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Research Article

Effect of Herbicides Against Root knot *Nematode Meloidogyne Incognita* on Tomato

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Abstract

Meloidogyne species are known to cause high levels of economic loss worldwide in a multitude of agricultural crops, including tomato. Herbicides are used extensively to control weeds. However, little is known about the non-target effects of herbicides on soil nematode assemblages. The different concentrations of herbicides used in pot culture. The observations to be recorded as Plant growth parameters Fresh weight (g), Shoot length (cm), Fresh root weight, dry shoot weight and population development of *M. incognita* on tomato (S.S-21) on number of egg Saccs and their population. The concentrations were used 0.25%, 0.5%, 1.0%, 1.25% of Cladinofop proparyl 15% WP, Clamazone 50%EC, Pendimithalin 30%EC, Imizathypyr 35% and 1.00%1.50%, 2.00%, 2.50 of Bispyribac sodium 10%SC on *M. incognita*.

Keywords: *M. incognita*, herbicides, growth parameters and population development of *M. incognita* on tomato (S.S-21)

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Introduction

Tomato (*Solanum lycopersicum*) belongs to the Solanaceae family it is popular vegetable crop worldwide and it is grown on more than 5 × 106 ha with a production of approximately 161 × 106 metric tons. In Africa and Asia account for more than 80% of the global tomato area, with about 70% of world output [1-3]. It is ranked first in the world for vegetables and accounts for 14% of world vegetable production (US$ 1.6 billion market value) [4,5]. Tomato is a rich source of micronutrients such as minerals, vitamins and antioxidants for a well-balanced human diet. It also contains high levels of lycopene, an antioxidant that reduces the risks associated with several cancers and neurodegenerative diseases [6,7]. Root-knot nematodes can cause severe damage to the roots of tomato. Symptoms are more prevalent with tropical species compared to temperate root-knot nematodes. Tomato cultivars have different degrees of susceptibility towards different Meloidogyne spp. Damage and yield loss studies conducted so far have shown a considerable difference in degree of susceptibility among tomato cultivars. Moreover, different populations of the same species of Meloidogyne even exhibit different degrees of pathogenicity on a specific tomato cultivar. A tomato cultivar that is absolutely susceptible to one population may be moderately resistant to another population of the same species. Several studies report the damage potential of different Meloidogyne spp. on different tomato cultivars under pot, microplot and field experiment conditions throughout the world. Experiments were done in different conditions and localities with different experimental approaches, making it difficult to extrapolate the results. In many agro ecosystems worldwide, herbicides are used extensively to control weeds, reduce soil erosion, conserve soil structure and improve labor efficiency. However, herbicides affect more than just weeds; they also impact upon soil biota directly or more frequently indirectly, through the alteration of plant cover and root exudates [8-12]. However, different types of herbicide are associated with negligible, positive or negative effects on various soil organisms' viz. microorganisms, nematodes, arthropods and earthworms [10]. A considerable number of studies have focused on the effects of herbicides on plant-parasitic nematodes, especially root-knot nematodes and cyst nematodes [5]. In most cases, herbicides are usually applied with other agricultural management practices like other pesticides, fertilization and tillage [8]. Because little is known about the non target effects of herbicides alone on soil nematode assemblages, the objective of the present study was to determine whether herbicides affect nematode trophic group composition. The present studies were thus, conducted to work out the nematicidal properties of a few herbicides against *M. incognita* associated with tomato and for their effect on vegetative and reproductive growth characters of the crop.

Materials and Methods

The following materials and methods were used during the present investigations.

Preparation of soil composite

The sandy loam soil for growing the test plant was collected from dusty acre farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. Soil was thoroughly washed with 3- 4 changes of water so as to remove the soluble leachiest and air dried. This soil was then mixed with well decomposed FYM (3:1) to prepare soil composite and same was used throughout the course of investigation.

Test organism

Root knot nematode Meloidogyne incognita (Kofoid and White1919. Chitwood, 1949) was used.

Host

Tomato (Solanum lycopersicum L.) variety S.S-21 which was susceptible to root knot nematode, Meloidogyne incognita, was obtained from certified seed from the market at Jabalpur.

Screening of different concentrations of herbicides against root knot nematode

Cladinofop proparyl 15% WP, 0.5%, 1.0%, 1.25% /1.5 kg soil, Clamazone 50%EC @ 0.25%, 0.5%, 1.0%, 1.25% /1.5 kg soil, Pendimithalin 30%EC @ 0.25%, 0.5%, 1.0%, 1.25% /1.5 kg soil, Bispyribac sodium 10%SC @ 0.25%, 0.5%, 1.0%, 1.25% /1.5 kg soil, Imizathypyr 35%WG @ 0.25%, 0.5%, 1.0%, 1.25% /1.5 kg soil.

Collection, Isolation, and Maintenance of pure culture of root knot nematode Meloidogyne spp.

Tomato plant roots infected with root knot nematode were collected from Panagar, Jabalpur (M.P.). The infected roots were washed and chopped into small pieces (1cm) and placed over extraction assembly. After 24 hours, freshly hatched second stage larval populations were collected from extraction assembly and inoculated on 21 days old seedling of Tomato (S.S-21). After 45 days, the roots along with soil were gently washed with running water. The single egg mass was picked from infected root and was inoculated on tomato seedling grown in 10 cm earthen pots containing steam sterilized soil to obtain mono specific population. The population obtained from single egg mass was maintained on tomato. This population was used throughout the present investigations.

Extraction assembly

Cobb's sieving and decanting method and modified Baermann Funnel Technique [2] were employed and egg masses were collected over 60 Mesh British Standard (BS) Sieve. Egg masses were further subjected to extraction assembly at room temperature. An extraction assembly had PVC-ring of 110 mm diameter holding double layered wet tissue paper supported by gauze cloth and tightly stretched with a rubber band. Extraction dish was placed over a piece of sponge measuring 15 cm × 15 cm for providing form support from the bottom to the tissue paper and allowing a fast passage of water and suspension containing freshly washed egg masses on 60 mesh B. S. Sieve was poured with the help of a jet of water. Assembly was later kept on a glass bowl (yera make) holding 60 ml of aqua-guard water. Extraction assembly was so placed, that the upper layer of water in glass bowl touches the stretched base of extraction dish to ensure a thin film leaving no air bubble. The extraction was carried out at room temperature and the second stage juveniles (j2) were collected after 24 and 48 hr. The extraction was further continued till 72 to 96 hr and juveniles emerged within 96 hr were used for the inoculation after calibrating the population.

Effect of inocula of Meloidogyne incognita on growth parameters of Tomato (cv. S.S-21) and nematode multiplication

Seeds of S.S-21 variety of tomato were surface sterilized with 0.1% mercuric chloride solution for one minute and subsequently washed three times in sterile water. The disinfected seeds so obtained were sown in 10 cm diameter earthen pots holding 200 cm^3 steam sterilized soil. In each pot, two plants were transplant at an even depth of 2 cm. After establishment single plant was retained in each pot. After 10 days when seedlings attained a height of 10 cm the pots were inoculated with inoculum. To obtained second stage larval population for inoculation, egg masses were collected from six weeks old infected plants of tomato and were kept in extraction dish for overnight for extraction. The populations (second stage larvae) so obtained were utilized to test the different levels of inocula on growth parameter of the tomato seedlings. The larval population was assessed by drawing five, aliquant of 1 ml each from 100 ml nematode suspension in a beaker and then multiplied by hundred to know the total population present in 100 ml beaker larvae which were dispersed individually in 10 ml of sterile water. Thus there were five treatments along with control. In control pots 10 ml of sterile water alone was used.

Inoculation of tomato seedlings with desired level of inoculum were carried out by removing the soil around root in radius of 2.0-2.5 cm and dispersing the required populations by dispenser holding appropriate populations in 10 ml water. After inoculation, the roots were covered with thin layer of fresh steam sterilized soil. These pots were irrigated with 100 ml of fresh water as and when required. The glass house temperatures were ranged between 28-32^{0}C during the course of investigation. The experiment was terminated after 45 days of transplanting. Observations on plant height, fresh and dry shoot and root weight, galls and egg masses / root system and soil population / 200 cm^{3}were recorded. For extraction of nematodes from roots each pot was flooded with water to saturate the soil and then immediately entire roots system along with soil was tapped out carefully by inverting the pot. The roots were washed with a gentle stream of running tap water to obtain intact root system. The extraction of nematode from the soil was carried out by modified Cobb's sifting and gravity technique to estimate the nematode population. For obtaining the fresh weight, whole root system was gently pressed between two pads of blotting paper and cut into small pieces of 2-3 cm and its weight was recorded. The larval population emerging from the roots was counted daily until extraction of maximum population.

Efficacy of herbicides against M. incognita

The five herbicides were further homogeneously mixed with the sterile soil composite at different concentrations viz. 0.25%, 0.5%, 1.0%, 1.25% per 500 g soil and filled in 10 cm pots containing 500 g soil. The pots were irrigated with fresh tap water and kept on the glass house bench. Then 21 days old seedlings of tomato were transplanted in the pots. Each pot received one seedling. On establishment of roots the pots were inoculated with 1000 freshly hatched second stage juveniles of M. incognita. The pots were randomized on glass house bench. Each treatment replicated three times. Experiment was terminated 35 days after inoculation. The following observations were recorded viz., plant height, fresh and dry weight of shoot, fresh weight of root, number of galls, number of egg saccs, number of eggs per sacc and final soil population.

Results and Discussion

I have collected five varieties of tomato from Karnataka (Dist- Kolar) where they grow commercially by farmers in an polyhouse and open field condition. These varieties are evaluated to test susceptibility for reproduction of root knot nematode (Meloidogyne spp.). Among these varieties noticed that SS 21 is highly susceptible and it can be used for further investigations. Effect of Cladinofop proparyl 15% WP concentrations on mortality of larvae over the concentrations are summarized in **Table 1**. The herbicide was effective in causing highest larval mortality with the 1.25 percent concentration being more efficacious. It showed a high significant difference than the other concentrations and untreated control (Table). Extent of mortality was greater within 40 days after addition of herbicide in pots holding tomato plant inoculated with 1000 J2 near the root zone. Reduction of final nematode population with reference to galls were 11.3, 11.6, 12 and 13 at 1.25, 1.0, 0.5 and 0.25 levels of concentration respectively. Similarly the egg masses, eggs/egg sacc and emergence of larvae reduced over untreated plants. The initial nematode population was 1000 J2 /500cc soil, data on nematode galls and egg saccs development eggs/egg sacc and emergence of larvae from the eggs shows significant reduction at 1.25 (253.3), 1.0 (201.6), 0.5 (195) and 0.25 (190) percent level of herbicide reduced over un treated control. Effect of herbicide on tomato plants revealed significantly enhanced in the presence than the control one (p=0.05). However there was significant increase in plant height, plant shoot weight, root weight and weight of dry shoot at individual treatments.

Effect of Clamazone 50% EC on root-knot development and tomato growth was studied with four levels and untreated tomato. Clamazone 50% EC applied on nematode infested pots significantly increased the total tomato growth characters over untreated control. Clamazone 50% EC at 1.25 percent concentration reduced both number of galls and egg masses to the tune of 11.3 per plant. Hatching of juveniles was effected at all the doses of above potential to the tune of 186.6, 198.3, 215.6 and 228.3 J2 per pot.There were significantly improvement for all growth parameters in all the treatments as compare to control. Improvement of plant height (11.3 cm), fresh shoot weight (0.46 g) and dry shoot weight (0.19 g) and root weight (0.15 g) was noticed at 1.25 percent concentrations compare to other concentrations and untreated control (**Table 2**).

Table 1 Effect of Cladinofop proparyl 15% WP at different Concentration on growth parameters and population development of *M. incognita* on tomato (S.S-21)

Varieties	No. of galls	No.of egg saccs	J2 from eggs	Soil population
1. SS 211. S.S-21	115	115	250	380
2. DS 22	65	65	170	250
3. S 22	30	30	110	180
4.American sathna	8	8	55	120
5. Damini131	20	20	90	170
Gall index (Taylor and Sasser, 1978)				

Scale	Galls/egg saccs	Reaction Index
0	0	Immune
1	1-10	highly resistant
2	11-20	moderate resistant
3	21-40	slightly resistant
4	41-100	succeptible
5	>100	highly susceptible

Treatments	Concen trations	Observations							
		Fresh shoot weight (g)	Shoot length (cm)	Fresh root weight (g)	Dry shoot weight (g)	No.of galls	No. of egg saccs	No.of eggs/ sacc	Soil populn
Cladinofop proparyl 15% WP	0.25%	0.23	7.3	0.05	0.05	13	13	230	190
	0.5%	0.25	8.6	0.06	0.07	12	12	215	195
	1.0%	0.26	9.6	0.07	0.08	11.6	11.6	210	201.6
	1.25%	0.28	11.3	0.15	0.11	11.3	11.3	195	253.3
	control	0.18	5.53	0.01	0.04	30	30	350	185.6
	SEm	0.031	0.798	0.012	0.026	0.563	0.563	6.637	3.883
	CD5%	0.095	2.419	0.037	0.080	1.709	1.709	20.131	11.779

Table 2 Effect of Clamazone 50% EC at different Concentrations on growth parameters and population development of *M. incognita* on tomato (S.S-21)

Treatments	Concen trations	Observations							
		Fresh shoot weight (g)	Shoot length (cm)	Fresh root weight (g)	Dry shoot weight (g)	No.of galls	No. of egg saccs	No.of eggs /sacc	Soil populn
Clamazone 50% EC	0.25%	0.21	9.6	0.03	0.09	12.6	12.6	293.3	186.6
	0.5%	0.3	10	0.05	0.13	12	12	231.6	198.3
	1.0%	0.31	10.6	0.06	0.15	11.6	11.6	220	215.6
	1.25%	0.46	11.3	0.15	0.19	11.3	11.3	210	228.3
	control	0.18	5.53	0.01	0.04	30	30	350	185.6
	SEm	0.038	0.702	0.013	0.023	0.535	0.535	5.528	11.255
	CD5%	0.115	2.130	0.040	0.068	1.621	1.621	16.767	31.104

Effect of Pendimithalin 30% EC on root-knot development and tomato growth was studied with four levels and un treated tomato. Pendimithalin 30% EC applied on nematode infested pots significantly increased the total tomato growth characters over untreated control Pendimithalin 30% EC at 1.25 percent concentration reduced both number of galls and egg masses to the tune of 10.3 per plant. Hatching of juveniles was effected at all the doses of above potential to the tune of 166.6, 178.3, 188.3 and 196.6 J2 per pot. There were significantly improvement for all growth parameters in all the treatments as compare to control. Improvement of plant height (9 cm), fresh shoot weight (0.25 g) and dry shoot weight (0.09 g) and root weight (0.05 g) was noticed at 1.25 percent concentrations compare to other concentrations and untreated control (**Table 3**).

Effect of Bispyribac Sodium 10% SC on nematode reproduction and plant growth was studied with 1.25, 1.0, 0.5 and 0.25 percent concentrations of herbicide. The data exhibited that herbicide sustained a great reduction in the number of root galls caused by *M. incognita.* The maximum reduction occurred at 1.25 percent concentration towards egg masses, eggs/egg sacc and juveniles population per 500cc soil at the time of observations. Number of galls and egg saccs were reduced at 1.25 percent (11.3) followed by 1.0 (11.6), 0.5 (12) and 0.25 (13.3) percent concentrations. Among the herbicide doses other treatments were also significant for the nematode development on tomato root. The data summarized in indicated that 1.25 dose was most effective followed by 1.0, 0.5, and 0.25 level of herbicide dose. It further shows that herbicide at different doses was found most efficacious in decreasing the incidence and development root galls, egg saccs, eggs/sacc and juveniles. The growth of tomato plants under above treatment showed significant and better growth ie plant height at 1.25 (9 cm) followed by 1.0, 0.5, and 0.25 percent dose. However, the study showed that in the presence of these treatments improvement of crop growth was observed (**Table 4**).

Table 3 Effect of Pendimithalin 30% EC at different Concentration on growth parameters and population development of *M. incognita* on tomato (S.S-21)

Treatments	Concen trations	Observations							
		Fresh shoot weight (g)	Shoot length (cm)	Fresh root weight(g)	Dry shoot weight (g)	No.of galls	No. of egg saccs	No.of eggs/ sacc	Soil populn
Pendimithalin 30% EC	0.25%	0.2	6	0.02	0.05	12.3	12.3	226.6	166.6
	0.5%	0.21	7.6	0.03	0.06	11.6	11.6	216.6	178.3
	1.0%	0.22	8	0.04	0.07	11.6	11.6	188.3	188.3
	1.25%	0.25	9	0.05	0.09	10.3	10.3	178.3	196.6
	control	0.18	5.53	0.01	0.04	30	30	350	185.6
	SEm	0.016	0.592	0.003	0.010	0.504	0.504	8.614	6.516
	CD5%	0.050	1.795	0.009	0.029	1.529	1.529	26.129	19.765

Table 4 Effect of Bispyribac Sodium 10% SC at different concentrations on growth parameters and population development of *M. incognita* on tomato (S.S-21)

Treatments	Concen trations	Observations							
		Fresh shoot weight (g)	Shoot length (cm)	Fresh root weight (g)	Dry shoot weight (g)	No.of galls	No. of egg saccs	No.of eggs/sacc	Soil populn
Bispyribac Sodium 10% SC	1.00%	0.2	10.6	0.03	0.08	12.3	12.3	281.6	191.6
	1.50%	0.25	10	0.04	0.09	12	12	261.6	198.3
	2.00%	0.35	9.6	0.06	0.1	11.6	11.6	254	208
	2.50%	0.46	9	0.18	0.23	11.3	11.3	184.3	215
	control	0.18	5.53	0.01	0.04	30	30	350	185.6
	SEm	0.046	0.807	0.020	0.018	0.535	0.535	6.328	4.672
	CD5%	0.138	2.449	0.060	0.055	1.621	1.621	19.195	14.170

Effect of Imizathypyr 35% WG on galls and egg sac of *M.incognita* on tomato plants were studied in pots. The observations present in revealed significant difference and suppress management of root knot disease at every level of concentrations. Reduction of final nematode population with reference to galls were 11.3, 11.6, 12 and 13.3 at 1.25, 1.0, 0.5 and 0.25 levels of concentration respectively. Similarly the egg masses, eggs/egg sacc and emergence of larvae reduced over un treated plants. The initial nematode population was 1000 J2 /500cc soil, data on nematode galls and egg saccs development eggs/egg sacc and emergence of larvae from the eggs shows significant reduction at 1.25 (200), 1.0 (195), 0.5 (190) and 0.25 (188.3) percent level of herbicide reduced over un treated control. Application of Imizathypyr 35% WG at all the concentrations to tomato plant significantly ($p=0.05$) increased the shoot weight (fresh and dry), shoot length and fresh root weight. However decrease in plant growth was evidenced due to nematode association during the plant growth period (**Table 5**).

Use of herbicides not only help in eradicating the weed plants but can also have role in reducing the population density of the nematodes. In the present finding the result obtained showed that herbicides viz, Cladinofop proparyl 15% WP Clamazone 50% EC, Pendimithalin 30% EC, Bispyribac sodium 10% SC, Imizathypyr 35% WG mitigated the deleterious effect of nematode and thereby enhancing the growth parameters of the tomato plants. The finding indicates that these herbicides exhibits marked reduction in galls, egg masses and J2 in soil. Worldwide conservation technologies have greatly to minimize soil loss. Use of herbicide application have been extensively adapted for the control of weeds, reduce soil erosion, conserve soil structure and improve the labour efficiency. These results are in agreement with the findings of [9] with the metribuzin (M) alone and in combination, on hatching, penetration, development, and reproduction of *Meloidogyne incognita* (race 3) *invitro*. [7,11] Reported that Application of integrated protocols including, urea, IAA combined with the herbicide pendimethalin deserves consideration in the future tactics to maximize the efficiency of nematode control, associated weeds infestation and promoting the yield. IAA either single or combined application showed a potential effects in suppressing root knot nematode *M.incognita* j2 in soil and increasing eggplant yield. These results are in agreement with the findings of [1].

Table 5 Effect of Imizathypyr 35% WG at different Concentrations on growth parameters and population development of *M. incognita* on tomato (S.S-21)

Treatments	**Concentrations**	**Observations**							
		Fresh shoot weight (g)	**Shoot length (cm)**	**Fresh root weight (g)**	**Dry shoot weight (g)**	**No.of galls**	**No. of egg saccs**	**No.of eggs/sacc**	**Soil population**
Imizathypyr 35% WG	0.25%	0.21	8	0.03	0.06	13.3	13.3	241.6	188.3
	0.5%	0.23	8.3	0.04	0.07	12	12	231	190
	1.0%	0.26	9	0.05	0.09	11.6	11.6	223.3	195
	1.25%	0.3	9.6	0.06	0.1	11.3	11.3	220	200
	Control	0.18	5.53	0.01	0.04	30	30	350	185.6
	SEm	0.032	0.807	0.009	0.020	0.535	0.535	6.209	8.213
	CD5%	0.096	2.449	0.028	0.062	1.621	1.621	18.834	24.913

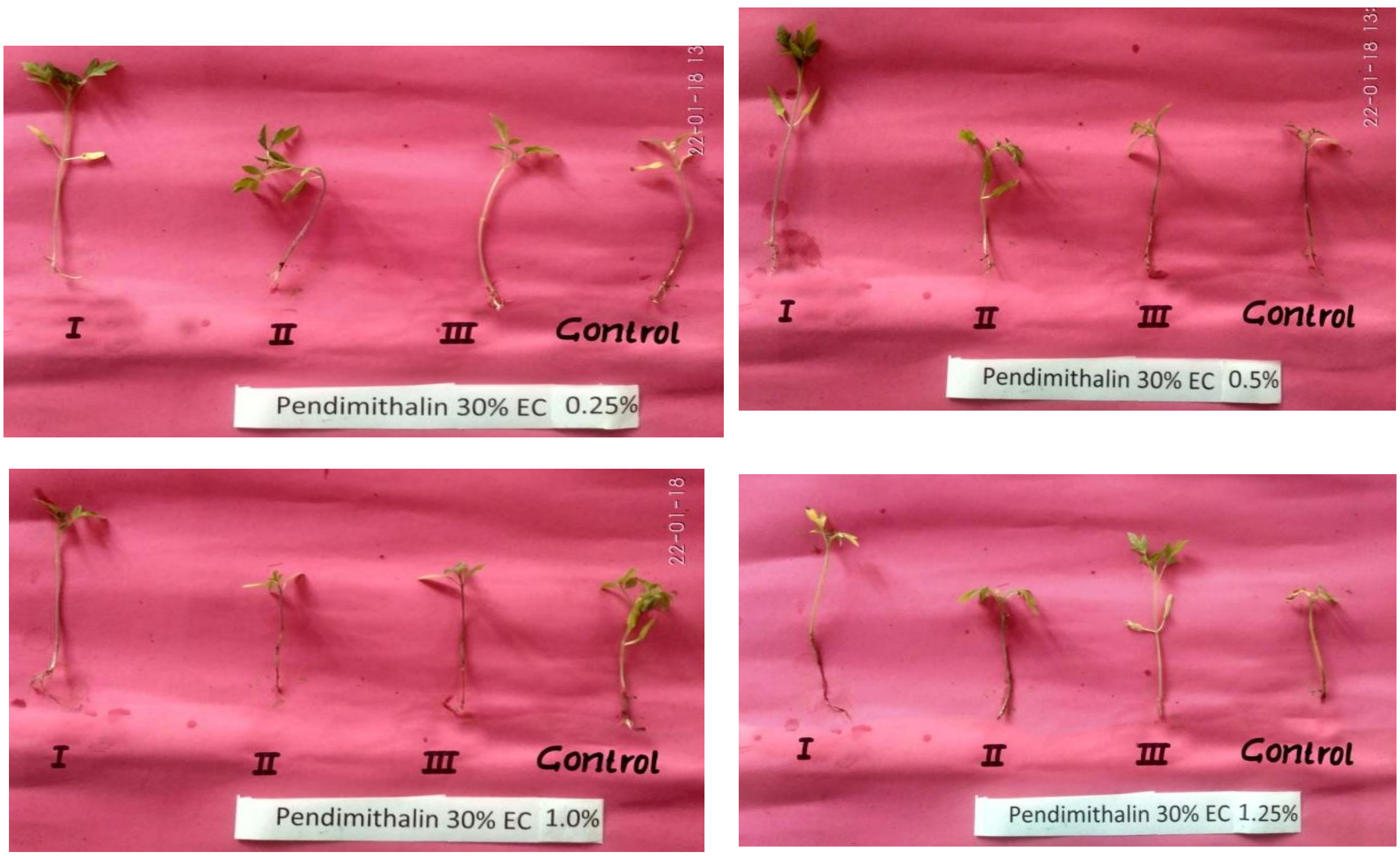

Plate 1 Effect of Pendimithalin 30% EC on growth of tomato and low development of galls and egg mass of *M. incognita* at different concentrations among five herbicides

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