EFFECT OF *HOPLOLAIMUS GALEATUS* AND OTHER NEMATODES ON YIELD OF SELECTED SOYBEAN CULTIVARS [EFECTO DE *HOPOLAIMUS GALEATUS* Y OTROS NEMATODOS SOBRE EL RENDIMIENTO DE CULTIVARES SELECTOS DE SOYA].

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ABSTRACT

Field experiments were conducted in 1975, 1977, 1978 and 1979 at Tallassee, Alabama to determine the degree of damage caused by *Hoplolaimus galeatus* (Cobb) Sher alone and in combination with *Meloidogyne incognita* (Kofoid and White) Chitwood, *Paratrichodorus (N) christiei* (Allen) Siddiqi, *Pratylenchus brachyurus* Steiner, and *Tylenchorhynchus claytoni* Steiner on selected soybean *(Glycine max)* cultivars. Control of *H. galeatus* with planting time applications of DBCP (14 l/ha) resulted in significant increments in yieldof most soybean cultivars in an experiment where the nematode was the only parasite. In another experiment, the combination of *H. galeatus* with *M. incognita* resulted in the greatest yield loss recorded for all experiments as measured by response to DBCP treatment. Control of *P. brachyurus* and *P. christiei* in combination with low numbers of *H. galeatus* also resulted in significant yield responses. Results suggested that losses from *T. claytoni* were not important at the levels of infestation tested.
Key Words: Control, Glycine max, resistant cultivars, lance, lesion, stubby root, and stunt nematodes, Nemagon, Fumazone, 1,2-dibromo-3-chloropropane.

INTRODUCTION

Soybeans *(Glycine max)* are subject to attack by a wide variety of nematodes (16). In the southeastern United States the principal nematodes include several root-knot nematode *(Meloidogyne* Goeldi), the cyst nematodoe *(Heterodera glycines* Ichinohe), the reniform nematode *(Rotylenchulus reniformis* Linford and Oliveira) and in Georgia and South Carolina the Columbia lance nematode *(Hoplolaimus columbus* Sher) (2, 3, 4, 11, 12). Because of their ubiquitous presence and the losses they cause in the crop, the root knot and cyst nematodes have received a great deal of attention. A number of cultivars adapted to the area with relatively high degree of resistance to these nematodes have been developed (6). The combination of resistant cultivars and nematicide treatments have been shown by several workers to be the most economical and effective means to control root knot and cyst nematodes (7, 8, 9, 10, 15). A number of other nematode species in genera other than *Meloidogyne* and *Heterodera* are found widely distributed in Alabama either alone or in combination with the root knot and cyst nematodes (12, and unpub.). These species although suspected to cause significant yield losses in soybeans have not been adequately studied. Results presented in this paper are from field experiments designed to determine the degree of damage caused by species of *Hoplolaimus, Pratylenchus, Paratrichodorus,* and *Tylenchorhynchus* which are found frequently in Alabama soybean fields.

MATERIALS AND METHODS

The performance of selected soybean cultivars was studied in the field on a Wickum loamy sand soil (Tipic Hapludult) located at the Plant Breeding Unit, Tallassee, Alabama. The field had been in a cotton, soybean and corn rotation. A part of the field was infested with root knot *(Meloidogyne incognita* (Kofoid and White) Chitwood), lance *(H. galeatus)* and stunt *(Tylenchorhynchus claytoni* Steiner) nematodes; other areas in the field were not infested with root knot nematodes but were infested with the other species and with stubby root *(Paratrichodorus* (N) *christiei* (Allen) Siddiqi) and lesion *(Pratylenchus brachyurus* (Godfrey) Goodey) nematodes.

Sub-plots were 4 (1.1 m wide) rows x 7 m long and the experimental design was a split plot in which the performance of the cultivars was examined in soil treated with 0 and 14.0 l/ha of DBCP (1,2-dibromo-3-chloropropane). The fumigant was injected at planting to a depth of 20 cm with two injectors per row each 7.5 cm on each side of the seed furrow. There were six replications of each cultivar at each level of DBCP. Cultural conditions and management of weeds, insects, and foliar diseases followed those recommended for the area (5).

Soil samples for nematode analysis were collected 80 days after planting and were processed by a modified flotation-sieving technique (14). Soybean yields were determined from the two center rows of each plot as each cultivar matured.

Cultivars used in the experiments are listed in Table 1 with a description of their relative susceptibility to *M. incognita* (6).

The field experiment in 1975 was located in an area infested with root knot, lance and stunt nematodes and included the cultivars: Mack, Forrest, Bragg, Ransom, Hutton, Cobb, and Coker 338. The experiment in 1977 was in a portion of the field infested with *H. galeatus* alone, and was designed to study the response of cultivars Centennial, Davis and F 70-2060 in addition to those in the 1975 experiment but Cobb. The experiment in 1978 had all the cultivars listed but Coker 338 and was located in an area infested with lance and stunt nematodes. The experiment in 1979

Table 1. Maturity groups and relative reaction to root knot nematode *(Meloidogyne incognita)* of soybean cultivars used in the experiment.

Cultivars	Maturity Group	Index *y*
Forrest	V	1.2 - 1.5
Mack	V	3.0 - 5.0
Centennial	VI	3.0 - 5.0
Davis	VI	4.0 - 4.5
Bragg	VII	1.0 - 2.0
Ransom	VII	3.5 - 4.8
Cobb	VIII	1.0 - 2.0
Coker 338	VIII	4.0 - 4.5
Hutton	VIII	1.0 - 1.3
F10-2060	VIII	1.0 - 2.0

y Root-knot disease ratings are based upon degree of galling development on roots. A rating of 1 is no galling; 5 is severe galling (6).

was located in soil infested with lance, stubby root, and lesion nematodes and contained the soybean cultivars: Bragg, Centennial, Cobb, Davis, Forrest, Hutton, and Ransom.

Data were analysed following standard procedures for analysis of variance and differences between means were evaluated for significance with a modified Duncan's multiple range test (17).

RESULTS

Application of DBCP generally reduced numbers of *H. galeatus* and *T. claytoni* in 1975 (Table 2). The interaction between cultivars and DBCP for lance nematode data was significant indicating that the degree of response to the nematicide was dependent on the cultivar. DBCP caused a reduction in the population levels of lance nematodes in some cultivars, e.g. Hutton, Ransom, Coker 338, whereas other cultivars, e.g. Bragg, Forrest, showed no significant change in nematode numbers. Differences in numbers of *T. claytoni* between cultivars were not significant in either treated or untreated plots. Significantly higher numbers of *H. galeatus* were recovered around the roots of Hutton soybeans than the roots of other cultivars in nonfumigated soil; all other differences between cultivars for this nematode were not significant. Highest numbers of root-knot nematode larvae in untreated plots were found in those planted to Mack soybeans and lowest in those with Bragg, Cobb, Coker 338, Forrest and Hutton. Cultivar Ransom supported intermediate levels of the larvae but the numbers were not significantly different from those of all other cultivars in the check plots. Fumigation resulted in significantly higher numbers of *M. incognita* in plots with Mack and Ransom soybeans; differences between treated and untreated plots for the remaining cultivars were not significant. Lowest yield was obtained with Mack and Forrest in check plots and Bragg, Forrest and Mack in treated plots. All cultivars gave significant increases in yields in response to the treatment. Greatest response was that for Mack (169%) and lowest for Bragg (34%).

Treatment with DBCP almost reduced populations of *H. galeatus* below detectable levels in 1977 (Table 3). Highest population of the nematode in untreated plots corresponded to those with the Forrest cultivar and lowest to those with Coker 338, Davis, F 70-2060, Hutton and Ransom; population levels in plots with Centennial and Mack were not significantly different from those of any other cultivar in untreated plots. The numbers of the nematode in plots with Bragg or F 70-2060 were lower than those with Forrest but not different from those that corresponded to the other cultivars. Treatment with DBCP resulted in yield increase in all cultivars but Bragg, Forrest, and Mack. Lowest yields in untreated plots were obtained with Forrest and Mack, and highest with Hutton; however, yield differences between Hutton and Bragg, Coker 338, Davis, F 70-2060, and Ransom were not significant. Also, differences in yield in untreated plots between Centennial, and Forrest or Mack were not significant. The average yield response to treatment with DBCP for the cultivars that gave significant yield increases was 11.3%. Highest yields in treated plots were those obtained with Coker 338, Davis, F 70-2060, Hutton, and Ransom, and lowest were with Forrest and Mack; plots with Centennial were intermediate and yield from those with Bragg were not different from those with Centennial, Forrest, and Mack.

DBCP in 1978 reduced the populations of *H. galeatus* and *T. claytoni* below detectable levels (Table 4). Lowest numbers of *H. galeatus* in untreated plots occurred in those with F 70-2060, Hutton, and Mack soybeans and the highest numbers occurred in plots with Bragg, Centennial, Cobb, and Davis, with intermediate levels in plots with Forrest and Ransom. Highest numbers of *T. claytoni* were associated with

Table 2. Effect of DBCP (14 l/ha) on soil populations of plant parasitic nematodes and yield of soybean cultivars in a field experiment at Tallassee, Alabama in 1975.

	Numbers per 50 cm³ soil.								
Cultivar	*Meloidogyne incognita*		*Hoplolaimus galeatus*		*Tylenchorhynchus claytoni*		Yield (kg/ha)		% Yield
	Check (larvae)	DBCP	Check	DBCP	Check	DBCP	Check	DBCP	Increase
Bragg	13.0 B	9.8 B	37.0 B	26.0 A	41.0 A	3.0 A	1722 A	2313 B	34.2
Cobb	5.3 B	0.6 B	51.0 B	30.0 A	55.8 A	4.5 A	2024 A	3019 A	49.2
Coker 338	2.2 B	2.6 B	65.0 B	10.0 A	38.8 A	2.6 A	2071 A	2966 A	43.2
Forrest	8.3 B	8.5 B	36.0 B	20.0 A	53.0 A	5.5 A	1224 B	2098 B	71.4
Hutton	6.0 B	3.1 B	124.0 A	21.0 A	72.1 A	4.0 A	1708 A	2959 A	73.2
Mack	55.2 A	72.5 A	40.0 B	15.0 A	60.6 A	3.3 A	881 B	2367 B	168.7
Ransom	23.0 AB	68.1 A	61.0 B	20.0 A	47.0 A	4.6 A	1715 A	3066 A	78.8

Each figure represents the average of six replications; those within a column followed by an identical letter were not statistically different ($P = 0.05$)

Table 3. Effect of DBCP (14 l/ha) on soil populations of *Hoplolaimus galeatus* and yield of soybeans in a field experiment at Tallassee, Alabama in 1977.

Cultivar	50 cm³ soil *Hoplolaimus galeatus*		Yield (kg/ha)		% Yield
	Check	DBCP	Check	DBCP	Increase
Bragg	21.3 BC	0.2 A	2741 AB	2415 BC	-11.9
Centennial	29.8 ABC	0.2 A	2494 BC	2699 B	8.2
Coker 338	13.7 C	0.3 A	2883 AB	3221 A	11.7
Davis	11.2 C	0.0 A	2715 AB	3023 A	11.3
F 70-2060	21.8 BC	0.3 A	2740 AB	3262 A	19.0
Forrest	43.2 A	0.3 A	2104 C	2045 C	-2.8
Hutton	11.5 C	0.2 A	3050 A	3336 A	9.4
Mack	35.0 AB	0.3 A	2034 C	2144 C	5.4
Ransom	11.5 C	0.3 A	2881 AB	3284 A	14.0

Each figure represents the average of six replications; those within a column followed by an identical letter were not statistically different (P = 0.05).

Centennial, Cobb, F 70-2060, and Mack but with the exception of F 70-2060 differences between all other cultivars were not significant. Application of DBCP resulted in increased yields of all cultivars except Davis and Hutton. The average yield increase among the cultivars that responded to fumigation was 14.2% over the control and the increase ranged form 27.9% (Mack) to 8.2% (Ransom). Highest yields in untreated plots were obtained with Davis, F 70-2060, Hutton and Ransom, and lowest with Bragg, Centennial, Cobb and Mack. Differences between Davis, F 70-2060 and the lowest yielding cultivars were not significant. Soybean yields in fumigated soil were highest with Cobb, Davis, F 70-2060, and Ransom, and lowest with Bragg, Centennial, Forrest, Hutton, and Mack. Differences between the lowest yielding cultivars and Cobb or Davis were not significant.

Numbers of *H. galeatus* in 1979 (Table 5) were lower than in the other tests. Differences between cultivars for this nematode were not significant. The DBCP treatment reduced *H. galeatus* and *P. brachyurus* to almost undetectable levels but only diminished numbers of *P. christiei* slightly and then only for some cultivars. Highest numbers of *P. christiei* in untreated soil were in plots with Bragg, Cobb, Davis, Forrest, and Hutton and lowest in those with Centennial and Ransom. However, differences between Cobb, Davis, and Forrest and Centennial or Ransom were not significant. Highest numbers of *P. brachyurus* in untreated soil occurred in plots with Bragg, Cobb, Hutton, and Ransom and lowest in plots with Centennial, Davis, and Forrest. Differences between Cobb, or Ransom and Centennial, Davis or Forrest were not significant. Application of DBCP resulted in significant yield increases for all varieties but Ransom. The average yield increase over the untreated controls for cultivars that responded to fumigation was 27.1% and it ranged from 44.4% (Forrest) to 18.8% (Centennial). Lowest yield in fumigated soil was obtained with Hutton followed in increasing order of response by Bragg and Forrest, Cobb and Centennial, Davis and Ransom. Differences in yield between Centennial, Cobb, Davis, and Ransom were not significant.

Table 4. Effect of DBCP (14 l/ha) on soil populations of two plant parasitic nematodes and on yield of soybeans in a field experiment at Tallassee, Alabama in 1978.

	Numbers per 50 cm^3 soil						
	Hoplolaimus galeatus		*Tylenchorhynchus claytoni*		Yield (kg/ha)		% Yield
Cultivar	Check	DBCP	Check	DBCP	Check	DBCP	Increase
Bragg	31 AB	0 A	54 AB	0 A	1492 C	1635 C	9.6
Centennial	34 A	0 A	64 AB	0 A	1760 BC	1916 BC	8.9
Cobb	20 ABC	0 A	54 AB	0 A	1747 BC	2038 AB	16.6
Davis	21 ABC	0 A	29 B	0 A	2067 AB	2105 AB	1.8
F 70-2060	10 C	0 A	86 A	0 A	1882 AB	2198 AB	16.8
Forrest	16 BC	0 A	24 B	0 A	1715 BC	1916 BC	11.7
Hutton	10 C	0 A	28 B	0 A	1840 AB	1916 BC	4.1
Mack	12 C	0 A	41 AB	0 A	1473 C	1884 BC	27.9
Ransom	16 BC	0 A	41 AB	0 A	2201 AB	2382 A	8.2

Each figure represents the average of six replications; those within each column the same column followed by the same letter were not statistically different (P = 0.05).

Table 5. Effect of DBCP (14 l/ha) on soil populations of plant parasitic nematodes and on yield of soybean cultivars in a field experiment conducted at Tallassee, Alabama in 1979.

	Numbers per 50 cm^3 soil								
	Hoplolaimus galeatus		*Paratrichodorus christiei*		*Pratylenchus brachyurus*		Yield (kg/ha)		% Yield
	Check	DBCP	Check	DBCP	Check	DBCP	Check	DBCP	Increase
Bragg	8.8 A	0.0 A	24.0 A	10.0 A	17.8 AB	0.0 A	1238 D	1570 C	26.8
Centennial	9.5 A	0.0 A	13.5 BC	10.3 A	7.7 C	0.3 A	1621 B	1926 AB	18.8
Cobb	11.0 A	0.0 A	17.8 ABC	16.2 A	14.2 ABC	0.0 A	1430 C	1783 B	24.7
Davis	12.2 A	0.0 A	19.2 ABC	11.5 A	11.7 BC	0.2 A	1474 BC	1856 AB	25.9
Forrest	7.0 A	0.0 A	18.3 ABC	11.8 A	8.2 C	0.3 A	1098 DE	1586 C	44.4
Hutton	9.2 A	0.0 A	24.5 A	13.5 A	19.5 A	0.2 A	1000 E	1219 D	21.9
Ransom	5.2 A	0.0 A	10.0 C	10.7 A	14.8 ABC	0.0 A	1888 A	1958 A	3.7

Each figure is the average of six replications; those within each column followed by an identical letter were not statistically different ($P = 0.05$).

DISCUSSION

The experiments were conducted in soils with four different combinations of plant parasitic nematode species. In each case, the levels of infestation found were those we consider common in Alabama soybean fields (unpublished data) and do not represent extreme degrees of severity. The types of nematode species comprise a good range of feeding habits varying from endoparasites *(M. incognita)* to ectoparasitic species *(T. claytoni* and *P. christiei)*, migratory endoparasites *(P. brachyurus)* and a species *(H. galeatus)* with both endo- and ectoparasitic feeding habits. We believe these results provide a good field evaluation of the relative damage of the species to soybeans. The damage to soybeans from *H. galeatus* alone (1977) can be significant and for most cultivars tested, of a degree that it would be profitable to use nematicides. The combination of *H. galeatus* and *T. claytoni* (1978) resulted in damage equivalent to that obtained with *H. galeatus* alone in 1977. This suggests that *T. claytoni* may not be important in causing yield losses, since the average levels of infestation of *H. galeatus* in both tests were comparable. The species combinations that included *M. incognita* (1975) resulted in the greatest yield response. Levels of *H. galeatus* in 1975 were about two times as large as those in 1977 and 1978 which could be expected to result in an increase in yield loss attributable to this nematode. We do not have available at present equations to relate numbers of *H. galeatus* to soybean yield loss for each cultivar to permit us to separate the damage attributable to *M. incognita* from that attributable to *H. galeatus*. However, the yield responses observed for cultivars with good resistance to *M. incognita* in comparison to responses from those that have no resistance to this nematode lead us to conclude again that the contribution to yield loss by *H. galeatus* is significant. Thus, comparisons of yield responses by cultivars within the same maturity groups, but with differing levels of resistance to *M. incognita* (Bragg vs Ransom: group VII, Forrest vs Mack: group V) suggest an additive effect of damages from *H. galeatus* and *M. incognita*. These comparisons could not be made for group VIII cultivars (Cobb vs Hutton) since an unexpected and significant increase in populations of *H. galeatus* was observed in plots with Hutton, the cultivar that had greatest level of resistance to *M. incognita*. This "shift in population" was not observed in the resistant cultivars in the other two maturity groups in the experiment. Results from 1979 with the combination of *H. galeatus*, *P. christiei* and *P. brachyurus* support the view that the soybean cultivars sustain significant damage from plant parasitic nematodes other than root-knot and cyst nematodes (16). The degree of damage may be dependent on the particular cultivar as is the case for root knot, cyst, and other nematodes (1, 6, 8, 9, 10, 13, 15).

Our results indicate that there may be differing levels of resistance to *H. galeatus*, *P. christiei*, and *P. brachyurus* among the soybean cultivars tested. Because of its practical importance, this idea should receive further study by plant breeders.

RESUMEN

El trabajo presenta resultados de experimentos de campo hechos en 1975, 1977, 1978 y 1979 en Tallasee, Alabama, con el propósito de determinar el grado de daño causado por *Hoplolaimus galeatus* individualmente y en combinación con *Meloidogyne incognita*, *Paratrichodorus christiei*, *Pratylenchus brachyurus*, y *Tylenchorhynchus claytoni*. La inyección de DBCP (14 l/ha) para combatir *H. galeatus* dió aumentos de rendimientos significativos en la mayoría de los cultivares utilizados en un experimento donde el nematodo era el único parásito presente. En otro experimento la combinación de *H. galeatus* con *M. incognita* dió el mayor aumento en rendimiento con la aplicación de DBCP en comparación al obtenido en los otros experimentos. Asi mismo, los resultados de un tercer experimento indicaron que la combinación de *H. galeatus* con *P. brachyurus* y *P. christiei* produjo bajas significativas en el rendimiento de los cultivares. Otros resultados indicaron que las pérdidas de producción atribuibles a *T. claytoni* no fueron significativas con los niveles de infestación presentes.

Claves: Combate de nematodos, Glycine max, cultivares resistentes, fitomejoramiento, nematodos lesionadores, de escobilla de la raíz, del achaparramiento, y de lanza, Nemagon, Fumazone, 1,2-dibromo-3-cloropropano.

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