Susceptibility of Almond Cultivars and Stone Fruit Species to Pruning Wound Cankers Caused by *Phytophthora syringae*

M. A. DOSTER, Graduate Research Assistant, and R. M. BOSTOCK, Associate Professor, Department of Plant Pathology, University of California, Davis 95616

ABSTRACT

Doster, M. A., and Bostock, R. M. 1988. Susceptibility of almond cultivars and stone fruit species to pruning wound cankers caused by *Phytophthora syringae*. Plant Disease 72:490-492.

For all almond cultivars commonly grown in California, inoculation of fresh pruning wounds with *Phytophthora syringae* resulted in canker development. Canker expansion rates were similar except in Ripon, which consistently had smaller cankers. Only Nonpareil developed cankers from inoculation of 3-wk-old wounds, which suggests that the length of cultivar susceptibility to infection may be important in determining disease severity in the orchard. Fresh wounds in almond, apricot, and peach trees were susceptible to infection and canker development caused by *P. syringae*, but only small cankers formed in plum and French prune trees.

Profusely gumming cankers are frequently associated with pruning wounds in almond trees (*Prunus dulcis* (Mill.) Webb) in California. *Phytophthora syringae* (Kleb.) Kleb. causes these cankers by infecting pruning wounds in the fall and winter (1). During 1982–1984, this disease was common in almond orchards in the Sacramento Valley, and orchards were observed in which approximately 25% of the pruning wounds developed cankers caused by *P. syringae* (2).

P. syringae has caused crown rots of almond, apricot (*P. armeniaca* L.), cherry (*P. avium* L.), peach (*P. persica* (L.) Batsch), and prune (*P. domestica* L.) trees in California (4,5,7) and of various species of stone fruit trees other than almond throughout the world (3,8). Because many hectares of various stone fruit trees are grown in California, it seemed possible that *P. syringae* could cause pruning wound cankers in stone fruit trees other than almond.

Almonds are a major crop in California, with over 170,000 ha. The relative susceptibility of almond cultivars to *P. syringae* was unknown because the disease has only recently been recognized. The objective of this study was to determine the susceptibility of the major almond cultivars and various stone fruit species grown in California to pruning wound cankers caused by *P. syringae*.

MATERIALS AND METHODS

General. An isolate of *P. syringae* (F-79) obtained from an almond pruning

Present address of first author: Department of Plant Pathology, Cornell University, Ithaca, NY 14853.

Accepted for publication 8 January 1988 (submitted for electronic processing).

wound canker and maintained on lima bean agar was used for inoculation. This isolate showed typical growth rates in media and almond bark tissue when compared with other *P. syringae* isolates.

All experiments used the following procedure. During winter, wounds were made in branches 1–3 cm in diameter by making transverse cuts with pruning shears in the middle of the branch. Wounds were inoculated by placing a mycelial plug (9 mm in diameter) from a culture growing in lima bean or cornmeal agar on the wound and covering with Parafilm. After 9–16 wk, the branches were excised, the outer bark removed, and the extent of inner bark discoloration measured. *P. syringae* was reisolated from some of the cankers to verify the causal agent (1). For controls, agar plugs with no fungal mycelium were placed on some wounds and covered with Parafilm.

Almond cultivar trials. Eleven almond cultivars commonly grown in California were tested in two bearing orchards during 1984 and 1985. One orchard, in Butte County, was inoculated 6 January 1984 and 18 January 1985; the resulting cankers were measured after 16 wk. The other orchard, in San Joaquin County, was inoculated 24 January 1984 and 1 February 1985; the resulting cankers were measured about 15 wk later. For each year, one branch approximately 2 cm in diameter was inoculated on 10 trees per cultivar at each site.

In February 1985, fresh and 2-wk-old wounds of the cultivars Nonpareil and Mission were inoculated in an orchard in Colusa County. The resulting cankers in the 10 replications were measured 6 wk later.

In 1986, the resistance of fresh and 3-wk-old wounds in seven almond cultivars was tested in two bearing orchards in Colusa and San Joaquin counties. The 10 replications per orchard were inoculated in February and cankers were measured 12 wk later.

Stone fruit species trials. Bearing trees of various stone fruit species were inoculated in early March 1984 in an orchard near Davis, CA. Cankers in eight branches per species were measured after 10 wk. Two-year-old potted trees were inoculated in early March 1985 and maintained in a lathhouse. Cankers in four trees for each species were measured after 9 wk.

RESULTS

The results of the almond cultivar trials for 1984, 1985, and 1986 are presented in Table 1. All inoculations of fresh wounds resulted in canker development. The interaction between cultivar and year was very significant ($P = 0.0001$) for the 1984 and 1985 trials, as shown by the large variation between canker expansion rates for most cultivars from year to year. For example, in Jordanolo, cankers expanded faster than in any other cultivar in 1984, but in 1985, cankers expanded faster in most of the other cultivars. Likewise, in the 1986 trial, the results for some cultivars (e.g., Price) were quite different from those in 1985. In the 1986 trial, however, no cultivars had significantly ($P < 0.01$) slower canker expansion, and in the 1984 and 1985 trials, only Ripon had slower canker expansion. There was a small (7.3%) but significant ($P < 0.05$) difference in the canker expansion rate between the two orchards in 1984 and 1985, but the cultivar × orchard interaction was not significant.

In 1985, 100% of the inoculated 2-wk-old wounds in Nonpareil, but only 50% of those in Mission, resulted in cankers (*data not shown*). In 1986, 31.6% of the inoculated 3-wk-old wounds in Nonpareil had cankers, whereas none of those in other cultivars tested resulted in cankers (Table 1).

In both experiments on various stone fruit species, only small cankers were formed in French prune and plum trees (Table 2). In orchard trees, the fastest canker expansion was observed in almond trees (1.86 mm/day), whereas in potted trees, the fastest was observed in apricot (1.66 mm/day). Canker expansion rates were also high in peach trees (1.1 mm/day in orchard trees), but both potted and orchard peach trees had lower rates than almond trees.

Table 1. Development of cankers caused by *Phytophthora syringae* in bearing trees of various almond cultivars in three orchards (Butte County, 1984 and 1985; San Joaquin County, 1984, 1985, and 1986; and Colusa County, 1986)

Cultivar[a]	Canker expansion rate (mm/day)				Cankers in aged wounds[c] (%)
	1984	1985	Mean[b]	1986	
Jordanolo	1.12	0.81	0.97	...	...
Butte	0.91	1.02	0.96	0.97	0.0
Merced	0.85	1.06	0.96	...	...
Mission	0.85	1.01	0.93	1.11	0.0
Fritz	0.87	0.97	0.92	...	...
Nonpareil	1.05	0.78	0.91	1.15	31.6[d]
Carmel	1.09	0.71	0.90	0.94	0.0
Ne Plus Ultra	0.84	0.82	0.83	0.81	0.0
Thompson	0.89	0.77	0.83	0.81	0.0
Price	0.85	0.61	0.73	1.12	0.0
Ripon	0.59	0.48	0.53	...	...
$LSD_{0.05}$	0.21	0.32	0.18	0.23	
$LSD_{0.01}$	0.30	0.45	0.26	0.34	

[a] All cultivars were represented in all orchards.
[b] Of 1984 and 1985 data.
[c] In 3-wk-old wounds in same orchards as 1986 trials.
[d] Nonpareil had significantly more cankers than any other cultivar, according to Fisher's exact test ($P = 0.01$).

Table 2. The development of *Phytophthora syringae* cankers in potted and orchard trees of various stone fruit species

Tree species	Cultivar	Canker expansion rate (mm/day)	
		Orchard trees	Potted trees
Almond (*Prunus dulcis* (Mill.) Webb)	Nonpareil	1.86	1.42
Peach (*P. persica* (L.) Batsch)	Fay Elberta	1.11	1.20
Apricot (*P. armeniaca* L.)	Blenheim	0.79	1.66
Cherry (*P. avium* L.)	Bing	...[a]	0.67
Plum (*P. salicina* Lindl.)	Santa Rosa	0.32	0.57
Prune (*P. domestica* L.)	French	0.27	0.17
	$LSD_{0.05}$	0.24	0.45
	$LSD_{0.01}$	0.32	0.62

[a] Not determined.

DISCUSSION

Naturally occurring pruning wound cankers have been observed in all almond cultivars tested (*personal observation*). However, since disease distribution in orchards was irregular and clustered, and disease incidence was correlated with pruning wound diameter (2), it was difficult to determine by observation the relative susceptibility of the cultivars. Cankers expanded at approximately the same rate in all almond cultivars except Ripon, in which expansion was slower (Table 1). This suggests there may be no difference in resistance among most cultivars once the canker is initiated.

For all almond cultivars tested, inoculated fresh wounds always resulted

in cankers. Almond bark wounds gradually develop resistance as they age. By 6 wk after pruning, almost all wounds are immune to infection by *P. syringae* (2). This immunity developed more slowly in Nonpareil than in Mission during 1985 and in the other cultivars tested in 1986 (Table 1). This suggests that Nonpareil, the most prevalent commercial cultivar in California, would be more likely to have pruning wound cankers because of the longer period of wound susceptibility. Determination of relative susceptibility of almond cultivars in the field is difficult, as disease incidence and severity are governed by the age of the wound as well as the cultivar.

Although we found no reports in the literature of pruning wound cankers caused by *P. syringae* in almonds outside of California or in other stone fruit species, several researchers have examined the relative susceptibility of some stone fruit species to collar rot caused by *P. syringae* (3,6,8). Two of these studies were done in New Zealand (8) and Greece (3) and only one included an almond cultivar (3). These studies consisted of inoculating trees and then determining the degree of girdling on 2-yr-old trees (3), the degree of girdling and canker length on 2-yr-old trees (6), and infection severity by subjective observation of trees of unspecified age (8). All studies found that cankers were most severe on apricot trees, somewhat less severe on peaches, and least damaging on plum trees (3,6,8). In our study involving 2-yr-old potted trees, apricots had the largest cankers, peaches had somewhat smaller cankers, and plums had small cankers. In orchard trees, however, peaches actually had larger cankers than apricots (Table 2). French prune trees had the smallest cankers in both potted trees and orchard trees (Table 2). The only study on collar rot to include an almond cultivar found inoculated almond trees to have a girdling index intermediate between apricots and peaches (3). This corresponds to what was observed in 2-yr-old potted trees in our study, but in orchard trees the cankers expanded the fastest in almond trees (Table 2). Very young potted trees may not be adequate predictors of mature tree resistance. Although various cultivars and diverse isolates of *P. syringae* were used in these studies, the results indicate that almond, apricot, and peach trees are very susceptible and plum and prune are relatively resistant. In California, pruning wound cankers caused by *P. syringae* have been observed in French prune and apricots, but these are rare (*personal observation*). At the present time, we do not know why Phytophthora pruning wound cankers have become common and widespread in almond orchards in California (1,2) but not in orchards of other stone fruit trees, even though the *P. syringae* isolated from almond grew well in other stone fruit trees.

The use of mycelial agar plugs to inoculate fresh wounds, although very convenient, may not be the most appropriate method to determine the relative susceptibility of trees to *Phytophthora* spp. Perhaps some cultivars are resistant to canker initiation by low levels of inoculum, but once the fungus is established in the host, the canker expands rapidly. An important component of the resistance of cultivars may be the rate at which aged wounds become resistant, as was observed in this study (Table 1).

ACKNOWLEDGMENTS

We thank the Almond Board of California for their financial support of this research and J. Connell, D. Rough, and J. Edstrom for assistance with the cultivar trials.

LITERATURE CITED

1. Bostock, R. M., and Doster, M. A. 1985. Association of *Phytophthora syringae* with pruning wound cankers of almond trees. Plant Dis. 69:568-571.
2. Doster, M. A. 1987. Epidemiology of pruning wound cankers caused by *Phytophthora syringae* in almond orchards and studies on the processes related to expression of disease resistance in wounded almond bark. Ph.D. dissertation. University of California, Davis. 144 pp.
3. Kouyeas, H. 1977. Stone fruit tree apoplexy caused by Phytophthora collar rot. EPPO Bull. 7:117-124.
4. Mircetich, S. M. 1975. Phytophthora root and crown rot of orchard trees. Calif. Plant Pathol. 24:1-2.
5. Mircetich, S. M. 1981. Phytophthora root and crown rot of deciduous fruit trees in California. Pages 42-48 in: Proc. XIII Annu. Br. Columb. Fruit Growers Assoc. Hortic. Forum.
6. Mircetich, S. M. 1982. Phytophthora root and crown rot of apricot trees. Acta Hortic. 121:385-396.
7. Mircetich, S. M., Moller, W. J., and Chaney, D. H. 1974. Phytophthora crown rot and trunk canker of almond trees. (Abstr.) Proc. Am. Phytopathol. Soc. 1:58-59.
8. Smith, H. C. 1956. Collar-rot of apricots, peaches, and cherries. Orchard N.Z. 29:22-23.