SOYBEAN CULTIVARS AND DEVELOPMENT OF POPULATIONS OF *MELOIDOGYNE INCOGNITA* IN SOIL

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ABSTRACT

Rodríguez-Kábana, R., and D.B. Weaver. 1984. Soybean cultivars and development of populations of *Meloidogyne incognita* in soil. Nematropica 14:46-56.

The effect of 3 soybean (*Glycine max*) cultivars on population development of *Meloidogyne incognita* was studied for 2 years in an infested field in south Alabama. Larval populations in soil developed according to the logistic equation model. The innate capacity for increase of the nematode population (r), was higher for 'Ransom' than for the other 2 cultivars, 'Bragg' and 'Foster'. The time required to attain 50% of the maximal possible population size for each cultivar was shortest for 'Ransom' soybean and the same for 'Bragg' and 'Foster'. Yields in unfumigated soil were highest for 'Foster' and lowest for 'Ransom'; however, in soil treated with 16.8 L ai/ha of EDB, 'Ransom' was the highest yielding cultivar in 1982 and 'Foster' in 1983. Percent yield increase in response to fumigation was lowest for 'Foster' and highest for 'Ransom' in both years.

Additional key words: plant breeding, population dynamics, resistant varieties, computer modelling, pest management, cultural practices, crop losses, nematode ecology.

RESUMEN

Rodríguez-Kábana, R., y D.B. Weaver. 1984. Sobre el desarrollo de poblaciones de *Meloidogyne incognita* en el suelo y los cultivares de soya. Nematrópica 14:46-56.

El trabajo presenta resultados sobre un estudio de 2 años de duración sobre los efectos de 3 cultivares de soya (*Glycine max*) en el desarrollo de poblaciones de *Meloidogyne incognita* en un campo del sur de Alabama, E.E.U.U. El desarrollo de las poblaciones de larvas del nematodo en el suelo siguió el modelo de la ecuación logística. La capacidad intrínsica de desarrollo de la población del nematodo (r) tuvo un valor más alto para la soya 'Ransom' que para los otros dos cultivares, 'Bragg' y 'Foster'. Los rendimientos en suelo no fumigado fueron más grandes con 'Foster' y los menores con 'Ransom', aunque en suelo fumigado con 16.8 L ai/ha de bibromuro de etileno (BBE) 'Ransom' fué el cultivar que rindió más en 1982 y 'Foster' en 1983. El porcentage de aumento en rendimiento resultante de la fumigación fué el de más valor para 'Ransom' y el menor para 'Foster'.

Palabras claves adicionales: fitomejoramieno, dinámica poblacional, modelos para simulación, manejo de plagas, prácticas culturales, cálculo de perdidas en rendimiento, ecologia.

INTRODUCTION

The soybean plant (*Glycine max* (L.) Merr.) is a good host for several species of plant-parasitic nematodes. Principal among these are the soybean cyst nematode *Heterodera glycines* Ichinohe and several species of *Meloidogyne* (6). Control of these parasites has been based on development of cultivars capable of producing "reasonable" yields when planted in fields infested with individual species or races of the nematodes; however, even these "tolerant" soybean cultivars respond to nematicide treatments, giving yield increases when planted in fields with severe infestations of root-knot (*Meloidogyne* sp.) nematode, the cyst nematode, or where combinations of root-knot, cyst or other nematodes occur in the same field (6,7,8,12,13,14). The use of nematicides should be necessarily limited to situations where the expected yield increases from their use can justify the cost of nematicide treatments. For some soybean cultivars, the relation between nematode numbers in soil and yield has been described (1,5,11,12). These relations can be used to calculate yield losses to determine the propriety of nematicide use in specific fields. There is however, a lack of information on the effect of soybean cultivars on the development of nematode populations in soil. Specifically, there is no information available on how soybean cultivars may affect the functions that describe population development of individual nematode species in the field. This paper presents results of a study conducted to determine the effect of soybean cultivars on development of larval populations of *Meloidogyne incognita* (Kofoid & White) Chitwood in an infested field.

MATERIALS AND METHODS

Two experiments were established in 1982 and 1983 to determine the effects of soybean cultivars on development of larval populations of *Meloidogyne incognita* in soil. The experiments were in a field near Elberta, Alabama, infested with the nematode. The field had been under continuous soybean culture for the preceeding 5 years and did not have significant populations of any other phytonematode species. The soil was a loamy sand with a pH of 6.2 and less than 1.0% (w/w) organic matter. The experiments were of a split plot design, each 10-m long plot consisting of 4 rows positioned 1 m apart. Two rows in each plot were treated with 16.8 L ai/ha of ethylene dibromide (EDB, formulated as Soilbrom® 90); the other 2 rows were left untreated to serve as checks. EDB was injected into the soil at planting time to a depth of 20 cm using 2 injectors per row set 20 cm apart with the seed furrow between the injectors. 'Ransom' (susceptible), 'Bragg' (tolerant), and 'Foster' (tolerant) soybeans (4,6) were used as the plot variables and there were 8 replications (plots) per cultivar. Soybeans were planted during the last week of May every year.

Soil samples were collected throughout the growing season from each subplot every 10-20 days beginning at planting time. Each sample consisted of 14-18 soil cores (2.5-cm diam) collected from the root zone to a depth of 18-24 cm using a standard soil auger. Numbers of nematodes in the samples were determined following incubation in water for 72 hr using the "salad bowl" technique (10).

Cultural practices and control of foliar diseases and insects were according to recommendations for the area (3). Yield was determined at maturity by harvesting the entire area of each subplot.

All data were analyzed following standard procedures for analysis of variance; differences between means were evaluated for significance using a modified Duncan's multiple range test (15). Unless otherwise indicated, differences referred to in the text were significant at the 5% or lower level of probability. Data on nematode development were fitted to equations following standard least square procedures (2,15).

RESULTS

1982 Experiment. Data on nematodes obtained in 1982 are presented in Fig. 1. The numbers of larvae in untreated soil were very low ($<10/100\ cm^3$ soil) during the first 30 days after planting for all cultivars. Significant larval populations were detected only in samples collected 55 days or more after planting for all cultivars. The rate of population development was highest for all cultivars in the period from 55-77 days after planting. While the rate of development decreased only slightly from 77 to 110 days for 'Bragg' and 'Foster', it was negative for 'Ransom' during this period. Maximal populations were observed for 'Ransom' 77 days after planting and at 110 days for the other cultivars.

Highest yield in unfumigated soil was obtained with 'Foster' soybean and no significant difference in yield was observed between 'Ransom' and 'Bragg' cultivars in the soil (Table 1). Highest yields in fumigated soil were with 'Ransom' soybean and the other 2 cultivars were equivalent in yield.

Nematode numbers in fumigated soil were lower than in untreated soil at all sampling dates except the first two (Fig. 1B). The rate of nematode population development in fumigated soil was highest for all cultivars in the period between 77-110 days after planting, although for 'Ransom' and 'Foster' the rate did not change much between 55 and 110 days after sampling. The rate of nematode development was negative or zero between the last 2 samplings.

1983 Experiment. Nematode data for the 1983 experiment are pre-

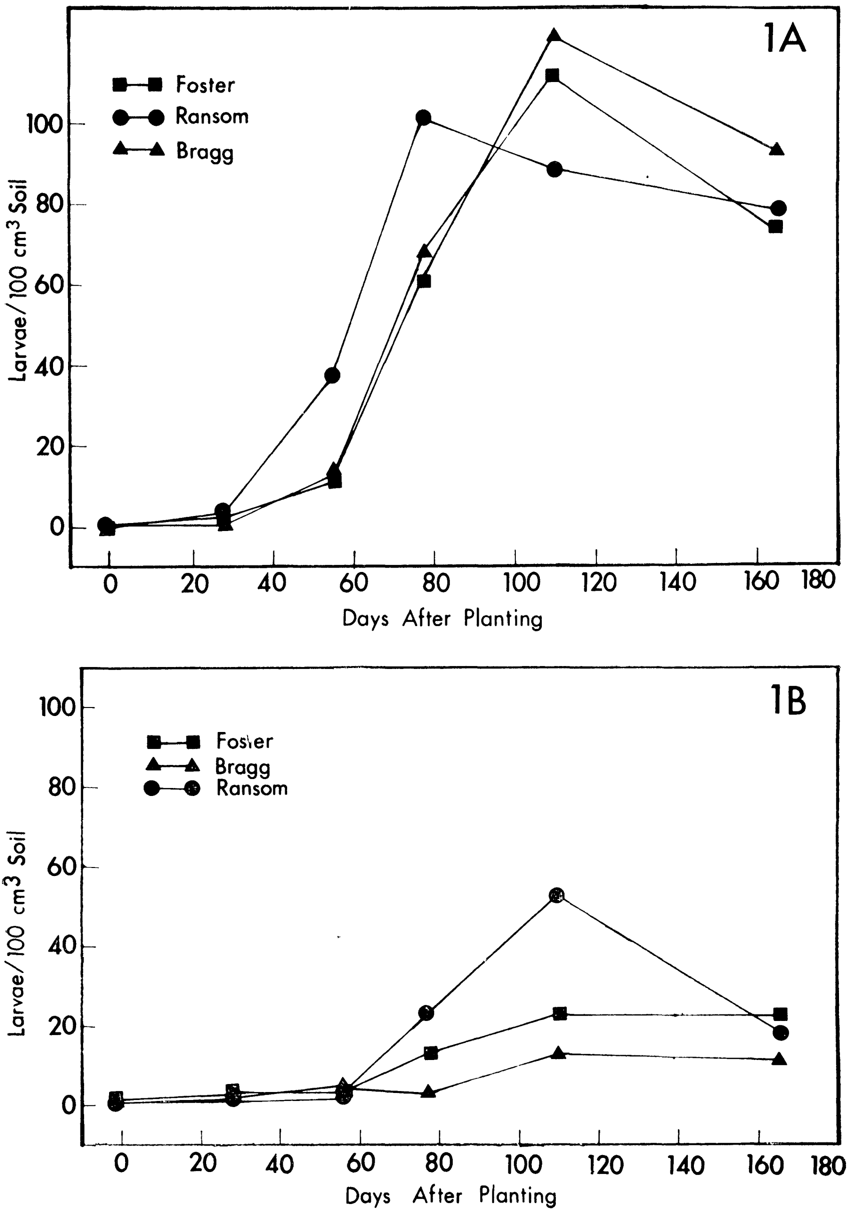


Fig. 1. Effect of 3 soybean cultivars on soil larval populations of *Meloidogyne incognita* in a field experiment near Elberta, Alabama, during the 1982 season. A. unfumigated soil. B. fumigated soil.

Table 1. Yields (kg/ha) of 3 soybean cultivars in a field near Elberta, Alabama, infested with *Meloidogyne incognita*.

Cultivar	1982		1983	
	unfumigated	fumigated[x]	unfumigated	fumigated
Ransom	429 b[y]	2545 a	595 c	2500 b
Bragg	606 b	2054 b	1032 b	2744 b
Foster	1314 a	1912 b	2088 a	3730 a

[x]Treated with 16.8 L ai/ha of EDB at planting time.
[y]Figures are the averages of 8 replications; those within each column followed by the same letter were not statistically different (P = 0.05).

sented in Fig. 2. In unfumigated soil, no significant change in larval numbers was observed during the first 28 days after planting, regardless of cultivar. Larval populations increased rapidly between 28 and 87 days. The rate of population increase was highest for 'Ransom' and approximately the same for the other 2 cultivars. Highest larval numbers in soil with 'Ransom' were observed 87-99 days after planting and for 'Bragg' and 'Foster' in the period 99-122 days after initiation of the experiment.

Numbers of larvae in fumigated soil (Fig. 2B) were generally very low for all cultivars at all sampling dates but the last two; differences in larval numbers between cultivars were not significant at any sampling date.

The highest yield in unfumigated soil was obtained with 'Foster' and the lowest with 'Ransom' (Table 1). There were no differences in yield between 'Ransom' and 'Bragg' in fumigated soil, but 'Foster' yielded significantly higher than the other 2 cultivars. Yields of all cultivars were improved by soil fumigation. Some seasonal differences in yield were apparent when comparing 1982 and 1983 data.

DISCUSSION

The rate of population development of a phytoparasitic nematode population in soil (dN/dt) can be expected to be dependent on many factors that include among others, the size of the existing nematode population (N) in the soil, the availability of suitable host roots, and the relative susceptibility of the host to parasitism by the nematode. In our case the amount of soybean roots available for parasitism increases throughout most of the season so that there is development of the nematode population commensurate with root system development. Also, each soybean cultivar can be expected to sustain a maximum number of

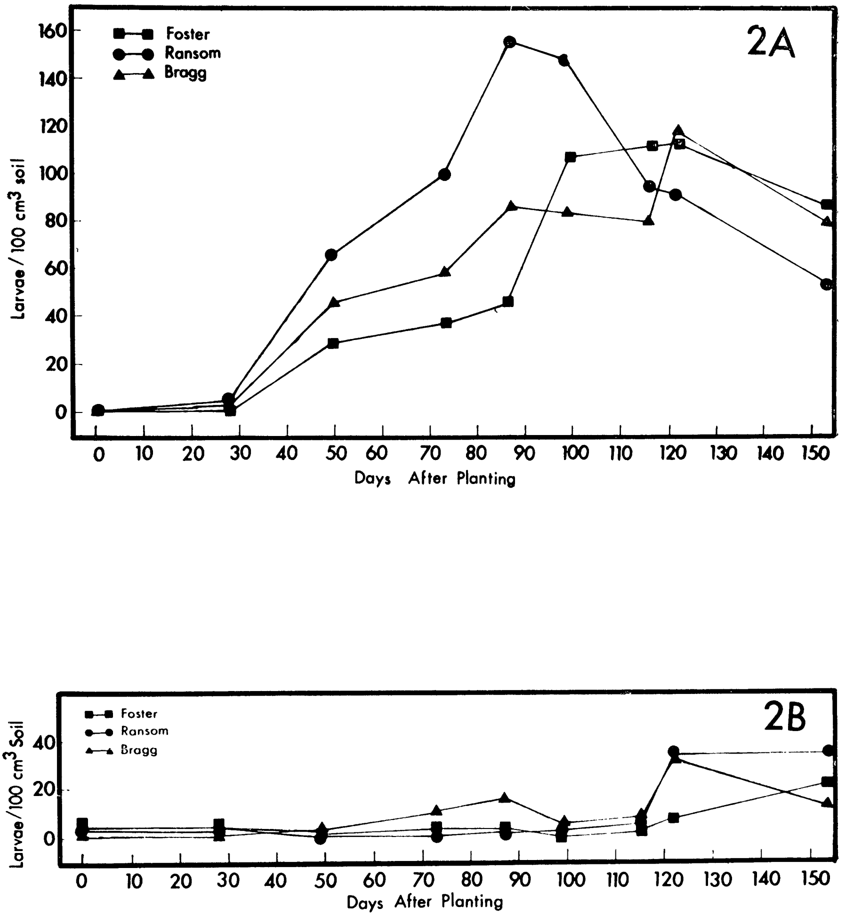


Fig. 2. Effect of 3 soybean cultivars on soil larval populations of *Meloidogyne incognita* in a field experiment near Elberta, Alabama, during the 1983 season. A. unfumigated soil. B. fumigated soil.

nematodes, i.e., to have a certain "carrying capacity", K. The value of K depends not only on the relative susceptibility of the soybean cultivar to parasitism by the nematode but also on other factors such as the type of season (e.g., wet or dry), soil type, soil temperature, etc. Each nematode species has a certain innate capacity for population increase (r), dependent also on the relative susceptibility of the soybean cultivar to the nematode and to some degree on the effect of the environment on the nematode x cultivar interaction. Thus, according to the logistic equation (2,9) mathematically it can be stated that at any one time in a field for a given soybean cultivar and nematode species, the rate of growth of the nematode can be expressed (2) as

$$dN/dt = kN(K - N) \qquad (I)$$

where (K – N) represents the unutilized "opportunity for growth", k a constant, and N the existing nematode population. Equation (I) can be expressed as:

$$\frac{1}{N(N - K)} dN = -kdt \qquad (II)$$

The left-hand side of (II) can be solved for N so that

$$\int \frac{1}{N(N - K)} dN = (1/K) \ln \left| \frac{N - K}{N} \right| + C \qquad (III)$$

where C is a constant. Since the right-hand side of (II) yields

$$-k \int dt = -kt + C' \qquad (IV)$$

C′ being a constant, equations (III) and (IV) can be combined so that

$$(1/K) \ln \left| \frac{N - K}{N} \right| + C = -kt + C'$$

hence

$$N - K = Ne^{-kKt}e^{K(C' - C)}$$

and if

$$-a = e^{K(C' - C)},$$

then

$$N(1 + ae^{-kKt}) = K \qquad (V)$$

where $kK = r$, the innate capacity for population increase. If we allow $\ln(a) = c$, then $a = e^c$, and from (V) we obtain:

$$N = K/(1 + e^{c-rt})$$

The nematode data from unfumigated soil in both years fitted the model defined by equation (VI) well (Table 2) when we considered changes in numbers of larvae that occurred between planting time and the time when maximal numbers were observed (Fig. 3). Values for r were higher for 'Ransom' soybean than for the other 2 cultivars, a reflection of the greater susceptibility of the 'Ransom' cultivar to *M. incognita* when compared with 'Bragg' or 'Foster' (4). There was little difference between r values of 'Bragg' and 'Foster' soybeans indicating that both cultivars were equally suitable for development of *M. incognita*.

Equation (VI) describes a type of population development in which an initial period of exponential growth is followed by a period of pro-

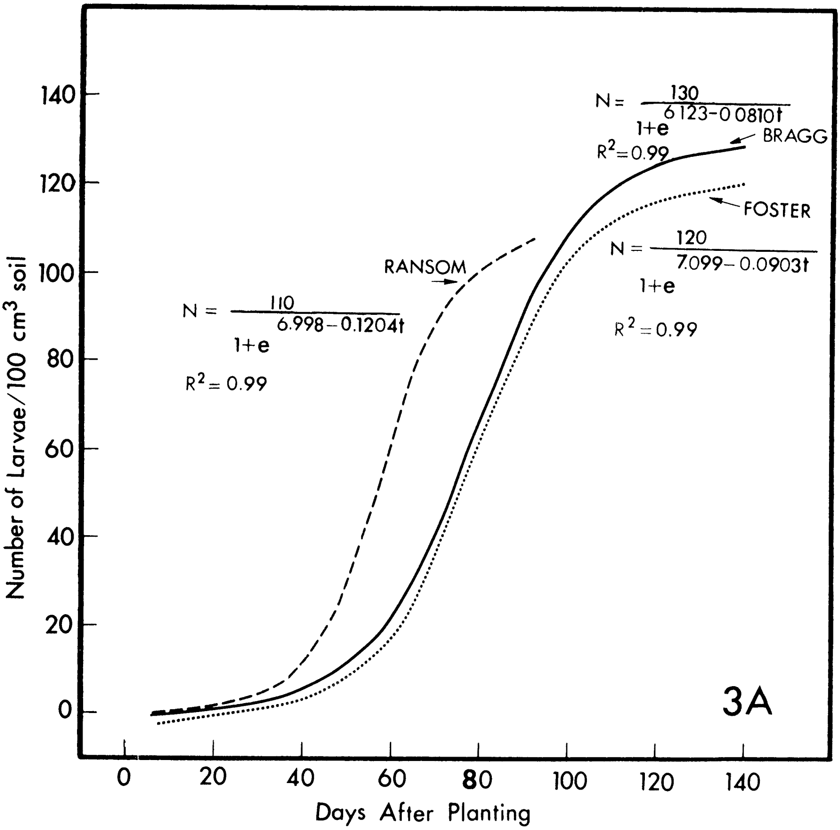
Table 2. Effect of 3 soybean cultivars on population development of *Meloidogyne incognita* in a field near Elberta, Alabama during the 1982 and 1983 seasons.

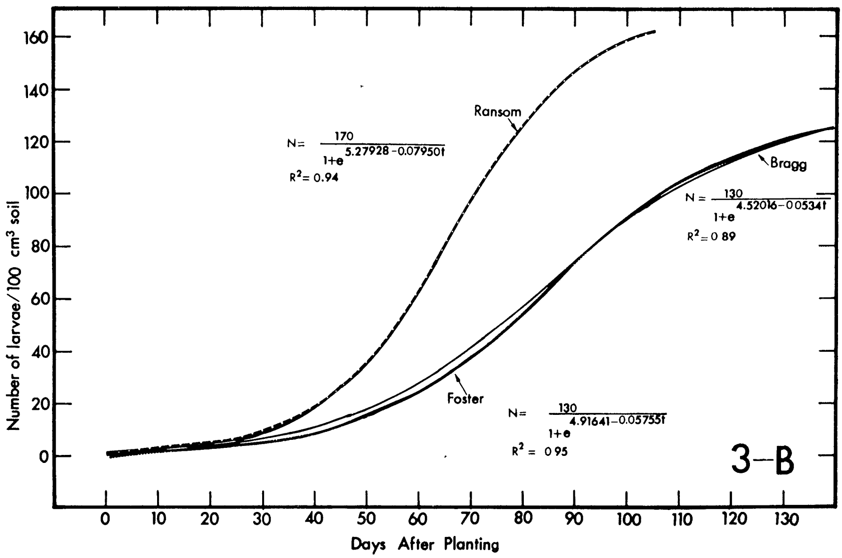
Cultivar	Capacity for growth[x] (r values)		Maximal population[x] (K value)		Days from planting[x] to inflection point (c/r)		Coefficient of determination (R^2)	
	1982	1983	1982	1983	1982	1983	1982	1983
Ransom	0.12038	0.07950	110[y]	170[y]	58[z]	66[z]	0.99	0.94
Bragg	0.08099	0.05347	130	130	79	84	0.99	0.89
Foster	0.09029	0.05755	120	130	78	85	0.99	0.95

[x]c, r, and k are constants for the logistic equation that describes the number of larvae in soil (N) as a function of days after planting (t) expressed as: $N = K/(1 + e^{c-rt})$.

[y]K = larvae per 100 cm^3 soil.

[z]Inflection point represents number of days to attain N = K/2.


Number of Larvae/100 cm³ soil
Days After Planting
N = 130 / 1+e^(6.123-0.0810t)
R² = 0.99
BRAGG
FOSTER
N = 120 / 1+e^(7.099-0.0903t)
R² = 0.99
RANSOM
N = 110 / 1+e^(6.998-0.1204t)
R² = 0.99
3A


Number of larvae/100 cm³ soil
Days After Planting
Ransom
N= 170 / 1+e^(5.27928-0.079501)
R² = 0.94
Bragg
N = 130 / 1+e^(4.52016-0.05341)
R² = 0.89
Foster
N= 130 / 1+e^(4.91641-0.05755t)
R² = 0.95
3-B

gressively diminishing rate of growth (dN/dt). Consequently, at some point when $d^2N/dt^2 = 0$, the period of exponential growth changes over to the slower form of development; $d^2N/dt^2 = 0$ when $t = c/r$, i.e., when $N = K/2$ (2). The data for all cultivars again indicated that the number of days after planting to reach the inflection point was much shorter for 'Ransom' than for the other 2 cultivars and that there was little difference between 'Bragg' and 'Foster' in the time required to reach the point (Fig. 3). These findings may appear puzzling in view of the yield data obtained in unfumigated soil with the 3 cultivars. 'Foster' was the highest yielding cultivar both years, yet differences between it and 'Bragg' in r values or in the time required to reach the inflection point were insignificant. There is thus a difference in yield response but not on suitability for development of soil larval populations of *M. incognita* between 'Bragg' and 'Foster'. In the case of 'Ransom,' *M. incognita* population developed quickest (highest r value and shortest time to inflection point), but the cultivar sustained considerable damage as reflected in large differences in yield (ΔY) between fumigated and nonfumigated soils. 'Foster' on the other hand showed smaller ΔY and r values and a longer time required to reach the inflection point than 'Ransom'; 'Bragg' showed larger average ΔY than 'Foster' but equivalent r values and times required to attain the inflection point.

In conclusion, our results indicate that larval population development of *M. incognita* in soil is affected by soybean cultivars both in relation to the innate capacity of the nematode to develop and with respect to the size of the maximal population possible. Also, our results indicate that the logistic equation provides a good model to describe larval population development in soil.

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Fig. 3. Logistic equation description of the development of larval populations of *Meloidogyne incognita* in unfumigated soil based on data obtained from experiments with 3 soybean cultivars conducted near Elberta, Alabama in 1982 (A) and 1983 (B).

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