



RESEARCH ARTICLE

Screening of chili genotypes against root-knot nematode (*Meloidogyne incognita*) under screen-house conditions

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Abstract

Chili (*Capsicum annuum* L.) is a vital crop in global agriculture, particularly in India, where it faces significant challenges from pests, notably root-knot nematodes (RKNs), specifically *Meloidogyne incognita*. This pathogen significantly impacts both the yield and quality of the crop. To counter these adverse effects, there is a pressing need for resistant genotypes. Consequently, this study was conducted to identify chili genotypes that exhibit resistance to root-knot nematodes, aiming to enhance economic yields. Based on the root-knot index and number of galls, six genotypes (Arka Swetha, Kashi Abha, CIAH/CHES/LPYCHG-2, CIAH/CHES/LPYCHG-3, AICRP-CH 2 and AICRP-CH 3) had shown susceptible reaction with 31.3 to 54.3 number of galls per root system, while 14 genotypes Kashi Anmol, Kashi Ratna, Pusa Sadabahar, CIAH/CHES/LPYCHG-1, CIAH/CHES/LPYCHG-4, CIAH/CHES/LPYCHG-5, CIAH/CHES/LPYCHG-6, CIAH/CHES/LPYCHG-7, CH 1 Raj 2022, CH 2 Raj 2023, AICRP-CH 4, AICRP-CH 5, AICRP-CH 6 and AICRP-CH 7) had shown moderately resistant reaction with 21.0 to 27.0 number of galls per root system and remaining six genotypes (Arka Khyati, Arka Meghana, Arka Harita, CH-RLC 2021, CH-WI 2020 and AICRP-CH 1) had shown resistant reaction with 4.7 to 9.0 number of galls per root system. The resistant genotypes exhibited the least percentage decrease in fresh root weight, fresh shoot weight, dry root weight and dry shoot weight compared to uninoculated plants, whereas the susceptible genotypes showed the greatest reductions. The lowest number of galls per plant, egg masses per root system and reproduction factor were observed in the Arka Harita variety, followed by Arka Meghana. In contrast, the highest values were recorded in Kashi Abha.

Keywords: Chili, Root-knot nematode, Resistance, Screen-house.

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Introduction

Chili (*Capsicum annuum* var. *annuum*) is a vital vegetable and spice crop from the Solanaceae family, cultivated globally for its aromatic, flavorful, and pungent fruits. *Capsicum* includes 22 wild species and three varieties, as well as five domesticated species and their wild relatives. Chili (*Capsicum annuum* var. *annuum*) is the most commercially cultivated species, while valuable disease-resistance genes are found in other domesticated species and their wild relatives. Plant-parasitic nematodes are the major biotic stressors in crop cultivation. They are referred to as plant-parasitic because the nutrients they obtain come directly from plants. These nematodes possess a needle-like structure called a stylet, which allows them to pierce plant cell walls and access the nutrient-rich contents they feed on (Tileubayeva *et al.*, 2021). Overall, plant-parasitic nematodes (PPNs) cause 21.3% crop losses, amounting to Rs. 102,039.79 million (approximately 1.58 billion USD) annually. Among different PPNs, RKNs alone are responsible for Rs. 77,373.87 million losses in different crops, constituting about 75.83% of the total estimated losses, thus proving to be the economically most important

of all the PPNs. About 15% of losses in chili crops are due to PPNs (Kumar *et al.*, 2020).

Root-knot nematodes (RKNs) of the genus *Meloidogyne* are prevalent soil pests found in warm climates or areas with mild winters. This genus includes more than 60 species that can affect approximately 2,000 plant species (Godwa *et al.*, 2024). Among these, four species *M. javanica*, *M. arenaria*, *M. incognita* and *M. hapla* are considered major global pests. The growth and production of plants, particularly chili crops, are significantly affected by these four main species of RKNs. Out of these four, *M. incognita* is the most extensively studied species due to its widespread prevalence in agricultural systems. However, *M. incognita* and *M. javanica* have more prevalence in the Haryana and Punjab regions (Adam *et al.*, 2014). Thus, controlling and managing root-knot nematodes (RKN) is a primary objective in stabilizing chili production in India. The wide host range and rapid reproduction rates of *Meloidogyne* species complicate RKN management. Controlling nematodes through chemicals is expensive and offers only a short-term solution. Additionally, the use of chemicals for nematode control can harm human health, soil quality and the environment due to chemical residues in fruits and soil. This contamination can negatively affect human immunity and disrupt beneficial organisms in the soil. Therefore, there is a pressing need to develop nematode-resistant varieties and hybrids. Thus, this study was conducted to integrate the above scientific approaches involving nematology aspects and evaluation of chili genotype against pathogen, *i.e.*, root-knot nematode, especially under protected cultivation and to get a cost-effective and environment-friendly solution to this devastating problem. The objective of this was to evaluate the chili genotypes for resistance against root-knot nematode (*Meloidogyne incognita*) under screen-house conditions.

Materials and Methods

Study location

The experiment was conducted at CCS Haryana Agricultural University, Hisar, situated at 29° 43' 92" N and 75° 72' 17" E at an elevation of 215.2 m above sea level during *Kharif* season, 2023 in a completely randomized design (CRD) that included three replications of 26 genotypes used during the course of an investigation.

Nematode resistance screening assay

About 26 genotypes of chili were procured from different sources (Table 1) to conduct screening of resistance against root-knot nematode (*M. incognita*). The seeds of these genotypes were sown in portrays to raise the seedlings in the poly house at the grafting unit of the vegetable science department, CCS Haryana Agricultural University, Hisar. About 35 days old seedlings were transplanted in

pots. The recommended package of practice was followed for successfully raising the chili crop. The seedlings were inoculated with 2000 freshly hatched second-stage juveniles of *M. incognita* per pot (*i.e.*, freshly hatched J₂/g soil) after one week of transplanting in the screen house.

Plant response to *M. incognita*

The pot-raised plants were examined after 45 days of inoculation with *M. incognita*. The plants were uprooted and washed carefully under running tap water to remove the adhering soil particles and, thereafter, dried with butter paper. The roots of the uprooted plants were examined for the number of galls per root system, the number of egg masses per root system and the root-knot index for categorization of the genotypes (AICRP Root-Knot Index).

Statistical analysis

The data obtained under the experiment was subjected to one-factorial Completely Randomized Design (CRD) and analyzed by using the OPSTAT program available online at CCS HAU, Hisar website (www.hau.ac.in). The statistical significance of the 'F' value was assessed at a 5% level of significance. Furthermore, the critical difference value was calculated with a significance level of 0.05. The necessary transformation of data was done.

Results

Among the inoculated genotypes, maximum fresh root weight was recorded in Arka Harita (4.90 g) and this is statistically at par with genotype Arka Khyati (4.61 g). Figure 1 depicted that the minimum reduction in fresh root weight of inoculated genotypes as compared to uninoculated was recorded in Arka Harita (7.7%), followed by Arka Meghana (9.5%). Conversely, the maximum reduction was recorded in Kashi Abha (58.3%), closely followed by AICRP-CH 2 (55.0%) and AICRP-CH 3 (54.3%), respectively. The results of Table 1 indicated that the minimum percent reduction in terms of fresh shoot weight over uninoculated was recorded in Arka Haritha (8.3%), followed by Arka Meghana (9.2%). The highest fresh shoot weight among inoculated genotypes was observed in Arka Harita (8.10 g) and this is statistically at par with genotype Arka Meghana (7.90 g). The lowest fresh shoot weight among inoculated genotypes was observed in Kashi Abha (3.23 g) and followed by AICRP-CH 2 (3.54 g). The maximum reduction was recorded in Kashi Abha (60.7%) and followed by AICRP-CH 2 (56.7%).

The maximum dry root weight among inoculated genotypes was recorded in Arka Harita (2.10 g) and this is statistically at par with genotypes Arka Khyati (2.00 g) and Arka Meghana (1.97 g). Figure 2 shows that the maximum reduction due to nematode infestation was recorded in Kashi Abha (59.1%) and followed by AICRP-CH 2 (55.3%) and AICRP-CH 3 (50.7%). The minimum reduction was recorded in Arka Harita (8.6%), followed by Arka Meghana (8.7%),

Table 1: Source of genotypes used for the experiment

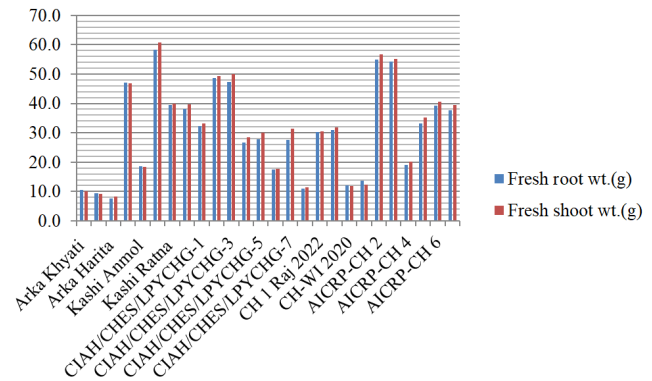
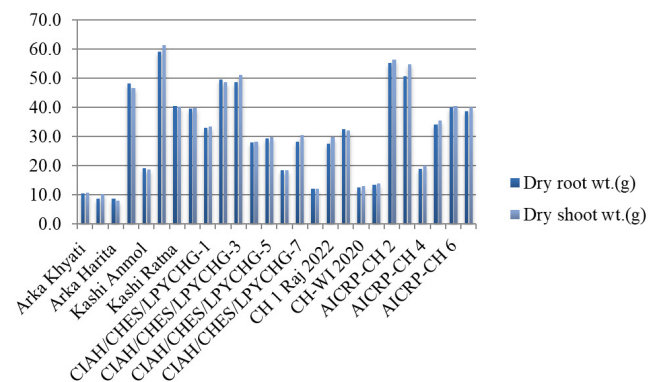
S. No.	Genotypes	Source
1	Arka Khyati	IIHR, Bangalore
2	Arka Meghana	IIHR, Bangalore
3	Arka Harita	IIHR, Bangalore
4	Arka Swetha	IIHR, Bangalore
5	Kashi Anmol	IIHR, Varanasi
6	Kashi Abha	IIHR, Varanasi
7	Kashi Ratna	IIHR, Varanasi
8	Pusa Sadabahar	IARI, New Delhi
9	CIAH/CHES/LPYCHG-1	Gujrat
10	CIAH/CHES/LPYCHG-2	Gujrat
11	CIAH/CHES/LPYCHG-3	Gujrat
12	CIAH/CHES/LPYCHG-4	Gujrat
13	CIAH/CHES/LPYCHG-5	Gujrat
14	CIAH/CHES/LPYCHG-6	Gujrat
15	CIAH/CHES/LPYCHG-7	Gujrat
16	CH-RLC 2021	Vegetable grafting unit, Hisar
17	CH 1 Raj 2022	Vegetable grafting unit, Hisar
18	CH 2 Raj 2023	Vegetable grafting unit, Hisar
19	CH-WI 2020	Vegetable grafting unit, Hisar
20	IET 2021/CHIHBY 6 (AICRP-CH 1)	AICRP
21	2020/CHIHBY 4 (AICRP-CH 2)	AICRP
22	IET 2021/CHIHBY 3 (AICRP-CH 3)	AICRP
23	2020/CHIHBY 3 (AICRP-CH 4)	AICRP
24	2020/CHIHBY 6 (AICRP-CH 5)	AICRP
25	IET 2021/CHIHBY 7 (AICRP-CH 6)	AICRP
26	IET 2021/CHIHBY 4 (AICRP-CH 7)	AICRP

Table 2: Categorization of genotypes (According to the AICRP root-knot index)

Gall index	Number of root galls/root system	Reaction
1	0	Highly resistant (HR)
2	1–10	Resistant (R)
3	11–30	Moderately resistant (MR)
4	31–100	Susceptible (S)
5	>101	Highly susceptible (HS)

Arka Khyati (10.6%) and CH-RLC 2021 (12.1%). The results from Table 3 depicted that all the genotypes showed a decreasing trend in terms of dry shoot weight with respect to the uninoculated genotypes due to nematode infestation.

Figure 2 shows that Arka Harita recorded a minimum reduction of 7.9%, while Kashi Abha recorded a maximum reduction of 61.3%. The highest dry shoot weight was

**Figure 1:** Percent reduction in fresh root and shoot weight over uninoculated genotypes**Figure 2:** Percent reduction in dry root and shoot weight over uninoculated genotypes

recorded in Arka Harita (2.30 g) and this is significantly different from other genotypes. The lowest dry shoot weight among the inoculated genotypes was observed in Kashi Abha (0.81 g) followed by AICRP-CH 2.

About 26 chili genotypes were screened and evaluated against *M. incognita*. Data regarding the root-knot index are presented in Table 4. Considering the root-knot index, the superior genotypes were Arka Khyati, Arka Meghana, Arka Harita, CH-RLC 2021, CH-WI 2020 and AICRP-CH 1 with a root-knot index of 2. The genotypes viz., Kashi Anmol, Kashi Ratna, Pusa Sadabahar, CIAH/CHES/LPYCHG-1, CIAH/CHES/LPYCHG-4 CIAH/CHES/LPYCHG-5, CIAH/CHES/LPYCHG-6, CIAH/CHES/LPYCHG-7, CH 1 Raj 2022, CH 2 Raj 2023, AICRP-CH 4, AICRP-CH 5, AICRP-CH 6 and AICRP-CH 7 were having a root-knot index of 3. The highest root-knot index of 4 was scored by Arka Swetha, Kashi Abha, CIAH/CHES/LPYCHG-2, CIAH/CHES/LPYCHG-3, AICRP-CH 2 and AICRP-CH 3. Based on the root-knot index and number of galls six genotypes (Arka Swetha, Kashi Abha, CIAH/CHES/LPYCHG-2, CIAH/CHES/LPYCHG-3, AICRP-CH 2 and AICRP-CH 3) had shown susceptible reaction with 31.3 to 54.3 number of galls per root system, while 14 genotypes Kashi Anmol, Kashi Ratna, Pusa Sadabahar, CIAH/CHES/LPYCHG-1, CIAH/CHES/LPYCHG-4 CIAH/CHES/LPYCHG-5,

Table 3: Effect of root-knot nematode (*M. incognita*) on fresh root and shoot weight (g) of different chili genotypes

S. No.	Genotypes	Fresh root wt.(g)		Fresh shoot wt. (g)	
		Uninoculated	Inoculated	Uninoculated	Inoculated
1	Arka Khyati	5.15 ^{ab}	4.61 ^{ab}	8.57 ^a	7.70 ^{ab}
2	Arka Meghana	5.05 ^{abc}	4.57 ^{ab}	8.70 ^a	7.90 ^a
3	Arka Harita	5.30 ^a	4.90 ^a	8.83 ^a	8.10 ^a
4	Arka Swetha	4.70 ^{bcd}	2.48 ^{kl}	7.80 ^{bcd}	4.15 ^{kl}
5	Kashi Anmol	5.00 ^{abc}	4.07 ^{bcd}	7.53 ^{cd}	6.15 ^{defg}
6	Kashi Abha	4.66 ^{bcd}	1.94 ^l	8.23 ^{abc}	3.23 ^m
7	Kashi Ratna	4.80 ^{abcd}	2.91 ^{hij}	8.33 ^{ab}	5.00 ^j
8	Pusa Sadabahar	5.00 ^{abc}	3.09 ^{fghi}	8.50 ^{ab}	5.12 ^{ij}
9	CIAH/CHES/LPYCHG-1	4.94 ^{abc}	3.35 ^{fgh}	8.23 ^{abc}	5.50 ^{ghij}
10	CIAH/CHES/LPYCHG-2	4.72 ^{bcd}	2.42 ^{kl}	8.33 ^{ab}	4.23 ^k
11	CIAH/CHES/LPYCHG-3	4.80 ^{abcd}	2.53 ^{ijk}	8.37 ^{ab}	4.18 ^{kl}
12	CIAH/CHES/LPYCHG-4	4.91 ^{abc}	3.60 ^{def}	8.70 ^a	6.23 ^{def}
13	CIAH/CHES/LPYCHG-5	4.85 ^{abc}	3.50 ^{ef}	8.43 ^{ab}	5.90 ^{efgh}
14	CIAH/CHES/LPYCHG-6	4.97 ^{abc}	4.10 ^{bcd}	8.13 ^{abc}	6.70 ^{cd}
15	CIAH/CHES/LPYCHG-7	4.81 ^{abcd}	3.48 ^{efg}	8.30 ^{ab}	5.70 ^{fghi}
16	CH-RLC 2021	5.01 ^{abc}	4.46 ^{abc}	7.33 ^d	6.50 ^{cde}
17	CH 1 Raj 2022	4.62 ^{cd}	3.22 ^{fgh}	8.20 ^{abc}	5.69 ^{fghi}
18	CH 2 Raj 2023	4.84 ^{abcd}	3.34 ^{fgh}	8.80 ^a	6.00 ^{efg}
19	CH-WI 2020	4.85 ^{abc}	4.26 ^{bc}	7.20 ^d	6.35 ^{def}
20	AICRP-CH 1	4.91 ^{abc}	4.24 ^{bc}	8.10 ^{abc}	7.10 ^{bc}
21	AICRP-CH 2	4.33 ^d	1.95 ^l	8.17 ^{abc}	3.54 ^{lm}
22	AICRP-CH 3	4.70 ^{bcd}	2.15 ^{kl}	8.47 ^{ab}	3.79 ^{klm}
23	AICRP-CH 4	4.87 ^{abc}	3.94 ^{cde}	7.80 ^{bcd}	6.23 ^{def}
24	AICRP-CH 5	4.74 ^{bcd}	3.17 ^{fgh}	8.10 ^{abc}	5.25 ^{hij}
25	AICRP-CH 6	4.82 ^{abcd}	2.93 ^{ghij}	8.60 ^a	5.12 ^{ij}
26	AICRP-CH 7	4.90 ^{abc}	3.06 ^{fghi}	8.27 ^{abc}	5.00 ^j
	Range	4.33-5.30	1.94-4.90	7.20-8.83	3.23-8.10
	SEm ±	0.09	0.10	0.14	0.13
	CD (p=0.05)	0.26	0.29	0.39	0.36
	CV (%)	3.31	5.39	2.92	3.85
	LSD	0.511	0.567	0.764	0.687

CIAH/CHES/LPYCHG-6, CIAH/CHES/LPYCHG-7, CH 1 Raj 2022, CH 2 Raj 2023, AICRP-CH 4, AICRP-CH 5, AICRP-CH 6 and AICRP-CH 7) had shown moderately resistant reaction with 21.0 to 27.0 number of galls per root system and remaining six genotypes (Arka Khyati, Arka Meghana, Arka Harita, CH-RLC 2021, CH-WI 2020 and AICRP-CH 1) had shown resistant reaction with 4.7 to 9.0 number of galls per root system (Table 4).

The effect of different chili genotypes on the reproduction of root-knot nematode was evaluated based on various parameters such as egg masses per root system, final nematode population (FNP) per 200 cc soil, number of eggs per egg mass and reproduction factor (RF). The number of egg masses per root system is presented in Table 6. The number of egg masses per root system among the different genotypes varied between 2.3 (Arka Harita) and 51.7 (Kashi

Table 4: Effect of root-knot nematode (*M. incognita*) on dry root weight (g) in different chili genotypes

S. No.	Genotypes	Dry root wt. (g)		Dry shoot wt. (g)	
		Uninoculated	Inoculated	Uninoculated	Inoculated
1	Arka Khyati	2.23 ^{ab}	2.00 ^{ab}	2.30 ^{abc}	2.05 ^{abc}
2	Arka Meghana	2.16 ^{abc}	1.97 ^{abc}	2.38 ^{ab}	2.14 ^{ab}
3	Arka Harita	2.30 ^a	2.10 ^a	2.50 ^a	2.30 ^a
4	Arka Swetha	1.90 ^{bc}	0.98 ^{klm}	1.95 ^{bc}	1.04 ^{ijkl}
5	Kashi Anmol	2.08 ^{abc}	1.68 ^{cde}	1.89 ^c	1.54 ^{efg}
6	Kashi Abha	1.90 ^{bc}	0.78 ^m	2.10 ^{abc}	0.81 ^l
7	Kashi Ratna	1.95 ^{abc}	1.16 ^{hijkl}	2.09 ^{abc}	1.25 ^{hijk}
8	Pusa Sadabahar	2.05 ^{abc}	1.24 ^{hijkl}	2.13 ^{abc}	1.28 ^{ghij}
9	CIAH/CHES/LPYCHG-1	2.00 ^{abc}	1.34 ^{fghi}	2.07 ^{abc}	1.38 ^{fgh}
10	CIAH/CHES/LPYCHG-2	1.91 ^{bc}	0.96 ^{klm}	2.06 ^{bc}	1.06 ^{ijkl}
11	CIAH/CHES/LPYCHG-3	1.97 ^{abc}	1.01 ^{klm}	2.14 ^{abc}	1.05 ^{ijkl}
12	CIAH/CHES/LPYCHG-4	2.03 ^{abc}	1.46 ^{defgh}	2.18 ^{abc}	1.56 ^{ef}
13	CIAH/CHES/LPYCHG-5	1.94 ^{abc}	1.37 ^{fghi}	2.11 ^{abc}	1.48 ^{efgh}
14	CIAH/CHES/LPYCHG-6	1.99 ^{abc}	1.62 ^{def}	2.05 ^{bc}	1.68 ^{de}
15	CIAH/CHES/LPYCHG-7	1.93 ^{abc}	1.38 ^{efghi}	2.06 ^{bc}	1.43 ^{efgh}
16	CH-RLC 2021	2.00 ^{abc}	1.76 ^{bcd}	2.20 ^{abc}	1.94 ^{bcd}
17	CH 1 Raj 2022	1.80 ^c	1.30 ^{ghij}	2.02 ^{bc}	1.42 ^{efgh}
18	CH 2 Raj 2023	1.78 ^c	1.20 ^{hijkl}	2.20 ^{abc}	1.50 ^{efgh}
19	CH-WI 2020	1.94 ^{abc}	1.70 ^{bcd}	2.24 ^{abc}	1.95 ^{bc}
20	AICRP-CH 1	1.96 ^{abc}	1.70 ^{bcd}	2.16 ^{abc}	1.86 ^{cd}
21	AICRP-CH 2	1.85 ^{bc}	0.83 ^m	2.04 ^{bc}	0.89 ^l
22	AICRP-CH 3	1.91 ^{abc}	0.94 ^{lm}	2.22 ^{abc}	1.00 ^{kl}
23	AICRP-CH 4	1.95 ^{abc}	1.58 ^{defg}	1.95 ^{bc}	1.56 ^{ef}
24	AICRP-CH 5	1.90 ^{bc}	1.25 ^{hijk}	2.03 ^{bc}	1.31 ^{fghi}
25	AICRP-CH 6	1.93 ^{abc}	1.16 ^{ijkl}	2.15 ^{abc}	1.28 ^{ghij}
26	AICRP-CH 7	1.96 ^{abc}	1.20 ^{hijkl}	2.08 ^{abc}	1.25 ^{hijk}
	Range	1.78-2.30	0.78-2.10	1.89-2.50	0.81-2.30
	SEm ±	0.07	0.05	0.08	0.05
	CD (p=0.05)	0.20	0.16	0.23	0.14
	CV (%)	6.16	6.86	6.44	5.74
	LSD	0.388	0.301	0.437	0.265

Abha). Observations regarding the number of eggs per eggmass indicated that the highest and lowest counts were found in the genotypes Kashi Abha and Arka Harita, with recorded numbers of 377 and 254 eggs, respectively. The highest nematode population was obtained from the genotype Kashi Abha with 750 nematodes per 200 cc soil, followed by AICRP-CH 6, Pusa Sadabahar and Arka Swetha with an average nematode population of 740, 723 and

719 per 200 cc soil respectively. The lowest population of nematodes was recorded from Arka Harita (200 J₂s/200 cc soil), followed by Arka Meghana and Arka Khyati, with an average population of 287 and 293 per 200 cc soil, respectively. The minimum (0.40) reproduction factor was found in Arka Haritha, which was followed by Arka Meghana, CH-RLC 2021, Arka Khyati, CH-WI 2020 and AICRP-CH 1 with reproduction factors of 0.75, 0.88, 1.00, 1.03 and 1.62

Table 5: Screening of chili genotypes against root-knot nematode, *M. incognita*

Gall index	Number of root galls/ root system	Reactions	Genotypes
1	0	Highly resistant (HR)	Nil
2	1-10	Resistant (R)	Arka Khyati, Arka Meghana, Arka Harita, CH-RLC 2021, CH-WI 2020 and AICRP-CH 1
3	11-30	Moderately resistant (MR)	Kashi Anmol, Kashi Ratna, Pusa Sadabahar, CIAH/CHES/LPYCHG-1, IAH/CHES/LPYCHG-4, CIAH/CHES/LPYCHG-5, CIAH/CHES/LPYCHG-6, IAH/CHES/LPYCHG-7, CH 1 Raj 2022, CH 2 Raj 2023, AICRP-CH 4, AICRP-CH 5, AICRP-CH 6 and AICRP-CH 7
4	31-100	Susceptible (S)	Arka Swetha, Kashi Abha, CIAH/CHES/LPYCHG-2, CIAH/CHES/LPYCHG-3, AICRP-CH 2 and AICRP-CH 3
5	>101	Highly susceptible (HS)	Nil

respectively. In contrast, the maximum reproduction factor (10.11) was found in Kashi Abha, which was susceptible to reaction.

Discussion

Chili is an important spice and vegetable crop in India, with significant export potential. However, the cultivation of chili, particularly in the hilly and northern plains of the country, is hindered by the problems posed by root-knot nematodes and viruses. Due to the lack of effective management strategies, cultivating resistant sources is the most economical approach to managing these diseases. Identifying resistant sources and utilizing them in breeding programs is essential for the long-term management of these pathogens. Consequently, this study was conducted with this objective in mind. The results showed that out of total 26 chili genotypes evaluated against root knot nematode (*M. incognita*), six were identified as resistant (Arka Khyati, Arka Meghana, Arka Harita, CH-RLC 2021, CH-WI 2020, and AICRP-CH 1). Fourteen genotypes displayed moderate resistance (LPYCHG-4, LPYCHG-5, LPYCHG-6, LPYCHG-7, Kashi Anmol, Kashi Ratna, Pusa Sadabahar, CH 1 Raj 2022, CH 2 Raj 2023, AICRP-CH 4, AICRP-CH 5, AICRP-CH 6, AICRP-CH 7), while six genotypes were found to be susceptible (LPYCHG-2, LPYCHG-3, Arka Swetha, Kashi Abha, AICRP-CH 2, and AICRP-CH 3). Plant growth parameters measured in terms of fresh shoot weight, dry shoot weight, fresh root weight and dry root weight of different chili genotypes exhibited marked variation with inoculum load of *M. incognita*. These variations may be linked to the different genetic compositions of the varieties. The reduction in plant growth observed in chili genotypes may be due to severe root galling and arrested root system by nematode infection. The presence of galled roots can alter the absorption of water and nutrients from the soil, as well as their translocation to the foliage, leading to chlorosis and stunted vegetative growth. Additionally, the impaired root system is unable to effectively explore the soil for adequate water and nutrients. (Sujatha *et al.*, 2017). Similar findings

were reported by Malhotra *et al.* (2012) as they observed that the cultivars Pusa Sadabahar and Mathania Local gave the highest percentage of reduction in both shoot and root fresh weights. The moderate percentage of reduction occurred in Jaipur Local and Pusa Jwala cultivars. The nematode infection induced significant reduction in shoot and root dry weight of Pusa Sadabahar and Mathania Local cultivars when compared with those of the check.

The susceptible genotypes supported the greatest number of juveniles that penetrated and completed their development to maturity, as indicated by a high gall index, a larger number of females, and more egg masses and eggs. These susceptible genotypes also exhibited significant reductions in root length and root dry weight. In contrast, in the resistant genotypes, only a limited number of juveniles were able to penetrate, develop to maturity, and lay egg masses. *M. incognita* reproduced variedly on all chilies germplasm. Different plant responses to nematode infection were observed due to the presence of a RKN resistant gene. These genes made the plant less attractive to attacking nematodes. Penetration of RKN in the host roots activated the resistant gene that led to compatible and incompatible reactions in the plant cells. The results are in accordance with the findings of Davis *et al.* (2000) and Mahmood *et al.* (2017). Root-knot nematodes failed to produce feeding sites in the host after penetration in roots due to hypersensitive responses in the resistant plants (Williamson and Kumar, 2006). There are two types of resistant mechanisms against RKN in plants have been response. I) Pre-infection resistant against RKN due to the toxic or antagonistic chemicals which produced by root tissue to prevents the RKN entry in roots (Bendezu and Starr, 2003). II) Post-infection resistance, RKN penetrates in the roots but failed to develop. It is often associated with an early hypersensitive reaction (IIR) due to the death of the cell in root tissue around the nematode. This mechanism prevents the formation of a feeding site (Williamson, 1999). The resistant cultivars have resistance genes in their gene pool against *M. incognita*. The compatible reactions observed in

Table 6: Effect of chili genotypes on reproduction of root-knot nematode (*M. incognita*)

Sr. No.	Genotypes	Galls/root system	Eggmasses/root system	FNP/200 cc soil	No. of eggs/eggmass	RF
1	Arka Khyati	7.3 ^{gh}	6.2 ^h	293 ⁱ	275 ⁱ	1.00
2	Arka Meghana	6.0 ^{gh}	4.6 ^{hi}	287 ⁱ	266 ^{ij}	0.75
3	Arka Harita	4.7 ^h	2.3 ⁱ	200 ^j	254 ^{ij}	0.40
4	Arka Swetha	31.3 ^c	14.7 ^{defg}	719 ^{ab}	368 ^{ab}	3.06
5	Kashi Anmol	25.0 ^{def}	13.0 ^{efg}	663 ^{de}	359 ^{abcd}	2.67
6	Kashi Abha	54.3 ^a	51.7 ^a	750 ^a	377 ^a	10.11
7	Kashi Ratna	27.0 ^d	21.3 ^{bc}	615 ^g	339 ^{cdefgh}	3.92
8	Pusa Sadabahar	26.0 ^{de}	25.0 ^b	723 ^{ab}	358 ^{abcde}	4.83
9	CIAH/CHES/LPYCHG-1	22.0 ^{ef}	13.3 ^{efg}	615 ^g	318 ^h	2.43
10	CIAH/CHES/LPYCHG-2	32.0 ^c	18.0 ^{cd}	710 ^{bc}	330 ^{gh}	3.33
11	CIAH/CHES/LPYCHG-3	31.7 ^c	16.0 ^{def}	715 ^{abc}	325 ^{gh}	2.96
12	CIAH/CHES/LPYCHG-4	22.3 ^{ef}	12.0 ^g	610 ^g	342 ^{bcddefgh}	2.36
13	CIAH/CHES/LPYCHG-5	21.7 ^f	13.0 ^{efg}	645 ^{defg}	333 ^{defgh}	2.49
14	CIAH/CHES/LPYCHG-6	24.7 ^{def}	12.0 ^g	661 ^{def}	347 ^{bcddefg}	2.41
15	CIAH/CHES/LPYCHG-7	21.0 ^f	16.3 ^{de}	680 ^{cd}	331 ^{efgh}	3.04
16	CH-RLC 2021	7.6 ^{gh}	5.5 ^{hi}	314 ⁱ	262 ^{ij}	0.88
17	CH 1 Raj 2022	25.0 ^{def}	15.7 ^{defg}	615 ^g	346 ^{bcddefg}	3.02
18	CH 2 Raj 2023	21.7 ^f	16.3 ^{de}	610 ^g	352 ^{abcdefg}	3.18
19	CH-WI 2020	8.3 ^{gh}	7.0 ^h	323 ^{hi}	246 ^j	1.03
20	AICRP-CH 1	9.0 ^g	8.2 ^h	355 ^h	353 ^{abcdef}	1.62
21	AICRP-CH 2	38.3 ^b	24.3 ^b	670 ^d	357 ^{abcdef}	4.67
22	AICRP-CH 3	38.0 ^b	23.3 ^b	645 ^{defg}	362 ^{abc}	4.55
23	AICRP-CH 4	24.3 ^{def}	12.3 ^{fg}	622 ^g	348 ^{bcddefg}	2.46
24	AICRP-CH 5	23.0 ^{def}	13.0 ^{efg}	625 ^{fg}	361 ^{abc}	2.66
25	AICRP-CH 6	26.9 ^d	15.3 ^{defg}	740 ^{ab}	279 ⁱ	2.51
26	AICRP-CH 7	26.0 ^{de}	23.0 ^b	630 ^{efg}	349 ^{bcddefg}	4.32
	Range	4.7-54.3	2.3-51.7	200-750	254-377	
	SEm $\pm$	0.7	0.7	6.7	5.1	
	CD (p=0.05)	2.1	1.9	19.2	14.4	
	CV (%)	5.6	7.6	2.0	2.7	
	LSD	4.106	3.725	37	27.786	

moderately resistant, susceptible, and highly susceptible chili genotypes to *M. incognita* infection indicate that these genotypes lack the necessary resistance genes, preventing them from halting the penetration, development, and reproduction of the nematodes. This highlights that we need to transfer resistant genes to our chili genotypes from germplasm to avoid the infection by nematodes, which is essential for the management of root knot nematodes. Similar findings were also reported by Reddy *et al.* (2018) and Hanume Gowda *et al.* (2024). This study helped to

contribute information on the reaction of various genotypes to *M. incognita*.

Conclusion

Based on the current investigation, among the 26 evaluated genotypes, six genotypes (Arka Khyati, Arka Meghana, Arka Harita, CH-RLC 2021, CH-WI 2020 and AICRP-CH 1) were identified as resistant to root-knot nematodes. These genotypes demonstrated superior performance compared to others in terms of plant growth parameters, while

exhibiting the lowest levels of nematode reproduction. Adopting resistant varieties such as Arka Khyati, Arka Meghana, Arka Harita, CH-RLC 2021, CH-WI 2020 and AICRP-CH 1 can be considered as the most suitable and environment friendly strategy for regions facing challenges with root-knot nematodes. It can be further exploited for future studies and breeding programmes.

References

- Adam, M., A. Westphal, J. Hallmann, and H. Heuer: Specific microbial attachment to root-knot nematodes in suppressive soil. *Applied and Environmental Microbiology*, 80, 2679-2686 (2014).
- Anonymous, (2020): Area and production of horticulture crops for 2019-20. National Horticulture Board Database 2019-2020 (3rd Advance). Available at www.nhb.gov.in. Accessed on 1st March, 2024.
- Bendezu, I. F. and J. L. Starr: Mechanism of resistance to *Meloidogyne arenaria* in the peanut cultivar - Coan. *Journal of Nematology*, 35(1), 115 (2003).
- Davis, E. L., R. S. Hussey, T. J. Baum, J. Bakker, A. Schots, M. N. Rosso and P. Abad: Nematode parasitism genes. *Annual Review of Phytopathology*, 38(1), 365-396 (2000).
- Food and Agricultural Organisation (FAO) Statistical Yearbook; 2022.
- Hanume Gowda, K., K. Madhavi Reddy, U. Maheshwari, P. Prabu, V. Hegde and R. Arutselvan: Screening, identification of root-knot nematode resistance sources using multivariate analysis and validation of molecular markers linked to Me genes in chili (*Capsicum annuum* L.). *Genetic Resources and Crop Evolution*, 1-15 (2024).
- Kumar, V., M. R. Khan and R. K. Walia: Crop loss estimations due to plant-parasitic nematodes in major crops in India. *National Academy Science Letters*, 43(5), 409-412 (2020).
- Mahmood, K., M. Shahid, M. Z. Niaz, F. Yousaf and H. Shehzadi: Reaction of two summer vegetables (Okra and Chilies) germplasm against root-knot nematode (*Meloidogyne incognita*). *Plant Protection*, 1(1), 23-27 (2017).
- Malhotra, A., T. Agarwal and P. C. Trivedi: Screening of some chili cultivars for their resistance against *Meloidogyne incognita*. *International Journal of Pharma Biosciences*, 3(1), 136-142 (2012).
- Patel, D. and J. R. Patel: Correlation and Path Analysis in chili (*Capsicum annuum* var. Longum (DC.) Sendt.). *Trends in Biosciences*, 7(24), 4422-4425 (2014).
- Reddy, Y. S., C. Sellaperumal, H. C. Prasanna, A. Yadav, S. P. Kashyap, S. Singh and B. Singh: Screening of tomato genotypes against root-knot nematode and validation of Mi 1 gene linked markers. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 88, 65-72 (2018).
- Tileubayeva, Z., A. Avdeenko, S. Avdeenko, N. Stroiteleva and S. Kondrashev: Plant-parasitic nematodes affecting vegetable crops in greenhouses. *Saudi Journal of Biological Sciences*, 28(9), 5428-5433 (2021).
- Williamson, V. M. and A. Kumar: Nematode resistance in plants: the battle underground. *Trends in Genetics*, 22(7), 396-403 (2006).
- Williamson, V. M.: Plant nematode resistance genes. *Current Opinion in Plant Biology*, 2(4), 327-331 (1999).

सारांश

मिर्च (कैप्सिकम एनुअम एल.) विश्व कृषि में एक महत्वपूर्ण फसल है, विशेष रूप से भारत में, जहाँ यह जड़ गाँठ सूत्रकृमि (मेलोइडोगाइन इन्कोग्निटा) जैसे प्रमुख कीटों के कारण गंभीर समस्याओं का सामना करती है। इसी उद्देश्य से, इस अध्ययन का संचालन किया गया, ताकि जड़ गाँठ सूत्रकृमि के प्रति प्रतिरोधी मिर्च जीनोटाइप की पहचान की जा सके और आर्थिक उपज में वृद्धि हो सके। अध्ययन के दौरान, रूट-नॉट सूचकांक और जड़ों पर गाँठों की संख्या के आधार पर छह जीनोटाइप (अर्का स्वेता, काशी अभा, CIAH/CHES/LPYCHG-2, CIAH/CHES/LPYCHG-3, AICRP-CH 2 और AICRP-CH 3) संवेदनशील पाए गए, जिनमें प्रति जड़ प्रणाली 31.3 से 54.3 गाँठें देखी गईं। चौदह जीनोटाइप (काशी अनमोल, काशी रत्न, पूसा सदाबहार, CIAH/CHES/LPYCHG-1, CIAH/CHES/LPYCHG-4, CIAH/CHES/LPYCHG-5, CIAH/CHES/LPYCHG-6, CIAH/CHES/LPYCHG-7, CH 1 राज 2022, CH 2 राज 2023, AICRP-CH 4, AICRP-CH 5, AICRP-CH 6 और AICRP-CH 7) मध्यम प्रतिरोधी पाए गए, जिनमें प्रति जड़ प्रणाली 21.0 से 27.0 गाँठें दर्ज की गईं। शेष छह जीनोटाइप (अर्का ख्याति, अर्का मेघना, अर्का हरिता, CH-RLC 2021, CH-WI 2020 और AICRP-CH 1) प्रतिरोधी पाए गए, जिनमें प्रति जड़ प्रणाली 4.7 से 9.0 गाँठें थीं। प्रतिरोधी जीनोटाइप्स में ताजे और सूखे जड़-तना वजन में सबसे कम कमी देखी गई, जबकि संवेदनशील जीनोटाइप्स में सबसे अधिक कमी पाई गई। अर्का हरिता में प्रति पौधा सबसे कम गाँठें, अंडे के गुच्छे और प्रजनन कारक पाए गए, उसके बाद अर्का मेघना का स्थान रहा। इसके विपरीत, काशी अभा में ये मान सबसे अधिक थे। यह अध्ययन मिर्च की खेती में जड़ गाँठ सूत्रकृमि के प्रबंधन हेतु प्रतिरोधी जीनोटाइप्स के चयन की दिशा में महत्वपूर्ण जानकारी प्रदान करता है।