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THE COMPARATIVE EFFECTIVENESS OF PRUNING VERSUS PRUNING PLUS INJECTION OF TRUNK AND/OR LIMB FOR THERAPY OF DUTCH ELM DISEASE IN AMERICAN ELM¹

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Abstract. During the 1976 season, American elm street trees infected with Dutch elm disease (DED) in Elmhurst, Illinois, and Shaker Heights, Ohio, were given one of the following treatments: (1) pruning; (2) limb injection with Lignasan BLP and pruning; (3) trunk injection with Lignasan BLP and pruning; or (4) trunk and limb injections and pruning. Trees with wilt symptoms greater than 30 percent when discovered were not treated but removed as soon as possible. By the end of the 1977 season, Treatment 4 seemed the most effective, followed by Treatment 3. The lower the percent of symptoms at time of treatment, the more successful were Treatments 1 and 2. The superiority of Treatments 3 and 4 was particularly evident when symptoms at time of treatment were 10 or 15 percent. As the distance between the last visible staining by DED and the pruning cut increased, so did the percentage of therapeutic success. Limb and trunk injection with Lignasan BLP followed by pruning is another tool to be used in the battle against DED, and is most effective if used before the disease symptoms are widespread.

Some salts of methyl 2-benzimidazole carbamate (MBC), a hydrolytic product of benomyl, have been shown to have prophylactic and therapeutic effects on Dutch elm disease (DED) when injected into elms (Kondo et al. 1973; Gregory et al. 1973). Himelick and Ceplecha (1976) reported successful DED therapy from pruning the symptomatic limb in the initial stages of the disease.

In a study that began in 1972, Campana and Gregory (1976) combined the injection of the hydrochloride salt of MBC (MBC.HCl) with the pruning of symptomatic limbs. They compared pruning before and after trunk injection with trunk injection alone and with pruning alone. They found that pruning after trunk injection was the most ef-

fective treatment. Pruning alone was the least effective, but was better than no treatment at all.

Since application at or near the leading front of the DED infection would seem to have potential for effective therapy, we thought that there was a reasonable probability that the disease could be arrested or eradicated if symptomatic limbs were injected. Our principal objective was to compare pruning alone, injection of limb or trunk plus pruning, and injection of both limb and trunk plus pruning.

The cities in which the study was conducted had relatively good DED control programs. Therefore, the removal of symptomatic limbs was necessary to eliminate this source of diseased wood for bark beetle colonization and subsequent emergence.

Materials and Methods

This study was conducted in 1976 in Shaker Heights, Ohio, and in Elmhurst, Illinois. In 1975, 5 percent of the city-owned American elms in Shaker Heights were lost to DED. In the preceding 4 years, losses to DED were between 1 and 2 percent per year for an elm population of 6,000 to 7,000. In Elmhurst, annual losses to DED from 1971 to 1974 ranged from 3.1 to 4.5 percent; in 1975, losses to DED totaled 3.1 percent. Removal of DED elms in both cities was 80 percent complete by August 31 of each year.

We compared: pruning of symptomatic limbs (Treatment 1); pressure injection of Lignasan BLP

¹Mention of a trade, firm, or corporation names does not constitute endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

into symptomatic limbs followed by pruning of these limbs (Treatment 2); pressure injection of Lignasan BLP into the trunk followed by pruning of symptomatic limbs (Treatment 3); pressure injection of Lignasan BLP into the trunk and into symptomatic limbs and subsequent pruning of these limbs (Treatment 4).

The treatments were assigned on a rotating basis as diseased elms were located by DED surveys conducted 5 times during the season. Trees with wilt symptoms of 30 percent or less were treated as soon as possible after discovery. Trees were treated only once. Trees that appeared to be infected via root-graft were excluded from this study, and those with more than 30 percent wilt symptoms were immediately listed for removal. All study trees were pruned of symptomatic limbs and the length of clear wood (length of symptomatic limb pruned beyond visible staining by DED in the outer sapwood) pruned out was measured. We wanted to prune back far enough to allow at least 10 feet of clear wood.

Limbs and trunks were injected at a rate of 84.6 ml/cm of tree circumference; we used a concentration of 6 g/l of Lignasan BLP. The methods and equipment used were similar to those described by Gregory and Jones (1975). This dosage for trunk injection is 5 times the labeled therapeutic rate.

Usually, pruning followed injection on the same day; occasionally several days elapsed before injected trees were pruned. Data from both locations were combined at the end of the 1977 season.

Results and Discussion

Fifty percent of all trees (5 to 30 percent wilt symptoms) that were limb and trunk injected with Lignasan BLP and then pruned of symptomatic limbs (Treatment 4) had no active wilt at the end of the 1977 season (Table 1). This was the best treatment. The least effective were Treatment 1, pruning only (32.6 percent had no active wilt), and Treatment 2, limb injection plus pruning (35.9 percent had no active wilt).

A high proportion of the elms were in the 5 percent wilt category at time of treatment, particularly for treatments 1 and 2. In this wilt category there

was no significant difference among treatments. Thus, the high proportion of elms in the 5 percent wilt category account primarily for the overall lack of significant differences among treatments (Table 1, bottom line). This is further documented by the fact that when the trees of each treatment are separated into those treated at 5 percent wilt and those treated at 10 percent wilt and above, the treatments are not significantly different for the 5 percent group (X^2 of 2.02), whereas the treatments are significantly different for the 10 percent and above group (X^2 of 9.48). However, treatments at various individual percentages were not significantly different except at the 10 percent level, where differences were highly significant (there were too few trees treated in each 5 percent percentile group above 10 percent for differences to be statistically significant).

A diseased elm with wilt symptoms of 5 percent or less probably has as good a chance of being saved by pruning alone as by any other treatment, particularly if the tree is pruned back to more than 5 feet of clear wood (Table 2). In practice, few elms are found when wilt symptoms are 5 percent or less, so the arborist must consider treatment for elms with symptoms of 10 percent or greater. Campana and Gregory (1976) found that diseased elms are best pruned after injection rather than before, so treatment should consist of trunk and possibly limb injection (limb injection in addition to trunk injection increases the chances of successful therapy) followed by pruning (ideally, several days after injection).

Arborists and researchers have suspected that pruning of symptomatic branches alone can free some elms of DED. This supposition was substantiated by Marsden (1952) and by Campana and Gregory (1976). Studies in Evanston, Illinois, have shown that about 60 percent of the elms with 5 percent symptoms could be freed of DED by pruning symptomatic limbs (Himelick and Ceplecha 1976). Our results agree with these findings (Table 2).

In their study comparing pruning alone, injection of MBC.HCl alone, pruning followed by MBC.HCl injection, and MBC.HCl injection followed by pruning, Campana and Gregory

(1976) found the therapeutic effects of injection followed by pruning to be roughly additive (the therapeutic effect of pruning followed by injection was not additive); that is why pruning followed injection in this study. They also found pruning less effective than injection alone or injection plus pruning. Our results also show that pruning alone is less effective than injection plus pruning (Table 1).

The amount of clear wood removed during pruning is an important factor in the success of the pruning operation. Campana and Gregory (1976) stressed that at least 10 feet of nonstained wood should be pruned from symptomatic limbs for maximum success.

Table 2 summarizes the effect of the extent of pruning on successful therapy for each treatment. For each treatment there was a highly significant difference in the success of therapy between trees pruned to more than 5 feet of clear wood and those pruned to 5 feet or less. Although the differences among treatments in either grouping were not statistically significant, for the 5 feet or less group the average percent of successful therapy (elms with no active wilt at least 1 full year after treatment) was 2.3 times greater for trees in Treatment 4 than for those in Treatment 1. There also was a large difference between Treatments 1 and 2 in the greater than 5 feet grouping (Table 2). Pruning to greater than 5 feet of clear wood greatly increases the chances of saving the DED

tree; this is particularly true for trees with wilt symptoms of 5 percent or less. There also may be a slight advantage in combining limb injection with pruning for trees with few symptoms; however, the advantage of limb injection combined with trunk injection would seem more effective for trees with wilt symptoms greater than 5 percent.

Table 2 also shows that when the distance of clear wood was greater than 5 feet, the success of therapy for pruning was about 60 percent, which generally agrees with results reported by Campana (1975) and Marsden (1952).

Conclusions

Trees with Dutch elm disease can be saved by limb and trunk injection of Lignasan BLP (84.6 ml/cm of circumference of a 6 g/l concentration). This treatment is relatively expensive, so it is particularly applicable for home landscape elms and public or private trees in parks, estates, or on historical sites.

The probability of saving DED elms by injection or pruning or both depends on the extent of the infection at the time of injection and pruning. Therefore, it is imperative that diseased elms are detected *as early as possible*. For city or private arborists and for individual homeowners this means frequent observations. For best results, trees should be examined daily.

Early detection also increases the possibility of successful therapy from pruning alone in the early

Table 1. Therapeutic success of pruning only or of injection of Lignasan BLP plus pruning as a function of percent of active wilt in crown at time of treatment in 1976, by number of elms treated and percent with no active wilt in September 1977.^a

Active wilt in crown in 1976 (percent)	Pruning (No. 1)		Limb injection plus pruning (No. 2)		Trunk injection plus pruning (No. 3)		Trunk and limb injection plus pruning (No. 4)		X ² value of treatment ^b
	No. elms treated	% elms free of active wilt	No. elms treated	% elms free of active wilt	No. elms treated	% elms free of active wilt	No. elms treated	of active wilt	
5	17	64.7	15	66.7	28	50.0	10	70.0	2.02
10	12	16.7	10	10.0	19	47.4	17	58.8	12.45
15	10	10.0	5	0.0	6	16.7	4	25.0	1.48
20-30	4	0.0	9	33.3	11	18.2	11	27.3	2.00
Total or average	43	32.6	39	35.9	64	40.6	42	50.0	3.05

^aTrees in this study were not reinjected, though, in practice, trees with few symptoms from recurrent infection would be reinjected.

^bX² = 7.81 at P < 0.05.

stages of the disease. But injection combined with pruning increases the chances of successful therapy both in the early stages and when the disease is somewhat more advanced. Since early detection is seldom achieved, limb and trunk injection followed by pruning enhances considerably the chances of saving elms.

It is important to note that injection plus pruning is only one tool, and that this treatment does not take the place of the prompt sanitation and spray programs, which are the mainstays of successful DED control for municipalities.

Table 2. Relationship between amount of clear wood removed and survival of elms that were pruned or injected with Lignasan BLP and pruned, indicated by number of elms treated and percent with no active wilt in September 1977.

Treatment (1976)	5 feet or less of clear wood		More than 5 feet of clear wood		χ^2 Value of treatment ^a
	No. elms treated	% elms free of active wilt	No. elms treated	% elms free of active wilt	
Pruning (No. 1)	29	17.2	14	64.3	9.52
Limb injection, pruning (No. 2)	30	20.0	9	88.9	14.28
Trunk injection, pruning (No. 3)	54	31.5	10	90.0	11.98
Trunk and limb injection, pruning (No. 4)	33	39.4	9	88.9	6.93
χ^2 value of treatment ^b	—	5.06	—	3.79	

^a $\chi^2 = 6.63$ at $P < 0.01$.

^b $\chi^2 = 7.81$ at $P < 0.05$.

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