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EFFECT OF *Meloidogyne incognita* ON THE GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L.) IN JOS NORTH LOCAL GOVERNMENT AREA, PLATEAU STATE, NIGERIA

[1]Lawal I.H., *[2]Ibrahim I.I., [1]Dogun O., [3]Ubong I.H., [1]Dinchi P.T., [4]Aminu A.A. and [1]Hassan I.A.

[1]Federal College of Forestry Jos, Plateau State, Nigeria
[2]Federal College of Forest Resources Management, Maiduguri, Borno State, Nigeria
[3]Federal College of Forest Resources Management, Ishiagu, Ebonyi State, Nigeria
[4]University of Jos, Plateau State, Nigeria.

*Corresponding author's e-mail: ibrahimiroibrahim@yahoo.com

ABSTRACT

Meloidogyne incognita, commonly known as root-knot nematode, is a microscopic pest that inflicts substantial damage to various crops, including okra (Abelmoschus esculentus L.). Understanding the impact of M. incognita on the growth and yield of okra is crucial for devising effective management strategies against the pest. This research work was conducted to determine the effect of M. incognita on the growth and yield of okra (Abelmoschus esculentus (L.). The experimental design used was Complete Randomised Design comprising of four treatments; control (I_0), Inoculum (I_{10}), Inoculum (I_{20}), and Inoculum (I_{30}). Data were collected on the number of galls, plant height, number of branches, number of flowers, and yield of okra. The data was analyzed using ANOVA with the aid of Mini-Tab 17 statistical package and where significance was declared on the result, Duncan Multiple Range Test was used to separate the means. The result shows that no significant difference in inoculum level was recorded on plant height, number of branches, and number of flowers, However, a significant difference was recorded on number of galls, and yield with I_{10} significantly gave the highest ($P \leq 0.01$) number of galls of (6.50) followed by I_{20} with (6.25) while I_0 recorded no galls. Similarly, I_0 significantly ($P \leq 0.05$) recorded the highest yield of (okra) 1314.64 kg ha^{-1} followed by I_{20} with 538.16 kg ha^{-1}. From this study, it can be concluded that larger variations in growth and yield variables of okra were found in response to M. incognita infection. Based on the result of the study, it is recommended that proactive and integrated management approaches are essential to sustainably address this nematode infestation and ensure the continued success of okra cultivation in affected regions.

Key words: nematode, inoculum, growth, okra, infected soils and yield

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench), is a crop that grows well in warm climates and is available in nearly every African market (Schipper, 2001). According to some scientists, the species may have evolved in Northern India, where *Abelmoschus tuberculatus,* a probable progenitor, is native. There is currently no evidence supporting the theory that the area of domestication is in Ethiopia or North Egypt, although some suggest otherwise based on the presence of *Abelmoschus ficulneus* and ancient agriculture in East Africa (Benjawan *et al.,* 2007). Okra is one of the most popular and widely used vegetable species in the Malvaceae family. It is an important food for humans since it contains proteins, lipids, carbohydrates, vitamins, and minerals. It is produced primarily for its immature pods which can be used in soups, stews, and salads or eaten boiled or fried and leaves, or consumed raw as a vegetable. The crop, *A. esculentus*, is referred to by a variety of regional names across the globe. According to Sorepong (2012), it is known as the Lady's finger in England, gambos in the United States, *guino-gombo* in Spanish, *guibeiro* in Portuguese, and *bhindi* in India. In Nigeria, okra is also referred to by such tribal names as *kubewa* in Hausa, *okuru* in Igbo, and *ila* in Yoruba.

In the vast savannah of Nigeria, increasing okra production via soil and agronomic management is of interest (Onah *et al.*, 2023; Obi *et al.*, 2024). Okra production is, however, affected by nematodes, and this can undermine the benefits due to improved production techniques. Nematodes are tiny, worm-like creatures that live in the soil. Though some are beneficial, many species are parasites onto plants, feeding on their roots and causing damage to mostly vegetables (Tileubayeva *et al.,* 2021). Their feeding on plants' roots can cause stunted growth, yellowing of leaves, and reduced yields. Nematodes are obligate parasites of the roots of thousands of plant species,

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and are found all over the planet. The population is growing rapidly, and so is the need for okra. This is because more people are becoming aware of how beneficial veggies are for providing their families with the nutrients they need (Hussain *et al.,* 2012).

Vegetables are important for protecting health and preventing diseases. They contain valuable nutrients that can be used to maintain and repair the body. Vegetable production has been increasing worldwide, as they remain a staple food in many countries. This is according to Ekunwe *et al.* (2017). One of the most widely planted crops in Nigeria after tomato and pepper is okra, but due to a number of related issues, including nematode-caused illness and insect pests, the output has been extremely poor (Food and Agricultural Organization, FAO, 2008). The microscopic parasitic nematodes known as *Meloidogyne incognita* species reside in the roots of infected plants. Nematodes with knotted roots thrive on suitable hosts. When nematode populations reach their peak in vulnerable plants, the plants die before they reach maturity (Hassan *et al.,* 2001). Numerous pests, such as root-knot nematodes, particularly *M. incognita*, damage okra and other vegetables (Haider *et al.,* 2003). According to Hussain *et al.* (2016), *M. incognita* stood out as one of the most prevalent groups of plant parasites. The *M. incognita* attacks over 300 plant species, causing significant harm and losses, including okra, which is more harmed by the nematode at greater infestation levels (Hussain *et al.,* 2012). In the light of these, the purpose of this study was to assess how *M. incognita* affects the growth and yield of okra in Jos North Local Government Area in Plateau State of North-Central Nigeria.

MATERIALS AND METHODS

Description of Study Area

Federal College of Forestry in Jos Plateau State, Nigeria, provided the screenhouse where the experiment was conducted. Jos is situated in the north-central region of Nigeria, and can located by latitude 9° 57' N and longitude 8° 54' E. With an average elevation of 1.250 m asl, an average annual temperature of about 22°C and a mean annual rainfall of 1260 mm, the environment is typically humid and tropical (University of Jos, Meteorological Station, 2020). The area is characterized by sandy-loam soil with a pH of 6.3 (Ntat *et al*., 2018).

Soil Collection and Preparation

Topsoil (0-15 cm depth) was collected from Federal College of Forestry Demonstration Farm. The soil collected was randomly cleared of all debris, thoroughly mixed, heat-sterilized and filled into large polyethylene bags, with each polyethylene containing 5.9 kg of soil. Each Polyethylene bag had a depth of 38 cm and a diameter of 27 cm. Thus, the soil was sterilized using heat treatment.

Source of Okra Seeds and Inoculum

The okra seeds (Clemsom spineless) were sourced from Plateau Agricultural Development Program (PADP) Jos North, Plateau State. Egg masses of *M. incognita* were obtained from the roots of infested tomato plants collected from local tomato farmers' farm and then cultured in the screen house of Federal College of Forestry Jos. The seeds of okra were sown into the pots at 2 seeds per pot and later thinned to 1 seedling after germination.

Inoculum Preparation and Inoculation

The tomato plants were carefully uprooted, washed with water, and taken to the laboratory for onward extraction of *M. incognita* egg masses. The roots were diced into smaller pieces and placed in an extraction dish. The egg masses were picked carefully into another Petri dish before inoculation.

Inoculation was done by applying the egg masses to the soil at 2 cm away from the plant by making a small circle around the plant 4 weeks after planting. The egg masses were applied as treatments in the following order: I_{10} = 10 egg masses, I_{20} = 20 egg masses, and I_{30} = 30 egg masses.

Experimental Design

Completely randomized designed (CRD) was used for the experiment. There were four inoculum levels of *Meloidogyne incognita* (I_0 control), $I_{10,}$ $I_{20,}$ and $I_{30,}$ which were replicated four times.

Data Collection

The following parameters were recorded: Plant height (cm) was recorded using a meter rule placed at the base of the plant to the apical tip of the plant. The reading was taken at two-week intervals for twelve weeks after inoculation (WAI). Branches were counted at 2WAI by counting the number of branches per treatment. Number of flowers was counted at 2WAI by counting the number of flowers per treatment. Total fruit yield: This was determined by weighting the fruits collected from the whole polythene bags and calculating the area of the whole bags used after which the following equation was used to extrapolate the yield;

$$\text{Yield (kg ha}^{-1}) = \frac{\text{weight of okra fruit} \times 10{,}000}{\text{area of polyethylene bag}}.$$

Root-knot/gall scoring

The formation of galls on okra plant was counted in the laboratory after harvesting the plant using the method as reviewed by Bridge *et al.* (1982). Then, the scoring was done on a scale of 0 to 10, thus; 0 - no knot on roots, 1 - small knots difficult to see, 2 - small knots only but clearly visible with main roots clean, 3 - few large knots visible but with main roots clean, 4 - large knots predominate but with main root clean, 5 - 50% of root knotted with the knotting on parts of main root system, 6 - knotting on some of main roots, 7 - majority of main roots knotted, 8 - all roots knotted with few clean roots visible, 9 - all roots severely knotted with plant usually dying, and 10 - all roots severely knotted with no root system and plant usually dead.

Data Analysis

The data collected was subjected to analysis of variance using Mini-Tab 17 statistical package. Treatment means were separated using Duncan Multiple Range Test at 5% level of probability.

RESULTS

Effect of *M. incognita* on Okra Plant Height

The plant height of okra as affected by different inoculum levels of *M. incognita* is presented in Table 1. The results showed that there were no significant differences ($p > 0.05$) in plant height of okra as a result of the differences in levels of *M. incognita* throughout the period under study. However, at 2 WAI, I_{10} recorded the highest plant height of 46.25 cm followed by I_0 having 44.30 cm, I_{30} having 39.00 cm and I_{20} had 36.52 cm. Also, at 4 WAI, I_{10} had the highest plant height value of 71.17 cm followed by I_0 with 66.87 cm, I_{30} with 60.00 cm and 1_{20} with 59.77 cm. Furthermore, at 6 WAI, I_{10} had the highest plant height of 89.55 cm followed by I_0 with height of 59.55 cm, while I_{20} had 79.75 cm and the least I_{30} had 72.87 cm. At 8WAI, I_0 had the highest plant height of 96.25 cm followed by I_{20} with 91.50 cm, I_{10} had 75.75 cm and I_{30} with 77.25 cm. At 10 WAI, I_0 has highest plant height of 100.05 cm and I_{10} with 99.00 cm while the lowest plant height I_{20} had 93.70 cm and I_{30} with 79.00 cm. The I_0 had the highest plant height of 105.53 cm (at 12 WAI) followed by I_0 with 104.12 cm and I_{20} with 97.52 cm while the least was I_{30} with 82.45 cm.

Effect of *M. incognita* on Branching of Okra

The effect of number of branches of okra to different inoculum levels of *Meloidogyne incognita* is presented in Table 2. Results showed that there were no significant ($p > 0.05$) differences in inoculum levels on Okra throughout the period under study. At 2 WAI, I_0 had the highest number of branches of 1.75 followed by I_{10} (1.25) while I_{20} and I_{30} recorded the lowest number of branches 1.00. Also, at 4 WAI, I_0 had 2.00 followed by I_{30}, I_{10} with 1.25 while I_{20} had the least value of 1.00. Similarly, at 6 WAI, I_0 had the highest number of branches 2.25 while I_{10}, I_{20}, and I_{30} had the lowest number of branches of 1.50. At 8WAI, I_{10} and I_{30} recorded the highest number of branches of 3.00 followed by I_{10} and I_{20} with 2.00 having the lowest number of branches. Also, at 10 WAI, I_{10} recorded the highest number of branches 3.50 followed by I_{30} with 3.25, I_{10} had 2.00 and the lowest number of branches was recorded in I_{20} with 1.50. Similarly, at 12 WAI I_0 recorded the highest number of branches with 4.00, I_{30} had 2.75, I_{10} had 2.00 and I_{20} with the lowest number of branches of 1.75.

Effect of *M. incognita* on Flowering of Okra

Number of flowers of okra as influenced by different inoculum level of *M. incognita* is presented in Table 3. The result reveals that there were no significant ($p > 0.05$) differences in inoculum levels on number of flowers for the period of research. However, a greater number of flowers were counted at 2 WAI for I_0 (3.50) followed by I_{10}, I_{20} with 2.75 each, while I_{30} had 2.50. At 4 WAI, I_{20} had 4.50, I_0 had 4.25, I_{30} had 4.00 and lowest number of flowers was recorded in I_{10} with 3.25. At 6 WAI, I_{20} had the highest number of flowers of 4.00 followed by I_0 with 3.50 while I_{30} recorded the lowest number of flowers of 2.25 and I_{10} with 2.00. The result also indicates that, at 8 WAI, significant difference was observed with I_{20} had the highest number of flowers of 3.00 followed by I_0 with 1.50 while I_{10} had the lowest number of flowers of 0.50 and I_{30} with 0.25. Similarly, at 10 WAI, I_0, I_{10}, I_{20} and I_{30} all recorded 1.50 respectively. The inoculation at 12 WAI, I_0 recorded the highest number of flowers of 0.75 followed by I_{10} with 0.50 while I_{30} had the lowest number of flowers of 0.25 and I_{20} with 0.00.

Table 1: Effect of *Meloidogyne incognita* on plant height of okra

Treatment	2WAI	4WAI	6WAI	8WAI	10WAI	12 WAI
Control (no inoculation), I_0	44.30	66.87	82.87	96.25	100.05	104.12
10 egg masses, I_{10}	46.25	71.17	89.55	75.75	99.00	105.53
20 egg masses, I_{20}	36.52	59.77	79.75	91.50	93.70	97.52
30 egg masses, I_{30}	39.00	60.00	72.87	77.25	79.00	82.45
SE±	9.00	15.38	18.76	22.86	18.50	18.71
P-value	0.99	0.85	0.84	0.76	0.66	0.60
LS	NS	NS	NS	NS	NS	NS

SE - standard error, $P > 0.05$, LS - level of significance. WAI - weeks after inoculation, NS - not significant.
Means within a column followed by different letter(s) are significant using DMRT method at 5% level of significance.

Table 2: Effect of *Meloidogyne incognita* on number of branches of okra

Treatment	2 WAI	4 WAI	6 WAI	8 WAI	10 WAI	12 WAI
Control (no inoculation), I_0	1.75	2.00	2.25	3.00	3.50	4.00
10 egg masses, I_{10}	1.25	1.25	1.50	2.00	2.00	2.00
20 egg masses, I_{20}	1.00	1.00	1.50	2.00	1.50	1.75
30 egg masses, I_{30}	1.00	1.25	1.50	3.00	3.25	2.75
SE±	0.38	0.48	0.57	0.12	1.24	1.49
P-value	0.22	0.23	0.48	0.74	0.35	0.46
LS	NS	NS	NS	NS	NS	NS

Abbreviations and explanations as in Table 1

Table 3: Effect of *Meloidogyne incognita* on number of flowers of okra

Treatment	2WAI	4WAI	6WAI	8WAI	10WAI	12 WAI
Control (no inoculation), I_0	3.50	4.25	3.50	1.50^{ab}	1.50	0.75
10 egg masses, I_{10}	2.25	3.25	2.00	0.50^{b}	1.50	0.50
20 egg masses, I_{20}	2.75	4.50	4.00	3.00^{a}	1.50	0.00
30 egg masses, I_{30}	2.50	4.00	2.25	0.25	1.50	0.25
SE±	0.25	0.83	0.76	1.07	1.50	0.43
P-value	0.77	0.49	0.60	0.04	1.00	0.38
LS	NS	NS	NS	*	NS	NS

SE - standard error, $P > 0.05$, LS - level of significance. WAI - weeks after inoculation, NS - not significant.
Means within a column followed by different letter(s) are significant using DMRT method at 5% level of significance.

Effect of Number of Galls of *M. incognita* on Okra

The results presented in Table 4 showed that there was high ($p \leq 0.01$) significant difference of inoculum levels on number of galls. The I_{10} recorded the highest number of galls of 6.50, followed by I_{20} having 6.25 galls, I_{30} with 6.00 galls, and I_0 with 0.00 which is the lowest.

Effect of *M. incognita* on Yield of Okra

Effect of *Meloidogyne incognita* on yield kg ha^{-1} of Okra is presented in Table 5. The result indicates that there were significant ($p < 0.05$) difference in inoculum levels on the yield of okra. Similarly, after harvest, I_0 recorded the heights yield value of 1314.64 kg ha^{-1} followed by I_{20} having 795.43 kg ha^{-1}, I_{30} recorded 646.41 kg ha^{-1} and I_{10} had the lowest yield value of 538.16 kg ha^{-1}.

DISCUSSION

There were no significant ($p < 0.05$) differences between inoculum levels on plant height, number of branches, number of flowers, throughout the period of the study. The result showed a decrease in growth characteristics of okra as a result of inoculation with *M. incognita*, indication that it has retarded the growth of okra. These findings are consistent with those of Karssen and Moens (2006), who found that the length of the plants decreased in nematode-infected plants. This was probably because of the damage from the increased cessation of water and nutrient intake. The initial density of nematodes in the soil directly affects the number of worms that infect plant roots, as well as the nematode populations and the consequent decrease in crop development and productivity. According to Singh and Khurma (2007), plants highly infested with root knot nematodes showed stunted development and poor production, and in some cases, the plants die before they reached maturity. These results corroborate the findings of Maleita *et al.* (2012). The presence of *M. incognita* in the soil interferes with the normal growth of okra plants. The nematode establishes a parasitic relationship with the okra roots, inducing the formation of characteristic root galls. These galls disrupt the normal root architecture, leading to reduced nutrient uptake and water absorption. Consequently, the plants exhibit stunted growth, chlorosis, and overall diminished vigor (Yaseen *et al.*, 2023).

Table 4: Effect of number of galls of *Meloidogyne incognita* on okra

Treatment	Number of Galls
Control (no inoculation), I_0	0.00^{d}
10 egg masses, I_{10}	6.50^{a}
20 egg masses, I_{20}	6.25^{b}
30 egg masses, I_{30}	6.00^{c}
SE±	1.44
P-value	0.002
LS	**

SE - Standard Error, **Significant at $p < 0.01$,
LS - level of significance. Means within a column followed by different letter(s) are significant by DMRT method at $p < 0.05$.

Table 5: Effect of *Meloidogyne incognita* on yield (kg ha^{-1}) of okra

Treatment	Yield (kg ha^{-1})
Control (no inoculation), I_0	1314.64^{a}
10 egg masses, I_{10}	538.16^{b}
20 egg masses, I_{20}	795.43^{b}
30 egg masses, I_{30}	646.41^{b}
SE±	202.78
P – value	0.01
LS	*

SE - Standard Error, *Significant at $p < 0.05$,
LS - level of significance. Means within a column followed by different letter(s) are significant by DMRT method at $p < 0.05$.

The result indicates a high significant ($p < 0.05$) differences between inoculums levels on number of galls after harvest during the period under study. The I_{20} gave the highest number of galls at the roots of okra plant. This reveals the number of nematodes (*M. incognito*) at the roots of the plant. The number of nematodes infecting roots is correlated with both the size and quantity of galls, according to Abdel-Momen *et al.* (1998) and Vovlas *et al.* (2005), although the inoculum concentration may not have as much of an impact at later stages of evaluation. Similarly, Haider *et al.* (2003) found that a considerable reduction in the growth characteristics of French beans and peas was generated by an inoculum level of 100 *M. incognita* per plant. Beyond physical damage, *M. incognita* influences the physiological processes within okra plants. The nematode induces stress responses, affecting hormone balance and nutrient transport systems (Hussain *et al.*, 2014). These disruptions contribute to the observed growth abnormalities and yield reduction. The weakened physiological state of the plants further makes them susceptible to secondary infections and environmental stressors.

However, there were significant ($p < 0.05$) differences between the non-inoculated plants and the inoculated ones, though not in okra yield rather decreased due to the inoculation. This shows that root damage caused by nematode entry and feeding impedes or disrupts the infected root systems' ability to absorb water (Di Vito *et al*., 2004). The female root knots disturb the xylem tissues and induce gall formation and large cells in the stellar region after entering the roots (Wyss, 2002) The upward absorption of nutrients and water is reduced as a result of widespread damage to xylem vessels. Permeability of roots to water is also impacted by the root-knot infection. According to Yaseen *et al.* (2023), the negative consequences of *M. incognita* infestation extend to the reproductive phase of okra plants, resulting in yield reductions. The compromised root system fails to support optimal flowering and fruit development. Also, nematode's interference with nutrient uptake adversely affects the quality and size of okra pods. This often leads to a lower number of marketable fruits and diminished overall crop productivity (Hussain *et al*., 2014).

CONCLUSION

It can be concluded that large variations in growth and yield variables in inoculum on okra were found in response to *M. incognita* infection. Increasing the Inoculum levels results in decrease growth and yield characteristics of okra. The *M. incognita* poses a substantial threat to okra cultivation by impeding both growth and yield. As a pervasive nematode, its impact is not limited to individual plants but extends to okra overall productivity. Proactive and integrated management approaches are essential to address this nematode infestation and ensure the continued success of okra cultivation in affected regions.

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