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Research Article

Relationship between Root-Knot Nematode *Meloidogyne javanica* Inoculum Densities and Ginger (*Zingiber officinale* Roscoe)

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Abstract: This study examined the relationship between six different root – knot nematode *Meloidogyne javanica* inoculum densities 0, 500, 1000, 2000, 4000 and 8000 eggs/plant and two varieties of ginger (*Zingiber officinale* Roscoe), UG1 and Himachal Pradesh. The greenhouse work was setup in complete randomized design of two ginger varieties, six root – knot nematode densities, in five replications raised for six months in 1,000cc of manured and sterilized soils bagged in about 2 litres –sized black polythene planting bags and planted with one rhizome/bag with nematodes inoculated at four weeks after planting. The results of the study indicated that M. *javanica* caused damage to the ginger at all density levels they were applied and below – ground growth values were significantly different from controls and the highest symptoms were obtained from plants treated with 8,000 nematode egg/plant. Also, top growth remained at a high level in spite of increased galling of the roots. Himachal Pradesh had significantly higher yield but significantly lower stem weight than UG1 and more damage symptoms confirming it to be more highly susceptible to *Meloidogyne javanica* infection than UG1. In addition, significant interaction between nematode density and variety was obtained on the damage symptoms on the ginger. The economic threshold level in this experiment was 1000eggs/plant as this is the level at which significant damage was obtained in the ginger roots.
Keywords: Root – knot, Nematode, *Meloidogyne javanica*, *Zingiber officinale*.

INTRODUCTION

The level of ginger *Zingiber officinale* Rosc. production in Nigeria is generally low compared to other export crops and the main production constrains are unavailability of improved varieties, low soil fertility and effects of pests and diseases [1-5]. With the introduction of new varieties from India, from where it is believed to have originated, ginger production and research in Nigeria have greatly increased in the recent times [4-6]. However, research recommendations in Nigeria in the area of pests and diseases of ginger are minimal and reports of pest damage on the crop especially of the most widely distributed root-knot nematodes *Meloidogyne* spp. are scanty [7].

Meloidogyne spp. have been reported on ginger and *M. incognita, M. javanica, M. arenaria* and *M. hapla* have been recorded as the most important pests of the crop in various countries [3]. The root – knot nematodes cause galling and rotting of roots and underground rhizomes. The second stage *Meloidogyne* spp. infective larvae invade the rhizome through the axils of leaf sheaths in the shoot apex. The nematode develops to maturity in 21 days in fleshy and fibrous roots but in rhizomes it requires 40 days at 30^0C [3, 8]. Galls are formed on the fibrous roots and infested rhizomes have brown water – soaked areas in the outer tissues and the angles between the shoots. Heavily infested plants are stunted, poorly tillered and have chlorotic leaves with marginal necrosis and infected ginger mature, dry faster and die sooner than healthy ones [3], leaving a poor harvest. Infected rhizomes also serve as a source of infection and a means of spread.

In a greenhouse screening of the ginger genebank at National Root Crops Research Institute, Umudike, it was found that of the seven available varieties at the time, two namely Rio de Janeiro and UG1 were resistant; UG2 showed signs of tolerance, while all the others were susceptible to *Meloidogyne* spp. However, crop loss assessment and the economic threshold level of the root-knot nematodes on the crop has not hitherto been carried out.

The objective of this greenhouse research done in Umudike ($5^0 29^1$N, $7^0 23^1$E) in 2003 growing season therefore was to study the relationship between the different inoculum densities of *M. javanica* on ginger and thereby determine the economic threshold level of the nematode pest at which significant damage occurred on the crop.

MATERIALS AND METHODS

Suitable top soil mixed with poultry manure in the ratio of 4:1 was steam-sterilized and used to fill black polythene bags of size 15cmx5cmx25cm up to ¾ level with 1000cc of soil and one ginger rhizome with at least 2 eyes was planted into each bag/pot. The potted plants were arranged in the green house in a completely randomized design consisting of 2 varieties of ginger (one resistant (UG1) and one susceptible (Himachal Pradesh), 6 nematode inoculum densities and 5 replications.

The nematode species used for this work was earlier identified as *M. javanica* by perineal pattern method of Caveness [9] and raised on potted Indian spinach culture plants. Six nematode inoculum levels 0, 500, 1,000, 2,000, 4,000, and 8,000 eggs per plant were used to inoculate the soil around the roots of 4 weeks-old root systems of the ginger plants. Six months after inoculation with nematodes, the ginger was harvested. The following growth parameters, and root-knot nematode development were measured:

- Fresh root, stem and leaf new and total rhizome weights
- Severity of galling estimated with an index scale of 0-5 [10] (see Table 1)
- Number of females counted with the aid of a steriomicroscope (X40 magnification)
- Final population of eggs extracted from the ginger roots by method of Hussey and Barker [11] and fixed and stained with a few drops of acid fuschin acetic acid solution and counted and evaluated with the aid of a steriomicroscope.

RESULTS AND DISCUSSION

The results of the effects of *M.javanica* on ginger are shown on Tables 2, 3 and 4.

In Table 2 showing the relationship between of *M. javanica* inoculum densities on ginger it is observed that the root-knot nematodes caused damage to the ginger in all levels of the inoculum used (with the exception of the control). In addition the above–ground growth weights were not significantly affected by increase in nematode density while the belowground values were significantly different from one another. The results also show that the lowest values for damage symptoms and growth parameters were obtained for plants treated with 1000 eggs per plant, which also strikingly had the lowest yield values. The highest damage symptoms were obtained from plants treated with nematode density of 8,000 eggs /plant followed by plants treated with 4,000 eggs /plant. It is noteworthy that top growth /yield remained at a high level in spite of increased galling of the ginger roots as shown in plants treated with 8,000 eggs/plant which had no significant difference in values compared to uninfected (control) plants.

In Table3, which shows the varietal reaction to infection by *M. javanica*, there was significant effect on stem weight and yield of the fresh rhizome (both new and total rhizome yield). Himachal Pradesh had higher yield but significantly lower stem weight than UG1.On the other hand the damage symptoms on both varieties were insignificant. Furthermore, Himachal Pradesh had higher damage symptoms than UG1 indicating that it was probably less resistant (i.e. more susceptible) than it to nematode infection confirming the initial rating of it as susceptible.

Table 4 shows the interaction of nematode inoculum density with variety and here there was significant interaction between these two factors on the damage symptoms on the ginger. It would thus appear that severity of the damage symptoms were the most important effects of the root-knot nematodes on the ginger production than yield values.

Table 1: Taylor and Sasser's Rating Scale For the presence of Root-knot Nematode Galls on Roots

Number of galls	Gall Index
0	0
1-2	1
3-10	2
11-30	3
31-100	4
100 and above	5

Table 2: Relationship between M. javanica inoculum densities and ginger

	Growth Parameters Means					Damage Symptoms Means		
Inoculum Density	Stem weight (gm)	Leaf weight (gm)	Feeder Root weight (gm)	New Rhizome Yield(gm)	Total Rhizome Yield(gm)	Gall (Severity) Index	Number of Eggs	Number of Females
0(No nematode)	9.83a	8.24a	19.02a	30.41ab	46.58ab	0.00b	0.00b	-0.00c
500 eggs/plant	7.80a	6.40a	10.92b	24.47ab	39.08ab	4.24a	122.32a	94.54ab
1,000 eggs/plant	5,25a	4.86a	8.87b	20.31b	30.82b	3.53a	62.60ab	58.28b
2,000 eggs/plant	8.09a	5.52a	11.88ab	26.05ab	45.37ab	4.10a	86.20a	78.10ab
4,000 eggs/plant	10.21a	6.99a	11.37ab	22.97ab	43.07ab	4.04a	108.87a	91.24ab
8,000 eggs/plant	10.30a	7.60a	9.46b	32.58a	52.11a	4.30a	131.60a	113.00a

Means with same letter are not significantly different according to Duncan's Multiple Range Test.

Table 3: Varietal effect on growth and yield of Ginger

Variety	Stem Weight(gm)	Leaf Weight(gm)	Feeder Root Weight(gm)	New Rhizome Yield(gm)	Total Rhizome Yield(gm)	Gall Severity Index	Number of Eggs	Number of Females
Himachal Pradesh	6.93b	5.85a	12.07a	29.99a	47.64a	3.52a	92.01a	82.88a
UG1	10.23a	7.36a	11.77a	22.26b	38.03b	3.23a	78.52a	62.17a

Means with the same letter are not significantly different according to DMRT

Table 4 The interaction of root-knot nematode inoculum density and variety on growth and yield of ginger

Variety	Inoculum Density (eggs/plant)	Growth Parameters (Mean Values)					Damage Symptoms (Mean Values)		
		Stem Wt(gm)	Leaf Wt(gm)	Feeder Root Wt(gm)	New Rhizome Wt(gm)	Total Rhizome Wt(gm)	Gall Severity Index	Number of Eggs	Number of Females
Himachal Pradesh	0	9.28	8.22	14.62	31.22	49.88	0.00	0.00	0.00
	500	7.19	6.48	13.07	27.6	43.24	4.49	171.25	131.07
	1000	5.16	4.94	9.98	25.94	40.56	4.00	78.40	69.00
	2000	6.50	4.14	14.50	31.18	50.96	4.20	84.60	89.80
	4000	8.00	6.98	13.00	28.66	48.56	4.60	155.00	133.40
	8000	5.48	4.32	7.24	35.40	52.64	3.8	62.80	74.00
UG1	0	10.38	8.26	23.42	29.60	43.28	0.00	0.00	0.00
	500	8.42	6.32	8.76	21.34	34.92	4.00	73.40	58.00
	1000	5.34	4.78	7.77	14.67	21.07	3.07	46.79	47.56
	2000	9.68	6.90	9.26	20.92	39.78	4.00	87.80	66.40
	4000	12.41	7.00	9.75	17.27	37.57	3.49	62.75	49.07
	8000	15.12	10.88	11.68	29.76	51.58	4.80	200.40	152.00
		n.s	n.s	n.s	n.s	n.s	*	*	*

n.s = not significant at Prob=0.05; * = significant at Prob=0.05

The top growth in this experiment remained at a high level in spite of increased damage of the roots by root-knot nematode galls. Reasons for this trend are not quite clear but Wallace [12] suggests that stimulatory factors such as root regeneration and increased production of growth substances could increase top growth and further states that both stimulation and inhibition could occur in the same plant infected with nematodes. It would also appear that ginger is peculiar in its response to *M. javanica* infection as the results of severity gall indices of the infected ginger roots were not significantly different from one another and only when destructively sampled for eggs and females did any significant differences appear.

The economic threshold level in this experiment is put at 1000egge/plant because this level significantly differed from all the other levels especially in the damage symptoms (i.e. mean numbers of eggs and females) and had the lowest yield values (mean total rhizome weight of 33.6gm). This means that in fields where initial root-knot nematode populations are approaching to these levels, measures like chemical or integrated control have to be applied.

CONCLUSION

Finally from the fore-going it is necessary to further screen these ginger varieties under natural field conditions in order to formulate an effective integrated pest control strategy

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