Cultivar Resistance to Field Infestations of Soybean Stem Canker

D. B. WEAVER, Assistant Professor, and B. H. COSPER, Research Associate, Department of Agronomy and Soils, and P. A. BACKMAN, Professor, and M. A. CRAWFORD, Research Associate, Department of Botany, Plant Pathology, and Microbiology, Alabama Agricultural Experiment Station, Auburn University 36849

ABSTRACT

Weaver, D. B., Cosper, B. H., Backman, P. A., and Crawford, M. A. 1984. Cultivar resistance to field infestations of soybean stem canker. Plant Disease 68: 877-879.

Forty-one adapted soybean cultivars were evaluated for resistance to stem canker caused by *Diaporthe phaseolorum* var. *caulivora* in naturally infested fields, and effects of the disease on seed yield were determined. In 2 yr of field evaluations, almost all adapted soybean cultivars were susceptible to stem canker. Disease expression among cultivars varied from highly resistant to highly susceptible, with most cultivars between these extremes. Braxton and Tracy-M were virtually immune, whereas Hutton, Coker 237, and other cultivars were highly susceptible. Seed yield was negatively correlated with disease severity in all environments.

Additional key words: genetic resistance, *Glycine max*

Stem canker disease of soybeans (*Glycine max* (L.) Merr.) caused by *Diaporthe phaseolorum* (Cke. & Ell.) (Sacc.) var. *caulivora* Athow & Caldwell was found in isolated areas of Alabama in 1977 (3). Since then, it has become widespread throughout the state, causing severe crop losses in 19 counties and moderate losses in 17 counties in 1983. It has also been found in varying levels of severity in South Carolina (9), Mississippi (7), and Tennessee (6), and unpublished reports of significant losses have come from Florida, Louisiana, and Georgia.

AAES Journal No. 3-84593. Supported in part by a grant from the Alabama Soybean Producers.

Accepted for publication 13 April 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.

Stem canker was first reported in the north central United States in 1947 (10), and yield losses were estimated as high as 50% in isolated cases (1). The disease became prevalent in the early 1950s with the release of two highly susceptible and widely grown cultivars, Blackhawk and Hawkeye (2). Stem canker was subsequently controlled by eliminating these susceptible cultivars and now causes little damage in the north central states.

Stem canker appears to be much more severe in the southeastern United States, where yield losses have often been as high as 80% with certain cultivars (9). Symptoms of the disease are interveinal chlorosis and necrosis of the leaves and sunken reddish brown to black elongate cankers on the soybean stem, which are usually observed late in the growing season after the R3 (4) stage of development. As the disease progresses, plants appear to be dead or dying after the R5 stage, with frequency and time of collapse depending on the degree of infection and the genetic resistance of the host. Control can be effected through chemical and cultural practices (P. A. Backman, *unpublished*); these practices are most effective when used with cultivars that possess some resistance. Keeling (7) reported four distinct phenotypes for reaction to stem canker using the greenhouse toothpick inoculation technique. This technique is good for screening large numbers of experimental breeding lines to eliminate those with high and moderate levels of disease susceptibility; however, it does not seem to differentiate between some cultivars that respond differently to stem canker under field conditions. This may be due to morphological defense mechanisms that are overcome by the toothpick technique.

One objective of this research was to evaluate several adapted soybean cultivars for stem canker resistance under conditions of natural field infestation, both to identify highly susceptible cultivars that should be eliminated from production and those with enough resistance to be included in disease management programs. A second objective was to determine the effects of the disease on seed yield among different genotypes.

MATERIALS AND METHODS

Forty-one adapted cultivars in maturity groups V, VI, VII, and VIII were evaluated during 1982 and 1983. Tests in both years were at Marion Junction, AL, on Vaiden clay and Sumter clay soil. In 1983, a test was also conducted at Shorter, AL, on Norfolk fine sandy loam. Test sites were selected because of natural stem canker infestation. Not all cultivars were included in all five tests, but 19 cultivars were common to all environments and 38 were evaluated in at least four environments. Plots were four rows, each 4.9 m long with 0.9 m spacing between rows, arranged in a randomized complete-block design with either three or four replicates. Planting dates were between 15 and 25 May for all environments, except the Vaiden clay in 1982, which was planted on 15 June. Plots were seeded at a rate of 32 viable seed per meter of row and end-trimmed at harvest to 3.7 m and the center two rows harvested. Yields were adjusted to 13% moisture before analysis.

Stem canker ratings were made when most cultivars were at the R5 to R7 stages of development (4), usually during September, depending on planting date. The percentage of dead or dying plants was estimated for each plot and converted to a scale of 0–5 for analysis. Disease categories were not equal percentage increments but were unequal categories (P. A. Backman, *unpublished*) similar to a system developed by Hills et al (5) based on one-fifth the angular transformation from 0 to 90°. A plot with no dead or dying plants was rated 0.0, one with 10% dead or dying plants was rated 1.0, 35% was rated 2.0, 65% was rated 3.0, 90% was rated 4.0, and 100% was rated 5.0. Damage was estimated to the nearest

Table 1. Stem canker ratings[a] and seed yields of soybean cultivars grown in five environments in Alabama

	1982				1983							
	Sumter clay		Vaiden clay		Sumter clay		Vaiden clay		Norfolk fsl[b]		Mean[c]	
Cultivar	Yield (t/ha)	Disease rating	Yield (t/ha)	Disease rating	Yield (t/ha)	Disease rating	Yield (t/ha)	Disease rating	Yield (t/ha)	Disease rating	Yield (t/ha)	Disease rating
Maturity group V												
Bay	2.32	0.3	2.80	M	1.87	M	4.01	0.3	···	···	···	···
Bedford	1.61	1.6	2.05	M	1.27	1.2	3.79	1.1	···	···	···	···
Deltapine 105	2.17	0.7	2.84	M	1.82	1.5	4.45	0.8	1.30	1.3	2.52	1.0
Deltapine 345	···	···	2.20	M	1.79	1.4	3.67	0.9	0.93	1.2	···	···
Essex	1.50	M	2.45	M	1.49	M	3.51	0.6	···	···	···	···
Forrest	1.70	1.0	2.52	M	1.16	1.5	3.93	1.1	1.03	1.4	2.06	1.2
Terra-Vig 505	···	···	2.21	M	1.74	1.6	4.35	0.7	1.32	1.1	···	···
Maturity group VI												
A 6520	···	···	···	···	1.40	1.1	3.90	0.8	···	···	···	···
AgraTech 67	1.50	2.0	···	···	1.50	0.9	4.05	0.1	1.89	0.3	···	···
Centennial	1.81	0.3	2.88	1.4	1.36	0.9	4.07	0.2	1.97	0.4	2.42	0.6
Coker 156	1.70	0.6	2.70	1.9	1.49	1.3	4.34	0.1	2.08	0.3	2.46	0.8
Davis	2.24	0.6	2.53	2.1	2.04	0.9	3.86	0.3	2.01	0.1	2.54	0.8
Deltapine 506	···	···	2.60	1.7	1.90	0.9	3.86	0.3	···	···	···	···
Hartz 7126	···	···	2.42	1.2	1.18	1.2	3.84	0.5	1.80	0.9	···	···
Jeff	1.80	0.8	2.23	1.6	0.95	2.1	3.44	1.3	1.13	1.6	1.91	1.5
Lee 74	1.67	1.2	2.37	2.1	1.40	1.4	3.44	0.8	···	···	···	···
RA 604	···	···	1.84	M	0.95	2.1	2.77	1.7	0.66	2.5	···	···
RA 680	···	···	2.44	1.3	1.35	0.9	3.97	0.1	2.03	0.2	···	···
S69-96	1.58	1.5	···	···	···	···	···	···	1.95	1.1	···	···
Terra-Vig 606	···	···	2.40	2.3	1.72	1.0	4.52	0.0	1.67	0.7	···	···
Tracy-M	2.33	0.0	2.59	M	1.40	0.0	4.05	0.0	1.71	0.0	2.41	0.0
Maturity group VII												
AP 70	1.79	2.0	2.49	1.2	2.03	0.7	3.68	0.1	1.89	0.6	2.38	0.9
Braxton	2.11	0.0	3.34	0.9	2.58	0.0	4.21	0.0	2.39	0.0	2.93	0.2
Coker 237	1.31	1.2	2.57	1.6	1.36	2.1	3.71	1.2	1.57	1.4	2.10	1.5
Coker 317	···	···	2.23	1.5	1.38	1.0	3.31	0.4	1.90	0.6	···	···
Deltapine 497	···	···	2.88	1.0	1.47	0.6	4.18	0.2	2.24	0.6	···	···
Duocrop	2.00	1.7	2.23	2.3	1.52	1.1	3.12	0.4	1.09	0.6	1.99	1.2
GaSoy 17	1.79	1.3	2.50	1.2	1.72	0.8	3.66	0.5	1.94	0.7	2.32	0.9
Govan	1.71	1.9	2.52	1.3	1.23	0.8	3.90	0.4	2.04	0.3	2.28	0.9
HB507-D1-7	···	···	2.97	1.4	1.97	0.8	4.30	0.2	1.79	0.3	···	···
Ransom	1.74	1.5	2.87	1.2	1.94	1.0	4.12	0.8	2.01	1.0	2.53	1.1
RA 702	···	···	1.52	2.1	0.94	2.2	2.26	2.0	1.24	1.8	···	···
Terra-Vig 708	···	···	···	···	···	···	···	···	1.14	1.4	···	···
Wilstar 790	0.58	2.2	1.85	1.8	1.36	1.6	2.38	1.5	···	···	···	···
Wright	1.75	1.3	2.60	1.3	2.07	0.6	4.14	0.1	2.01	0.6	2.51	0.8
Maturity group VIII												
Cobb	1.66	1.7	2.46	0.9	1.70	0.7	3.49	0.2	···	···	···	···
Coker 488	1.60	1.6	2.99	0.7	1.43	0.9	3.57	0.4	2.15	0.5	2.35	0.8
Foster	1.50	1.8	2.35	1.3	1.19	0.5	3.53	0.4	1.73	1.2	2.06	1.0
Hutton	0.64	2.2	1.66	2.0	0.48	2.5	1.51	2.1	0.79	2.1	1.01	2.2
Kirby	1.26	1.7	2.64	0.9	1.04	0.7	3.45	0.7	1.89	0.2	2.06	0.8
RA 801	···	···	1.82	1.9	0.60	2.3	1.53	2.1	0.98	1.9	···	···
$\overline{X}$	1.68	1.2	2.45	1.5	1.48	1.2	3.64	0.7	1.69	0.9	2.26	1.0
LSD 0.05	0.40	0.6	0.48	0.5	0.41	0.5	0.48	0.3	0.68	0.4	0.18	0.2
r^d	−0.73		−0.61		−0.62		−0.78		−0.77		−0.83	

[a] Disease rated on a scale of 0–5 based on transformed arc sine scale, where M = mature at rating date, 0 = no disease, 1 = 10%, 2 = 35%, 3 = 65%, 4 = 90%, and 5 = 100% dead or dying plants.
[b] Fine sandy loam.
[c] Means computed only for those cultivars tested in all environments.
[d] Correlation between stem canker rating and seed yield.

5% and converted to the rating scale accordingly. Thus, a plot judged to have 25% dead or dying plants was rated 1.6. Seed yield and disease rating data were analyzed for each environment using analysis of variance procedures, and differences between cultivar means were tested using Fisher's least significant difference procedure.

RESULTS

Significant disease development occurred in all environments. Disease ratings ranged from a mean of 0.7 in the 1983 Vaiden clay environment (fewer than 10% dead or dying plants per plot) to 1.5 in the 1982 Vaiden clay environment (20% dead or dying plants per plot) (Table 1). Cultivars differed significantly from each other ($P = 0.05$) in disease severity in all tests. Tracy-M and Braxton consistently had the lowest disease ratings across all environments, with mean ratings of 0.0 and 0.2, respectively. No other cultivars approached these low ratings when averaged across all environments. Several cultivars had consistently high levels of susceptibility, particularly Ring Around 604, Jeff, Coker 237, Ring Around 702, Hutton, and Ring Around 801. Hutton averaged 40% damaged plants across all environments. The remaining cultivars could generally be classified as moderately resistant to moderately susceptible and had disease ratings that depended somewhat on the disease level or the virulence of the biotype present in the particular environment. For example, Davis rated 0.1 (one damaged plant per plot) in the Norfolk test, with a fairly light level of disease, and rated 2.1 (40% damaged plants) in the 1982 Vaiden test, with severe stem canker disease. When ratings were analyzed across environments for those cultivars common to all tests, the cultivar × environment interaction was highly significant ($P = 0.01$). Some early-maturing cultivars, such as Essex, were near maturity when the experiments were rated and data were collected on seed yield only.

Cultivars also showed significant differences ($P = 0.05$) in seed yields in all environments. In general, cultivars with high levels of disease had the lowest yields. Braxton, one of the most resistant cultivars, had the highest seed yield in three of the five environments and significantly higher mean yield than any other cultivar across all environments. Tracy-M had the highest seed yield in the severe disease of the 1982 Sumter clay environment, but its performance in the other tests was about average. Yields of cultivars considered moderately resistant or susceptible were less affected by the disease than those considered susceptible. Yield was negatively correlated with disease rating in all environments, with correlation coefficients ranging from −0.62 to −0.78.

DISCUSSION

Most adapted cultivars had at least some degree of resistance to stem canker and several had levels that could be effective in reducing disease losses when combined with recommended chemical and cultural control practices. Because of the wide variation in expression of resistance, it seems likely that resistance is controlled by more than one gene pair. Only Braxton was superior in both disease resistance and yield. Neither Braxton nor Tracy-M have any genetic resistance to the soybean cyst nematode (*Heterodera glycines* Ichinohe) and thus should not be used in fields where this pest is a major problem. Soybean cyst or root-knot (*Meloidogyne* spp.) nematodes are frequently a major problem in areas where stem canker has been identified. Cultivars with multiple nematode resistance such as Forrest, Bedford, Jeff, Foster, and Kirby were rated as moderately susceptible to stem canker. Only Centennial could be classified as a multiple-nematode-resistant cultivar with moderate stem canker resistance. A major objective of plant breeders in the immediate future should be to incorporate the stem canker resistance of Tracy-M and Braxton into genotypes with multiple nematode resistance. Because of the significant genotype × environment interaction for disease rating, there may be some degree of variation within the pathogen population. There is evidence that races of the pathogen exist (8); this will cause further complications for plant breeders.

Elimination of highly susceptible types from all soybean production systems is highly advisable. At least two of these, Coker 237 and Hutton, have been widely grown in recent years. These and other susceptible cultivars have probably contributed to the stem canker epiphytotic. A strong effort should be made to educate producers, encouraging them not to grow these cultivars in the future. This may prove helpful in decreasing the severity of stem canker as it did in the north central U.S. soybean production area. Research is needed to determine the virulence of southern isolates of *D. phaseolorum* var. *caulivora* on northern soybean cultivars. The possibility exists that the spread of these isolates will continue until other major soybean-growing areas have been affected.

LITERATURE CITED

1. Andrews, E. A. 1950. Stem blight of soybeans in Michigan. Plant Dis. Rep. 34:214.
2. Athow, K. L. 1973. Fungal diseases. Pages 459-489 in: Soybeans: Improvement, Production, and Uses. B. E. Caldwell, ed. American Society of Agronomy, Madison, WI. 681 pp.
3. Backman, P. A., Crawford, M. A., White, J., Thurlow, D. L., and Smith, L. A. 1981. Soybean stem canker: A serious disease in Alabama. Auburn Univ. Highlights Agric. Res. 28(4):6.
4. Fehr, W. R., Caviness, C. E., Burmood, D. L., and Pennington, J. S. 1971. Stage of development descriptions for soybeans. Crop Sci. 11:929-931.
5. Hills, F. J., Chiarappa, L., and Geng, S. 1980. Powdery mildew of sugar beet: Disease and crop loss assessment. Phytopathology 70:680-682.
6. Hilty, J. W. 1981. Soybean stem canker, a major disease in 1981. Tenn. Farm Home Sci. (120): 16-17.
7. Keeling, B. L. 1982. A seedling test for resistance to soybean stem canker caused by *Diaporthe phaseolorum* var. *caulivora*. Phytopathology 72:807-809.
8. Keeling, B. L. 1984. Evidence for physiologic specialization in *Diaporthe phaseolorum* var. *caulivora*. J. Miss. Acad. Sci. Suppl. 29:5.
9. Krausz, J. P., and Fortnum, B. A. 1983. An epiphytotic of Diaporthe stem canker of soybean in South Carolina. Plant Dis. 67:1128-1129.
10. Welch, A. W., and Gilman, J. C. 1948. Hetero- and homothallic types of *Diaporthe* on soybeans. Phytopathology 38:628-637.