Yield Losses in Soybeans Caused by Bacterial Tan Spot

J. M. DUNLEAVY, Research Plant Pathologist, Agricultural Research Service, U.S. Department of Agriculture, 317 Bessey Hall, Iowa State University, Ames 50011

ABSTRACT

Dunleavy, J. M. 1984. Yield losses in soybeans caused by bacterial tan spot. Plant Disease 68: 774-776.

In a preliminary field test, cupric hydroxide was effective as a protectant in the field against *Corynebacterium flaccumfaciens*, the cause of soybean bacterial tan spot, in uninoculated, susceptible Clark soybeans. It failed, however, to eradicate the disease in inoculated plants. The disease spread in both inoculated and unsprayed rows. In other trials, seed yield losses to tan spot ranged from 0.0 to 18.8%. Mean yield losses of 12.5% in 1979, 0.0% in 1980, and 4.3% in 1981 were measured at three locations, and a mean yield loss of 7.7% was measured at one location in 1978.

Bacterial tan spot of soybeans (*Glycine max* (L.) Merr.), caused by *Corynebacterium flaccumfaciens* (Hedges) Dowson, was recently reported from Iowa (1). The first symptom is leaf chlorosis, which frequently begins at the edge of a leaflet and progresses toward the midrib. After several days, the chlorotic tissue dries and turns tan. Lesions sometimes develop in an oval or elongate pattern on the leaflet surface and progress toward both the midrib and leaflet edge. During high winds, the necrotic portions of lesions may fall, giving a ragged appearance to leaves. A single lesion on a young, expanding leaflet may spread over the entire surface. Such leaves form abscission layers and fall to the ground. Bacterial tan spot has been known to be very destructive to leaf tissue of susceptible cultivars, but its effect on yield was unknown. Therefore, this study was undertaken to investigate possible seed yield losses caused by *C. flaccumfaciens*.

Joint contribution: Agricultural Research Service, U.S. Department of Agriculture, and Journal Paper No. J-11075 of the Iowa Agriculture and Home Economics Experiment Station, Ames; Project 2475.

Accepted for publication 27 February 1984.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

MATERIALS AND METHODS

Tests were conducted in Iowa near Ames (central), Kanawha (north central), and Nashua (northeast) on fertile, well-managed soils. A preliminary test was conducted only at Ames to determine the effects of *C. flaccumfaciens* inoculation and a protective spray of cupric hydroxide on seed yield of susceptible soybean cultivars Clark, Cutler 71, and Wayne. Treatments were inoculated, unsprayed; inoculated, sprayed; uninoculated, unsprayed; and uninoculated, sprayed. Other details of this test are as described for the 3-yr study.

For 3 yr, yield losses to *C. flaccumfaciens* were determined for three susceptible cultivars (Chippewa, Clark, and Rampage) and three resistant cultivars (Amsoy 71, Beeson, and Harcor). Susceptibility or resistance of these cultivars was determined in an earlier study (1). Plants were grown in rows 3 m long and 1 m wide. Each plot consisted of three rows; the center row was harvested for determination of seed yield.

At each location, plots of each cultivar were either inoculated and unsprayed or uninoculated and sprayed until runoff with a spray containing cupric hydroxide (77% a.i., 2 g/L) and phthalic glyceryl alkyd resin (spreader-sticker) at a concentration of 0.3 ml/L. Plants were sprayed weekly from 15 June (growth stage V1) until plant maturity (growth stage R7) (2). Each treatment was replicated six times in a complete randomized block. Inoculum was prepared as described elsewhere (1). Plants were inoculated as seedlings when the first trifoliolate leaves were expanding. Four plants were inoculated by rubbing at each of three locations in the row, at the center of the row, and 30 cm from each end. The percentage of diseased plants was determined 6 wk after inoculation by examining the first 50 plants in each row, and only leaves above the third trifoliolate were examined.

Table 1. Effect of *Corynebacterium flaccumfaciens* inoculation and protective sprays of cupric hydroxide on bacterial tan spot incidence and on seed yield of three susceptible soybean cultivars in 1978

	Cultivar					
	Clark		Cutler 71		Wayne	
Treatment	Diseased plants (%)	Seed yield (q/ha)	Diseased plants (%)	Seed yield (q/ha)	Diseased plants (%)	Seed yield (q/ha)
Inoculated, unsprayed	94.7[a]	22.1[a]	91.8	23.3	89.3	23.0
Inoculated, sprayed	91.8	22.3	90.3	22.9	91.5	22.8
Uninoculated, unsprayed	87.7	22.7	90.8	22.9	88.8	22.7
Uninoculated, sprayed	0.7**[b]	24.3*	0.3**	25.0*	0.2**	24.7*

[a] Represents mean of six replicates.

[b] * = Significantly different from other treatments of the same cultivar at $P < 0.05$; ** = significantly different from other treatments of the same cultivar at $P < 0.01$.

RESULTS AND DISCUSSION

In 1978, cupric hydroxide was effective as a protectant in uninoculated, sprayed rows. The disease was not eradicated by the chemical in inoculated, sprayed rows, and consequently, spread of the disease to all unsprayed rows was rapid and extensive (Table 1). Fewer than 1% of the plants in the uninoculated, sprayed plots were infected; incidence of infected plants in the remaining treated plots (inoculated, unsprayed; inoculated, sprayed; and uninoculated, unsprayed) ranged from a mean of 87.7 to 94.7%. Yields from uninoculated, sprayed plots were greater (significant at $P<0.05$) than yields from plots receiving all other treatments. When seed yields from uninoculated, sprayed plots were compared with those from uninoculated, unsprayed plots, the respective percentages of yield loss caused by bacterial tan spot for Clark, Cutler 71, and Wayne were 6.6, 8.4, and 8.1. The mean yield loss for these cultivars was 7.7%.

In 1979, the first year of a 3-yr study, bacterial tan spot spread rapidly on leaves of susceptible plants at all three locations. Leaves of plants in the Kanawha test were moderately torn by hail in mid-August. At Ames, respective seed yields of susceptible cultivars Chippewa, Clark, and Rampage were 13.2, 8.3, and 8.8% lower (significant at $P<0.05$) in inoculated, unsprayed plots than is uninoculated, sprayed plots (Table 2). The mean yield for these cultivars was 10.1% lower, and the mean percentage of diseased plants in the inoculated, unsprayed rows was 91.2% compared with 0.6% in the uninoculated, sprayed rows. At Kanawha, respective seed yields of the same cultivars were 18.8, 13.5, and 18.4% lower (significant at $P<0.01$) in inoculated, unsprayed plots than in uninoculated, unsprayed plots. The mean yield for these cultivars was 16.9% lower, and the mean percentage of diseased plants in the inoculated, unsprayed rows was 95.6% compared with 5.0% in the uninoculated, sprayed rows. At Nashua, respective seed yields of the same cultivars were 10.0, 12.0, and 9.9% lower (significant at $P<0.01$) in inoculated, unsprayed plots than in uninoculated, sprayed plots. The mean yield for these cultivars was 10.6% lower, and the mean percentage of diseased plants in the inoculated, unsprayed rows was 98.3% compared with 0.6% in the uninoculated, sprayed rows.

In 1980, bacterial tan spot spread slowly in plots of susceptible cultivars at Ames, and the disease rarely affected leaves above the sixth trifoliolate leaf. At Kanawha and Nashua, disease development was greater than at Ames but was less than in 1979. Seed yields from susceptible cultivars in uninoculated, sprayed plots were not significantly different from those of inoculated, unsprayed plots at any location. Among susceptible cultivars, the percentage of diseased plants in the inoculated, unsprayed rows differed significantly ($P<0.01$) from that in the uninoculated, sprayed rows at all locations.

In 1981, lack of rain early in the season prevented disease spread from inoculated plants at Ames. At Kanawha, there was some disease development but less than in 1979. Disease development at Nashua was equivalent to that observed in 1979, and yields from inoculated, unsprayed plots of susceptible cultivars were lower (significant at $P<0.05$) than yields from uninoculated, sprayed plots. Respective seed yields of susceptible cultivars Chippewa, Clark, and Rampage were 12.5, 13.1, and 13.1% lower (significant at $P<0.05$) in inoculated, unsprayed plots than in uninoculated, sprayed plots. The mean yield loss for these cultivars was 12.9%, and the mean percentage of diseased plants in the inoculated, unsprayed rows was 97.2% compared with 3.3% in the uninoculated, sprayed rows.

During the 3 yr of testing, the seed yield losses in susceptible cultivars ranged from 0.0 to 18.8%, with mean yield losses at the three locations of 12.5% in 1979, 0.0 in 1980, and 4.3% in 1981. Plants of resistant cultivars were not infected by *C. flaccumfaciens*, and their seed yields were unaffected by treatment with cupric hydroxide. No disease except bacterial tan spot reduced the yield in unsprayed plots of susceptible plants and cupric hydroxide was neither phytotoxic nor stimulatory to resistant plants. The highest mean yield loss at a location (16.9%) occurred at Kanawha in 1979. Hail caused some leaf damage to these

Table 2. Disease incidence and seed yield from *Corynebacterium flaccumfaciens*-inoculated, unsprayed and uninoculated, cupric hydroxide-sprayed plots of soybean cultivars resistant and susceptible to bacterial tan spot at three locations in Iowa in 1979, 1980, and 1981

Year, cultivar, and disease reaction[a]	Ames				Kanawha				Nashua			
	Inoculated, unsprayed		Uninoculated, sprayed		Inoculated, unsprayed		Uninoculated, sprayed		Inoculated, unsprayed		Uninoculated, sprayed	
	Diseased plants (%)	Seed yield (q/ha)	Diseased plants (%)	Seed yield (q/ha)	Diseased plants (%)	Seed yield (q/ha)	Diseased plants (%)	Seed yield (q/ha)	Diseased plants (%)	Seed yield (q/ha)	Diseased plants (%)	Seed yield (q/ha)
1979												
Chippewa (S)	96.7[b]	17.1[b]	1.7**[c]	19.7*	98.3	17.3	8.3**	21.3**	98.3	21.6	0.0**	24.0**
Clark (S)	88.3	22.2	0.0**	24.2*	91.7	21.1	0.0**	24.4**	100.0	21.9	1.7**	24.9**
Rampage (S)	88.6	19.8	0.0**	21.7*	96.7	18.6	6.7**	22.8**	96.7	21.9	0.0**	24.3**
Amsoy 71 (R)	0.0	23.2	0.0	24.1	0.0	23.6	0.0	23.1	0.0	26.7	0.0	25.7
Beeson (R)	0.0	26.5	0.0	27.1	0.0	25.2	0.0	25.6	0.0	26.8	0.0	26.3
Harcor (R)	0.0	26.8	0.0	25.7	0.0	24.6	0.0	24.7	0.0	29.0	0.0	29.0
1980												
Chippewa (S)	34.3	22.0	0.0**	21.6	56.7	17.2	0.0**	17.1	53.3	22.2	0.0**	21.9
Clark (S)	31.7	23.9	0.0**	22.7	60.0	16.9	0.0**	16.6	66.7	22.5	0.0**	22.7
Rampage (S)	35.0	22.7	0.0**	23.8	55.0	20.1	0.0**	18.7	65.0	21.8	0.0**	22.1
Amsoy 71 (R)	0.0	26.4	0.0	25.9	0.0	21.1	0.0	20.8	0.0	26.0	0.0	25.8
Beeson (R)	0.0	28.2	0.0	28.9	0.0	23.3	0.0	23.4	0.0	27.5	0.0	26.9
Harcor (R)	0.0	26.1	0.0	26.6	0.0	23.1	0.0	23.9	0.0	25.9	0.0	26.9
1981												
Chippewa (S)	0.0	21.0	0.0	20.9	51.7	22.7	0.0**	23.4	100.0	19.6	5.0**	22.4*
Clark (S)	0.0	28.7	0.0	28.9	58.3	20.6	0.0**	20.5	95.0	23.3	3.3**	26.8*
Rampage (S)	0.0	21.4	0.0	22.4	58.3	24.9	0.0**	24.5	96.7	19.3	1.7**	22.2*
Amsoy (R)	0.0	25.8	0.0	25.3	0.0	24.8	0.0	26.0	0.0	28.0	0.0	27.6
Beeson (R)	0.0	26.4	0.0	27.0	0.0	26.9	0.0	29.0	0.0	30.2	0.0	29.5
Harcor (R)	0.0	23.6	0.0	23.0	0.0	25.4	0.0	24.7	0.0	24.4	0.0	26.5

[a] S = susceptible, R = resistant.
[b] Represents mean of six replicates.
[c] * = Significant at $P<0.05$; ** = significant at $P<0.01$.

plants. Zaumeyer and Thomas (3) noted that after hailstorms, *C. flaccumfaciens* spread over almost entire bean fields where only a few infected plants had been observed previously. They also reported bean fields in Colorado were nearly a total loss because of the severity of bean wilt, the disease that *C. flaccumfaciens* produces in beans. Bacterial tan spot symptoms on susceptible soybean plants were less severe than those described by Zaumeyer and Thomas for bean.

Although seed yield losses were variable, bacterial tan spot can be an important soybean disease when it occurs on very susceptible cultivars. Resistance to *C. flaccumfaciens* in soybeans is readily available among improved, high-yielding cultivars (1). Use of cultivars resistant to bacterial tan spot by soybean producers would be beneficial in areas where bacterial tan spot occurs.

ACKNOWLEDGMENT

I wish to thank J. W. Keck for his technical assistance.

LITERATURE CITED

1. Dunleavy, J. M. 1983. Bacterial tan spot, a new foliar disease of soybeans. Crop Sci. 23:473-476.
2. Fehr, W. R., and Caviness, C. E. 1977. Stages of soybean development. Spec. Rep. 80. Ia. State Univ., Ames. 11 pp.
3. Zaumeyer, W. J., and Thomas, H. R. 1957. A monographic study of bean diseases and methods for their control. U.S. Dep. Agric. Tech. Bull. 868. 255 pp.