electrical resistance between the sound wood that had developed since wounding and the discolored interior wood produced as a result of wounding. In practice, it was not possible to detect the narrow band of discolored wood in strong compartmentalizers, possibly because of the short distance (5 mm or 0.2 in) between the contact points of the probe. However, the discolored wood in the "wedge" zone of weak compartmentalizers did exhibit a reduction in electrical resistance. The trees were felled after Shigometer readings were taken and checked for wood discoloration, and the results indicated that reliable predictions of weak compartmentalization in red maple could be made with this technique.

Mature trees of many cultivars growing on the grounds or in test plots of the U.S. National Arboretum, Washington, D.C., were wounded two or more times at about 1.4 m (4.5 ft) above ground level by pounding a 1.9 cm (0.75 in)-wide chisel into the trunk to a depth of about 5 mm (0.2 in). These cultivars included *Acer rubrum* L. 'Armstrong,' 'Gerling,' 'October Glory,' 'Tilford,' and 'Wageri'; *Fraxinus pennsylvanica* Marsh. 'Marshall Seedless'; *Gleditsia triacanthos* L. 'Imperial,' 'Majestic,' 'Moraine,' 'Shademaster,' 'Skyline,' and 'Sunburst'; *Pyrus calleryana* Dcne. 'Bradford'; *Sophora japonica* L. 'Regent'; *Tilia americana* 'Nova'; *Ulmus americana* L. 'Princeton'; and *Ginkgo biloba* L. 'Pendula.'

The trees were wounded on either April 23, 1979, or July 11, 1981. Some of the trees wounded on the earlier date were examined with the twisted wire probe of a Shigometer on October 18, 1979. Failure to distinguish any trees that could be classified as weak compartmentalizers led to the conclusion that a longer period of time should elapse between the time of wounding and examination for compartmentalization.

To determine compartmentalization in older trees, a core of wood was removed from these trees on May 24, 1983, with a 4.3 mm (0.17 in) increment border inserted directly through the original wound area.

The remainder of the cultivars were maples represented by plants propagated from rooted cuttings and donated as one-year-old plants in 1979 by J. Frank Schmidt & Son, Boring, Oregon. These included the red maple (*Acer rubrum* L.) cultivars 'Autumn Flame,' 'Bowhall,' 'Gerling,' 'October Glory,' 'Red Sunset,' 'Scarlet Sentinel,' and 'V.J. Drake'; 'Emerald Queen' Norway maple (*A. platanoides* L.) and 'Silver Queen' silver maple (*A. saccharinum* L.). Both 'Gerling' and 'October Glory' red maples were also represented by wounded mature specimens.

These young trees were wounded on July 5, 1980, during their second growing season, by removing two small wedges of wood from opposite sides of the stem with a knife blade and also by drilling a 3 mm (0.12 in) hole completely through the stem. The trees were harvested on January 24, 1981, and sawn through at the wound zones.

The young cultivars were wounded again on November 12, 1982, by making shallow wounds 2 mm (0.08 in) deep with an 8 mm (0.32 in) wide chisel on opposite sides of the stems. These trees were harvested on October 24, 1983, one full growing season after wounding.

Results and Discussion

One significant fact emerged from the Shigometer probing of various cultivars of honeylocust and the American elm cultivar 'Princeton.' Trees of both genera contained internal bacterial wetwood and the release of liquid caused by the entrance of the drill into the wetwood zone completely eliminated any meaningful measurements of electrical resistance. In some cases, the internal wetwood pressure caused liquid to spurt or drip from the drill hole. Thus, we had to use another technique, the increment borer, for non-destructive determination of compartmentalization in older trees.

Felling and observation of several test trees of species with and without wetwood indicated that the increment borer technique was accurate. However, because of the invasion of wetwood along the path of the drill hole used for Shigometer probing the increment borer did not give reliable data on 'Imperial,' 'Moraine,' or 'Shademaster' honeylocusts or 'Princeton' American elm. Increment cores of strong-compartmentalizing maples showed only the discoloration resulting from the original wound, while discoloration in weak compartmentalizers was more extensive (Fig. 2).

Young stems of red maple cultivars wounded in July, 1980 and harvested in January 1981, less than one full growing season after wounding, did not show any cultivar with weak compartmentalization. It was determined that at least one full growing season should elapse between wounding and observation for an accurate appraisal of compartmentalization potential. However, even on young maples wounded in November, 1982, and harvested in October 1983, none showed weak compartmentalization. Mature trees of 'Gerling' and 'October Glory' also exhibited strong compartmentalization as determined by increment cores.

In fact, all of the commercially propagated cultivars tested in all genera were found to exhibit strong Wall 2 compartmentalizations of trunk wounds (Figs. 1, 2).

This result might not be too surprising in view of the fact that propagation by budding and grafting is dependent on rather severe wounding, including severance, of both stock and scion. While it may be difficult to envision any comparison between the wounding processes involved in propagation and chisel-wounding the xylem of a tree trunk, there may be some similarities in physiological and biochemical responses.

Thus, it is possible that nurserymen have inadvertently been selecting for strong compartmentalization by their choice of budding or grafting as a propagation method for their cultivars. Such a selection would not pertain to clones of species propagated by the rooting of

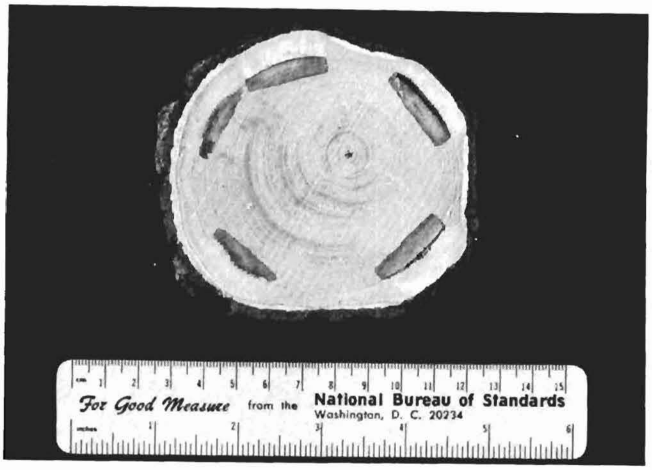

Fig. 1. **Cross-section through trunk of *Ginkgo biloba* 'Pendula,' showing strong compartmentalization of chisel wounds.**

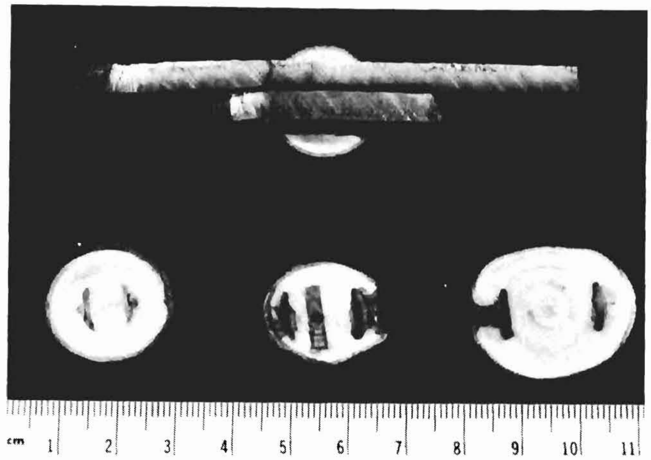

Fig. 2 **Above—increment cores from strong compartmentalizing 'October Glory' red maple with only the original 7 mm (0.28 in) wound zone discolored (upper core) compared with core from weak compartmentalizing tree showing extensive discoloration. Below—left to right: 'Gerling' red maple wounded 1980; 'Silver Queen' silver maple drilled through in 1980, chisel-wounded 1982; 'Gerling' wounded 1982—all showing strong compartmentalization.**

cuttings. For instance, Shigo *et al.* (7) and Santamour (unpublished) have found wide variations in wound compartmentalization response among hybrid poplar clones that had been exclusively propagated from cuttings. However, if cultivars that had long been propagated by budding are subsequently propagated from cuttings (such as many red maples) they will obviously retain their genetically-controlled potential for strong compartmentalization.

Does the inherent wound compartmentalization response of stock and scion have any relation to graft incompatibility? Certainly wound compartmentalization potential would appear to be related to the realization of the degree of grafting success necessary for extensive commercial propagation. Many nurserymen have selected trees as potential cultivars that never become items of commerce because of the lack of grafting success. Could the inability to graft certain selections be traced to weak compartmentalization potential of the scion? Could the failure of a certain percentage of grafts on a known strong-compartmentalizing cultivar on seedling rootstocks of unknown potential be attributed to weak compartmentalization of those rootstocks? We must also keep in mind that there may be real differences between the kind of graft "failure" that occurs in the first year following propagation and the latent "incompatibility" that may be visibly manifested only after several years. Studies to determine the role of weak compartmentalization potential of both stock and scion in all types of grafting problems are currently underway.

Significance to the Nursery Industry

It is of great significance to nurserymen and to their customers that many, if not all, of the widely available landscape tree cultivars possess the highly desirable trait of being able to strongly compartmentalize trunk wounds. Budding and grafting propagation techniques may have provided a screening process for the selection of strong compartmentalization. As suggestive as the evidence presented in this paper might be, we should continue to test more of the commercial cultivars, with special attention being given to woody plants that have been traditionally propagated by cuttings and have not been subjected to the grafting-screening procedure.

Literature Cited

1. Gallagher, P. and T.D. Sydnor. 1981. Variation in wound-closure rates among *Acer rubrum* cultivars. Ohio Agric. Res. Dev. Ctr., Res. Cir. 263, p. 23-25.

2. Gallagher, P.W. and T.D. Sydnor. 1983. Variation in wound response among cultivars of red maple. J. Amer. Soc. Hort. Sci. 108: 744-746.

3. Santamour, F.S., Jr., 1979. Inheritance of wound compartmentalization in soft maples. J. Arboriculture 5:220-225.

4. Santamour, F.S., Jr. 1984. Early selection for wound compartmentalization potential in woody plants. J. Environ. Hort. 2:126-128.

5. Shigo, A.L. and H.G. Marx, 1977. Compartmentalization of decay in trees. USDA Forest Service, Agric. Inform. Bull. No. 405, 743 p.

6. Shigo, A.L., W.C. Shortle, and P.W. Garrett. 1977. Genetic control suggested in compartmentalization of discolored wood associated with tree wounds. Forest Sci. 23:179-182.

7. Shigo, A.L., W. Shortle, and P. Garrett. 1977. Compartmentalization of discolored and decayed wood associated with injection-type wounds in hybrid poplar. J. Arboriculture 3:114-118.