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Pathogenicity of root-knot nematode (*Meloidogyne incognita*) on sweet potato (*Ipomoea batatas* L.)

O.S. Osunlola[1*], B. Fawole[2]

[1]*Department of Crop Production, Kwara State University, Kwara State, Nigeria*

[2]*Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria*

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Abstract

Root-knot nematode, *Meloidogyne incognita*, is a major biotic factor militating against sweet potato production. The pathogenicity of *M. incognita* on three sweet potato cultivars: Kayode, TIS 4400-2 and TIS 70357-OP-1-79 was investigated in a screen house experiment at the Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria. A vine cutting of each cultivar was planted in a 16 litre polyethylene pot containing 15 litre steam-sterilized sandy loam soil. Three weeks after planting, the seedlings were inoculated separately at four inoculum densities: 0, 30,000, 60,000 and 90,000 eggs of *M. incognita* using a 3 x 4 factorial experiment replicated four times in a randomized complete block design. Data were collected on fresh shoot weight, fresh root weight, dry shoot weight, dry root weight, galling index, tuber yield, tuber quality and nematode reproduction. All data were analyzed using ANOVA ($p<0.05$). *M. incognita* significantly ($p<0.05$) reduced the fresh shoot weight by 16.3-23.6%, fresh root weight by 28.3-62.3%, number of tubers by 63.2-69.2% and tuber yield by 72.3-83.2%. The gall index and the final nematode population increased with increase in inoculum density. The result showed that *M incognita* caused growth, yield and quality reduction in sweet potato; therefore, management of root-knot nematode should be part of sweet potato production efforts especially in areas where the nematode is endemic.

* **Corresponding Author:** O.S. Osunlola ✉ remiosunlola@gmail.com

Introduction

Sweetpotato is a dicotyledous plant that belongs to the family Convolvulaceae.. It originated from Central America and the North Western part of South America from where it was introduced to Europe by Columbus and to Asia, Africa and North America by Spanish and Portuguese explorers and traders (Onwueme and Charles, 1994). Currently, sweetpotato is grown throughout the tropical and sub-tropical world and in the warmer parts of the temperate countries and it forms an important part of the diet of these communities (Lenne, 1991). It is cultivated for its large, starchy, and sweet tasting tuberous roots. In addition, the young leaves and shoots are sometimes consumed as a vegetable (Woolfe, 1992; Odebode, 2008). Sweetpotato tubers are rich in carbohydrates, vitamins A and C, thiamine, niacin, riboflavin and also contains significant amounts of calcium and iron (Onwueme and Charles, 1994).

The increased consumption of sweetpotato is one important strategy for preventing vitamin A deficiency, especially among women and children (Odebode, 2008). It is consumed boiled, baked, roasted, or fried. Fresh tubers may also be fed directly to livestock or processed into flour which may be added to wheat flour for bread making (Onwueme and Charles, 1994; Odebode, 2008). Other processed products from sweetpotato include starch, alcohol, syrups, acetone, pectin, acetic acid, dyes, noodles, candy, desserts, and jam (Chivinge, *et al.*, 2000; Odebode, 2008).

Losses caused by plant-parasitic nematodes to sweetpotato production around the world were estimated to 10.7% in 1987 causing losses of at least 2.6 billion US dollars (Sasser and Freckman, 1987). The root-knot nematodes (*Meloidogyne* spp*)* are considered to be the most important nematode in the production of sweetpotato (Oversweet, 2009). Root-knot nematode symptoms on sweetpotato include round to spindled shaped swellings (galls) on fibrous roots and cracks on fleshy storage roots (Lawrence *et al.*, 1986). *M. incognita* has been implicated in yield reduction of sweetpotato by earlier workers. Gapasin and Validez (1979) reported a yield loss of 47.7% while Theberge (1985) recorded a yield reduction of 20- 30 % in his study. In the Philippines, losses of 50% have been recorded but it could lead to a total loss with three continuous cultivation in *M. incognita*-infested soil (Gapasin, 1984; 1986).In North Carolina,root-knot nematode was reported to cause yield loss of 6% in 1991. Information on effects of nematode on sweetpotato is very rare or scanty in Nigeria, therefore, this study was undertaken to evaluate the effect of *M. incognita* on the growth, yield and quality of sweetpotato cultivars commonly grown in Nigeria.

Materials and methods

Planting and inoculation of sweetpotato seedlings

Three *Meloidogyne incognita* - susceptible cultivars of sweetpotato namely: Kayode, TIS 70357–0P-1-79 and TIS 4400-2 obtained from the Department of Agronomy, University of Ibadan were used for this study. The *M. incognita* eggs that served as inoculum were extracted from roots of three- month old *M incognita*-galled *Celosia argentea* using 0.5% sodium hypochlorite method (Hussey and Barker, 1973). A 30cm long vine cutting of each cultivar was planted in a 16 l polyethylene bag containing 15 litres of steam – sterilized sandy loam soil.Three weeks after the establishment of sweetpotato seedlings, they were inoculated at 0, 30,000, 60,000 or 90,000 eggs/plant (or 0, 2, 4, or 6 egg per ml of soil) by pipeting the desired number of eggs in water into four holes each about 4cm deep made at the base of the plants. Ordinary water was introduced into the holes for 0 eggs (control). After inoculation, the holes were covered with sterilized sandy-loam soil. The experiment was a 3 x 4 factorial (three cultivars of sweetpotato and four levels of inoculum) arranged in four randomized complete blocks on the roof top garden of the Department of Crop Protection and Environmental Biology, University of Ibadan. Each treatment was replicated four times.

Data collection

The plants were watered daily throughout the period

of study. At harvest, data were collected on fresh shoot weight and degree of galling using the galling index (GI) on a scale of 0-5 (Fawole and Osunlola,1999) where 0 = no gall;1 = 1-20% of the root system galled; 2 = 21-40% of the root system galled; 3 = 41-60% of the root system galled; 4 = 61-80% of the root system galled; and 5 = 81-100% of the root system galled. Data on weights of tubers, number of tubers, and quality of tubers, fresh root weight and the root and soil nematode populations were also taken. The soil nematode population was determined from 250 ml soil sample obtained from each pot after mixing, using the extraction tray method (Whitehead & Hemming, 1965). For the root population, eggs were extracted from the root system of each plant using the sodium hypochlorite method (Hussey and Barker, 1973). After this, the roots and shoots were each put in well-labeled envelopes and transferred into an oven set at a temperature of 80°C for 48 hours. Data were then taken on dry root and shoot weights. The experiment carried out twice without any modifications.

Data analysis

All data were processed with ANOVA using the Statistical Analysis Systems (SAS, 1999) and the means were partitioned using the Least Significant Difference (LSD) at a probability level of 5%.

Results

The mean gall index differed significantly ($P < 0.05$) at different inoculum densities. Plants inoculated with 90,000 nematode eggs with mean gall index (3.3) followed by those inoculated with 60,000 eggs (2.9) were significantly higher than those inoculated with 30,000 eggs (2.3) and control (0.0). The trend was the same for both trials (Table 1). The highest gall index was recorded on CV TIS 4400 – 2 (2.4) followed by CV Kayode (2.1) and then CV TIS -70357 OP-1-79 (1.8) in the first trial (Table 2).

Table 1. Effect of *M.incognita* populations on growth parameters of sweetpotato.

Treatment	Gall index	Fresh shoot weight (g)	Dry shoot Weight (g)	Fresh Root Weight(g	Dry root weight (g)	Tuber yield (g)	Tuber number	Tuber quality*	Final nematode population	RF+
First trial (2003)										
Control	0.0	193.9	37.5	116.4	21.3	62.5	1.9	0.0	0.0	0.0
30,000 eggs	2.3	189.6	32.4	84.0	12.2	38.3	1.0	0.9	123833.3	4.1
60,000eggs	2.9	179.5	29.1	69.9	7.8	26.3	0.8	1.3	252116.7	4.2
90,000eggs	3.3	162.4	24.1	43.9	6.0	17.3	0.7	1.3	269283.3	2.9
LSD (P≤0.05)	0.4	7.6	2.5	21.1	5.4	31.9	0.9	1.1	86207	1.4
Second trial (2004)										
Control	0.0	305.3	59.4	106.6	14.4	55.4	1.3	0.0	0.0	0.0
30,000eggs	2.0	273.0	47.4	93.4	10.8	29.1	0.8	1.0	60975.0	2.0
60,000eggs	2.9	263.3	43.4	88.6	8.3	17.5	0.6	1.0	109337.0	1.8
90,000eggs	3.3	233.4	37.5	76.5	7.7	9.3	0.4	1.6	123900.0	1.4
LSD(P≤0.05)	0.4	38.0	8.3	19.7	4.7	29.7	0.8	1.1	41728.0	0.9

*0=Completely smooth tubers/no cracks; 1=1-20% of the tubers skin rough/cracked; 2=21-40% of the tubers skin rough/cracked; 3=41-60% of the tuber skin rough/cracked; 4=61-80% of the tuber skin rough/cracked; and 5=81-100% of the tuber skin rough/cracked.

Each value is a mean of four replicates.

+RF= Reproductin factor.

The mean fresh and dry shoot weights and the fresh and dry root weights also differed significantly ($P < 0.05$) at different inoculun densities for both trials. The lowest significant mean values for these parameters were recorded from plants inoculated with the highest inoculum density (90000 eggs) followed by the plants infected with 60000 eggs while the uninoculated plants (control) had the highest mean values.

The least mean values for sweetpotato yield, number of tubers and tuber quality were recorded from plants

infected with 90,000 eggs followed by plants recorded for plants inoculated with 60,000 eggs, while the highest significant values came from uninfected plants. The highest mean yield was recorded for cultivar Kayode which was not significantly higher than values from other cultivars in both trials.

The mean final nematode population and nematode reproductive factor also differed significantly from each other. The highest mean final nematode population was recorded in plants inoculated with 90,000 eggs and this did not differ ($P < 0.05$) from the value recorded in plants infected with 60,000 eggs in the two trials. The lowest significant mean value was obtained from control plants (Table 1). For the reproductive factor, the highest mean value came from the plants inoculated with 60000eggs in the first trial and from plants that received30000 in the second trial. The lowest value was recorded in control plants for both trials (Table 1) The mean final nematode population recorded in the cultivars differed significantly from each other. The highest mean nematode population (282975 was obtained from CV TIS 4400-2) in the first trial. In the second trial, CV Kayode produced the highest significant mean final nematode population (115890) while the lowest value came from CV 70357-OP-1-79 in both trials (Table 2). The highest mean significant mean reproductive factor came from CV TIS 4400-2 in the first trial, in the second trial however, CV Kayode produced the highest significant reproductive factor. The least value was recorded from CV 70357-0-OP-1-79 in both trials (Table 1).

Table 1. Effects of *M.incognita* inoculation on growth parameters of various sweetpotato cultivars.

Cultivars	Gall index	Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)	Tuber yield (g)	Tuber number	Tuber quality*	Final nematode population	RF+
First trial (2003)	h									
TIS 4400-2	2.4	187.9	28.7	58.0	11.7	32.7	0.9	0.6	28295	4.9
TIS 70357	1.8	168.9	29.6	111.5	11.7	33.0	1.0	0.9	65475	1.2
Kayode	2.1	187.1	34.1	66.1	12.1	42.6	1.4	1.1	135475	2.4
LSD(P≤0.05)	0.4	6.6	2.2	18.3	4.7	25.7	0.8	1.0	74657.0	0.8
Second trial (2004)										
TIS 4400-2	2.4	275.1	46.0	61.3	5.9	26.5	0.8	0.8	58231	1.1
TIS 70357	1.8	311.0	54.6	123.1	13.2	27.9	0.8	0.9	46538	0.9
Kayode	1.9	220.5	40.1	89.4	11.7	29.0	0.8	1.1	115890	1.9
LSD(P≤0.05)	0.4	32.9	7.2	17.1	4.1	25.7	0.7	0.9	36137	0.84

*0= Completely smooth tubers/ no cracks;1=1-20% of the tubers skin rough/cracked; 2=21-40% of the tubers skin rough/cracked; 3=41-60% of the tuber skin rough/cracked; 4=61-80% of the tuber skin rough/cracked; and 5=81-100% of the tuber skin rough/cracked.

Each value is a mean of four replicates.

+RF= Reproduction factor.

Discussion

The result of this investigation indicates that the pathogenic effects of *M. incognita* on sweetpotato increased with increase in the initial nematode population density. The reduction of mean shoot and root weights by root- knot nematodes observed in this work is similar to the findings of Gapasin (1980) who reported stunting and reduction of root and top weights of cassava as the *M. incognita* population levels increased. Reduction in root and top weights were different at the 10,000 and 20,000 eggs over the control. Sasanelli *et al.* (1992) found out that cabbage plants attacked by *M. incognita* showed stunting and yellowing within two weeks of infestation. They also reported that top and root weight of the plants were greatly affected by the nematode. Walters and Barker (1993) reported that *Rotylenchulus reniformis* restricted storage root growth and increased the root necrosis on 'Beauregard' sweetpotato .Ononuju and Fawole (1999) found out that *M. incognita* race 2

infection of two banana cultivars (Fagamou and Paranta) led to reduction in pseudostem height, pseudostem girth , number of developing suckers and emerging leaves as nematode population increased. Gergon *et al.* (2002) also observed reduction in plant height, leaf dry weight and root length with increase in the inoculum densities of *M. graminicola* in yellow granex bulb onion The growth of tomato and pepper were also reported to be curtailed by *M. incognita* which reduced the fresh weight of both crops (Mekete *et al.*, 2003). The tuber yield reduction of 72.3-83.2% recorded in this study agrees with the report of other workers (Gapasin and Validez 1979 ; Gapasin, 1984; 1986).

Reduced top growth could be due to root destruction by root-knot nematode and utilization of nutrients and related resources by the galled roots to the detriment of the tops. This might have resulted from poor absorption of water and mineral salts leading to a decreased growth rate. Taylor and Sasser (1978) found infection with *Meloidogyne* to cause an increased protein synthesis in galls and the consequent disruption of growth regulators and other compounds between roots and stems and these result in profound disturbance of top growth. Also there is a reduction in the photosynthetic rates of plants due to nematode infection and this contributed to reduction in growth rates (Loveys and Birds, 1973; Wallace, 1974).

This study also revealed that galling indices increased with increase in inoculum density. This is similar to the findings of earlier workers who reported that root-knot gall index increased exponentially with increase in initial population levels of *Meloidogyne* spp. on various crops (Okorocha and Ezeigbo, 1992; Zahid *et al.* 2001; Mekete *et al.*, 2003). This means the higher the initial nematode population, the higher the level of root damage of sweetpotato. The high reproductive rate of *M. incognita* and degrees of root damage (galls or knots) exhibited by *M. incognita* on sweetpotato indicates the suitability of sweetpotato as a host for this nematode. It further indicates that severe damage could occur if the crop is grown in field infested by the nematode. The ability of *M. incognita* to suppress the growth and yield of sweetpotato under controlled conditions emphasizes the potential importance of the nematode on the crop.

A nematode management programme is therefore essential to reduce pre- plant nematode population in an infested soil as its high potential fecundity will permit population densities to reach an economic threshold and lead to great damage. Awareness should be created among farmers about root- knot nematode and its damage potentials to crops. There are several options available for a viable nematode management and these include: chemical method, use of resistant cultivars, biological control, cultural method etc. a suitable method of control should be formulated which may incorporate two or more compatible measures which should be effective, environmentally safe and economical to farmers.

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