ASSESSMENT OF PEANUT YIELD LOSSES CAUSED BY *MELOIDOGYNE ARENARIA*

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ABSTRACT

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Regression analyses were performed on data from 16 peanut (*Arachis hypogaea* L) field experiments to determine the relation between yield and larval numbers of *Meloidogyne arenaria* (Neal) Chitwood. The experiments were located in southeastern Alabama and consisted of nematicide treatments applied during 1979, 1980, and 1981. Treatments included a fumigant (EDB) and systemic nematicides (aldicarb, carbofuran, oxamyl, and phenamiphos). Each experiment consisted of 14 treatments replicated 8 times. Results indicated that yields were negatively related to larval numbers determined near harvest. Quadratic equations described the relation between the two variables better than the linear models. Results indicated the possibility of significant seasonal influences on the values of regression coefficients. The average yield loss caused by the average number of larvae/ 100 cm^3 soil ranged from 427-539 Kg/ ha. The equations obtained suggested that yield losses caused by *M. arenaria* occur even on lightly infested soil (< 50 larvae/ 100 cm^3 soil) and do not support the view that there is a range of larval population levels for which there is no corresponding yield reductions.

Additional key words: population dynamics, nematode control, methods, integrated pest management, Dowfume, Furadan, Nemacur, Soilbrom, Temik, Vydate.

RESUMEN

Rodríguez-Kábana, R., J.C. Williams, y R.A. Shelby. 1982. Evaluación de las pérdidas en rendimientos de maní causadas por *Meloidogyne arenaria*. Nematrópica 12:279-288.

Se efectuaron análises de regresión con datos obtenidos de 16 experimentos de campo con maní (*Arachis hypogaea* L.) para determinar la relación entre los rendimientos y el número de larvas de *Meloidogyne arenaria* (Neal) Chitwood. Los experimentos estuvieron localizados en el sureste de Alabama y eran pruebas con tratamientos nematicidas efectuados en 1979, 1980 y 1981. Los tratamientos se hicieron con un fumigante (EDB) y con varios nematicidas sistémicos (aldicarb, carbofurán,

oxamil y fenamifos). Cada prueba contuvo 14 tratamientos con 8 replicaciones cada uno. Los resultados de los análises señalaron que los rendimientos esaban correlacionados negativamente con los números de larvas determinados cerca del tiempo de la cosecha. Ecuaciones cuadráticas representaron la relación entre las dos variables mejor que las lineares. Los resultados también señalaron la posibilidad que existan efectos significativos del año de producción sobre los valores de los coeficientes de regresión. El promedio de pérdidas en la producción causadas por el promedio de larvas/100 cm^3 de suelo osciló entre 427-529 Kg/ha. Las ecuaciones obtenidas indicaron que las pérdidas en rendimiento causadas por *M. arenaria* ocurren aun en suelos ligeramente infestados (< 50 larvas/100 cm^3 suelo) y no apoyan la creencia que existe una escala de niveles de población de larvas para la cual no hay reducciones en rendimientos correspondientes.
Palabras claves adicionales: dinámica poblacional, combate de nematodos, métodos, manejo de plagas, Dowfume, Furadan, Nemacur, Soilbrom, Temik, Vydate.

INTRODUCTION

The peanut plant (*Arachis hypogaea* L.) is subject to attack by a variety of plant parasitic nematodes. The root-knot nematodes, *Meloidogyne arenaria* (Neal) Chitwood and *M. hapla* Chitwood, are considered the most economically important nematodes on the crop (8). In Alabama, root-knot nematodes occur in 40% of the peanut fields (3,4) and *M. arenaria* is the most common species. Yield losses caused by *M. arenaria* in the state are severe (9,10,12). Presently, there are no commercially available peanut cultivars resistant or tolerant to *M. arenaria.* Consequently, control of the nematode is based on the use of rotations and routine applications of nematicides (8). Increased costs of nematicide applications and relatively low world market price for peanuts dictate a careful evaluation of the damage caused by nematodes in fields to determine the economic merit of nematicide use in specific fields. Such evaluations require knowledge of the quantitative relation between yields and levels of nematode infestation. Although considerable information is available on the relative efficacy of nematicides for control of *M. arenaria* in peanuts (5,6,7,9,10,12) the information can only be considered to be of a qualitative nature. The present study was conducted to develop regression equations for use by advisory personnel to estimate peanut yield losses caused by *M. arenaria* under irrigated conditions in Alabama.

MATERIALS AND METHODS

Data for this study were obtained from field experiments conducted at the Wiregrass Substation, near Headland, Alabama, during 1979, 1980, and 1981. The experiments were established in an irrigated field heavily infested with *M. arenaria.* The field had been under peanut culture for the preceeding 5 years and each year was planted with hairy vetch (*Vicia villosa* Roth.) soon after peanut harvest to maintain nematode populations. The soil was a silt loam with pH = 6.2, and less than 1.0% (w/w) organic matter. All experiments were with Florunner peanuts and each experiment consisted of 14 treatments in a randomized complete block design with 8 replications/treatment. Plots (replications) in each experiment were 2 rows each 91 cm wide and 10 m long. Treatments consisted of different rates of nematicide applied at planting time. The nematicides were EDB (Soilbrom®90), aldicarb, carbofuran, oxamyl, or phenamiphos. The nematicide treatments were used to establish a range of nematode levels and a corresponding range in yields. Six experiments were conducted in each of 1979 and 1980 and 4 in 1981. In all experiments control of weeds, diseases and insects was according to recommended practices for the area (2) and the field was irrigated as needed.

Soil samples for nematode analysis were collected within 3 weeks of harvest. Samples consisted of 15-20 soil cores each 2.54-cm-diam taken along the center of each plot from the root zone to a depth of 15-20 cm. The cores from each plot were composited and a 100 cm^3 subsample was used to determine nematode numbers with the "salad bowl" incubation technique (11). Yields were obtained from the entire plots at maturity of the crop.

All data were subjected to standard procedures for regression analyses (16). In establishing regression coefficients between yields and numbers of *M. arenaria* larvae only the means from each treatment in every experiment were used.

RESULTS

Statistical analysis of the data from 1979 indicated that yields were correlated with numbers of larvae (Table 1). Although the correlations could be described with linear equations, the quadractic model $Y = a + b_1N + b_2N^2$ resulted in a closer fit between yields (Y) and numbers of larvae (N). Values for the b_1 coefficient of the quadratic equation varied from -43.2402 to as high as -3.9943; values for the b_2 coefficient ranged from -0.0111 to 0.0875. The coefficient of deterination (R^2) for all the experiments was significant. The common regression equation obtained with the data from all the 1979 experiments was $Y = 3737 - 4.941N + 0.0049N^2$, (Fig. 1); the coefficient of determination for the equation was 0.248 which was significant at a probability level of less than 0.0001. Yields for 1979 ranged from 406-5588 Kg/ha and larval numbers from 0-2378/100 cm^3 soil. The average yield for the 1979 experiments was 3260 Kg/ha and the average number of larvae 124.5 larvae/100 cm^3 soil.

The relation between yield and larval numbers for the data from the 1980 experiments was also significant (Table 2). The quadratic equation described the relation between the two variables better than the linear model. Values for the b_1 coefficients of the equations varied fro -17.9045 to -2.0315, and values for b_2 ranged from -0.0068 to 0.0671. The quadratic equations described well the relation between yield and larval numbers since all equations were signifi-

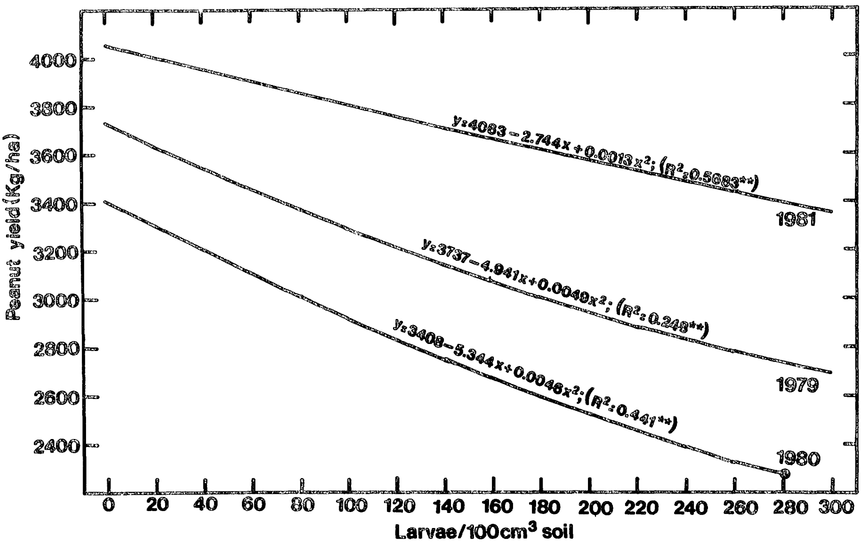

Fig. 1. Relation between peanut (cv = Florunner) yields and numbers of larvae of *Meloidogyne arenaria* determined near harvest time using an incubation technique (11). All equations were significant at $P<0.0001$.

cant ($P < 0.026$). Yield values for the 1980 experiments ranged from 705 to 4991 Kg/ha, and larval numbers from 0-765 larvae/100 cm^3 soil. The average yield for the 1980 experiments was 2987 Kg/ha and the average number of larvae 91.5/100 cm^3 soil. The common regression equation relating yield and larval numbers for all the 1980 data was $Y = 3408 - 5.344N + 0.0046N^2$, (Fig. 1), a significant regression ($P < 0.001$, $R^2 = 0.44$).

Results for the 1981 experiments are presented in Table 3. As for data from the preceeding 2 years, the relation between yield and larval numbers was best described with a quadratic equation. The b_1 coefficients for the quadratic equations ranged in value from -17.3871 to -0.2651, and the b_2 coefficient from -0.0019 to 0.0822; R^2 values for all equations were significant ($P = 0.0155$ or less). Yields in 1981 ranged from 1763 to 5479 Kg/ha and larval numbers from 0-825/100cm^3 soil. The average yield was 3664 Kg/ha and the average number of larvae/100 cm^3 soil was 169. The common regression for yield and larval numbers was $Y = 4063 - 2.744N + 0.0013N^2$; the regression was significant ($P < 0.0001$) and R^2 was 0.57.

DISCUSSION

Results indicate that *M. arenaria* causes significant yield losses under Alabama conditions. The calculated average yield loss caused by the average number of larvae/100 cm^3 soil ranged from 427 Kg/ha for 1981 to 539 Kg/ha

Table 1. Results of the regression analyses of Florunner peanut yields (Y) on numbers of larvae of *Meloidogyne arenaria* with data from 6 field experiments conducted in 1979 at the Wiregrass Substation near Headland, Alabama.

Experiment No.[x]	Y Intercept	Regression (b_1)	Coefficients (b_2)	Coefficient of Determination (R^2)	Probability[y]	Range		Average		Standard Deviation	
						Yield (Kg/ha)	Larvae per 100 cm³ Soil	Yield (Kg/ha)	Larvae per 100 cm³ Soil	Yield (Kg/ha)	Larvae per 100 cm³ Soil
I	4753	-7.1924	0.0059	0.687	0.0017	1193-5588	0-2378	3516	236	640	348
II	5222	-24.6368	0.0598	0.545	0.0132	406-5560	0-653	3202	137	626	128
III	7443	-43.2402	0.0875	0.758	0.0004	1085-5099	32-573	2685	178	618	77
IV	3867	-9.8941	-0.0052	0.750	0.0005	1709-4910	0-402	3433	42	475	60
V	4230	-17.7476	0.0625	0.861	<0.0001	1573-4503	0-664	3212	27	470	75
VI	4230	-3.9943	-0.0111	0.647	0.0093	814-5289	4-586	3510	127	732	107

[x]Total number of pairs per experiment = 14; each pair represented the means of 8 field observations for yield and number of larvae.
[y]Observed probability from test of quadratic regression equation.

Table 2. Results of the regression analyses of Florunner peanut yields (Y) on numbers of larvae of *Meloidogyne arenaria* with data from 6 field experiments conducted in 1980 at the Wiregrass Substation near Headland, Alabama.

Experiment No.[x]	Y Intercept	Regression (b_1)	Coefficients (b_2)	Coefficient of Determination (R^2)	Probability[y]	Range: Yield (Kg/ha)	Range: Larvae per 100 cm^3 Soil	Average: Yield (Kg/ha)	Average: Larvae per 100 cm^3 Soil	Standard Deviation: Yield (Kg/ha)	Standard Deviation: Larvae per 100 cm^3 Soil
VII	3389	-12.7044	0.0446	0.487	0.0256	976-4638	0-413	2681	101	537	88
VIII	3723	-2.0315	-0.0068	0.775	0.0003	1248-4991	0-765	3444	92	492	104
IX	3999	-17.9045	0.0671	0.588	0.0076	1166-4665	0-348	3138	75	636	65
X	3902	-11.0205	0.0161	0.603	0.0062	1899-4638	0-419	3345	57	433	64
XI	3078	-6.0523	0.0067	0.866	<0.0001	1302-4503	0-502	2883	37	510	73
XII	2969	-3.8530	0.0041	0.628	0.0044	705-3933	0-704	2433	187	367	117

[x]Total number of pairs per experiment = 14; each pair represented the means of 8 field observations for yield and number of larvae.
[y]Observed probability from test of quadratic regression equation.

Table 3. Results of the regression analyses of Florunner peanut yields (Y) on numbers of larvae of *Meloidogyne arenaria* with data from 4 field experiments conducted in 1981 at the Wiregrass Substation near Headland, Alabama.

Experiment No.[x]	Y Intercept	Regression (b_1)	Coefficients (b_2)	Coefficient of Determination (R^2)	Probability[y]	Range		Average		Standard Deviation	
						Yield (Kg/ha)	Larvae per 100 cm^3 Soil	Yield (Kg/ha)	Larvae per 100 cm^3 Soil	Yield (Kg/ha)	Larvae per 100 cm^3 Soil
XIII	4226	-17.3871	0.0822	0.617	0.0051	2333-5045	0-230	3876	25	389	31
XIV	4423	-5.7576	0.0087	0.591	0.0073	2333-5208	0-541	3950	111	367	106
XV	4321	-3.9684	0.0013	0.531	0.0155	1763-5479	2-825	3465	237	421	137
XVI	3670	-0.2651	-0.0019	0.546	0.0130	1844-4665	0-647	3366	305	370	117

[x]Total number of pairs per experiment = 14; each pair represented the means of 8 field observations for yield and number of larvae.
[y]Observed probability from test of quadratic regression equation.

for 1979. The common regression equations obtained for each year indicate that the relation between yield and larval numbers varied somewhat each year. The relation between yield and larval numbers is probably asymptotic and we expect it to be described better by a theoretical function not yet available. However, quadratic equations developed in this study provide good estimates for peanut yield losses within the range of values of the data used. With this limitation it is possible to determine the lowest yield possible for each year. Lowest yield for each year corresponds to a larval population (Nm) where $dY/dN = 0$, or

$$dY/dN = b_1 + 2b_2N = 0 \qquad \text{I}$$

The Nm value corresponding to 1981 was 1055/100 cm^3 soil and those for 1979 and 1980 were 504 and 581. These values correspond to yield losses of 1246 Kg/ha for 1979 and 1552 and 1448 for 1980 and 1981, respectively. This indicates that approximately twice as many larvae were required in 1981 to obtain maximal yield loss as in the preceeding 2 years. However, when we consider larval numbers in the range of 0-300/100 cm^3 soil, differences between equations are not so pronounced. Thus, if we calculate the area subtended by each equation in this larval range

$$\int_0^{300} f(N)dN = \int_0^{300} (a + b_1N + b_2N^2)dN \qquad \text{II}$$

and substract from II the area 300.f(300), the difference may be used to gain an overall view of the relation between yield and larval numbers for each year. The calculated areas for 1979 and 1980 were 1.35 and 1.58 times greater than the area for 1981, respectively. We consider the larval range between 0 and 300 larvae/100 cm^3 soil most representative of the level of infestation found in Alabama peanut fields (3,4). Our calculations indicate that there is probably a significant effect of season (year) on the relation between yield and larval numbers. Our data although representative for each of the years studied were not sufficiently extensive to determine the effect of season (year) on the relation between yield and larval numbers.

Results from our study are useful in that they establish a basis for developing information to predict yield losses caused by *M. arenaria.* The study was based on larval counts obtained at or near harvest. Ideally, for predictive purposes, the relation between larval numbers and yield would be more useful if established with larval counts determined prior to planting of the crop. However, this is not possible with existing methodology. Other studies have shown (3,4) that larval populations of *M. arenaria* in Alabama peanut fields are very low during late-winter and spring preplant period and estimates of their numbers from samples collected during this period are not reliable if they are based on results from direct extraction or incubation techniques.

The equations developed from this study were based on 224 means from 1792 pairs of field observations for yield and larval numbers. The range for each of the variables was sufficiently broad to represent situations varying from those found in severely infested fields to fields with no nematode problems. Therefore, the equations, when adjusted for seasonal variations, can be expected to describe well the relation between yield and larval numbers in Alabama peanut fields under irrigation.

The method used to obtain data for the present study was similar to that used before to derive equations relating soybean yields to larval numbers of *M. arenaria* or *Heterodera glycines* Ichinohe (13, 14). A similar approach has been useful in determining yield: pathogen relations for other plant diseases (1,15). The method relies on the use of nematicides to establish a broad range of larval populations and a corresponding range of yields. With the exception of oxamyl, the nematicides used in the study were those available to farmers and were applied in the manner recommended for use by farmers. The data thus represent more closely the situations in typical irrigated peanut fields in Alabama. The method described in this paper avoids the need to introduce selected isolates of the nematode into pasteurized or "sterilized" soils to establish a range of nematode population levels. The biological components of the soil in our study were thus less likely to be disturbed than if the soil had been subjected to "sterilization" followed by reinfestation with nematodes. We believe it is important in establishing equations relating yields to nematode numbers to work with systems that simulate as much as possible the situation encountered in farmers' fields. This is particularly so when the equations are to be used for predictive purposes to form recommendations for farmers.

The equations obtained in this study are of an empirical nature and must be considered as preliminary. They suggest, however, that within the limits of detection of the methods used, yield losses caused by *M. arenaria* occur even on lightly infested soil ($<$ 50 larvae/100 cm^3 soil). Therefore, the equations do not support the view that there is a range of larval numbers for which there is no corresponding yield reductions; however, the equations do indicate that the change in yield in relation to increasing larval numbers (dY/dN) is not constant implying that as larval numbers increase their effect on yield will progressively diminish.

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