Comparative Host Suitabilities of Snap Beans to the Soybean Cyst Nematode (*Heterodera glycines*)

T. A. MELTON, Extension Nematologist, G. R. NOEL, Research Plant Pathologist, USDA, ARS, and B. J. JACOBSEN, Professor, Department of Plant Pathology, University of Illinois, Urbana 61801; and D. J. HAGEDORN, Professor, Department of Plant Pathology, University of Wisconsin, Madison 53706

ABSTRACT

Melton, T. A., Noel, G. R., Jacobsen, B. J., and Hagedorn, D. J. 1985. Comparative host suitabilities of snap beans to the soybean cyst nematode (*Heterodera glycines*). Plant Disease 69:119-122.

Twenty-three bush-type snap bean (*Phaseolus vulgaris*) lines were evaluated for their suitabilities as hosts for two populations of soybean cyst nematode (*Heterodera glycines*) using naturally infested soil in a greenhouse. Except for its sister line WIS (RRR) 46, WIS (RRR) 36 was a less suitable host ($P < 0.05$) than all other snap beans. Populations of white females from 12 commercial snap bean cultivars were equal to or greater than the susceptible soybean (*Glycine max*) cultivar Williams 79 for the race 3 population. Additionally, 18 snap bean cultivars supported the same number of white females per plant as did Williams 79 for the second population, which was similar to race 4. This wide range of host responses suggests that resistance is controlled by more than one gene.

Additional key words: host range

Soybean cyst nematode (SCN) (*Heterodera glycines* Ichinohe) was reported in Illinois on bush-type snap beans (*Phaseolus vulgaris* L.) in 1981. Stunting and chlorosis, typical for SCN-infected soybeans (*Glycine max*), was observed in pockets throughout the field (12). Snap beans were first reported as a host of SCN by Skotland et al (17). Although *Phaseolus* spp. have been included in other host range studies (3–6,9,15,16), researchers have not compared the relative host suitabilities of commonly grown snap bean cultivars. On the basis of experimentation with the cultivar Contender, snap bean was reported as a poor host (4). Other research indicated that most snap bean cultivars tested were susceptible to SCN (15,16). Kentucky Wonder Pole and Kentucky Wonder Improved Rust Resistant were resistant to SCN in a comprehensive host range study (16). In an initial study with Eagle and WIS (RRR) 36, we confirmed the resistant reaction of Kentucky Wonder Pole. After SCN was identified in commercial snap bean production areas where soybeans are also grown, the host suitabilities of snap bean cultivars were required to develop a sound SCN management program. In this study, host suitabilities of 23 snap bean and four soybean lines were compared.

MATERIALS AND METHODS

In trial 1, resistance to two populations of SCN was evaluated using the snap bean lines Aristocrop, Nemasnap, Bush Blue Lake (BBL) 47, BBL 94, BBL Advance, Cascade, Crossville, DM, Eagle, Earlybird, Early Gallatin, Galagreen, Goldenrod, Golden Sands, Tidal Wave, Torrent, WIS (RRR) 36, WIS (RRR) 46, WIS (RRR) 104, and WIS (RRR) 105 and the soybean lines Fayette, Franklin, PI 90763, and Williams 79. In trial 2, the snap bean lines PI 165426, Slenderette, and Tenderette were also included. Nemasnap and PI 165426 are root-knot (*Meloidogyne incognita* (Kofoid & White) Chitwood) resistant lines from the U.S. Vegetable Laboratory, Charleston, SC. WIS (RRR) 36, WIS (RRR) 46, WIS (RRR) 104, and WIS (RRR) 105 are breeding lines developed at the University of Wisconsin for resistance to a root-rot complex.

Silt loam soil from a soybean field infested with SCN race 3 (population A) containing 28 cysts (2,930 eggs and larvae) per 100 cm^3 of soil and loamy sand from a soybean field infested with a population (B) of 36 cysts (3,840 eggs and larvae) per 100 cm^3 of soil were used for evaluations. Each soil was mixed thoroughly before potting. Pots 10 cm in diameter containing 350 cm^3 of soil, arranged in a randomized complete block design with five replicates on a greenhouse bench, were planted with three seeds per pot and thinned to one per pot at emergence.

Snap bean lines were evaluated for resistance when first-generation SCN females were fully developed. After soaking in water for about 5 min, root balls were removed from pots and soil was dislodged from the roots (with further soaking). Roots were then placed on a screen with 850-μm openings nested on one with 250-μm openings. Females were dislodged from roots with a stream of water, caught on the bottom screen, and counted. The experiments were repeated, and after the second evaluation was completed, roots were air-dried on a greenhouse bench for 96 hr and weighed. Female populations were calculated as numbers per gram of dry root and numbers per root system. Numbers were transformed to $\log_{10}(x + 1)$ because of the large variances within the susceptible lines. An analysis of variance was conducted for each experiment. Comparisons between lines for transformed white female numbers were conducted using Fisher's LSD (18) at $P < 0.05$.

RESULTS

Population A. The rankings of snap bean lines were similar for both trials, from most susceptible to most resistant (based on number of white SCN females per root system) (Table 1). In trial 1, WIS (RRR) 36 was a poorer host ($P < 0.05$) than all other snap bean lines tested. Of the six most susceptible snap bean lines in trial 1, five were also among the six most susceptible in trial 2. Eagle, Goldenrod, Torrent, Earlybird, Galagreen, and Cascade were most susceptible in trial 1, whereas in trial 2, Cascade was replaced by Golden Sands.

In trial 2, WIS (RRR) 36 did not differ from WIS (RRR) 46 in host suitability but was less suitable than all other snap bean lines tested. WIS (RRR) 46 was less suitable than 17 of the 23 lines tested. For trial 2, lines were also evaluated on the basis of transformed numbers of white SCN females per gram of dried root tissue (Table 1). By this criterion, WIS (RRR) 36 was less suitable than all other snap bean lines tested.

Williams 79 soybean supported the same number of white females per plant as 13 snap bean lines in trial 1 (Table 1) and as 12 in trial 2. Seventeen snap bean

Portion of a thesis submitted by the first author in partial fulfillment of the requirement for the Ph.D. degree, University of Illinois.

Research supported by Illinois Agricultural Experiment Station, Project ILLU-68-326.

Accepted for publication 5 July 1984.

---

lines did not differ in host suitability (based on females per gram of dried root) from the susceptible soybean (Table 1).

Population B. In trial 1, fewer SCN females were recovered than in trial 2 (Table 2). WIS (RRR) 104, Torrent, and WIS (RRR) 36 were the most resistant lines. WIS (RRR) 104 was a less suitable host than 15 of 20 snap bean lines and was equal to Williams 79 ($P < 0.05$). Williams 79 supported a density lower than 10 of the 20 snap bean lines and Franklin soybeans ($P < 0.05$). Cascade, Goldenrod, and Nemasnap supported the highest densities, which were greater ($P < 0.05$) than any of the Wisconsin snap beans (Table 2).

Results of trial 2 differed from those of trial 1. The host suitability of WIS (RRR) 36 was the poorest of all the snap bean lines and did not differ (per plant or per gram of dried root) from the resistant soybeans Fayette, and PI 90763. In trial 2, Franklin soybean again supported a higher population per plant and per gram of dried root than any snap bean or soybean line. Williams 79 supported a population equal to that of 18 snap bean lines but less than that of Franklin and greater than that of Cascade and the WIS (RRR) lines. Slenderette (not in trial 1), Eagle, Golden Sands, Goldenrod, BBL 47, Galagreen, and Torrent supported the highest populations, which were greater than those on the Wisconsin lines. However, only Eagle and Goldenrod were also included in the six most susceptible lines in trial 1.

DISCUSSION

The impact of SCN on the snap bean industry is not known because field yield losses have only been estimated for soybean. Greenhouse data indicate that snap and red kidney beans can be damaged by SCN but only at greater population levels than soybean (1). Because most Illinois snap bean producers also grow soybeans and certain snap bean cultivars are good hosts for SCN, their cultivar selection and rotation plans may be affected. When snap beans or soybeans are grown in consecutive years or even in 1-yr rotations with corn, SCN populations may increase from nondetectable levels to those causing losses. In fact, the first snap bean field in Illinois where SCN was detected had been in a corn-soybean rotation for several years, and SCN was never detected until snap beans were grown in 1981 (13).

Population A fits the description of race 3 using Fayette, Franklin, Williams 79, and PI 90763 as differential lines. Population B does not fit into any of the known race designations (7,10). This population was selected for this experiment because of its high reproduction and damage to Franklin soybean in the field, indicating that it was race 4. Epps and Hartwig (5) reported that PI 90763 has a "mixture of plant types in terms of reaction to race 4," and Thomas et al (19) classified PI 90763 as moderately resistant to their population of race 4. Our population reacted similarly to one selected on PI 89772 (12). The relatively poor host suitability of Williams 79 for this population may be due to a gene for resistance (11).

Variation in the experiments may be attributed to several factors. Unusually high numbers of females occurred on a few susceptible plants, indicating a possible uneven distribution of viable inoculum in the soil. Particularly low numbers may be due to the occasional difficulty encountered in removing hardened soil aggregates from the roots, which may have dislodged some females. Finally, seedling emergence occurred over about 2 days and was generally uniform within lines. A particular plant would occasionally emerge late and, thus, have a smaller root system and allow less time for nematode maturation. In addition, variability may have been decreased and accuracy increased if the number of SCN progeny on each line had been determined (14).

Cultivar morphology and growth patterns may have affected the results. Certain cultivars tend to emerge earlier and produce roots more quickly. In this case, larger infection sites may be

Table 1. Numbers[a] of white female *Heterodera glycines* race 3 (population A) on snap bean and soybean lines after one generation

Trial 1		Trial 2			
Cultivar	$\log_{10}(x+1)$ per plant	Cultivar	$\log_{10}(x+1)$ per plant	Cultivar	$\log_{10}(x+1)$ per gram of dried root
Eagle	2.31	Williams 79[b]	2.54	Galagreen	3.10
Goldenrod	2.28	Galagreen	2.48	Slenderette	3.04
Torrent	2.22	Earlybird	2.40	Williams 79[b]	3.03
Earlybird	2.21	Eagle	2.40	Eagle	3.00
Williams 79[b]	2.19	Torrent	2.38	Golden Sands	3.00
Galagreen	2.17	Golden Sands	2.37	Tenderette	3.00
Cascade	2.16	Goldenrod	2.33	Torrent	2.94
Early Gallatin	2.15	Tidal Wave	2.32	Goldenrod	2.94
Golden Sands	2.10	Slenderette	2.28	Aristocrop	2.93
Crossville	2.08	Aristocrop	2.28	Nemasnap	2.92
BBL 47	2.07	Nemasnap	2.21	Tidal Wave	2.90
BBL Advance	2.00	DM	2.20	Earlybird	2.89
Nemasnap	1.95	Tenderette	2.19	Cascade	2.85
DM	1.94	BBL Advance	2.16	Early Gallatin	2.85
BBL 94	1.84	Cascade	2.12	DM	2.85
Aristocrop	1.83	BBL 47	2.09	BBL Advance	2.82
WIS (RRR) 104	1.62	Early Gallatin	2.06	BBL 47	2.73
WIS (RRR) 105	1.54	BBL 94	2.04	BBL 94	2.58
WIS (RRR) 46	1.54	Crossville	1.85	Crossville	2.45
WIS (RRR) 36	1.09	WIS (RRR) 104	1.80	WIS (RRR) 104	2.40
Fayette[c]	1.00	WIS (RRR) 105	1.61	WIS (RRR) 46	2.39
PI 90763[c]	0.29	WIS (RRR) 46	1.47	WIS (RRR) 105	2.26
		WIS (RRR) 36	1.15	WIS (RRR) 36	1.68
		Fayette[c]	0.62	Fayette[c]	0.98
		PI 90763[c]	0.17	PI 90763[c]	0.26
		Franklin[c]	0.00	Franklin[c]	0.00
FLSD (0.05)	0.332	FLSD (0.05)	0.391	FLSD (0.05)	0.471
C.V.	14.3	C.V.	15.9	C.V.	15.1
R^2	0.82	R^2	0.87	R^2	0.86

[a] Transformed to $\log_{10}(x+1)$.

[b] Susceptible soybean.

[c] Resistant soybean.

Table 2. Numbers[a] of *Heterodera glycines* (population B) females on snap bean and soybean lines after one generation

Trial 1		Trial 2			
Cultivar	$\log_{10}(x+1)$ per plant	Cultivar	$\log_{10}(x+1)$ per plant	Cultivar	$\log_{10}(x+1)$ per gram of dried root
Franklin[b]	2.31	Franklin[b]	2.95	Franklin[b]	3.62
Goldenrod	1.94	Eagle	2.75	Slenderette	3.46
Nemasnap	1.89	Slenderette	2.70	Eagle	3.45
Cascade	1.87	Golden Sands	2.65	BBL 47	3.33
Eagle	1.87	Goldenrod	2.63	Golden Sands	3.29
Crossville	1.86	Galagreen	2.56	Goldenrod	3.26
Aristocrop	1.81	BBL 47	2.49	BBL Advance	3.25
Early Gallatin	1.80	Torrent	2.47	Tenderette	3.25
BBL 47	1.66	Tenderette	2.47	Early Gallatin	3.23
Golden Sands	1.62	BBL Advance	2.46	Torrent	3.18
BBL 94	1.59	Early Gallatin	2.45	Galagreen	3.12
Tidal Wave	1.53	Williams 79[b]	2.45	Aristocrop	3.11
BBL Advance	1.50	Earlybird	2.41	Crossville	3.08
Earlybird	1.46	Crossville	2.41	Earlybird	3.05
DM	1.43	Aristocrop	2.33	DM	3.03
WIS (RRR) 46	1.37	DM	2.31	BBL 94	3.03
Galagreen	1.34	BBL 94	2.24	Williams 79[b]	3.00
WIS (RRR) 105	1.28	WIS (RRR) 104	2.05	Tidal Wave	2.92
WIS (RRR) 36	1.21	Nemasnap	2.05	Nemasnap	2.89
Williams 79[b]	1.08	Tidal Wave	2.05	Cascade	2.77
Torrent	0.94	Cascade	1.89	WIS (RRR) 104	2.67
WIS (RRR) 104	0.86	WIS (RRR) 105	1.80	WIS (RRR) 105	2.58
Fayette[d]	0.24	WIS (RRR) 46	1.68	WIS (RRR) 46	2.46
		PI 165426	1.50	PI 165426	2.17
		PI 90763[c]	1.43	PI 90763[c]	2.12
		WIS (RRR) 36	1.25	WIS (RRR) 36	1.85
		Fayette[d]	0.97	Fayette[d]	1.44
FLSD (0.05)	0.493	FLSD (0.05)	0.428	FLSD (0.05)	0.428
C.V.	23.3	C.V.	15.5	C.V.	12.2
R^2	0.73	R^2	0.73	R^2	0.73

[a] Transformed to $\log_{10}(x+1)$.

[b] Susceptible soybean.

[c] Soybean generally considered susceptible to race 4, but has been reported as moderately resistant.

[d] Resistant soybean.

available early, causing these cultivars to appear more susceptible than some "slow starters." Although seeds of some cultivars were treated with fungicides, there was no association between treated cultivars and SCN population levels.

The snap bean lines Nemasnap and PI 165426, from which Nemasnap's resistance was derived, are resistant to the root-knot nematode (*M. incognita*) (20). Population levels on Nemasnap did not show significant resistance to either SCN population. The PI 165426 seeds germinated only in trial 2 of the population B evaluation. Even then, they emerged 9 days later than most other lines, which probably accounts for the low recovery of white females. Therefore, it is doubtful that SCN resistance is controlled by the same genes as root-knot nematode resistance.

The four Wisconsin root rot-resistant, WIS (RRR), lines supported only relatively low populations of SCN. Although WIS (RRR) 36 and 46 are sister lines, 36 matures slightly earlier. WIS (RRR) 46 carries high-level resistance to a root rot complex composed of *Pythium* spp., *Aphanomyces euteiches* Drechs. f. sp. *phaseoli, Fusarium solani* f. sp. *phaseoli* (Burkh.) Snyd. & Hans., and *Rhizoctonia solani* Kühn (8). WIS (RRR) 104 and 105 are from reciprocal crosses of WIS (RRR) 46 and BBL 94. BBL 94 is tolerant to the Wisconsin root rot complex and is one of the least susceptible to SCN of the commercial snap bean cultivars tested. WIS (RRR) 36 supported the lowest numbers of white females, except in trial 2 of population B, when variation was unusually high. Results were similar for both SCN populations indicating that resistance may not be race-specific.

From this study, it is evident that some commonly grown bush-type snap bean cultivars may be equal or better hosts for SCN than certain susceptible soybean cultivars. However, several snap bean cultivars were identified as less favorable hosts and WIS (RRR) 36 as having a relatively high level of resistance.

Management of SCN is important for Illinois snap bean-soybean producers. Carbamate and organophosphate nematicides are impractical for control because snap beans are double-cropped with snap beans and the time required for crop maturation is so short that residue problems are likely to occur. Fumigants used on snap beans to control root knot have resulted in lower yields (2). A complete SCN management plan would include resistant snap bean and soybean cultivars and rotation with nonhost crops.

ACKNOWLEDGMENTS

We thank the following for supplying seed: Asgrow Seed Co., Ferry Morse Seed Co., Gallatin Valley Seed Co., Musser Seed Co., L. D. Maffei Seed Co., and J. E. Wyatt, U.S. Vegetable Laboratory at Charleston, SC. We also thank Robert W. Frank, Jackson County Agricultural Extension Adviser, for providing and delivering population B.

LITERATURE CITED

1. Abawi, G. S., and Jacobsen, B. J. 1984. Host efficiency and effect of initial densities of *Heterodera glycines* on soybean and dry bean under greenhouse conditions. Phytopathology 74:1470-1474.
2. Clayton, C. N., and Ellis, D. E. 1949. Soil treatments with chloropicrin, DD, and Uramon for control of root-knot nematode. Phytopathology 39:583-589.
3. Epps, J. M., and Chambers, A. Y. 1959. Mung bean (*Phaseolus aureus*), a host of the soybean cyst nematode (*Heterodera glycines*). Plant Dis. Rep. 43:981-982.
4. Epps, J. M., and Chambers, A. Y. 1966. Comparative rates of reproduction of *Heterodera glycines* on 12 host plants. Plant Dis. Rep. 50:608-610.
5. Epps, J. M., and Hartwig, E. E. 1972. Reaction of soybean varieties and strains to race 4 of the soybean cyst nematode. (Abstr.) J. Nematol. 4:222.
6. Fujita, K., and Miura, O. 1934. On the parasitism of *Heterodera schachtii* Schmidt on beans. Trans. Sapporo Nat. Hist. Soc. 13:359-364.
7. Golden, A. M., Epps, J. M., Riggs, R. D., Duclos, L. A., Fox, J. A., and Bernard, R. L. 1970. Terminology and identity of intraspecific forms of the soybean cyst nematode (*Heterodera glycines*). Plant Dis. Rep. 54:544-546.
8. Hagedorn, D. J., and Rand, R. E. 1980. Wisconsin (RRR) 46 snap bean breeding line. HortScience 15:529-530.

9. Ichinohe, M. 1953. On the parasitism of the soybean nematode, *Heterodera glycines*. Hokkaido Nat. Agric. Exp. Stn. Bull. 64:113-124.
10. Inagaki, H. 1977. Race status of five Japanese populations of *Heterodera glycines*. Jpn. J. Nematol. 9:1-4.
11. Luedders, V. D., and Dropkin, V. H. 1983. Effect of secondary selection on cyst nematode reproduction on soybeans. Crop Sci. 23:263-264.
12. McCann, J., Luedders, V. D., and Dropkin, V. H. 1982. Selection and reproduction of soybean cyst nematodes. Crop Sci. 22:78-80.
13. Noel, G. R., Jacobsen, B. J., and Leeper, C. D. 1982. Soybean cyst nematode in commercial snap beans. Plant Dis. 66:520-522.
14. Noel, G. R., Stanger, B. A., and Bloor, P. V. 1983. Population development, reproductive behavior, and morphology of race 4 of soybean cyst nematode, *Heterodera glycines*, on resistant soybeans. Plant Dis. 67:179-182.
15. Riggs, R. D., and Hamblen, M. L. 1962. Soybean-cyst host studies in the family Leguminosae. Ark. Agric. Exp. Stn. Rep. Ser. 110.
16. Riggs, R. D., and Hamblen, M. L. 1966. Further studies on the host range of the soybean-cyst nematode. Ark. Agric. Exp. Stn. Bull. 718.
17. Skotland, C. B., Sasser, J. N., and Winstead, N. N. 1955. Preliminary reports of research on the soybean cyst nematode in North Carolina. Pages 19-25 in: Annual Report of Soybean Cyst Nematode Control. U.S. Dep. Agric. Plant Pest Control Branch.
18. Steel, R. G. D., and Torrie, J. H. 1980. Principles and Procedures of Statistics: A Biometrical Approach. McGraw-Hill, New York. 633 pp.
19. Thomas, J. D., Caviness, C. E., Riggs, R. D., and Hartwig, E. E. 1975. Inheritance of reaction to race 4 of soybean cyst nematode. Crop Sci. 15:208-210.
20. Wyatt, J. E., Fassuliotis, G., Johnson, A. W., Hoffman, J. C., and Deakin, J. R. 1980. B4715 root-knot nematode resistant snap bean breeding line. HortScience 15:530.