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Identification of resistant sources of cucumber against *Meloidogyne incognita*

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Abstract
Cucumber (*Cucumis sativus*) is widely grown in open as well as in protected cultivation in Punjab. Among phytonematodes, the genus *Meloidogyne*, popularly known as root-knot nematode is an important constraint in production of cucumber. Use of resistant cultivar is an important measure for managing root knot nematode as compared to the other management strategies. Of the thirty genotypes, twenty eight genotypes were found to be susceptible or highly susceptible against *Meloidogyne incognita.* Genotype PBRK3 was found to be moderately resistant and one genotype Pant Khira was found to be moderately susceptible. Plant height was also affected by the infestation of *M. incognita* in different genotypes and significant decrease was observed as compared to control. In the case of highly susceptible cultivars, the reductions in yield parameters were maximum, whereas the reductions in moderately resistant and moderately susceptible cultivars were found to be minimum. Minimum percent reduction in height was found in PBRK 3 (4.54 percent) over control and 7070 cucumber genotype showed maximum reduction in height over control of 75.68 percent.

Keywords: Cucumber, *Meloidogyne incognita*, screening, resistance

Introduction
India has wide variability of climate and soil which helps to produce a variety of horticultural crops and is considered as fruit and vegetable basket of the world. Among the vegetables, cucumber (*Cucumis sativus*) belonging to the family cucurbitacae is widely grown in open as well as in protected cultivation in Punjab. Polyhouses/nethouses farming is recently picking up in Punjab to take crops in off season with minimal use of chemicals. Root knot nematodes are an economically important pathogen of cucumber infesting the crop in open as well as under protected structures. These nematodes cause characterized gall like symptoms on the roots of plants which hampers the uptake of nutrients to plant causing yellowing stunting and loss in productions. These nematodes belong to genus *Meloidogyne* amongst which, *M. incognita* is reported to be widely associated with cucumber and responsible for its low production [1]. Yield loss up to 6-18 per cent has been reported in India [2]. The damage severity caused, however vary depending on the susceptibility of the variety, nematode population density, environmental conditions and presence of other pathogens in the soil. The losses are more severe under protected cultivation due to favorable microclimate and continuous availability of host [3].

Managing the population of these nematodes below damaging levels is important for reducing economic losses and sustaining productions. Different control methods have been used against the root-knot nematodes, like chemical, cultural and biological, but some of them stand out as inefficient and others can cause environmental damage. The use of resistant cultivars is a widely accepted alternative method to combat *M. incognita* menace, due to its low cost, high efficiency and environmentally benign effect [4]. Hence the possible knowledge of resistant sources from a wider genetic diversity of crop, be it wild or cultivated helps in the development of successful cultivars with better traits. Biotechnologists and breeders can use the platform of identified resistant sources from the wider genetic diversity for transfer of genes to susceptible cultivars. These are lately used in breeding programs such as those of tomato where the characterization of wild accessions has contributed considerably to increases in tomato productivity [5]. In this context, the present studies were undertaken to identify resistant sources in cucumber for their use in management programs of *Meloidogyne incognita* which is continuously becoming a hurdle in production of cucumber especially under protected cultivation in Punjab.

Materials and Methods

Thirty genotypes of cucumber were procured from Department of Vegetable Sciences, Punjab Agricultural University Ludhiana. The genotypes were screened in pot house, Department of Plant Pathology, Punjab Agricultural University Ludhiana for resistance against root knot nematode, *Meloidogyne incognita*. Earthen pots of 30 cm diameter were filled with *Meloidogyne incognita* infested soil. The initial population of the soil was assessed by taking a core of ten samples and was estimated as 266.66 nem/250cc soil. In all, 120 pots were filled to accommodate 30 genotypes with four replications for each genotype. Seeds of cucumber genotypes were directly sown in pots. Five seeds of each genotype were sown per pot and after germination and seedlings were thinned to one plant in each pot. Pots were kept in screen house and watered as per requirement.

Forty five days after sowing, plants were uprooted to record observations on plant growth parameters (shoot length, root length, shoot weight, root weight), as well as root gall index and soil nematode population. Soil samples were washed using Modified Cobb's sieving and decanting technique [6] [7] to estimate nematode population in soil, while infestation in roots was rated on the basis of root galls. Galling on the roots was scored according 0-10 rating scale [8] where rating '0' =no knots on roots; 1 = small knots but difficult to find (only on some plants); 2 = small knots only but clearly visible; main roots clean; 3 = some larger knots visible, but main roots clean; 4 = larger knots predominate but main roots clean; 5 = 50% of roots knotted; knotting on parts of main root system, 6 = knotting on some of main roots; 7 = majority of main roots knotted; 8 = all main roots knotted, few clean roots visible; 9 = roots severally knotted, plant usually dying and 10 = all roots severally knotted, no root.

Each genotype was designated resistant or susceptible as per categorization index [9], where genotypes having RGI less than 2 were categorized as immune, genotypes with RGI ranging from 2.0-3.0 were moderately resistant, genotypes with RGI from 3.0-5.0 were found to be moderately susceptible, genotypes with RGI ranging from 5.0-7.0 were categorized as susceptible and genotypes with RGI more than 7 were found to be highly susceptible. Soil population was also recorded by using Modified Cobb's sieving and decanting method. Reproduction factor (Rf) was calculated as follows;

Reproduction Factor Rf= Pf/Pi

Where, Pf is Final nematode population and Pi is initial nematode population. Rf greater than 1, denotes reproduction, while Rf of less than 1, implied no reproduction.

The formula for calculating root galling index was:

$$RGI = \frac{\text{Sum total of grades of all the plants observed}}{\text{Total number of plants observed}}$$

Results and Discussion

Evaluation of cucumber genotypes for resistance against *Meloidogyne incognita*

Thirty genotypes of cucumber were evaluated for identification of resistant source/s in cucumber. A perusal of data of Table 1 revealed that these genotypes exhibited variable response from moderately resistant to susceptibility. Seven genotypes were found to be highly susceptible. The roots of these genotypes showed excessive galling and plants were rated as highly susceptible on the basis of RGI scale (RGI>7). These genotypes were; PBRK 5, PBRK 7, PBRK 13, Raspal, Cucumber 1, 7070, Pant Sanker. Soil nematode population in these genotypes was also found to be high ranging from 634-898 nem/250 cc soil indicating greater multiplication of the nematode on these genotypes. Twenty one genotypes were found to be susceptible to root knot nematode *viz*; Punjab Naveen, PBRK 1, PBRK2, PBRK 4, PBRK 6, PBRK 8, PBRK 9, PBRK 11, Multistar, Poinsette, Japneese Long Green, Black Wander, 416, Cucumber 2, Swarna Agati, NCH 1, NCH 12, TMG, Summer Khira, Pant Khira 1 and Nepal. Root galling index ranged from 5-7 in these genotypes and soil nematode population ranged from 333-566 nem/250 cc soil. Pant khira genotype showed moderate susceptibility (RGI-4.0). One genotype PBRK 3 was found to be moderately resistant indicating lesser multiplication of root knot nematode in this genotype (RF <1). The categorization of these genotypes into different categories for their reaction from susceptibility to moderately resistant has been given in Table 2. It had been reported that none of the fifteen cultivars of cucumber (*Cucumis sativus*) tested for their response to *M. incognita* was immune or highly resistant [10]. Earlier, 289 cucumber accessions had evaluated and all were found susceptible to *M. incognita* and these were marked by profuse galling and nematode reproduction [11] while *C. metuliferus* had reported as highly resistant to the root knot nematode [12].

Table 1: Evaluation of genotypes of cucumber against root knot nematode, *Meloidogyne incognita*

Genotypes	Shoot length (cm)	Root length (cm)	Shoot weight (gm)	Root weight (gm)	Soil nematode population/ 250cc soil	Reproduction Factor (Rf=Pf/Pi)	RGI**
Punjab-Naveen	60.75	15.94	27.63	2.01	333 (18.44*)	1.24	5.2
PBRK-1	53.46	14.45	25.04	2.44	416 (21.09*)	1.56	5.8
PBRK-2	58.78	15.17	27.75	2.12	362 (18.89*)	1.35	5.4
PBRK-3	75.60	18.70	30.25	1.94	224 (10.42*)	0.84	3.0
PBRK-4	48.56	12.52	21.98	2.78	533(22.59*)	1.99	6.6
PBRK-5	12.42	8.44	10.75	3.66	813 (26.97*)	3.04	8.0
PBRK-6	50.20	13.65	23.74	2.56	462 (23.00*)	1.73	6.2
PBRK-7	24.56	8.76	11.88	3.37	776(25.43*)	2.91	7.4
PBRK-8	46.89	12.94	23.46	2.65	496 (21.65*)	1.86	6.4
PBRK-9	48.99	12.88	22.67	2.66	512 (22.18*)	1.92	6.4
PBRK-11	45.22	11.79	21.98	2.82	556 (22.91*)	2.08	6.8
PBRK-13	18.76	8.52	11.72	3.48	798 (25.99*)	2.99	7.4
Raspal	30.21	9.90	14.75	3.13	634 (23.92*)	2.37	7.2
Multistar	48.71	12.76	22.61	2.71	516 (22.26*)	1.93	6.4
Poinsette	53.17	14.33	24.90	2.46	423 (21.71*)	1.58	5.8
Japneese-Long-	50.23	13.66	23.73	2.63	476 (22.21*)	1.78	6.2

Green							
Black-Wander	45.37	11.77	20.88	2.89	562 (23.19*)	2.1	6.8
416	45.57	11.65	20.82	2.99	566 (23.22*)	2.12	6.8
Cucumber-1	29.43	9.75	14.14	3.24	666(24.29*)	2.49	7.2
Cucumber-2	52.56	13.75	24.75	2.52	446 (21.88*)	1.67	6.0
Swarna-Agati	57.17	15.11	26.68	2.16	366 (19.63*)	1.37	5.4
NCH-1	56.26	14.99	26.76	2.33	376 (20.18*)	1.41	5.6
NCH-12	60.43	15.76	27.60	2.11	349 (18.74*)	1.3	5.2
7070	10.55	8.14	10.02	3.78	898 (27.34*)	3.36	8.0
PantKhira	76.17	18.10	33.45	1.24	276 (16.46*)	0.86	4.0
TMG	53.66	13.72	24.66	2.54	456 (21.36*)	1.71	6.0
Pant-Sanker	25.23	9.05	12.81	3.34	735 (25.02*)	2.75	7.4
Summer-khira	47.76	12.74	22.56	2.73	526(22.36*)	1.97	6.4
PantKhira-1	55.35	14.86	25.46	2.35	392 (20.39*)	1.47	5.6
Nepal	54.48	14.66	25.16	2.39	396 (21.13*)	1.48	5.6
CD (P=0.05)					3.67		1.14

Initial population- 266.66 nem/250cc soil
*Figures in parentheses are square root transformed values of respective data
**Root Gall Index

Table 2: Categorization and reaction of genotypes of cucumber

Reaction	RGI (Root Gall Index) (0-10 scale)	Genotypes
Immune	Less than 2	Nil
Moderately resistant	2.0-3.0	PBRK 3
Moderately Susceptible	3.0-5.0	Pant Khira
Susceptible	5.0-7.0	Punjab Naveen, PBRK 1, PBRK 2, PBRK 4, PBRK 6, PBRK 8, PBRK 9, PBRK 11, Multistar, Poinsette, Japneese Long Green, Black Wander, 416, Cucumber 2, Swarna Agati, NCH 1, NCH 12, TMG, Summer Khira, Pant Khira 1, Nepal
Highly susceptible	More than 7	PBRK 5, PBRK 7, PBRK 13, Raspal, Cucumber 1, 7070, Pant Sanker,

Effect of *M .incognita* on plant height of cucumber

The data in Table 3 revealed that plant height was affected by the infestation of *M .incognita* in different genotypes evaluated and significant decrease was observed as compared to control. Due to infection of *M .incognita*, PBRK 3 and Pant Khira were found to be at par in maximum average height with 94.3 and 94.27cm height respectively. Minimum percent reduction in height was found in PBRK 3 (4.54 percent) over control. Minimum average height 18.69 cm was found in 7070 cucumber genotype with maximum reduction in height over control of 75.68 percent. The effect of nematode infestation was higher in highly susceptible genotypes where more than fifty percent reduction in height of the plant was observed. In the case of highly susceptible cultivars, the reductions in yield parameters were maximum, whereas the reductions in resistant and moderately resistant cultivars were found to be minimum. The maximum decrease in growth and yield variables of susceptible cultivars can be ascribed to severe root damage owing to nematode entry and/or feeding which resulted in impairment and disruption of water absorption by the infected root systems. As the infected plants face insufficient supply of nutrients, energy, water etc., therefore, development and growth of leaf tissues and their essential constituents particularly chlorophyll pigments, are greatly hampered [1]. The stunted and reduced growth of foliar parts subsequently results in reduced biomass and productivity [13].

Table 3: Comparative plant height of different genotypes of cucumber in *M .incognita* in inoculated and non inoculated soil

Genotypes	Plant height (cm) in *M .incognita* infested soil	Plant height (cm) in non *M .incognita* infested soil	Percent reduction in plant height
Punjab-Naveen	76.69	86.62	11.46
PBRK-1	67.91	75.36	9.89
PBRK-2	73.95	78.45	5.74
PBRK-3	94.3	98.78	4.54
PBRK-4	61.08	72.35	15.58
PBRK-5	20.86	68.29	69.45
PBRK-6	63.85	74.34	14.11
PBRK-7	33.32	68.2	51.14
PBRK-8	59.83	67.65	11.56
PBRK-9	61.87	69.68	11.21
PBRK-11	57.01	66.98	14.89
PBRK-13	27.28	71.42	61.80
Raspal	40.11	74.65	46.27
Multistar	61.47	69.26	11.25
Poinsette	67.5	77.62	13.04
Japanese-Long-Green	63.89	78.31	18.41
Black-Wander	57.14	64.61	11.56
416	57.22	63.85	10.38

Cucumber-1	39.18	67.13	41.64
Cucumber-2	66.31	73.54	9.83
Swarna-Agati	72.28	76.42	5.42
NCH-1	71.25	78.21	8.90
NCH-12	76.19	82.45	7.59
7070	18.69	76.84	75.68
PantKhira	94.27	99.36	5.12
TMG	67.38	78.24	13.88
Pant-Sanker	34.28	73.54	53.39
Summer-khira	60.5	69.64	13.12
PantKhira-1	70.21	79.64	11.84
Nepal	69.14	78.84	12.30

Conclusion

It is concluded from the present study that cultivation of susceptible and highly susceptible cultivars increases *M. incognita* infestation in soil while cultivation moderately resistant cultivar would help to decrease the infestation of *M. incognita.* Moderately resistant genotype PBRK 3 and moderately susceptible genotype Pant Khira did not support nematode population and there was no significant damage to the plant as compared to susceptible genotype of cucumber to and hence these can be explored for crop improvement breeding program.

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