VERTICAL DISTRIBUTION OF *MELOIDOGYNE ARENARIA* JUVENILE POPULATIONS IN A PEANUT FIELD[1]

R. Rodríguez-Kábana and D. G. Robertson
Department of Plant Pathology, College of Agriculture and Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama 36849, U.S.A.

Accepted:
16.X.1987
Aceptado:

ABSTRACT

Rodríguez-Kábana, R., and D. G. Robertson. 1987. Vertical distribution of *Meloidogyne arenaria* juveniles in a peanut field. Nematropica 17:199-208.

The relation between soil depth and population development of *Meloidogyne arenaria* juveniles was studied for a 15-month period beginning in January 1986 in a peanut field at the Wiregrass substation, Headland, Alabama. The soil was sandy loam with <1.0% (w/w) organic matter and had been in peanut culture for the preceeding 10 years. Juvenile numbers in soil were highest in the top 30-40 cm of the soil profile. A fairly constant but low (<20 juveniles/100 cm^3 soil) population of juveniles was observed throughout the study at depths below 40 cm. The relationship between numbers of juveniles (J) and soil depth in cm (X) conformed to the equation: $J = A \cdot B^{(1/X)} \cdot X^C$, where A, B, and C are constants and X>0. The equation predicted largest numbers of juveniles at ca. 12 cm depth. The greatest fluctuations in juvenile population size occurred in the top 30-40 cm of the profile. Juvenile populations were highest just prior to peanut harvest and lowest in the late-winter-spring period.

Additional key words: pest management, ecology, edaphic factors, soil texture, legumes, quantitative nematology.

RESUMEN

Rodríguez-Kábana, R., y D. G. Robertson. 1987. Sobre la distribución vertical de *Meloidogyne arenaria* en un suelo con maní. Nematrópica 17:199-208.

Se estudió por un período de 15 meses la relación entre el desarrollo de *Meloidogyne arenaria* y la profundidad del suelo en un campo de maní ubicado en la estación experimental Wiregrass, aledaña a Headland, Alabama. El suelo en el campo es un limo arenoso con <1.0% (p/p) de materia orgánica en el cual se había cultivado maní continuamente por 10 años precedentes al estudio. Los números de larvas de *M. arenaria* en el suelo fueron mayores en los 30-40 cm superiores del perfil edáfico. También se notó que existía una población baja (<20 larvas/100 cm^3 suelo) pero constante en las capas de suelo por debajo de los 40 cm de profundidad. La relación entre el número de larvas (L) y la profundidad del suelo en cm (X) se ajustó al modelo: $L = A \cdot B^{(1/X)} \cdot X^C$, en el cual A, B, y C son constantes y X>0. El modelo señaló que el número más alto de larvas se encontraba a una profundidad de 12 cm aproximadamente. Las fluctuaciones más agudas en el tamaño de las poblaciones larvales se observaron en los 30-40 cm superiores del perfil edáfico. También, las poblaciones larvales fueron más grandes en el momento de la cosecha y más reducidas en el período de invierno-primavera antes de la siembra.

Palabras claves adicionales: manejo de plagas, ecología, factores edáficos, textura de suelos, leguminosas, nematología cuantitativa, cacahuete.

INTRODUCTION

The peanut root-knot nematode *Meloidogyne arenaria* (Neal) Chitwood is widespread in peanut (*Arachis hypogaea* L.) fields of Alabama and adjoining areas of the southeastern United States (4,5,9). Yield losses on peanut caused by this nematode are severe (9,12,17) and continued economic production of peanut is not possible without appropriate management of the nematode (12). Management of *M. arenaria* in Alabama has been based on the use of nematicides (8,14) and rotations to maintain populations at low levels (13). Recent suspensions of dibromochloropropane and ethylene dibromide from use in peanut has left producers with relatively few alternative nematicides for the crop. This situation coupled with the lack of commercially available cultivars resistant (or tolerant) to *M. arenaria* (12) makes the development and reliance on other management systems preemptory. A key component for management models is an accurate description of the population dynamics of the nematode. Recently we reported on seasonal fluctuations in juvenile numbers of *M. arenaria* in peanut (18). There is, however, lack of quantitative descriptions of the relationship between soil depth and juvenile population development of *M. arenaria*. This paper presents information from a study on the vertical distribution of juvenile populations of the nematode.

MATERIALS AND METHODS

The relationship between soil depth and population dynamics of juveniles of *M. arenaria* was studied for a 15-month period in an irrigated peanut field at the Wiregrass substation, Headland, Alabama. The 7-ha field had been continuously in peanut with a winter cover crop of hairy vetch (*Vicia villosa* Roth) for the preceeding 10 years. The soil was a sandy loam with pH = 6.2 and organic matter content <1.0% (w/w). The physical analysis of the soil in relation to profile depth (10) is presented in Table 1. The vertical distribution study was initiated on 21 January, 1986 and was concluded on 28 April 1987.

The effect of the 1985 peanut crop on the vertical distribution of *M. arenaria* was studied following the 1985 peanut season. The field had been planted with 'Florunner' peanut on 10 May 1985. The crop was maintained in good growing condition by following local recommendations for control of foliar diseases, insects, weeds, and other standard cultural practices (2). Twenty plots were established at random in the field. Each plot was 10 m long and 4 rows (each 0.9 m) wide. Peanuts in 10 plots were dug on 27 September 1985, and the other 10 plots were left with the plants growing until killed by frost (12 December 1985). On 21 January and 13 February 1986, all plots were sampled using a 5-cm-d hydraulically operated cylindrical probe mounted on a pick-up

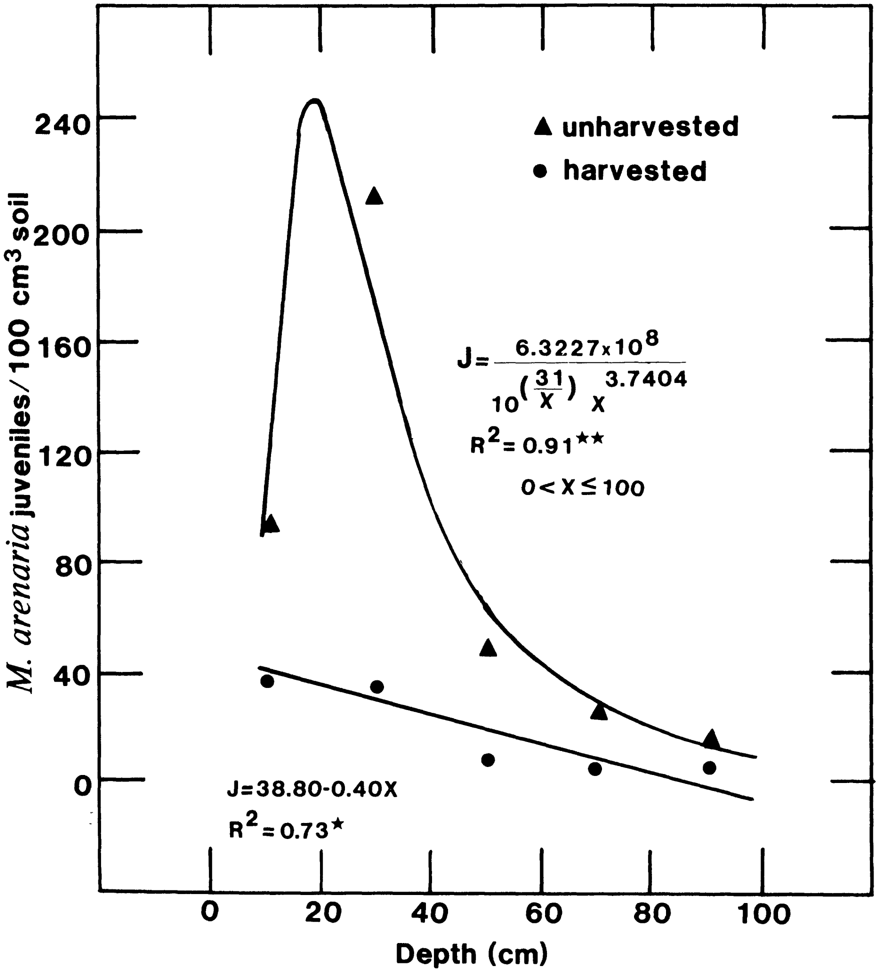

Fig. 1. Relationship between numbers of juveniles (J) of *Meloidogyne arenaria* and soil depth (x) in winter 1986 in plots with unharvested peanut and in others where the plants had been dug in September 1985.

truck load deck. The probe permitted collection of soil samples to depths of over one meter. A total of 4 cores were taken from each plot. Each core was divided with a spatula so as to have samples from the following depths (cm): 0-20, 21-40, 41-60, 61-80, and 81-100. Each plot sample from each depth was composited and a 100-cm³ subsample was used to determine nematode numbers with the "salad bowl" incubation technique (15).

The position of the plots was marked to permit sampling of the same plots during the 1986 season. 'Florunner' peanut was again planted in

Table 1. Soil texture as a function of depth for a Dothan soil located on the Wiregrass substation near Headland, Alabama.[z]

Depth (cm)	% Sand	% Silt	% Clay
0-25	74.4	15.4	10.2
25-40	59.7	13.7	26.6
41-70	54.7	11.9	33.4
71-85	49.9	8.8	41.3
86-115	50.5	7.4	42.1
116+	54.5	8.4	37.2

[z]Data from Puckett (10).

the field on 13 May 1986 and dug on 17 October 1986. Sampling of the plots after February 1986 was conducted as described, but the individual cores were divided to have samples from depths (cm): 0-15, 16-30, 31-45, 46-60, 61-80, 81-100, and 101-115. Samples were collected on 22 July and on 25 September 1986. Post-harvest samplings were on 19 February and on 28 April 1987. Sampling dates were chosen to coincide with periods where critical changes in juvenile populations of *M. arenaria* were expected in peanut (18).

All data were analyzed following standard procedures for analysis of variance (19). Fisher's least significant differences were calculated and are included in the tables together with the corresponding standard errors of the mean. Correlation analysis and curve fitting also followed standard procedures (6,7,19). Unless otherwise stated, all differences referred to in the text were significant at the 5% or lower level of probability.

RESULTS

Numbers of juveniles of *M. arenaria* were higher in unharvested plots than in those that were harvested (Table 2). Factorial analysis of the data from unharvested plots revealed no significant soil depth x sampling time interaction. The analysis indicated a sharp decrease in juvenile populations from the January to the February 1986 samplings. The analysis also revealed a definite general pattern of change in juvenile populations with soil depth. The relationship between numbers of *M. arenaria* juveniles (J) in unharvested plots and soil depth (x) shown in Fig. 1 was described ($R^2 = 0.91^{**}$) by the function:

$$J = \frac{632300000}{[10^{(31/x)} x^{3.7404}]} \qquad \text{(I)}$$

Factorial analysis of the data from the harvested plots (Table 2) also revealed no significant sampling date x soil depth interaction. As with

Table 2. Vertical distribution of *Meloidogyne arenaria* juveniles in the winter of 1986 in a peanut field with plots that had been harvested and others with unharvested plants.

Soil depth (cm)	Juveniles per 100 cm^3 soil[y]			
	Unharvested		Harvested	
	Jan. 21	Feb. 13	Jan. 21	Feb. 13
0-20	142	42	58	14
21-40	372	63	41	27
41-60	84	9	11	3
61-80	51	14	13	4
81-100	19	11	11	7
LSD (P=0.05):	198	22	29	16
$S\bar{x}$:[z]	68	8	10	5

[y]Data represent the average of 10 replications.
[z]$S\bar{x}$ = Standard error of the mean.

the unharvested plots, there was a significant overall decline in juvenile population size from the January to the February samplings. The effect of soil depth on juvenile populations did not follow the pattern observed for the unharvested plots. There was a linear decline in juvenile numbers with increasing soil depth in harvested plots which was described (R^2 = 0.73*) by the equation:

Table 3. Changes in juvenile populations of *Meloidogyne arenaria* in soil in relation to depth and time of sampling.

Soil depth (cm)	Juveniles per 100 cm^3 soil by sampling date[y]			
	22 July 1986	25 Sept. 1986	19 Feb. 1987	28 March 1987
0-15	75	235	35	34
16-30	152	351	89	127
31-45	13	6	9	15
46-60	4	8	7	13
61-80	8	4	5	0
81-100	6	6	1	4
101-115	1	4	2	0
LSD (P=0.05):	53	183	30	42
$S\bar{x}$:[z]	18	63	11	15

[y]Data represent the average of 20 replications.
[z]$S\bar{x}$ = Standard error of mean.

$$J = 3830 - 0.40\ x \qquad \text{(II)}$$

Numbers of juveniles of *M. arenaria* in harvested plots changed significantly with time from January 1986 through the last sampling of the study in April 1987 (Tables 2, 3). Most of the changes in juvenile numbers occurred in the top 0-40 cm: populations in deeper strata of the soil profile remained fairly constant at levels <20 juveniles/100 cm^3 soil throughout the entire study.

The relationship between juvenile numbers and soil depth in harvested plots considered independently of sampling time (Fig. 2) conformed (R^2 = 0.89**) to the function:

$$J = \frac{57370000}{[10^{(19/x)} x^{3.6974}]} \qquad \text{(III)}$$

The model was analogous to equation I and indicated that maximal populations occurred at ca. 12 cm depth.

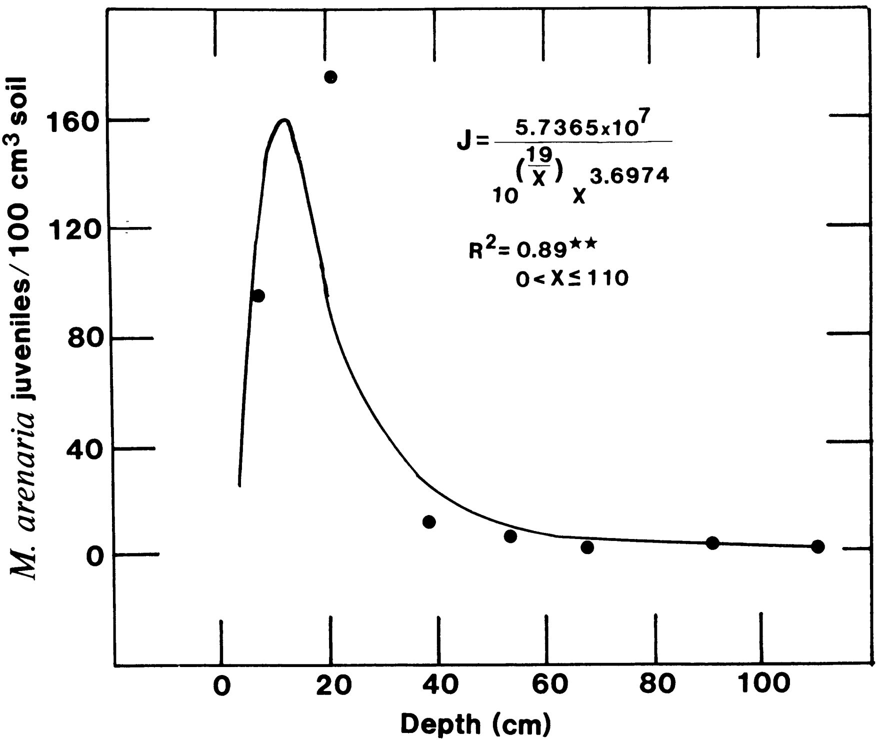

Fig. 2. Numbers of juveniles (J) of *Meloidogyne arenaria* as a function of soil depth x).

DISCUSSION

There were significant differences in the vertical distribution of *M. arenaria* juveniles in the soil. On all sampling dates, the greatest numbers of juveniles were found in the top 0-40 cm of the soil profile. It is in this upper profile where soil texture was lightest (Table 1), i.e., clay content was the lowest. The peanut plant develops most of its root system in this lighter section of the profile with fewer roots penetrating into the heavier clay strata found below the 40 cm depth (1,11). This suggests a direct relation between juvenile numbers and root density that is dependent on light soil texture.

The equation used to describe juvenile numbers as a function of soil depth predicted maximal juvenile populations at a depth of ca. 12 cm with numbers of juveniles increasing sharply from 0-12 cm depth and a quasi-hyperbolic decline in numbers with increasing depth below the 12-cm maximum. This pattern of distribution has practical implications for nematode sampling and the placement of nematicides. The equation suggests, at least for this soil, that fumigant nematicides which dissipate upwards from the point of application in soil should be placed so as to have these materials move through the section of the soil profile where most juveniles are found, i.e., 0-30 cm. This agrees well with our previous finding on the use of 1,3-D for control of *M. arenaria* in this same field (16); the most efficacious applications of the fumigant were those delivered at a depth of 23 cm when compared to other shallower or deeper application depths. Application of 1,3-D deeper than 23 cm actually resulted in some loss of control presumably because the fumigant was "entrapped" in the clay of the deeper strata.

Routine sampling of peanut fields is performed to a depth of 15-20 cm. Our findings suggest that this sampling depth is likely to furnish adequate description of the juvenile population in our soils. A population of *M. arenaria* juveniles fairly stable in number was found throughout the study at depths below 40 cm. This observation agrees with those of García (3) in Florida. He found that while juvenile numbers at soil depths of 0-15 cm and 15-30 cm decreased rapidly beginning 2 months after peanut harvest, numbers at deeper levels in the soil remained more constant. These findings indicate that however successful control of *M. arenaria* may be in the top 0-40 cm of the soil profile, there exists a "reservoir" population of the nematode deeper in the soil that is potentially capable of regenerating the nematode problem. This hypothesis appears plausible when it is considered that *M. arenaria* juvenile populations in peanut fields develop exponentially (18) according to:

$$J = Ae^{Bt} \qquad \text{(IV)}$$

where A and B are constants and t represents days after planting. We have shown previously (18) that initial (planting time) *M. arenaria* juvenile populations of <10 juveniles/100 cm^3 soil were capable of developing large populations (>200 juveniles/100 cm^3 soil) within the course of a single season.

Our findings indicate that in management schemes there must be consideration that *M. arenaria* is a pathogen emplaced deeply in soil. This implies that practices for successful long-term management of the nematode must be able to reduce populations found deep in the soil profile.

Results from unharvested plots in January and February 1986 indicated that harvesting of peanuts reduces populations in the top 40 cm of the soil more drastically than in the lower strata. This is to be expected since the digging of peanuts results in the removal of the root system of the plant from the top 0-30 cm section of the soil profile. This results in a loss of inoculum and subsequent reduction in juvenile populations in soil (18).

Changes in *M. arenaria* juvenile populations with time confirm previous findings (18). Juvenile populations were low (<20 juveniles/100 cm^3 soil) in the winter-spring period prior to planting. Numbers remained low even after peanut planting (early-mid-May) so that it was only after mid-July that populations increased and then did so exponentially according to equation IV; maximal numbers of juveniles in soil are always found immediately before harvest (mid-September to early October). It is significant that populations in the 0-15 cm and the 16-30 cm depths followed essentially the same pattern of change with time.

The soil chosen for our study is typical of the peanut fields in Alabama and other southeastern states. However, it is likely that differences in texture between soils at various depths may result in different patterns of vertical distribution of *M. arenaria.*

LITERATURE CITED

1. BOOTE, K. J., J. R. STANSELL, A. M. SCHUBERT, and J. F. STONE. 1982. Irrigation, water use, and water relations. Pp. 164-205. *in* H. E. Pattee and C. T. Young (eds.): Peanut Science and Technology. Amer. Peanut Res. and Ed. Soc., Inc. Yoakum, Texas. 825 pp.
2. EVEREST, J. W., A. K. HAGAN, and J. C. FRENCH. 1986. Peanut pest management. Alabama Coop. Ext. Serv. ANR 360.
3. GARCIA, R. M. 1976. Vertical distribution and survival stages of *Meloidogyne arenaria* in Florida with peanut as a host crop. M.S. Thesis, University of Florida, Gainesville. 38 pp.

4. INGRAM, E. G. 1978. Nematological survey of the peanut producing area of Alabama. M.S. Thesis, Auburn University, Auburn, Alabama. 126 pp.
5. INGRAM, E. G., and R. RODRIGUEZ-KABANA. 1980. Nematodes parasitic of peanuts in Alabama and evaluation of methods for detection and study of population dynamics. Nematropica 10:21-30.
6. KOLB, W. M. 1983. Curve fitting for programmable calculators. INTEC, Bowie, Maryland. 144 pp.
7. LITTLE, T. M., and F. J. HILLS. 1978. Agricultural experimentation. John Wiley and Sons, New York. 350 pp.
8. MINTON, N. A., and L. W. MORGAN. 1974. Evaluation of systemic and non-systemic pesticides for insect and nematode control in peanuts. Peanut Sci. 1:91-98.
9. PORTER, D. M., D. H. SMITH, and R. RODRIGUEZ-KABANA (eds.). 1984. Compendium of peanut diseases. The Disease Series of the American Phytopathological Society. APS Press, St. Paul, Minnesota. 73 pp.
10. PUCKETT, W. E. 1983. Hydraulic and related physical properties of coastal plain soils. M.S. Thesis, Auburn University, Auburn, Alabama.
11. ROBERTSON, W. K., L. C. HAMMOND, J. T. JOHNSON, and G. M. PRINE. 1979. Root distribution of corn, soybeans, peanuts, sorghum, and tobacco in fine sands. Proc. Soil Crop Sci. Soc. Fla. 38:54-59.
12. RODRIGUEZ-KABANA, R. 1982. Diseases caused by nematodes. Pp. 378-410 *in* H. E. Pattee and C. T. Young (eds.): Peanut Science and Technology. APRES, Yoakum, Texas. 825 pp.
13. RODRIGUEZ-KABANA, R., and H. IVEY. 1986. Crop rotation systems for the management of *Meloidogyne arenaria* in peanut. Nematropica 16:53-63.
14. RODRIGUEZ-KABANA, R., and P. S. KING. 1985. Evaluation of selected nematicides for control of *Meloidogyne arenaria* in peanut: a multi-year study. Nematropica 15:155-164.
15. RODRIGUEZ-KABANA, R., and M. H. POPE. 1981. A simple incubation method for the extraction of nematodes from soil. Nematropica 11:175-186.
16. RODRIGUEZ-KABANA, R., and D. G. ROBERTSON. 1987. Control of *Meloidogyne arenaria* with 1,3-D: relative efficacy and application depth. Nematropica 17:17-29.
17. RODRIGUEZ-KABANA, R., J. C. WILLIAMS, and R. A. SHELBY. 1982. Assessment of peanut yield losses caused by *Meloidogyne arenaria.* Nematropica 12:278-287.

18. RODRIGUEZ-KABANA, R., C. F. WEAVER, D. G. ROBERTSON, and E. L. SNODDY. 1986. Population dynamics of *Meloidogyne arenaria* in a field with Florunner peanut. Nematropica 16:185-196.
19. STEEL, R. G. D., and J. H. TORRIE. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., New York. 481 pp.

Received for publication:
8.IX.1987
Recibido para publicar:

---

[1]AAES Journal No. 18-871377P.