Annals of Applied Nematology 2:65–69. 1988.

Performance of Soybean Cultivars in *Hoplolaimus columbus*-infested Fields[1]

J. D. MUELLER,[2] D. P. SCHMITT,[3] G. C. WEISER,[4]
E. R. SHIPE,[4] AND H. L. MUSEN[4]

Abstract: Yield performance and host suitability to *Hoplolaimus columbus* of 18 soybean cultivars in maturity groups V and VI and 21 cultivars in groups VII and VIII were evaluated in 10 experiments. No cultivar was highly resistant to *H. columbus.* Within individual experiments, few differences were detected in yield losses among cultivars; however, over all locations Braxton, Coker 485, and Leflore were intolerant to *H. columbus.* Braxton also exhibited pronounced chlorosis at all locations. Coker 368, Coker 488, Deltapine 506, Foster, Kirby, Ring Around 680, and Young sustained high yields.
Key words: Columbia lance nematode, *Glycine max, Hoplolaimus columbus,* resistance, soybean, tolerance, yield.

The Columbia lance nematode, *Hoplolaimus columbus* Sher, occurs in the coastal plains of Georgia, North Carolina, and South Carolina (3,5,13). It causes yield losses up to 70% on soybean (*Glycine max* (L.) Merr.) (1,10). Management of this nematode is difficult because of its wide host range (7,9) and ability to survive extreme environments (6). Failure of nematicides to provide economical control makes the identification and use of resistant or tolerant cultivars critical for economical management of *H. columbus* on soybean (1,13).

Performance of soybean in *H. columbus*-infested fields varies among cultivars. Centennial, Coker 156, Coker 368, Coker 4504, D71-9257, Dyer, ED-371, Foster, Hardee, W-4, and Wright are tolerant (3,9–11,13), whereas Bragg, Braxton, Coker 237, Davis, Deltapine 105, Gordon, and Pickett are intolerant (1,3,9–11,13). Our objective was to identify other soybean cultivars adapted to the southeastern United States that would achieve high yields in *H. columbus*-infested fields.

MATERIALS AND METHODS

Ten randomized complete block design (RCBD) experiments were conducted over a 3-year period to evaluate soybean cultivars for performance in one *H. columbus*-infested field in North Carolina and two fields in South Carolina. Five of these experiments were conducted to compare cultivars in maturity groups V and VI, and the remainder were conducted to compare cultivars in maturity groups VII and VIII.

The two sites in South Carolina were in Barnwell County and Darlington County (Pee Dee Research and Education Center). The Barnwell County site was a Varina loamy sand (85% sand, 8% silt, 7% clay, 1% organic matter; pH 6.2). At-planting population densities of *H. columbus* were 80/100 cm^3 soil in 1985 and 40/100 cm^3 soil in 1987. The Darlington County site was a Goldsboro sandy loam (78% sand, 18% silt, 4% clay, 0.8% organic matter; pH 6.1). At-planting population densities of *H. columbus* were 83/100 cm^3 soil in 1986 and 57/100 cm^3 soil in 1987. Soil at the third site, in Scotland County, North Carolina, was not analyzed for texture but it was a loamy sand similar to the Darlington County site and contained at-planting *H. colum-*

Received for publication 16 March 1988.
[1] Contribution No. 2823 of the South Carolina Agricultural Experiment Station, Clemson University.
[2] Assistant Professor, Department of Plant Pathology and Physiology, Edisto Research and Education Center, Clemson University, Blackville, SC 29817.
[3] Professor, Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695.
[4] Assistant, Associate, and Professor Emeritus, Department of Agronomy and Soils, Edisto Research and Education Center, Clemson University, Blackville, SC 29817.
We thank C. P. Alston, K. M. Carman, and J. A. Phillips for technical assistance.

TABLE 1. Source and maturity groups of soybean cultivars evaluated for yield performance and host suitability to *Hoplolaimus columbus* at two sites in South Carolina and one site in North Carolina.

Source	Group V	Group VI	Group VII	Group VIII
Asgrow Seed Co. (Marion, AR)		A6381, A6785		
Coker's Pedigreed Seed Co. (Hartsville, SC)	Coker 485	Coker 596, Coker 156 Ring Around 680	Coker 237 Ring Around 702	Coker 368, Coker 488
Delta and Pine Land Co. (Wilson, NC)	DP 105	DP 506, DP 566	DP 417	
Farmer's Forage Research (West Lafayette, IN)			FFR 711	
Jacob Hartz Seed Co. (Stuttgart, AR)	Hartz 5171 Hartz 5370	Hartz 7126		
Northrup King Co. (Dallas, TX)		S69-54	McNair 770	
Pioneer Hi-Bred Int'l. (Tipton, IN)	9571			
Public cultivars	Narow	Centennial Davis Leflore Young	Braxton Duocrop Gasoy 17 Gordon Wright	Cobb Foster Hutton Johnston Kirby

bus population densities of 157/100 cm^3 soil.

Seed bed preparation was by conventional tillage. Plots in South Carolina consisted of two 6.5-m rows 96 cm apart in 1985 and four rows in 1986 and 1987. Plots in North Carolina consisted of four 12-m rows 91 cm apart. Seed, sown at 26/m of row, were planted with commercial cone planters, and all plots were in-row subsoiled at planting. All plots were treated with recommended preplant incorporated and postplant broadcast herbicides, and insecticides and fertilizer were applied as needed for each field (12).

Population densities of *H. columbus* were determined at planting and midseason. Soil samples consisted of 10–12 2.5-cm-d cores taken 15–20 cm deep in the row and composited. Nematodes were extracted from 100 cm^3 soil using centrifugation-flotation (8) in South Carolina and from 500 cm^3 soil using a combination of elutriation (4) and centrifugal-flotation (8) in North Carolina. At midseason, roots from soil samples collected on a 710-μm-pore seive were also placed in a mist chamber for 5 days in North Carolina (2). Roots placed in the mist chamber for 7 days in South Carolina consisted of a 15-g fresh weight sample from seven root systems excavated at midseason from each plot.

Data were subjected to analysis of variance for a RCBD. In experiments with a significant F value, treatment means were separated using a Waller–Duncan k-ratio t-test with k-ratio = 100 (P = 0.05). Relative yields were determined by first calculating, by location, the ratio of the mean yield of each cultivar by the mean yield of either Centennial or Coker 317. The mean relative yield over all locations was then calculated to allow nonstatistical comparisons between locations.

Cultivars tested are listed by their source and maturity group in Table 1. Four experiments (experiments 1–4) were conducted at the Barnwell County site, two in 1985 established on 28 May and two in 1987 established on 14 May. Seventeen cultivars in maturity groups V and VI and 20 cultivars in maturity groups VII and VIII were used in experiments 1 and 2, respectively, which were replicated three times. Twelve cultivars in maturity groups V and VI and 14 cultivars in maturity

TABLE 2. Yield and relative yield of soybean cultivars in maturity groups V and VI grown in fields infested with *Hoplolaimus columbus*.

Cultivar	Yield (kg/ha) Expt. 1	Expt. 3	Expt. 5	Expt. 7	Expt. 9	Relative yield†
Asgrow 6381	2,235 a				350 a	0.99
Asgrow 6785		2,961 a		2,308 ab		1.10
Centennial	1,771 a	2,547 abc	1,672 a	2,228 ab	478 a	1.00
Coker 156	2,087 a	2,096 bc	1,367 a	2,212 ab	498 a	0.97
Coker 485	1,164 a	1,986 bc	1,463 a	2,220 ab	404 a	0.83
Coker 596	1,655 a					0.94
Davis	2,049 a				814 a	1.43
Deltapine 105	1,737 a	2,108 bc	1,652 a	2,091 ab	444 a	0.93
Deltapine 506	1,818 a	2,153 bc		2,003 ab	868 a	1.15
Deltapine 566	1,551 a	2,489 abc	1,539 a	1,801 b	551 a	0.95
Hartz 5171	2,083 a				424 a	1.03
Hartz 5370	1,724 a	2,413 abc		1,713 b	706 a	1.04
Leflore	1,569 a	2,437 abc	1,241 a	2,252 ab	330 a	0.86
Narow	1,159 a					0.65
NK's S69-54	2,051 a					1.16
Pioneer 9571	2,096 a	1,919 c	1,098 a	1,737 b	578 a	0.92
Ring Around 680	1,941 a	2,670 ab		2,236 ab	565 a	1.08
Young	2,603 a	2,343 abc	1,465 a	2,646 a	464 a	1.09

Data are means of three replications (experiment 1), five replications (experiments 5, 9), or six replications (experiments 3, 7). See text for location and year of each experiment. Means followed by the same letter within a column are not different ($P = 0.05$) according to a Waller–Duncan k-ratio t-test (k-ratio = 100).

† Relative yield over all locations was calculated as the mean of the yield of each cultivar divided by the yield of Centennial at each location.

groups VII and VIII were used in experiments 3 and 4, respectively, which were replicated six times.

Four experiments (experiments 5–8) were conducted at the Darlington County site, two in 1986 established on 4 June and two in 1987 established on 21 May. Eight cultivars in maturity groups V and VI and eight cultivars in maturity groups VII and VIII were used in experiments 5 and 6, respectively, which were replicated five times. Twelve cultivars in maturity groups V and VI and 14 cultivars in maturity groups VII and VIII were used in experiments 7 and 8, respectively, which were replicated six times.

Experiments 9 and 10, conducted at the Scotland County site, consisted of five replications of 14 cultivars in maturity groups V and VI and 16 cultivars in maturity groups VII and VIII, respectively, planted 2 June 1986.

RESULTS AND DISCUSSION

Recovery of *H. columbus* varied greatly among cultivars within locations; however, these differences were not usually significant ($P = 0.05$). The exceptions were experiment 4, where recovery from FFR 711 (392/g root dry weight) was greater than from Deltapine 417 (141/g root dry weight), and experiment 5, where recovery from Deltapine 105 (269/g root dry weight) was greater than from all cultivars except Coker 485 (141/g root dry weight).

Differences among yields did not occur in all tests, nor were differences consistent among tests for cultivars in either maturity groups V and VI (Table 2) or maturity groups VII and VIII (Table 3) ($P = 0.05$). Yield of Braxton was less than that of FFR 711 and Wright in experiment 2 and of Coker 368 and Coker 627 in experiment 6 (Table 3). Yield of FFR 711, however, was less than that of Deltapine 417, Coker 6738, and Kirby in experiment 8 (Table 3). Yield of Young was greater ($P = 0.05$) than that of Deltapine 566, Hartz 5370, and Pioneer 9571 in experiment 7 (Table 2). Yields from soybean cultivars grown at the North Carolina site were greatly suppressed by extreme drought conditions

TABLE 3. Yield and relative yield of soybean cultivars in maturity groups VII and VIII grown in fields infested with *Hoplolaimus columbus.*

Cultivar	Yield (kg/ha)					Relative yield†
	Expt. 2	Expt. 4	Expt. 6	Expt. 8	Expt. 10	
Braxton	1,426 b	2,634 a	1,208 b	2,071 ab	377 a	0.85
Cobb	1,814 ab					0.75
Coker 317	2,428 ab	2,718 a	1,122 b	2,135 ab	592 a	1.00
Coker 368	2,399 ab	3,101 a	1,883 a	2,255 ab	666 a	1.20
Coker 488	2,482 ab	2,774 a		2,247 ab	679 a	1.06
Coker 627	2,748 ab		1,780 a		720 a	1.31
Coker 6738		2,695 a		2,672 a		1.12
Deltapine 417	2,074 ab	2,687 a		2,729 a	518 a	1.00
Duocrop	2,569 ab					1.06
Foster	2,446 ab	2,758 a	1,504 ab	2,055 ab	599 a	1.07
FFR 711	2,928 a	2,472 a	1,533 ab	1,862 b	572 a	1.07
Gordon	2,329 ab	2,286 a		2,175 ab	632 a	0.97
Gasoy 17	1,977 ab					0.81
Hartz 7126	2,152 ab	2,798 a		2,199 ab	457 a	0.93
Hutton	1,616 ab				491 a	0.75
Johnston	2,715 ab				316 a	0.83
Kirby	2,623 ab	2,812 a	1,544 ab	2,632 a	504 a	1.12
McNair 770	1,946 ab	2,590 a	1,255 ab	2,400 ab	457 a	0.95
Perrin	2,006 ab	2,628 a		2,424 ab		0.98
Ring Around 702	2,235 ab				511 a	0.89
Wright	2,598 a	2,639 a		2,207 ab	444 a	0.96

Data are means of three replications (experiment 2), five replications (experiments 6, 10), or six replications (experiments 4, 8). See text for location and year of each experiment. Means followed by the same letter within a column are not different ($P = 0.05$) according to a Waller–Duncan k-ratio t-test (k-ratio = 100).

† Relative yield over all locations was calculated as the mean of the yield of each cultivar divided by the yield of Coker 317 at each location.

(Tables 2, 3). Braxton had a pronounced chlorotic appearance in all experiments and appeared to be more intolerant of *H. columbus* than other cultivars evaluated (Table 3). This may be a heritable trait since Bragg, a parent of Braxton, exhibits similar chlorosis. Detection of differences in yield, but not infection rates, supports previous reports (3,11) that soybean exhibits tolerance rather than resistance to *H. columbus.*

Deltapine 506, Ring Around 680, and Young in maturity groups V and VI (Table 2) and Coker 368, Coker 488, FFR 711, and Kirby in maturity groups VII and VIII had greater yields than Centennial or Coker 317 over all locations. These cultivars appear suited for use in *H. columbus*-infested fields, whereas Braxton, Coker 485, and Leflore had lower yields than Centennial or Coker 317 and are inappropriate for use.

Ratings of cultivars from our tests matched those reported previously, with the exception of Davis being more tolerant than reported previously (1). Also, in a previous late planted test (10) Foster appeared to be more tolerant than Coker 368, whereas the opposite was true here. Late planting dates may alter test results because of increases in nematode activity (11). Furthermore, some of the differences between locations may be due to differences in aggressiveness between geographic isolates of *H. columbus.*

LITERATURE CITED

1. Appel, J. A., and S. A. Lewis. 1984. Pathogenicity and reproduction of *Hoplolaimus columbus* on 'Davis' soybean. Journal of Nematology 16:349–355.

2. Barker, K. R., J. L. Townshend, G. W. Bird, I. J. Thomason, and D. W. Dickson. 1978. Determining nematode population responses to control agents. Pp. 283–296 *in* K. D. Hickey, ed. Methods for evaluating pesticides for control of plant pathogens. St. Paul, MN: American Phytopathological Society Press.

3. Boerma, H. R., and R. S. Hussey. 1984. Tolerance to *Heterodera glycines* in soybean. Journal of Nematology 16:289–296.

4. Byrd, D. W., Jr., K. R. Barker, H. Ferris, C. J. Nusbaum, W. E. Griffin, R. H. Small, and C. A. Stone. 1976. Two semiautomatic elutriators for extracting nematodes and certain fungi from soil. Journal of Nematology 8:206–212.

5. Fassuliotis, G., G. J. Rau, and F. H. Smith. 1968. *Hoplolaimus columbus*, a nematode parasite associated with cotton and soybeans in South Carolina. Plant Disease Reporter 52:571–572.

6. Fassuliotis, G. 1974. Tolerance of *Hoplolaimus columbus* to high osmotic pressures, desiccation, and high soil temperature. Journal of Nematology 3:309–310 (Abstr.).

7. Fassuliotis, G. 1974. Host range of the Columbia lance nematode, *Hoplolaimus columbus*. Plant Disease Reporter 58:1000–1002.

8. Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Disease Reporter 48:692.

9. Lewis, S. A., and F. H. Smith. 1976. Host plants, distribution, and ecological associations of *Hoplolaimus columbus*. Journal of Nematology 8:264–270.

10. Mueller, J. D., and G. B. Sanders. 1987. Control of *Hoplolaimus columbus* on late planted *Glycine max* with aldicarb. Annals of Applied Nematology (Journal of Nematology 19, Supplement) 1:123–126.

11. Nyczepir, A. P., and S. A. Lewis. 1979. Relative tolerance of selected soybean cultivars to *Hoplolaimus columbus* and possible effects of soil temperature. Journal of Nematology 11:27–31.

12. Palmer, J. H., F. H. Smith, E. C. Murdock, J. W. Chapin, C. E. Curtis, H. M. Harris, D. B. Luke, C. E. Drye, C. L. Parks, F. J. Wolak, and R. A. Spray. 1985. Growing soybeans for profit in South Carolina. Clemson University Cooperative Extension Service, Clemson, SC.

13. Schmitt, D. P., and J. L. Imbriani. 1987. Management of *Hoplolaimus columbus* with tolerant soybean and nematicides. Annals of Applied Nematology (Journal of Nematology 19, Supplement) 1:59–63.