EFFECT OF TREE SIZE, HOLE LOCATION, AND WETWOOD FLUXING ON HEALING OF INJECTION WOUNDS IN AMERICAN ELMS

by Robert W. Stack[1]

Abstract. Elm trees treated by injection for protection from Dutch elm disease were examined after 22 months. The degree of healing of injection wounds was determined. Injection holes in roots healed faster than those in stems, and with notable exceptions those on smaller trees faster than those on larger trees. There was no relationship between wetwood symptoms on the tree and healing of injection sites.

Protection of elms against Dutch elm disease by injection of systemic fungicides has become commonplace in many parts of the United States (4,7). The recent development and registration of chemical rates that allow 3 years between injections have reduced some of the risks of such treatments (1,3,6). Location of injection sites on roots or the root collar has been stressed for improved uptake and distribution of chemicals (3,4,7). Both internal damage (6) and external symptoms (1,5) resulting from injection wounds have been studied. Most elms suffer from wetwood disease caused by *Erwinia nimipressuralis* Cart., which results in bleeding from wounds (2). The effect of wetwood on healing of injection wounds is undetermined.

The trees in this study were injected in the summer of 1981. Preliminary observations in 1982 suggested that there might be significant relationships between wetwood symptoms, hole location and healing.

Methods and Materials

There were 45 American elm *(Ulmus americana)* trees included in this study. They were located on the campus of North Dakota State University, Fargo. Many of them were planted in the 1890s.

Tree condition was generally good although some had suffered root injury from street construction. Trees ranged in size from 25 cm to 94 cm diameter breast height (dbh). The tree sizes were in the following distribution: 25 to 50 cm, 13 trees; 51 to 70 cm, 22 trees; 71 to 94 cm, 10 trees. During July 1981 these trees received prophylactic treatments against Dutch elm disease with thiabendizolehypophosphite (Arbotect 20-S) at 12 ounces per 5 inches of diameter (3). The apparatus used for injection was the Elm Research Institute (ERI) low pressure system (7). Holes for injection tees were drilled with a hand-held half-inch electric drill equipped with a 5/16" diameter twist bit. Holes were drilled approximately 15 cm apart as low to the ground as possible on the root flare, collar or stem. All trees included in this study were healthy at the time of injection.

Of all injection holes examined in this study, 38% were on stem, 50% on the trunk flare, and 12% on the roots. "Stem" sites were on the upright trunk of the tree. "Root" sites were on areas which had bark characteristics of roots rather than stem bark and correspond to Gkinis and Stennes (3) term "root flare" or Kondo's (4) "root collar." The "trunk flare" is the tapering lower part of the trunk out to the roots but still having typical trunk bark.

In May of 1983, 22 months after injection, the injection holes were examined and degree of healing was determined. To estimate healing we measured wound closure. Wooden dowels were used as gauges to probe the holes. Complete healing was noted visually. On roots wounds, healing was at the bark surface and easily observed. On trunk wounds, especially on older

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trees with thick outer bark, the healing was deeper but still observable. Bleeding from injection holes was determined at the time healing measurements were made. Each tree was rated for the presence of slime fluxing or bark stains from wetwood bleeding. We used a wetwood rating system based on the external symptoms of the tree. From ground level we examined the trunk and main branches of each tree for wounds and cracks, the usual site of wetwood fluxing (2). A tree was placed in 'slight' category if a few wounds showed only minor fluxing and there were some non-fluxing wounds also present. If all wounds showed fluxing or if many wounds showed extensive fluxing, the tree was placed in the 'moderate-to-severe' category.

Results

Healing of injection wounds. Tree size influenced healing of injection wounds. A larger proportion of the injection holes healed on the smaller trees than on the larger trees (Table 1). Healing of all injection wounds on a tree was also related to size (Table 1). Over 75% of the trees in the smaller size class had all injection holes completely healed, as compared to only 18% and 10%, respectively, of the trees in the two larger size classes.

Healing was also related to the position of the injection wound on the trees. More than 90% of injection wounds in roots healed in all tree size classes. As the injection site went higher on the tree, the rate of healing declined to 77% on the trunk flare and 61% on the stem. This relationship was more pronounced on the larger trees. In the largest trees, less than half of the wounds on the stem had healed (Table 1). A chi-square contingency table analysis of the hole counts in the various classes showed that the two factors, position of holes and size of trees were independent and no interaction occurred between them. The effect of these two factors was cumulative, however, so that the best healing was with root injections on small trees (100%) and the poorest was with stem injections on large trees (45%).

Expression of wetwood symptoms was not related to tree size (data not shown). The degree of wetwood fluxing symptoms on the trees, regardless of size, did not appear to relate to the healing of injection wounds (Table 2).

The number of injection holes showing bleeding was only 12%. The extent of bleeding was greatly influenced by the position of the injection wound and only slightly related to wetwood fluxing symptoms on the tree (Table 2). Bleeding was most common in stem wounds, less from those on the flare, and least on root wounds. There was no relationship detected between tree size and extent of bleeding of wounds.

Table 1. Healing of injection wounds on American elm trees by tree size and wound site.

Percent of injection wounds completely healed				
Injection site	*Tree size class (dbh) cm*[1] *below 51*	*51-70*	*above 70*	*Mean*[2]
Root	100.0	92.3	95.4	94.4a
Trunk flare	96.0	73.3	79.5	77.9b
Stem	91.0	58.8	45.2	61.2c
Mean[2]	96.0a	71.0b	72.0b	
Percent of trees with all injection holes completely healed				
	76.9	18.2	10.0	33.3

[1] There were 13 trees below 51 cm, 22 trees 51-70 cm, and 10 trees above 70 cm dbh.

[2] Means followed by the same letter were not significantly different at $P = .05$ when tested by the chi-square test.

Table 2. Relationship of wetwood fluxing symptoms and injection site to bleeding of injection holes and healing.

	Degree of wetwood symptoms *None*	*Slight*	*Moderate to severe*	*Total*
Number of Trees	*13*	*14*	*18*	*45*
Injection Site	*Percent of injection holes bleeding*			*Mean*[1]
Root	*0*	*0*	*3.0*	*1.8a*
Trunk flare	*6.0*	*5.1*	*14.0*	*10.0b*
Stem	*15.0*	*14.0*	*23.0*	*18.0c*
Mean[1] *(all sites)*	*9.4a*	*9.7a*	*19.0b*	
Percent of injection wounds healed	*70.*	*76.*	*76.*	

[1] Means followed by different letters are significantly different at $P = .05$ (chi square).

Discussion

One can expect the best healing of injection wounds in roots and on smaller trees, but there may be important exceptions. Such exceptional trees may have environmental advantages or inherently better healing. Root injection is more important on larger trees where the rate of healing of stem holes is sharply reduced. The degree of wetwood fluxing on a tree is not a useful predictor of quick healing of injection wounds. Valuable trees which show heavy slime fluxing should not be excluded from a protective program solely on the basis of wetwood symptoms. To emphasize this point, one large (88 cm dbh) tree with severe wetwood fluxing was the single tree in its size class which showed healing of 100% of all injection holes regardless of their position.

Kondo has emphasized the use of root injection to improve fungicide distribution (4). Improved wound healing is another reason for root injection. In this study we did not observe the bark cracking and cankers associated with stem injections as reported elsewhere (5). Since the purpose of the treatments here reported was to preserve the trees it was not possible to dissect them to show the comparative wound-healing processes in stems and roots. Such studies on root injection wounds would no doubt prove enlightening. Tree injection is going to be with us for many years to come. These results suggest ways that the damage can be minimized.

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ABSTRACT

MUIR, J. 1984. **Silvicultural information to help select and manage native trees in urban or suburban developments.** Arboricultural Journal 8: 13-17.

In planning or maintaining housing developments in forested areas of British Columbia and other areas of the Pacific Northwest, a major challenge is to manage the native forest trees, particularly conifers. Considerable silvicultural, ecological, and forest biological information has been developed that should be considered in judging how a particular tree, or stand of trees, should be managed. How some of this information can be applied to arboriculture is described briefly. Criteria used to select trees are based on three categories: growth requirements of tree species, general background information called silvics and silviculture, and specific features which can be evaluated for individual trees and shrubs.