AN EVALUATION OF ARBOTECT AND LIGNASAN TRUNK INJECTIONS AS POTENTIAL TREATMENTS FOR OAK WILT IN LIVE OAKS[1]

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Abstract. Arbotect-20S® (2-(2)thiazolyl) benzimidazole) and Lignasan® (methyl-2-benzimidazol carbamate phosphate) were mixed with low volumes of water and injected into the xylem of live oaks in an effort to stop or prevent oak wilt (caused by *Ceratocystis fagacearum*) development. Healthy trees near the advancing edge of oak wilt infection centers were not protected by fungicide treatments. Some of the infected trees showed an initial slowdown in the rate of tree degeneration after injections, but after 15 months there was no significant difference in treated and untreated trees.

There is a growing demand for treatments against oak wilt (caused by *Ceratocystis fagacearum*) in central Texas. The disease affects all native *Quercus* species but is of particular concern in high value ornamental and shade trees, such as live oak *(Q. virginiana)*. Thousands of oaks, some with historical importance, are killed or threatened by wilt each year (5), but there are no known chemical treatments for the disease. Several systemic fungicides have been tested for possible use against vascular wilts in oak trees (1-4, 7). In preliminary tests, diseased live oaks treated with low dilutions of either Lignasan (methyl-2-benzimidazole carbamate phosphate) or Arbotect-20S (2-thiazolyl) benzimidazole) lived longer than untreated controls (4). The purpose of this study was to further evaluate solutions of Lignasan and Arbotect-20S in relatively high concentrations as preventative and therapeutic treatments for oak wilt.

Materials and Methods

Live oaks with initial or advanced oak wilt symptoms and uninfected trees near infection centers were treated with fungicides. Oak wilt was confirmed by diagnostic symptoms and/or fungus isolation prior to treatment. Lignasan (0.7% a.i.) and Arbotect-20S (20% a.i.) were diluted with low volumes of water to give a more potent fungicidal solution for delivery into the xylem.

Fungicide mixtures were pressure (20 psi) injected into the xylem through 5/16 inch holes about 1 ½ inches deep. Injection sites were about 6 inches apart and on either root flares or the lower part of the bole.

Root grafts were not broken because one of the study objectives was to see if the fungicide treatment alone could protect healthy trees from advancing oak wilt infections.

Numerical disease ratings were defined and assigned to trees prior to and after fungicide treatments. Disease ratings (pretreatment and posttreatment) were defined as follows: 0 = uninfected but within 25 to 100 feet of nearest known infected tree; 1 = early phase of infection, trees with initial leaf symptoms; 2 = advanced phase of infection, thin crowns and twig dieback but no dead limbs; 3 = crown mortality phase, trees having fewer than 50% of limbs dead; and 4 = terminal phase, 50% or more of crown dead (also includes complete mortality). Only trees with pretreatment ratings of 0, 1, and 2 were used in this study.

Kerrville, Texas treatments. Arbotect-20S (20% a.i.) was diluted with water (1:24 vol:vol) to give a 0.8% a.i. mixture for tree injections. Forty trees were injected with 100 ounces of the mixture per each 5 inches of tree dbh (4.5 feet above ground level). Lignasan (0.7% a.i.) was diluted with water (1:2 vol:vol) to give a 0.23% a.i. mix-

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ture. There were 44 trees injected with 96 ounces per each 5 inches of tree dbh and 28 trees marked as untreated controls.

Bandera, Texas treatments. A complete block consisting of 145 high-value live oaks was initially treated with Lignasan during the period of August 2 to 21, 1979. Oak wilt was moving into the treated area from a large infection center on adjacent property. At the time of treatment, 12 (8.3%) of these 145 live oaks were infected, but all were treated. Lignasan (0.7 a.i.) was diluted with one part water to give a .35% a.i. mixture. Each tree was initially injected with 64 ounces of the mixture per each 5 inches of tree dbh. The rate of fungicide uptake per minute was calculated for each tree. The trees were pruned, fertilized, and sprayed with insecticides by a professional arborist after treatment. They were also watered with an automatic sprinkler. Some root disruption by the installation of underground utility and lawn sprinkler lines had been made prior to treatments. The spread of infection was observed over a 4-year period and notes were made when additional treatments were applied. One additional treatment with Lignasan was given in 1980 to infected trees only; then all trees, both infected and noninfected, were given injections of Arbotect in 1981 and 1982 at the recommended rate as given by the label for oak decline.

Results

Kerrville, Texas treatments. The disease conditions worsened in both treated trees and controls (Table 1). Within 15 months after treating trees in category 0, 68% of the Arbotect, 75% of the Lignasan, and 66.7% of the control trees became infected. At 15 months after treatment, there was no significant difference (ANOV) in the mean tree disease ratings for treated and control trees (Table 1). All of the trees that had been

Table 1. Evaluation of Arbotect and Lignasan treatments for oak wilt *(Ceratocystis fagacearum)* in live oak after 15 months.

Treatment	*No. trees treated*	*Percent trees per each disease rating*					*Posttreatment*
		0	*1*	*2*	*3*	*4*	*Mean disease rating*
Arbotect[a]							
Rating = 0[b]	25	32	0	8	8	52	2.48
Rating = 1	9	0	0	0	22.2	77.7	3.78
Rating = 2	6	0	0	0	16.7	83.3	3.8
Lignasan[c]							
Rating = 0	24	25	0	0	12.5	62.5	2.9
Rating = 1	16	0	0	0	37.5	62.5	3.6
Rating = 2	4	0	0	0	0	100	4.0
Control							
Rating = 0	12	33.3	0	0	25	41.7	2.42
Rating = 1	12	0	0	8.3	8.3	83.3	3.75
Rating = 2	4	0	0	0	0	100	4.0

[a] Arbotect (20% a.i.) was diluted 1:24 by volume (with water) and injected at the rate of 100 ounces per each 5 inches of tree dbh.

[b] Pretreatment and post-treatment disease ratings: 0 = healthy, but within 25-75 feet of nearest infected tree; 1 = early phase of infection, trees with initial oak wilt leaf symptoms; 2 = advanced phase of infection, thin crowns and twig dieback but no dead limbs; 3 = crown mortality phase, less than 50% dead limbs; and 4 = terminal phase, 50% or more of crown dead. Also includes complete mortality.

[c] Lignasan (0.7% a.i.) was diluted 1:2 by volume (with water) and injected at the rate of 96 ounces per each 5 inches of tree dbh.

classified in category 1 and 2 were either dead or exhibited crown mortality within 15 months after treatment.

Fungicide treatments occasionally slowed down, but did not stop, the rate of oak wilt progression. Two trees at opposite ends of a mott (group) of live oaks sharing the same root system were colonized by *C. fagacearum* but showed no symptoms and had full crowns in June 1979. They were similar in size and form and probably originated from a common parent through root sprouting. One was treated with Arbotect and the other left as a comparable untreated control. After 2 months, the untreated control was dead to the root collar, and the treated tree was still alive but with active infection, foliar symptoms, and 25% crown mortality. The treated tree survived through fall and winter but died the following spring. Similar responses were occasionally observed in other trees.

Some treated trees died as rapidly as untreated controls. One live oak, with no oak wilt symptoms prior to treatment, was treated with Arbotect in June 1979. Just 2 months later it was uniformly wilted, and in 4 months it was dead.

Bandera, Texas treatments. The rate of fungicide uptake per injection site (drilled hole) ranged from less than 0.3 oz. to 4 oz. per minute. No correlations could be drawn with respect to the rate of fungicide uptake and treatment success. The number of infected trees increased each of the 4 years of the study. Tree location with respect to its distance from the nearest infected tree, rather than the rate of uptake, was the most important contributing factor. The pattern of spread was from infected to the nearest uninfected tree, apparently through root grafts, even though all of the trees had been treated with fungicide.

Surviving trees with active infection were retreated with Lignasan in 1980, but the disease continued to advance. During 1981 and 1982, the ranch manager at Bandera treated both infected and noninfected trees with Arbotect at the rates suggested by the label for Texas oak decline. The progression of infection continued and is summarized in Table 2.

Two of the 12 original infected trees were still surviving in 1983, but *C. fagacearum* had not been eliminated by the treatments, because it was reisolated from both trees. Also, the tree condition had deteriorated over the 4-year period, and both exhibited more than 50% crown mortality by September 1983.

Table 2. Yearly progression of oak wilt infections in 145 live oaks after initial preventive treatment with Lignasan in 1979.

Year	*Percent infection*
1979	8.3 [a]
1980[b]	29.0
1981[c]	53.7
1982[c]	62.8
1983	74.4

[a] Infection prior to treatment.

[b] Surviving infected trees were re-treated with Lignasan in 1980.

[c] Infected and noninfected trees were treated with Arbotect-20S in 1981 and/or 1982.

Discussion

The success of fungicidal treatments for oak wilt control in high value shade and ornamental trees cannot be measured by survival alone. The aesthetic quality of the surviving tree is also important. Some untreated live oaks survive for several years after becoming infected with oak wilt (5) but are not suitable for ornamental purposes because of severe crown mortality. The most desirable treatment would be one that arrests oak wilt symptom development, prevents crown mortality, and allows the tree to recover its normal form after a period of time.

Only premature illusions of treatment success were achieved when live oaks were treated with Lignasan and Arbotect at the rates used in the study. Treatments appeared to prolong the life of some infected trees for a few months, but the mortality rate was essentially the same in both treated and untreated after about a year. Also, oak wilt infections increased at similar rates in treated and untreated healthy trees near the advancing edge of infection centers. The treatments were unable to protect healthy trees from the advancing oak wilt infections.

The amount of fungicide injected into each tree should have been sufficient to kill the fungus. *Ceratocystis fagacearum* does not grow *in vitro* in the presence of 1 ppm (a.i.) of either Arbotect or Lignasan (5). Based on volume and weight tables for willow oak *(Q. phellos)*, a tree with a height of 70 feet and dbh of 15 inches should have a total volume (all above-ground parts of the tree) of 43.6 cubic feet (6) or an equivalent of 41,747 ounces. Trees of different oak species do not share the same total tree volume based on tree dbh; however, fungicide label injection rates are based on dbh alone. The willow oak example is used here because volume tables are not available for live oaks. Arbotect applied at the rate used in this study would yield an equivalent of 57.0 ppm active ingredient for the total tree volume (excluding roots) and Lignasan would yield an equivalent of up to 15.75 ppm active ingredient. Based on this example, the amount of fungicide injected into each tree should have exceeded the amount required to inactivate *C. fagacearum* by several times.

Systemic infections require systemic distribution of effective fungicides for their control. If Arbotect and Lignasan were uniformly distributed through all functional parts of the tree, including roots, *C. fagacearum* would likely be eradicated with a single treatment. Apparently, the major problem with current treatments is inadequate distribution of fungitoxicants in bole and root tissues of both infected and noninfected trees.

Whenever infected trees are injected, some xylem dysfunction will have already occurred. The function of fungicides is to reduce or eliminate the fungus population. An ideal therapeutic treatment would successfully arrest the infectious agent in all parts of the tree, including roots, and promote restoration of vital host tissues, while a preventative treatment would not allow infection to occur.

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ABSTRACT

POWELL, C.C. 1984. **Let us spray — but how?** Arbor Age 4(3): 12-17.

Most arborists would agree that spraying is a necessary and vital part of tree care. The fact remains, however, that most spraying operations are extremely inefficient. An understanding of the ways pesticides are applied is required to ensure their success. Pesticides work to control insect or disease problems because of proper attention to four basic "rights." These four rights are: the right diagnosis of the problem; the right selection of material to combat the problem; the right method of application; and the right timing of the application. Because proper application is the key to the success of any pesticide, we will focus our attention on the important principles involved in the spraying process.