



VARIABILITY OF HOST DAMAGE AND RESPONSE OF SOME COWPEA BREEDING LINES TO ROOT-KNOT NEMATODES, *Meloidogyne* spp.

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ABSTRACT

Field and screen house studies were conducted at the International Institute of Tropical Agriculture (IITA) Research Farms, Minjibir, Kano State and farmer's plot, Ringim, Jigawa State in Sudan Savannah Agro-ecological Zone, North-Western, Nigeria to investigate the reaction of ten cowpea breeding lines to infestation of *Meloidogyne* spp. Seven-day old seedlings were inoculated with 0 or 5000 eggs of *Meloidogyne* spp. The experiment was a 2 x 10 factorial, fitted into Randomized Complete Block Design laid out in the fields while the screen house trial laid in Completely Randomized Design. In each location, treatments were replicated four times. Data were collected on plant height, stem girth, root galls, number of days 50% to flowering, pods/plant and seeds/pod. Data obtained were subjected to Analysis of Variance. Statistically variable treatment means were separated using standard error of means at 5% level of probability. Results showed that *Meloidogyne* spp. induced stunting which results in poor growth and in severe cases affects the time of maturity on susceptible cowpea plants. Hence, highly nematode infested soil should be treated before sowing in order to ensure high qualitative harvest.

Key words: Cowpea, *Meloidogyne* spp., plant height, stem girth.

INTRODUCTION

Cowpea {*Vigna unguiculata* (L.) Walp} is a food and fodder legume of significant economic importance worldwide, especially in semi-arid regions of Africa. Cowpea was cultivated in an estimated area of 12.52 million hectares with an annual production of 5.59 million tonnes of dry grains worldwide (FAOSTAT, 2014). Nigeria, with grain production estimated at 2.14 metric tonnes on 3.7 million ha (FAOSTAT, 2014), reviewed the largest producer of cowpea in the world.

Cowpea is an important grain legume in the savannas of West Africa providing a relatively cheap source of vegetable protein to the urban and rural poor, as well as mineral and protein rich fodder for livestock feeding and cash to the farmers. Cowpea is an essential component of cropping systems in the drier regions of the tropics and subtropics (Singh *et al.*, 2003) and is important to the livelihood of millions of people (Quin, 1997). As a legume, cowpea can contribute to soil fertility, mainly through its nitrogen fixing abilities. Its residue is an important fodder resource for ruminant livestock (Tarawali *et al.*, 1997) and provides an inexpensive and nutritious food for human consumption (Quin, 1997).

Plant-parasitic nematodes are microscopic worms that live in the soil and feed on the roots of plants or in other plant parts such as tubers, leaves, buds, flowers or seeds. Nematode damage limited the root system, which leads to reduced rate of uptake of nutrients and water (Anwar and Din, 1986). Impaired water relations appear to contribute substantially to reduced rates of top growth. This is probably because the developing giant cell systems and disruption of the developing xylem, which interferes with translocation of food and water to foliage (Davis *et al.*, 2003;

Anwar and Van Gundy, 1993). Symptoms of infection are presence of root galls, excessive branching of roots, and reduced root systems. Poor germination, death of seedlings and yield loss may be observed in cases of heavy infestations (Mishra, 1992).

Root-knot nematode, *Meloidogyne* spp. was first observed in Nigeria on cowpea in 1958 and documented in 1960 (Anon., 1961). Olowe (2009) reported a yield reduction of 10 to 65 %, similarly, a cowpea grain yield loss of 69 % caused by root-knot nematode was also reported by Babatola and Omotade (1991). The aim of this research is to study the host responses of ten cowpea breeding lines infestation with root-knot nematode.

MATERIALS AND METHODS

Experimental Design Set up: The experiments were conducted in the fields and screenhouse during the 2012 dry season cropping period. Field experiments were conducted at the IITA Research Farms, Minjibir, Kano State and farmer's plot at Ringim, Jigawa State and later evaluated in the screenhouse. On the field, a 10x2 factorial experiment, fitted into randomized complete block design with four replications was laid out. Twenty treatments were replicated four times making 80 plots in each location. Each plot was 1.2 m x 1.8 m (2.16 m²) with space of 0.5 m between the plots in a column and 1.0 m between the rows.

The screenhouse experiment was carried out in the screenhouse at IITA Kano station (Latitude 11° 58' N and Longitude 8° 33' E). Twenty treatments were replicated four times in completely randomized design (CRD). Sandy-loam top soil was used as planting medium because of its good tilth, good structure and moderate soil moisture.

The soil was steamed and sterilized manually (by heating the soil in a drum) for 2 hours. The soil was then allowed to cool for 20 minutes before transferring in to jute sac where it was allowed to settle for six weeks. Prior to planting, samples from the sterilized soil were tested for presence of nematodes using Whitehead and Hemming's (1965) method and no live nematode was found.

Preparation and calibration of Inoculum: Eggs of *Meloidogyne* spp. were extracted from the roots of garden egg (*Solanum gilo*) that is highly susceptible to root-knot nematodes from farmer's plot (Netscher and Sikora, 1990) using 0.52 % a.i. sodium hypochlorite (NaOCl) method of Hussey and Barker (1973). The plants were lifted gently from farmers' field in the study areas and washed under gentle stream of cool tap water in the laboratory. The roots were chopped in to 1-2 cm pieces and poured in to 1liter conical flask containing 0.52 % a.i NaOCl solution prepared from commercial bleach as follows using the formula of Theodore *et al.* (2009). The conical flask was corked tightly then manually and vigorously shaken for four minutes to dissolve the gelatinous egg matrices. The suspension now containing free eggs was poured over 200-mesh sieve nested upon 500-mesh sieve. The 500-mesh sieve containing the eggs was rinsed gently under cool gentle stream of tap water to remove the residual bleach. The mesh was thereafter rinsed in to a beaker to collect the eggs. The suspension was adjusted to 150 ml volume and the number of eggs per ml was estimated with the aid of Doncaster (1962) counting dish under a stereomicroscope.

Inoculation of Cowpea seedlings: At seven days after germination, cowpea seedlings were inoculated with 0 or approximately 5,000 eggs of root-knot nematode (*Meloidogyne* spp.) by pipetting the eggs in to the holes around the base of the plant and filling the holes with moist soil. Seedlings with 0 inoculations served as control.

Data collection and Analysis: At four, six and eight weeks after inoculation (WAI) data were collected on plant height using measuring tape and stem girth using thread and ruler. Also, data on number of days to 50 % flowering was collected. At maturity, data were also collected on number of pods/plant and number of seeds/pod. The data collected were subjected to analysis of variance (ANOVA) and treatment means were separated using standard error of means (SEM) at 5 % level of probability.

RESULTS

It was observed that there were significant differences between cowpea lines inoculated with different levels of *Meloidogyne* spp. eggs (Tables 1-3). Plant height and stem girth in the uninoculated plants were significantly higher ($p = 0.05$) than the inoculated ones for all the breeding lines except IT84S-2246-4. Plants heights were significantly affected mostly at 6 and 8WAI in the fields at both locations while some breeding lines were only affected at 8WAI.

Table 1 showed that the difference in plant height of IT07K-141 was significant ($p = 0.05$) at 4, 6 and 8WAI. While the differences in plant height of IT06K-

111 and IT06K-116 were statistically significant ($p = 0.05$) at 6 and 8WAI. However, the differences in plant height of all the cowpea lines were not statistically significant ($p = 0.05$) at 4WAI. The difference in plant height of IT89KD-288, IT07K-244-1-1 and IT07K-240-1-4 were statistically significant ($p = 0.05$) at 8WAI only, but not significant at 4 and 6WAI. The differences in plant height of other cowpea breeding lines were not statistically significant ($p = 0.05$) throughout the period of the assessment. The differences in stem girth of IT89KD-288 and IT07K-141 were statistically significant ($p = 0.05$) at 6 and 8WAI while the stem girth of IT06K-116 and IT07K-293-3 were statistically significant ($p = 0.05$) at 8WAI only. At 4WAI, the differences of stem girth of the 10 cowpea breeding lines between inoculated and uninoculated were not statistically significant ($p = 0.05$).

Table 2 shows the effects of *Meloidogyne* spp. on plant height. At Ringim, the difference in plant height between inoculated and uninoculated cowpea breeding lines in IT89KD-288, IT07K-293-3, IT07K-220-1-9 and IT07K-188-4-4-1 were statistically significant ($p = 0.05$) between 4, 6 and 8WAI, but only significant between 6 and 8WAI in IT07K-141, IT06K-111 and IT06K-116. The table also showed that the differences in plant height in IT07K-240-1-4 and IT07K-244-1-1 were significant ($p = 0.05$) at 8WAI only. The results also showed that the difference in plant height at Minjibir, between inoculated and uninoculated of IT07K-141, IT07K-244-1-1, IT06K-111, IT84S-2246-4, IT07K-220-1-9 and IT07K-188-4-4-1 were significant at 8WAI only. However, the results showed that there was significant difference in plant height in IT07K-240-1-4, IT06K-116 and IT07K-293-3 at 6 and 8WAI while IT89KD-288 was found significant at 4, 6 and 8WAI.

The result in table 3 revealed that the difference in mean stem girth at Minjibir, between inoculated and un-inoculated IT89KD-288, IT07K141 and IT07K-240-1-4 were statistically significant ($p = 0.05$) from 4 through 8WAI. Also, the difference in stem girth in lines IT07K-188-4-4-1, IT06K-111 and IT06K-116 were found significant ($p = 0.05$) at 6 and 8WAI while IT07K-244-1-1, IT07K-293-3 and IT07K-220-1-9 were significant ($p = 0.05$) only at 8WAI. The difference in stem girth at Ringim as a result of root-knot nematodes were statistically significant ($p = 0.05$) in IT07K-244-1-1 and IT07K-293-3 at 4, 6 and 8WAI but only significant between 6 and 8WAI in IT06K-111, IT06K-116 and IT07K-188-4-4-1 while the differences were significant in IT89KD-288, IT07K-141 and IT07K-240-1-4 at 8WAI. There was no significant difference in stem girth in IT84S-2246-4 and IT07K-220-1-9 due to root-knot nematodes inoculation.

Table 4 showed that there was a highly significant difference ($p < 0.01$) between locations and parameters meaning that parameters (plant height, stem girth, days to 50 % flowering, number of seeds/pod and number of pods/plant) have performed differently in the fields and greenhouse. Similar significant differences ($p < 0.01$) were recorded between treatments and parameters (treatments performed differently in relations with parameters) except for seed/pod which was not significant.

Also, the interaction between locations by treatments with parameters was found to be highly significant ($p < 0.01$) except for seed/pod which was significant at 5 % level of probability.

Moreover, days to 50 % flowering were higher in inoculated susceptible cowpea breeding lines in the presence of *Meloidogyne* spp. as shown in table 5. The results revealed that there were significant ($p = 0.05$) differences between inoculated and uninoculated in number of days to 50 % flowering in all the cowpea lines except IT84S-2246-4, IT07K-240-1-4, IT07K-293-3 and IT07K-188-4-4 at Ringim. Days to 50 % flowering were significantly ($p = 0.05$)

affected by activities of *Meloidogyne* spp. in IT89KD-288, IT07K-240-1-4, IT06K-111, IT06K-116, IT07K-220-1-9 and IT07K-188-4-4 at Minjibir. Also, There were significant ($p = 0.05$) differences in number of days to 50 % flowering in all the cowpea lines screened except IT84S-2246-4, IT07K-240-1-4, IT07K-293-3 and IT07K-188-4-4 in the greenhouse. However, high difference in number of days to 50 % flowering (-6.0) were recorded in IT07K-220-1-9 at Ringim and Minjibir while IT89KD-288 and IT07K-141 had high difference in number of days to 50 % flowering (-10.0 and -8.0) respectively in the greenhouse.

Table 1. Effect of *Meloidogyne* spp. on plant height and stem girth of ten cowpea lines in a screenhouse.

Cowpea Lines	Inoculum Level	Mean Plant height (cm)			Mean Stem girth (cm)		
		4WAI	6WAI	8WAI	4WAI	6WAI	8WAI
IT89KD-288	0	17.0	17.7	23.4	1.5	1.7	1.9
	5000	16.8	17.2	18.0	1.4	1.5	1.7
	Diff	0.2	0.5	5.4*	0.1	0.2*	0.2*
IT07K-141	0	19.7	27.4	31.9	1.6	1.9	2.8
	5000	12.2	15.8	16.7	1.6	1.6	2.3
	Diff	7.5*	11.6*	15.2*	0.0	0.3*	5.0*
IT07K-240	0	20.3	24.7	37.4	1.5	1.7	2.4
	5000	19.3	24.9	38.4	1.5	1.8	2.6
	Diff	1.0	-0.2	-1.0*	0.0	-0.1	-0.2
IT07K-244-1-1	0	20.9	25.7	51.7	1.6	1.8	2.2
	5000	21.0	27.4	56.0	1.4	1.7	2.3
	Diff	-0.1	-1.5	-4.3*	0.1	0.1	0.1
IT06K-111	0	14.5	19.0	34.4	1.3	1.6	2.0
	5000	16.6	24.2	51.4	1.3	1.5	2.0
	Diff	-2.1	-5.2*	-17.0*	0.0	0.1	0.0
IT06K-116	0	16.4	21.7	30.3	1.3	1.4	1.9
	5000	14.6	17.1	22.8	1.3	1.3	1.4
	Diff	1.8	4.60*	7.50*	0.0	0.1	0.5*
IT07K-293-3	0	19.5	24.1	36.9	1.3	1.6	1.9
	5000	20.9	26.2	37.2	1.4	1.7	2.3
	Diff	-1.40	-1.9	-0.3	-0.1	-0.1	-0.4*
IT84S-2246-4	0	17.2	22.2	36.5	1.5	1.5	2.5
	5000	18.2	24.2	36.6	1.4	1.6	2.5
	Diff	-1.0	-2.0	-0.1	-0.1	-0.1	0.0
IT07K220-1-9	0	19.3	24.9	41.7	1.4	1.6	2.2
	5000	18.0	22.8	40.3	1.3	1.5	2.3
	Diff	1.3	2.1	0.4	0.1	0.1	-0.1
IT07K-188-4-	0	19.6	24.6	40.6	1.4	1.7	2.1
	5000	17.4	21.0	40.3	1.4	1.6	2.1
	Diff	2.20	3.6	0.3	0.0	0.1	0.0
SEM(±)		2.69	4.50	0.43	0.11	0.16	0.27
CV (%) ^a		12.8	14.98	23.87	7.48	8.25	11.46

Each value is a mean of four replicates.

SEM= Standard error of means, CV = coefficient of variation, Diff. = Difference between inoculated and uninoculated WAI = weeks after inoculation, *= significant ($p = 0.05$)

Table 2. Effect of *Meloidogyne* spp. on plant height of ten cowpea lines evaluated in the fields.

Cowpea Lines	Inoculum Level	Ringim			Minjibir		
		Mean Plant height (cm)			Mean plant height (cm)		
		4WAI	6WAI	8WAI	4WAI	6WAI	8WAI
IT89KD-288	0	16.7	18.2	22.9	8.2	8.4	8.5
	5000	15.0	15	13.9	7.7	7.6	7.5
	Diff	1.7*	3.2*	9.0*	0.5*	0.8*	1.0*
IT07K-141	0	13.8	15.5	16.9	7.8	8.0	8.3
	5000	14.0	14.1	13.1	7.6	7.9	7.7
	Diff	-0.2	1.4*	3.8*	0.2	0.1	0.6*
IT07K-240	0	12.9	13.6	14.5	6.7	7.0	7.5
	5000	12.8	13.1	12.4	6.5	6.4	6.4
	Diff	0.1	0.5	2.1*	0.2	0.6*	0.9*
IT07K-244-1-1	0	13.8	14.5	15.6	6.5	6.9	7.5
	5000	14.0	13.9	13.2	6.7	6.7	6.6
	Diff	-0.2	0.6	2.4*	0.2	0.2	0.9*
IT06K-111	0	13.6	14.8	16.3	7.4	7.6	8.1
	5000	12.8	13.0	12.0	7.5	7.5	7.4
	Diff	0.8	1.8*	4.3*	0.1	0.1	0.7*
IT06K-116	0	15.6	17.0	18.1	5.5	6.1	6.8
	5000	14.7	14.1	13.0	5.4	5.2	5.1
	Diff	0.9	2.9*	5.1*	0.1	0.9*	1.7*
IT07K-293-3	0	14.4	15.0	16.1	6.2	6.7	7.5
	5000	13.4	13.0	12.4	6.0	6.1	5.9
	Diff	1.0*	2.0*	3.7*	0.2	0.6*	1.6*
IT84S-2246-4	0	13.8	14.7	15.9	5.0	5.7	6.5
	5000	13.3	14.5	16.5	4.8	5.3	5.9
	Diff	0.5	0.2	-0.6	0.2	0.4	0.6*
IT07K220-1-9	0	13.5	14.2	15.4	7.8	8.0	8.3
	5000	12.5	12.3	12.2	7.4	7.5	7.4
	Diff	1.0*	1.9*	3.2*	0.4	0.5	0.9*
IT07K-188-4-4-	0	14.7	15.6	17.3	6.3	7.0	7.8
	5000	13.4	13.2	12.9	6.3	6.5	6.3
	Diff	1.3*	2.4*	4.4*	0.0	0.5	1.5*
SEM (±)		0.95	0.97	1.13	0.50	0.54	0.56
CV(%) ^a		5.98	5.96	6.54	6.69	6.93	6.99

Each value is a mean of four replicates.

SEM= Standard error of means CV = coefficient of variation WAI = weeks after inoculation * = significant (p = 0.05) Diff. = Difference in plant height between inoculated and uninoculated.

Table 3. Effect of *Meloidogyne* spp. on stem girth of ten cowpea lines in the fields.

Cowpea lines	Inoculum level	Minjibir Mean stem girth (cm)			Ringim Mean Stem girth(cm)		
		4WAI	6WAI	8WAI	4WAI	6WAI	8WAI
IT89KD-288	0	1.6	1.6	1.7	1.5	1.6	0.8
	5000	1.6	1.6	1.4	1.3	1.4	1.2
	Diff	0.0	0.0	0.3*	0.2*	0.2*	-0.4*
IT07K-141	0	1.2	1.2	1.3	1.3	1.3	1.4.
	5000	1.1	1.1	1.0	1.1	1.1	0.9
	Diff	0.1	0.1	0.2*	0.2*	0.2*	0.5*
IT07K-240	0	1.5	1.6	1.8	1.4	1.3	1.4
	5000	1.3	1.4	1.3	1.2	1.1	1.0
	Diff	0.3*	0.2*	0.5*	0.2*	0.2*	0.4*
IT07K-244-1-1	0	1.4	1.6	1.7	1.1	1.2	1.4
	5000	1.2	1.2	1.1	1.1	1.1	0.9
	Diff	0.2*	0.4*	0.6*	0.0	0.1	0.5*
IT06K-111	0	1.3	1.4	1.5	1.1	1.3	1.4
	5000	1.2	1.2	1.1	1.0	1.1	0.9
	Diff	0.1	0.2*	0.4*	0.1	0.2*	0.5*
IT06K-116	0	1.0	1.2	1.4	1.0	1.2	1.4
	5000	1.1	1.0	0.9	1.1	0.9	0.8
	Diff	0.1	0.2*	0.5*	-0.1	0.3*	0.5*
IT07K-293-3	0	1.4	1.4	1.5	1.3	1.4	1.6
	5000	1.2	1.1	1.0	1.3	1.3	1.2
	Diff	0.2*	0.3*	0.4*	0.0	0.1	0.4*
IT84S-2246-4	0	1.2	1.3	1.5	1.2	1.3	1.5
	5000	1.2	1.4	1.6	1.2	1.4	1.6
	Diff	0.0	-0.1	-0.1	0.0	0.1	0.1
IT07K220-1-9	0	1.0	1.1	1.4	1.1	1.1	1.4
	5000	1.0	1.0	1.3	1.0	1.0	0.9
	Diff	0.0	0.1	0.1	0.1	0.1	0.5*
IT07K-188-4-4	0	1.1	1.2	1.3	1.1	1.3	1.3
	5000	1.0	1.0	0.9	1.0	1.0	0.9
	Diff	0.1	0.2*	0.4*	0.1	0.3*	0.4*
SEM (±)		0.11	0.11	0.16	0.11	0.11	0.11
CV (%) ^a		6.29	8.71	9.15	9.41	8.96	8.79

Each value is a mean of four replicates.

SEM= Standard error of means CV = coefficient of variation WAI= weeks after inoculation * = significant (p = 0.05) Diff. =Difference in stem girth between inoculated and uninoculated.

Table 4: Mean squares from analyses of variance of effect of *Meloidogyne* spp. on plant height stem girth, days to 50% flowering, number of pods per plant, number of seeds per pod and root galls.

Sources of variation	Df	Parameters					
		Plant height	Stem girth	Days to 50% flw	Pods/plant	Seeds/pod.	Galls
Loc. (L)	2	21323.53**	22.90**	114.82**	2086.08**	12.72NS	86.72**
Loc × Rep	9	15.7	0.40	12.05	84.31	3.81	5.71
Treatment (T)	19	103.36**	0.49**	1006.28**	744.43**	77.31**	25.93**
L × T	38	141.90**	0.20**	25.79**	143.64**	3.96*	3.37**
L×T×R	171	28.67	0.03	3.89	23.50	2.34	0.63

Df = degree of freedom, Loc = Location, Rep = Replication, Flw = flowering

Ns = not significant, * = significant at 0.05 level of probability and ** = significant at 0.01 level of probability

Table 5 Effect of *Meloidogyne* spp. infection on mean days to 50 % flowering of ten cowpea breeding lines evaluated in a field at Ringim, Minjibir and Screenhouse.

Cowpea Lines	Inoculum Level	Ringim			Minjibir			Screenhouse		
IT89KD-288	0		65		65		49			
	5000		69		68		59			
	Diff		-4.0*		-3.0*		-10*			
IT07K-141	0		73		73		63			
	5000		75		75		71			
	Diff		-2.0		-2.0		-8.0*			
IT07K-240	0		53		53		53			
	5000		56		57		55			
	Diff		-3.0*		-4.0*		-2.0			
IT07K-244-1-1	0		52		52		52			
	5000		53		53		53			
	Diff		-1.0		-1.0		-1.0*			
IT06K-111	0		41		41		41			
	5000		46		45		45			
	Diff		-5.0*		-4.0*		-4.0*			
IT06K-116	0		47		47		47			
	5000		50		50		50			
	Diff		-3.0*		-3.0*		-3.0*			
IT07K-293-3	0		42		42		42			
	5000		44		44		44			
	Diff		-2.0		-2.0		-2.0			
IT84S-2246-4	0		47		47		48			
	5000		47		47		47			
	Diff		0.0		0.0		1.0			
IT07K220-1-9	0		50		50		50			
	5000		56		56		55			
	Diff		-6.0*		-6.0*		-5.0*			
IT07K-188-4-4-	0		43		43		43			
	5000		46		46		45			
	Diff		-3.0*		-3.0*		-2.0			
SEM (±)			2.07		2.07		2.50			
CV (%) ^a			3.47		3.47		4.36			

Each value is a mean of four replicates.

SEM= Standard error of means, CV = coefficient of variation *=significant (P= 0.05) Diff. = Difference between inoculated and uninoculated.

DISCUSSION

Meloidogyne spp. reproduced in all the cowpea line evaluated except IT84S-2246-4 and successfully induced root galls and egg masses on roots of susceptible cowpea plants. The resistance response of IT84-2246-4 to *Meloidogyne* spp, in all the experiments showed an increase in growth parameters than the susceptible breeding lines. Plant height and stem girth were significantly affected by *Meloidogyne* spp. as indicated by control (uninoculated) plants. This suggests that eggs inoculum was viable. The uninoculated (control) plants gave significantly better vegetative growth than their inoculated counterparts.

For all the cowpea breeding lines inoculated with eggs of *Meloidogyne* spp, there was a decrease in plant height and stem girth. Inoculum led to reductions in growth parameters. Cowpea plants inoculated with *Meloidogyne* spp. showed a decrease in growth parameters than the uninoculated. This was most likely due to damage caused by the increasing number of nematodes that invaded plant roots, probably causing reduced nutrient and water uptake (Karssen and Moens, 2006). The decreasing agronomic parameters (plant height and stem girth) recorded for the susceptible cowpea was probably a result of stunting action of the root-knot nematodes. This is conformity with finding of Ezigbo (1973) reported that *Meloidogyne* spp. induced stunting which results in poor growth and in severe cases premature death in cowpea, a decline in quality and yield of the crop and reduced resistance to other stresses. Moreover, according to (Hussey, 1989), an increase in stem diameter was due to the uptake and transportation of water and nutrients which are dependent on the health of the roots. Gommers *et al.* (1991) also reported that increase in stem diameter was due to the translocation of water and nutrients to the shoots. The uninoculated (control) plants gave significantly better vegetative growth than their inoculated counterparts. According to (Eisenback *et al.* 1991), heavily diseased plants do not respond to water, this is because the nematodes have severely damaged the conducting tissues of the plant at the roots. As a consequence, stem diameter and top growth is reduced. The reduction in stem girth can cause a significant yield loss which is similar to the finding of (Robert, 1987 and Sikora and Fernandez, 1990) reported that flow of water and nutrients in to the plants is greatly influenced due to reduction in stem girth. Powell, (1971); Anwar and Din, (1986); and Khan *et al.*, (2000) reported that in addition to

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nematode infestation reduction in stem girth causes disturbance in nutrients up take and leads to nutrient deficiency.

The control (uninoculated) plants started flowering earlier than the inoculated. Early flowering is very important because it affects the time of maturity and harvesting of plants. The number of days for 50% to flower when compared between inoculated and uninoculated shows that Shorter generation time suggests more susceptibility while longer generation time which translated to low gall index is a reflection of low root-knot nematode infection and damage as recorded in IT84S-2246-4. This therefore accounts for its enhanced root development and ability to tap nutrient from the soil to carry out normal physiological functions.

CONCLUSION

This result shows that *Meloidogyne* spp. induced stunting which results in poor growth and in severe cases affects the time of maturity and harvesting of cowpea in all the ten cowpea breeding lines except IT84S-2246-4.

Recommendations: It is therefore recommended that (i) soils be screened for the presence / level of root-knot nematode, prior to planting of cowpea (ii) highly nematode infested soil be treated before sowing in order to ensure high qualitative harvest.

Contribution of Authors: This research article is part of the first author's Master's Degree Dissertation. He, therefore, carried out the field layout of the experimental design, sterilized the soil for greenhouse experiment, sowing of seeds, management of plots, nematode assay, data collection at both fields and greenhouse, data analyses and report writing. The second author supervised the research activities from planning to completion. He guided preparation of the manuscript and edited the report.

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