EVALUATION OF SELECTED SOYBEAN CULTIVARS IN A FIELD INFESTED WITH *MELOIDOGYNE ARENARIA* AND *HETERODERA GLYCINES* [EVALUACION DE CULTIVARES SELECTOS DE SOYA EN UN CAMPO INFESTADO CON *MELOIDOGYNE ARENARIA* Y *HETERODERA GLYCINES*].

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ABSTRACT

Soybean cultivars were studied for 2 years in a field in South Alabama, U.S.A., infested with a mixed population of the root-knot nematode *Meloidogyne arenaria* and race 3 of the cyst nematode *Heterodera glycines.* Cultivars in the study, selected for their relative tolerance to either parasite, were: Bedford, Braxton, Bragg, Centennial, Cobb, Davis, Dowling, Forrest, Govan, Hutton, Ransom, and F-70-2060. Each cultivar was planted in untreated plots and in plots fumigated with EDB (Soilbrom® 90 EC). A singificant negative correlation was detected between larval populations of *H. glycines* and *M. arenaria* indicating that resistance to *H. glycines* in a given cultivar resulted in increased larval populations of *M. arenaria.* Fumigation was more efficacious against *M. arenaria* than against *H. glycines.* The best nematode control and yield responses were obtained when cyst resistant cultivars, Bedford, Forrest, and Centennial were planted in fumigated soil.
Key Words: integrated pest management, resistant varieties, crop rotation, population dynamics.

INTRODUCTION

The two major nematode problems of soybeans *(Glycine max)* in the Southeastern U.S.A. are those caused by species of root-knot nematodes *(Meloidogyne* spp.) and the cyst nematode *Heterodera glycines.* Control of these parasites has depended on development and use of resistant cultivars and on the use of the inexpensive nematicide DBCP (4,6,8,9). Although the use of resistant cultivars is essential for controlling these parasites, yields of cultivars resistant to either *Meloidogyne* spp or *H. glycines* have been shown to increase significantly with the use of nematicides (4,6,8,9). A difficulty posed by reliance on resistant cultivars for control of the parasites is the present lack of cultivars with combined resistance to the various races of *H. glycines* (3) and to the economically important species of *Meloidogyne.* In many cases, fields planted to soybeans contain mixed populations of root-knot and cyst nematodes. Under this condition a choice must be made between the use of a cultivar resistant to the *Meloidogyne* species present or one resistant to the race of *H. glycines* present. No information is available on the relative value of root-knot resistant and cyst resistant cultivars in mixed populations. This paper reports results of a study on the performance of selected soybean cultivars in a field infested with *M. arenaria* and race 3 of *H. glycines.*

MATERIALS AND METHODS

Experiments were conducted in a field with a sandy loam (pH 6.2, organic matter 1%) infested with *Meloidogyne arenaria* and race 3 of *Heterodera glycines*. The field, located on the Engel farm near Summerdale, Alabama, had been in soybeans for 2 years. The level of infestation determined prior to planting was 25 and 30 larvae/50 cm^3 soil for *M. arenaria* and *H. glycines*, respectively.

Soybean cultivars were planted in untreated plots and plots treated with the fumigant nematicide Soilbrom 90 EC (90% EDB, w/w). The fumigant was injected into the soil at planting time at 9.35 L/ha (1978) or at 18.7 L/ha (1979) with 2 injection chisels per row each 10 cm on each side of the seed furrow (5,7,11).

In 1978 the cultivars Centennial, Davis, Bragg, Ransom, Govan, Hutton, Cobb, Dowling, Braxton, and F-70-2060 were planted. In 1979 the cultivars Forrest, Bedford, and Braxton were included in adddition to all those tested in 1978 with the exception of Govan and Dowling which were not included. Maturity group and relative resistance to *M. arenaria* and *H. glycines* of these cultivars are listed on Table 1 (3).

Treatments were replicated 6 times in 4 row plots, 96 cm wide and 6 m long. The treatments were arranged in a split plot design with the nematicide treatments comprising the main plot and cultivars comprising the sub-plots. Cultural practices, fertilizers, herbicides, and insecticides used were those recommended for South Alabama (2).

Soil samples for nematode analysis in 1978 were taken during the second week of September to coincide with maximal population development of *Meloidogyne* spp.(1). In 1979 the samples were collected 6 weeks after planting since late sampling was found inadequate for *H. glycines*. Each sample consisted of 15-20 2.5-cm-diam soil cores collected to a depth of 15-20 cm from the root zone along the 2 center rows of each plot. The cores were composited and a 50 cm^3 subsample was used to extract nematodes by the molasses flotation sieving technique (10). Yield was obtained from the 2 center rows of each plot.

All data were statistically analysed following standard procedures for analyses of variance of split plot experiments and least significant differences (12). Unless otherwise stated, all differences mentioned in the text were significant at a probability level of 5% or lower.

RESULTS AND DISCUSSION

1978 Experiment. Highest numbers of *M. arenaria* larvae occurred in untreated plots with Davis, Centennial and Ransom, and those with Davis had significantly higher numbers of the larvae than those with Ransom (Table 2); differences in numbers of larvae in plots of other cultivars were not significant. Differences among cultivars with respect to the number of larvae of *H. glycines* in untreated plots were not significant. This is attributed to the lateness of the sampling since most of the roots were dead in all varieties when the soil was obtained and egg hatching probably continued after the root system died. This appears to affect larval populations of *H. glycines* more significantly than those of *M. arenaria*. Fumigation significantly reduced numbers of larvae of *M. arenaria* so that there were no significant differences in number of *M. arenaria* between cultivars in the treated plots. The number of larvae of *H. glycines* in fumigated plots were higher than in untreated plots. This was possibly because root systems were probably more developed and remained functional for a longer time than those in untreated plots. Numbers of larvae of *H. glycines* in treated

Table 1. Maturity groups and relative tolerances of soybean cultivars to *Meloidogyne arenaria* and race 3 of *Heterodera glycines*.

Cultivar	Maturity Group	*M. arenaria*	*H. glycines* race 3
Bedford	V	2.0[x]	+[y]
Braxton	VII	1.6	-
Bragg	VII	2.5	-
Centennial	VI	4.5	+
Cobb	VIII	3.0	-
Davis	VI	4.0	-
Dowling	VIII	5.0	-
Forrest	V	1.2	+
Govan	VII	1.8	-
Hutton	VIII	4.5	-
Ransom	VII	5.0	-
F-70-2060	VIII	1.5	-

[x] Based on a scale where 1 = highly resistant and 5 = very susceptible.
[y] + = resistant and - = susceptible.

plots were lowest in those planted with Centennial and highest in plots with Bragg, Davis, and Ransom; larval numbers in plots planted to Centennial, Cobb, Govan, Hutton and F-70-2060 were not significantly different. A weak negative correlation (r=-0.383) occurred between numbers of larvae of *M. arenaria* and *H. glycines*. However, the lateness of sampling probably influenced the closeness of the correlation since the number of *H. glycines* larvae in untreated plots was very low.

Highest soybean yields in untreated plots were obtained with Centennial and the lowest with Cobb, Dowling, Braxton, Ransom, Hutton, and Davis; yields from Bragg, Govan and F-70-2060 were intermediate and showed no marked differences in yield between them. The interaction between cultivars and fumigation treatments was not insignificant so that the pattern of response described for cultivars in untreated plots was true for fumigated soil. There were, however, some differences. Davis, which was among the lowest yielding cultivars in untreated plots, produced significantly higher yields in fumigated soil than all cultivars but Centennial and Ransom. Calculations of the percent yield response to fumigation for each cultivar revealed that although the cyst nematode resistant cultivar Centennial produced the highest yield in fumigated plots, its percent yield response (66.3%) to fumigation relative to its yield in untreated plots was markedly lower than the corresponding response values obtained with Davis (170.3%), Ransom (142.3%), or even Dowling (132.4%).

Yield data for Centennial (cyst resistant) in untreated plots was significantly higher than that from Govan (*M. arenaria* tolerant). This finding suggests that in the mixed population infestation existing in the experimental field, damage from *H. glycines* was

Table 2. Soybean yields, *Meloidogyne arenaria* and *Heterodera glycines* larval populations as affected by fumigation. 1978.

Cultivar	Numbers/50 cm^3 soil				Yield (Kg/ha)	
	M. arenaria		*H. glycines*			
	Control	Fumigated	Control	Fumigated	Control	Fumigated
Bragg	19.0	5.8	7.8	40.2	295	377
Braxton	31.5	9.7	10.8	26.3	195	397
Centennial	66.5	17.2	0.5	6.8	650	1081
Cobb	24.3	9.0	12.3	15.7	133	223
Davis	94.8	22.8	12.5	40.2	263	711
Dowling	25.0	11.3	5.3	26.8	145	337
Govan	21.0	11.3	6.7	17.7	288	507
Hutton	28.2	7.3	6.5	17.7	243	418
Ransom	50.5	22.7	5.7	43.2	243	589
F-70-2060	25.3	17.7	6.2	18.2	308	507
LSD (P=0.05):	20.2	20.2	12.1	12.1	143	143
LSD (P=0.01):	26.7	26.7	16.0	16.0	189	189

more determinant of yield losses than that from *M. arenaria*.

1979 Experiment - Larvae of *M. arenaria* and *H. glycines* were significantly reduced by treatment with Soilbrom 90 EC under some cultivars (Table 3). Degree of reduction of larval numbers attained with the fumigant was greater for *M. arenaria* than for *H. glycines*. Larvae of *M. arenaria* were almost eliminated in fumigated plots whereas those of *H. glycines* were in relatively high numbers in plots with Braxton, Cobb, and Davis. Highest numbers of *M. arenaria* larvae in untreated soil were in plots with Centennial and Bedford and the lowest numbers in plots with Bragg, Braxton, and Ransom. Larval numbers for *H. glycines* in untreated plots were highest with Cobb and lowest with Forrest, Centennial and Bedford. Numbers of *H. glycines* in plots with Bragg, Braxton, Davis, Hutton and Ransom were significantly higher than those in plots with Bedford, Centennial, or Forrest, but significantly lower than the number in Cobb plots. A significant ($P = 0.01$) negative correlation ($r = -0.756$) between the numbers of larvae of *M. arenaria* and those of *H. glycines* was detected in untreated plots. Cultivars such as Bedford or Centennial with a high degree of tolerance for *H. glycines* had low numbers of *H. glycines* larvae and high numbers of *M. arenaria.* Conversely, cultivars (Bragg, Braxton) with low populations of *M. arenaria* sustained high populations of *H. glycines*. Although this inverse relationship was generally in accordance with what is known (3) about the relative tolerance of these cultivars to the two nematodes (Table 1), there were some exceptions. Thus, cultivar Ransom, which has little or no tolerance to *M. arenaria* or *H. glycines*, had very low numbers of larvae of *M. arenaria* and high numbers of *H. glycines*. We interpret such a response as due to a greater degree of competitiveness of *H. glycines* than *M. arenaria* in this cultivar.

Table 3. Soybean yields, *Meloidogyne arenaria* and *Heterodera glycines* larval populations as affected by fumigation. 1979.

Cultivar	Numbers/50 cm^3 soil				Yield (Kg/ha)	
	M. arenaria		*H. glycines*			
	Control	Fumigated	Control	Fumigated	Control	Fumigated
Bedford	29.1	0.0	3.7	0.8	692	1367
Bragg	8.5	0.0	36.3	10.5	142	866
Braxton	5.0	0.0	53.3	34.0	167	675
Centennial	42.0	0.0	0.8	0.5	610	1404
Cobb	12.7	0.0	79.0	18.8	102	411
Davis	18.3	0.0	21.8	35.1	366	1172
Forrest	19.5	0.0	2.7	1.3	622	1367
Hutton	11.5	0.0	27.7	7.7	142	574
Ransom	3.3	0.2	45.0	5.8	256	895
LSD (P=0.05):	16.8	16.8	17.6	17.6	166	166
LSD (P=0.01):	22.3	22.3	23.3	23.3	220	220

Similar but less promounced patterns of behavior of the 2 nematode species were observed for other cultivars such as Hutton and Cobb, with analogous tolerance levels.

The interaction of cultivars by fumigant treatments was not significant for *M. arenaria* larvae. However, the interaction of cultivars by fumigant treatments was significant ($P = 0.01$) for *H. glycines* larvae, indicating that degree of reduction in larval populations obtained with the fumigant was dependent on the cultivar.

Yields in the treated plots were highest in those with the 3 cyst-resistant cultivars. Marked differences in yield were noted among the cyst-susceptible cultivars in fumigated plots. Davis produced the highest yields, followed in descending order by Ransom and Bragg, Braxton and Hutton, and Cobb; the difference between Cobb and Hutton was not significant. The yield response of cyst-susceptible varieties to fumigation is probably a reflection of their relative susceptibility to *H. glycines* since *M. arenaria* was almost eliminated from the treated plots by the fumigant.

CONCLUSIONS

Our data show that in a mixed population situation, it is not possible to culture soybeans without adequate nematicidal treatments. A significant negative correlation exists between *H. glycines* and *M. arenaria* suggesting that continued use of cultivars with single nematode species resistance in soil with multiple species infestations may result in a rapid increase of the nematode to which the cultivar is susceptible. Therefore, chemicals or some other control measure must be also utilized.

Our data also indicate that of the two parasites, greatest damage to a cultivar susceptible to both nematodes can be expected from *H. glycines*. Results support the view that it is easier to obtain adequate control of *M. arenaria* through the use of efficacious nematicides than it is to control *H. glycines*. An *H. glycines*-resistant cultivar should be planted in fields infested with the mixed populations accompanied by nematicidal treatments. If available it is advisable to use a cultivar resistant to both nematode species. However, at present, this course does not exist commercially.

RESUMEN

Las respuestas de cultivares de soya en un campo con una población mixta de *Meloidogyne arenaria* y la raza 3 de *Heterodera glycines* fueron estudiadas en un campo en la región meridional de Alabama por un período de dos años. Los cultivares estudiados, seleccionados según su tolerancia relativa a los parásitos, fueron: Bedford, Braxton, Bragg, Centennial, Cobb, Davis, Dowling, Forrest, Govan, Hutton, Ransom, y F-70-2060. Cada cultivar se sembró en parcelas fumigadas con bibromuro de etileno (Soilbrom 90 EC) y también en otras no fumigadas. Los rendimientos más altos se obtuvieron con los cultivares resistentes a *H. glycines:* Bedford, Centennial, y Forrest. Se detectó una correlación negativa y válida entre las poblaciones de larvas de *H. glycines* y las correspondientes de *M. arenaria* lo que indicó que resistencia a *H. glycines* en un cultivar iba asociada a un aumento en el número de larvas de *M. arenaria* en el suelo. La fumigación fue más efectiva contra *M. arenaria* que contra *H. glycines*. Los resultados indicaron que el mayor grado de combate de los nematodos y mayores aumentos en rendimiento se obtuvieron con el uso de cultivares resistentes a *H. glycines* sembrados en suelo fumigado.
Claves: combate de nematodos, fitomejoramiento, dinámica de poblaciones, manejo de plagas, rotación de cultivos, variables resistentes.

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