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Management of root-knot nematode (*Meloidogyne incognita*) in cucumber using different botanicals

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Abstract

A Pot experiment was conducted to find out effective management practices of root-knot nematode *Meloidogyne incognita* in cucumber variety GCU-1 with different treatments viz., T₁: *Calotropis procera* Ait. (Madar), T₂: *Azadirachta indica* A. Juss (Neem), T₃: *Jatropha curcas* (Jatropha), T₄: *Aegle marmelo* Corr. (Bael), T₅: *Tagetes* spp. (Marigold), T₆: *Brassica juncea* (Mustard), T₇: *Catharanthus roseus* (Periwinkle) and T₈: Control. All the botanicals were applied in soil for 20 days and observations on plant growth character viz., vine length, fresh shoot and root weight, nematode characters viz., root-knot index, soil nematode population/pot, eggmasses/g/plant and no. of females/g/plant has been recorded. The results of experiment showed that among the tested botanicals, treatment of *C. procera* Ait. (Madar) showed maximum vine length (153.67 cm), fresh shoot weight (9.27 g), root weight (3.09 g), minimum root-knot index (2.50), soil nematode population (2190), no. of eggmasses (3.17) and no. of females/g/plant (86.65) followed by the treatment *A. indica* A. Juss (Neem).

Keywords: Botanicals, cucumber, root-knot nematode, management

Introduction

Cucumber (*Cucumis sativus* L.), a widely cultivated popular vegetable crop in the gourd family, Cucurbitaceae grown broadly throughout the world. It is eaten as a popular domestic fruit called kakadi or kheera in Hindi. It is being used in many ways in the daily diet of humans and widely cultivated worldwide (Bhati and Baheti, 2021) [3]. There are so many health benefits of cucumber as these are rich in antioxidants and help in weight loss (Kumar *et al.*, 2010) [9]. In view of the year demand, cucumber is the second most popular crop grown under protected or covered structures (Mao *et al.*, 2016) [11]. However, continuous cultivation of cucumber and adequate soil moisture in greenhouses, promote the development of certain diseases in severe form, especially the nematode diseases such as root-knot caused by *Meloidogyne* spp. (Khan *et al.*, 2012a) [8]. Nematodes, being ubiquitous burrowers and a hidden enemy, cause discernible damage to the crop because of a longer duration with a deeper root system. They have a needle-like structure called a stylet that helps them to pierce the plant cell walls and reach the juicy contents on which they feed (Bernard *et al.*, 2017) [1]. Root-knot nematodes is a major pathogen affecting cucumber production globally, particularly in regions where the crop is grown under protected environments such as polyhouses and greenhouses (Tariq *et al.*, 2025; Bhati and Baheti, 2020; Gine *et al.*, 2014) [12, 2, 4]. It is a serious pest of vegetable crops (Khan, 2012) [8], and cucumber is highly susceptible to *M. incognita* (Huang *et al.*, 2016) [6]. Root-knot nematodes, *Meloidogyne* spp., are considered among the most important PPNs worldwide, with *M. incognita*, *M. javanica*, *M. arenaria* and *M. hapla* being the most damaging species (Greco and Vito, 2009) [5]. The extent of damage and crop loss, depends on the initial nematode population density at planting making it crucial to establish a threshold for effective management (Jain, 1992) [7]. Overall, plant-parasitic nematodes cause 21.3% crop losses amounting to ₹ 102,039.79 million (1.58 billion USD) annually; the losses in 19 horticultural crops were assessed at ₹ 50,224.98 million, while for 11 field crops it was estimated at ₹ 51,814.81 million. Root-knot nematodes, *Meloidogyne* spp., are responsible for 12.00% estimated losses in the cucumber crop with monetary loss of Rs.110.46 million per annum in open field (Kumar *et al.*, 2020)

[10]. Hence, present investigation was carried out to find out effective botanical for management of root-knot nematode in cucumber.

Materials and Methods

The experiment was under taken to find out effective botanicals for management of root-knot nematode in cucumber. Plastic pots of 15 cm diameter were disinfected using 4% formaldehyde solution. After drying, pots were filled with nematode infected soil (1 kg/pot) incorporating fresh chopped leaves @ 0.1% (w/w). These botanicals were allowed for decomposition for 20 days. After 20 days, three seeds of cucumber var. GCU-1 were sown per pot and thinned down upon germination by keeping one plant/pot. Watering and plant protection measurements were taken as per the requirements. The plants were removed carefully after 45 days of sowing and observations were recorded on germination count/pot, vine length (cm) (at 45 days after seeding), fresh shoot and root weights (g), soil nematode population/pot and root nematode population/g/plant, root-knot index (0-5 scale) (Taylor and Sasser, 1978). Finally, data were subjected to statistical analysis using Duncan's New Multiple Range Test (DNMRT)

Results and Discussion

Germination percentage

Cent percent seeds were germinated in both the years as well as in pooled, indicating that there was no adverse effect of different botanicals on seed germination. However, during 2023 and 2024, 11.11% reduction in seed germination was observed in treatment T₄ and T₃ respectively (Table 1).

Vine length (cm)

Significant differences were recorded in vine length between control and all other treatments during year 2023, 2024 and in pooled analysis. The results for 2023, 2024, and pooled data provide a comprehensive picture of treatment effect on plant growth, along with their percentage increases over control. The findings clearly show that different treatments exerted significant influences on growth, producing distinct levels of improvement compared to the baseline. Maximum vine length 152.00, 155.33 and 153.67 were registered in treatment T₁ (*C. procera*) followed by T₂ and T₆ with 27.33, 26.98 and 27.34 percent increase in vine length during 2023 and 2024 as well as in pooled respectively (Table 1). All three treatments (T₁, T₂ and T₆) remained at par with each other. Significantly less vine length was recorded in control. Rest of the treatments has mediocre effect.

Fresh shoot weight (g)

The results on fresh shoot weight across 2023, 2024, and pooled analysis highlight a clear and consistent impact of different treatments compared to the untreated control. Data presented in table 2 revealed that treatment of *C. procera* yielded maximum fresh shoot weight among all the treatments. During 2023 and pooled analysis treatment T₁ give significantly higher i.e. 9.21 and 9.27 g fresh shoot weight respectively followed by T₂. Minimum fresh shoot weight 5.69 and 5.93 g was noticed in control in the year 2023 as well as in pooled respectively. Rest of the treatments had intermediate effect and statistically at par with each other. In the year 2024 treatment T₁ remained on

top with maximum (9.32 g) fresh shoot weight followed by T₂ and T₆.

Fresh root weight (g)

The data on fresh root weight (Table 2) indicated similar trend as observed in plant fresh shoot weight during both the years and in pooled analysis. The data on fresh root weight (g) across 2023, 2024, and pooled analysis revealed a strong and highly significant influence of treatments compared to the untreated control. Importantly, the year effect and year × treatment interaction (Y × T) were non-significant. The treatment T₁: *C. procera* (Madar) recorded the highest fresh root weight, with 3.16 g in 2023 and 3.02 g in 2024. The pooled mean was 3.09 g, representing a remarkable 183.2% increase over control followed by the treatment T₂: *A. indica* (Neem) with 2.61 g (150.96% increase) in 2023 and 2.49 g (120.35% increase) in 2024. The pooled mean was 2.55 g, with an average increase of 136.00% over control. However, minimum fresh root weight was observed in T₇ (control) during 2023, 2024 as well as pooled over the years.

Root-knot index (0-5)

Significant differences were recorded in root-knot index between control and all treatments during year 2023, 2024 and in pooled analysis. The data on root-knot index (RKI) recorded during 2023, 2024, and pooled analysis clearly show that all treatments significantly reduced root-knot index compared to the untreated control, though the degree of reduction varied among treatments. The year effect and year × treatment (Y × T) interaction were non-significant, confirming consistency of treatment effects across seasons. The treatment T₁: *C. procera* (Madar) was the most effective treatment recording significantly less RKI i.e. 2.33, 2.67 and 2.50 with 53.33, 46.67 and 50.00% reduction in RKI over control in the year 2023, 2024 and pooled results respectively. Next best effective treatment is T₂ which remain at par with T₁ (Table 3). Maximum RKI (5.00) was recorded in control.

Soil nematode population

During 2023, there was significantly less soil nematode population (2130) in the treatment of *C. procera* followed by treatment of *A. indica* (2433) and *B. juncea* (2640) and not differ significantly from each other. Control had maximum soil nematode population (3360) which statistically at par with T₃, T₄, T₅ and T₇.

In the year 2024, lowest soil nematode population was recorded in the treatment T₁ followed by T₂. However, statistically not differ from each other. Control had maximum (3420) soil nematode population and remain at par with rest of the treatments except T₁ and T₂ (Table 3). The same trend was observed when data pooled over the year.

Root nematode population

Perusal of data presented in table 4 number of females indicated differences among botanicals except T₄. Though the magnitude of reduction varied among treatments. In the year 2023, botanical *C. procera* turnout as a most effective treatment with significantly less (78.00) female population as compare to remaining treatments. However, it remains at par with T₂. Maximum number of female (147.33, 165.00 and 156.17 respectively) was observed in control during 2023, 2024 and pooled over year. Same trend was observed

in 2024 and pooled over years.

In the year 2023, number of eggmasses were minimum (3.00) in the treatment T₁ followed by T₂ (4.00), T₅ (5.33), T₆ (4.33) and T₇ (5.00) not differing significantly from each other (Table 4). Control has maximum (14.67) eggmasses. Data on number of eggmasses of second year (2024)

revealed that *C. procera* mixed with soil containing root-knot nematode effectively reduced eggmasses (3.33). T₂ is next best treatment (4.33) statistically remain at par with T₆ and T₇. Control has maximum (16.33) eggmasses. Pooled data for two years exhibited same trend as observed during 2024.

Table 1: Effect of different botanicals on root-knot nematode (*Meloidogyne incognita*) and their impact on germination percentage, vine length of cucumber (*Cucumis sativus* L.) var. GCU-1

S.N	Treatments	Germination Percentage						Vine length (cm)					
		2023	% Reduction over control	2024	% Reduction over control	Pooled	% Reduction over control	2023	% Increase over control	2024	% Increase over control	Pooled	% Increase over control
1	<i>Calotropis procera</i> Ait. (Madar)	100	0.00	100	0.00	100	0.00	152.00 ^a	27.73	155.33 ^a	26.98	153.67 ^a	27.34
2	<i>Azadirachta indica</i> A. Juss (Neem)	100	0.00	100	0.00	100	0.00	147.00 ^{ab}	23.53	149.00 ^{ab}	21.80	148.00 ^{ab}	22.65
3	<i>Jatropha curcas</i> (Jatropha)	100	0.00	88.89	11.11	94.44	5.56	129.00 ^{cd}	8.40	128.17 ^{cde}	4.77	128.00 ^{cd}	6.56
4	<i>Aegle marmelo</i> Corr.(Bael)	88.89	11.11	100	0.00	94.44	5.56	122.67 ^{cd}	3.08	124.00 ^{de}	1.37	123.33 ^{de}	2.21
5	<i>Tagetes</i> spp. (Marigold)	100	0.00	100	0.00	100	0.00	131.00 ^{cd}	10.08	130.00 ^{cd}	6.27	130.50 ^{cd}	8.15
6	<i>Brassica juncea</i> (Mustard)	100	0.00	100	0.00	100	0.00	145.67 ^{ab}	22.41	142.33 ^b	16.35	144.00 ^b	19.33
7	<i>Catharanthus roseus</i> (Periwinkle)	100	0.00	100	0.00	100	0.00	135.67 ^{dc}	14.01	132.17 ^c	8.04	133.92 ^c	10.98
8	Control	100	0.00	88.89	0.00	94.44	0.00	119.00 ^d	0.00	122.33 ^e	0.00	120.67 ^e	0.00
	S.Em.±Y	-	-	-	-	1.70	-	-	-	-	-	1.21	-
	T	3.93	-	5.51	-	3.62	-	4.27	-	2.30	-	2.40	-
	Y*T	-	-	-	-	4.81	-	-	-	-	-	3.43	-
	CD (0.05) T	NS	-	NS	-	NS	-	12.79	-	6.91	-	6.89	-
	Y*T	-	-	-	-	NS	-	-	-	-	-	NS	-
	CV%	6.90	-	9.9	-	8.51	-	5.46	-	2.95	-	4.39	-

Table 2: Effect of different botanicals on root-knot nematode (*Meloidogyne incognita*) and their impact on fresh shoot weight, root weight of cucumber (*Cucumis sativus* L.) var. GCU-1

S.N.	Treatments	Fresh shoot weight (g)						Fresh root weight (g)					
		2023	% Increase over control	2024	% Increase over control	Pooled	% Increase over control	2023	% Increase over control	2024	% Increase over control	Pooled	% Increase over control
1	<i>Calotropis procera</i> Ait. (Madar)	9.21 ^a	61.86	9.32 ^a	51.05	9.27 ^a	56.32	3.16 ^a	203.85	3.02 ^a	166.26	3.09 ^a	186.11
2	<i>Azadirachta indica</i> A. Juss (Neem)	7.47 ^b	31.28	8.47 ^{ab}	37.28	7.97 ^b	34.40	2.61 ^b	150.96	2.49 ^b	120.35	2.55 ^b	136.11
3	<i>Jatropha curcas</i> (Jatropha)	6.53 ^d	14.76	6.39 ^a	3.57	6.46 ^{df}	8.94	1.24 ^f	19.23	1.29 ^{cd}	14.16	1.26 ^{de}	16.67
4	<i>Aegle marmelo</i> Corr. (Bael)	6.63 ^d	16.58	7.03 ^{cde}	13.94	6.83 ^{de}	15.18	1.18 ^g	13.46	1.20 ^d	6.19	1.19 ^{de}	10.18
5	<i>Tagetes</i> spp. (Marigold)	7.28 ^{bc}	27.94	7.16 ^{cde}	16.05	7.22 ^{bcd}	21.73	1.31 ^e	26.28	1.36 ^{cd}	20.35	1.34 ^{cd}	24.07
6	<i>Brassica juncea</i> (Mustard)	7.37 ^b	29.52	8.22 ^{abc}	33.22	7.79 ^{bc}	31.36	1.43 ^c	37.50	1.57 ^c	39.23	1.50 ^c	38.89
7	<i>Catharanthus roseus</i> (Periwinkle)	6.73 ^{cd}	18.28	7.43 ^{bcd}	20.42	7.08 ^{cd}	19.39	1.37 ^d	31.73	1.40 ^{cd}	24.19	1.39 ^{cd}	28.70
8	Control	5.69 ^e	0.00	6.17 ^{de}	0.00	5.93 ^f	0.00	1.04 ^h	0.00	1.13 ^d	0.00	1.08 ^e	0.00
	S.Em.±Y	-	-	-	-	0.11	-	-	-	-	-	0.03	-
	T	0.19	-	0.38	-	0.23	-	0.01	-	0.10	-	0.07	-
	Y*T	-	-	-	-	0.30	-	-	-	-	-	0.10	-
	CD (0.05) T	0.56	-	1.52	-	0.67	-	0.29	-	0.30	-	0.20	-
	Y*T	-	-	-	-	NS	-	-	-	-	-	NS	-
	CV%	4.55	-	8.84	-	7.15	-	10.06	-	10.26	-	10.16	-

Figures indicating common alphabets in superscript do not differ significantly at 5% level of significance according to DNMR

Table 3: Effect of different botanicals on root-knot index and soil nematode population in cucumber (*Cucumis sativus* L.) var. GCU-1

S.N	Treatments	RKI (0-5)						Soil nematode population/pot					
		2023	% Reduction over control	2024	% Reduction over control	Pooled	% Reduction over control	2023	% Reduction over control	2024	% Reduction over control	Pooled	% Reduction over control
1	<i>Calotropis procera</i> Ait. (Madar)	1.68 ^d (2.33)	53.33	1.76 ^c (2.67)	46.67	1.72 ^e (2.50)	50.00	45.96 ^c (2130)	36.61	47.28 ^c (2250)	34.21	46.62 ^d (2190)	35.40
2	<i>Azadirachta indica</i> A. Juss (Neem)	1.86 ^{cd} (3.00)	40.00	1.84 ^{bc} (3.00)	40.00	1.85 ^{de} (3.00)	40.00	49.11 ^c (2433)	27.59	51.49 ^{bc} (2655)	22.37	50.30 ^{cd} (2544)	24.96
3	<i>Jatropha curcas</i> (Jatropha)	2.12 ^{abc} (4.00)	20.00	2.20 ^{ab} (4.33)	13.33	2.17 ^{abc} (4.17)	16.67	56.92 ^{ab} (3240)	3.57	57.07 ^a (3270)	4.39	57.00 ^a (3255)	3.98
4	<i>Aegle marmelo</i> Corr. (Bael)	2.20 ^{ab} (4.33)	13.33	2.27 ^a (4.67)	6.67	2.23 ^{ab} (4.50)	10.00	57.82 ^a (3345)	0.45	58.23 ^a (3390)	0.88	58.02 ^a (3367)	0.66
5	<i>Tagetes</i> spp. (Marigold)	2.04 ^{bc} (3.67)	26.67	2.20 ^{ab} (4.33)	13.33	2.12 ^{bc} (4.00)	20.00	56.08 ^{ab} (3150)	6.25	56.64 ^{ab} (3210)	6.14	56.36 ^{ab} (3180)	6.19
6	<i>Brassica juncea</i> (Mustard)	1.95 ^{bcd} (3.33)	33.33	2.04 ^{abc} (3.67)	26.67	1.10 ^{cd} (3.50)	30.00	51.31 ^{bc} (2640)	21.43	54.24 ^{ab} (2943)	13.95	52.77 ^{bc} (2791)	17.65
7	<i>Catharanthus roseus</i> (Periwinkle)	2.04 ^{bc} (3.67)	26.67	2.12 ^{bcd} (4.00)	20.00	2.08 ^{bcd} (3.83)	23.33	55.45 ^{ab} (3078)	8.39	56.30 ^{ab} (3180)	7.02	55.88 ^{ab} (3129)	7.70
8	Control	2.35 ^a (5.00)	0.00	2.35 ^a (5.00)	0.00	2.35 ^a (5.00)	0.00	57.97 ^a (3360)	0.00	58.48 ^a (3420)	0.00	58.23 ^a (3390)	0.00
	S.Em.±Y		-	-	-	0.04	-		-	-	-	0.65	-
	T	0.09	-	0.12	-	0.07	-	1.93	-	1.74	-	1.26	-
	Y*T		-	-	-	0.11	-		-	-	-	1.84	-
	CD (0.05) T	0.26	-	0.37	-	0.21	-	5.79	-	5.12	-	3.62	-
	Y*T		-	-	-	NS	-		-	-	-	NS	-
	CV%	7.41	-	10.21	-	8.96	-	6.21	-	5.48	-	5.85	-

Figures indicating common alphabets in superscript do not differ significantly at 5% level of significance according to DNMR. Figures in parentheses are retransformed values of square root transformation

Table 4: Effect of different botanicals on root nematode population in cucumber (*Cucumis sativus* L) var. GCU-1

S.N	Treatments	No. of eggmasses/g/plant root						No. of females/g/plant root					
		2023	% Reduction over control	2024	% Reduction over control	Pooled	% Reduction over control	2023	% Reduction over control	2024	% Reduction over control	Pooled	% Reduction over control
1	<i>Calotropis procera</i> Ait. (Madar)	1.82 ^d (3.00)	79.55	1.95 ^e (3.33)	79.59	1.89 ^e (3.17)	79.57	8.86 ^e (78.00)	47.06	9.79 ^e (95.30)	42.22	9.32 ^c (86.65)	44.50
2	<i>Azadirachta indica</i> A. Juss (Neem)	2.11 ^d (4.00)	72.73	2.20 ^{de} (4.33)	73.46	2.15 ^{de} (4.17)	73.12	9.35 ^{de} (87.00)	40.95	10.27 ^{de} (105.00)	36.36	9.81 ^c (96.00)	38.53
3	<i>Jatropha curcas</i> (Jatropha)	2.85 ^{bc} (7.67)	47.74	2.97 ^{bc} (8.33)	48.97	2.91 ^{bc} (8.00)	48.39	10.83 ^{bc} (117.00)	20.59	11.64 ^{bc} (135.00)	18.18	11.24 ^b (126.00)	19.32
4	<i>Aegle marmelo</i> Corr. (Bael)	2.96 ^b (8.33)	43.19	3.24 ^b (10.00)	38.76	3.10 ^b (9.17)	40.86	11.64 ^{ab} (135.00)	8.37	12.39 ^{ab} (153.00)	7.27	12.01 ^a (144.00)	7.79
5	<i>Tagetes</i> spp. (Marigold)	2.41 ^{bcd} (5.33)	63.64	3.03 ^{bc} (8.67)	46.93	2.72 ^{bc} (7.00)	54.84	10.66 ^{bc} (114.00)	22.62	11.51 ^{bc} (132.00)	20.00	11.09 ^b (123.00)	21.24
6	<i>Brassica juncea</i> (Mustard)	2.20 ^d (4.33)	70.46	2.35 ^{de} (5.00)	69.38	2.27 ^{de} (4.67)	69.89	10.40 ^{cd} (108.00)	26.70	11.09 ^{cd} (123.00)	25.45	10.74 ^b (115.50)	26.04
7	<i>Catharanthus roseus</i> (Periwinkle)	2.34 ^{cd} (5.00)	65.92	2.73 ^{cd} (7.00)	57.13	2.54 ^{cd} (6.00)	61.29	10.70 ^{bc} (114.00)	22.62	11.23 ^{cd} (126.00)	23.64	10.97 ^b (120.00)	23.16
8	Control	3.89 ^a (14.67)	0.00	4.08 ^a (16.33)	0.00	3.98 ^a (15.50)	0.00	12.15 ^a (147.33)	0.00	12.86 ^a (165.00)	0.00	12.50 ^a (156.17)	0.00
	S.Em.±Y		-	-	-	0.05	-		-	-	-	0.11	-
	T	0.18	-	0.13	-	0.01	-	0.33	-	0.28	-	0.21	-
	Y*T		-	-	-	0.015	-		-	-	-	0.31	-
	CD (0.05) T	0.53	-	0.37	-	0.32	-	0.99	-	0.85	-	0.6	-
	Y*T		-	-	-	NS	-		-	-	-	NS	-
	CV%	11.99	-	7.66	-	9.87	-	5.39	-	4.33	-	4.86	-

Figures indicating common alphabets in superscript do not differ significantly at 5% level of significance according to DNMR. Figures in parentheses are retransformed values of square root transformation

The present study emphasized the exploration of botanicals as eco-friendly approaches for the management of root-knot nematodes (*Meloidogyne incognita*). The results clearly demonstrated that among the tested treatments, T₁: *C. procera* Ait. (Madar) was the most effective, followed by the treatments T₂: *A. indica* A. Juss (Neem), in depleting nematode populations and improving plant growth parameters. These findings are in line with earlier reports, highlighting the potential of certain botanicals in nematode suppression. Several researchers have previously documented the efficacy of organic amendments and plant-based materials for nematode management. For instance, incorporation of naffatia (*Ipomoea fistulosa*), water hyacinth (*Eichhornia crassipes*), aak (*C. procera*), or congress grass (*Parthenium hysterophorus*) into soil 15 days prior to seeding was found highly effective in controlling root-knot disease in nematode-infested tomato nurseries. Similarly, the application of madar (*C. procera*) and neem (*A. indica*) leaves showed reduction of root-knot index and also enhance plant growth traits in crops like bitter gourd and bottle gourd (Venkatesan, 2009; Singh and Patel, 2015) [14, 13]. These consistent findings across different host crops highlight the versatility of botanicals such as *C. procera* and *A. indica* in nematode management. Their effectiveness could be attributed to bioactive compounds present in the plant tissues, which may act directly as nematicides or indirectly by improving soil health and promoting antagonistic microbial activity. Thus, the integration of botanicals like madar and neem into sustainable agricultural practices not only reduces the dependency on chemical nematicides but also provides long-term ecological benefits by ensuring safer crop production and maintaining soil fertility.

Conclusion

The data of the experiment showed that different botanicals significantly effective in improving plant growth character to the varied degree and reduce nematode reproduction over control. Among all the botanicals soil application of the treatment *C. procera*, 20 days prior to crop seeding reduce soil nematode population and improve crop growth followed by soil application of the treatment of *A. indica*.

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