Claves: fitomejoramiento de pastos, resistencia a nematodos, respuesta de variedades Trichodorus christiei, Hoplolaimus galeatus.

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RESPONSE OF A RESISTANT SOYBEAN CULTIVAR TO FUMIGATION AT-PLANTING FOR THE CONTROL OF SOYBEAN CYST AND ROOT-KNOT NEMATODES [REACCION DE UN CULTIVAR DE SOYA RESISTENTE A LA FUMIGACION PARA EL COMBATE DE LOS NEMATODOS ENQUISTADOR DE LA SOYA Y EL NODULADOR].

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ABSTRACT

In field soil infested with the soybean cyst nematode, *Heterodera glycines* Ichinohe, dibromoethane (Soilbrom® 90EC at 4.7 and 9.4 l/ha) and dibromochloropropane (Fumazone® 86 E at 9.4 l/ha) significantly increased yields over untreated checks of the resistant soybean, *Glycine max* L. Merr. cultivar 'Centennial'. In a companion study involving 'Centennial' growing in soil infested with the southern root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood, no treatment significantly increased yields. However, Soilbrom 90EC at 18.7 and 37.4 l/ha had a significantly adverse effect on the levels of root-knot nematode in the soil. Early season stand and vigor ratings, which decreased with increases in treatment rates, were highly correlated with harvested yields in both studies.
Key Words: dibromoethane, dichloropropene, dichloropropene — dichloropropane mixture.

INTRODUCTION

Nematodes are a major limiting factor in soybean *(Glycine max* (L.) Merr.) production in the southeastern United States. Of particular importance are the soybean cyst nematode *Heterodera glycines* Ichinohe, and the southern root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood. Selective soybean breeding has been successful in producing several cultivars that have a high degree of resistance to these nematodes (6), and their cultivation has become a major means of nematode control. However, additional nematicidal fumigation of a resistant cultivar has been required for optimum yields in heavily infested fields (5). Because of its efficacy, relatively low cost, and its ease of application, dibromochloropropane (DBCP) has been the most widely used nematicide for this purpose.

Recently disclosed environmental problems concerning DBCP (1) have raised questions relative to its future use, and have encouraged a reevaluation of the efficacy of at-planting application of other fumigant nematicides. For this reason, two field experiments were established to evaluate the efficacy of various rates of fumigant nematicides in comparison with a standard rate of DBCP in controlling soybean cyst nematode and southern root-knot nematode on a newly released soybean cultivar, 'Centennial', formerly breeding line D70-3185 (4). This is the most resistant cultivar to race 3 of the soybean cyst nematode (3) and southern root-knot nematode released to date.

MATERIALS AND METHODS

Nematicide evaluations were conducted on two sandy-loam soil field sites at the University of Florida, Agricultural Research Center, Jay, Florida. One site was infested with race 3 of the soybean cyst nematode and the other with the southern root-knot nematode. Coincident soil infestations of *Helicotylenchus dihystera* (Cobb) Sher, and *Paratrichodorus christiei* Allen were present in both sites. Each plot was assayed for nematodes prior to treatment and after harvest by sugar-centrifuge extraction (2) from a 100 cm^3 subsamble of eight 2.54 X 17.00 cm soil cores.

Nematicides applied were dichloropropene (Telone ® II), dibromoethane (Soilbrom® 90EC), dichloropropene—dichloropropane mixture (D-D®) and dibromochloropropane (Fumazone® 86E).

Dosage rates (Tables 1,2) and field plot arrangement were similar in both tests. Nematicides were applied at planting to plots 9.0 m long with two rows set 0.9 m apart. All treatments were replicated four times in a randomized complete block design with tiers separated by alleyways 6.0 m wide. The nematicides were applied by gravity flow equipment with two chisels per row, set 0.14 m on either side of the row, and injected to a depth of 0.28 m. Both tests were planted with 'Centennial', and each contained replicated untreated check plots. In the cyst nematode site, four additional untreated plots were planted to the cyst-susceptible cultivar 'Bragg'. Similar plots were planted to the root-knot susceptible cultivar 'Pickett 71' in the root-knot nematode site.

Six weeks following planting, each plot was visually rated for stand and vigor according to the following scale:

5. Complete stand; plants of uniform height.
4. Complete stand; some height variation.
3. Complete stand; considerable height variation.
2. Incomplete stand; few plants missing; considerable height variation.
1. Incomplete stand; as many as 25% of the plants missing.
0. Incomplete stand; in excess of 25% of the plants missing.

RESULTS AND DISCUSSION

Rainfall averaged 2.5 cm per day for the nine days following treatment and planting. This wet soil condition was highly conducive to producing phytotoxicity since the fumigants were likely prevented from rapid dispersion out of the root-zone. Stand ratings, taken 6 weeks after planting, decreased with increasing treatment rate for each fumigant (Table 1, 2). The higher rates of Telone II and D-D were the most phytotoxic.

In both tests the susceptible checks suffered from nematode damage and produced yields well below all other treatments. The 'Bragg' susceptible cultivar in the cyst nematode test was damaged early in the season, as indicated by the low stand rating. Of the other treatments in the cyst nematode test, only Fumazone 86E at 9.4 l/ha and Soilbrom 90EC at 4.7 and 9.4 l/ha significantly outyielded the untreated 'Centennial' check. Reproduction of *H. glycines* was not evident from the postharvest assays from

Table 1. Influence of fumigant nematicides on the growth and yield of soybean and on the abundance of soybean cyst nematode and coincident nematodes. Means of four replicates.

		Nematodes/ 10 cm^3 soil									
		Helicotylenchus dihystera		*Paratrichodorus christiei*		*Heterodera glycines*		*H. glycines* cysts/ 100 cm^3			
Treatment*	l/ha	Pi	Pf**	Pi	Pf	Pi	Pf	Pi	Pf	Stand*** Rating	Yield (Kg/ ha)
Telone II	9.4	3	27a****	0	2	0	0	3	0	3.75bcd****	2986abc****
Telone II	18.7	4	12 b	0	4	1	0	4	0	3.25 cdef	2805abcd
Telone II	28.1	2	7 bcd	0	5	1	0	4	1	3.00 def	2556 de
Telone II	46.8	3	2 cd	1	4	1	0	3	0	4.25ab	3047ab
Soilbrom 90EC	4.7	2	2 cd	1	4	1	0	3	0	4.25ab	3047ab
Soilbrom 90EC	9.4	3	0 d	0	4	1	0	5	0	3.50 bcde	3074ab
Soilbrom 90EC	18.7	3	0 d	0	5	1	0	4	0	3.50 bcde	2906abcd
Soilbrom 90EC	37.4	3	0 d	1	3	1	0	3	0	3.25 cdef	2906abcd
D-D	9.4	1	11 bc	0	3	0	0	3	0	3.50 bcde	2818abcd
D-D	18.7	5	9 bc	0	2	1	0	3	0	3.75 bcd	2764 bcd
D-D	28.1	2	12 b	0	3	0	0	5	1	2.75 ef	2368 e
D-D	46.8	2	5 bcd	0	2	0	0	4	0	2.75 ef	2394 e
Fumazone 86E	9.4	2	2 cd	1	3	1	0	2	0	4.75a	3202a
Resistant CK	----	3	7 bcd	1	3	1	0	2	0	4.00abc	2590 cd
Susceptible CK	----	4	8 bcd	1	2	1	3	3	7	2.25---	935----

*Treatments applied to *Heterodera glycines* resistant cultivar, 'Centennial'.
**Pi : pretreat population; Pf : postharvest population.
***0 : in excess of 25% of the plants missing; 5 : complete stand. Correlation between stand ratings and yield significant P : 0.01 (df : 54). Susceptible CK excluded.
****Means followed by the same letter are not significantly different (P : 0.05). Duncan's Multiple Range Test.

Table 2. Influence of fumigant nematicides on the growth and yield of soybean and on the abundance of root-knot nematode and coincident nematodes. Means of four replicates.

		Nematodes/10 cm^3 soil								
		Helicotylenchus dihystera		*Paratrichodorus christiei*		*Meloidogyne incognita*		*Meloidogyne incognita* increase		
Treatment*	l/ha	Pi	Pf**	Pi	Pf	Pi	Pf	Log[(P 1)/(P 1) 1]	Stand*** Rating	Yield (Kg/ha)
Telone II	9.4	17	62	0	1	9	137	1.17a****	4.50a****	3019ab****
Telone II	18.7	4	18	0	2	5	59	1.04a	3.25 cd	2628abc
Telone II	28.1	8	32	0	2	5	41	0.90a	3.00 de	2568abc
Telone II	46.8	7	13	0	1	14	76	0.78ab	2.50 e	1818
Soilbrom 90EC	4.7	27	23	0	1	9	156	1.22a	4.75a	3033ab
Soilbrom 90EC	9.4	38	6	0	2	9	58	0.83ab	4.25ab	3435ab
Soilbrom 90EC	18.7	5	1	0	2	14	15	0.32 bc	4.75a	3598a
Soilbrom 90EC	37.4	5	1	0	4	13	0	0.04 c	3.50 bcd	3139ab
D-D	9.4	13	66	0	1	9	146	1.19a	4.25ab	2644abc
D-D	18.7	26	90	0	1	4	128	1.42a	4.25ab	2672abc
D-D	28.1	23	38	0	1	4	91	1.28a	3.25 cd	2669abc
D-D	46.8	21	34	0	3	10	70	0.87ab	3.25 cd	2476 bc
Fumazone 86E	9.4	1	12	0	2	16	188	1.08a	3.50 bcd	3071ab
Resistant CK	----	12	23	0	1	8	105	1.10a	4.00abc	2892ab
Susceptible CK	----	12	17	0	1	11	517	1.64--	4.75--	1291--

*Treatments applied to *Meloidogyne incognita* resistant cultivar, 'Centennial'.
**Pi : pretreat population; Pf : postharvest population.
***0 : in excess of 25% of the plants missing; 5 : complete stand. Correlation between stand ratings and yield significant P : 0.01 (df : 54). Susceptible CK excluded.
****Means followed by the same letter are not significantly different P : 0.05. Duncan's Multiple Range Test.

any 'Centennial' plot. This cultivar was apparently highly resistant to the population of soybean cyst nematode under study, and yielded well even without treatment. The significantly greater yields from the aforementioned treatments were possibly due to early season control preventing root invasion by second stage *H. glycines* juveniles. All other treatments in the cyst nematode test gave yields that were not significantly different from the resistant check with the exception of the higher rates of D-D which produced significantly lower yields. This was likely due to phytotoxic effects.

The susceptible check, 'Pickett 71', grew well in early season but was severely damaged by root-knot nematode towards maturity. One plot of this cultivar was devoid of plants by harvest. In comparison, the resistant check 'Centennial' supported only one fifth of the population of root-knot nematode, and was not significantly out-yielded by any of the nematicidal treatments. However, Telone II at 46.8 l/ha yielded significantly less than the check.

Influence of fumigant action on root-knot nematode was computed by a logarithmic transformation of initial (Pi) and final (Pf) population counts (Table 2). The higher rates of Soilbrom 90EC had a more significant influence on the population of root-knot nematode than any other treatment. No root-knot nematode juveniles were recovered from the post-harvest samples from plots treated with Soilbrom 90EC at 37.4 l/ha.

In both tests there were highly significant correlations between early season stand ratings and yield. It is likely that the yields of the resistant cultivar, 'Centennial' were as much influenced by the degree of fumigant toxicity as they were by nematode control. Neither Fumazone 86E, nor any rate of Soilbrom 90EC, produced stand and vigor ratings significantly different than the checks in both tests. The effectiveness of these fumigants in influencing yield through nematode control would probably be more evident when immediate post-treatment soil conditions are more moderate than those experienced in these tests.

The value of resistant cultivars is evident from these and other data (5), and grower adoption of these should remain the first line of defense against *H. glycines* and *M. incognita*. Further yield increases through the additional use of fumigant nematicides can be expected if soil conditions at planting are not conducive to phytotoxic effects and applied rates are not excessive.

RESUMEN

La inyección de dibromoetano (Soilbrom® 90EC a 4.7 y 9.4 l/ha) y dibromocloropropano (Fumazone® 86E a 9.4 l/ha) a un suelo infestado con el nematodo enquistador de la soya, *Heterodera glycines* Ichinoe, resultó en aumentos en rendimiento del cultivar resistente de soya *(Glycine max* (L.) Merr.) "Centennial". En otro estudio semejante también con "Centennial" pero en suelo infestado con el nematodo nodulador *Meloidogyne incognita* (Kofoid y White) Chitwood, no se registraron aumentos significativos en rendimiento aunque la inyección de Soilbrom 90EC a 18.7 y 37.4 l/ha tuvo un efecto adverso en los niveles de nematodos noduladores en el suelo. Los índices de vigor y densidad de plantas a principios de la estación disminuyeron en relación con el aumento de fumigante y estuvieron altamente correlacionados con los rendimientos en ambos estudios.

Claves: dibromoetano, dicloropropeno, mezcla de dicloropropano—dicloropropeno.

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NEMATODOS FITOPARASITOS ASOCIADOS CON LA CAÑA DE AZUCAR EN VARIAS ZONAS DE COSTA RICA [PLANT PARASITIC NEMATODES ASSOCIATED WITH SUGAR CANE IN SEVERAL AREAS OF COSTA RICA].

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RESUMEN

Se analizó un total de 146 muestras procedentes de cañales de 6 a 12 meses de edad durante el año 1977 y parte de 1978 en cinco provincias de Costa Rica. Los géneros identificados fueron *Pratylenchus, Helicotylenchus, Meloidogyne, Longidorus, Xiphinema, Trichodorus, Criconemoides, Criconema, Heterodera, Ditylenchus, Paratylenchus, Paratrophurus, Tylenchus, Psilenchus, Aphelenchus, Hemicycliophora* y *Tylenchorhynchus.* Los más importantes por su frecuencia dentro del total de muestras analizadas fueron: *Helicotylenchus, Pratylenchus, Criconemoides, Longidorus* y *Meloidogyne,* presentes en un 88.4%, 45.2%, 34.9%, 32.9% y 28.1%.

Claves: Saccharum officinarum, registros nematológicos, ecología.

INTRODUCCION

El cultivo de la caña de azúcar *(Saccharum officinarum* L.) se encuentra bastante difundido en la mayor parte de los países agrícolas del mundo. Los nematodos fitoparásitos, entre otros, son patógenos económicamente importantes del cultivo (5, 7, 9, 11, 12, 15, 18, 21, 22).

En la actualidad no existe en Costa Rica un registro o recopilación de datos que mencione los géneros de nematodos fitoparásitos asociados con la caña de azúcar. Algunas observaciones (L.A. Salas, R. López, comunicación personal, 1978) han indicado que los géneros *Helicotylenchus, Meloidogyne, Pratylenchus, Tylenchorhynchus, Longidorus, Trichodorus, Tylenchus, Xiphinema* y *Ditylenchus,* se encuentran asociados con la caña de azúcar en diferentes zonas del país. Tarjan (15) mencionó a los géneros *Helicotylenchus* y *Tylenchus* y a *Longidorus laevicapitatus* como parásitos de la caña de azúcar en Paraíso de Cartago. Lamberti y Tarjan (8) describieron *Xiphinema costaricense* en asocio con varios cultivos, entre los cuales se cita la caña de azúcar.

Estudios realizados en diferentes partes de América, con el fin de combatir a los nematodos fitoparásitos de la caña azúcar, mencionan que ciertas especies de los géneros *Meloidogyne, Tylenchus, Xiphinema, Hoplolaimus, Ditylenchus,*