Winter Air-Blast Sprayer Applications of Benomyl for Reduction of Eutypa Dieback Disease Incidence in a Concord Grape Vineyard in Michigan

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ABSTRACT

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The efficacy of closely managed pruning and winter air-blast spraying of mature Concord grapevines with benomyl or benomyl plus oil for control of Eutypa dieback disease caused by *Eutypa lata* was evaluated in a commercial-scale test plot. Three pruning and spraying timings (early winter, mid-winter, or late winter–early spring) were tested. Blocks of vines were sprayed as soon after pruning as possible prior to any rain, and when the ambient temperature was above 0 C. An air-blast sprayer was calibrated to deliver 281 h/ha of spray (30 gallons/acre). Benomyl 50W or benomyl 50DF was applied at 1.12 kg 814/ha (1 lb a.i./acre) with or without Volck Supreme oil at 1% (v/v). A pruned but unsprayed control was included in each pruning-spraying timing block. Pruning-spraying was initiated in December 1984. Each pruning-spraying block received annual superimposed treatments for 5 yr. Symptom counts were made annually from May 1988 through 1992. Rainfall amount and duration and periods of temperature below freezing were recorded relative to pruning and spraying for a period of at least 30 days after sprays were applied. The early winter timing block did not provide useful data, due to low disease incidence. The mid-winter pruning–benomyl-sprayed treatment (early January to mid-February) resulted in a significant 5-yr cumulative reduction of 48.5% of vines with Eutypa dieback compared with the unsprayed, pruned control vines. The late winter–early spring pruning-spraying treatment resulted in a significant cumulative 5-yr reduction of vines with Eutypa dieback resulting from benomyl sprays (34% reduction) and benomyl plus oil sprays (21% reduction) compared with pruned and unsprayed control vines.

Eutypa dieback, caused by *Eutypa lata* (Pers:Fr.) Tul. & C. Tul. (syn. *E. armeniacae* Hansf. & M. V. Carter), is an economically important disease of the grapevine in the western (7), north central (13), and eastern (10) United States, and in Europe (1). Late autumn, winter, and spring are the main periods of ascospore release in the north central (13) and eastern United States (10). In Michigan, if the temperature is above freezing for a few hours concomitant with approximately 2 mm of rain, ascospore release and infection of pruning wounds occur (13). Ascospores subjected to five cycles of freezing (−20 C) and thawing exhibit a high percentage of germination (13). Trese et al (14) showed that there is a reduction in level of pruning wound susceptibility over a 56-day period (vines held at −1 C to +1 C). Although healing occurs over time, a low frequency of infection can occur even at 56 days after pruning.

Numerous attempts to control infection of pruning wounds by hand-painting the pruning cuts with benomyl have been partially successful (3,6,9), especially in warmer climates. This method may be practical in California, where relatively fewer cuts per vine are made during pruning. However, in the eastern United States it is common to make 50 or more cuts on a vine. A pneumatic pruner/sprayer has been used in Australia (2) and California (9), but the apparatus is bulky and slows the pruning process considerably.

Gendloff et al (5) conducted field trials in a Concord vineyard in Michigan using a knapsack sprayer to apply benomyl, captafol, or an antagonistic fungus (*Fusarium lateritium* Nees:Fr.) to pruning wounds at 1 or 14 days after pruning. Although Australian workers reported some success with *F. lateritium* (3), it had minimal effect on disease control in Michigan. Up to 74% reduction in pruning wound infection was achieved with benomyl at 4.8 g a.i./L sprayed on wounds and inoculated with an ascospore suspension either 1 day or 14 days after applying the fungicide. These data were used to obtain a federal label for use of benomyl on grape in the winter for reduction of Eutypa dieback in the eastern United States.

Pruning wounds are susceptible for 1 mo in California (8,11). Researchers in California evaluated several fungicides for control of Eutypa dieback during this period. Some applications were made by painting the wounds and some involved the use of a pruner/sprayer apparatus (9). Flusilazol and benomyl were quite effective in two small noncommercial-scale field trials.

In 1984, when our field research was initiated, there were no data dealing with commercial air-blast application of fungicides for the control of Eutypa dieback in vineyards. The objectives of this research were to test the feasibility of closely managing pruning and fungicide application using commercial air-blast equipment for control.

The ability of highly purified spray oil to provide better coverage of the benomyl on the pruned stubs, and perhaps improve penetration of the bark, as was demonstrated with almond (*Prunus dulcis*) (12), was also studied.

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MATERIALS AND METHODS

Field trials, 1984-1992. A well-managed mature Concord vineyard (approximately 30 yr old) with a moderate amount of Eutypa dieback was selected for the test plot, near Lawton, MI. The vines were planted with 2.43 × 2.54 m (8 × 10 ft) spacing. Three separate blocks were used in the test. Each block had from 187 to 376 vines. One block was pruned and sprayed annually in early winter (usually about 10 December). A second block was pruned and sprayed annually in mid-winter (mid-January to mid-February), and a third one was pruned and sprayed annually in late winter to early spring (mid-February to mid-April). Spray applications were made as soon as possible after pruning was completed if the ambient temperature was 0 C or above, and, if possible, before any rain occurred. Based on previous epidemiological studies, spraying after pruning was necessary whenever the temperature was at or above freezing and prior to any rain (13,14). Each treatment/timing block was sprayed with the same chemical treatment each year for 5 yr.

A Myers A32-TM 3-point hitch, PTO-powered air-blast sprayer (F. E. Myers Co., Ashland, OH) was used throughout this experiment. The sprayer was calibrated to deliver 281 L/ha (30 gal/A) at 1,050 Kpa/cm^2 (150 psi) at 5.75 km/h (3.5 mph). During the 5 yr of pruning and spraying the snow was never too deep to prevent spraying. On one occasion, spraying was begun at 0 C, but soon after the temperature dropped, causing the spray to freeze inside the nozzles. After waiting 1 day for the temperature to rise, spraying was completed.

Each pruning/spray timing block was divided into three equal parts. One part consisted of an untreated control, one part was treated with benomyl 50W or 50DF at 2.24 kg/ha (2 lb/A) or benomyl 50W or 50DF at 2.24kg/ha (2 lb/A) plus Volck Supreme oil at 1% (v/v). In 1986 the formulation of benomyl was changed from a 50% wettable powder (50W) to a 50% dry flowable (50DF). The chemical treatments were not replicated within each pruning-timing block. In order to keep the plots of workable size from a logistical point of view and to avoid interplot interference, each year was considered a replication of the annual treatments. For statistical analysis, Student's *t* test (4) was used for paired two-sample means (i.e., comparing the control vs. one benomyl treatment or the other, or comparing one benomyl treatment with the other, within the pruning-timing blocks). The hypothesis tested was H_o: treatment 1 = treatment 2.

The first pruning/spraying treatment was done in 1984. Temperature and precipitation data (every 3 h) were obtained from a NOAA weather station at Kalamazoo, MI (16 km to the east), in order to have a record of rainfall and temperature events for the period from pruning to at least 1 mo after spraying.

Beginning in May 1988, each plot was visually evaluated for Eutypa dieback leaf and shoot symptoms. At this time, when vines are leafing out but not yet in full leaf, symptoms diagnostic for the disease are easy to see. Symptomatic vines were counted as they appeared each year. The grower did not remove vines as they became symptomatic or dead. In some cases symptomatic vines may have been counted for 2 or 3 yr in a row. There is a 4-yr incubation period between ascosporic infection of pruning wounds and the appearance of foliar symptoms (observed in controlled inoculation experiments, D. C. Ramsdell, *unpublished*). Thus, foliar symptoms observed in 1988 reflected infections occurring in 1984.

RESULTS AND DISCUSSION

Disease reduction in pruning-spraying timing blocks. *Early winter pruning-spraying.* Differences between treatments in the early winter pruning-spraying timing block were not significant due to the low level of disease observed (Table 1).

Mid-winter pruning-spraying. Over the 5-yr period, a mean of 5.43% of the untreated vines showed Eutypa dieback symptoms, while 2.80% of the vines treated with benomyl 50W/50DF at 2.24 kg/ha exhibited symptoms ($P = 0.01$, Table 1). On a cumulative basis over the 5-yr period, benomyl 50W/50DF without oil reduced by 48.5% the number of vines exhibiting symptoms compared with untreated control vines. A mean of 4.4% of the vines treated with benomyl 50W/50DF at 2.24 kg/ha plus Volck oil at 1% (v/v) showed symptoms. Benomyl plus oil did not give an overall significant reduction in disease. The formulation change for benomyl by the manufacturer is the probable explanation for this failure of control. Whereas the 50W formulation was compatible with the Volck oil, the 50DF formulation, evaluated from 1986 to 1988 with oil, resulted in the formation of globs of solid material that collected in the main strainer of the sprayer.

Late winter–early spring pruning-spraying. In the late winter–early spring pruning-spraying timing block, 3.6% of the untreated vines and 2.39% of the vines treated with benomyl 50W/50DF at 2.24kg/ha exhibited Eutypa dieback symptoms ($P = 0.01$, Table 1). The benomyl plus oil treatments reduced symptoms by 2.86% compared with the control vines ($P = 0.01$). On a cumulative basis over the 5-yr period, benomyl 50W/50DF with and without Volck oil gave significant reductions of 21 and 34%, respectively, in the number of vines showing symptoms, compared with the untreated control vines (Table 1).

Table 1. Control of Eutypa dieback by application of benomyl or benomyl plus Volck oil (1%) immediately following pruning (Lawton, MI)[x]

Treatment and dates of disease assessment	Time of pruning: Early winter[y]	Mid-winter[y]	Late winter–early spring[y]
25 May 1988			
Untreated	4/205 (1.91%)	9/199 (4.33%)	14/376 (3.6%)
Benomyl 50 W/DF 2.24 Kg/ha	0/187 (0.00%)	6/232 (2.52%)	8/367 (2.13%)
Benomyl 50 W/DF 2.24 Kg/ha + Volck Oil 1% (v/v)	4/205 (2.49%)	6/176 (3.30%)	8/364 (2.15%)
25 May 1989			
Untreated	2/205 (0.97%)	6/199 (2.92%)	8/376 (2.08%)
Benomyl 50 W/DF 2.24 Kg/ha	1/187 (0.53%)	3/232 (1.28%)	5/367 (1.34%)
Benomyl 50 W/DF 2.24 Kg/ha + Volck Oil 1% (v/v)	1/205 (0.49%)	4/176 (2.22%)	5/364 (1.36%)
30 May 1990			
Untreated	1/205 (0.97%)	7/199 (3.40%)	11/376 (2.84%)
Benomyl 50 W/DF 2.24 Kg/ha	2/187 (1.06%)	5/232 (2.11%)	4/367 (1.08%)
Benomyl 50 W/DF 2.24 Kg/ha + Volck Oil 1% (v/v)	1/205 (0.49%)	4/176 (2.22%)	5/364 (1.36%)
22 May 1991			
Untreated	2/205 (1.0%)	9/199 (4.5%)	14/376 (3.7%)
Benomyl 50 W/DF 2.24 Kg/ha	2/187 (1.1%)	2/232 (0.9%)	1/367 (0.3%)
Benomyl 50 W/DF 2.24 Kg/ha + Volck Oil 1% (v/v)	2/205 (1.0%)	9/176 (5.5%)	8/364 (2.2%)
20 May 1992			
Untreated	9/205 (4.2%)	27/199 (12.0%)	23/376 (5.8%)
Benomyl 50 W/DF 2.24 Kg/ha	11/187 (5.8%)	18/232 (7.2%)	28/367 (7.1%)
Benomyl 50 W/DF 2.24 Kg/ha + Volck Oil 1% (v/v)	7/205 (3.3%)	18/176 (9.3%)	26/364 (6.7%)
Grand means[z]			
Untreated	1.81% a	5.43% a	3.60% a
Benomyl 50 W/DF 2.24 Kg/ha	1.71% a	2.80% b	2.39% b
Benomyl 50 W/DF 2.24 Kg/ha + Volck Oil 1% (v/v)	1.46% a	4.40% ab	2.86% b

[x]Each block of vines labeled "Early winter," "Mid-winter," or "Late winter–early spring" were pruned and sprayed at those times annually for 5 yr from 1984 to 1989. Eutypa vine symptom counts were made in May of each year from 1988 through 1992.

[y]Numerator = number of vines showing Eutypa dieback symptoms. Denominator = number of vines in that particular pruning-spraying timing block. Values in parentheses are percentage of vines showing symptoms.

[z]Student's *t* test values ($P = 0.01$–significant difference). Means followed by the same letters in a column do not differ significantly ($P = 0.01$) according to Student's *t* test of paired means within a spraying block.

Disease reduction relative to rain events and rain duration. *Late winter–early spring pruning-spraying.* The lack of disease control in the late winter–early spring plot for the symptom counts made 20 May 1992 (Table 1) is probably explained by rainfall that occurred after pruning and before spraying in 1988 (Fig. 1A). The block was pruned from 4 to 6 March 1988. On 8 March, when the temperature had risen to 0 C or above, it rained 4 mm before any sprays could be applied. Also, there were seven additional rain events through 2 April, totaling 51 mm, which would have washed off most of the active residue. Similarly, rain events that occurred in 1985 (Fig. 1B) probably adversely affected the disease control count 4 yr later in May 1989. Between pruning and spraying, two rain events resulted in 7 mm of rain. This was sufficient to trigger ascospore release. In the month following spraying, nine rain events occurred resulting in 63 mm of rain, washing off most of the active residue. In 1984, 1986, and 1987, no rain events occurred between pruning and spraying. Those years also did not have enough rain in the month following spraying to wash off significant amounts of fungicide residue. When disease incidence was counted 4 yr later, in 1988, 1990, and 1991 (Table 1), benomyl 50W/DF gave good control of disease.

Mid-winter pruning-spraying. In the mid-winter block, rainfall timing relative to pruning and spraying interfered minimally with control. No rain events occurred between pruning and spraying in 1985–1988. In 1984, 1.5 mm of rain fell during pruning and 25 mm fell in a 20-h period immediately after spraying. This could have decreased control of Eutypa dieback, which would be reflected in the disease counts made 4 yr later in 1988. Fungicide wash off by rain in the month following pruning and spraying was minimal in 1985, 1986, and 1987. Fungicide wash off was moderate in 1984 and 1988 with totals of 46 mm in five events and 33 mm in five events, respectively. Any reduction in control from wash off in these 2 yr would be reflected in disease counts made in 1988 and 1992, since none occurred between pruning and spraying.

The economics of fungicide application. In terms of the economics of production, the results of this study translate into significant savings. For example, if one assumes a life of 50 yr for Concord vines and annual production of 8,981 kg/ha (4 metric ton/A), 1,346 vines/ha, (545 vines/A) and an annual farm gate price of $280 per metric ton, benomyl applications would have saved $4,547/ha ($1841/A) in the mid-winter block and $2,090/ha ($847/A) in the late winter–early spring block, based on today's costs. However, if one assumes the cost of chemicals and application was $74.10/ha ($30/A), most of the gain would have been lost (50 yr × $30 = $1,500). On the other hand, if the value of the vine itself is considered, (vine loss and vine replanting/training costs), some real gains are realized. If a Michigan vineyard is worth about $12,350/ha ($5,000/A), and the unplanted land is worth $2,470/ha ($1,000/A), then a vine is worth $7.35. If the benomyl treatment saves 2.5% of the vines per year (based on this particular study), or 13.6 vines per year, this translates into a savings of $12,350/ha ($5,000/A) over a 50-yr period.

In conclusion, benomyl 50W/50DF at 2.24 kg/ha applied during the winter and spring pruning season, using a commercially available air-blast sprayer, resulted in an economic reduction of Eutypa dieback disease. However, benomyl should be used as part of an overall disease control program that includes removal and burning of dead and dying vines in order to lower the inoculum levels in the vineyard. Even though the early winter pruning-spraying timing block did not provide usable data due to a lack of sufficient disease, early winter pruning and spraying are expected to provide results similar to those of the mid-winter and late winter–early spring timing, under commercial conditions.

It is anticipated that some fungicides that may come on the market in the next few years will give higher activity than benomyl. In fungicide-amended PDA tests of several fungicides, tebuconazole, fluazinam, and chlorathalonil were very active against *E. lata* (D. C. Ramsdell, *unpublished*). It is also possible that effective biological control agents will be developed. Further testing of commercial air-blast application of agents for the control of Eutypa dieback disease should be done, especially in the eastern United States, where paintbrush or pruner/sprayer devices are not practical for widespread use.

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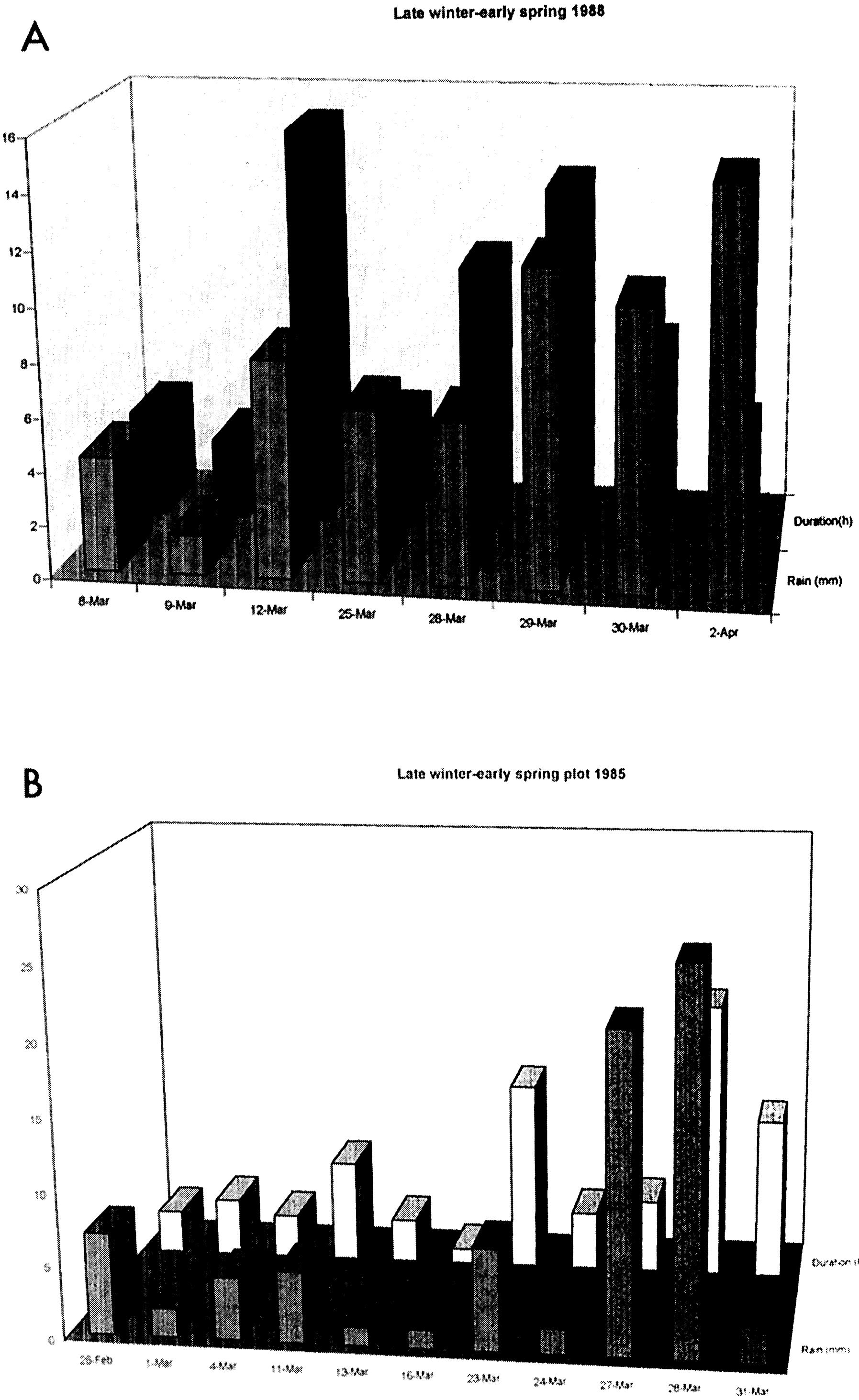

B

Fig. 1. Hourly rain events and amounts relative to pruning and spraying grape vineyard blocks for control of Eutypa dieback disease. **(A)** x axis = rain dates 1988 (pruned 4 to 6 March 1988, sprayed 8 March 1988). **(B)** x axis = rain dates 1985 (pruned 25 February 1985, sprayed 2 March 1985).

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