Failure of Canker Removal and Postharvest Fungicide Sprays to Control Nectria Twig Blight on Apples

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ABSTRACT

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Experiments were conducted to test control measures for Nectria twig blight caused by *Nectria cinnabarina*. Both captafol at 1,200 μg/ml and benomyl at 300 μg/ml inhibited germination of *N. cinnabarina* conidia in vitro, but postharvest treatments in 1978 failed to reduce the incidence of twig blight in 1979. Spring applications of captafol were also ineffective. Neither captafol at 6,000 μg/ml nor the combination of benomyl at 300 μg/ml + 0.25% 70° spray oil applied 2 days after harvest in 1979 reduced disease incidence in 1980. Removal of infected twigs by pruning during July 1979 also failed to reduce 1980 disease incidence. No twig blight infections developed in two previously uninfected orchards following postharvest inoculation of broken fruit pedicels with conidia of *N. cinnabarina*.

Twig blight of apple (*Malus domestica* Borkh.) caused by *Nectria cinnabarina* (Tode) Fr. (=*Tubercularia vulgaris* (Tode) Fr.) has been reported from numerous locations throughout the world (1,2,4,6,8,9). However, little is known about the epidemiology and control of this disease because it usually affects only Rome Beauty, Ben Davis, and Twenty Ounce cultivars, appears only sporadically, and seldom causes serious damage to infected trees (4). During 1978, we observed orchards severely infected with Nectria twig blight in both the Hudson Valley and Lake Ontario fruit districts of New York. Several growers indicated that the severity of the disease had consistently increased during the previous 2–3 yr. Because *N. cinnabarina* is considered a wound parasite in other host plants (5) and infection of apple might occur through broken fruit pedicels following harvest (4,8), this study was conducted to determine whether growers could prevent or reduce Nectria infections in problem blocks by applying a postharvest fungicide or by removing infected twigs during summer pruning.

MATERIALS AND METHODS

An in vitro spore germination test was used to determine the activity of benomyl (Benlate 50W, E. I. du Pont de Nemours & Company, Wilmington, DE 19898) and captafol (Difolatan 4F, Chevron Chemical Company, San Francisco, CA 94105) against conidia of *N. cinnabarina*. Conidia were collected from sporodochia on infected twigs in March, and a lawn of spores was sprayed onto plates of potato-dextrose agar (PDA). Filter paper disks 12 mm in diameter were dipped in fungicide solutions, blotted dry, and placed on the inoculated plates. Concentrations of benomyl tested were 30, 150, and 300 μg a.i./ml; those of captafol were 120, 600, and 1,200 μg a.i./ml.

During 1978 and 1979, fungicides were applied after harvest in two commercial orchards to determine whether picking wounds could be protected from infection by *N. cinnabarina*. Replicated four-tree plots in a block of mature Ben Davis apple trees located in the Lake Ontario fruit district were sprayed with captafol at 6.7 kg a.i. (7.0 L Difolatan 4F) per hectare on either 1 November 1978, 4 April 1979, or both. Materials were applied in 904 L of water per hectare using an air-blast sprayer. The three treatments and an untreated control were replicated five times in a randomized block design. Plots were evaluated 26 June 1979 by counting the number of Nectria-girdled twigs (strikes) per tree on the center two trees in each plot.

A block of mature Rome Beauty apple trees growing on seedling rootstock and showing an estimated 55–75 strikes per tree in 1978 was used to evaluate potential control measures in the Hudson Valley. The orchard was not near woods or hedgerows and therefore was not subject to *N. cinnabarina* inoculum from other reported hosts (5,7). Postharvest sprays of captafol (1,200 μg a.i./ml) and benomyl(300 μg a.i./ml) were applied 31 October 1978 by spraying to runoff (about 3,640 L/ha) with a handgun at 2,760 kPa. The two treatments and an untreated control were replicated four times in a randomized block design with five trees per plot. In 1979, a randomized block, split-plot design was used to compare captafol at 6,000 μg a.i./ml, benomyl at 300 μg a.i./ml plus 0.25% 70° spray oil, and an untreated check. Treatments were replicated on both summer-pruned and unpruned trees. The summer pruning consisted of removing all visible Nectria infections during late July. The split-plot design was used to allow summer pruning in larger blocks of trees and to minimize contamination of pruned plots by spores from unpruned plots. The fungicide treatments were applied 26 October 1979, and plots were replicated three times on both pruned and unpruned trees using five trees per plot.

The 1978 treatments on Rome Beauty trees were evaluated 4 June 1979 by counting the number of Nectria strikes (Fig. 1) in the lower part of the crowns (below 2 m) of the five trees in each plot. We counted only the strikes in the lower portion of each tree because the large number of strikes and the large tree size made an accurate count in the upper crown impractical. The 1979 treatments were evaluated 24 June 1980, and the number of strikes in the entire tree crown was counted because the disease incidence was much lower than in 1979.

Twigs infected with *N. cinnabarina*

Fig. 1. Late-June foliar symptoms of Nectria twig blight on Rome Beauty apple trees.

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were collected throughout late summer and fall of 1979 and winter of 1980 and were checked for conidiospore production by washing them in sterile distilled water and examining the wash water for spores. To determine whether *N. cinnabarina* conidia can cause infection through fresh picking wounds, 10-μl droplets containing 4.4×10^4 conidia of *N. cinnabarina* were placed on pedicel scars and on "pulled stems" immediately after Rome Beauty fruit were harvested on 24 October 1978. Pulled stems are pedicels that are pulled from fruit during harvest and remain attached to the cluster base (Fig. 2). Inoculations were made on 15 pedicel scars and 15 pulled stems, and equal numbers of each wound type were treated with 10 μl of water as a control. Spores for the inoculations were harvested from 20-day-old cultures of *N. cinnabarina* on PDA.

In a second inoculation test, five to eight *N. cinnabarina* cankers with abundant sporodochia were placed in wire mesh baskets and suspended about 1 m above the crown in eight Rome Beauty trees on 27 October 1979. Fruit on four trees was not harvested and was allowed to drop as it matured. On the other four trees, 100 fruit were harvested with pulled stems. Rainfall totaling 41 mm began within 15 hr of the time fruit were harvested. The inoculum cankers were left in place through May 1980. The experimental orchards used for the 1978 and 1979 inoculation experiments had no Nectria infections prior to our inoculations.

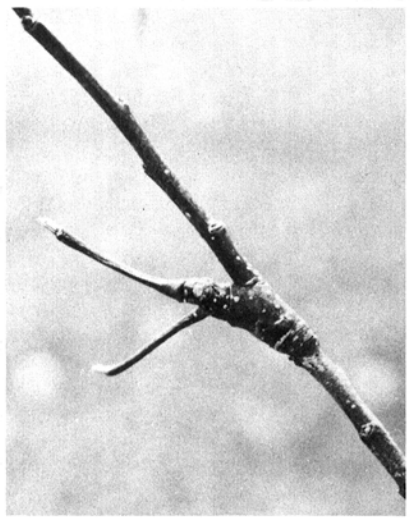

Fig. 2. Uninfected fruit pedicels or "pulled stems" on Rome Beauty apple trees.

Fig. 3. *Nectria cinnabarina* canker on Empire apple. Note abundant sporodochia produced on the canker and pruning cut **(upper right)** where infection apparently originated.

RESULTS AND DISCUSSION

Periodic washings from Nectria cankers during 1978 and 1979 showed that conidia of *N. cinnabarina* were available for dissemination from early September through March, when observations were discontinued. Even after several months of subfreezing temperature, 80–90% of the conidia washed from cankers germinated when placed on PDA. However, no infections resulted from any of the inoculations made in 1978 or from suspending inoculum over trees in 1979. The failure of our inoculations may have been caused by the absence of predisposing factors, such as water stress (7) or cold temperatures (8), that may increase host susceptibility.

All of the concentrations of benomyl and captafol tested in vitro completely inhibited spore germination in zones extending a minimum of 4 mm from the filter disks. No zones of inhibition occurred around filter disks treated with sterile water. We chose to test captafol and benomyl because of their in vitro activity, the effectiveness of captafol in reducing leaf-scar infections of apple by *Nectria galligena* Bres. (3), and the limited systemic activity of benomyl. Spring applications of captafol were tested because viable conidia are still abundant in spring, and the period of host susceptibility has not been determined.

None of the 1978 or 1979 fungicide treatments reduced the incidence of Nectria strikes the year following treatment (Table 1). Removal of inoculum by pruning in 1979 also failed to significantly ($P = 0.05$) reduce disease incidence in 1980. The mean numbers of cankers per tree in 1980 were 2.4 and 2.9 for pruned and unpruned trees, respectively. Cankers causing strikes evident in June and July were located at the base of the previous year's terminal growth. Pulled stems from apples harvested the previous year were generally present on cluster bases where cankers were initiated. The location of Nectria cankers in relation to seasonal terminal growth of the trees precludes the possibility that the counts we made reflected preexisting infections or that treatments we applied could affect disease incidence beyond the period of our observations.

Fall fungicide treatments may have failed because picking wounds may have become infected via rain-dispersed conidia before fungicides were applied. Treatments were applied 2–7 days after the end of harvest, but in all of our trials rain occurred between the beginning of harvest and the application of fungicides. In the Hudson Valley, treatments were delayed because the grower wished to harvest dropped fruit before fungicides were applied. Possibly fungicides could be applied immediately after harvest in some years, but windy conditions or rain during harvest would make immediate protection of picking wounds impossible in many cases.

The failure of canker removal to reduce significantly the incidence of Nectria twig blight may have resulted from our inability to find all of the cankers hidden among the summer foliage of large trees. Although strikes with dead or flagging leaves were easy to spot, cankers on dead twigs infected during previous seasons were less obvious, and some were probably overlooked. Similarly difficult to spot were occasional cankers that

Table 1. Incidence of *Nectria cinnabarina* on mature Rome Beauty and Ben Davis apple trees as affected by fungicide sprays

Treatment[a]	Season of application	Mean number of strikes following treatment[b]		
		1978–1979 Ben Davis[c]	1978 Rome[c]	1979 Rome[c]
Check		13.2	9.0	2.0
Benomyl	Fall	···	7.1	3.7
Captafol	Fall	12.0	7.2	2.3
	Spring	10.0	···	···
	Fall & Spring	9.6	···	···

[a] Benomyl was applied at 300 μg a.i./ml in 1978 and 1979, but 0.25% 70° spray oil was applied with the benomyl in 1979. Captafol was applied at 1,200 μg a.i./ml in the Ben Davis and 1978 Rome treatments, and at 6,000 μg a.i./ml in 1979 Rome treatments.

[b] Strikes per tree were counted 26 June 1979, 6 June 1979, and 24 June 1980 for Ben Davis, 1978 Rome, and 1979 Rome treatments, respectively, except that counts for 1978 Romes are the number of strikes on the lower 2 m of the crown only.

[c] *F*-test showed no significant differences ($P = 0.05$) between means.

persisted in wood 2–3 yr old without girdling the infected branches.

Infected twigs pruned from the trees during summer were left on the orchard floor and were still producing viable spores at harvest. Conidia of *N. cinnabarina* are water disseminated (5) and could have been carried to lower limbs by splashing rain, but infections in pruned trees were not predominantly on low limbs as would be expected if inoculum came from the orchard floor. Most of the 1980 infections in pruned trees occurred in conical patterns 2–3 m below old cankers that were missed during pruning.

Nectria twig blight is the only form of *N. cinnabarina* infection previously reported on apple, but during the course of this study we observed one Empire and one Idared orchard in the Lake Ontario region and one McIntosh orchard on Long Island where *N. cinnabarina* apparently had invaded pruning cuts (Fig. 3). Abundant sporodochia were produced below the pruning cuts, and the cankers completely girdled limbs as large as 5 cm in diameter. Cankers caused by *N. cinnabarina* have previously been reported on shade trees (5), but factors favoring invasion of large apple limbs by *N. cinnabarina* have not been determined.

Our study has shown that effective control measures for *N. cinnabarina* on apple cannot be developed without more information on the biology of the pathogen. More detailed studies are needed to determine periods of host susceptibility, factors predisposing trees to infections, and environmental conditions needed for infection of apple.

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