

Evaluation of Metalaxyl and Captafol Soil Drenches, Composted Hardwood Bark Soil Amendments, and Graft Union Placement on Control of Apple Collar Rot

M. A. ELLIS, Associate Professor, Department of Plant Pathology, D. C. FERREE, Professor, Department of Horticulture, and L. V. MADDEN, Assistant Professor, Department of Plant Pathology, The Ohio State University, Ohio Agricultural Research and Development Center, Wooster 44691

ABSTRACT

Ellis, M. A., Ferree, D. C., and Madden, L. V. 1986. Evaluation of metalaxyl and captafol soil drenches, composted hardwood bark soil amendments, and graft union placement on control of apple collar rot. *Plant Disease* 70:24-26.

Protectant applications (soil drenches) of metalaxyl and captafol provided control of apple collar rot on trees inoculated with *Phytophthora cactorum* in the field. Eighty-one percent of all inoculated, untreated trees developed typical collar rot symptoms and died before the end of the study. No inoculated trees treated with metalaxyl and only one treated with captafol developed collar rot. Incorporation of a 1:1 mixture of composted hardwood bark and field soil into the planting hole at time of planting resulted in significantly fewer infected trees than untreated controls but significantly more infected trees than either fungicide treatment. Placement of the graft union on susceptible rootstock above or below the soil line appeared to have no effect on collar rot control.

Collar rot of apple is caused by *Phytophthora cactorum* (Leb. & Cohn.) and several other *Phytophthora* spp. (10). Disease incidence is generally greater in heavy and poorly drained soils (3,12). Differences in susceptibility of various apple rootstocks have been reported (14). However, few apple cultivars or commercially used clonal rootstocks are considered highly resistant (11,12), and the reports are inconsistent. The most effective methods for controlling the disease have been the selection and use of resistant rootstocks and the selection of well-drained planting sites that are not conducive to disease development. Fungicide drenches or sprays applied to soil or infected portions of the tree have not provided adequate control. The introduction of fungicides such as metalaxyl (Ridomil 2E) that are systemic as well as highly effective against pythiaceous fungi may be useful in providing chemical control (4,5,7,8,16).

Spring et al (15) reported that the percentage kill of 3-wk-old apple seedlings was significantly lower in a composted hardwood bark (CHB) container medium than in a peat medium after inoculation with *P. cactorum* zoospores and oospores. In addition,

sporngial production and zoospore viability was significantly lower in aqueous leachates from bark compost than in leachates from peat. These results suggest that CHB may be useful in biological control of apple collar rot.

For years, many apple producers have speculated that burying the graft union on susceptible apple rootstocks is beneficial in controlling collar rot. We find nothing in the literature to substantiate this belief.

In 1979, we initiated a study to evaluate the effects of preventative (preinfection) drenches of metalaxyl and captafol and preplant soil incorporation of CHB on collar rot control. In addition, we studied the effect of burying the graft union on rootstock infection by *P. cactorum*. The results of these studies are presented in this paper.

MATERIALS AND METHODS

Rootstock and planting depth. A field study was established in May 1979 with 1-yr-old nursery whips of Golden Delicious apple trees on Malling-Merton 106 (MM106) rootstock or MM106 rootstock with an East Malling 9 (M9) interstem. The orchard was planted at Horticulture Unit II of the Ohio Agricultural Research and Development Center, Wooster, on an old orchard site known to have a history of apple collar rot. Trees were planted with 3 m between trees and 5.5 m between rows in holes (61 × 61 cm) dug by a mechanical auger. Soil type was Wooster silt loam. All trees were planted on one of the following rootstocks and depths of planting: MM106 with graft union above soil line, MM106 with M9 interstem and lower graft union about 8 cm below soil line, and MM106 with M9 interstem and lower graft union

above soil line. Hollow cylinders (collars) were cut from 20-cm-diameter plastic pipe. One collar (20 cm long) was placed around the base of each tree and embedded 10 cm into the soil. Plastic collars were intended to maintain inoculum and moisture around the base or crown of the tree.

Soil treatments. CHB was obtained from Paygro, Inc., South Charleston, OH. Trees were planted in a 1:1 (v/v) mixture of CHB and soil removed from the planting hole (about 35 L of bark). Metalaxyl and captafol (Difolatan 4F) were evaluated as fungicide drenches at the rate of 500 and 600 µg a.i./ml, respectively. Fungicides were applied in 1 L of water inside the collar around the base of each tree. Application dates were 19 July and 16 September 1979, 18 April and 12 September 1980, 15 April and 7 October 1981, and 30 April and 23 September 1982. Fungicides were not applied in 1983.

Inoculation with *P. cactorum*. One-half of all trees were inoculated with oospores of *P. cactorum*. Hemp seed broth was prepared by autoclaving 30 g of hemp seed in 1 L of distilled water for 30 min, filtering through four layers of cheesecloth, and autoclaving a second time. An agar plug from the edge of a 7-day-old culture was added to 125-ml flasks containing 25 ml of hemp seed broth. Oospores were produced after 2-3 wk in the dark at 24 C. Oospores were harvested by grinding cultures in an Omni Mixer for 60 sec at high speed and freezing for 24 hr at -20 C to kill mycelial fragments and sporangia (1). After thawing, cultures were regrown for 15 sec to suspend the oospores. The oospores were counted with a hemacytometer, and their concentrations were adjusted by diluting with distilled water. Trees were inoculated by pouring 10 ml of a suspension containing 10,000 oospores per milliliter of water inside the collar around the base of the tree. Inoculations were made on 20 July and 15 September 1979 and on 15 April 1980. During dry periods, collars around all trees were flooded with water to ensure high moisture levels around the crown of the tree. Collars were flooded about every 2 wk during the 1979 and 1980 growing seasons. Collars were removed from all trees in May 1981. After removal of the collars, fungicide drenches were applied to the bark and soil immediately around

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the trunk of each tree. Applications were made so that fungicides came in contact with the bark (phelloderm) around the base of each tree.

The development of collar rot symptoms was recorded throughout the growing season each year. All infected trees developed a region of discolored, rotted bark above and/or below the soil line. When trees developed obvious symptoms, isolations were made to confirm the presence of *P. cactorum*. Bark and wood samples were cut from the margin of discolored tissue on each tree. Samples were surface-disinfested by soaking in a 0.25% solution of sodium hypochlorite for 2 min, then washed in sterile, distilled water. Samples were cut into several small sections (a minimum of 50 per sample), and sections were placed on pentachloronitrobenzene-benomyl-neomycin-chloramphenicol (PBNC) medium (13). The presence of *P. cactorum* was recorded after 7 days at 24 C. At the end of the 1983 growing season, most of the inoculated, untreated trees were dead, and the experiment was terminated.

Data analysis. The experiment was established as a completely randomized design with 12 single-tree replicates per treatment. Data on number of infected and uninfected trees were analyzed with a log-linear contingency table model (2) using the BMDP statistical computer package (6). With this analysis, the significance of rootstock and planting depth, soil treatment, and inoculation as well as the interactions of these experimental factors were determined.

RESULTS AND DISCUSSION

Eighty-one percent of all inoculated, untreated trees developed typical collar rot symptoms and died before the end of the experiment (Table 1). Most trees died within the same growing season in which symptoms first appeared. This is not typical of apple collar rot in Ohio. In commercial orchards, trees initially show

symptoms of foliar chlorosis and reduced terminal growth, then gradually decline and eventually die within 2-3 yr. The rapid death of trees observed in this study was probably due to high levels of inoculum and wet soil conditions that favored disease development. The number of trees that died in 1979, 1980, 1981, 1982, and 1983 were 0, 2, 15, 17, and 12, respectively. Only 17% of all uninoculated, untreated trees became naturally infected. *P. cactorum* was isolated from 38% of all trees with collar rot symptoms.

Soil treatments ($\chi^2 = 70.34$, $df = 3$, $P < 0.01$) and inoculation ($\chi^2 = 30.94$, $df = 1$, $P < 0.01$) were highly significant. The rootstock and depth of planting factor and all interactions of experimental factors ($P > 0.50$) were not significant. The goodness of fit of the log-linear model was high ($\chi^2 = 19.91$, $df = 38$, $P > 0.99$). These results indicate that burying the graft union on susceptible rootstocks is not beneficial in controlling collar rot. Estimated log-linear parameters and their standard errors were used to compare treatment values. The following information was derived at $P = 0.05$. Significantly more trees developed symptoms and died in the untreated control than any other treatment. There were no significant differences between soil treatment with captafol and metalaxyl, and both fungicide treatments had significantly fewer infected trees than any other treatment. Soil incorporation of CHB resulted in significantly fewer infected trees than the control but significantly more infected trees than either fungicide treatment (Table 1).

Symptom development was not observed on any tree treated with metalaxyl, and only one treated with captafol (inoculated on MM106 rootstock) became infected. These results suggest that preventative fungicide drenches may be beneficial in controlling apple collar rot. Several reports have indicated that

metalaxyl is effective in controlling *Phytophthora* crown or root rots on avocado (4), apple (7), and citrus (5,8,16). Postinfection curative activity of metalaxyl has been reported for *P. cactorum* on apple (7) and *P. cinnamomi* on avocado (4). Our data suggest that metalaxyl may also provide good protectant activity against *P. cactorum* on apple. Captafol lacks systemic activity and therefore is unlikely to provide postinfection curative activity. Captafol does appear to have good protectant activity against *P. cactorum* on apple. Our results suggest that if protectant treatments are initiated before infection and continued on an annual basis, good control may be obtained. If treatment is initiated after infection has occurred, protectant fungicides will probably be of little value. One factor that could greatly reduce the effectiveness of protectant fungicides for collar rot control is that *Phytophthora* spp. may be introduced into the orchard in or on infected nursery stock (9).

Spring et al (15) reported that CHB was suppressive to *P. cactorum* in greenhouse studies. Our results suggest that CHB may be beneficial in suppressing *P. cactorum* in the field. The incorporation of CHB into soil appeared to be effective in controlling collar rot; however, 25% of all inoculated trees in CHB became infected and died. This level of control would not be satisfactory on a commercial scale. However, the degree of control obtained in CHB may have been adversely affected by the high level of inoculum and moisture used in this study. Only one tree died in the uninoculated CHB treatment. The effectiveness of CHB as a biocontrol material for collar rot of apple needs further study.

Our results suggest that chemical control of apple collar rot can be obtained. We feel, however, that fungicide application should not be considered as the primary means of control. The development and use of

Table 1. Effect of metalaxyl, captafol, composted hardwood bark, and graft union planting depth on percentage of trees killed after inoculation with *Phytophthora cactorum*

Treatment (rate)	Rootstock and graft union position ^x					
	MM106, graft union exposed		M9 interstem/MM106 rootstock, lower graft union buried		M9 interstem/MM106 rootstock, lower graft union exposed	
	I ^y	NI	I	NI	I	NI
Composted hardwood bark (35 L/tree in planting hole, 1:1 mixture with soil)	25 ^z	0	17	0	33	8
Metalaxyl (1 L/tree of 500 µg a.i./ml)	0	0	0	0	0	0
Captafol (1 L/tree of 600 µg a.i./ml)	8	0	0	0	0	0
Untreated	92	8	83	25	67	17

^xAll trees were cultivar Golden Delicious and were 1-yr-old nursery whips at the initiation of the experiment (1979).

^yI = inoculated; trees inoculated three times (on 20 July and 15 September 1979 and 15 April 1980) with 10 ml of a suspension containing 10,000 oospores per milliliter of *P. cactorum*. NI = not inoculated.

^zAll figures represent the percentage of trees killed by *P. cactorum* from 1980 through 1983 and are based on 12 single-tree replicates per treatment. On the basis of a log-linear contingency table model, the experimental factors of soil treatment and inoculation were highly significant ($P < 0.01$), whereas rootstocks and depth of planting were not ($P > 0.50$).

more resistant rootstocks combined with the selection of planting sites that are not conducive to disease development remain, in our opinion, the most effective and economical means of control. The use of fungicides such as captafol and metalaxyl within a total disease management program involving resistant rootstocks, proper site selection, and clean nursery stock could aid in obtaining a higher level of disease control.

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