ASSESSMENT OF SOYBEAN YIELD LOSSES CAUSED BY *MELOIDOGYNE ARENARIA*

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ABSTRACT

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Linear regression analyses were performed on data from 13 soybean [*Glycine Max* (L.) Merr.] field experiments to determine the relation between yield and larval numbers of *Meloidogyne arenaria* (Neal) Chitwood. The experiments were nematicide efficacy tests conducted in South Alabama using cultivars Ransom or Bragg during 1978, 1979 and 1980. The tests contained treatments with fumigants (DD, DBCP, and EDB) and systemic nematicides (aldicarb, carbofuran, oxamyl, and phenamiphos). Each experiment consisted of 14 treatments replicated eight times. Thus a total of 1456 paired observations (yield: larval numbers) were available for the study. Results indicated that yield losses are linearly and negatively related to larval numbers determined near harvest. The average regression coefficient for Bragg soybeans (tolerant) was approximately half as large as that corresponding to Ransom soybeans (susceptible). Results also indicate the possibility of significant seasonal influences on the value of regression coefficients. The method used in this study to develop regression equations may be of value to advisory services involved in prediction of yield losses caused by plant parasitic nematodes and in development of control recommendations.
Additional key words: population dynamics, modelling, plant breeding, nematode control, methods, Dowfume, Furadan, Nemacur, Soilbrom, Temik, Vydate

RESUMEN

Rodriguez-Kábana, R., y J.C. Williams. 1981. La estimación de las pérdidas en rendimientos de soya causadas por *Meloidogyne arenaria.* Nematrópica 11: 105-114.

Se efectuaron análises de regresión linear con datos obtenidos de 13 experimentos de campo con soya [*Glycine Max* (L.) Merr.] para determinar la relación entre los rendimientos y el número de larvas de *Meloidogyne arena-*

ria (Neal) Chitwood. Los experimentos consistieron de pruebas sobre las eficacias de nematicidas y estuvieron localizados en la zona meridional de Alabama efectúandose con los cultivares Ransom o Bragg durante los años 1978, 1979 y 1980. Las pruebas se hicieron con tratamientos de fumigantes (DD, DBCP, bibromuro de etileno) y también con nematicidas sistémicos (aldicarb, carbofuran, fenamifos y oxamil). Cada prueba contuvo 14 tratamientos con ocho replicaciones cada uno de manera que se dispuso de 1456 pares de observaciones (rendimiento: número de larvas) para el estudio. Los resultados de los análises señalaron que los rendimientos estaban correlacionados de manera linear y negativa con el número de larvas en el suelo determinado cerca del tiempo de la cosecha. El valor del promedio de los coeficientes de regresión con los datos del cultivar Bragg (tolerante) fue casi la mitad del correspondiente al cultivar Ransom (susceptible). Los resultados también señalaron la posibilidad que existan efectos significativos del año de producción sobre los coeficientes de regresión. El método utilizado en este estudio para desarrollar las ecuaciones de regresión puede ser de valor para los servicios de asesoramiento del productor en los pronósticos de rendimiento y para la determinación de la utilidad de recomendaciones para el combate de nematodos.
Palabras claves adicionales: dinámica poblacional, simulación, fitomejoramiento, combate de nematodos, métodos, Dowfume, Furadan, Nemacur, Temik, Vydate.

INTRODUCTION

The soybean plant [*Glycine Max* (L.) Merr.] is subject to attack by a variety of plant parasitic nematodes principal among which are species of root-knot nematodes (*Meloidogyne* Goeldi) and several races of *Heterodera glycines* Ichinohe (4,5). Yield losses caused by root-knot nematodes in the southeastern United States are significant (4, 6, 9, 11). Current control recommendations for these nematodes are based on development and use of resistant cultivars. However, recent studies have demonstrated that substantive increases in yield can be obtained with the use of nematicides in fields infested with species of *Meloidogyne* where resistant cultivars were planted (4, 7, 10, 11). The use of nematicides on soybeans in Alabama has increased significantly in the past decade. Because of escalating costs of nematicides a need has developed for predicting accurately expected returns from the use of nematicides on the crop. The present study is part of an effort to develop regression equations relating soybean yields to larval populations of *Meloidogyne* spp determined in a manner amenable to use by advisory extension personnel.

MATERIALS AND METHODS

Data for the study were obtained from soybean nematicide tests conducted at the Gulf Coast Substation near Fairhope, Alabama, during 1978, 1979 and 1980. Each year the experiments were established in a field with a sandy loam soil infested with *Meloidogyne arenaria* (Neal) Chitwood. The soil had an average pH of 6.2 and organic matter content of less than 1%. The field had been under continuous soybean culture for at least five years prior to 1978. The experiments consisted of randomized complete blocks with 14 treatments replicated eight times. Treatments were with fumigants (DD, DBCP, and EDB) and systemic nematicides (aldicarb, carbofuran, oxamyl, and phenamiphos). Plots (replications) were two-row (each 91 cm) wide and six meters long. There were two tests in 1978, six tests in 1979 and five in 1980. Experiments in 1978 and 1980 were with the Ransom cultivar and those in 1979 with Bragg soybeans.

Soil samples for nematode analyses in all tests were taken from each plot 2-3 weeks before harvest to coincide with the period of maximal population development for *M. arenaria* (1, 3). Each sample consisted of 15-20 one-inch (2.54 cm) diameter soil cores collected from the root zone to a depth of 15-20 cm along the center of both rows. The cores from each plot were composited and a 100 cm^3 subsample was used to extract nematodes with a pie-pan method. The soil was spread evenly on a double layer of "Scotties" tissue paper covering a 15-cm diameter 1 mm-mesh fiberglass screen glued between two PVC drain pipe sections. The lower section was 2.54 cm long and the top section 10 cm long. The screen was placed in a plastic "salad bowl" and enough water was added (approximately 1.5 liter) to cover the soil. Nematodes were allowed to migrate into the water for 72 hours when the water was passed through a 400 mesh (38 μm) stainless steel screen to collect the nematodes. The number of *M. arenaria* larvae from each sample was determined by direct counting with a dissecting scope.

Cultural practices, control of weeds, insects, and foliar diseases in all tests were as recommended for the area (2). Yields were obtained at maturity by harvesting the entire plot area.

All data were subjected to standard procedures for regression analyses (12). In establishing regression and correlation coefficients between yields and numbers of *M. arenaria* larvae only the means from each treatment in every experiment were used.

RESULTS

Statistical analyses of the 1978 data with Ransom soybeans (Table 1) indicated that yields were correlated with larval numbers. The linear regression coefficients (slope, b) for yield (Y) as dependent variable and larval numbers were -7.33 and -13.49 kg/larva for the two experiments, respectively. The degree of fit (r^2) to the linear model for experiment II was closer (r^2 =

Table 1. Results of the linear regression analyses of Ransom soybean yields as dependent variable (Y) on numbers of larvae of *Meloidogyne arenaria* with data from two field experiments conducted in 1978 at the Gulf Coast Substation near Fairhope, Alabama.

Experiment No.[w]	Y intercept	Regression Coefficient (b)	Coefficient of Determination (r^2)	Probability for b[z]	Range		Average	
					Yield (kg/ha)	Larvae per 100 cm^3 Soil	Yield (kg/ha)	Larvae per 100 cm^3 Soil
I	1804	-7.23	0.266	0.05	823-1724	31-110	1211	81
II	3496	-13.49	0.759	<0.0001	874-3066	38-170	1895	118

[w]Total number of pairs per experiment = 14; each pair represented the means of eight field observations for yield and numbers of larvae.

[z]Test for b = 0.

Table 2. Results of the linear regression analyses of Bragg soybean yields as dependent variable (Y) on numbers of larvae of *Meloidogyne arenaria* with data from six field experiments conducted in 1979 at the Gulf Coast Substation near Fairhope, Alabama.

Experiment No.	Y intercept	Regression Coefficient (b)	Coefficient of Determination (r^2)	Probability for b^z	Range		Average	
					Yield (kg/ha)	Larvae per 100 cm^3 Soil	Yield (kg/ha)	Larvae per 100 cm^3 Soil
III	1979	-3.96	0.577	0.002	1169-2069	40-195	1392	148
IV	1818	-1.88	0.332	0.03	1332-2070	55-250	1531	152
V	2220	-2.13	0.805	$<$0.0001	1500-2161	54-400	1718	235
VI	2176	-3.08	0.536	0.003	1347-2075	108-267	1535	207
VII	2253	-3.48	0.461	0.03	1383-2232	99-265	1603	186
VIII	1842	-0.60	0.313	0.04	1485-1876	181-536	1632	346

[w]Total number of pairs per experiment = 14; each pair represented the means of eight field observations for yield and numbers of larvae.

[z]Test for b = 0.

Table 3. Results of linear regession analyses of Ransom soybeans yields as dependent variable (Y) on numbers of larvae of *Meloidogyne arenaria* with data from five field experiments conducted in 1980 at the Gulf Coast Substation near Fairhope, Alabama.

Experiment No.[w]	Y intercept	Regression Coefficient (b)	Coefficient of Determination (r^2)	Probability for b[z]	Range: Yield (kg/ha)	Range: Larvae per 100 cm^3 Soil	Average: Yield (kg/ha)	Average: Larvae per 100 cm^3 Soil
IX	2069	-5.48	0.750	<0.0001	742-1719	95-263	1335	138
X	1859	-4.28	0.541	0.003	539-1729	57-313	1031	193
XI	2489	-4.68	0.548	0.002	1246-2029	109-255	1591	191
XII	2091	-4.02	0.714	<0.0001	1149-2166	27-245	1343	186
XIII	2402	-6.18	0.642	0.0006	1383-2502	5-148	1928	76

[w]Total number of pairs per experiment = 14; each pair represented the means of eight field observations for yield and numbers of larvae.
[z]Test for b = 0.

0.759) than that for experiment I (r^2 = 0.2665) although in both cases the coefficients of determination were significant (P = 0.05). The data indicated that the average loss for the year 1978 was of 10.36 ± 3.13 kg soybeans/larva. The generalized equation for the year was: Y = 2802-12.4535N, where N represented the number of root-knot nematode larvae and the coefficient of determination (r^2) for the equation was 0.667.

Analyses of data from the 1979 experiments with Bragg soybeans also indicated significant linear regression coefficients between yield and larval numbers for all six experiments (Table 2). Slope values ranged from -0.60 to -3.96 with an average loss of 2.52 ± 1.12 Kgs soybeans/larva. The generalized equation for all the 1979 experiments was: Y = 1946-1.769N with r^2 = 0.429.

The average slope of the regression equation for yield and larval numbers in the 1980 experiments with Ransom soybeans was higher than that corresponding for the 1978 experiments (Table 3). Analyses of the 1980 data demonstrated significant negative slopes for the linear regression between yield and larval numbers for all experiments. Slope values ranged from -4.02 to -6.18 and the average yield loss per larva was 4.89 ± 0.77; the generalized equation combining data from all the 1980 experiments was: Y = 2198-4.7766N , with a corresponding r^2 = 0.609.

DISCUSSION

Analyses of our results indicate that significant losses in soybean yields are caused by *M. arenaria* under conditions prevalent in south Alabama and that the losses may be predicted with linear regression models. Our data are based on the response of two cultivars Ransom and Bragg. The first cultivar has no resistance to *M. arenaria* or any other common *Meloidogyne* species, while the Bragg cultivar possesses resistance to *M. incognita* and some tolerance to *M. arenaria* (4). This difference in susceptibility to *M. arenaria* was reflected in the slope values obtained. A comparison of the 1979 data (Bragg) with results from the 1980 experiments (Ransom) indicated that the slope values for each cultivar were significantly different; losses sustained by Ransom being approximately double of those observed for Bragg. This difference could even be greater as indicated by comparisons between the slopes obtained with the 1978 experiments (Ransom) and the 1979 tests. However, the data for 1978 were limited and a fair comparison could not be made.

Our analyses also indicated that differences in slope values may vary with the season as suggested by differences in the average slopes obtained with Ransom soybeans for 1978 and 1980.

Results from our study are useful in that they establish a basis for predicting losses in fields infested with *M. arenaria.* Ideally, one should be able to determine the number of larvae of *M. arenaria* prior to planting in any one year and be able to predict yield losses in the same season. This however, is not possible, since larval populations during the winter and early spring months are typically too low to establish the type of relations obtained in this paper

(3). Our equations thus may be of use to estimate yield losses on the following season based on final larval populations in the current season or on the population present soon (1-2 months) after harvesting.

Our analyses were based on 182 pairs of means from 1456 field observations providing for a sufficiently large data base to reflect the situation encountered in typical fields of southern Alabama. The range of values covered for *M. arenaria* larvae varied from 5 to 536/100 cm^3 soil and for yield 539-3066 kg/ha. These ranges encompass the situation encountered in fields with severe infestations of the nematode with final larval population greater than 250 larvae/100 cm^3 soil, down to the situation in fields with light infestations (less than 50 larvae/100 cm^3 soil). We consider that the equations obtained may be generally applicable to the area provided corrections are made for cultivars and seasons. The effects of seasons and cultivars on slope values is clearly an area of research that will require further study. The influence of soil texture and other factors peculiar to each field may be expected to affect the value of slopes. It will therefore be necessary to determine their influence before equations can be used for routine recommendations to farmers.

The method chosen to obtain the data for regression analyses was based on the use of nematicides to establish the ranges of values in yield and larval populations necessary for use of standard techniques for regression analyses. Successful application of the method is therefore limited to situations where a wide range of values for yield and larval numbers can be established. The nematicides used varied from fumigants such as EDB, DD, and DBCP to granular systemic nematicides, i.e., aldicarb, carbofuran, oxamyl and phenamiphos. The approach chosen uses the existing nematode population in a given field thus incorporating the genetical variation of the nematode in the field into the development of the equations. In cases where fields contain mixtures of several parasitic nematode species it may be possible to establish regression equations through the use of multiple regression analyses. This constrasts with methods based on the use of microplots or even pot experiments in which one or a very limited number of isolates of a nematode species are used. Reliance on few isolates may result in restrictions in the gene pool available for establishment of regression equations. We consider that our approach is less subject to this limitation and the derived equations more generally applicable to field situations. In addition, since the data used were obtained from nematicide tests, recommendations for treatment to farmers will be based on equations derived from data based on the use of the very materials used in recommendations for nematode control. In contrast, in the typical microplot or pot experiment the soil is sterilized first and after a period of "ageing" the nematodes are introduced. The process of sterilization eliminates many components of the soil biological system (8) that may be significant in establishing an accurate yield:nematode relationship.

In summary the method chosen for our study can obtain the necessary predictive equations in a relatively short time without the need of special equipment or costly experimental arrangements and in a way that simulates closely the situation in standard soybean production fields.

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