POPULATION DYNAMICS OF *MELOIDOGYNE ARENARIA* JUVENILES IN A FIELD WITH FLORUNNER PEANUT

R. Rodríguez-Kábana, C. F. Weaver, D. G. Robertson, and E. L. Snoddy
Department of Plant Pathology, Auburn University, Alabama Agricultural Experiment Station, Auburn, Alabama 36849, U.S.A.

Accepted:
23.X.1986
Aceptado:

ABSTRACT

Rodríguez-Kábana, R., C. F. Weaver, D. G. Robertson, and E. L. Snoddy. 1986. Population dynamics of *Meloidogyne arenaria* juveniles in a field with 'Florunner' peanut. Nematropica 16:185-196.

The development of juvenile populations of *Meloidogyne arenaria* was studied for 3 years in a peanut field near Headland, Alabama. The field had been in peanut for the preceeding 7 years. Soil samples for the study were collected from 20 different sites in the 7-ha field. Each site consisted of a plot 2 rows wide and 20 m long. Soil samples were collected every 2-3 wk through the peanut-growing season (May-September). In the last year of the study (1985 season) samples were also taken after harvest at 1-2 month intervals. Samples were collected to a depth of 20-25 cm and consisted of 16-20 cores (2.5-cm-diam.) per site. The cores from each site were composited and a 100-cm^3 subsample was used to determine juvenile populations. Juvenile numbers were low (<50/100 cm^3 soil) during the first 80 days after planting but increased rapidly through the last month before harvest. The relation between numbers of juveniles in soil (J) and days from planting to harvest (T) was best described each year by $J = Ae^{BT}$, where A and B are constants characteristic for each season. Juvenile populations declined sharply after harvest; the relation between numbers of juveniles and days after harvest (t) was described ($R^2 = 0.87$) by $J = 344.53(0.99)^t/t^{0.18}$.

Additional key words: nematode ecology, pest management, quantitative nematology, methodology, Arachis hypogaea, legumes, nematode control.

RESUMEN

Rodríguez-Kábana, R., C. F. Weaver, D. G. Robertson, y E. L. Snoddy. 1986. Dinámica de la pobación larval de *Meloidogyne arenaria* en un campo de maní 'Florunner'. Nematrópica 16:185-196.

Se estudió por 3 años el desarrollo de poblaciones de larvas de *Meloidogyne arenaria* en un campo de maní de 7 ha que había estado con este cultivo durante los 7 años precedentes al estudio. Se tomaron muestras de suelo de 20 parcelas diferentes en el campo. Cada parcela era de dos surcos de ancho y 10 m de largo. Las muestras de suelo se tomaron cada 2-3 semanas cada año en el período del cultivo del maní (Mayo-Septiembre). También, en el último año del estudio (1985) se tomaron muestras cada 1-2 meses después de haberse cosechado el maní. Las muestras para cada parcela se tomaron de la región radicular de las plantas y hasta una profundidad de 20-25 cm componiéndose de 16-20 cilindros de suelo tomados con un taladro tubular de 2.5 cm de diámetro. Los cilindros correspondientes a cada parcela se mezclaron bién y se tomó una porción de 100 cm^3 de la mezcla para determinar la población de larvas. El número de larvas fué bajo (<50 larvas/100 cm^3 suelo) durante los primeros 80 dias después de la siembra pero aumentó rápidamente especialmente en el último mes antes de la cosecha del maní. La relación entre el número de larvas en el suelo (J) y el número de dias (T) transcurridos entre la siembra y el momento de la cosecha se pudo caracterizar cada año con la función $J = Ae^{BT}$, en la cual A y B son constantes caracteristicas de cada año. Las poblaciones larvales disminuyeron rápidamente después de la cosecha. La relación entre el número de larvas y el número de dias transcurridos después de la cosecha (t) se pudo caracterizar ($R^2 = 0.87$) con la función: $J = 344.53(0.99)^t/t^{0.18}$.

Palabras claves adicionales: ecología de nematodos, manejo de plagas, nematología cuantitativa, Arachis hypogaea, leguminosas, combate de nematodos, metodologá.

INTRODUCTION

The root-knot nematode *Meloidogyne arenaria* (Neal) Chitwood is one of the major limiting factors in the production of peanuts (*Arachis hypogaea* L.) in the southeastern United States (7,8,20) and indeed in many other areas of the United States (9). Surveys conducted in Alabama by Ingram in 1977 (3,4) indicated that this root-knot nematode was present in 47% of the peanut fields in the southeastern counties, the principal peanut-producing region of the state. The survey also showed that 20% of the peanut acreage was infested with the nematode to such levels that treatment with nematicides would likely result in economical yield responses (6,11). Information on the population dynamics of *M. arenaria* on peanut is limited (1,4). However, quantification of the population dynamics of the nematode is essential to be able to predict losses (20), to make better use of the nematicides available (6,11,13,14,18), and in general to assist the development of strategies that will lead to proper management of nematode populations in peanut fields (10,17). This paper presents results of a 3-year study conducted to obtain a quantitative description of the development of root-knot nematode in a field of 'Florunner' peanut.

MATERIALS AND METHODS

The study was conducted in a 7-ha field at the Wiregrass substation near Headland, Alabama. The field was uniformly infested with *M. arenaria* and had been in continuous peanut production for 7 years prior to initiation of the study in 1983. Each year hairy vetch (*Vicia villosa* Roth) was planted as a winter cover crop which was turned under approximately 4-6 weeks before peanut planting time. The soil was a sandy loam with an organic matter content of less than 1.0% (w/w) and pH=6.0-6.2. Each year a total of 20 sites were established for the study in the field. Each site consisted of a plot 2 rows wide (approx. 2 m) x 10 m long. Each year, soil samples were collected from each site at intervals of 15-20 days during the peanut growing season (May-September), beginning at planting. In addition, in 1985 sampling of all sites was continued after harvest at 1-2 month intervals until early spring 1986. In 1985 one half of the plots were harvested and the other half was not. Soil samples were collected to a depth of 20-25 cm and consisted of 16-20 cores (2.5-cm-diam.) per site. The cores from each site were composited and a 100-cm^3 subsample was used to determine juvenile populations with the "salad bowl" incubation technique (15).

Cultural practices and control of foliar diseases, insects, and weeds were as recommended for the area (2). The field was irrigated as needed.

All data were analyzed following standard methods for regression analysis and least square procedures for curve fitting (5,22).

RESULTS

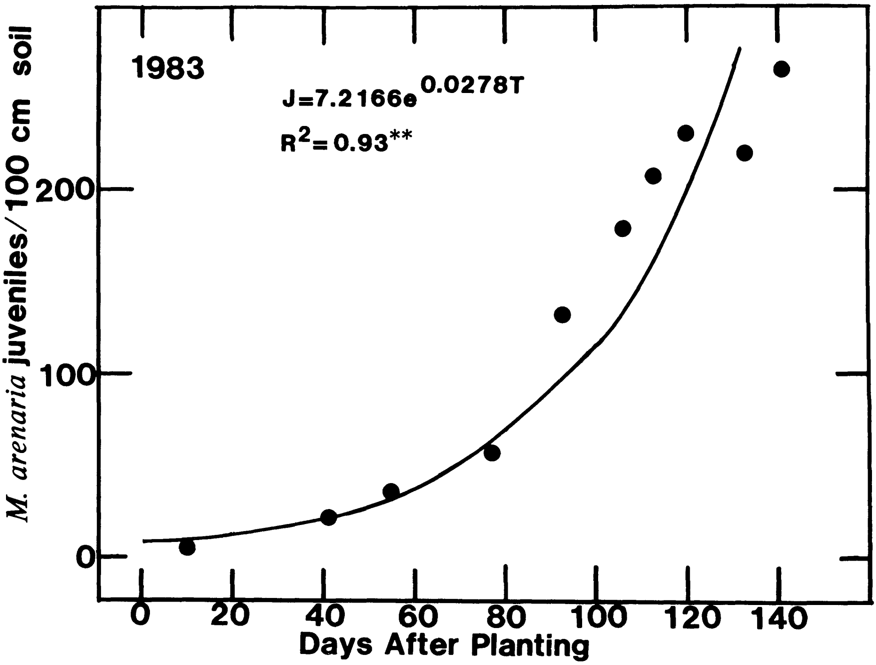
Data for the three peanut growing seasons of the study are presented in Fig. 1. Juvenile populations were very low during the first 80 days after planting; in no year did the population exceed 50 juveniles per 100 cm^3 soil during this period. Numbers of juveniles at planting time varied from 10-47/100 cm^3 soil. The period of maximal population development corresponded to the last 4-6 weeks of the crop. Population development for all three years was described by an exponential equation of the type:

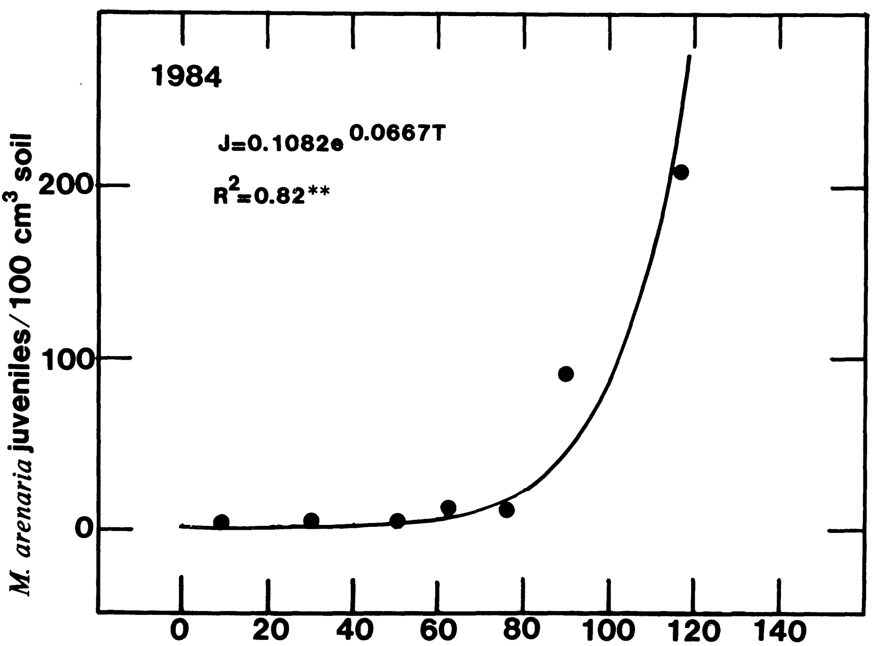
$$J = Ae^{BT} \qquad \text{(I)}$$

where J represents number of juveniles, T the number of days between planting and harvest time, and A and B constants; values for A and B differed for each season.

Fig. 2 presents all results for the 1985 samplings. The graphs present results obtained during the peanut-growing period and those obtained after harvest for both unharvested and harvested plots.

The data for unharvested plots (Fig. 2B) showed that juvenile population development continued after harvest time reaching a maximum value 164 days after planting (late October 1985). The population decreased sharply after attaining the maximum, so that 257 days after planting (mid-January 1986) the numbers of juveniles was approximately equal to that recorded at harvest time. Sampling in the unharvested plots was discontinued after January 1986 since the land was plowed in early March, 1986 in preparation for peanut planting. The data from these plots for the first 164 days after planting agreed well with the exponential model of equation I (Fig. 3); the B coefficient for the equation was similar to the corresponding coefficient of the equation describing population development in 1985 up to harvest time (Fig. 1).


1983
J=7.2166e 0.0278T
R2= 0.93**
M. arenaria juveniles/100 cm soil
0
100
200
0
20
40
60
80
100
120
140
Days After Planting


1984
J=0.1082e 0.0667T
R2=0.82**
M. arenaria juveniles/100 cm3 soil
0
100
200
0
20
40
60
80
100
120
140
Days After Planting

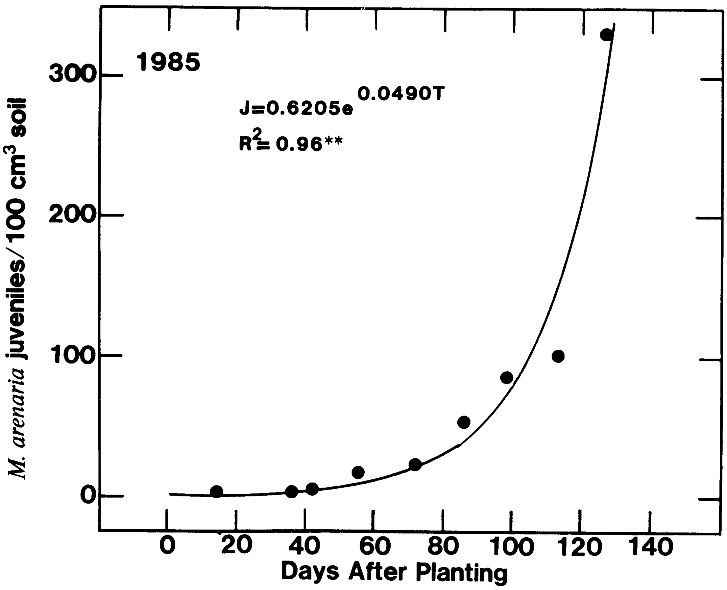


Fig. 1. Population development of *M. arenaria* juveniles (J) as a funciton of time since planting (T) during the 1983, 1984, and 1985 seasons in a field with 'Florunner' peanut near Headland, Alabama.

The data for the harvested plots (Fig. 2A) indicated that juvenile population development reached a maximum value at harvest time 120 days after planting and then declined sharply after harvest. Population development to harvest time was best described by the exponential equation model I as represented in Fig. 1. The decline in juvenile numbers after harvest was exponential in nature so that by planting time (1986) the size of the population was the same as that observed at the same time in the previous season. The exponential model equation (I) did not describe the decline in population size as well as the Hoerl (5) equation (Fig. 4):

$$J = A(B^t)(t^C) \quad \text{(II)}$$

where t represents days after harvest, A, B, and C constants, and J numbers of juveniles per 100 cm^3 soil.

DISCUSSION

Development of juvenile populations of *M. arenaria* in the peanut field of this study followed the unrestricted growth model of equation

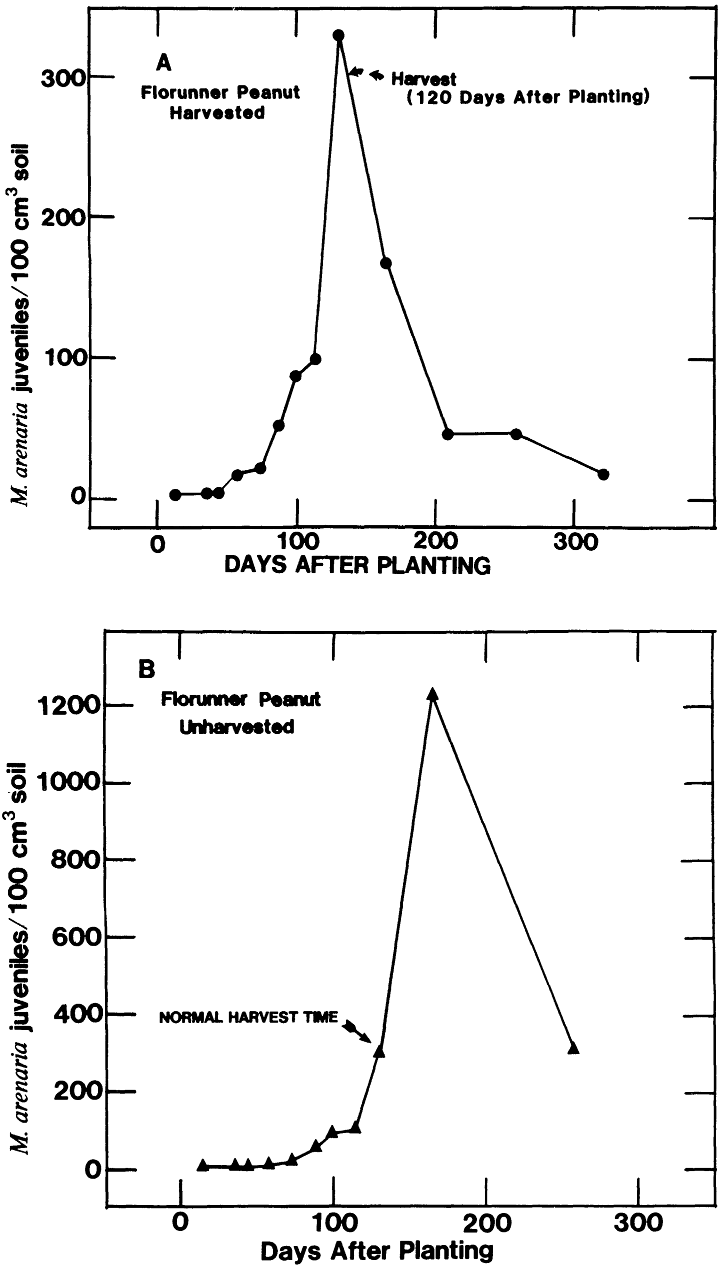


Fig. 2. Changes in juvenile populations of *M. arenaria* during the 1985 peanut season in plots that were harvested (A) and in plots that were not harvested (B).

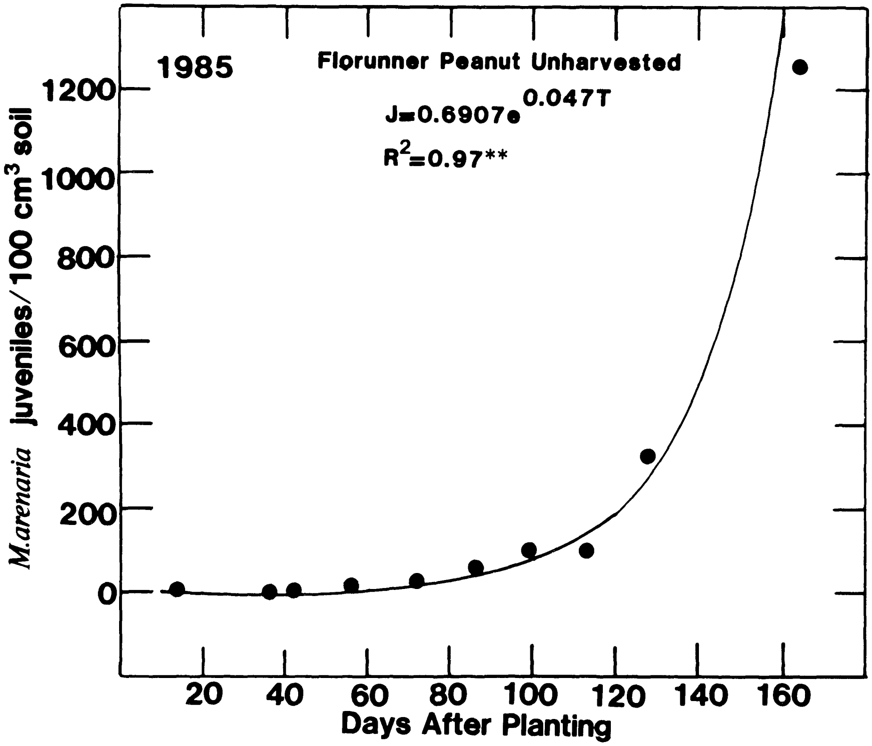


Fig. 3. Exponential curve describing *M. arenaria* juvenile population (J) development in unharvested plots as a function of time since planting (T) for the 1985 peanut crop.

I (21). The model assumes that the rate of development of a population (dJ/dT) is directly proportional to the number of individuals present or:

$$dJ/dT = BJ \qquad \text{(III)}$$

A solution for this differential equation is equation I. Equation III implies that the rate of development will increase as the value of J increases. This is of great practical importance for the management of *M. arenaria* in peanut. Equation III indicates that to keep dJ/dT low one must maintain the value of J as low as possible and as early in the season as feasible. Each year of the study, planting time juvenile populations were very low and indeed remained low (<50 juveniles/100 cm^3 soil) for the first 80 days of the crop. It is during this early part of the season when dJ/dT is low that one must succeed in controlling the nematode if one is to impede population development and consequent yield loss. These concepts agree with what is known about the use of nematicides

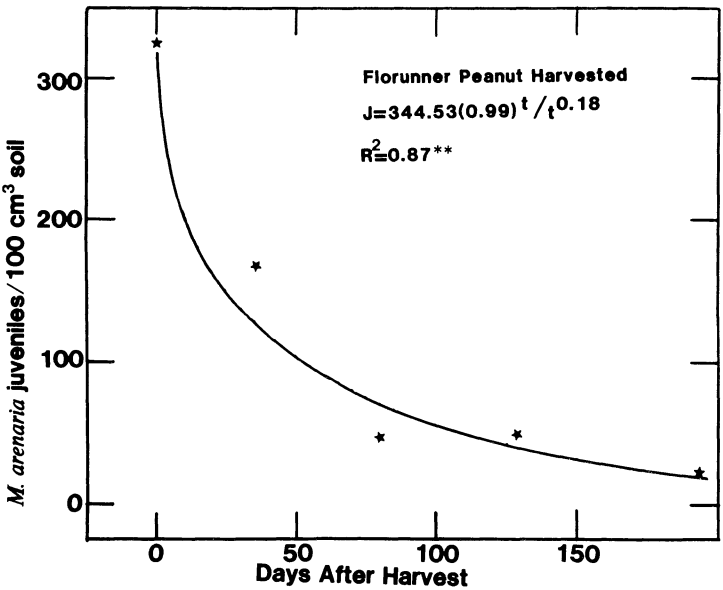


Fig. 4. Decline in *M. arenaria* juvenile populations (J) as a function of time (T) following harvest of the 1985 peanut crop.

for management of *M. arenaria* in peanut. Previous work has shown that nematicide applications in 'Florunner' peanut are most successful when practiced at planting time or within 2-4 weeks after planting (12,16). Also, nematicide applications performed at blooming-pegging time, 60-80 days after planting, are not as effective as those practiced at or near planting time (16). When effective planting-time applications of nematicides are used, previous results have shown that additional pegging time treatments with nematicides do not result in additional economical yield response or nematode control over what is obtained with the planting time treatment alone (16,18). Our results indicate that *M. arenaria* juvenile populations undergo drastic declines following harvest or death of the peanut plant following frost (November 1986) in unharvested plots. Studies by García (1) in Florida peanut fields showed that there are no egg masses of *M. arenaria* in the fields except toward the end of the peanut season just prior to harvest. In Alabama we have been unable to recover egg masses of *M. arenaria* during the winter or spring periods (unpublished data). These observations suggest that it is the juvenile population that maintains *M. arenaria* in peanut fields from season to season. It is thus important to determine the best time for sampling to assess juvenile populations. Our results indicate that maximal populations exist at harvest time. Therefore, it is at this time when samples should be taken. Limitations in the accuracy of existing extraction or incubation methods for assessment of juvenile populations in soil preclude the use of samples obtained during the spring or immediately before planting when juvenile numbers are at the lowest level. Ingram (3,4) has shown that the best way to assess root-knot nematode populations in peanut fields from winter or spring samples is to rely on bioassay techniques. It is thus not surprising that in previous studies we were able to correlate peanut yield loss to juvenile populations assessed at or near harvest time with the incubation method used in the present study (20); however, we have not been able to establish such correlations using spring or planting-time samples (unpublished data).

The exponential equations describing *M. arenaria* juvenile population development in peanut for the 3 years of the study differed significantly in the values of the B coefficient; the highest value corresponded to 1984 and the lowest for 1983. Since juvenile numbers at planting time were very low each year, the value of B determined the rate of population development, i.e., dJ/dT. This suggests that there are significant seasonal effects influencing juvenile population development in peanut fields. The field for the study was irrigated and water availability was not a limiting factor. Also, soil temperatures (20 cm depth) from planting time (late April-mid May) to harvest (mid-September) in Alabama range from 24-32C. This range of temperatures is well within what is optimal for development of the nematode. We therefore do not believe that in our case soil temperature or water availability had a significant influence on development of juvenile populations. Seasonal differences in population development must be due to other factors as yet unknown to us. It is possible that there may be significant seasonal differences in the distribution of juvenile populations throughout the soil profile. Ingram (3,4) and Garcia (1) have shown that *M. arenaria* juvenile populations persist through the winter at depths lower than 20 cm. Soil temperature changes in late fall-spring in Alabama are characteristically more variable than the summer temperatures. This could affect significantly the distribution and survival of juvenile populations throughout the soil profile.

Juvenile population development in peanut differs significantly from that observed for juveniles of *M. incognita* (19) in soybean (*Glycine max* Merr.). Populations of *M. incognita* developed according to the logistic equation model (21) which implies that there is a maximal population (K) possible in a field and that

$$dJ/dT = kJ(K-J) \qquad (IV)$$

where k is a constant. Factors such as the availability of feeding sites, hence food available, limit the rate of population development. Equation III has no such limitation on dJ/dT. However, this apparent discrepancy is resolved if one considers that harvesting of peanut is performed before juvenile populations have exhausted food availability. This is supported by the 1985 post-harvest data; values for the B coefficient before harvest was essentially identical to that of the equation describing population development in unharvested plots before the frost. In contrast to soybean, the peanut provides feeding sites for root-knot nematodes not only on the roots but also in the pods and pegs (8). This suggests that the peanut may have a greater carrying capacity for *M. arenaria* than the soybean. In warmer climates not subject to frost, we would expect the development of juvenile populations of *M. arenaria* in peanut to continue and eventually become limited by feeding sites, i.e., dJ/dT would decline and population growth would follow a logistic or similar type model.

LITERATURE CITED

1. 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.
2. GAZAWAY, W. S., F. A. GRAY, and R. ADAMS. 1977. Alabama plant disease and nematode chemical control handbook. Ala. Coop. Ext. Serv. Cir. ANR-105, Auburn, Alabama. 94 pp.
3. INGRAM, E. G. 1978. Nematological survey of the peanut producing area of Alabama. M.S. Thesis, Auburn University, Auburn, Alabama. 126 pp.
4. 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.
5. KOLB, W. M. 1983. Curve fitting for programmable calculators. INTEC, Bowie, Maryland. 144 pp.
6. MINTON, M. 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.
7. MOTSINGER, R. E., J. L. CRAWFORD, and S. S. THOMPSON. 1976. Nematode survey of peanuts and cotton in southwest Georgia. Peanut Sci. 3:72-74.
8. 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.

9. 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.
10. RODRIGUEZ-KABANA, R., and H. IVEY. 1986. Crop rotation systems for the management of *Meloidogyne arenaria* in peanut. Nematropica 16:53-63.
11. 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.
12. RODRIGUEZ-KABANA, R., P. S. KING, H. W. PENICK, and H. IVEY. 1979. Control of root-knot nematodes on peanuts with planting time and post-emergence applications of ethylene dibromide and ethylene dibromide-chloropicrin mixtures. Nematropica 9:54-60.
13. RODRIGUEZ-KABANA, R., P. S. KING, and M. H. POPE. 1981. Comparison of in-furrow applications and banded treatments for control of *Meloidogyne arenaria* in peanuts and soybeans. Nematropica 11:53-67.
14. RODRIGUEZ-KABANA, R., P. G. MAWHINNEY, and P. S. KING. 1980. Efficacy of planting time injections of three systemic nematicides against root-knot nematodes in peanuts. Nematropica 10:45-49.
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., R. A. SHELBY, P. S. KING, and M. H. POPE. 1982. Application time and effectiveness of four systemic nematicides against *Meloidogyne arenaria* on Florunner peanuts. Nematropica 12:85-96.
17. RODRIGUEZ-KABANA, R., and J. T. TOUCHTON. 1984. Corn and sorghum as rotational crops for management of *Meloidogyne arenaria* in peanut. Nematropica 14:26-36.
18. RODRIGUEZ-KABANA, R., C. F. WEAVER, and P. S. KING. 1985. Combinations of 1,3-D and aldicarb for management of *Meloidogyne arenaria* in peanuts. Nematropica 15:93-106.
19. RODRIGUEZ-KABANA, R., and D. B. WEAVER. 1984. Soybean cultivars and development of populations of *Meloidogyne incognita* in soil. Nematropica 14:46-56.
20. RODRIGUEZ-KABANA, R., J. C. WILLIAMS, and R. A. SHELBY. 1982. Assessment of peanut yield losses caused by *Meloidogyne arenaria.* Nematropica 12:278-287.
21. SAPIO, R. De. 1978. Calculus for the life sciences. W. H. Freeman & Co., San Francisco. 740 pp.

22. STEEL, R. G. D., and J. H. TORRIE. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York. 481 pp.

Received for publication:

18.IX.1986

Recibido para publicar: