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EFFECT OF INOCULUM DENSITY OF *Meloidogyne incognita* ON THE GROWTH AND YIELD OF EGGPLANT (*Solanum* spp. L.) IN ZARIA, SUDAN SAVANNA OF NIGERIA

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ABSTRACT

This study was conducted in a screenhouse during the months of September/October, 2015 to investigate the effect of inoculum density of *Meloidogyne incognita* on the growth and yield of eggplant. The experiment was laid out in a completely randomized design with six treatments and replicated five times. The inoculum levels were: 0, 500, 1000, 2000, 4000 and 8000 eggs/juveniles of *M. incognita*. Three weeks old eggplant seedlings were inoculated three days after transplanting in 5 L plastic pots. Data were taken on plant height, plant girth, days to 50% flowering, fruit number/plant, fruit weight/plant, shoot and root weights (fresh and dry weights), root galls and nematode population in soil. The results showed that all the inoculum levels reduced the plant height, stem girth, flowering, fruit number, fruit weight and fresh and dry shoot and root weights with corresponding decrease in yield. This indicates that the lowest nematode population used (500 eggs/juveniles of *M. incognita*) is capable of reducing yield of the variety used. Hence other works can be done to screen more varieties of eggplant for proper recommendation.

Keywords: *Meloidogyne incognita*; Inoculum; Growth; Yield; *Solanum* spp.

INTRODUCTION

Eggplant (*Solanum* spp. L.) is a short-lived perennial herb that belongs to the family solanaceae. It is one of the most consumed fruit vegetables in tropical Africa; probably the fourth after tomato, onion and okra (Grubben and Denton, 2004). It grows best in warm climate. It has both nutritive and medicinal value. Hundred grams of edible part of eggplant contains carbohydrates 2.2 g, protein 1.8 g, fat 2.2 g, vitamin 520 mg, iron 0.9 mg, calcium 28 mg, water 92.4 ml, ash 1.3 g and carotene 850 mg (Meah, 2003). It ranked high amongst the economically important vegetables of the world. The production and economy of crops is affected in a variety of ways by plant-parasitic nematodes particularly in terms of quality and quantity. Various types of pests are responsible for low yield. The vegetables are attacked by many pests including root-knot nematodes especially *Meloidogyne incognita*. *M.*

incognita stands out as the dominant group of plant parasites. More than 300 plant species are attacked by *M. incognita* resulting in severe damage and losses (Hussain *et al*., 2012; Kayani *et al*., 2013). Instead of various control strategies (Kayani *et al.*, 2012; Mukhtar *et al.*, 2013; 2014), the nematode continues to damage eggplant at higher inoculum levels. Different symptoms are produced by root-knot nematodes like formation of root galls, stunted growth, and severe wilting with reduced uptake of water and nutrients and ultimately low yield from infected plants.

Root-knot nematodes survive well in appropriate hosts. Nematode populations increase to the maximum level in susceptible plants (Shurtleff and Averre, 2000) resulting in death before maturity (Singh and Khurma, 2007). Damage caused by the nematodes can be determined by measuring reductions in growth and yields of annual crops. In the present study, the effect of six inoculum levels of *M. incognita* was assessed on different growth and yield parameters of eggplant and the rate of multiplication of the nematode on the host.

MATERIALS AND METHODS

Study Area

The experiment was conducted during the months of September - October, 2015 at the Teaching and Research Screenhouse of the Department of Crop Protection; Ahmadu Bello University, Zaria located on latitude 11011N', longitude 7038'E and 686m above sea level in Northern Guinea Savannah Ecological Zone of Nigeria.

Soil Sample Collection and Sterilization

Top soil (0 – 15 cm) depth collected from a field close to Department of Crop Protection, Ahmadu Bello University, Zaria, was mixed with river sand in a ratio of 3:1) and then heat sterilized using half cut drum size with fire from firewood underneath the half drum size for 2 hours 30 minutes, by turning the moist heated soil at intervals of 20 minutes.

Raising of Seedlings

Eggplant species "Farin-Yalo" obtained from the National Horticultural Research Institute (NIHORT), Bagauda was raised in nursery trays (100 x 50 cm) quarter filled with sterilized soil in the screenhouse. Shallow furrow for timely emergence of seeds were made on soil surface in the trays. Eggplant seeds at distance of 3 cm were finely spread along furrows before it was lightly covered and mulched with dry grasses. This was watered every day as necessary for proper germination and seedling establishment.

Screenhouse Study

The experiment consisted of six treatments viz; 0, 500, 1000, 2000, 4000 and 8000 nematodes per pot. Each treatment was repeated five times. Uninoculated pot (i.e. zero) served as control. The pots were arranged in a Completely Randomized Design (CRD) on the screenhouse bench. Five kilograms of sterilized soil was weighed into 5 litre plastic pots of 15 cm diameter × 22 cm height, perforated at the base for drainage. Four weeks old eggplant seedlings were transplanted per pot, and watered when necessary. The seedlings were thinned to one per pot seven days after transplanting. The different population densities were prepared using sodium hypochlorite (NaOCl) method of Hussey and Barker (1973). Experiment was terminated 60 days after transplanting.

Data Collection and Analysis

Data collected were plant height (cm), stem girth (cm), fruit number/plant, fruit weight/plant, fresh and dry shoot and root weights (g). Nematode data collected includes nematode population in 500 cm^3 of soil and 10 g of roots and nematode extraction was done using modified sieving and decanting technique and maceration technique as described by Coyne *et al*. (2007). Number of galls was counted using Daykin and Hussey (1985) method. Root gall index was assessed using the scale of Taylor and Sasser (1978): 0 = No galls, 1 = 1 – 2 galls, 2 = 3 – 10 galls, 3 = 11 – 30 galls, 4 = 31 – 100 galls, 5 = > 100 galls. Data obtained were subjected to Analysis of Variance using SAS Program 8.1 (SAS, 2000). Means were separated using Student's Newman Keuls Test (SNK) at 5% level of significance ($P \leq 0.05$).

RESULTS

Inoculation of different population densities of *Meloidogyne incognita* showed that plant height of eggplant species was correspondingly reduced. At 1 and 2 weeks after inoculation (WAI), reduction in plant height was not significant ($P \leq 0.05$) at pre-plant population of 0, 500, 1000, 2000, 4000 and 8000 eggs/J2 of *M. incognita* (Table 1). However, at 3 to 8WAI, the height of these plants was significantly ($P \leq 0.05$) different at each of the initial population densities (Pi) (Table 1). Reduction in height of plants ranged from 15% at Pi of 500 nematodes to 48% at Pi of 8000 nematodes/5litre pot.

Table 1: Effect of Initial Population Densities of *Meloidogyne incognita* on Plant Height from 1 to 8 Weeks after Inoculation in Pot Culture in the Screenhouse at Samaru, 2015

	Plant height (cm)							
Pi	1WAI	2WAI	3WAI	4WAI	5WAI	6WAI	7WAI	8WAI
0 (control)	15.5	16.0	30.9a	39.0a	46.9a	50.9a	52.9a	55.3a
500	15.5	15.9	25.6b	33.0b	42.2b	45.9b	47.9b	50.9b
1000	15.5	16.0	22.3c	29.3c	37.2c	40.6c	42.6c	45.1c
2000	15.5	15.8	19.2d	24.0d	31.6d	33.9d	35.6d	40.6d
4000	15.5	16.0	17.7e	20.0e	23.2e	24.7e	26.7e	34.2e
8000	15.0	15.8	16.2f	18.8f	19.7f	22.2f	24.2f	27.7f
SNK ±	0.24	0.11	0.34	0.34	0.41	0.50	0.50	0.30

Means within the same column followed by the same letter(s) are not significantly different according to Student's Newman Keuls Test (SNK) at ($p \leq 0.05$), WAI = Weeks after inoculation; Pi = Initial nematode population density

Further analysis showed that reduction in height was more at earlier than at later stages of growth. For instance, plant height decreased by 15%, 10% and 8% at 4, 6 and 8 weeks respectively after inoculation with Pi of 500 nematodes per pot (Table 1). Corresponding values at Pi of 8000 nematodes per pot were 52%, 56% and 50% respectively. Similar observations were made for stem girth. It decreased from10% at Pi of 500 nematodes to 50%

at Pi of 8000 nematodes per pot. Decrease of 15%, 7% and 6% were recorded at 4, 6 and 8 WAI respectively at Pi of 500 nematodes compared to 62%, 50% and 50% at Pi of 8000 nematodes/5litre pot (Table 2).

Table 1: Effect of Initial Population Densities of *Meloidogyne incognita* on Plant girth from 1 to 8 Weeks after Inoculation in Pot Culture in the Screenhouse at Samaru, 2015

	Plant girth (cm)							
Pi	1WAI	2WAI	3WAI	4WAI	5WAI	6WAI	7WAI	8WAI
0 (control)	0.4a	0.8a	1.0a	1.3a	1.3a	1.4a	1.5a	1.6a
500	0.4	0.7a	0.9b	1.1b	1.1b	1.3b	1.3b	1.5b
1000	0.4	0.6b	0.8c	0.8c	0.9c	1.0c	1.2c	1.4c
2000	0.3	0.5b	0.7d	0.7d	0.8c	0.9d	1.1d	1.2d
4000	0.3	0.5b	0.6e	0.6e	0.7d	0.8e	0.8e	0.9e
8000	0.3	0.4c	0.5f	0.5f	0.5e	0.7f	0.7f	0.8f
SNK±	0.02	0.02	0.01	0.02	0.02	0.03	0.02	0.02

Means within the same column followed by the same letter(s) are not significantly different according to Student's Newman Keuls Test (SNK) at ($p \leq 0.05$), WAI = Weeks after inoculation; Pi = Initial nematode population density

Reduction in plant height was associated with a decline in shoot and root weight (Figure 1). There was statistical difference between the shoot and root weight of the control plants and that of plants grown in soil inoculated with 500 nematodes/5litre pots. The reduction in shoot weight caused at 500 nematodes per pot were quite similar to those caused at 1000 nematodes per pot showing that there is no significant difference in these two levels and similar trend is followed at 2000 and 4000 nematodes per pot except for 8000 nematodes which gave significantly the lowest shoot weight. Significant difference was observed in the root between the control and the lowest Pi. However, the root weight of plants inoculated with the lowest pre-plant nematode population (500/5litre pot) was significantly lower than that of the control plants. Initial population density of 1000 to 8000 reduced both plant height and root weight significantly when compared with the control. Decrease in shoot weight range from 26% to 80% while that of root weight ranged from 25 to 82% at Pi of 500 to 8000 nematodes/5litre pot.

Figure 2 and 4 showed that increasing nematode population densities significantly increases both root galls and nematode population after harvest. It was observed that the nematode caused damage to the roots of the eggplant at all levels of the inoculum tested (from 500 juveniles/5 litre pot to 8000 nematodes/5 litre pot). The plants inoculated with the lowest pre-plant nematode population of 500 juveniles/5 litre pot, has the lowest population density of *M. incognita* while plants inoculated with initial nematode population density of 8000 nematodes/5 litre pot has the highest. Significant increases in number of galls were also observed at all inoculum levels. Highest galls were produced at population level of 8000 nematodes/pot followed by 4000, 2000 and 1000 while the lowest galls were recorded in plants inoculated with 500 nematodes/pot. Root galls, root gall index and subsequent reproduction within the root by the nematode increased with increasing initial population density (Figures 2, 3 and 4).

Increase in root galls with increasing initial population density was accompanied by increase in multiplication of the nematode as it can be seen from the final nematode population density (Figures 2 and 4). Reproduction increased at a declining rate as the initial population density of the nematode increased. Percentage increase in reproduction was 42%

at initial population density of 500 nematodes/5litre pot, whereas its reproduction increased by 50%, 52%, 41% and 8% at Pi of 1000, 2000, 4000 and 8000 nematodes respectively.

There was substantial decrease in the number of fruits and fruits weights at pre-plant population density of 500 nematodes/5litre pot to 8000 nematodes/5litre pot (Figure 5 and 6). Percentage decrease in fruits weights was 43.3%, 71.7%, 85.2%, 95.6% and 95.6% at Pi of 500, 1000, 2000, 4000 and 8000 nematodes respectively. Similar trend was observed in number of fruits.

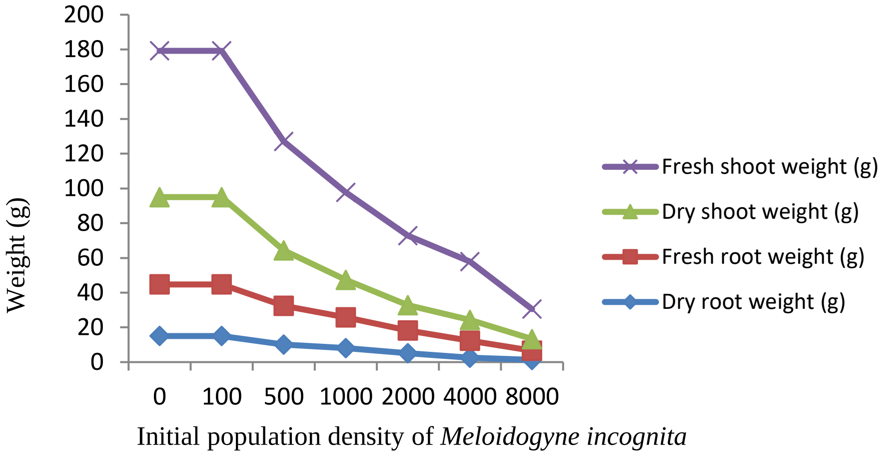

Figure 1: Effect of initial population densities of *Meloidogyne incognita* on fresh and dry weight of eggplant “Farin-Yalo” (*Solanum* spp. L.) at harvest

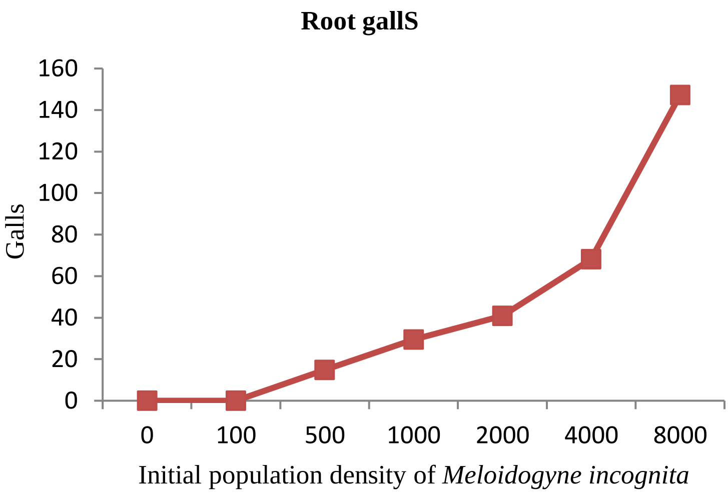

Figure 2: Effect of initial population densities of *Meloidogyne incognita* on root galls of eggplant “Farin-Yalo” (*Solanum* spp. L.) at harvest.

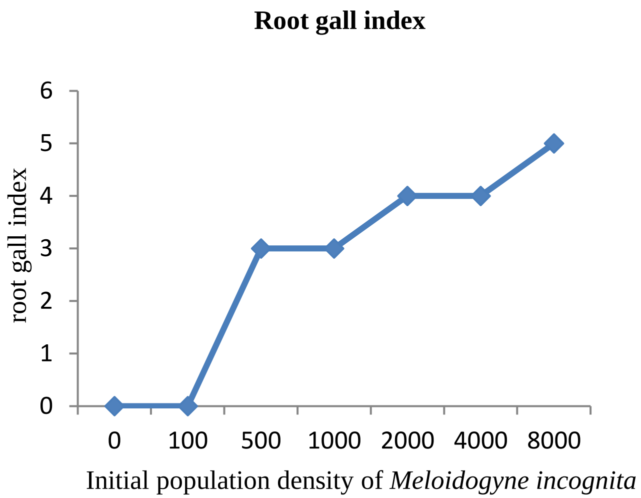

Figure 3: Effect of initial population densities of *Meloidogyne incognita* on root gall index of eggplant “Farin-Yalo” (*Solanum* spp. L.) at harvest.

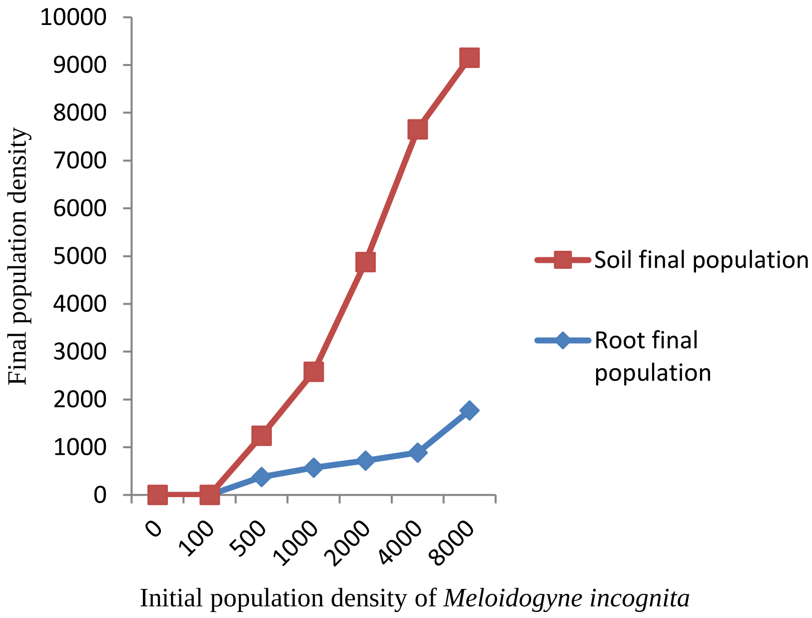

Figure 4: Effect of initial population densities of *Meloidogyne incognita* on soil and root final population densities at harvest.

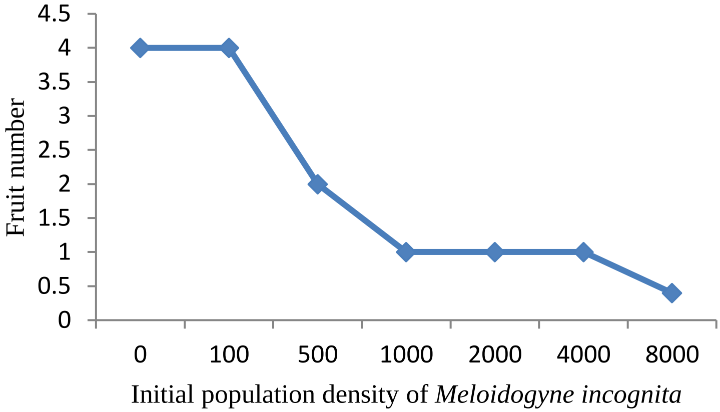

Figure 5: Effect of initial population densities of *Meloidogyne incognita* on fruit number of eggplant “Farin-Yalo” (*Solanum* spp. L.) at harvest.

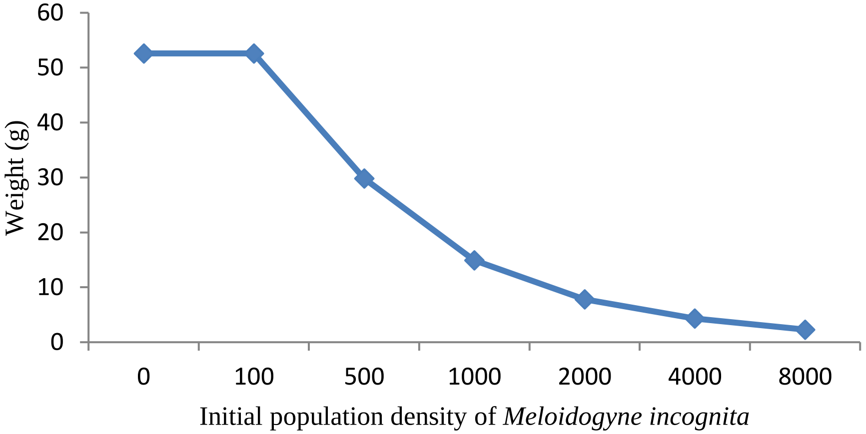

Figure 6: Effect of initial population densities of *Meloidogyne incognita* on fruit weight of eggplant “Farin-Yalo” (*Solanum* spp. L.) at harvest.

DISCUSSION

Results of this study in pot culture on effect of initial population density of *Meloidogyne incognita* on the eggplant spp. “Farin-Yalo”, show that plant growth (shown by plant height, stem girth, shoot weight and root weight) and yield (number of fruits and fruits weights) were significantly reduced at all the populations tested (500 to 8000 nematodes per pot). This implied that nematode populations of *M. incognita* as low as 500 are capable of causing significant ($p<0.05$) damage on eggplant. This agrees with the report of Kankam (2014) who reported damaging population levels of *M. incognita* on tomato in Ghana to be between 500 and 2000 nematodes per litre of soil. Similarly, Chindo and Khan (1988) and

Chindo *et al*. (1997) reported damaging populations of *M. incognita* on tomato to be between 1000 – 2000 nematodes/litre of soil and 500 to 2000 for *Pratylenchus brachyurus* on maize in northern Nigeria.

Nematode multiplication was found to decrease with increasing initial population density of *M. incognita*. This might be due to the destruction of root system by the parasitism of root-knot nematode which led to competition for food and infection sites among the developing and invasive nematodes within the root system (Ogunfowora, 1977; Chindo and Khan, 1988; Khan *et al*., 2004). The high rate of multiplication at low levels of inocula, on the other hand, could possibly be due to the positive factors like abundance of food, lack of competition and the ability of host to generate adventitious root (Chindo and Khan, 1988; Khan *et al*., 2004). According to Oostenbrink (1966), the increase in the nematode populations and the subsequent reduction in the yield of crops are directly influenced by the initial density of the nematodes in the soil. His view holds true with the present findings where in plant growth was proportionately affected with increase in the number of galls and final nematode population. The progressive decrease in plant growth and nematode multiplication with the increasing inoculum of root-knot nematode on different crops has also been reported by (Khan *et al*., 2004; Khan and Ashraf, 2006; Khan *et al*., 2006).

There was also substantial decrease in the number of fruits and fruit weights at pre-plant population density of 500 nematodes/5litre pot to 8000 nematodes/5litre pot. This may have resulted from responses to nematode infection; hence number of fruits and fruits weights were probably delayed and/or decreased due to nutritional inadequacies. The result of this study confirms the findings by Nwode *et al*. (2014) who found that two tomato varieties had delayed and/or decreased fruiting due to responses to *M. incognita*. Similarly, Nwanguma *et al*. (2013) in South-western Nigeria found that eight pepper cultivars had delayed and/or decreased fruiting due to *M. incognita* infection.

The damage level in this experiment was 500 eggs/plant as this is the level at which significant damage was obtained in the eggplant growths and yield parameters (shown by percentage reduction in plant height, stem girth, shoot and root weights, fruit number and fruit weight/plant). This means that in fields where initial population density of *M. incognita* are approaching to these levels, measures like chemical or integrated control have to be applied.

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