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Assessment of avoidable yield losses due to root-knot nematode, *Meloidogyne incognita* infesting fig under field conditions

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Abstract
The field experiment was conducted during November, 2017 to assess the avoidable yield losses due to root- knot nematode in fig (cv. Poona fig) with paired plot design by soil application of carbofuran 3 G at 2.00 kg a.i./ha. The results indicated that the loss in yield of fig in an untreated trees ranged from 16.57 to 31.60%. However, average avoidable loss in the fruit yield of fig was recorded to be 24.92 per cent, when the crop was treated with carbofuran 3 G @ 2 kg a.i./ha.

Keywords: *Meloidogyne incognita, Ficus carica,* carbofuran 3 G

Introduction
Fig, *Ficus carica* Linn. is commonly known as Angir belongs to Moraceae family of Umbar breed. In India, its cultivation is mostly confined to Western parts of Maharashtra, Gujarat, Uttar Pradesh, Karnataka and Tamil Nadu. Poona fig is the most popular cultivar grown in India. The fig fruits are often consumed as dried or canned. As a fresh fruit, it has luscious taste. Fig fruits have been prized over centuries for the medicinal and dietary properties. It is rich in calories (269), protein and calcium (higher than milk), iron and fibre content. Such an important crop is attacked by several insect and non- insect pests and disease caused by phytonematodes. Phytonematodes in general and root- knot nematodes in particular are one of the limiting factors in cultivation of this crop in Maharashtra causing considerable yield losses. The root- knot nematodes are basically parasites of roots, causing root galls or knots as a below ground symptoms which cause slow debility of roots in its function of nutrient and water uptake and translocation. In above ground symptoms, the plants may be dwarfed, yellowish with smaller foliage and poor and fewer fruits. Besides, the direct damage caused to the plants, the root knot nematodes are notorious for disease complexes involving fungi, bacteria, virus, mycoplasma, insects and other nematodes (Dasgupta and Guar, 1986) [3]. The estimated direct crop losses due to phytonematodes ranged from 5 to 10 per cent of the crop value annually. The information on monetary losses due to phytonematodes is essential for undertaking the control measures. Therefore, the field experiment was conducted to assess the avoidable yield losses due to root- knot nematode in fig (cv. Poona fig). The information regarding this aspect on fig is scanty.
However, the avoidable yield loss of 23.03% in grapevine (Anonymous, 1997) [1], 30.9% in banana (Jonathan and Rajendran, 2000) [4], 31.17% (Walunj, 2013) [7] and 32.80% (Kadam, 2014) [5] in pomegranate and 23.77% in guava (Patil *et. al*, 2016) [6] were reported due to root-knot nematode (*M. incognita*), when these crops were treated with carbofuran 3 G at 2 to 4 kg a.i/ha.

Materials and Methods
A statistically designed field experiment was conducted during November, 2017 on naturally root- knot nematode infested fig orchard at All India Co- ordinated Research Project on Arid Zone Fruit Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri to assess the avoidable yield losses due to root- knot nematode in fig. The experiment was laid out in paired plot design with ten replications and two treatments including an untreated control. In treated treatment, the granular nematicide, carbofuran 3 G was applied @ 2 kg a.i./ha. The nematicide was mixed thoroughly in the infested soil around the tree in root zone area by ring method and then well covered with soil. Initial, intermediate and at termination

sampling of the soil and root samples with the help of soil auger at 30 to 60 cm depth was done from the root zone of the tree to count the nematode population before the commencement, intermediate and at termination of the experiment. The 200 g of composite soil and root samples were collected at the time of each observation. The soil samples were processed by Cobb's Decanting and Sieving Method (Cobb, 1918) [2] for nematode count in the laboratory. The residues of 350 mesh sieves were collected in plastic beaker and kept for 24 hrs. For extraction of nematodes. For nematode count the average of 10 counts of 1 ml suspension was recorded and from it was calculated to 200 ml of suspension. The number of root galls and egg masses/ 5 g roots were also recorded at the time of each observation. To count egg masses easily staining of galled roots was done by dipping the roots in 1.0% solution of tryphan blue for 2 minutes. After dipping, the roots were washed carefully with tap water to remove excess stain. From these observations per cent decrease in root- knot nematode population, number of root galls and egg masses were calculated. Fig fruit yield were recorded at termination of the experiment and expressed in tonnes/ ha. The data obtained were subjected to statistical analysis for 't' test to find out the significance of differences between two treatments.

Results and Discussion

Root- knot nematode population:

It could be seen from the Table 1 that the highly significant differences in treated and an untreated trees in recording soil population of root- knot nematode were observed at intermediate and termination stage of the crop. The reduction of soil population of root-knot nematode at intermediate stage of the crop ranged from 46.43 to 62.07 per cent in treated trees with carbofuran 3 G at 2 kg a.i./ha. However, the average reduction of 53.90 per cent population of root-knot nematode was recorded in this treatment.

At termination, the reduction in soil population of root-knot nematode ranged from 28.57 to 44.44 per cent in the trees treated with carbofuran 3 G at 2 kg a.i./ha. However, the average reduction of 33.51 per cent in the population of root-knot nematode was recorded in this treatment.

Number of root galls and eggs masses

It could be seen from the Table 2 and 3 that the highly significant differences in treated and an untreated trees in recording the number of root galls were observed at intermediate and termination stage of the crop. The reduction in the number of root galls at intermediate stage of the crop ranged from 47.06 to 62.50 per cent in the treated trees with carbofuran 3 G at 2 kg a.i./ha. However, the average reduction of 54.23 per cent in root galls was recorded in this treatment.

At termination, the reduction in root galls of root-knot nematode was ranged from 25.71 to 39.47 per cent in trees treated with carbofuran 3 G at 2 kg a.i./ha. However, the average reduction of 31.46 per cent in the root galls was recorded in this treatment.

The highly significant differences in treated and untreated trees in recording the number of egg masses (Table 3) were observed at intermediate and termination stage of the crop. The reduction of number of egg masses at intermediate stage of the crop ranged from 28.57 to 62.50 per cent in treated trees with carbofuran 3 G at 2 kg a.i./ha. However, the average reduction of 47.18 per cent in egg masses of root-knot nematode was recorded in this treatment.

At termination, the reduction in egg masses of root-knot nematode were ranged from 14.29 to 42.86 per cent in trees treated with carbofuran 3 G at 2 kg a.i./ha. However, the average reduction of 28.29 per cent in the number of egg masses was recorded in this treatment.

Yield losses

It is revealed from Table 4 that the average yield recorded in treated and untreated trees of fig were 15.09 and 11.34 tonnes/ha, respectively. The loss in yield of fig in an untreated trees ranged from 16.57 to 31.60 per cent. However, average loss of 24.92 per cent in the yield of fig was recorded in an untreated trees when the crop was treated with carbofuran 3 G at 2 kg a.i./ha.

Previously, the avoidable loss of 23.03% in the yield of grapevine was recorded due to root-knot nematode, *M. incognita* by using soil application of carbofuran 3 G at 2 kg a.i./ha (Anonymous, 1997) [1]. Jonathan and Rajendran (2000) [4] reported 30.9% avoidable yield loss in banana cv. Poovan due to *M. incognita* by using carbofuran 3 G @ 4 kg a.i./ha. Significant reduction in plant height, pseudostem girth, number of leaves and leaf area was observed due to the nematode infestation. Walunj (2013) [7] and Kadam (2014) [5] conducted field experiments on pomegranate to assess the avoidable yield loss due to root- knot nematode. The results indicated that avoidable loss in yield of pomegranate was 31.17 and 32.80%, respectively when the crop was treated with phorate 10 G @ 2 kg a.i./ha. Patil *et al.* (2016) [6] also conducted an experiment to assess the avoidable yield loss due to root- knot nematode in guava (cv. Sardar) with paired plot design by soil application of carbofuran 3 G at 2 kg a.i./ha. The results indicated that the avoidable loss in the fruit yield of guava was reported to be 23.77%, when the crop was treated with carbofuran 3 G @ 2 kg a.i./ha.

Conclusion

The results indicated that the average yield recorded in treated and an untreated trees of fig were 15.09 and 11.34 tonnes/ha, respectively. The avoidable loss in yield of fig over an untreated trees ranged from 16.57 to 31.60 per cent. However, average avoidable loss of 24.92 per cent in the yield of fig was recorded in an untreated trees, when the crop was treated with carbofuran 3 G at 2 kg a.i./ha.

Table 1: Effect of treated treatment on root-knot nematode, *M. incognita* population in assessment of avoidable yield losses in fig.

Replications	Root-knot nematode population(J_2) / 200 $cm^3$of soil						Decline in nematode population in treated plots (%)	
	Initial		Intermediate		Termination			
	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	Intermediate	Termination
1	580	640	220	660	400	720	62.07	31.03
2	620	560	300	660	420	680	51.61	32.26
3	580	480	280	520	380	640	51.72	34.48
4	520	580	260	620	360	660	50.00	30.77
5	560	600	300	600	400	700	46.43	28.57
6	540	560	220	620	360	660	59.26	33.33
7	580	600	300	660	380	700	48.28	34.48
8	560	620	220	660	360	780	60.71	35.71
9	600	520	280	580	420	780	53.33	30.00
10	540	600	240	640	300	740	55.56	44.44
Mean	568	576	262	620	378	706	53.90	33.51
't' cal.	0.372		16.4033a		14.5573a			

't' Table (0.05) = 2.262 and (0.01) = 3.250

a = Highly significant differences from an untreated control according to 't' tests for paired comparison.

Table 2: Effect of treated treatment on number of root galls of *M. incognita* in assessment of avoidable yield losses in fig.

Replications	Number of root galls / 5 g roots						Decline in number of root galls in treated plots (%)	
	Initial		Intermediate		Termination			
	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	Intermediate	Termination
1	39	31	20	37	26	42	48.72	33.33
2	37	32	17	44	27	46	54.05	27.03
3	34	30	18	37	24	42	47.06	29.41
4	32	29	13	38	21	41	59.38	34.38
5	40	33	16	41	29	42	60.00	27.50
6	36	32	18	42	25	45	50.00	30.56
7	37	32	19	45	26	43	48.65	29.73
8	40	35	15	43	25	45	62.50	37.50
9	35	34	17	37	26	40	51.43	25.71
10	38	30	15	35	23	44	60.53	39.47
Mean	36.8	31.8	16.8	39.9	25.2	43.0	54.23	31.46
't' cal.	0.104		12.214a		13.640a			

't' Table (0.05) = 2.262 and (0.01) = 3.250

a = Highly significant differences from an untreated control according to 't' tests for paired comparison

Table 3: Effect of treated treatment on number of egg masses of *M. incognita* in assessment of avoidable yield losses in fig.

Replications	Number of egg masses / 5 g roots						Decline in number of egg masses in treated plots (%)	
	Initial		Intermediate		Termination			
	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	Intermediate	Termination
1	26	24	18	31	22	35	30.77	15.38
2	30	27	14	35	23	36	53.33	23.33
3	27	25	13	31	17	34	51.85	37.04
4	32	28	12	32	20	36	62.50	37.50
5	27	29	16	34	22	37	40.74	18.52
6	21	23	15	31	18	41	28.57	14.29
7	28	28	14	33	16	38	50.00	42.86
8	22	25	12	30	15	31	45.45	31.82
9	26	22	13	29	17	35	50.00	34.62
10	29	26	12	28	21	40	58.62	27.59
Mean	26.8	25.7	13.9	31.4	19.1	36.3	47.18	28.29
't' cal.	0.390		10.400a		7.876a			

't' Table (0.05) = 2.262 and (0.01) = 3.250

a = Highly significant differences from an untreated control according to 't' tests for paired comparison

Table 4: Assessment of avoidable yield losses due to root- knot nematode, *M. incognita* in fig.

Replications	Yield (t/ha)		Loss in yield (%)
	Treated (Carbofuran 3 G at 2 kg a. i./ha)	Untreated control	
1	14.55	10.08	30.72
2	14.45	11.60	19.72
3	15.35	10.50	31.60
4	16.00	12.30	23.13
5	15.10	12.08	20.00
6	14.13	10.06	28.80
7	15.70	10.90	30.57
8	14.80	11.60	21.62
9	15.63	13.04	16.57
10	15.23	11.20	26.46
Mean	15.09	11.34	24.92
't' cal	9.673a		

't' Table (0.05) = 2.262 and (0.01) = 3.250

a = Highly significant differences from an untreated control according to 't' tests for paired comparison.

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