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Screening and evaluation of tomato varieties against root-knot nematode, *Meloidogyne incognita*

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Abstract
Twenty five tomato varieties were screened to study their reactions to root-knot nematode (*Meloidogyne incognita*) and the nematode reproduction in the nematode induced pot culture experiment. At 30 days after nematode inoculation, whole plants were uprooted, washed and ranked for root galling on the basis of root-knot index (1-5 scales). All the tomato varieties had shown varying degree of responses. Out of 25 varieties screened, only two varieties were resistant with least gall number (4-6 galls/plant), one variety was moderately resistant (25 galls/plant), nine varieties were susceptible (32-66 galls/plant) and eleven were highly susceptible (105-132 galls/pant). Due to infection of root-knot nematode, the maximum average shoot length of tomato varieties was 60.43 cm in variety Banki local. The decrease in shoot length was more pronounced with 23.43 cm in Utkala kumari variety, which was statistically different from other varieties. The decrease possibly due to improper uptake and transport of elements, nutrients and water resulted from nematode infection. The decrease in shoot weight (8.53 g) and dry root weight (0.40 g) of the tomato varieties, Utkala kumari and Utkala dipti was significantly different from the rest varieties possible reason for reduction of shoot weight and root weight in infected plant may be due to improper supply of nutrients resulting from nematode infection for which it is compensated to some extent in resistant varieties.

Keywords: Tomato, nematode, *Meloidogyne incognita*, screening, resistance

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most popular vegetable crops worldwide, owing to its high nutritive value and diversified use. India ranks second after china with annual production of 18.7 tonnes covering an area of about 808500 hectare (Horticultural Statistics-2017, Ministry of Agriculture & Farmer's welfare, GOI). The low yield is attributable a number of abiotic and biotic factors including bacteria, fungi, virus and particularly nematodes [1] which reduce quality and quantity of tomato. Among nematodes, the root knot nematode, *Meloidogyne incognita* is a major pest and is reported to cause yield loss of 35% [2] in India. Damage to plants is influenced by root penetration, development, reproduction potential and inoculums density of *M. incognita* in adjacent soil [3]. It also alters the host physiology and on severe infestations can kill the tomato plant outright [4]. Various approaches such as chemical application, good agricultural practices (GAP), resistance breeding etc. have been devised to manage RKN.

The degree of root galling generally depends on the magnitude of *Meloidogyne* population density, host plant species and cultivar. Severe nematode infections result in decreased yield of tomato and the quality of the marketable products is reduced and cause tissue breakdown, deformation or discoloration. Several researchers have suggested the utilization of resistant varieties is one of the cheap, primary, economically feasible and environmentally benign methods to combat *M. incognita* menance in tomato as compared to nematicides [5][6][7]. It has been found that root-knot nematodes may enter susceptible and resistant tomato varieties in about equal numbers. Hence breaking of resistance in tomato cultivars to *M. incognita* may occur naturally or by selection of tomato plants with one or more resistant genes [8]. The primary objective of the current research was to evaluate the available tomato genotypes by screening method against root knot nematode *M. incognita.*

Materials and methods

Experimental procedure

Seeds of twenty five tomato (*Solanum lycopersicum*) varieties were procured from AICRP on Vegetable crops, OUAT, Bhubaneswar, Indian Institute of Vegetable research (IIVR), Varanasi and different localities of Odisha to test their reactions to the test nematode, *Meloidogyne incognita*. Pot culture experiment was carried out in CRD design with three replications in the green house of Department of Nematology, College of Agriculture, OUAT, Bhubaneswar during *Kharif* 2017-18. Earthen sterilized pots of 15 cm diameter were filled with denematised, sterilized sand, soil and FYM mixture in 2:1:1 ratio @ 1kg/pot. Seeds of each variety were sown in the earthen pots containing steam sterilized soil.

M. incognita pure culture was initiated from single egg masses and propagated on roots of highly susceptible tomato genotype in the greenhouse. Eggs were collected from galled roots of tomato and inoculated with the potted plants maintained as pure culture. This was done two months prior to the start of the experiment.

Nematode Inoculation

Freshly hatched second stage juveniles (J_2) of *Meloidogyne incognita* were isolated and were counted in rectangular counting dish under a stereoscopic microscope. Each pot was inoculated with infective J_2 of root-knot nematode, *M. incognita* @ $1000J_2$/kg soil on 15 days after sowing.

Screening of tomato varieties against root-knot nematode

At 30 days after inoculation, inoculated plants were removed from the pot soil carefully. Roots were washed free from soil and other adhering particles by gentle stream of water. Roots were observed under a stereoscopic microscope and the numbers of galls produced on each plant roots were counted. Tomato varieties were categorized as per the Root-knot Index Scale given below [9].

Table 1: Root-knot Index Scale (Taylor and Sasser, 1978)

Scale	No. of galls/eggs/ eggmass	Reactions
1	0	Highly resistant (HR)
2	1-10	Resistant (R)
3	11-30	Moderately resistant (MR)
4	31-100	Susceptible (S)
5	More than 100	Highly susceptible (HS)

Evaluation of tomato varieties against root-knot nematode

Observations were recorded on shoot length, fresh shoot weight, dry shoot weight, root length, fresh root weight, dry root weight, number of galls/plant, final nematode population on each variety in soil as well as in root and reactions of the varieties to the test nematode, *Meloidogyne incognita*.

Results and discussion

Effect of nematode inoculation on gall production in varieties

Table 2 depicted that out of twenty five varieties of tomato screened, two varieties i.e. banki local and Rajsunakhala local were found to be resistant with least number of galls i.e 4 galls/plant and 5.67 galls/plant respectively, while one variety i.e Kashi aman was found to be moderately resistant with gall no 25 galls/plant, nine varieties were found to be susceptible with gall number 32-66 galls/plant and eleven varieties were found to be highly susceptible with gall number 105-132 galls/pant. Root gall production on the roots of all the tomato genotypes due to *Meloidogyne incognita* inoculation at differential rates, might be due to differences in genetic makeup among the genotypes [10]. High root gall indices (4 to 5) for all twenty tomato varieties rendered them as good host of *M. incognita* whereas lowest root gall index (2) were found in the resistant tomato varieties of Banki local and Rajsunakhala local. The nematode resistant plants are characterized by failure of the nematodes to produce functional feeding sites in the host after invasion and to develop hypersensitive responses [11].

Table 2: Screening of tomato varieties against root-knot nematode, *Meloidogyne incognita*

S. No.	Varieties	No. of galls	Root-knot index	Reaction
1	Utkala Kumari	132.33	5	HS
2	Pusa Ruby	127.33	5	HS
3	Nayagarh local	128.00	5	HS
4	Banki local	4.00	2	R
5	S-22 (Dhanalaxmi hybrid)	51.33	4	S
6	JK-119	48.33	4	S
7	Utkala Dipti	66.00	4	S
8	Utkala Raja	122.67	5	HS
9	Utkala Prangya	114.00	5	HS
10	Utkala Pallavi	120.67	5	HS
11	Sundergarh local	46.00	4	S
12	Baragarh local	35.67	4	S
13	Rajsunakhala local	5.67	2	R
14	Utkala Urbasi	32.33	4	S
15	Kashi Amrut	41.33	4	S
16	Kashi Aman	25.67	3	MR
17	Kashi hemant	110.67	5	HS
18	Kashi Bishes	105.67	5	HS
19	Kashi Anupam	115.67	5	HS
20	Kashi Sarada	63.00	4	S
21	Bariguma local	103.67	5	HS
22	Umerkot local	61.00	4	S
23	Nimapada local	125.67	5	HS
24	Arka Vikash	37.33	4	S
25	IIVR Selection-2	45.67	4	S

	SE(m) ±	2.03		
	CD(0.05)	5.86		

Effect of nematode infections on shoot growth parameters:

Also Table 3 depicted that among all the tested tomato varieties there were significant differences in decline of shoot growth parameters after *M. incognita* infection. Due to infection of root-knot nematode, the maximum average shoot length and fresh shoot weight of tomato varieties were 60.43 cm and 46.93 g respectively in variety Banki local and the decrease in shoot length and fresh shoot weight were more pronounced with 23.40 cm and 8.53 g, respectively in Utkala Kumari variety, which was statistically different from other susceptible varieties. The dry shoot weight was maximum 8.40 g in variety Rajsunakhala local i.e. in resistant variety and was minimum in case of Utkala Kumari i.e. 2.60 g tomato variety among all susceptible varieties.

Table 3: Evaluation of tomato varieties against root-knot nematode, *Meloidogyne incognita*

S. No.	Varieties	Shoot length (cm)	Fresh shoot wt.(g)	Dry shoot wt.(g)	Root length (cm)	Fresh root wt.(g)	Dry root wt.(g)	Final Nematode population (Soil and Root)
1	Utkala Kumari	23.40	8.53	2.60	16.30	2.60	0.63	1987.00(3.30)*
2	Pusa Ruby	49.33	36.53	7.43	35.80	9.10	2.00	1925.67(3.28)
3	Nayagarh local	46.13	16.70	3.70	25.93	4.10	3.20	1945.67(3.29)
4	Banki local	60.43	46.93	6.37	39.20	7.23	1.20	326.00(2.51)
5	S-22 (Dhanalaxmi hybrid)	48.70	32.80	8.20	26.70	9.30	2.63	1353.67(3.13)
6	JK-119	51.70	30.07	6.67	34.10	7.77	1.80	1280.67(3.11)
7	Utkala Dipti	27.70	12.93	2.80	17.13	3.00	0.40	1821.00(3.26)
8	Utkala Raja	29.83	25.33	4.87	20.10	5.03	2.23	1853.00(3.27)
9	Utkala Prangya	40.93	34.53	3.60	16.63	3.80	1.30	1735.00(3.24)
10	Utkala Pallavi	23.67	19.53	6.17	18.73	3.77	2.50	1821.00(3.26)
11	Sundergarh local	45.40	28.40	5.33	26.63	4.00	3.60	1485.00(3.17)
12	Baragarh local	37.30	20.90	3.63	25.10	3.23	2.10	1125.67(3.05)
13	Rajsunakhala local	58.53	46.60	8.40	31.73	11.23	6.13	500.00(2.70)
14	Utkala Urbasi	33.40	16.80	5.93	19.03	5.00	4.00	1045.00(3.02)
15	Kasi Amrut	46.90	22.80	4.80	27.10	6.10	2.93	1194.67(3.08)
16	Kasi Aman	44.10	14.63	4.20	21.83	9.73	1.30	644.67(2.81)
17	Kasi hemant	37.87	11.93	4.67	24.33	3.30	2.00	1704.33(3.23)
18	Kasi Bishes	38.47	19.20	4.10	24.23	4.23	2.73	1610.33(3.21)
19	Kasi Anupam	35.60	22.20	4.63	23.90	5.73	1.10	1792.67(3.25)
20	Kasi Sarada	33.40	20.73	5.27	18.03	3.73	2.10	1391.67(3.14)
21	Bariguma local	34.70	14.60	5.10	24.70	3.40	1.70	1523.00(3.18)
22	Umerkot local	39.40	18.33	6.90	22.73	4.90	2.70	1378.00(3.14)
23	Nimapada local	39.73	22.03	7.70	17.43	3.00	2.63	1921.67(3.28)
24	Arka Vikash	34.77	13.83	2.73	23.50	3.63	1.53	1098.67(3.04)
25	IIVR Selection-2	32.83	12.07	2.63	21.33	3.33	1.23	1351.00(3.13)
	SE(m) ±	1.66	1.21	0.30	0.65	0.36	0.22	0.05
	CD(0.05)	4.79	3.50	0.87	1.88	1.04	0.64	0.14

* Figures in parentheses are log transformed values

Effect of nematode infections on root growth parameters

Due to infection of root-knot nematode, the maximum average root length of tomato varieties was 39.20 cm in Banki local. The decrease in root length was more pronounced with 16.30cm in Utkala Kumari variety, which was statistically different from other susceptible varieties. Maximum fresh root weight and dry root weight was 11.23 g and 6.13 g respectively in Rajsunakhala local and minimum fresh root weight and dry root weight 2.60 g and 0.63 g respectively in case of Utkala Kumari tomato varieties among all susceptible and resistant varieties. Plant growth reduction in tomato genotypes might be due to severe root galling and arrested root system by nematode infection. The decrease is possibly due to improper uptake and transport of elements, nutrients and water resulted from nematode infection [12].

Reaction of cultivars to the test nematode

Table 3 reveal that final nematode population in both soil and root was marked maximum in highly susceptible varieties like Utkala Kumari (1987), Pusa Ruby (1925.67) and Nimapada local (1921.67), susceptible varieties like Utkala dipti (1821), Sundergarh local (1485) and Bargarh local (1125.67) and least in resistant varieties like Banki Local (326) and Rajsunakhala local (500). The occurrence of variation in susceptibility among twenty five tomato variety to *M. incognita* might be due to genetic differences [10]. The population of females per soil and root was significantly increased in highly susceptible and susceptible tomato varieties and that was decreased in moderately resistant and resistant tomato varieties. So number of females, number of egg masses and number of eggs per gram of root recorded in tomato varieties are the better indicators of nematode reproduction than root gall index [13].

Conclusion

This study indicated that the resistant cultivars (Banki local, Rajsunakhala local) and moderately resistant cultivar (Kashi Aman) are therefore recommended for cultivation under integrated production systems because these would be a profitable alternative for the production of healthy, toxic free tomato to the consumers and in developing new resistant cultivars.

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