

Distribution and Control of *Sclerotium rolfsii* on Apple

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ABSTRACT

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Sclerotium rolfsii is more prevalent in the southernmost than in the other apple-growing areas of Georgia. Recovery of the fungus from naturally infested areas is inconsistent, however. Captafol effectively reduces growth of *S. rolfsii* at 100 ppm in vitro and as a drench treatment. Both captafol and copper sulfate reduce recovery of *S. rolfsii* from roots and trunk tissue of apple trees.

The girdling of apple trees (*Malus domestica* Borkh.) by *Sclerotium rolfsii* Sacc. was first reported on Northern Spy rootstocks (1) and has since been identified in both nurseries and orchards (4,8). Southern blight of apple is characterized by white weblike mycelium at the base of the plant. Fungal growth is confined primarily to root tissue, which may be killed rapidly, but the tissue slightly above the soil surface may also be invaded. During later development, white to brown sclerotia form on the mycelial mat, and the entire plant may wilt and die. Losses of up to 30% in the first year have been reported in North Carolina (4) and Georgia (8), and a 10% loss occurred in an Indiana nursery (7). The random disease incidence in orchards has been attributed to limited distribution of sclerotia (7), temperature (3), soil moisture (5), and previous crop (6). Disease incidence has been higher in nursery trees that have been cultivated by hoeing. Pathogenicity was demonstrated by applying inoculum to injured and noninjured stems of both the scion and the rootstock areas of 3-yr-old apple trees (9); although the infection rate was high, only 17 of 44 plants died within 49 days.

Control of *S. rolfsii* in the field is difficult because fungal growth seems to be environmentally controlled. A large

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number of chemicals have been tested for control of *S. rolfsii* but many are unacceptable because of high cost, unsatisfactory methods of application, or registration problems (2). Questions concerning distribution and control of *S. rolfsii* led to studies in established orchards and to a series of laboratory bioassays to study the effects of some commonly used fungicides registered for use on apples.

METHODS AND RESULTS

Bioassay studies. The fungus used was obtained from a diseased apple tree in Peach County, Georgia. Inoculum was grown on potato-dextrose agar (PDA, Difco) at 29 C for 6 days, at which time a sterilized number 2 cork borer (5 mm diam) was used to cut agar plugs from the advancing mycelial margin. The concentration of chemical to be tested was obtained by adding the appropriate amount of stock suspension to a flask containing 500 ml of cooled PDA.

Fungicide treatments for 1976 were: 1) ethazole (Truban 24 EC), 2) captafol (Difolatan 39 Flowable), 3) benomyl (Benlate 50 WP), and 4) captan (Captan 50 WP). Rates tested were 1,000, 500, 250, 100, 50, and 0 ppm. Treatments for 1978 were: 1) benomyl, 2) captafol, 3) pentachloronitrobenzene (PCNB, Terraclor 75 WP), and 4) captan. Rates tested were 700, 600, 500, 400, 300, 200, 100, and 0 ppm.

Four agar plugs were placed on each petri dish, and five petri dishes were used for each rate. All treatments were placed under fluorescent lamps on a bench in the laboratory at about 21 C. Growth was measured 4 days after initial transfer.

In 1976 the growth of *S. rolfsii* in vitro varied greatly with the chemical and rate used. No significant reduction in growth

was obtained with captan at 50, 100, and 250 ppm, but growth at 500 ppm was significantly reduced ($P = 0.01$); no growth was observed at 1,000 ppm, indicating a toxic level between 500 and 1,000 ppm. Mycelial development was significantly reduced by ethazole at each increase in concentration from 50 to 250 ppm but not at concentrations from 250 to 1,000 ppm. Although benomyl at 50 ppm was no more effective than the control, a significant reduction was obtained at each concentration thereafter; no growth was observed at 1,000 ppm, indicating control at a level between 500 and 1,000 ppm. Captafol reduced the growth of *S. rolfsii* significantly at 50 ppm and nearly eliminated growth at each concentration thereafter.

Results were similar in 1978 (Table 1). Captan and benomyl at 600 ppm totally inhibited mycelial growth. Each successive concentration of benomyl significantly reduced the growth of *S. rolfsii* up to the point of no growth. Growth was significantly reduced by PCNB at 100 ppm, but no further significant reductions were obtained with increases in concentration. Captafol nearly eliminated mycelial growth at rates of 100 ppm and higher; sporadic growth was observed from a few replicates with positive readings for growth.

Field studies. Three established apple orchards from middle to north Georgia were selected. Fungicides were applied either to the trunk from the scaffold limbs to the ground to run off (trunk spray) or at the base of the tree and to the ground (drench treatment). Total amounts per established tree were about 3.79 L for trunk sprays and about 7.60 L for drench treatments. Fungicide treatments and rates per liter were: 1) copper sulfate (7.2 g) as a drench plus captafol (12.6 ml) as a trunk spray; 2) copper sulfate (7.2 g) as a drench plus benomyl (1.2 g) as a trunk spray; 3) copper sulfate (7.2 g) as a drench plus PCNB (7.2 g) as a drench and benomyl (1.2 g) as a trunk spray; 4) copper sulfate (7.2 g) as a drench; 5) captafol (12.6 ml) as a drench and trunk spray; 6) benomyl (1.2 g) as a drench and trunk spray; 7) copper sulfate (7.2 g) as a drench plus PCNB (7.2 g) as a drench and

Table 1. Effect of five chemicals at different concentrations on the growth of *Sclerotium rolfsii* in vitro^w

Concentration (ppm)	Growth (mm) ^x				
	Captan	PCNB	Benomyl	Captafol	Ethazole ^y
0	32.10 a ^z	32.45 a	32.25 a	32.40 a	35.95 a
100	31.85 a	6.20 b	28.45 b	0.00 c	21.50 b
200	31.60 a	6.20 b	22.80 c	1.80 b	...
300	26.65 b	6.20 b	13.00 d	0.00 c	...
400	25.10 b	6.25 b	5.35 e	0.35 bc	...
500	22.25 c	5.95 b	2.25 f	0.80 bc	5.95 c
600	0.00 d	5.95 b	0.00 g	0.00 c	...
700	0.00 d	5.95 b	0.00 g	0.00 c	...

^wChemicals were added to cooled potato-dextrose agar, and data were taken 4 days after inoculum transfer.

^xEach value is the mean of 20 replicates.

^yNo significant difference was determined between 500 and 1,000 ppm.

^zValues followed by different letters are significantly different ($P=0.01$) according to Duncan's multiple range test.

captafol (12.6 ml) as a trunk spray; and 8) PCNB (7.2 g) as a drench plus benomyl (1.2 g) as a trunk spray. Untreated trees were used as controls. Drench treatments were applied only in the spring, whereas trunk sprays were applied in both spring and fall. Chemical treatments were randomized with five tree treatments with four replicates in the Burke County and Fannin County orchards and one tree treatments with 12 replicates in the McDuffie County orchard.

Disease development was observed and samples were taken before chemical treatments during the spring and fall of each year. Initially, during the spring of 1976, the Burke County orchard was in the fourth leaf, the McDuffie County orchard was in the sixth leaf, and the Fannin County orchard was in the first leaf.

The percentage of *S. rolfsii* detected over a 3-yr period was greatest in the southernmost (Burke County) orchard; none was detected the northernmost (Fannin County) orchard. Fluctuations in infected trees were similar in the Burke County and McDuffie County orchards over the 3-yr period. In 1976, 14% of the trees in Burke County and 6% of those in McDuffie County, 30 miles north, were

infected. The incidence increased to 22 and 10%, respectively, in the fall of 1976, decreased to 5 and 8% in the fall of 1977, and increased to 7 and 14% in 1978.

During the 3-yr period, *S. rolfsii* was detected only once in the trees treated by copper sulfate (CuSO_4) drench or by captafol drench and trunk spray. *S. rolfsii* was not detected in the Burke County trees treated by PCNB drench plus captafol trunk spray or in the Burke County and McDuffie County trees treated by CuSO_4 drench plus benomyl trunk spray. The southern blight fungus was isolated most often from untreated control trees in both Burke and McDuffie counties. *S. rolfsii* was found in trees treated by PCNB drench plus benomyl trunk spray at every sampling date except in McDuffie County during the fall of 1978. Recovery of *S. rolfsii* was inconsistent in most treatments throughout the study period at both locations.

DISCUSSION

Bioassay and field studies showed that captafol used alone reduced growth and recovery of *S. rolfsii* from roots and tissue. When captafol was used with other compounds, *S. rolfsii* was isolated from a moderate number of replicates, which

may indicate loss of fungicidal effectiveness. Copper sulfate used alone performed well in the field but when combined with other compounds, except benomyl, was not effective. The same principle may apply with CuSO_4 as with captafol; benomyl may be considered compatible with CuSO_4 . Benomyl used alone had little or no effect on *S. rolfsii*, either in vitro or in vivo.

The inability to consistently isolate *S. rolfsii* from the same area may indicate an environmental effect on the viability of propagules or, as Shay (7) suggested, uneven distribution coupled with environmental variation within the field. Taylor and McGlohon (8) observed that the distribution of southern blight was uneven and that southern apple-growing areas sustained considerably greater losses than northern apple-growing areas. Our data show a pattern in the distribution within Georgia, with the southernmost (Burke County) orchard yielding the most *S. rolfsii* and the northernmost (Fannin County) orchard showing no evidence of southern blight. This difference may be attributed to soil type, soil moisture, temperature, or previous plant crop (2,5).

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