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Assessment of avoidable yield loss due to root-knot nematode, *Meloidogyne incognita* infesting *Luffa acutangula* (L.) Roxb.

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Abstract
Present study was conducted to assess the yield loss caused by root knot nematode *Meloidogyne incognita* in ride gourd. Study was conducted in naturally infected plot, which was divided into two parts i.e., untreated and treated one and each plot again subdivided in 10 sub plots with size 3m x 2m size, as replication. All the treated plots were treat by Carbofuran (Furadon 3G) @ 2 kg a.i/ha before the sowing of ridge gourd seeds and it was followed by light irrigation. The experiment was ceased 100 days after sowing and the observations were recorded in both treated and untreated plots on plant growth parameters as well as on the nematode population development. Result of present study revealed that preventable yield losses due to root-knot nematode in ridge gourd was up to 74.52 percent under field conditions with application of Furadon 3G at 2 kg a.i./ha. Furthermore, there was maximum reduction in reproduction factor which was found highest decrease in replication 2 (72.72%) and least in replication 10 (26.49%).

Keywords: Meloidogyne incognita, ridge gourd, *Luffa acutangula* L. Roxb., yield loss, plant growth parameters

Introduction
Root - Knot nematodes are major obligate parasites which disturb host metabolism by making various changes in physiological and biochemical mechanisms of host plants. According to Krusberg 1963 [12], plant system decided the resistance or susceptibility of the host plant towards nematode attack. Various researchers such as Howell & Krusberg, 1966 [11], Ganguly & Dasgupta (1983) [7], Mohanty *et al*. (1995) [13] and Nayak (2015) [14] had made some progress towards understanding the biochemical mechanism of plant- nematode interactions. Crop protection is a major sector of agriculture, which attempts to reduce the losses due to insect pests, diseases and nematodes etc. which are considered as the major constraint in the production and productivity of economically important crops. Indiscriminate and injudicious use of chemical pesticide has caused harm to human health, environment and pollute ground water. Therefore, ecologically safe option of integrated pest management considered as a spring board to sustainable crop management is a present day necessity. Among the production constraints, plant parasitic nematodes are one of the major limiting factors to production. Plant-parasitic nematodes are now recognized as potentially serious constraint to crop productivity. One of the most wide spread nematode limiting world agriculture productivity is the root-knot nematode, *Meloidogyne species*. It has a very wide distribution and causes serious losses to important crop plants, particularly damaging to vegetable crops in tropical and sub-tropical countries (Sikora and Fernandez, 2005) [16]. The root-knot nematodes (*Meloidogyne* spp.) are cosmopolitan pathogens of plants and cause over $100 billion in annual crop losses worldwide (Bird *et al*., 2009) [1]. The host range of Root-knot nematode is extensive with more than two thousands of plant species (Sasser, 1980; Bird *et al*., 2009) [1]. Four common Meloidogyne species (*Meloidogyne incognita, Meloidogyne javanica, Meloidogyne hapla* and *Meloidogyne arenaria)* comprise up to 95% of all root-knot nematode populations. *M. incognita* is the most common species accounting for 64 percent of total population and infects almost all cultivated plants, which makes it perhaps the most damaging of pathogens.

Material and Method

An experiment was conducted using pair plot technique at Department of Nematology of College of Agriculture, OUAT to evaluate the preventable yield loss of ridge gourd cultivers due to root-knot nematode. For this experiment sick plot was created and the plot was naturally infested with root-knot nematode. The field was thoroughly cultivated and pulverized soil samples (200c.c) were taken with the help of a hoe upto a depth of 15 cm and mixed thoroughly to prepare composite sample, one sample of 200 c.c was taken and processed for nematode extraction following Cobb's sieving process and decanting method (Cobb, 1918) to know the initial nematode population. An experiment was conducted in the sick plot which was divided into two fragments i.e., untreated and treated each having 10 sub plots each of size 3m x 2m, as replication. Carbofuran (Furadon 3G) @ 2 kg a.i/ha was applied for treated plots before the sowing of ridge gourd seeds followed by light irrigation. Following all agronomic package and practices the crop was grown. The experiment was ceased 100 days after sowing and the observations were recorded in both treated and untreated plots on plant growth parameters as well as on the nematode population development. At the termination of the experiment different plant growth parameters like root and shoot length, dry and fresh shoot and root weights, yield, number of root galls per egg masses, gall index and Rf factor were observed and following different statistical analysis methods it was analysed.

Results and Discussions

The estimated direct crop losses due to phytonematodes ranged from 5 to 10 percent of crop value annually. The information on monetary losses due to phytonematodes is essential for understanding the control measures. The experiment was conducted under field conditions to evaluate the preventable yield losses due to root knot nematode on ridge gourd using paired plot with soil application of carbofuran 3 G at 2 kg a.i./ha over untreated control. The results indicated that the preventable yield loss in ridge gourd cv. Harsha was recorded to be 74.52 percent with application of carbofuran 3 G at 2 kg a.i./ha. It is clearly evident from the table 1 that, there was a increase in shoot length in different replication in treated plants over untreated counterparts and maximum increase was found in replication no.10 (7.86%) & least percent was observed in replication no.3 (1.04%).While, there was maximum increase in root length in replication no.6 (25.87%) and least increase was in replication no.7 (7.74%).

It is clearly evident from the table 2 that, there was a increase in fresh root weight in different replication in treated plants over untreated counterparts and maximum increase was found in replication no.9 (39.38%) & least percent was observed in replication no.3 (18.02%).While, there was a maximum increase in fresh shoot weight in replication no.6 (15.56%) and least increase was in replication no.3 (1.97%). It is clearly evident from the table 3 that, there was a increase in dry root weight in different replication in treated plants over untreated counterparts and maximum increase was found in replication no.4 (74.48%) & least percent was observed in replication no.3 (45.52%).While, there was maximum increase in dry shoot weight in replication no.8 (13.70%) and least increase was in replication no.4 (12.14%). The avoidable loss in the yield of bottle gourd ranged from 4.09 to 74.52 percent. As the literature on estimation of yield losses by root knot nematode in cucurbitaceous crops especially on ridge gourd is scanty the present findings are compared with some other vegetable crops. Darekar and Mhase (1988) [3] they estimated the yield loss in different crops infected by root-knot nematode such as brinjal, bitter gourd and tomato as 32.73 percent,36.72 percent and 46.92 percent respectively. Further, it was also observed yield loss due to root-knot nematode in bitter gourd as 22.9 to 42.8 percent by Khanna and Kumar (2003) [15]. It is clearly evident from the table 4 that, there was a reduction in number of root galls per egg masses per plant in different replication in treated plants over untreated counterparts and maximum decrease was found in replication no. 5 & 8 (16.66%) & least percent was observed in replication no.4 (3.92%).While, there was maximum decrease in gall index per plant in replication no.3 (36%) and least increase was in replication no.4 &10 (20%).Furthermore, there was maximum reduction in reproduction factor which was found highest decrease in replication 2 (72.72%) and least in replication 10 (26.49%).

Table 1: Effect of nematicidal treatment on root and shoot length of ridgegourd infested with root-knot nematode, *M. incognita*

Replications	Root Length(cm)			Shoot Length(cm)		
	Treated (Carbofuran 3G @ 2 kg a.i./ha)	Untreated control	%increase over control	Treated (Carbofuran 3G @ 2 kg a.i./ha)	Untreated control	% increase over control
1	45.30	38.51	17.63	310.29	298.21	4.05
2	44.31	36.23	22.30	302.59	297.52	1.70
3	42.21	35.03	20.49	301.65	298.53	1.04
4	41.23	33.89	21.65	305.28	297.55	2.59
5	43.12	34.52	24.91	311.80	298.82	4.34
6	45.88	36.45	25.87	302.66	297.65	1.68
7	40.32	37.42	7.74	303.45	287.45	5.56
8	40.20	32.44	23.92	306.48	285.25	7.44
9	38.20	31.43	21.53	304.42	282.23	7.86
10	35.21	32.48	8.40	309.45	281.14	
SE(m)±	0.706			2.682		
t value	9.567			4.987		

Table 2: Effect of nematicidal treatment on fresh weight of root and shoot of ridge gourd infested with root-knot nematode, *M. incognita*

Replications	Fresh weight ofroot/plant (g)			Fresh weight ofshoot/plant (g)		
	Treated(Carbofuran 3G @ 2 kg a.i./ha)	Untreated Control	%increaseover control	Treated (Carbofuran 3G @ 2 kg a.i./ha)	Untreated control	%increase over control
1	50.70	42.75	18.59	125.21	98.2	27.5
2	51.24	41.55	23.32	125.35	118.21	6.04
3	50.10	42.45	18.02	123.75	121.35	1.97
4	48.75	36.45	33.74	124.81	120.85	3.27
5	45.23	38.23	18.31	128.72	125.75	2.36
6	42.21	31.31	34.81	141.51	122.45	15.56
7	40.55	30.45	33.16	123.58	119.21	3.66
8	40.23	31.25	28.73	119.83	99.35	20.61
9	45.23	32.45	39.38	112.86	98.25	14.87
10	41.11	32.35	27.07	102.92	94.48	8.93
SE(m)±	0.612			2.744		
t value	15.701			4.025		
CD(0.05)	11.425			13.132		

Table 3: Effect of nematicidal treatment on dry weight of root and shoot of ridge gourd infested with root-knot nematode, *M. incognita*

Replications	Dry weight of root/plant (g)			Dry weight of shoot/plant (g)		
	Treated (Carbofuran 3G @ 2 kg a.i./ha)	Untreated control	%increase over control	Treated (Carbofuran 3G @ 2 kg a.i./ha)	Untreated Control	%increase over control
1	19.51	11.95	63.26	81.75	72.75	12.42
2	20.75	12.93	60.47	82.35	72.45	13.66
3	20.01	13.75	45.52	83.78	73.85	13.44
4	17.85	10.23	74.48	81.25	72.45	12.14
5	20.07	12.30	63.17	80.35	71.23	12.80
6	17.02	10.75	58.32	84.25	74.25	13.46
7	18.25	11.00	65.90	85.31	75.35	13.21
8	17.75	10.88	63.14	83.48	73.42	13.70
9	17.25	11.09	55.54	84.45	74.41	13.49
10	16.85	10.85	55.29	82.23	72.41	13.56
SE(m)±	0.23			0.154		
t value	30.09			62.771		
CD(0.05)	9.78			11.493		

Table 4: Effect of nematicidal treatment on yield of ridge gourd infested with root-knot nematode, *M. incognita*

Replications	Yield in kg/m^2 at termination		
	Treated (Carbofuran 3G @ 2 kg a.i./ha)	Untreated control	% increase over control
1	4.10	3.80	7.89
2	4.07	3.91	4.09
3	3.82	2.80	36.42
4	3.90	2.24	74.10
5	3.74	2.60	43.84
6	4.00	3.82	4.71
7	3.81	2.65	43.77
8	3.90	2.42	61.15
9	3.70	2.12	74.52
10	4.00	3.72	7.52
SE(m)±	0.192		
t value	4.661		
Average yield loss	22.951		
% yield loss	29.787		
CD(0.05)	1.064		

Table 5: Effect of nematicidal treatment on number of root galls/egg masses gall index and Rf(reproduction factor) of root-knot nematode, *M. incognita* infesting ridge gourd

Replications	Number of root galls/egg masses/plant at termination			Gall index/plant at termination			*Rf (reproduction factor)		
	Treated (Carbofuran 3G @ 2 kg a.i./ha)	Untreated Control	%decrease over control	Treated (Carbofuran 3G @ 2 kg a.i./ha)	Untreated control	%decrease over control	Treated (Carbofuran 3G @ 2 kg a.i./ha)	untreated control	% decrease over control
1	47	54	12.96	3.8	5	24	0.57	1.19	52.10
2	38	43	11.62	3.3	5	34	0.39	1.43	72.72
3	34	40	15	3.2	5	36	0.36	1.14	68.42
4	49	51	3.92	4	5	20	0.61	1.18	48.30
5	35	42	16.66	3.4	5	32	0.53	1.11	52.25
6	44	52	15.38	3.7	5	26	0.49	1.10	55.45
7	47	51	7.84	3.9	5	22	0.64	1.19	46.21
8	45	54	16.66	3.3	5	34	0.43	1.23	65.04
9	37	44	15.90	3.6	5	28	0.60	1.05	42.85
10	48	56	14.28	4	5	20	0.86	1.17	26.49
SE(m)±	0.667			0.09			0.06		
t value	9.438			14.31			9.87		
CD(0.05)	7.484			1.82			0.83		

Conclusion

The evaluation of avoidable yield losses due to root-knot nematode in ridge gourd indicated the loss in yield of ridge gourd upto 74.52 percent under field conditions, when the crop was treated with carbofuran 3 G at 2 kg a.i./ha.It can be inferred that root - Knot nematodes are major obligate parasites which disturb host metabolism. Understanding the biochemical and molecular basis of plant nematode interaction will help us in identifying new targets to intervene with nematode parasitism and develop novel strategies to combat them. The information generated from this investigation can be manipulated through advanced biotechnological research for planning suitable management strategies. The present study that provides same basic information relating to host-pathogen interaction and bio-chemical mechanism of resistance. The above knowledge of physiological and bio-chemical events during the post-infection period have initiated search for molecules, which can trigger the function of enzymes involve in hyper sensitive response, production of phytoallexins lignin or other secondary metabolites which are detrimental to nematode feeding and development.

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