Effects of Septoria Brown Spot on the Yield Components of Soybeans

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ABSTRACT

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In 1978 and 1979, the effects of brown spot caused by *Septoria glycines* on the yield components of Williams soybeans at three canopy levels were investigated. In 1978, seed weights of plants inoculated with *S. glycines* were significantly reduced. Seed weight reductions in the upper, middle, and lower canopy levels were 8, 11, and 16%, respectively, when compared with uninoculated plants sprayed with benomyl. In 1979, seed weight reductions of 8 and 5% in the lower canopy of naturally infected and inoculated plants were significantly different from seed weights of inoculated plants sprayed with benomyl. Number of pods per plant or of seeds per pod did not differ significantly, except for the greater number of seeds per pod in the upper canopy of inoculated plants sprayed with benomyl in 1978. Brown spot severity, brown spot vertical progress, and defoliation were greatest in plots of inoculated soybeans.

Additional key words: disease losses, *Glycine max*

Brown spot of soybeans (*Glycine max* (L.) Merr) caused by *Septoria glycines* Hemmi is a common leaf spot disease in the Midwest (1). The pathogen spreads from lower to upper leaves in warm, humid weather (5). Severe infection often results in premature defoliation. Brown spot is now the most prevalent foliar disease of soybeans in Illinois (12). Yields have been reduced from 12 to 34% following inoculations with *S. glycines* (8,15,16). Yields have been reduced about 8% following natural brown spot infection (8).

Ultimately, brown spot influences soybean yields through its effect on yield components, ie, number of pods per plant, number of seeds per pod, and seed weight. Young and Ross (16) reported a negative correlation between seed size and *S. glycines* infection. Correlations were significant when brown spot was severe and not significant when brown spot was less severe. In a study that simulated defoliation from foliar diseases, Lockwood et al (9) reported soybean yield reductions of about 20% when leaves from the lower two-thirds of the canopy were removed at early flowering and progressive defoliation from the lower to upper canopy was continued throughout the season. Greater reductions occurred when defoliation was more severe. The yield reductions were the result of fewer pods, fewer seeds per pod, and lower seed weights. Other investigators have also reported yield reductions due to defoliation in soybeans (2,7,11,13,14).

Because brown spot spreads from lower to upper leaves, its effects on yield components may vary at different levels of the crop canopy. This study sought to determine the effects of brown spot on soybean yield components at different canopy levels.

MATERIALS AND METHODS

We planted Williams soybeans in a Drummer silty clay loam at Urbana, IL, in rows 6.7 m long and spaced 75 cm apart on 26 May 1978 and 23 May 1979. The planting rate was approximately 37.5 seeds per meter. Both fields had been planted to corn the previous year.

Four replications of four treatments were arranged in a randomized complete block design. The four treatments, which were applied to six-row plots, consisted of inoculation with *S. glycines*, inoculation with *S. glycines* and benomyl sprays, benomyl sprays, and natural brown spot infection. The benomyl (Benlate 50W) was applied at early (R1), middle (R3), and late (R6) reproductive growth stages (3).

Inoculum was produced by culturing *S. glycines* (ATCC 38699) on potato-dextrose agar at 22–26 C for 2–3 wk. Cultures were comminuted in tap water and filtered through several layers of cheesecloth. Inoculum concentration was adjusted to approximately 10^6 spores per milliliter. The plants were inoculated at

Table 1. Yield components at the upper, middle, and lower canopy levels of Williams soybeans inoculated with *Septoria glycines* or protected with benomyl

	Upper			Middle			Lower		
Treatment	Pods (no.)[a]	Seeds per pod (no.)[b]	Seed weight (mg)[c]	Pods (no.)	Seeds per pod (no.)	Seed weight (mg)	Pods (no.)	Seeds per pod (no.)	Seed weight (mg)
					1978				
Uninoculated; benomyl[d]	14.7	2.2	173	29.2	2.3	199	17.1	2.0	186
Inoculated; benomyl	13.8	2.4	169	28.0	2.3	189	16.2	2.0	181
Natural infection	13.8	2.2	174	25.8	2.2	197	14.6	2.0	180
Inoculated	14.3	2.2	159	25.8	2.3	177	12.7	1.9	156
F.L.S.D. (0.05)[e]	NS[f]	0.15	8.2	NS	NS	14.2	NS	NS	18.7
					1979				
Uninoculated; benomyl	12.4	2.4	186	27.3	2.6	196	22.0	2.5	187
Inoculated; benomyl	12.4	2.6	199	26.2	2.6	202	18.5	2.4	192
Natural infection	13.7	2.5	192	28.1	2.6	186	20.8	2.5	177
Inoculated	13.8	2.5	179	29.1	2.6	183	19.4	2.5	182
F.L.S.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	8.7

[a] Mean number of pods per one-third of the plant.
[b] Mean number of seeds per pod.
[c] Mean individual seed weight.
[d] Applied at 1.12 kg/ha at the R1, R3, and R6 growth stages (3).
[e] F.L.S.D. = Fisher's Least Significant Difference.
[f] NS = not significant.

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the V4 growth stage.

Every 7–14 days from inoculation to harvest maturity, we evaluated soybeans for disease using a modified Horsfall-Barratt rating system (6). Brown spot severity, expressed as the percentage of the total leaf area diseased, was determined by converting ratings with the Elanco conversion tables (Elanco Products Co., Indianapolis, IN 46140). The vertical spread of brown spot from lower to upper leaves was measured at each rating. This vertical progress was expressed as the percentage of the plant height (in nodes) to which brown spot had spread, according to the following formula: vertical progress (%) = (maximum height of brown spot symptoms/maximum height of plant) x 100. Defoliation percentage was also measured at each rating, based on the number of nodes from which leaves had dropped.

At maturity, we harvested 10 adjacent plants by hand from a section about 0.5 m long in the middle two rows of each six-row plot. Harvest dates were 11 October 1978 and 2 October 1979. Each plant was divided into upper, middle, and lower thirds according to the number of nodes on the main stem. Yield components—number of pods, seeds per pod, and seed weight—were measured for each third of each plant.

RESULTS

In 1978, seed weights from the upper, middle, and lower canopies of inoculated plants were significantly less than those from corresponding canopy levels of uninoculated plants sprayed with benomyl (Table 1). Inoculated plants had 8, 11, and 16% less seed weight in the upper, middle, and lower canopies, respectively. However, seed weights of plants exposed only to natural infection were not significantly different from those of any other treatment. The only significant difference among treatments in the number of pods per plant or of seeds per pod occurred in the upper canopy of inoculated plants sprayed with benomyl, which produced the highest number of seeds per pod.

In 1979, seed weights in the lower canopy of naturally infected and inoculated plants were significantly less (8 and 5%) than those in the lower canopy of inoculated plants sprayed with benomyl (Table 1). No significant differences in seed weights were found among treatments in the middle and upper canopies, although mean seed weights were lowest for inoculated plants. There were also no significant differences among treatments in other yield components.

Brown spot severity and vertical progress were greatest in plots of inoculated plants (Figs. 1 and 2). During the midreproductive growth stages (R3 to R6, late July to early September), the severity in plots of inoculated plants increased from 15 to 57% in 1978 and from 18 to 46% in 1979. In plots of uninoculated plants sprayed with benomyl, severity was less than 15% at R6 in both years. In 1978, vertical progress on inoculated plants reached more than 50% at R3, but the progress did not increase greatly until R6. In 1979, however, vertical progress reached 35% on inoculated plants at R3 and increased rapidly to 63% at R6. Vertical progress during midreproductive growth on uninoculated plants sprayed with benomyl was less than 15% in 1978 and 35% in 1979.

Defoliation was also greatest in plots of inoculated plants (Fig. 3). In 1978, defoliation was 25–35% in inoculated plots during midreproductive growth and increased to more than 60% at R7. In 1979, defoliation in inoculated plots was about 30% from R4 to maturity. In plots sprayed with benomyl, defoliation was below 25% except at R7 in 1978.

DISCUSSION

In this experiment, severe brown spot reduced seed weights in plots of inoculated soybeans. These results are in agreement with those of Young and Ross (16), who reported that soybean yield loss due to *S. glycines* occurs through reduced seed size. The seed weight reductions

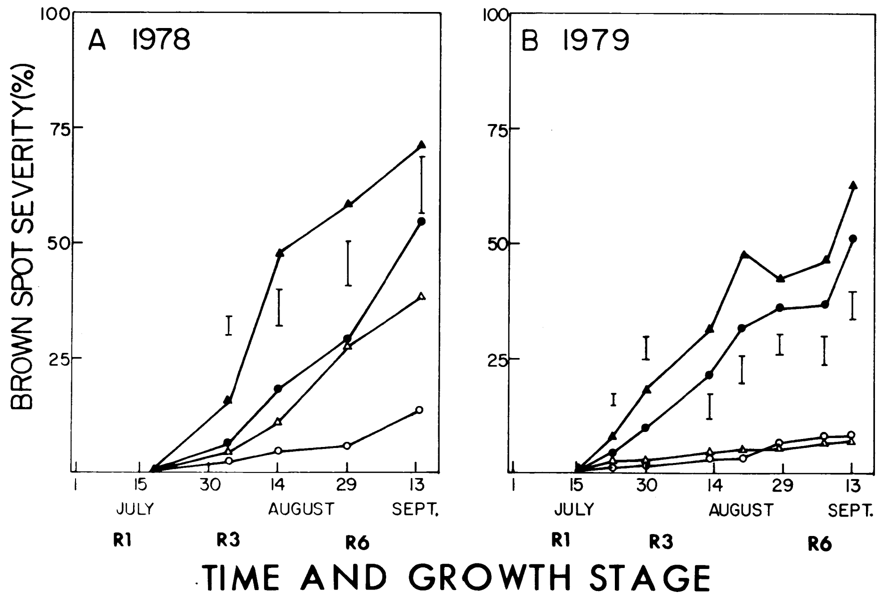

Fig. 1. Brown spot severity in **(A)** 1978 and **(B)** 1979 for Williams soybeans inoculated with *Septoria glycines* (▲), inoculated and sprayed with benomyl (Δ), sprayed with benomyl (o), or natural brown spot infection (●). Vertical bar = least significant difference ($P = 0.05$) for values shown.

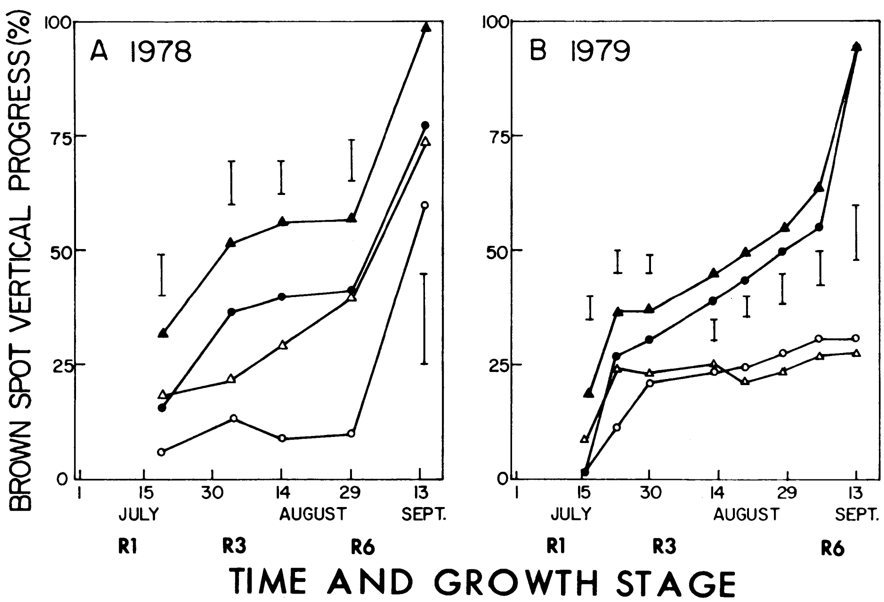

Fig. 2. Brown spot vertical progress in **(A)** 1978 and **(B)** 1979 for Williams soybeans inoculated with *Septoria glycines* (▲), inoculated and sprayed with benomyl (Δ), sprayed with benomyl (o), or natural brown spot infection (●). Vertical bar = least significant difference ($P = 0.05$) for values shown.

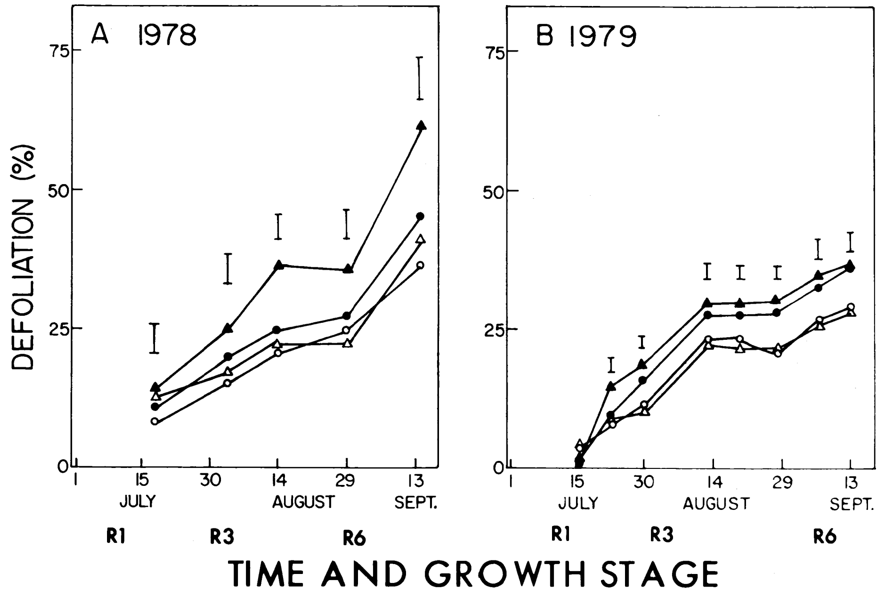

Fig. 3. Defoliation in **(A)** 1978 and **(B)** 1979 for Williams soybeans inoculated with *Septoria glycines* (▲), inoculated and sprayed with benomyl (Δ), sprayed with benomyl (o), or natural brown spot infection (●). Vertical bar = least significant difference ($P = 0.05$) for values shown.

observed in this study were apparently a result of changes in the physiology of infected plants (eg, reduced photosynthesis and movement of metabolites to infection sites rather than to developing seed).

Fucikovsky (4) reported that levels of chlorophyll a and b were decreased in soybean leaves infected with *S. glycines.* We would expect chlorophyll content in the inoculated plants in this study to be reduced at all canopy levels because the vertical progress of brown spot was greater than 90% for inoculated plants at R7. In the middle and lower canopies of inoculated plants, where seed weight reductions were the greatest in 1978, chlorophyll content may have been reduced during most of pod filling (R3–R6), as indicated by severity and vertical progress in August.

In a histologic study of brown spot, MacNeill and Zalasky (10) reported that soybean seeds can become detached from pods when *S. glycines* invades the placentae and funiculi. This type of pod infection could also reduce seed weights, although severe pod infection was not observed in this study.

Premature defoliation may account for some of the reduced seed weight; however, defoliation was extremely severe only at late growth stages in 1978. Although inoculated plants were significantly more defoliated than plants sprayed with benomyl, the defoliation was still substantially less than that reported in experiments that investigated the effects of leaf removal on soybean yield components (2,7,11,13,14). Furthermore, other studies of soybean defoliation have linked yield reductions with number of pods per plant and of seeds per pod (2,7,11,13,14), whereas these two yield components were not greatly affected in this study. All three yield components may be reduced when brown spot and premature defoliation are both severe.

The quantitative relationships between brown spot and soybean yield losses should be further investigated through studies of severity, vertical progress, defoliation, and yield components. Studies of the physiologic changes in soybeans infected with brown spot are also needed to understand better how this disease affects yields. These studies could provide useful information for developing controls of brown spot through disease tolerance, disease resistance, or chemical sprays.

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LITERATURE CITED

1. Chamberlain, D. W. 1973. Soybean diseases in Illinois. Ill. Univ. Coop. Ext. Serv. Circ. 1085. 33 pp.
2. Egli, D. B., Gossett, D. R., and Leggett, J. E. 1976. Effect of leaf and pod removal on the distribution of ^{14}C labeled assimilate in soybeans. Crop Sci. 16:791-794.
3. Fehr, W. R., Caviness, C. E., Burmood, D. T., and Pennington, J. S. 1971. Stage of development descriptions for soybeans, *Glycine max* (L.) Merrill. Crop Sci. 11:929-931.
4. Fucikovsky, L. A. 1972. Pigments of soybean leaves infected by *Septoria glycines* and *Pseudomonas glycinea.* Trans. Br. Mycol. Soc. 59:506-508.
5. Hemmi, T. 1915. A new brown-spot disease of the leaf of *Glycine hispida Maxim.* caused by *Septoria glycines* sp. n. Trans. Sapporo Nat. Hist. Soc. 6:12-17.
6. Horsfall, J. G., and Barratt, R. W. 1945. An improved system for measuring plant diseases. (Abstr.) Phytopathology 35:655.
7. Johnston, T. J., and Pendleton, J. W. 1968. Contribution of leaves at different canopy levels to seed production of upright and lodged soybeans. Crop Sci. 8:291-292.
8. Lim, S. M. 1980. Brown spot severity and yield reduction in soybean. Phytopathology 70:974-977.
9. Lockwood, J. L., Percich, J. A., and Maduewesi, J. N. C. 1977. Effect of leaf removal simulating pathogen-induced defoliation on soybean yields. Plant Dis. Rep. 61:458-462.
10. MacNeill, B. H., and Zalasky, H. 1957. Histological study of host-parasite relationships between *Septoria glycines* Hemmi and soybean leaves and pods. Can. J. Bot. 35:501-505.
11. McAlister, D. F., and Krober, O. A. 1958. Response of soybeans to leaf and pod removal. Agron. J. 50:674-677.
12. Pataky, J. K., Lim, S. M., Jordan, E. G., and Warsaw, R. L. 1979. Monitoring soybeans for foliar disease. Ill. Res. 21 (3):3-4.
13. Teigen, J. B., and Vorst, J. J. 1975. Soybean response to stand reduction and defoliation. Agron. J. 67:813-816.
14. Weber, C. R. 1955. Effects of defoliation and topping simulating hail injury to soybeans. Agron. J. 47:262-266.
15. Williams, D. J., and Nyvall, R. F. 1980. Leaf infection and yield losses caused by brown spot and bacterial blight diseases of soybeans. Phytopathology 70:900-902.
16. Young, L. D., and Ross, J. P. 1979. Brown spot development and yield response of soybeans inoculated with *Septoria glycines* at various growth stages. Phytopathology 69:8-11.