African Crop Science Conference Proceedings, Vol. 11. pp. 293 - 296
Printed in Uganda.
ISSN 1023-070X/2013 $ 4.00

Effect of root knot nematodes on the growth of indigenous leafy vegetables in Kenya

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Abstract African indigenous leafy vegetables play an important role as income and food security crops in many rural and urban households in Kenya. However, root knot nematodes (RKN) constrain the production causing yield losses of 80 to 100 % on some of the vegetables depending on susceptibility and levels of inocula in the soil. The objective of this study was to investigate the effect of root knot nematodes on the growth of popular indigenous leafy vegetables. A green house experiment was conducted twice, where six indigenous leafy vegetables namely spider plant (*Cleome gynandra*), amaranth (*Amaranth hybridus*), black night shade (*Solanum nigrum*), cowpea (*Vigna unguiculata*), jute mallow (*Corchorus spp*) and sun hemp (*Crotalaria juncea*) were tested. The vegetables were planted in pots with sterilized soils. Half of the pots were infested with 2000 second stage juveniles of root knot nematodes. During growth, plant height data was taken every fortnight and on termination at 60 days after planting, data on galling index, egg mass index and the second stage juvenile counts was recorded. Root galling was estimated on a scale of 1-10, where 1 = resistant and 10 = most susceptible. The egg mass index was estimated on a scale of 1-5 and the juveniles count made from the roots. Galling index (GI), egg mass index and the juvenile (J2) counts differed significantly ($p<0.05$) among the vegetables tested. Amaranth had the least GI (1.7) and egg mass index (1.0) while black night shade had the highest GI (7.0), egg mass index (3.7) and the highest counts of juveniles. Spider plant, sun hemp and amaranth were rated as resistant while jute mallow, cow pea and black night shade were rated as susceptible. The identified resistant varieties can be used as rotation crops in agricultural production systems as a component of root knot nematode suppression in the soil.

Key words: *Amaranth hybridus*, *Crotolaria* spp., juveniles, root-knot nematodes, *Solanum nigrum*, susceptibility, resistance

Introduction

Indigenous leafy vegetables (ILVs) play an important role as income and food security crops in many rural and urban households in Kenya (IPGRI, 2004). However, the potential in alleviating poverty and ensuring household food and nutrition security has not been exploited. Besides being used as food, ILVs also provide income for farmers. The demand for ILVs supersedes the supply. The ILVs can alleviate hidden hunger and malnutrition among the resource poor communities. The indigenous vegetables leaves and seeds provide vitamins A and C, calcium, iron, proteins, carbohydrates and lipids (Abukutsa-Onyango, 2003). According to Khalpesh *et al.* (2008) ILVs have health benefits such as being antioxidants, anti-carcinogenic, analgesic and having immunomodulatory properties. Consumers and growers prefer indigenous leafy vegetables to other vegetables because they are adapted to low-input agriculture, are readily available, have a short maturity period and have a high potential for yield per unit area (Mbugua *et al.,* 2005). Knowledge on the effects of root knot nematodes on the growth of indigenous leafy vegetables is scanty. Research on ILVs, in Kenya, has concentrated on nutrient chemical composition neglecting biotic constraints in production especially nematodes of economic importance. Identification of resistant indigenous leafy varieties would contribute greatly to the management of the pests in the cropping systems. Therefore, the objective of this study was to assess the effect of root knot nematodes on growth of indigenous leafy vegetables.

Materials and methods

Greenhouse screening of ILVs and parameters measured
The experiments were carried at the College of Agriculture and Veterinary Sciences. Extraction using the modified Baermann technique (Hooper *et al*., 2005) and preparation of nematode inoculum used to inoculate the ILVs was carried out at the Plant pathology laboratories. The nematode innoculum consisted of the eggs and second stage juveniles (J2).The selected (ILVs) used in the experiments were sun hemp (*Crotolaria spp*), jute mallow (*Cochrus* spp), amaranth (*Amaranth hybridus*), cow peas (*Vigna unguiculata*), spider plant (*Cleome gynandra*) and black nightshade (*Solanum nigrum*). The ILVs were established in pots and artificial inoculation of nematodes was done in half of the pots with the growing plants. The first inoculation with 2000 J2 juveniles per pot was done ten days after planting and was repeated two weeks later after the first inoculation. Sixty days after transplanting the experiment was terminated .The soil and root samples were taken from the rhizosphere of the plants in each pot by gently removing the soil. Both roots and soil samples were placed in labeled polythene sample bags and transported to the laboratory in a cool box where the samples were stored at 10^{o}C before nematode bioassays were conducted. The roots were carefully and gently washed with tap water and blotted dry. The galling index

rating was assessed using a chart illustrated by Coyne *et al.* (2007) on a scale of 1 -10 where 1 indicated no galling and 10 indicated severe galling. After assessing the galling index the root knot nematodes juveniles (J2) were extracted by use of the modified Baermann technique (Hooper *et al*., 2005) to identify and count the nematodes. The egg mass index was also assessed on a scale of 1-5. Galling index, egg mass index and the juveniles in the soil samples from each plant were used to rate nematode infestation and levels of infestation for the selected six indigenous leafy vegetables to root knot nematodes. These parameters were used to determine the plants susceptible or resistant to root knot nematodes.

Data analysis. Data on J2 counts was log transformed before being subjected to analysis of variance (ANOVA) using Genstat computer software package (Lawes Agricultural Trust Rothamsted Experimental Station 2006, version 9). Analysis of variance was conducted to compare the parameters obtained from the selected six ILV species to determine the most susceptible species to RKNs. Significance of differences between treatments was measured by *T*-test, while the treatment means were compared using Fisher's protected least significant difference (LSD) at p=0.05.

Results

The African leafy vegetable species inoculated with root knot nematodes formed galls of variable sizes. The galling index, egg mass index and juvenile stage two populations differed significantly (P<0.05) among treatments (Table 1). The highest galling index rating was observed in black nightshade at an average of 7.0 followed by jute mallow (6.7), cowpea (6.3), spider plant (3.0), sunhemp (2.0) and amaranth (1.7) . Black night shade, cowpeas and jutemallow had the highest egg mass indices with mean of 3.7 each. The least egg mass index was recorded in amaranth (1) (Table 1).

The three crops, black night shade, cowpea and jute mallow also had high nematode log transformed counts with mean averages of 8.85, 8.42 and 8.42, respectively (Table 1). The least root knot nematode population was recorded in sun hemp at 6.03 and did not differ significantly from 6.45 that was recorded in amaranth (Table 1). The spider plant and sun hemp recorded relatively low rating for galling, egg mass indexes and root knot nematode population recovered from the soils around the root area (Table 2). The most resistant plant species to root knot nematodes under greenhouse condition was amaranth with mean galling index of 1.5, egg mass index of 1.0 and second stage juvenile population log transformed mean of 6.49 in both seasons. (Table 1 and 2). Egg and galling indices and second-stage juvenile numbers were comparable in amaranth and sun hemp while the black night shade had the highest egg mass, galling indices and second-stage juvenile populations.

Discussion

This study has demonstrated that the indigenous leafy vegetables tested had a varied reaction to root knot nematodes. Amaranth was the most resistant to the root knot nematodes and could be cultivated in areas where the pathogenic nematodes are endemic. This would ensure sustainable food, income and nutrition security among rural and urban households. The black night shade can be used as a susceptible control in experiements evaluating for resistance to the root knot nematodes. Stunted growth, reduced plant height and vigour in the inoculated vegetables were associated with root knot nematode infestation. These results compare to those of Mcsorley *et al.* (2004), who reported suppressed plant growth on crops that host root knot nematode. The presence of galls on the roots of susceptible varieties such as the cow pea and black night shade was responsible for stunted growth and wilting of the plants. Galls on the plant roots interfere with nutrients and water absorption leading to discoloration of the leaves displaying symptoms that resemble those of nutrient deficiencies (Atkins *et al.,* 2004).

The high egg and galling mass indices observed in black nightshade, cowpea and jute mallow implied that these crops were more susceptible to root knot nematodes compared to amaranth, spider plant and sun hemp. Similar

Table 1. Galling index, egg masses and number of Juveniles observed in the soil and the plant roots for nematode inoculated crop species under greenhouse conditions in season one.

Crop variety	Egg mass index (1-5)	Galling index (1-10)	J2 /200cm3 (log_2X)	Reaction
Amaranth (*Amaranth hybridus*)	1.0	1.7	6.45	Resistant
Cowpeas (*Vigna unguiculata*)	3.7	6.3	8.42	Susceptible
Sun hemp (*Crotalaria juncea*)	1.7	2	6.03	Resistant
Jute mallow (*Corchorus spp.)*	3.67	6.7	8.42	Susceptible
Spider plant (*Cleome gynandra*)	1.7	3	6.78	Resistant
Black nightshade (*Solanum nigrum)*	3.7	7	8.85	Susceptible
[1]LSD value (P<0.05)	0.92	0.79	0.27	
Significance level	*	*	*	
[2]C v %	19.8	9.8	2	

[1]Least significance difference [2]coefficient of variation, *significance difference (p<0.05).
Galling index score (1-10) where 1-3 = resistant and > 3= susceptible, Egg masses count in the plant roots score of 1-5 where 1 = resistant and 5= susceptible, J2-Second stage juveniles populations recovered from the soil in 200cm^3, Log-Logarithm.

Table 2. Galling index, egg masses and number of Juveniles observed in the soil and the plant roots for nematode inoculated crop species under greenhouse conditions season two.

Crop species	Egg mass index	Galling index	J2/200cm^3 (log_2X)	Reaction
Amaranth (*Amaranth hybridus*)	1.0	1.3	6.54	Resistant
Cowpeas (*Vigna unguiculata*)	3.7	7	8.49	Susceptible
Sun hemp (*Crotalaria juncea*)	1.0	1.7	6.02	Resistant
Jute mallow (*Corchorus spp.)*	3.7	6.3	8.38	Susceptible
Spider plant (*Cleome gynandra*)	1.7	2.7	6.92	Resistant
Black nightshade (*Solanum nigrum)*	3.7	7.7	8.78	Susceptible
[1]LSD value (p<0.05)	0.79	0.92	0.26	
Significance level	*	*	*	
[2]C v %	17.8	11.4	1.9	

[1] Least significance difference, [2]coefficient of variation, *significance difference (p<0.05)
Galling index score (1-10) where 1-3 = resistant and > 3= susceptible, Egg masses count in the plant roots score of 1-5 where 1 = resistant and 5= susceptible,J2-Second stage juveniles populations recovered from the soil in 200cm^3, Log-Logarithm.

Figure 1a. Root mass for Amaranth with with the least galls (Most tolerant).

Figure 1b. Root mass for black nightshade with the least galls (Most tolerant).

results were reported by Nchore *et al*. (2011), on the incidence and prevalence of root knot nematodes in indigenous leafy vegetables. The authors reported that black night shade (*Solanum* spp*)* was the most susceptible and frequently attacked by root knot nematodes compared to spider plant (*Cleome* spp) and amaranths (*Amaranthus* spp*)*.

Conclusion and recommendation

This study showed a varied reaction to root knot nematode infestation by the different indigenous leafy vegetables. Amaranth, sun hemp and spider plant were resistant to root knot nematode infestation while black night shade, cowpea and jute mallow were susceptible. Root knot infestation caused galls, deformed roots, yellowing and wilting of plants leading to low biomass yield required for consumption. Knowledge generated in this study can support development of effective strategies for root knot nematode management for increased ILVs productivity.

Acknowledgement

University of Nairobi is acknowledged for the facilities and the logistical and institutional support.

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