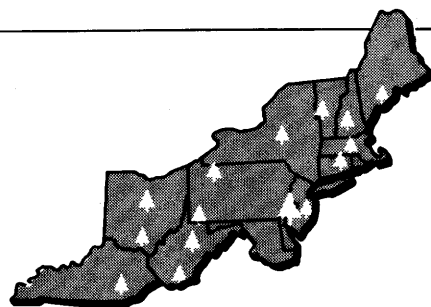


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PRESSURE INJECTION OF SOLUBILIZED BENOMYL FOR PREVENTION AND CURE OF OAK WILT

Abstract—A preliminary evaluation of the effectiveness of injecting solubilized benomyl into oaks for prevention or cure of oak wilt disease is presented. Symptom development was greatly reduced or prevented in trees injected with fungicide before inoculation. Symptom development was markedly arrested in diseased trees by fungicide injected before more than 10 percent of the crown was wilted, but treatment of trees with more advanced disease symptoms was not effective.

Benomyl (methyl 1-(butylcarbamoyl)-2-benzimidazole carbamate), a broad-spectrum systemic fungicide, is being widely investigated as a control agent for Dutch elm disease. We are also studying the effectiveness of this fungicide for control of oak wilt, a similar vascular wilt disease.

Various workers (1, 6, 12, 13) have applied benomyl to the soil around healthy elms to provide protection from Dutch elm disease. Results have ranged from good protection to no protection. Smalley (12) and Hart (5) have reported success with spray application of benomyl to American elm for protection from natural infection. Solubilized benomyl injected into the xylem of oaks, elms, and maples becomes distributed in the branches and twigs (3); and Gregory *et al* (4) reported the effectiveness of solubilized benomyl injected into red oak seedlings as a protectant and therapeutic for oak wilt disease.

This is a report of preliminary results of studies to determine the value of pressure injection of methyl 2-benzimidazole carbamate

hydrochloride (MBC·HCl) solutions into the xylem of large red oaks for prevention and therapy of oak wilt.

Benomyl hydrolyzes to methyl 2-benzimidazole carbamate, butylamine, and carbon dioxide. Of these hydrolysis products, methyl 2-benzimidazole carbamate (MBC) is considered to be the active fungicidal material in plants treated with benomyl (11). Buchenaur and Erwin (2) applied a spray containing MBC to cotton plants for control of *Verticillium* wilt. The fungicidal properties of certain benzimidazole carbamates were reported in patents by Klopping (8). Littler *et al*. (9) patented the use of MBC and some of its fungitoxic salts as foliar fungicides. McWain and Gregory (10) reported a process for converting benomyl to water-soluble MBC·HCl, and this was the solution used in these tests.

Pressure injection of fungicide directly into the xylem of trees was selected as the application method for these studies because it seems to offer many advantages over other methods. With injection, the fungicide is con-

fined within the tree, so the environmental contamination hazard is minimal. Less fungicide is required with this method, and there is almost no delay between treatment and establishment of an effective dosage at desired sites.

METHODS

Methods for the prophylactic study and the therapeutic study were similar. The studies were made in an even-aged oak-hickory stand in southern Ohio. Study trees were northern red oak, *Quercus rubra* L., black oak, *Q. velutina* Lam., and scarlet oak, *Q. coccinea* Muench., 7 to 21 inches d.b.h. Species was ignored in assigning treatments. Study trees were divided into five size classes. Each treatment of the two studies was randomly assigned to one tree in each size class so each treatment was repeated five times.

Prophylactic Study

Study trees were injected during the last week in May, using the pressure injection apparatus and method described by Jones and Gregory (7). Injected solutions were of solubized benomyl (MBC·HCl) at concentrations of 0.67, 4.0, and 24.0 g./l. Injection volumes were approximately proportional to the d.b.h. of the tree (2,280 ml. for 7-inch trees to 7,015 ml. for 21-inch trees). The number of injection sites per tree was 2, 3, or 4 for 7-9, 10-13, or 14-21 inch d.b.h. trees, respectively. The injection sites were evenly spaced around the tree trunk 1 to 3 feet above the ground. Injection pressure was 80 p.s.i.

During the first week of June (1 week after injection), the trees were inoculated in one of two ways; through 1/2-inch wood-chisel cuts into the xylem at 4-inch intervals around the bole of the tree at breast height or through one 1/2-inch wood-chisel cut into the xylem of a branch located about midway between the top and bottom of the crown at a point on that branch about 8 feet from the bole of the tree. About 5 million conidia of *Ceratocystis fagacearum* (Bretz) Hunt, suspended in water, were applied to each chisel cut.

These particularly severe inoculation procedures were used to rigorously test the value of the MBC·HCl injection treatments.

Treatment checks consisted of trees that

were injected but not inoculated, and inoculation checks consisted of trees that were inoculated but not injected.

Observations of symptom development were made at approximately weekly intervals throughout the growing season.

Therapeutic Study

Study trees were inoculated in the crown during the first week in June as described for the preceding study. When trace, 25 percent, or 50 percent crown symptoms were apparent, the trees were injected, as previously described, with either 4 or 24 g./l. MBC·HCl solution. Injection pressure was 80 p.s.i.

Inoculation checks consisted of trees that were inoculated but not treated. Treatment checks from the prophylactic study were considered to be applicable also to this study. Oak wilt infection in trees of both studies was confirmed by isolation of the pathogen from branch samples.

RESULTS AND DISCUSSION

In the prophylactic study, symptom development in bole-inoculated trees decreased as concentration of injected MBC·HCl increased (table 1) and was limited to an average of only 12 percent of the crown in trees treated with the highest concentration. In crown-inoculated trees, symptom development was not prevented by the low concentration of solution, but virtually no symptoms developed in trees treated with the medium and high concentrations.

In the therapeutic study, a marked reduction in symptom expression occurred in trees injected at trace (5 to 10 percent) symptom development with either concentration of MBC·HCl (table 2). But treatment of trees with 25 and 50 percent crown symptoms was not effective.

No evidence of chemical phytotoxicity or mechanical damage from the pressure injection was observed in the crowns of any treated trees. However, there was some tissue damage in the boles of some trees treated with the high-concentration solution. In these trees, the cambium was killed in a narrow strip extending from a few inches to a few feet above and below the injection site. By the end of the growing season, healthy callus tissue was evident

Table 1.—*Prophylactic study: average percent of oak wilt crown symptom development at end of 1972 growing season in inoculated trees previously injected with solubilized MBC-HCl*

Treatment	Noninoculated	Bole inoculated	Crown inoculated
No injection	0	84	28
Water injection	0	76	44
MBC-HCl injection			
Low concentration (0.67 g./l.)	0	32	45
Medium concentration (4.0 g./l.)	0	21	1
High concentration (24.0 g./l.)	0	12	0

Table 2.—*Therapeutic study: average percent of oak wilt crown symptom development at the end of the 1972 growing season in crown inoculated trees injected with solubilized MBC-HCl*

Treatment	No injection (checks)	Treatment at trace symptoms	Treatment at 25% symptoms	Treatment at 50% symptoms
No injection	85	—	—	—
MBC-HCl injection				
Medium concentration (4 g./l.)	—	22	79	71
High concentration (24 g./l.)	—	37	74	85

around the margin of these wounds, and they appeared to be healing satisfactorily. Injection wounds, where no chemical injury was apparent, were two-thirds callused over by the end of the growing season.

Time required for solution injection was quite variable, but for healthy trees in the prophylactic study averaged 22 minutes per tree. Injection time for diseased trees in the therapeutic study averaged 52, 89, and 93 minutes per tree for trees treated with trace, 25, and 50 percent symptom development, respectively.

CONCLUSIONS

The preliminary results of these studies suggest that injecting solubilized benomyl into red oaks can be effective for prevention of oak wilt disease. But this conclusion is based on the condition of study trees at the end of only one growing season after treatment. Of much greater significance will be the condition of these trees next summer when we can better judge the duration of the protection afforded by the injection treatment. Conclusions about the curative value of the injection treatment must be deferred until we determine whether arrestment of symptom progression in diseased trees is permanent or temporary.

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