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Yield Loss in Soybean Caused by *Heterodera glycines*

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Abstract: Yields of four soybean cultivars were measured for 4 years in a field infested with *Heterodera glycines* race 3 and in a field infested with *H. glycines* race 14. Cultivars included Hutcheson (susceptible to both races), Deltapine 415 (resistant to race 3 and susceptible to race 14), Asgrow 5979 (resistant to both races), and Harwig (resistant to both races as well as most other known races of *H. glycines*). Although no above-ground symptoms of nematode infection were visible, mean yield was 16-32% greater for Asgrow 5979 than for Hutcheson. Yield for Deltpine 415 was similar to that of Asgrow 5979 in the field infested with race 3 and similar to that of Hutcheson in the race 14-infested field. Hartwig produced lower yields than Asgrow 5979 in both fields. Yield differences, particularly between Asgrow 5979 and Hutcheson, were attributed primarily to nematodes because both cultivars have been shown to produce similar yields in the absence of *H. glycines*. This study illustrates the importance of knowing which race of the nematode is prevalent in a field and demonstrates that the nematode can cause significant yield loss in the absence of visible symptoms of infection.

Key words: Glycine max, Heterodera glycines, resistance, soybean, soybean cyst nematode, yield loss.

The soybean cyst nematode *Heterodera glycines* Ichinohe is a major pest of soybean (*Glycine max*) in the United States. Planting resistant soybean cultivars and rotating soybean with nonhost crops are the tactics most often used to limit yield loss. Producers associate nematode damage with severe stunting and chlorosis of plants. However, Noel (10) measured 20-30% yield losses in fields infested with the nematode when there was an absence of severe stunting and chlorosis. Niblack et al. (9) indicated that symptoms are not consistently observed in fields with known infestations of the nematode.

Yield loss caused by the nematode has been estimated by comparisons of susceptible cultivars treated and untreated with nematicides. However, nematicides have given inconsistent yield improvement of susceptible cultivars, and untreated resistant cultivars often yield more than nematicide-treated susceptible cultivars (4,8,11). Another method of estimating yield reduction has been to measure yield of cultivars with differing susceptibilities but with comparable yield potential (12).

The objective of this study was to measure yield of cultivars with comparable yield potential (except Hartwig) and varying susceptibility or resistance to the nematode in fields infested with either *H. glycines* race 3 or 14.

Materials and Methods

Four soybean cultivars (Asgrow 5979, Deltapine 415, Hartwig, and Hutcheson) of Maturity Group V were grown in two fields near Grand Junction, Tennessee, from 1991 through 1994. Asgrow 5979 is resistant to *H. glycines* races 3 and 14 (5); Deltapine 415 is resistant to race 3 (5); Hartwig is resistant to most, if not all, races (1); and Hutcheson is susceptible to all races (2).

One field was infested with *H. glycines* race 3 and the other was infested with race 14. Mean numbers of eggs per 450 cm^3 soil, followed by the standard error of the mean in parentheses, at planting were 1,790 (298), 2,674 (284), 10,720 (778), and 14,801 (1,317) in the race 3-infested field and 1,282 (194), 1,826 (301), 4,709 (385), and 4,258 (421) in the race 14-infested field, respectively, for 1991-94. Soil in both fields was a Lexington silt loam (30% sand, 63% silt, and 7% clay). The pH ranged from 6.5-7.2, phosphorus level was high, and potassium level ranged from medium to high, according to the Tennessee Agricultural Extension Service soil testing laboratory. Ninety kg/ha of potassium (K_2O

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equivalent) was added when the soil test indicated a medium level of this nutrient. Trifluralin was preplant incorporated each year, bentazon and(or) fomesafen were applied postemergence as needed in 1991 and 1992; and imazaquin was applied with the trifluralin in 1993 and 1994 for weed control. Plots also were cultivated one or two times for additional weed control when needed.

Individual plots were four rows spaced 91 cm apart and 5.8 m long with 1.2 m between ranges of plots. At maturity, the center two rows were harvested after they were trimmed to 4.9 m. Plots were grown each year in an area that had been planted in the previous year with susceptible cultivar Hutcheson in the race 3-infested field and Deltapine 415 in the race 14-infested field. Plots were planted 6 June 1991, 22 May 1992, 24 (race 14-infested field) or 27 May 1993, and 18 May 1994. They were harvested 17 October 1991, 19 October 1992, 25 October 1993, and 24 October 1994.

Twelve soil cores, 2.5-cm-diam., were taken to a depth of 15 cm in the center two rows of each plot within 1 day after planting and again within 30 days of harvest. Cysts were extracted by elutriation (3) from a 450-cm^3 subsample of soil collected from each plot. Cysts were collected on a 250-μm-pore sieve, handpicked from the debris with the aid of a stereomicroscope, and crushed with a Ten-Broeck tissue homogenizer to free eggs for counting.

Cultivars were grown in randomized complete blocks with six replications. Number of eggs at planting and at harvest as well as yield data were subjected to analysis of variance for each year and combined years for each field. Replications for each test were nested within years for the combined years analysis. Number of eggs was analyzed with and without transformation to natural log values. Results were the same for both analyses, and the analyses of untransformed data are reported.

Results and Discussion

There were significant effects of year for all combined analyses except for number of eggs at harvest in the race 14-infested field (P = 0.05). Yields were lower in 1991 and 1993 than in 1992 and 1994 (Table 1). In the race 3-infested field, there was a year × cultivar interaction effect on yield and number of eggs at harvest.

Yield of Asgrow 5979 was greater than yield of Hutcheson in the race 3-infested field in 3 of the 4 years (P = 0.05) (Table 1). In the race 14-infested field, the yield of Asgrow 5979 was higher than yield of Hutcheson in 1992 (P = 0.05). In both

Table 1. Yield of four soybean cultivars in fields infested with either *Heterodera glycines* race 3 or race 14, 1991–94.

Soybean cultivar	Yield (kg/ha)				
	1991	1992	1993	1994	Overall
		Race 3-infested field			
Asgrow 5979	2,471	4,296	2,608	4,258	3,409
Deltapine 415	2,801	3,802	2,455	4,230	3,322
Hartwig	2,414	3,792	2,392	3,656	3,063
Hutcheson	1,787	3,482	2,202	2,891	2,591
LSD (0.05)	500	183	ns	453	180
		Race 14-infested field			
Asgrow 5979	2,529	4,068	3,370	4,567	3,634
Deltapine 415	2,130	3,648	2,835	4,506	3,280
Hartwig	2,081	3,552	2,696	3,883	3,053
Hutcheson	2,035	3,471	3,154	3,877	3,134
LSD (0.05)	ns	392	237	ns	224

Values are means of six replications for annual data and 24 replications for the overall data; ns = not significant.

fields, the 4-year mean yield of Asgrow 5979 was greater than that of Hutcheson, and 4-year mean yield of Hartwig was less than those of either Asgrow 5979 or Deltapine 415 in both fields. Average yield of Deltapine 415 was not different from that of Asgrow 5979 in the race 3-infested field but was less in the race 14-infested field ($P = 0.05$).

The differences in yield between resistant Asgrow 5979 and susceptible Hutcheson can be attributed to the effects of *H. glycines*. The basis for this attribution is that mean yields for Asgrow 5979, Deltapine 415, and Hutcheson in the University of Tennessee cultivar trials for the 2 years prior to establishment (1989-90; 5 locations/year) of this study and 3 additional years (1992-94; 6 locations/year) were not different ($P = 0.05$) (6,7). One of the locations used for the University of Tennessee trials was infested with *H. glycines* race 2; no information was given on nematode infestations for the other sites. Trials at the race 2-infested site were conducted in an area planted with corn in the previous year (7).

Further evidence that yield differences can be attributed to the effect of the nematode is that the 4-year mean yield of Deltapine 415 did not differ from that of Asgrow 5979 in the race 3-infested field; both cultivars were resistant to race 3. However, in the race 14-infested field, 4-year mean yield of Deltapine 415 (susceptible) was less than yield of Asgrow 5979 (resistant) and similar to yield of susceptible Hutcheson. No other diseases or pests were noted in these fields to which yield suppression could be attributed.

Results illustrate the importance of knowing which *H. glycines* race is in each field. Selection of Asgrow 5979 for planting in the race 14-infested field resulted in 350 kg/ka (4-year mean) more yield than selection of Deltapine 415. In addition to the 4-year mean yield, significant yield suppression of Deltapine 415 occurred in 1992 and 1993. There was no difference in yields between Asgrow 5979 and Deltapine 415 in the race 3-infested field except in 1992.

Susceptible cultivars did not show typical symptoms of nematode infection such as severe stunting and chlorosis. The average plant height of Hutcheson in 1993 and 1994 was lower than for Asgrow 5979 in both years. This difference in plant height was, however, probably mostly due to genetic differences rather than damage by the nematode. Average plant heights in the University of Tennessee cultivar trials (1993-94) for Asgrow 5979 and Hutcheson were 94 and 86 cm, respectively (7). Nematodes may have reduced plant height of Hutcheson to some degree in the race 3-infested field, where the yield difference between Asgrow 5979 and Hutcheson aver-

TABLE 2. Number of *Heterodera glycines* eggs obtained within 30 days of harvest in plots of four soybean cultivars grown in fields infested with either race 3 or race 14, 1991–94.

Soybean cultivar	1991	1992	1993	1994	Overall
		Race 3-infested field			
Asgrow 5979	270	1,570	295	3,020	1,289
Deltapine 415	225	840	910	2,745	1,180
Hartwig	65	95	835	1,135	532
Hutcheson	3,990	22,555	6,115	13,280	11,485
LSD (0.05)	1,623	5,931	1,700	3,681	1,728
		Race 14-infested field			
Asgrow 5979	240	2,105	1,620	1,585	1,388
Deltapine 415	3,975	3,790	5,730	3,660	4,289
Hartwig	0	0	395	60	114
Hutcheson	4,435	5,025	6,260	8,030	5,938
LSD (0.05)	2,085	2,342	3,452	2,388	1,229

Values are means of six replications for annual data and 24 replications for the overall data.

aged 887 kg/ha. The canopy width at flowering appeared narrower for the susceptible cultivars than for Asgrow 5979. This apparent difference in canopy width would not be visually detectable in a field planted only with a susceptible cultivar. Other researchers (9,10) have reported yield losses caused by this nematode in the absence of visual symptoms of nematode infection.

Planting the cultivar Hartwig can eliminate the need for knowing which race is present in a field. However, the lower yield potential of this cultivar makes this an expensive alternative to identification of the *H. glycines* race in a field and use of a cultivar with resistance to that race. Hartwig yielded (4-year mean) less than Asgrow 5979 in both fields and did not yield better than Hucheson in the race 14-infested field, but it was effective in reducing the number of eggs present in the fall (Table 2).

Heterodera glycines can cause yield reduction in the absence of visible symptoms. Periodic sampling of fields used for soybean production is necessary to monitor *H. glycines* infestations. In addition, race determination of *H. glycines* populations is necessary in order to choose the best resistant cultivar when resistance is the control measure used.

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