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Assessment of Resistance in Some Tomato Germplasm and Estimation of Crop Yield Loss Due to Root-Knot Nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood

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ABSTRACT

Root knot nematode (RKN), *Meloidogyne incognita,* is one of the constraints in reducing the quantity and quality of tomato in tomato growing areas of the world. The experiment was carried out to evaluate thirty one germplasm of tomato under net house conditions against RKN along with field estimation of avoidable yield loss of the crop under Directorate of Research, BCKV, West Bengal, India. Highly nematode resistant germplasm were not obtained from the experiment, however 3 (EC - 620394, EC – 620427 and EC – 617047) were recorded resistant and 10, 20 and 18 numbers exhibited moderately resistant, susceptible and highly susceptible in reaction. The growth of root length is negatively correlated (r = -0.867) while, positive correlation was observed with root knot index in case of number of egg mass, weight of fresh and dry root (r = 0.723, 0.855, 0.761 respectively).The use of Carbofuran 3G at the rate of 3 kg a.i/ha increased the yield of tomato ranging from 5.62- 9.45%. The avoidable yield loss was 5.32 - 8.63% for both the years. The output of the study will be helpful to find out resistant tomato cultivars for future healthy seed production program against root knot nematode. Awareness among the farming community about the losses caused by these pests is very less if proper management strategies are not adopted on the crops. Therefore, necessary steps should be taken in the field of awareness as well as management of these nematodes to minimise economical losses to the farmer.

Keywords Tomato, Germplasm, Yield loss, Carbofuran, *Meloidogyne incognita.*

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INTRODUCTION

Tomato (*Solanum lycopersicum*, family, Solanaceae) is a popular vegetable crop worldwide. It is a rich source of a number of micronutrients along with high levels of lycopene, an important antioxidant. Low tomato production per hectare (214.5 q/ha) in India, as compared to the other countries, is because of some factors. Tomato crop is susceptible to different diseases caused by fungi, virus, bacteria. Apart from other pathogens, nematodes cause serious problems due to their soil dwelling habit and microscopic nature. Keren-Zur *et al*. (2000) reported that an estimated amount of US$500 million was spent on nematode control in the world to minimize these losses. Being sedentary endoparasitic nature these nematodes have the most evolved interactions with their host. They buildup permanent feeding cells inside the vascular tissue after penetration in the root and migration. Normal plant growth is hampered due alteration in the distribution of hormones and minerals. According to Sharma *et al.* (2013) the vigoros economic damage to plants by nematode root feeding and interaction with other organisms renders the plants further vulnerable to other biotic and abiotic stresses. Growing of resistant crops is an effective and ecofriendly components of integrated pest management and inclusion of this component ensures increased crop yield in the presence of nematode (Khan and Mukhopadhyay 2004). Crop cultivars showing high degree of resistance with acceptable agronomic characteristics are commonly recommended for nematode infested fields either as a routine crop or in a rotational sequence of the crops. The use of resistant cultivars is the cheapest and the most effective method but resistant cultivars are largely unavailable to farmers (Noling 2002). So there is a need for the identification of source of resistant tomato cultivars against root-knot nematode (RKN) for future healthy seed production program. Keeping in mind the above background information, the present study was conducted to evaluate the response of some tomato germplasm against root-knot nematodes (*Meloidogyne incognita* race 2) in pots and to understand the avoidable yield losses at field condition due to this nematode on tomato.

MATERIALS AND METHODS

Response reaction of germplasm

Thirty one (31) tomato germplasm were screened in pot under net house condition at Directorate of Research, BCKV, Kalyani, Nadia, WB, during 2017 to evaluate their reaction to RKN. In net house condition the pure culture of the nematode was maintained on brinjal. The extraction procedure for nematode eggs were done by following the modified method of Hussey and Barker (1973) and modified Baermann tray method of Whitehead and Hemming (1965). Soil, sand and vermicompost were used as a potting medium by mixing in the ratio of 3:1:1 and sterilized by 10 % formaldehyde solution to make it free from nematodes. After 3 weeks, required number of earthen pots of size 6 " were filled with sterilized soil @ 1000 cc of soil per pot and tomato seeds were sown. The inoculation @ one 2nd stage juvenile (J_2) per cc of soil i.e. 1000 J_2 per pot was done at 2 weeks after sowing at 3-4 leaves stage. Then J_2 were inoculated in 3-4 holes with the help of 10 ml pipette per plant to a depth of 3-5 cm, near the rhizosphere and covered with soil and lightly watered. After 45 days of inoculation uprooting of the tomato plants was done carefully. The data on root knot index (0-5 scale, as per following chart mentioned below, Table 1), root and shoot length, fresh & dry root weight, egg masses per plant were recorded. Counting of galls and egg masses were carried in the laboratory under stereo zoom binocular. Then roots were kept in dry air oven at 45^{o}C for 4-5 days for taking the dry weight. As per Heald et al. (1989), the root knot index was determined to show the degree of resistance. The critical difference (CD) at 5% level of significance was calculated from the recorded data and compared according to Duncan's Multiple Range Test at 5% level of probability; the data was statistically analyzed in CRD.

Table 1. Rating chart for evaluation of host response (0-5 scale).

Observations	Gall index	Host reaction
No galls and egg masses	0-1.0	Highly resistant
1-10 galls/egg masses	1.1 – 2.0	Resistant
11-30 galls/egg masses	2.1 – 3.0	Moderately resistant
31-100 galls/egg masses	3.1 – 4.0	Susceptible
101 and above galls/egg masses	4.1–5.0	Highly susceptible

Source : Used in AICRP on nematodes

Estimation of yield loss

This study was conducted on root knot nematode sick plots at Central Research Farm (CRF), BCKV during *rabi*, 2015-16 and 2016-17. Paired plot technique given by Leclerg, was followed in the experiment, viz., there were two treatments, treated (T_1) and untreated (T_2) and each treatment was replicated ten

Table 2. Yields from a field experiment conducted to compare treated and untreated plots and some of the computations necessary for a test of significance between the two treatments.

Paired plots (No.)	Yield/plot (kg) Treated (x_1)	Untreated (x_2)	Difference (x_1-x_2)	Deviations from the mean of the difference (d)	Square of the deviations from the mean (d^2)
1	14.6	6.2	8.4	- 0.1667	0.0278
2	12.6	3.3	9.3	0.7333	0.5377
3	15.0	6.8	8.2	- 0.3667	0.1345
4	15.6	6.6	9.0	0.4333	0.1877
5	12.7	4.2	8.5	- 0.0667	0.0044
6	12.0	4.0	8.0	- 0.5667	0.3211
Sum	82.5	31.1	51.4		1.2132
Mean	13.75	5.18	8.5667		

times (Leclerg 1971). Initial population of RKN was determined before sowing of seeds by counting the number of J_2 following Cobb's sieving and decanting method from multiple samples and presented as number of INP/ 200 cm^3 soil. Seedlings were transplanted at a spacing of 60 cm X 40 cm plant to plant and row to row respectively. Ten plots were treated with *Carbofuran granules* @ 3 kg a.i. /ha before transplanting and the rest ten plots were kept as untreated. Observations on plant stands were taken at 15 days after transplanting and at harvest. Uprooted plants from each plot were washed carefully in the tap water to remove adhering soil particles. Number of root galls on roots per plant was counted and gall index as 1 to 5 scales were calculated. Yield (kg/ plots) was recorded and converted to quintal/ha. For determination of final nematode population, Cobb's sieving and decanting method was followed from 200 cc of composite soil sample.

Statistical analysis

Per cent yield increase and avoidable loss was calculated by the formula given below (Table 2).

Method of computation of t-value

From first set of paired plots in Table, the values in the last three columns are determined as follows: -

Difference, x_1-x_2 = 14.6 – 6.2 = 8.4

Deviation from the mean of the difference (d)

d = 8.4 - 8.5667 = 0.1667

Square of the deviation from the mean difference (d^2)

d^2 = (- 0.1667)2 = 0.0278

Similar procedure is followed to obtain the values for the remaining paired plot data.

In this example

n =number of paired plots = 6

(n-1) = degree of freedom i.e. 6-1 = 5

Mean difference = 51.4/6 = 8.5667

S = Standard deviation

$$= \sqrt{\frac{\text{sum of } d^2}{n-1}} = \sqrt{\frac{1.2132}{3}} = \sqrt{0.2426} = 0.4925$$

$$\text{Standard error (se)} = \frac{\text{Standard deviation}}{\sqrt{n}}$$

SD = standard error of mean difference

$$S = \frac{0.4925}{\sqrt{n}} = \frac{0.4925}{\sqrt{6}} = 0.201$$

Substituting in Equation (1), we obtain:

$$T = \frac{x_1 - x_2}{sd} = \frac{8.57}{0.201} = 42.64 = t$$

This calculated value of't' needs to be compared with tabulated value to ascertain whether the observed value is statistically significant at 0.05 and 0.01

probability levels.

From the two mean tables in Table, one can compute the percentage reduction in actual yield per cent avoidable losses in yield.

$$100 \times \frac{(13.75 - 5.18)}{13.75} = 62.3\%$$

$$\text{Percent avoidable loss in yield} = \frac{\text{Yield in treated plots – Yield in contrated Plots}}{\text{Yield in treated plots}} \times 100$$

$$\text{Percent increase in yield} = \frac{\text{Yield in treated plots – Yield in contrated Plots}}{\text{Yield in untreated plots}} \times 100$$

RESULTS AND DISCUSSION

The screening experiment of germplasm in tomatoes consists of 31 genotypes including the var Patharkuchi as a check. The longest root length was found in accession EC- 620394 (7.9 cm) and the smallest (4.1 cm) in accession EC – 538153 (Table 3). The 2 accessions (EC-617047 and EC-620361) were found statistically at par with the longest one. The highest fresh root weight (5 g) and dry root weight (0.90 g) were observed in accession EC – 620410. All the genotypes showed different levels of gall index and the reaction of the host plant against *M. incognita.* Out of 31 germplasm, 3 germplasm were

Table 3. Evaluation of tomato germplasm against root knot nematode at Nadia, West Bengal.

Sl. No.	Germplasm	Root parameters					
		Root length (cm)	Fresh root weight (g)	Dry root weight (g)	Root knot index	Egg mass/ 5 g root	Reaction
1	EC- 151568	4.87	3.30	0.45	5	21	HS
2	EC- 162601	4.80	2.40	0.33	4.4	13	HS
3	EC- 163605	5.16	1.60	0.21	4	18	S
4	EC- 164334	4.30	2.30	0.30	4.8	17	HS
5	EC- 164670	4.60	2.30	0.30	4.4	21	HS
6	EC- 164838	4.76	2.70	0.43	4.4	16	HS
7	EC- 164863	6.26	1.10	0.15	3	11	MR
8	EC- 165395	5.23	1.30	0.18	3.6	1	S
9	EC- 165690	5.40	1.70	0.25	3.8	15	S
10	EC- 165700	6.36	1.10	0.15	2.8	9	MR
11	EC- 520078	6.10	0.66	0.13	3	8	MR
12	EC- 521067-B	6.40	1.10	0.13	2.8	9	MR
13	EC- 528368	5.50	1.80	0.22	4	11	S
14	EC- 538153	4.10	2.60	0.38	4.2	18	HS
15	EC- 538156	5.10	2.30	0.37	4	23	S
16	EC- 567305	6.00	2.30	0.30	4	40	S
17	EC- 617047	7.30	0.70	0.12	2	2	R
18	EC- 620361	7.20	0.80	0.13	2.8	5	MR
19	EC- 620372	5.30	2.90	0.47	4.4	35	HS
20	EC- 620373	6.20	1.70	0.27	3.4	7	S
21	EC-620382	6.30	1.70	0.25	4	13	S
22	EC- 620394	7.90	0.70	0.12	2	3	R
23	EC- 620396	5.00	3.20	0.47	4.6	20	HS
24	EC- 620397	5.80	2.30	0.33	3.8	11	S
25	EC- 620410	5.50	5.00	0.90	5	19	HS
26	EC- 620417	6.30	2.20	0.28	3.2	6	S
27	EC- 620427	7.00	0.60	0.11	2	2	R
28	EC- 631359	6.10	2.40	0.37	3.8	11	S
29	EC- 631369	4.70	2.60	0.42	4.4	10	HS
30	EC- 620387	6.33	1.10	0.18	2.4	5	MR
31	Check (Patharkuchi)	4.40	2.50	0.39	4.6	10	HS
	Lsd(5%)	0.75	0.45	0.084	0.787	4.688	-
	CV (%)	8.23	13.98	17.66	16.811	20.789	-

R=Resistant, MR= Moderately resistant, S= Susceptible and HS=Highly susceptible, cm= centimeter, g = gram.

Table 4. Correlation between root knot index and other parameters.

Parameters	Root length	Fresh root weight	Dry root weight	Egg mass
Root-knot index	-0.867 **	0.855**	0.761**	0.723**

** Significant at 1% level of significance.

recorded resistant, 6 were moderately resistant, 11 germplasm were susceptible, and 11 were highly susceptible. The lowest egg mass (1 egg mass) was found in the roots of the germplasm EC- 165395 and this was statistically insignificant. The roots of germplasm EC – 567305, recorded maximum egg masses. The correlation study of the root-knot index with root characters reveals a negative correlation (r = -0.867) between the growth of root length and the root-knot index while a positive correlation was found between the egg mass, fresh root weight, and dry root weight with root-knot index (r = 0.723, 0.855, 0.761 respectively) (Table 4). El-Sherif *et al.* (2007) also reported that root-knot nematode increases root weight for the most susceptible cultivar compared to resistant cultivar.

The yield loss assessment revealed that application of carbofuran 3G @ 3kg a.i. ha^{-1} increased the yield of tomatoes by 5.62 % and 9.45 % in 2015-16 and 2016-17 respectively. No significant reduction in the root-knot index was noticed in the first year while a significant reduction in the root-knot index was found in 2016-17. A reduction in the *M. incognita* population by about 25% was observed by the application of carbofuran 3G @ 3 kg a.i. ha^{-1}.The reduction in the number of gall index in treated plots was about 20%. The average initial population of larvae of root-knot nematodes was 360.25 and 230.15 per 200 cm^3 of soil for two years respectively. The avoidable yield losses were recorded at 5.32 % & 8.63 % for two years respectively (Table 5).

It is revealed from the study that when the tomato variety, Patharkuchi, was treated with Carbofuran 3G at 3 kg a.i. /ha it showed a better effect than the untreated control for both the years. The tomato fruit yield in the untreated control plot was low probably because of the growth-inhibiting action of root-knot nematode (*M. incognita*). On the other hand, the carbofuran treated plot recorded a higher yield of the crop. The sedentary endoparasitic feeding habit of root-knot nematode causes direct damage to the root system resulting in the reduction of crop yield. Carbofuran causes suppression in the root penetration of nematodes by virtue of its ovicidal action. It may give an idea that carbofuran may act directly on the soil nematodes thereby affecting egg hatching and larval movement inside the root. This statement is supported by the work of Di-Sanzo (1973), Adegbite, and Agbaje (2007). The mean root gall index (on a 0-5 scale) in treated plots was about 20% lower than that obtained from untreated roots. It meant that plants growing in nematode-infected soil suffered. significantly more root infection and that Carbofuran adversely affected the root penetration of *M.*

Table 5. Estimation of avoidable yield loss due to *Meloidogyne incognita* in tomato during 2015-2016 and 2016-17 at Nadia, West Bengal.

Treatment	Gall index (1-5 scale)			Final population of J^2/200 cm^3 soil			Yield (q/ha)			% increase in yield		% avoidable yield loss	
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	2015-16	2016-17
T1	2.59	2.40	2.49	3011.42	1102.20	2056.81	257.30	375.42	316.36	5.62	9.45	5.32	8.63
T2	2.90	3.32	3.11	4242.17	1238.20	2740.18	243.60	343.00	293.30				
Calculated t at 0.05%	1.15	8.49	-	1.91	1.07	-	1.37	1.48					
Table value	2.2	2.26	-	2.2	2.26	-	2.2	2.26					

T_1=Treated, T_2=Untreated, cm^3=centimeter cube, q= quintal, J_2= 2nd Juvenile stage *incognita* J_2s, which eventually led to significantly reduced galling. Percent decline in final nematode population over untreated control was to the tune of 25.54 and 10.98 in Carbofuran treated plots, during the years respectively. The two season's data from yield losses on tomato variety Patharkuchi revealed that the infestation of root-knot nematode inflicted an average yield loss of 6.98 % and the adoption of appropriate control measures for the nematode can increase the average yield of the crop up to 7.54 %. Literature in support of tomato yield loss against root-knot nematode is insufficient. Because of this, the experimental outcomes are compared with some other crops. The results of the study are in agreement with Darekar and Mhase (1988), who reported that root-knot nematode, *M. incognita* race 3 causes 36.72% losses of bitter gourd yield in Coimbatore White long variety. Krishnaveni and Subramanian (2002) and Khanna and Kumar (2003) also recorded 69.2 % and 22.9 to 42.8% yield losses against root-knot nematode in cucumber and bitter gourd, respectively. Khan *et al.* (2014) also reported similar results on some cucurbitaceous crops like bottle gourd, snake gourd, bitter gourd, cucumber, and pumpkin. Lack of proper diagnostic above-ground symptoms, farmers are unaware of this hidden enemy of the crops due to which the crop losses increase with emphasis on proper management strategies against this nematode. Under these circumstances, the implementation of requisite steps should be done for the awareness as well as management of these nematodes to minimize economical losses to the farmer.

CONCLUSION

It can be concluded that 6 medium resistant germplasms including 3 resistors (EC-617047, EC-620394, and EC-620427) are recommended for use in breeding studies as a potential component for the development of root-knot nematode-resistant varieties. The estimated loss of avoidable yield on tomatoes under field conditions in West Bengal is 5.32 -8.63%. Applying Carbofuran 3G @ 3 kg a.i can increase crop yield by 5.62 to 9.45%. Therefore, root-knot nematode (*M. incognita*) needs to be managed to get the maximum yield of the tomato crop.

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