Population Dynamics of *Botryosphaeria* spp. in Peach Gummosis Cankers

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ABSTRACT

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Peach twigs naturally infected with the gummosis fungi *Botryosphaeria dothidea, B. obtusa*, and *B. rhodina* were sampled at monthly intervals for 2 yr. Fungi were isolated systematically from live twig segments distal to each of 20 cankers on each date to ascertain patterns of twig colonization. Forty percent of the twigs contained all three species. Incidence of *Botryosphaeria* spp. peaked early in the summer, when all three species were present, and was lowest in the fall. *B. dothidea* was dominant in the summer. Populations of *B. rhodina*, though never very large, also increased in the summer. Increases from January to April were due to the presence of *B. obtusa*, which represented 90% of the population during these months. *B. obtusa* was isolated every month, but *B. dothidea* and *B. rhodina* were not detected in January. *Botryosphaeria* spp. isolated at the leading edge of colonization distal to the cankers followed a similiar seasonal pattern.

Most peach orchards in Georgia are infected with *Botryosphaeria* spp. that cause gummosis cankers. In 1974, Weaver (8) attributed this disease to *Botryosphaeria dothidea* (Moug. ex Fr.) Ces. & de Not (8). However, three *Botryosphaeria* spp. that were isolated from gummosis cankers produced indistinguishable symptoms on inoculated trees: *B. dothidea, B. obtusa* (Schw.) Shoem., and *B. rhodina* (Berk. & Curt.) von Arx (2).

In 1982, we sampled at least 200 cankers in each of three peach-growing regions of Georgia and isolated *B. obtusa* from gummosis cankers much more frequently than the other two species in all three regions (2). *B. obtusa* was most prevalent in the northern section of the state, where the disease had only recently appeared. To evaluate the possibility of an ecological succession in the population of *Botryosphaeria* spp. in gummosis cankers, four orchards in central Georgia were sampled at monthly intervals for 2 yr.

MATERIALS AND METHODS

Throughout the summer of 1982, monthly samples were taken of cankers on twigs, scaffold limbs, and tree trunks. Five samples of each type were taken from each of four orchards near Fort Valley, GA, each month. Twigs were removed at the canker site and the live, symptomless portion of twig distal to the canker was cut in 2.5-cm segments numbered to record their proximity to the canker. These segments were surface-sterilized for 1 min in a solution of 0.5% sodium hypochlorite in 10% ethanol, transferred to acidified potato-dextrose agar (APDA) in 9-cm-diameter petri dishes, and kept under fluorescent lights (50 μE cm^{-2} s^{-1}) for 14 days before identification of the pathogens. Scaffold limbs and trunks were sampled with a bark increment hammer. Five 7-mm-diameter cores were removed from the margin of each canker, surface-sterilized, transferred to one dish of APDA, and incubated as described before.

Botryosphaeria spp. were differentiated on the basis of conidial morphology. Conidia of *B. dothidea* are hyaline, nonseptate, clavate, 16–31 × 4–8 μm, and form within typically compound pycnidia (*Dothiorella* state). Conidia of *B. rhodina* melanize and become monoseptate with longitudinal striations when mature, ranging from 20–23 × 10–18 μm (*Lasiodiplodia* state). Pycnidia may be uniloculate or multiloculate. Conidia of *B. obtusa* are also brown when mature but form no septa (*Sphaeropsis* state). These faintly echinulate spores range from 22–26 × 10–12 μm. The pycnidia are typically uniloculate (E. S. Luttrell, *personal communication*).

For the 2-yr survey, five samples of live twigs with cankers were taken from each of the four orchards near Fort Valley at monthly intervals and processed as described. The percentage of twig segments colonized by each species was determined.

The *Botyrosphaeria* spp. isolated from the most distal twig segment was considered to be the pathogen responsible for canker elongation at that time. Hyphae extended as far as 250 cm beyond the externally visible canker or any internal discoloration. The percentage of colonization margins inhabited by each fungus was determined for each orchard, and the means for all orchards were determined (Fig. 1). The seasonal changes in populations of each species were evaluated by F tests with $\alpha = 0.05$, using the four orchards as replicates.

RESULTS

There were no significant differences in relative isolation frequencies of *Botryosphaeria* spp. from diseased twigs, scaffold limbs, and trunks. However, *Botryosphaeria* spp. were isolated three to 11 times more frequently from twigs than from scaffold limbs or trunks (Table 1). We then chose infected twigs as the optimum sample type for the duration of the 2-yr study because plating out the entire twig gave a higher isolation frequency and because twigs also offered a convenient system to determine the leading edge of fungal colonization beyond visible symptoms.

Data in Figure 2 represent the percentage of segments that contained each *Botryosphaeria* sp. and the sum of plates yielding any of the three species. During the summer, most twig cankers sampled were inhabited by all three species of *Botryosphaeria*. Forty percent of the twigs during the entire study contained all three species. No long-term trend in the proportions of species was found; however, significant seasonal shifts recurred over the 2 yr studied.

B. dothidea was the dominant species in the summer. This organism was not isolated from twigs in the winter. *B. rhodina* was isolated from the twigs early in the summer and again in the fall, but levels of this fungus remained low, never exceeding 20% of the twig segments.

Segments sampled in the fall, winter, and spring contained increasing levels of *B. obtusa*, which represented more than 50% of the *Botryosphaeria* spp. present in twigs from October through May, but the population declined in summer to less than 20%. The frequency of isolation dropped to a mean of about 10% in the summer and fall.

The seasonal changes in isolation percentages from colonization margins were similar to the seasonal colonization pattern of the twig as a whole. *B. dothidea* dominated the colonization margin in the summer only (maximum 44%). *B. rhodina* was found at 20% of the margins in fall 1982 and at 15% in summer 1983, then decreased to 10% in fall 1983. Winter

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and spring isolations showed a predominance of *B. obtusa* (maximum 92%). *Cytospora* and *Phomopsis* spp. were isolated from less than 2% of the cankers.

DISCUSSION

Each of the three species of *Botryosphaeria* can cause gummosis cankers that are indistinguishable on the basis of symptoms (2). These survey data indicate that in the field, these fungi are active concurrently in many cankers. The three species probably present a continuum of colonization effort that grants the tree no season of respite. The similarity of seasonal fluctuations in isolation frequencies at the leading edge of fungal colonization with those of the twig as a whole supports the hypothesis that the three *Botryosphaeria* species are each in turn active in expanding the canker.

The fact that *B. dothidea* predominates in the summer suggests that this species possesses some competitive advantage over *B. obtusa* at higher temperatures. *B. obtusa* predominates in the winter, when competition from *B. dothidea* declines. This may reflect differences in the interaction of these species with the host tree, such as a preference for the dormant or actively growing host.

Both *B. dothidea* and *B. obtusa* are canker pathogens on apple trees as well as peach trees. In Georgia, in contrast with most northern states, *B. obtusa* is a relatively weak canker pathogen on apple, acting as a secondary invader of twigs killed by fire blight (7).

B. dothidea is a more aggressive canker pathogen on apple in Georgia. It is probable that the relative importance of these pathogens on apple trees in Georgia, as well as their shifting proportions in the total *Botryosphaeria* population in peach gummosis cankers through the seasons, are due in part to differences in the temperature optima for infection by these species. The optimum temperature for apple infection by *B. dothidea* is 30 C with a range of 24–40 C (5), whereas the optimum for infection by *B. obtusa* is 20 C with a range of 8–28 C (4). It is therefore not surprising that *B. dothidea* is most active in the summer, whereas *B. obtusa* prevails in the winter and spring.

A similar phenomenon is found in the ecology Cytospora canker on *Prunus* spp. The optimum temperature for *C. leucostoma* is higher (33 C) than that for *C. cincta* (24 C). *C. leucostoma* is more virulent during the summer and *C. cincta* is more virulent during the spring (1).

The apparent disappearance of *B. dothidea* and *B. rhodina* in the winter is puzzling; possibly the mycelium of these fungi enters a static condition that is not released by the normally growth-promoting environment of light at 24 C on APDA. Perhaps changes in bark biochemistry mediate this effect. Alternatively, the mycelium may die each winter.

English et al (3) studied *B. dothidea* on almond trees in California and characterized this disease as an annual canker (3). Although *B. dothidea* could still be isolated from half of the inactive cankers, the trees were able to outgrow infection, minimizing the disease impact. Perhaps the significant difference in the Georgia gummosis disease is the involvement of *B. obtusa* during the winter. This organism may, through its winter activities, prevent the tree from establishing effective anatomical or biochemical boundaries.

If in Georgia, as in California, *B. dothidea* is an annual rather than a

Table 1. Isolation of *Botryosphaeria* spp. from different parts of peach trees with gummosis in central Georgia in summer 1982

Tree part sampled	Percentage of samples containing *B. obtusa*[z]	*B. dothidea*	*B. rhodina*
Twigs	66 a	75 a	56 a
Scaffold limbs	16 b	15 b	17 b
Trunks	6 b	7 b	7 b

[z]Values are means of 80 samples. Means in columns followed by the same letter do not differ significantly ($P = 0.05$) according to Duncan's multiple range test. There are no significant differences in the relative frequencies of species.

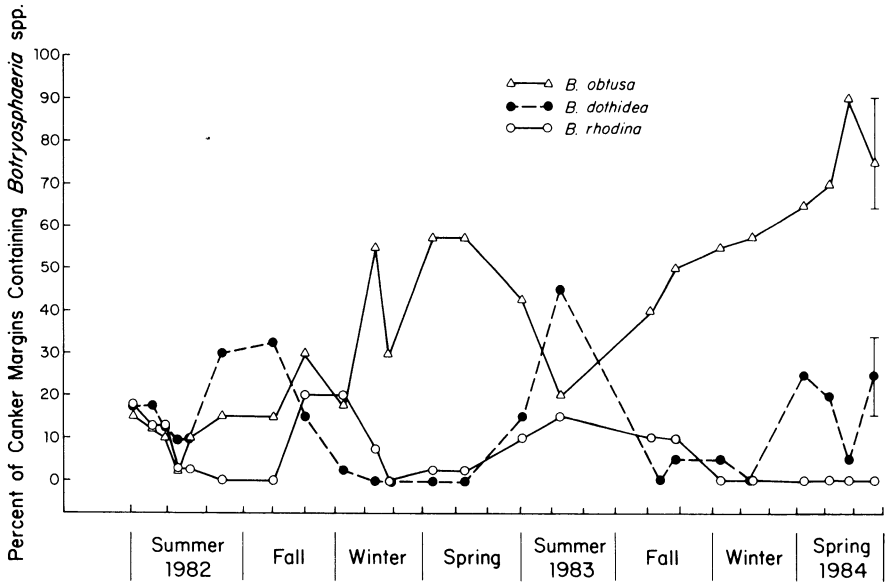

Fig. 1. Frequencies of isolation of the *Botryosphaeria* spp. most distal to the visible canker on peach twigs near Fort Valley, GA, expressed as percentages of 20 twigs. Bars indicate LSD at $P = 0.05$ for each species over time. There was no significant difference in the isolation frequency for *B. rhodina*.

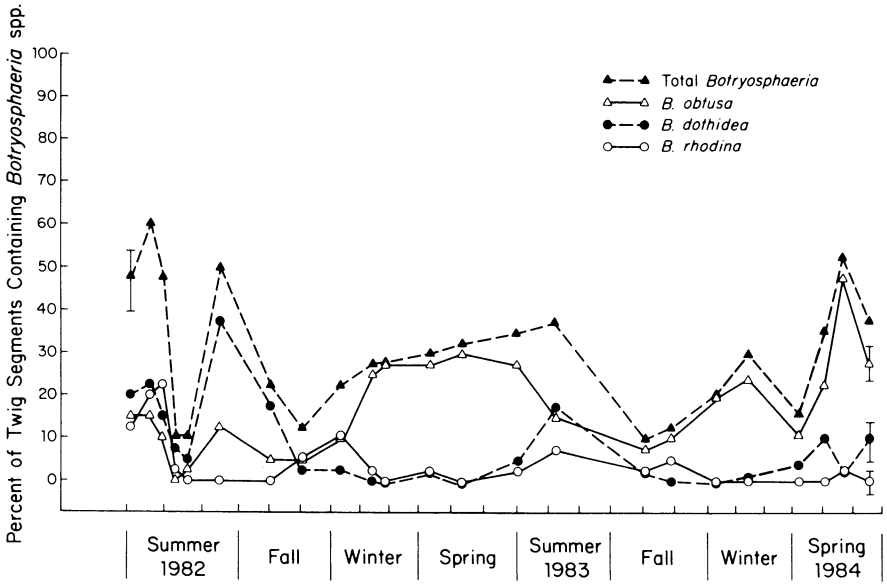

Fig. 2. Percentage of 2.5-cm segments from live twigs distal to cankers yielding *Botryosphaeria* spp. near Fort Valley, GA, in 1982–1984. Data represent means for 20 twigs on each sample date. Bars indicate LSD at $P = 0.05$ for each species over time.

perennial pathogen, the significance of annual availability of inoculum is greatly increased. The present grower practice of mowing prunings is not effective in reducing inoculum (6). These fungi are vigorous saprophytes and may colonize dead and sloughing canker tissue from previous years, using this as a food base from which to expand the canker.

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