EFFECT OF *Meloidogyne incognita* (ROOT- KNOT NEMATODE) ON THE DEVELOPMENT OF *Abelmoschus esculentus* (OKRA)

AGWU, Julia Ekenma and EZIGBO, Joseph Chidera
Department of Zoology, University of Nigeria, Nsukka, Enugu State, Nigeria

Corresponding Author: AGWU, J. E. Department of Zoology, University of Nigeria, Nsukka, Enugu State, Nigeria. Email: ekenmajulia@fastermail.com

ABSTRACT

Seedlings of Okra Abelmoschus esculentus were inoculated with different numbers of egg masses (0, 4, 8 and 12) of Meloidogyne incognita. The different inoculums elicited varied reactions on the Okra plants. Root galls increased progressively and significantly with increased levels of inoculum. At 0 (zero) inoculum level no root gall was observed. At low inoculum levels, 4 and 8 egg masses, the plants performed seemingly better than the control (in terms of plant dry weight, flower and fruit production). At high inoculum levels very low mean yields of the above parameters were recoded when compared to the control. The implications of enhanced performance observed at low inoculum levels on experimental crops are discoursed.

Keywords: *Meloidogyne incognita,* Root-knot nematode, *Abelmoschus esculentus,* Okra, Root galls

INTRODUCTION

Successful production of vegetables in Nigeria has been hampered to some extent by nematode pests, especially the root- knot nematodes *Meloidogyne* spp. (Ogbuji, 1983a, 1983b; Atu and Ogbuji, 1986 Enopka *et al.*, 1996; Agu and Ogbuji, 2001).

Three species of root-knot nematodes, *M. javanica, M. incognita* and *M. arenaria*, are found in Nigeria and they attack over 140 species of cultivated plants amongst which are important food crops and vegetables (Ezigbo, 1973; Idowu, 1981; Ogbuji, 1983a, 1984; Enokpa *et al.*, 1996).

There have been reports on the effects of population densities of root-knot nematodes on growth and yield of vegetable crops in Nigeria. Ezigbo (1973) reported that *Meloidogyne* spp. induced dwarfing, withering, discoloration of leaves, flower abortion and in severe cases premature death in cowpea. Enokpa *et al.* (1996) also reported stunted growth in tomato plant treated with *Meloidogyne* spp. Reports of stunted growth, chlorotic and early senescence were reported in pepper (Capsicum *annuum)* inoculated with *Meloidogyne* Spp. (Ogbuji and Okarfor, 1984). In these examples authors reported that the *Meloidogyne* led to poor yields. The inducing of adventitious root formation in cowpea by root – knot nematode has also been reported (Ezigbo, 1973).

Abelmoschus esculentus commonly called Okra ranks high amongst the economical important vegetables of the world. The immature fruits of Okra, which are good sources of vitamin C, are used for the preparation of certain soups and sauces (Diouf, 1997). In the Tropics, *M.incognita* very frequently attack okra (Seck, 1990; Singh *et al.*, 1993; Khan and Khan, 1994; Khan *et al.*, 1998). Kahn *et al.* (1994) reported that *M. incognita* elicited leaf browning, suppression in plant growth, fruit yield and photosynthetic pigments in okra.

Two species of root- knot nematodes, *M. incognita and M. javanica* very frequently attack *A. esculentus* in numerous farms in Nigeria (Caveness, 1976). In Nigeria, Okra is not only planted as the sole crop in farms but also used as a traditional intercrop planted with yams *(Dioscorea* spp.) (Ogbuji, 1986). Ogbuji (1986) further reported that this intercropping of okra with *Dioscorea rotunda* resulted in greater damage on the harvested tubers as a result of cross infestation of *M.incognita* from the Okra to the yams.

This paper reports the effects of *M. incognita* on the vegetative development of *Abelmoschus esculentus* in Nsukka, Nigeria.

MATERIALS AND METHODS

Seedlings of *Abelmoschus esculentus* were raised in black polythene sowing bags containing steam-sterilized soil. Three weeks old seedlings of the crops of about the same size were selected from the nursery and transplanted into each of 60 (sixty) experimental polythene bags. The bagged plants were arranged in a Complete Randomized Block Design and in three replicates to facilitate analysis of the results. Each replicate contained four rows with five plants per row totaling twenty (20) plants in each replicate.

Preparatory to the experiment, *M. incognita* originating from roots of field grown *Abelmoschus esculentus* were maintained on roots of tomato cultivars in special nursery bags. The species of the experimental nematode was confirmed from the examination of the perennial patterns (Ezigbo, 1973). Mass propagation of *M.incognita* was noticed on the tomato roots. In the experimental phases, egg masses of *M. incognita* of uniform size from the tomato root were inoculated thus:

- 0 egg mass per plant (control)

- 4 egg mass inoculum level (IL4) i.e. 4 egg masses per plant.
- 8 egg mass inoculum level (IL8) i.e. 8 egg masses per plant.
- 12 egg mass inoculum level (IL12) i.e. 12 egg masses per plant.

To inoculate each experimental plant, appropriate egg mass inoculum was added to a 3 cm depression ring in the soil around the roots of the three week old plants. The first row in each replicate were the control plants in which there was no infestation with nematode .The second row were those infected with four (4) egg masses per plant While the third and fourth rows were treated with 8 and 12 egg masses per plant respectively. The potted plants were duly tended and exposed to normal daylight. Dieldrex 20 (20 % dieldrin w/v) at 0.51 in 30 litres of water was sprayed weekly against insect attack. During harvesting, fruits were picked when they attained marketing quality (5.82 ± 0.19 cm). The first harvest took place seven weeks after planting. The numbers of aborted / dehisced fruits were also recorded. Once every week from week five (5) to six (6) and from week seven (7) to ten (10) when the experiment was terminated. Data collected for analysis were as follows:

5th to 8th week: the number of leaves, flowers and fruits per stand; 9th week: total number of fruits per plant, number of aborted fruits per plant; 10th week: dry weight of shoot per plant, dry weight of root per plant, length (cm) of shoot per plant, dry weight of fruits per plant, number of galls per plant. The dry weights were measured with a weighing balance to the nearest 0.05 grams.

RESULTS

Figure 1 shows the weekly mean shoot height of *A. esculentus* in relation to the inoculum levels of *M. incognita*. As shown on figure 1, inoculated plants were taller than the control at the 5th and 6th weeks. Subsequently the uninoculated planets were tallest. However from the seventh week to the end of the experiment control plants attained the tallest shoot heights followed closely by plants inoculated with 8 egg masses, while the plants inoculated with 12 egg masses recorded the lowest shoot height. These effects were shown to be significant ($P < 0.001$).

Figure 2 shows the effect of different inoculum levels of *M. incognita* on mean number of leaves of *A. esculentus*. At the 5th week the number of leaves on plants treated with 4 and 8 egg masses of *M. incognita* were a little more than those of control plants and plants treated with 12 egg masses. From the 6th week to the end of the experiment, plants treated with 8 egg masses of *M. incognita* clearly exhibited the highest number of leaves, followed by those four egg masses, the control plants and plants with 12 egg masses These differences in leaf number was not significant ($P > 0.001$). Highest number of leaves was produced at the 5th week and the leaves of the plants treated with 8 egg masses of *M.incognita* were the most luxuriant.

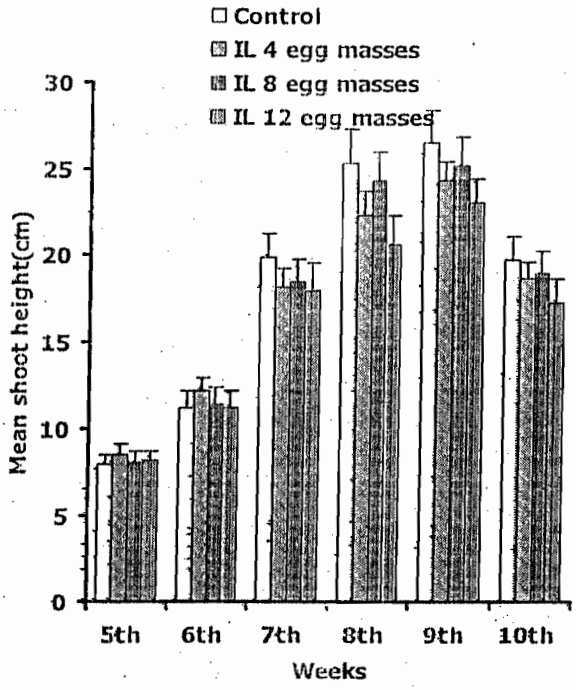

Figure 1: Weekly mean shoot height of Abelmoschus esculentus in relation to the inoculum levels of M. incognita

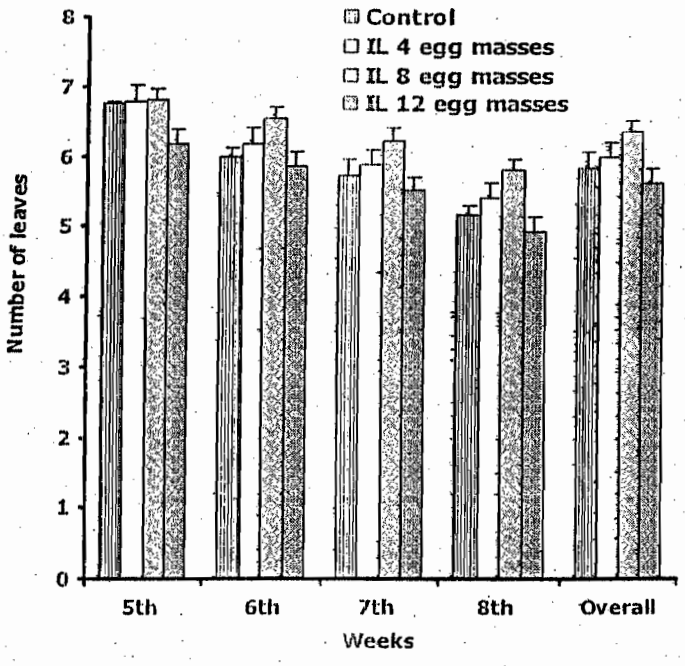

Figure 2: Weekly mean number of leaves (additional relative to time) of A. esculentus in relation to inoculum levels of *M. incognita*

The control plants were the only plants flowering in the 5th week, but from the 6th to 8th week the inoculated plants started flowering (Table 1). For both the control and inoculated plants, peak flowering was in the 7th week, with the plants inoculated with 8 egg masses producing the highest number of flowers (80), followed by plants inoculated with 4 egg masses (70), control plants (53) and 12 egg masses inoculated plants (30) respectively. Form the 6th week; the 8 egg masses inoculated plants produced the highest number of flowers at each time interval.

Table 1: Total number (additional relative to time intervals) of flowers per treatment and numbers actually flowering, (give in brackets) at different time intervals during the experiment

	Number of flowers and plants flowering/Treatment			
Week	Control	IL 4 egg masses	IL 8 egg masses	IL 12 egg masses
5th week	4(4)	0(0)	0(0)	0(0)
6th week	20(8)	28(13)	32(15)	21(2)
7th week	53(15)	70(14)	80(15)	30(10)
8th week	18(12)	16(8)	35(15)	15(8)
9th week	0(0)	0(0)	1(1)	0(0)

Stands in the IL8 egg masses produced the highest number of fruits, 116, while the lowest number of fruits 17, was produced by stands treated with IL 12 egg masses (Table 2).

Table 2: Total number (cumulative) of fruits formed at different time intervals during the experiment

	Number of fruits formed/Treatment			
Weeks	Control	IL 4 egg masses	IL 8 egg masses	IL 12 egg masses
7th week	41	20	26	7
8th week	48	55	70	13
9th week	65	78	116	17

The highest number of fruits 10, was aborted in plants treated with IL 12 egg masses, while the least fruit abortion 2, occurred in the control plants (Table 3).

Table 3: Summary of observations made on fruits maturation during the experiment

Treatment	No. of aborted fruits	No. of Damaged fruits	No. of Undamaged fruits	Total no. of fruits formed	% wholesome fruits
Control	2	3	60	65	92.3
IL 4 egg masses	8	40	30	78	38.4
IL 8 egg masses	4	55	57	116	49.13
IL 12 egg masses	10	4	3	17	17.64

The highest number of damaged fruits 55, was recorded in plants treated with IL 8 egg masses, while 40, 4 and 3 were recorded in plants treated with IL 4 egg masses, IL 12 egg masses and the control plants respectively (Table 3). When the number of fruits aborted and damaged per treatment were added, 92.3 % of total fruits in the control were normal, while for plants treated with IL8 egg masses, only 49.13 % of the fruits were normal (Table 3). Out of the 78 fruits yielded by the fruits treated with IL4 egg masses only 38.4 % were normal, while only 17.6 % of fruits produced by plants treated with IL 12 egg masses were normal (Table 3).

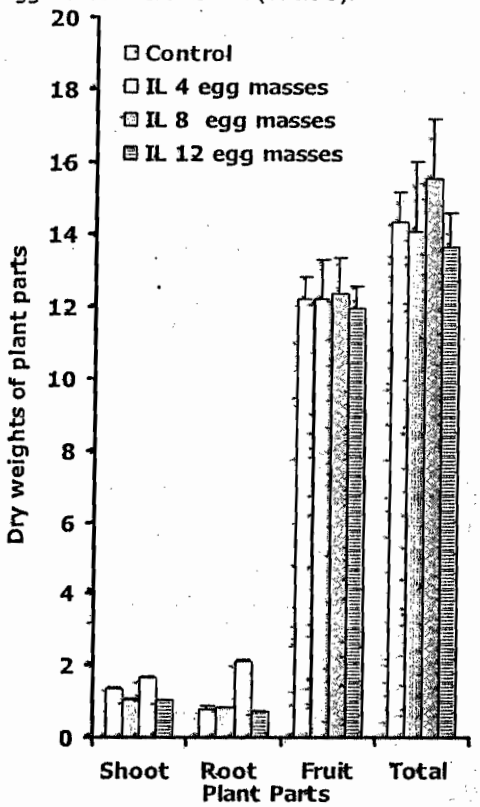

Figure 3: Effect of different inoculum levels of *M. incognita* on mean dry plant weight (g) of *A. esculentus*

Figure 3 gives the mean dry weight of the shoots, roots, fruits and total weight of the plant in grams. The mean dry shoot weight of the plants treated with IL8 egg masses was the highest (1.6 g), followed by the control plants (1.36 g). The least mean dry shoot weight occurred in plants treated with IL12 egg masses (1.017 g). The mean dry root weight was significantly different ($P < 0.05$) amongst treatments. The stands with IL8 egg masses had the highest mean dry root weight (2.1 g) while the IL4, control and IL12 egg masses had 0.8 g, 0.79 g and 0.3 g respectively. The mean dry fruit weight of the control and treated plants did not show any significant variation ($P > 0.05$). Table 4 illustrates the effects of *M. incognita* in galls formation on *A. esculentus.*

Table 4: effect of *Meloidogyne incognita* on mean number of galls on *A. esculentus*

Treatment	Mean number of galls
Control	0.00
IL 4 egg masses	50 ± 18.53
IL 8 egg masses	100 ± 65.99
IL 12 egg masses	120 ± 21.66

The control plants had no galls on them, while plants treated with IL12 egg masses had the highest number of galls (120 ± 21.66), followed by those treated with IL8 egg masses (100 ± 65.99). The least galls occurred in those treated with IL4 egg masses (50 ± 8.53). The mean number of galls for the treatments when tested statistically was significantly different ($P < 0.05$).

DISCUSSION

In this study, the occurrence of taller shoots in nematode infected plants than in the controls from week 5 to 6 after inoculation could be explained by the findings of Ezigbo, 1973. Ezigbo (1973), in his study of the effect of root- knot nematode on vegetables established that the first response to root - knot nematode stimulation is the formation of galls. Galls are induced by surface feeding without actual entry of the larvae into the roots. On galls formation, Ezigbo (1973) reported the formation of lateral roots in the region of the galls. These additional lateral roots, enhances the uptake of water and mineral salts by the treated plants and this enhancement manifested as increased shoot height in the treated plants, until the damage of root cells by the entry of the second stage infective larva. In this sturdy it is therefore assumed that from the seventh week to the end of the experiment when the control shoots were taller than the treated shoots, the second stage larvae may have eaten up part of the roots of the treated plants .The damage done was insufficient to hamper abundant flower and fruit production.

The control plants attained the tallest heights from the 7th to the 8th week .The finding was in line with the findings of Ezigbo (1973), Singh *et al.* (1993) and Enopka *et al.* (1996) . These authors in their various works on the effects of root-knot nematodes on vegetables observed some pathological changes in the inoculated plants. These pathological changes manifested in shoot heights, shoot weights, root weights, and most importantly in fruit development and maturation.

Among the nematode inoculated plants, 8 egg masses inoculated plants had higher shoot height than 4 and 12 egg masses inoculated plants. A convex interaction is demonstrated between the nematode and the host plant at various levels of inoculum.

Low nematode levels stimulating plant growth, food production and maturation have been reported by other workers Khan *et al.*, 1996 and Rao and Krishnappa, 1994). Khan *et al* (1996) infected cowpeas with various inoculums of *M. incognita* while Rao and Krishna (1994), infected chickpea with different inoculum densities of the same root knot-nematode; they found that growth stimulation occurred at low infection levels. At higher infection levels growth was suppressed. They concluded that at low inoculum levels of *M. incognita,* the production of lateral roots was stimulated and this accounts for the increased root weight of the plants and possibly increased nutrient uptake. This observation of Khan *et al.* (1996) and Rao and Krishnappa (1994), could be used to explain the occurrence of low flower and fruit production in plants inoculated with 12 egg masses. The findings of Khan *et al.* (1996) and Rao and Krishnappa (1994) were also supported by the findings in this study in which low inoculum levels of 4 and 8 egg masses gave the highest flower, food production and dry root weights of plants than the control. However plants treated with 4 egg masses having fewer flowers, lower shoot height and fruit yield than those treated with 8 egg masses, presupposes that the nematode *M. incognita* elicits a positive interaction though at different degrees at low inoculum levels. This assumption presupposes that at inoculum level 8 egg masses, *M. incognita* elicits a higher degree of positive interaction in A. *esculentus.*

Although more fruits were produced at low inoculum levels as shown with 4 and 8 egg masses inoculated plants, more marketable and healthier fruits were recovered from the control plants. This root stimulation seemingly advantageous would in the long run be detrimental to the plant in terms of fruit production, development and maturation. Increased inoculum levels lead to increased root galling in *A. esculentus.*

ACKNOWLEDGEMENT

The authors wish to thank Prof. E. E. Ene-Obong of the Cross River State, University of Technology for designing the experiment and Mr. O. Nnate of the Crop Science Department of the University of Nigeria, Nsukka, for sterilizing the soil and manure used for the experiment. We would also like to thank Prof. R. O. Ogbuji of the Crop Science Department of the University of Nigeria, Nsukka for reviewing the manuscript.

REFERENCES

AGU, C. M. and OGBUJI, R. O. (2001). Effect of soil nature on soybean inherent resistance status to root-knot nematode *(Meloidogyne javanica). International Journal of Agriculture and Rural Development, 2:* 35 – 42.

ATU, U. G. and OGBUJI, R. O. (1986). Root-knot nematode problems with intercropped yam (*Dioscorea rotundata). Phytoprotectioin, 67:* 35 – 38.

CAVENESS, F. E. (1976). Root-knot nematodes in Nigeria. *In: Proceedings of the Research Planning on Root-knot nematodes Meloidogyne incognita.* International Institute of Tropical Agriculture, Ibadan, June 7- 11, 1976.

DIOUF, M. (1997). Research on African vegetables at the Horticultural Development Center (CDH), Senegal. Pages 39 – 45. *In:* Guarino, I. (ed.). *Traditional African vegetables. Proceedings of the IPGRI International workshop on genetic resources of traditional vegetables in Africa: Conservation and use, held at ICRAF, Nairobi, Kenya, 29 – 31 August 1995,* International Plant Genetic Resources *Institute* (IPGRI), Rome, Italy.

ENOPKA, E. N. OKWUJIAKO, I. A. and MADUNAGU, B. E. (1996). Control of root – knot nematodes in tomato with Furadan. *Global Journal of Pure and Applied Sciences 2 (2):* 131 – 136.

EZIGBO, J. C. (1973). *Aspects of the host – parasite relationships of root – knot nematodes (Meloidogyne spp.) on cowpeas.* M.Sc. thesis (Unpublished). Imperial College of Science and Technology, Berkshire, London. 250 pp.

IDOWU, A. A. (1981). The distribution of root-knot nematodes (*Meloidogyne* spp.) in relation to elevation and soil type in vegetable growing areas of upper northern Nigeria. Pages 128 – 134. *In:* Proceedings third IMP (International *Meloidoogyne* Project) Research and Planning Conference on root – knot nematodes, *Meloidogyne* spp., Regions IV and V. November 16- 20, 1981. International Institute of Tropical Agriculture, Ibadan, Nigeria.

KHAN, M. R. and KHAN, M. W (1994) Single and interactive effects of root – knot nematode and coal- smoke on okra. *New Phytologist, 126(2):* 337 – 342.

KHAN, Z., JAIRAJPURI, M.S., KHAN, M. and FAUZIA, M. (1998). Seed soaking treatment in culture filtrate of a blue- green algae, *Microcolues vaginatus,* for the management of *Meloidogyne incognita* on okra. *International Journal of Nematology 8(1):* 40 – 42.

OGBUJI, R. O. (1983a). Variability in the infection *Meloidogyne arenaria* Race 2 on differential hosts. *Nigerian Journal of Plant protection, 7:* 48 – 51.

OGBUJI, R. O. (1983b). Susceptibility of maize cultivars to Race I of *Meloidogyne incognita* in Nigeria. *Beitrage tropica Landwirtsch Veterinamed, 21(1):* 101 – 105.

OGBUJI, R. O. (1986). Permanent crops as a reservoir of plants of plant-parasitic nematodes in Asa County, Imo State, Nigeria. *Beitrage tropica Landwirtsch Veterinamed, 24(3):* 323 – 328.

OGBUJI, R. O. and OKARFOR, M. O. (1984). Comparative resistance of nine pepper (*Capsicum annuum L.)* cultivars to three root – knot nematode (*Meloidogyne)* species and their related use in traditional cropping systems. *Beitrage tropica Landwirtsch Veterinamed, 22 (2):* 167 – 170.

SECK, A. (1991). Okra evaluation in Senegal. Pages 31 – 33. *In: Report of an international workshop on okra genetic resources.* Held at the National Bureau for Plant Genetic Resources, New Delhi, 8 - 12 October 1990. International Crop Network Series Number 5, India.

SINGH, R. K., SINGH, R. R. and PANDEY, R. C. (1993). Screening of okra, *Abelmoschus esculentus* varieties/ cultivars against root-knot nematode, *Meloidogyne incognita. Current Nematology, 4(2):* 229 – 232.