Shoot Blight of Pistachio Caused by *Botrytis cinerea*

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ABSTRACT

Bolkan, H. A., Ogawa, J. M., and Teranishi, H. R. 1984. Shoot blight of pistachio caused by *Botrytis cinerea*. Plant Disease 68:163-165.

A shoot blight disease caused by *Botrytis cinerea* is reported for the first time on pistachio (*Pistacia vera*) in California. Shoot blighting resulted from initial infection of catkins and racemes and progress of the fungus into stems. Partial girdling of shoots or twigs resulted in shriveled leaves showing necrosis from water stress. Petiole infections resulted in death of individual leaves and/or shoot blight. Incidence of the disease was high on male trees because of the high susceptibility of catkins. The disease was favored by prolonged rainfall and relatively low temperatures. Fungicides applied during full bloom of male flowers and partial bloom of female flowers reduced the number of blighted shoots. Benomyl was the most effective fungicide under field conditions.

The pistachio nut tree (*Pistacia vera* L.) is native to Asia and Asia Minor. It was introduced into the United States in 1902 (3) and is now grown commercially in the central valleys of California and in Arizona and Texas (8). In California, about 17,000 ha of pistachio trees are in production, with an estimated annual harvest of 13 million kilograms. In spring of 1983, after heavy and prolonged rains and cool weather, a disease of unknown etiology characterized by blighted shoots was observed initially in Solano County (Sacramento Valley) and subsequently in Madera County (San Joaquin Valley) in California. Isolations from infected parts consistently yielded the fungus *Botrytis cinerea* Pers.:Fr. Although the pathogen has been reported to attack a wide variety of plants (1,4,9), as far as we can ascertain, this is the first report on the occurrence of *B. cinerea* on pistachios.

The objectives of this study were to describe the symptomatology of naturally occurring infections, establish proof of pathogenicity, and evaluate fungicides for disease control. A survey was also made to determine the prevalence of the disease in commercial orchards.

Accepted for publication 14 October 1983.

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MATERIALS AND METHODS

Isolation. Naturally infected pistachio catkins, racemes, twigs, and shoots were collected from several orchards in various counties in California during April and May. Diseased twigs and shoots (2–8 cm long) were washed under running tap water, surface-sterilized for 3 min in 1% sodium hypochlorite, and rinsed twice in sterile water. Samples (1–2 mm) were aseptically cut from infected areas and plated on Difco potato-dextrose agar (PDA). Isolation plates were then incubated on a laboratory bench at room temperature (24 ± 1 C) for 5 days. Twenty-five monoconidial isolates of *B. cinerea* established from five isolates were selected randomly and compared for cultural and morphological characteristics. No variation was observed, and a single isolate was used for further studies.

Pathogenicity tests. Pathogenicity tests were conducted on 17 May on female and male pistachio trees of the cultivars Kerman and Peters, respectively, at Wolfskill Experimental Orchards of the University of California at Davis. Current-season shoots (30–60 cm long) were injured using a cork borer to remove a plug of bark 4 mm in diameter. Inoculum of *B. cinerea* was prepared by growing the fungus on PDA for 7 days at room temperature (24 ± 1 C). A plug of agar 4 mm in diameter, with mycelium plus conidia, was placed on the cut surface of the shoot and secured with masking tape. Twenty shoots (10 from a male tree and 10 from a female tree) were inoculated. On all shoots, the inoculation point was 5 cm above the shoot base. Shoots prepared similarly but inoculated with sterile PDA plugs served as controls.

Fungicides tested. The field plot for fungicide tests was established on a commercial orchard of cultivar Kerman in Madera County. The fungicides used were benomyl (Benlate 50W), 840 g a.i./ha; CGA-64251 (Vangard 10W), 840 g a.i./ha; captafol (Difolatan 4F), 1,812 g a.i./ha; and copper hydroxide, copper equivalent 50% (Kocide 101 77W), 3,000 g a.i./ha. The fungicides were applied with a hand sprayer once on 15 April, when the female trees were at 50–60% of full bloom, using about 10 L of water per tree. Controls consisted of unsprayed trees. The experimental layout was a completely randomized block design with 10 single-tree replicates. Three days after the treatments, 0.8 mm of rain fell. Disease control data were taken 33 days after the fungicide spray.

RESULTS

Symptoms and distribution of the disease. The first symptoms observed were wilting, shriveling, and drying of leaves at the tips of young shoots. Scattered shoots then died and leaves remained attached to the twigs (Fig. 1B,D). Twig girdling was characterized by dead bark and cambium. Sometimes, as a result of petiole infections through bud scales, single leaves or leaflets were

found shriveled and dried (Fig. 1A). In such cases, the base of the petioles and the adjacent girdled stem were discolored darkly (Fig. 1A). Infection of racemes, which was suspected to originate from basal scales of the emerging flower cluster, caused shriveling and drying of the nuts as well as shoot blight (Fig. 1C). On twigs, the fungus caused dark lesions that enlarged and coalesced to produce sunken cankers 3–24 cm long. Diseased petioles, catkins, and racemes that remained attached to the infected twigs and shoots were generally covered by buff-colored masses of conidia of *B. cinerea*.

Symptoms were especially severe and incidence of the disease was high on male trees (Table 1) because of the presence of catkins, which served as points of infection leading to shoot dieback (Fig. 1D). The disease was most severe in areas where total rainfall for April and May was higher than 36 and 5 mm, respectively, and where mean temperatures ranged from 13.6 to 14.4 C in April and from 16.3 to 21 C in May.

Table 1. Incidence of blighted shoots caused by *Botrytis cinerea* on pistachio trees under field conditions in various California counties

Orchard[a]	Location	Incidence (%)[b]	
		Male trees	Female trees
A	Madera County	57	16
B	King County	1	0
C	Kern County	1	0
D	Kern County	1	T[c]
E	Yolo County	37	5
F	Butte County	88	28

[a] A = Madera Farming Co., B = S & J Ranch, C = Superior Farming, D = Tejon Farming, E = Wolfskill Experimental Orchards, and F = Ord Bend Farms.
[b] Average percentage of shoots with dieback. One hundred shoots per tree were selected at random and evaluated. Five trees were surveyed for orchard E and 50 each for orchards A, B, C, D, and F.
[c] T = trace (0.2%).

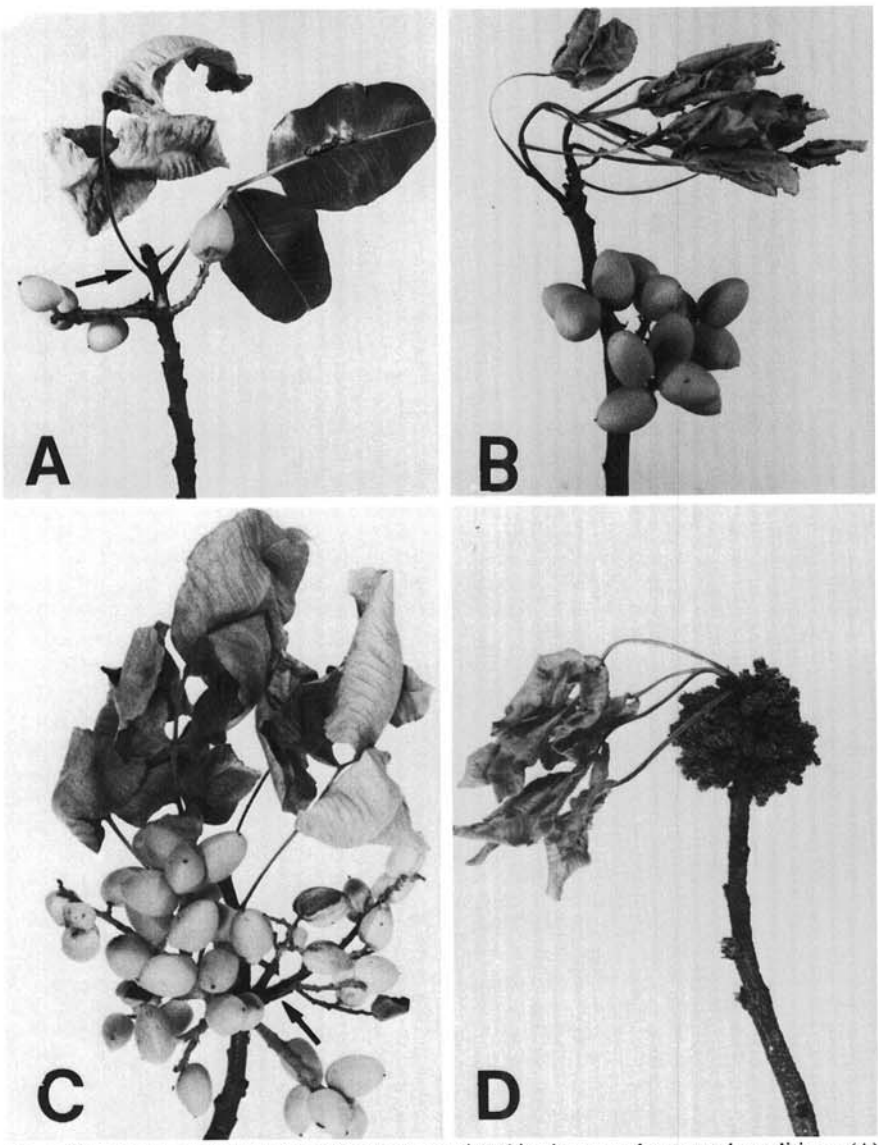

Fig. 1. Symptoms caused by *Botrytis cinerea* on pistachio shoots under natural conditions: **(A)** shriveled and dried single leaflet caused by petiole infection (indicated by arrow), **(B)** shriveled and dried leaflets caused by girdling of twig, **(C)** raceme infection (indicated by arrow), and **(D)** infected catkins attached to blighted twig.

Isolation of the pathogen. During the 1983 growing season, *B. cinerea* was consistently isolated from diseased female and male pistachio stems of the cultivars Kerman and Peters, respectively, collected from several widely separated locations in the San Joaquin Valley and as far south as Kern County in California. Identification of *B. cinerea* was based on morphological and cultural characteristics of the fungus as described by Ellis and Waller (6).

Pathogenicity tests. Within 7 days of inoculation, male and female pistachio shoots developed symptoms similar to those observed on naturally infected shoots. Leaves at the tips of inoculated male and female shoots wilted, shriveled, and dried. On twigs, dark lesions expanding 3–10 cm in both directions from the point of inoculation were visible. Control shoots remained symptomless. Reisolation from artificially inoculated shoots yielded only fungal isolates morphologically similar to the original inoculum. No apparent differences in susceptibility of shoots from male and female pistachio trees were observed.

Fungicide tests. All fungicides tested significantly reduced shoot infection (Table 2) but benomyl was the most effective. There were no significant differences in disease reduction between CGA-64251 and captafol treatments (Table 2). Copper hydroxide appeared to be the least effective.

DISCUSSION

Shoot blight of pistachios was shown to be caused by *B. cinerea*. Occurrence of the problem was sporadic, but the disease was observed in all pistachio-growing areas examined in California during April and May 1983. Onset of the disease appeared to coincide with precipitation. It is generally agreed that infection by *B. cinerea* requires a period of high humidity or rain and low to moderate temperatures (1,7). In 1983, higher than normal rainfall and relatively low temperatures occurred during bloom. This may explain the outbreak of the disease. Orchards in Butte, Madera, and Solano counties had the most severe outbreaks (Table 1) and the most precipitation in April–May (65–87 mm compared with the normal 32 mm for these months).

Incidence of Botrytis shoot blight was more severe on male trees than on female

Table 2. Efficacy of various fungicides applied to prevent shoot blight caused by *Botrytis cinerea* on female pistachio trees under field conditions

Treatment	Rate (g a.i./ha)	Blighted shoots per tree (%)	Infected shoots per tree[y] (%)
Control	...	4.6 a[z]	9.5 a
Copper hydroxide	3,000	2.3 b	5.2 b
Captafol	1,812	1.5 c	6.2 b
CGA-64251	840	1.3 c	5.9 b
Benomyl	840	0.2 d	3.3 c

[y] Shoots showing *B. cinerea* infection but not killed.
[z] Means in the same column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

trees. This may reflect that infection by *B. cinerea* spores is enhanced by the presence of pollen grains (2,5,9). Blighted catkins (Fig. 1D) with sporulating *B. cinerea* were observed on most twigs on male trees, indicating that catkins were infected initially and the fungus moved down and girdled the twigs.

Satisfactory control of *B. cinerea* was obtained with a single application of benomyl, captafol, CGA-64251, or copper hydroxide spray. All fungicide-treated trees showed significantly reduced incidence of disease compared with untreated trees. Benomyl, however, was superior to the other three fungicides. There was no evidence of phytotoxicity with any of the fungicides at the rates tested.

ACKNOWLEDGMENTS

Research was conducted at the University of California, Davis, with partial support from California Pistachio Commission. The first author was partially supported by a grant from the Brazilian National Council for scientific research and technology (CNPq). We thank M. W. Hoy, R. H. Beede, J. Maranto, and B. T. Manji for their cooperation and technical assistance.

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