Dynamics and Pattern of Latent Infection Caused by *Botryosphaeria dothidea* on Pistachio Buds

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ABSTRACT

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A study was conducted in four commercial pistachio orchards to monitor the presence and pattern of external contamination and latent infections of buds by *Botryosphaeria dothidea* between 1998 and 2000. Symptomless buds were sampled every 2 to 3 weeks and analyzed either by a washing/crushing method or by direct plating of split (half) or intact buds on lactic acid potato dextrose agar. The proportion of infected buds varied among orchards over time. Levels of latent infections were highest in February and March when they reached as much as 60% in orchards of Glenn and Yolo counties. This period corresponded to the months with the highest rainfall. Buds collected from orchards in Glenn and Yolo counties had, in general, higher incidence of infection than buds from San Joaquin and Merced counties. Buds became infected in June immediately after their formation. Infection incidence on basal segments of buds from male trees was approximately twice (19%) that of apical or middle segments (11%). Plating of split buds resulted in similar levels of incidence as the plating of intact buds. The number of *B. dothidea* propagules on bud surfaces varied over time and among orchards. In general, the number of propagules per bud was highest in February and March (approximately seven propagules per bud) when the rainfall amount was highest.

Additional keywords: *Botryosphaeria* blight, disease detection, epidemiology, *Pistacia vera*

Pistachio (*Pistacia vera* L.) is a dioecious plant. Two cultivars, Kerman and Peters, widely grown in California, are used in commercial orchards as female and male trees, respectively. Since the late 1980s, *Botryosphaeria dothidea* (Moug. ex Fr.) Ces. & de Not. (imperfect stage is a *Fusicoccum* sp.), causal agent of *Botryosphaeria* panicle and shoot blight, has become one of the most important pathogens of pistachio in northern and central California (13). Previous research showed that the disease was sparsely distributed among the many orchards surveyed (6). Initially, pistachios grown in the Sacramento Valley were affected, but in 1995 and 1996 severe epidemics of the disease were observed in orchards throughout the Central Valley, resulting in substantial yield loss in fruit quantity and quality by killing fruit panicles (7).

B. dothidea is an ascomycete fungus that is difficult to control once it has been established in a pistachio orchard (9,11). The pathogen produces pycnidia within the bark where fungicides cannot reach. Under natural conditions, mycelia are subdermal

and intercellular. *B. dothidea* overwinters on retained rachises, fruit mummies, petioles, and cankers of blighted shoots and panicles (6). These constitute the main sources of primary inoculum by providing pycnidiospores for up to 6 years (6,14). A recent survey of commercial pistachio orchards revealed only the presence of the

pycnidial stage of the pathogen (12,13). It was also noticed that several native and cultivated plants (various tree species) grown near pistachios harbored the pathogen (12). The teleomorph (ascocarp) and anamorph phases of *B. dothidea* have been reported in California in 1986 on giant Sequoia (*Sequoiadendron giganteum*) and on coastal redwood (*Sequoia sempervirens*) (20). The ascocarpic stage intermingled with pycnidia of *B. dothidea* was also discovered on olive (*Olea europaea*) and firethorn (*Pyracantha* spp.) growing close to pistachios in 1999 (T. J. Michailides, unpublished data). However, no ascocarps of the pathogen have yet been discovered in pistachio orchards. Because ascocarps of *B. dothidea* occur sporadically, pycnidiospores are believed to be the main source of inoculum, causing primary infections during early spring. Early season (spring) infections remain latent until later in the season (June through August) when symptoms of the disease appear. Under favorable conditions during August, the disease can suddenly increase on infected clusters and kill them within 2 to 3 weeks (12,15,16). The objective of this study was to determine the dynamics of the incidence of latent bud infections and number of external *B. dothidea* propagules on bud surfaces. Periodic sampling would also

Fig. 1. Dynamics of infection caused by *Botryosphaeria dothidea* on female buds (cv. Kerman) collected between 1 October 1998 and 1 April 1999 from four commercial pistachio orchards based on the split (half) bud-plating method.

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allow the determination of the earliest infection event and the location of the infection sites on the bud. Preliminary results of the study were previously reported (17).

MATERIALS AND METHODS

To determine the levels and period of bud infection, 100 symptomless, reproductive buds of Kerman pistachio trees were arbitrarily collected every 3 weeks between 1 October 1998 and 1 April 1999 from four commercial orchards, one each in Glenn, Yolo, Merced, and San Joaquin counties in California. Buds were surface-disinfested for 3 min in 0.525% of sodium hypochlorite (household bleach) and allowed to dry for 30 to 45 min on a clean paper towel in a laminar airflow hood. Dried buds were individually and aseptically sectioned longitudinally in half, and each bud half was placed cut surface down on a 10 × 1.5-cm-diameter petri plate containing lactic acid (2.5 ml of 25% vol/vol lactic acid/water per liter medium) potato dextrose agar (APDA). Four split buds (eight halves) were plated on each plate and a total of 25 plates were used for each sampling date per orchard.

Between 1 June 1999 and 1 September 2000, the experiment was expanded to compare plating methods and levels of infection between buds from male (Peters) and female (Kerman) trees from the same four orchards. Approximately 135 to 150 fully differentiated symptomless, reproductive pistachio buds were arbitrarily collected from male or female trees every 2 to 3 weeks. Buds from male and female trees were collected and processed separately. Buds from each group were divided into three sub-samples of 45 buds each. Buds of one sub-sample were processed using the bud crushing/washing method (see below) to detect levels of free viable *B. dothidea* propagules on bud surface. The remaining buds were used for direct plating of split (second sub-sample) or intact (third sub-sample) buds to determine internal latent infection.

For the crushing/washing method, 15 buds were individually crushed using a mortar and pestle, and placed in a plastic bottle containing 20 ml of sterile distilled water. The buds were shaken for 2 h at 180 rpm (low speed) on a two-speed orbital shaker (Eberbach Corporation, Ann Arbor, MI) to release *B. dothidea* propagules trapped among bud scales. Three bottles (a total of 45 buds) were used for male or female buds per orchard. One hundred microliters of the bud washing suspension was plated onto a 10 × 1.5-cm-diameter petri plate containing APDA. Six plates were used per bottle and a total of 18 plates were used per orchard and sampling date.

The remaining 90 buds were surface-disinfested for 3 min in 0.525% sodium hypochlorite with 0.001% Tween 20 and allowed to dry for 30 to 45 min on clean paper towels in a laminar airflow hood.

Forty-five buds were individually and aseptically sectioned longitudinally in half, and each bud half was placed cut surface down on APDA. Five split buds (10 halves) were placed on each plate and a total of nine plates were used for each sampling date per orchard. The remaining 45 disinfested buds were directly plated on APDA. Five intact buds were placed in each APDA plate and a total of nine plates were used per orchard and sampling date.

To determine the location of infection on buds by *B. dothidea* for each sampling

date, six additional buds were first sectioned longitudinally in half, and each piece was cut into three segments. A total of six segments (two apical, two middle, and two basal segments) was sectioned per bud and was placed on APDA in petri plates. All plates were incubated at 30°C, the optimum temperature for growth of *B. dothidea* (6). White, fluffy, fast-growing colonies from bud washings or bud tissue were identified as *B. dothidea* and recorded initially after 3 or 4 days. Identity of *B. dothidea* colonies was confirmed after 6 or

Fig. 2. Rainfall and dynamics of infection caused by *Botryosphaeria dothidea* on buds collected between 1 June 1999 and 1 September 2000 from Kerman (female) or Peters (male) trees in three commercial pistachio orchards based on the split (half) bud-plating method. Arrow indicates initiation of bud formation.

7 days of incubation when they turned greenish and started to produce pycnidia. When necessary, pycnidiospores were examined microscopically to confirm identity. Colonies growing from either half of the same bud were counted as one infected bud.

Data analysis. The experiment was a repeated-measure design with orchard, cultivar, and plating method as main effect sources of variation. Sampling dates were repeated measures over months and years. For each growing season, percentages of infected buds and number of colonies from free viable *B. dothidea* propagules for all orchards and sampling dates were subjected to analysis of variance (ANOVA) using the PROC GLM procedure of the SAS software package (SAS Institute, Cary, NC). Mean comparisons were conducted using the Fisher's protected least significant difference (LSD) test. A repeated measures ANOVA was performed on pooled data of the three growing seasons using the PROC GLM procedure of the SAS software to compare the year effect.

RESULTS

Monitoring bud infection. The frequencies of infected buds in samples collected from four orchards between October 1998 and March 1999 are reported in Figure 1. Buds collected during this period from the orchard in Glenn County consistently had a greater incidence of infection than buds collected from the orchards in San Joaquin, Merced, and Yolo counties. On average, 51% of buds collected from Glenn County were infected, while only 16 to 17% of buds were infected in the other orchards. Except for the Glenn County orchard where levels of infection remained high throughout the sampling period, the highest levels of infection were recorded in March 1999 for the orchards of San Joaquin, Yolo, and Merced counties (Fig. 1).

There was a high variability in the percentage of infected buds among samples collected from Glenn, Yolo, and San Joaquin counties between June 1999 and September 2000 (Fig. 2). In San Joaquin and

Yolo counties, maximum infection frequency (16 and 60%, respectively) was observed on male buds (Peters) in March 2000. Detection of the pathogen in buds that had formed in May showed that some of them were infected soon after formation. In Glenn County, for example, 5 and 11% of newly formed buds collected from male trees in early June of 1999 and 2000, respectively, were infected (Fig. 2). Approximately 11% of female buds collected from Glenn County on 5 June 2000 were also infected. Percentages of infection of new buds from male trees in San Joaquin and Yolo counties on 5 June 2000 were 4 and 13%, respectively. For most orchards in 1999 and 2000, the frequency of infected buds was significantly higher in February and March than other months (based on LSD test, $P < 0.001$, Table 1).

Comparison of levels of bud infection for all sampling dates showed that the percentage of infected buds differed significantly ($P < 0.0001$) among the orchards sampled between 1998 and 2000 (Table 2). Incidences of infection of buds from or-

chards in Yolo (16.6%) and Glenn (15.4%) counties were significantly ($P < 0.0001$) higher than levels of infection of buds from orchards in Merced (4.6 %) and San Joaquin (4.5%) counties. Frequency of bud infection also varied among years and months of sample collection. Overall, 24.2, 8.1, and 12.3% of the sampled buds were infected in 1998, 1999, and 2000, respectively. The cultivar effect (buds from male [cv. Peters] or female [cv. Kerman] trees) was not significant ($P = 0.117$). Also, there was no significant difference ($P = 0.25$) between the plating methods (split buds versus intact buds). All interactions among years, months, orchards, and cultivar were significant ($P < 0.01$) (Table 2).

Since all interactions involving the year effect were significant ($P \leq 0.0022$) (Table 2), data for each growing season were analyzed separately. During the crop year 1999, the month $\times$ orchard, and month $\times$ cultivar interactions were significant ($P < 0.01$). Therefore, overall means could not be calculated. But in 2000, overall means of infection recorded between June and

Table 2. Repeated measures analysis of variance (ANOVA) of frequency of pistachio buds infected by *Botryosphaeria dothidea*^y

Source of variation	df	MS	P
Sampling date per month	2	55.9	0.250
Plating method ^w	1	5.9	0.250
Cultivar ^x	1	134.2	0.117
Orchard	3	1462.3	<0.0001
Cultivar $\times$ orchard	3	72.8	0.100
Error (A) ^y	7	34.1	
Year	2	1281.2	<0.0001
Cultivar $\times$ year	1	1680.5	<0.0001
Orchard $\times$ year	4	631.6	<0.0001
Cultivar $\times$ orchard $\times$ year	1	524.0	0.0022
Month	9	974.9	<0.0001
Cultivar $\times$ month	8	245.1	<0.0001
Orchard $\times$ month	23	138.9	0.0003
Cultivar $\times$ orchard $\times$ month	16	114.7	0.0098
Error (B) ^z	157	54.1	

^y Buds were collected from Peters (male) or Kerman (female) trees in four commercial orchards in California 2 to 3 times per month, from October 1998 to September 2000.

^w Intact-bud and split (half)-bud methods.

^x Male buds collected from the cv. Peters and female buds from the cv. Kerman.

^y Error (A) was used for testing effects of repetition, plating method, cultivar, orchard, and cultivar $\times$ orchard interaction.

^z Error (B) was used for testing effects of year and month and all their interactions with orchard and cultivar.

Table 1. Mean monthly incidence of bud infection caused by *Botryosphaeria dothidea* on pistachio buds collected from Peters (male) or Kerman (female) trees from four commercial orchards in four counties in 1998 and 1999, and three commercial orchards in three counties in 2000

Month	1998				1999				2000		
	Glenn	San Joaquin	Yolo	Merced	Glenn	San Joaquin	Yolo	Merced	Glenn	San Joaquin	Yolo
June	... ^y	...	...	...	2.5 c ^z	1.1 b	...	1.1 b	10.6 b	3.0 c	10.0 cd
July	...	...	...	...	4.3 c	0.8 b	...	0.6 b	13.3 b	2.5 c	14.2 cd
August	...	...	...	...	10.0 c	1.4 b	...	0.3 b	9.2 b	4.2 bc	8.6 d
September	...	...	...	...	24.5 b	2.8 b	...	1.1 b	...	...	...
October	55	9	11	14	...	...	...	...	...	...	...
November	50	3	8	7	11.1 c	0.3 b	8.3 b	...	...	...	...
December	50	19	14	19	6.7 c	0.6 b	7.8 b	...	...	...	...
January	...	...	...	...	29.0 b	7.0 b	16.0 ab	...	12.2 b	3.9 bc	18.3 c
February	...	...	...	...	56.0 a	21.5 a	13.5 b	28.0 a	16.1 ab	11.7 a	30.0 b
March	...	...	...	...	47.5 a	26.0 a	27.5 a	11.5 b	24.4 a	11.1 ab	53.9 a

^y Buds not collected in the given month.

^z Values within columns followed by the same letter are not significantly different ($P > 0.05$) according to Fisher's protected least significant difference.

September were calculated because the month effect and interactions involving months were not significant ($P > 0.05$). Overall, incidence of infection in buds collected from the Yolo County orchard (16.7%) was significantly ($P < 0.001$) higher than that of buds from the Glenn County orchard (12%), which had higher levels of infection than the San Joaquin County orchard (3.9%) (Table 3). For all orchards, buds from male trees (Peters) had a level of infection twice (14.5%) that of female buds (7.0%). No significant difference ($P = 0.095$) in infection frequency was observed between intact (11.1%) and split buds (10.4%).

Infection pattern of buds by *B. dothidea*. The effect of position of bud segments on infection incidence varied significantly ($P = 0.007$) among orchards and between buds from male (Peters) and female (Kerman) trees. For buds from male trees of the Glenn County orchard, basal segments were significantly ($P < 0.05$) more infected (26.5%) than apical segments (13.3%) (Table 4). Since the interaction between orchard and cultivar was significant ($P = 0.0003$), overall means could not be calculated. There was no infection pattern observed on buds collected from female trees from any orchard. However, basal segments of female buds from Yolo County were slightly more infected than middle or apical segments, although the difference was not significant ($P = 0.058$) (Table 4).

Dynamics of *B. dothidea* propagules on bud surface. Bud crushing/washing experiments conducted in 1999 and 2000 showed variation over time in the number of viable propagules of *B. dothidea* (Fig. 3). Buds from male trees (Peters) had a significantly ($P = 0.032$) higher number of free propagules than buds from female trees (Kerman). On average, buds from the orchard in Yolo County had five *B. dothidea* propagules, while each bud from orchards in Glenn, San Joaquin, and Merced counties had 2.3, 0.3, and 0 propagules, respectively. One exception to this (18 July 2000) was a sample from Glenn County, in which 49 propagules per bud were recorded. However, the number of propagules per bud did not differ significantly ($P > 0.08$) among orchards. Also, slightly more propagules were ob-

tained in the 2000 crop year (three propagules per bud) than in the 1999 crop year (one propagule per bud), but the difference was not significant ($P = 0.50$). For all orchards, significantly ($P = 0.05$) higher numbers of *B. dothidea* propagules per bud were found in samples collected in February and March (seven spores/bud) than in samples collected later in the season (June, August, and September) (≤ 2 spores/bud).

DISCUSSION

Understanding the biology and epidemiology of *B. dothidea* is essential for developing appropriate management strategies for Botryosphaeria shoot and panicle blight. Results of this study showed that the populations of the pathogen varied over time and among orchards. Buds collected in February and March, during the rainy season, consistently had a higher incidence of infection than buds collected at other dates (Table 1). This agrees with reports from North Carolina on blueberry that many infections occurred in March and April (5). Results of the present study differed somewhat from those of previous research on peach in Georgia (19). Weaver (19) reported that most infections of peach tree gummosis caused by *B. dothidea* occurred in July when temperature and rainfall are favorable for dispersal and infection. Since precipitation does not usually occur in the Central Valley of California in summer (July to September), spore dispersal and infections must take place during the rainy season (fall/winter or early spring) with infections remaining latent until suitable conditions for symptom development occur in summer. Winter rains contribute to natural spread and infection

of apple and peach buds by *B. obtusa* (1,2). In pistachio orchards, conidia of *B. dothidea* can be released and dispersed by winter rains on the plant surface and be trapped among bud scales (15,16), leading to infection of vegetative and reproductive buds. This infection can kill buds or lead to blighting of developing shoots and panicles later in the growing season (8).

Although there was adequate precipitation for spore dispersal in December 1999 and January 2000, lower incidence of infected buds and lower numbers of *B. dothidea* propagules per bud were recorded during that period. This situation may be explained by the fact that a lower mean temperature could have suppressed spore production during the early cold winter months or conidia could have been washed from plant surfaces before germination and attachment could occur. Sutton (18), in his research on *B. dothidea* on apple in North Carolina, suggested that lower temperatures in winter might result in suppressed spore production during those months. Also, conidia of *B. dothidea* were not recovered from peach gummosis cankers during two consecutive winters in Georgia (2). While these studies support the low propagule numbers obtained from buds collected in winter (Fig. 3), the bud infection incidence of 3 to 10% for this same time period (Fig. 2) might illustrate the difference in infection potential due to differences in quantity of primary inoculum in the different orchards. Variation in levels of primary inoculum may also explain the observed differences in incidence of infected buds among years. High levels of bud infection were recorded between October 1998 and March 1999 (Fig. 1)

Table 4. Incidence of infection of bud segments by *Botryosphaeria dothidea* in the 2000 growing season

Bud type	Position	Orchard location		
		Glenn	San Joaquin	Yolo
Female	Tip	0.0 a ^z	0.0 a	7.0 a
	Middle	3.4 a	0.9 a	5.3 a
	Base	2.6 a	0.0 a	12.3 a
Male	Tip	13.3 b	2.6 a	11.4 a
	Middle	14.3 ab	3.4 a	11.4 a
	Base	26.5 a	4.3 a	19.3 a

^z Values followed by the same letter within bud type and orchard are not significantly different ($P > 0.05$) according to Fisher's protected least significant difference.

Table 3. Percentage of buds infected with *Botryosphaeria dothidea* collected between 1 June and 1 September 2000 from Kerman (female) and Peters (male) trees from three commercial pistachio orchards using the direct-plating method of split or intact buds

County	Percentage of infected buds (%)				Mean		Overall mean
	Half buds		Intact buds				
	Kerman	Peters	Kerman	Peters	Kerman	Peters	
Glenn	8.3 a ^z	17.0 a	6.7 ab	16.1 ab	7.5 a	16.6 a	12.0 b
San Joaquin	2.8 b	3.9 b	1.8 b	7.2 b	2.3 b	5.6 b	3.9 c
Yolo	8.7 a	22.4 a	14.3 a	21.4 a	11.5 a	21.9 a	16.7 a
Mean	6.5	14.2	7.4	14.7	7.0	14.5	
Overall mean	10.4		11.1				

^z Values followed by the same letter within columns are not significantly different ($P > 0.05$) according to Fisher's protected least significant difference.

following high disease levels recorded during the previous growing season (10), while moderate levels of bud infection were obtained after a season with low disease levels (crop year 1999). Effects of temperature and relative humidity on spore production and factors triggering the appearance of symptoms in orchards are under investigation.

We also showed that buds might be infected soon after they form. Buds break dormancy in early April and develop into fruit clusters or vegetative shoots. Primor-

dia of new buds differentiate in May and reach a maximum size approximately 1 June (4). Approximately 5 to 10% of the newly formed buds collected from the Glenn County orchard in early or mid-June were infected with *B. dothidea* (Fig. 2). These new infections may be due to the combined effect of dew, or as little as 2 mm of rain, and high temperatures that may occur in June or later. Infection of buds by *Botryosphaeria* species has been reported for peaches in Georgia (2). The prevalence of *Botryosphaeria* spp. fluctu-

ated over a 2-year period with *B. dothidea* prevailing during summer and *B. obtusa* during winter and spring. In the present study we showed that *B. dothidea* fluctuated throughout the year with high levels of infected or infested buds recorded in February and March shortly before bud expansion. *B. obtusa* is not considered a pathogen of California pistachio, even though it has been isolated occasionally (T. J. Michailides, unpublished data). Although heavy contamination of pistachio buds by *B. dothidea* was reported in a previous study (14), this is the first description of fluctuations of bud infection by *B. dothidea* throughout the growing season and infection pattern on buds. The fact that buds first became infected at their base could explain why fruit clusters or shoots are often completely and rapidly killed and infections usually first appear at the base of fruit clusters or shoots. Destruction of fruit clusters would also explain why the disease continues to cause yield losses and is considered a potential threat to pistachio crops in California (3).

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LITERATURE CITED

1. Beisel, M., Hendrix, F. F., Jr., and Starkey, T. E. 1984. Natural inoculation of apple buds by *Botryosphaeria obtusa*. *Phytopathology* 74:335-338.
2. Britton, K. O., and Hendrix, F. F. 1986. Population dynamics of *Botryosphaeria* spp. in peach gummosis cankers. *Plant Dis.* 70:134-136.
3. California Pistachio Commission, 1998. *Botryosphaeria*: #1 priority. Pistachio Perspective. April, Fresno.
4. Crane, J. C., Catlin, P. B., and Al-Shalan, I. 1976. Carbohydrate levels in pistachio as related to alternate bearing. *J. Am. Soc. Hortic. Sci.* 101:371-374.
5. Creswell, T. C., and Milholland, R. D. 1988. Spore release and infection periods of *Botryosphaeria dothidea* in North Carolina. *Plant Dis.* 72:342-346.
6. Michailides, T. J. 1991. Pathogenicity, distribution, sources of inoculum, and infection courts of *Botryosphaeria dothidea* on pistachio. *Phytopathology* 81:566-573.
7. Michailides, T. J., and Morgan, D. P. 1992. Effects of temperature and wetness duration on infection of pistachio by *Botryosphaeria dothidea* and management of disease by reducing duration of irrigation. *Phytopathology* 82:1399-1406.
8. Michailides, T. J., and Morgan, D. P. 1993. Spore release by *Botryosphaeria dothidea* in pistachio orchards and disease control by altering the trajectory angle of sprinklers. *Phytopathology* 83:145-152.
9. Michailides, T. J., and Morgan, D. P. 1998. Update on *Botryosphaeria* panicle and shoot blight management programs for California pistachio. Pages 152-154 in: *Calif. Pistachio Ind., Annu. Rep., Crop Year 1997-98*. California Pistachio Commission, Fresno.
10. Michailides, T. J., Morgan, D. P., and Felts, D. 1999. BUDMON, a bud monitoring technique

Fig. 3. Rainfall and dynamics of propagules of *Botryosphaeria dothidea* associated with buds collected between 1 June 1999 and 1 September 2000 from Kerman (female) or Peters (male) trees in three commercial pistachio orchards based on the bud-crushing/washing method. Arrow indicates initiation of bud formation.

- to predict *Botryosphaeria* blight in pistachio orchards. Pages 39-48 in: Calif. Pistachio Ind., Annu. Rep., Crop Year 1998-99. California Pistachio Commission, Fresno.
11. Michailides, T. J., Morgan, D. P., and Felts, D. 1999. Chemical control of *Botryosphaeria* blight of pistachio in California. Pages 84-100 in: Calif. Pistachio Ind., Annu. Rep., Crop Year 1998-99. California Pistachio Commission, Fresno.
 12. Michailides, T. J., Morgan, D. P., Felts, D., and Chitzanidis, A. 1998. Disease monitoring and prediction of *Botryosphaeria* blight in California pistachio orchards. Pages 72-79 in: Calif. Pistachio Ind., Annu. Rep., Crop Year 1997-98. California Pistachio Commission, Fresno.
 13. Michailides, T. J., Morgan, D. P., and Sullivan, A. 1996. Spread of *Botryosphaeria dothidea* in pistachio orchards of the San Joaquin Valley. Pages 123-128 in: Calif. Pistachio Ind., Annu. Rep., Crop Year 1995-96. California Pistachio Commission, Fresno.
 14. Michailides, T. J., and Ogawa, J. M. 1987. New findings on the epidemiology and control of *Botryosphaeria* panicle and shoot blight of pistachio. Pages 99-107 in: Calif. Pistachio Ind., Annu. Rep., Crop Year 1986-87. California Pistachio Commission, Fresno.
 15. Ntahimpera, N., Driever, G. F., and Michailides, T. J. 1999. Biology, epidemiology, monitoring, and control of *Botryosphaeria* panicle and shoot blight on pistachio. Pages 13-36 in: Calif. Pistachio Ind., Annu. Rep., Crop Year 1999-2000. California Pistachio Commission, Fresno.
 16. Ntahimpera, N., Driever, G. F., and Michailides, T. J. 2000. Biology, epidemiology, monitoring, and control of *Botryosphaeria* panicle and shoot blight on pistachio. Pages 8-37 in: Calif. Pistachio Ind., Annu. Rep., Crop Year 2000-2001. California Pistachio Commission, Fresno.
 17. Ntahimpera, N., Driever, G. F., and Michailides, T. J. 2000. Monitoring latent infections caused by *Botryosphaeria dothidea* on pistachio buds, leaves, and fruit clusters. (Abstr.) *Phytopathology* 90:S56.
 18. Sutton, T. B. 1981. Production and dispersal of conidia by *Physalospora obtusa* and *Botryosphaeria dothidea* in apple orchards. *Phytopathology* 71:584-589.
 19. Weaver, D. J. 1979. Role of conidia of *Botryosphaeria dothidea* in the spread of peach tree gummosis. *Phytopathology* 69:330-334.
 20. Worrall, J. J., Correll, J. C., and McCain, A. H. 1986. Pathogenicity and teleomorph – anamorph connection of *Botryosphaeria dothidea* on *Sequoiadendron giganteum* and *Sequoia sempervirens*. *Plant Dis.* 70:757-759.