# EFFECT OF "COTTON COMPLEX" NEMATODES ON SEED YIELDS OF SOYBEAN

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## ABSTRACT

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Field experiments were conducted for 3 years to assess yield loss to a mixture of lance (*Hoplolaimus galeatus*), lesion (*Pratylenchus spp.*), stubby-root (*Paratrichodorus christiei*), and spiral nematodes (*Helicotylenchus dihystera*) in 7 soybean cultivars. Yield loss was assessed by comparing control plots with plots that received a planting-time application of 18.7 L EDB/ha. In the first year nematodes reduced yield by 24% with no effect on above-ground appearance of plants. Fumigation also influenced nematode numbers the first year, but cultivars did not. Yield loss from nematodes was slightly less during the next 2 years (14% and 13%). Cultivars affected nematode numbers only in one of 3 years. We concluded that this particular nematode complex was capable of causing significant yield loss, and that genetic variability among the cultivars tested for reaction to individual nematode species was minimal.

*Additional key words: Gossypium hirsutum, pest management, host-plant resistance, ectoparasitic nematodes, crop loss assessment.*

## RESUMEN

Weaver, D. B., y R. Rodríguez-Kábana. 1987. Efecto del "complejo de nematodos del algodón" sobre el rendimiento de la soya. Nematrópica 17:7-15.

Se efectuaron experimentos de campo por 3 años para determinar las pérdidas en rendimientos de 7 cultivares de soya (*Glycine max*) causadas por una mezcla de especies de fitonematodos compuesta de: *Hoplolaimus galeatus, Pratylenchus* spp., *Paratrichodorus christiei*, y *Helicotylenchus dihystera*. Las pérdidas se evaluaron comparando los rendimientos de los cultivares en parcelas testigos con los correspondientes en parcelas fumigadas con 18.7 L EDB/ha. En el primer año los nematodos causaron reducciones del 24% en el rendimiento de semillas aún cuando no se observaron síntomas de daños en las partes superiores de las plantas. Las pérdidas en rendimiento en los dos años siguientes fueron algo menores (14% y 13%). Los efectos de los cultivares sobre las poblaciones de nematodos fueron significativos en sólo un año de los 3 del estudio. Los resultados señalan que el complejo de especies de fitonematodos estudiado puede causar pérdidas serias en los rendimientos de la soya y que la variabilidad genética existente entre los cultivares de soya en relación a la reacción contra los nematodos del complejo es mínima.

*Palabras claves adicionales: Gossypium hirsutum, manejo de plagas, resistencia, nematodos ectoparásitos, cálculo de pérdidas de rendimiento.*

## INTRODUCTION

The soybean [*Glycine max* (L.) Merr.] is subject to attack by several species of nematodes (12). Much research has been conducted on yield loss and management of root-knot (*Meloidogyne* spp.) and soybean cyst (*Heterodera glycines* Ichinohe) nematodes (3), however information on yield loss and management of other plant-parasitic nematode species on soybeans is less available. Other species that attack soybeans and cause economic losses include lance nematodes (*Hoplolaimus* spp.) (1, 5) and lesion nematodes (*Pratylenchus* spp.) (6). Stubby-root nematodes (*Paratrichodorus christiei* [Allen] Siddiqi) and spiral nematodes (species of *Helicotylenchus, Scutellonema,* and *Rotylenchus*) are known to attack soybeans, but the extent of yield loss caused by these species is uncertain (12), especially when these nematodes occur in mixtures and at populations low enough that above-ground plant appearance is not conspicuously affected.

High populations of the Columbia lance nematode (*Hoplolaimus columbus* Sher) can reduce yields 90% (1). This yield loss is due to both direct feeding and predisposition of the host plants to attack by other pathogens (5). Rodríguez-Kábana and Thurlow (9) found yield loss to *Hoplolaimus galeatus* (Cobb) Thorne to be significant, especially when occurring in mixtures with root-knot nematodes (*Meloidogyne incognita* [Kofoid and White] Chitwood). Efforts to find sources of genetic resistance to *H. columbus* have not been successful (7). Koenning *et al.* (4) found that planting date of soybeans influenced amount of yield lost and population of lesion nematodes (*Pratylenchus brachyurus* [Godfrey] Filipjev and Schuurmans-Stekhoven). Lindsey and Cairns (6) found significant genetic variation for reaction to *P. brachyurus* based on yield loss and root pruning in the greenhouse.

Soybeans are often rotated with other crops, such as upland cotton (*Gossypium hirsutum* L.), which is also a known host of *H. galeatus* (13). The effect on soybean yields by a nematode complex that had been allowed to develop on cotton for several years has not been investigated. The objectives of this study were to determine the amount of soybean yield loss due to nematodes in a cotton field free of *H. glycines* and *Meloidogyne* spp., and to determine the effect of soybean genotypes on yield loss and nematode populations.

## MATERIALS AND METHODS

Field experiments were conducted at the Plant Breeding Unit near Tallassee, Alabama on a Cahaba fine sandy loam (Typic Hapludults) with less than 1% organic matter (w/w) during 1983, 1984, and 1985. Cotton had been grown on this field for at least 5 years previously. In January 1983, soil pH was 6.4 and P and K levels were medium (13-25 mg/kg and 21-40 mg/kg respectively). Nutrients were applied as recommended by the soil tests. In January 1986, soil pH was 5.6, P was medium, and K was high (41-80 mg/kg). Seedbed preparation consisted of chiseling and heavy disking in the spring, followed by a spike-tooth harrow. Weeds were controlled with a preplant incorporation of 0.56 kg/ha trifluralin (α,α,α-trifluro-2,6-dinitro-*N*,*N*-dipropyl-p-toluidine).

Treatments consisted of 7 soybean cultivars and two rates of ethylene dibromide (0 and 18.7 L/ha). Nematode effects on yield were assessed by comparing fumigated vs. nonfumigated plots. The 14 treatments were arranged in a 2 x 7 factorial structure in a randomized complete block design with 8 replications. Plots consisted of two rows 7.5 m long with 1.0-m spacing between rows, end-trimmed at harvest to a length of 6.0 m. Experiments were conducted on the same site each year, but treatments were assigned randomly to different plots in different years. During the winter, the field was fallowed but weeds were not controlled. Planting dates were 31 May, 16 May, and 15 May in 1983, 1984, and 1985 respectively.

Cultivars evaluated in each season were 'Forrest' (Maturity Group V); 'Davis', 'Centennial' (Maturity Group VI); 'Braxton', 'Ransom' (Maturity Group VII); 'Cobb', and 'Kirby' (Maturity Group VIII). All are resistant to *M. incognita* except 'Ransom' and 'Davis'; 'Forrest', 'Centennial,' and 'Kirby' are also resistant to *Heterodera glycines* (race 3). Soil samples for nematode analysis were collected 6 to 8 wk before harvest at the late R6 development stage (2). Samples from each plot consisted of a composite of 16 to 20 soil cores (each 2.5-cm diam.) from the root zone to a depth of 20 to 25 cm. A 100-cm3 subsample was used to determine total nematode numbers by the "salad bowl" incubation technique (8). Seed yields were obtained by harvesting the entire end-trimmed plot area with a small plot combine.

All data were analyzed following standard procedures for analysis of variance (ANOVA) and differences between means were tested using Fisher's least significant difference. Unless otherwise indicated, differences reported are significant at the 5% probability level.

## RESULTS AND DISCUSSION

Nematode species present in 1983 were lance (*H. galeatus*), lesion (*P. brachyurus*), stubby-root (*P. christiei*), and spiral (*H. dihystera*). Root-knot nematodes were present, but in low numbers and the data are not reported. In 1983, fumigation increased yield over nonfumigated plots by 32% (Table 1). Subjective ratings on plot appearance (data not shown) were influenced by differences among cultivars but not by nematicide treatment. Thus nematode feeding caused significant yield loss but above-ground appearance was not affected. Lesion nematodes were re-

Table 1. Effect of EDB on seed yields and nematode populations of selected soybean cultivars during 1983.

| Cultivar | Seed yield (kg/ha) | | Nematode populations/100 cm³ soil | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *H. galeatus* | | *Pratylenchus* spp. | | *P. christiei* | | *H. dihystera* | |
| | Cont.[y] | Fum.[y] | Cont. | Fum. | Cont. | Fum. | Cont. | Fum. | Cont. | Fum. |
| Braxton | 2300 | 2990 | 22 | 12 | 7 | 2 | 45 | 27 | 31 | 5 |
| Centennial | 2250 | 2870 | 31 | 5 | 6 | 1 | 28 | 25 | 20 | 2 |
| Cobb | 2130 | 2890 | 29 | 14 | 11 | 4 | 41 | 48 | 22 | 5 |
| Davis | 2140 | 2830 | 22 | 14 | 6 | 4 | 21 | 20 | 19 | 7 |
| Forrest | 1760 | 2510 | 27 | 9 | 8 | 6 | 18 | 22 | 15 | 8 |
| Ransom | 2170 | 2820 | 15 | 8 | 7 | 1 | 33 | 42 | 17 | 4 |
| Kirby | 2070 | 2720 | 22 | 5 | 9 | 3 | 35 | 30 | 26 | 2 |
| $\bar{X}$ | 2120 | 2800 | 24 | 10 | 8 | 3 | 32 | 31 | 21 | 5 |
| LSD[z](0.05) | 250 | | 13 | | 6 | | 17 | | 11 | |

[y]Cont. = Control (no nematicide); Fum. = Fumigated with EDB at a rate of 18.7 L/ha.

[z]Least significant difference (LSD) values are for comparison of any treatment-cultivar combination pair.

duced by fumigation but populations did not vary among cultivars. Lance nematodes responded similarly. Stubby-root nematodes, however, showed the opposite response; differences among cultivars were significant but the main effect of fumigation had no effect. 'Davis' and 'Forrest' had consistently lower stubby-root nematodes at both nematicide levels. Spiral nematodes were most reduced by fumigation, but were not affected by cultivars. No significant interactions were detected between cultivars and fumigation treatment for any variables.

Mean yield was increased slightly in 1984 compared to 1983 but yield response to nematicide was 16% in 1984 (Table 2). Nematode species present were the same as in 1983, but populations were somewhat lower, except for lesion nematodes which where slightly higher. Response of nematode populations to treatments were the same as in 1983 with two exceptions. Stubby-root nematodes were increased by fumigation, probably as a result of reduced competition for feeding sites from other species. This has been reported previously by Weaver *et al.* (14) for stubby-root nematodes as well as soybean cyst nematodes in combination with root-knot nematodes in EDB-treated plots. Cultivars influenced numbers of spiral nematodes which they did not do in 1983. However, trends were the same in both years, with 'Forrest' tending to support lower spiral nematode populations.

In 1985 all nematode numbers except *H. galeatus* declined further compared to previous seasons (Table 3). Spiral nematodes were found but in very low numbers and the data are not reported. Yields were slightly lower than in previous years, but nematicide treatment resulted in only an average 15% yield increase. Cultivars were different for numbers of lance and lesion nematodes. 'Ransom' and 'Kirby' tended to support lower numbers of lance nematodes, while 'Centennial' and 'Forrest' tended to have fewer lesion nematodes. Cultivars also influenced populations of stubby-root nematodes. The only significant cultivar x fumigation interaction in the experiment was for lesion nematodes in 1985, but nematode numbers were so low for this species that the results are not meaningful.

Lance nematode populations declined only slightly during the 3 years of continuous soybeans, falling from an average of 17/100 $cm^3$ of soil in 1983 to 11/100 $cm^3$ in 1985. Lesion nematodes were maintained at a relatively low level, declining from an average of about 6/100 $cm^3$ of soil in 1983 to 4/100 $cm^3$ of soil in 1985. Stubby-root nematodes declined by about one-half and spiral nematodes ceased to be a factor. Spiral nematode numbers have been shown to be enhanced by *H. columbus* on cotton (10), and this may have also occurred for *H. galeatus* in our experiment during the years while cotton was grown. There is some evidence that spiral nematodes may cause yield loss in soybeans, because their disappearance coincided with reduced yield response to fumiga-

Table 2. Effect of EDB on seed yields and nematode populations of selected soybean cultivars during 1984.

| | Seed yield (kg/ha) | | Nematode populations/100 $cm^3$ soil | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *H. galeatus* | | *Pratylenchus* spp. | | *P. christiei* | | *H. dihystera* | |
| Cultivar | Cont.[y] | Fum.[y] | Cont. | Fum. | Cont | Fum. | Cont. | Fum. | Cont. | Fum. |
| Braxton | 2530 | 3020 | 22 | 3 | 11 | 5 | 21 | 43 | 17 | 2 |
| Centennial | 2330 | 2860 | 29 | 4 | 18 | 3 | 19 | 26 | 17 | 1 |
| Cobb | 2450 | 2770 | 22 | 3 | 6 | 1 | 27 | 51 | 24 | 3 |
| Davis | 2530 | 2770 | 17 | 6 | 6 | 2 | 21 | 32 | 28 | 5 |
| Forrest | 1750 | 2280 | 24 | 2 | 10 | 1 | 16 | 24 | 4 | 1 |
| Ransom | 2570 | 2770 | 13 | 4 | 11 | 3 | 22 | 22 | 16 | 2 |
| Kirby | 2160 | 2490 | 9 | 0 | 14 | 1 | 14 | 19 | 13 | 0 |
| $\bar{X}$ | 2330 | 2710 | 19 | 3 | 11 | 2 | 20 | 31 | 17 | 2 |
| LSD[z](0.05) | 260 | | 12 | | 7 | | 18 | | 12 | |

[y]Cont. = Control (no nematicide); Fum. = Fumigated with EBD at a rate of 18.7 L/ha.
[z]Least significant difference (LSD) values are for comparison of any treatment-cultivar combination pair.

Table 3. Effect of EDB on seed yields and nematode populations of selected soybean cultivars during 1985.

| | Seed yield (kg/ha) | | Nematode populations/100 $cm^3$ soil | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | *H. galeatus* | | *Pratylenchus* spp. | | *P. christiei* | |
| Cultivar | Cont.[y] | Fum.[y] | Cont. | Fum. | Cont | Fum. | Cont. | Fum. |
| Braxton | 2240 | 2490 | 18 | 3 | 7 | 0 | 10 | 9 |
| Centennial | 2200 | 2610 | 26 | 6 | 1 | 1 | 20 | 16 |
| Cobb | 2370 | 2810 | 15 | 4 | 5 | 1 | 14 | 19 |
| Davis | 2280 | 2410 | 18 | 0 | 13 | 1 | 24 | 22 |
| Forrest | 2240 | 2690 | 23 | 2 | 3 | 3 | 16 | 10 |
| Ransom | 2160 | 2650 | 11 | 2 | 5 | 0 | 15 | 15 |
| Kirby | 2120 | 2330 | 12 | 2 | 5 | 2 | 11 | 15 |
| $\bar{X}$ | 2230 | 2570 | 18 | 4 | 6 | 1 | 16 | 15 |
| LSD[z](0.05) | 230 | | 8 | | 4 | | 9 | |

[y]Cont. = Control (no Nematicide); Fum. = Fumigated with EBD at a rate of 18.7 L/ha
[z]Least significant difference (LSD) values are for comparison of any treatment-cultivar combination pair.

tion and because of relatively high numbers ion 1983. Apparently, soybeans are not a good host for spiral nematodes, as their numbers were nondetectable after 3 years of continuous soybeans.

Along with the decline in nematode populations, response to nematicide also decreased. This, along with consistent yield response to fumigation, is evidence that this particular nematode complex caused significant yield loss, even though above-ground plant appearance was unaffected. Average response to nematicide over the 3-year period was 470 kg/ha. Thus, managing these nematode species either by chemicals, rotation with nonhost crops, or genetic resistance would result in substantial yield increases. The effectiveness of EDB in controlling three of the species present has been demonstrated, but the effectiveness of other chemicals currently available needs to be investigated.

Potential for breeding cultivars with genetic resistance to lance, lesion, or spiral nematodes is unknown. The almost total lack of a cultivar x nematicide treatment interaction indicates a lack of high levels of genetic resistance within the germplasm tested. This is in disagreement with previous studies (6,7) on lesion and lance nematodes. The study by Lindsey and Cairns (6) indicated a relationship between resistance to other nematode species and tolerance to lesion nematodes. In our study 'Forrest', which has resistance to *H. glycines* (race 3) and *M. incognita*, tended to support lower numbers of spiral nematodes in nonfumigated plots, but numbers of lesion nematodes were about average. Nyczepir and Lewis (7) screened genotypes in the field for resistance to *H. columbus* and found certain genotypes that failed to respond to fumigation, but they were unadapted and yielded less in fumigated plots than susceptible genotypes in nonfumigated plots. Our studies showed differences among cultivars for stubby-root nematodes in every year. Differences among cultivars for numbers of other nematodes were found in only one year of the study. Thus evidence for genetic variation for reaction to these species was weak.

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