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Research Article
Nematicidal Effect of Fumigants on the *Meloidogyne incognita* and *Fusarium oxysporum* F. sp. *cucumerinum* on Cucumber in Polyhouse

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Abstract

Background and Objective: Root-knot nematode and *Fusarium oxysporum* f. sp. *cucumerinum* is one of the most damaging pests in polyhouse crops under protected conditions. Effective fumigants are needed for controlling these destructive pathogens in under protected conditions. The experiment was conducted under polyhouse conditions to study the effect of soil fumigants on the population of root-knot nematode and disease incidence (%) of the fungus on cucumber. However, till date there is very less work have been done on this aspect. **Materials and Methods:** Autoclaved sterilized soil inoculated with *Meloidogyne incognita* and *Fusarium oxysporum* f. sp. *cucumerinum*. Infested soil fumigated with formalin at 5, 10 and 30% and dazomet at 0.3, 0.6 and 0.9 g kg^{-1} soil for the management of both the pathogens. Chemical checks with Bavistin at 2 g L^{-1} water and carbofuran at 1 mg a.i. kg^{-1} soil, as well as untreated check, were also maintained. **Results:** The results revealed that all the fumigants were significantly improved plant growth parameters and reduced galling, egg masses formation, final nematode population (PF), reproduction factor (RF) and disease incidence (%) as compared untreated inoculated check. **Conclusion:** In the present study, results clearly indicated that fumigants have wide range of the nematicidal activity for the reducing nematode as well disease incidence (%).

Key words: Root-knot nematode, soil fumigants, nematode management, polyhouse condition, cucumber

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is widely cultivated crop in the gourd family Cucurbitaceous grown all over the world due to a good source of vitamins, minerals, fiber and roughages. Though in the polyhouses, crops are grown under protected conditions, yet the crops are not protected even under protected conditions. Polyhouse cultivation involves intensive cultivation of crops, optimum use of fertilizers and frequent use of irrigation, but continuous growing of the same crop with high day temperature and relative humidity within the greenhouse, polyhouse and low tunnel along with poor plant hygienic conditions inside and outside the greenhouse increase problem of soil-borne pests and diseases including plant-parasitic nematodes Minuto *et al.*[1] which results in the availability of ideal conditions for the growth and multiplication of these pests.

Plant-parasitic nematodes are recognized as major agricultural pathogens and are known to attack plants and cause crop losses throughout the world. Root-knot nematode is the most damaging plant-parasitic nematode Barker[2]. Under polyhouse cultivation crops, are attacked by a number of pests and diseases including nematodes which interfere with the successful cultivation under protected conditions. Among the nematodes, root-knot nematode (*Meloidogyne* spp.) is the most damaging under polyhouse conditions, parasitizing almost all the polyhouses crops. Root-knot nematode, *Meloidogune incognita* was found to be the major plant-parasitic nematode under protected conditions. A frequency of occurrence of root-knot nematode was recorded to be 63.15% and population density range was 30-10000 j2/200cc soil[3]. The damage becomes very severe in association with fungi. Though yield loss due to this nematode is difficult to predict, approximate yield loss due to this nematode has been predicted by many authors in various crops. Another important biotic stress to which the crop exposed is the fungus, *Fusarium oxysporum* f. sp. *cucumerinum*. Plants infected with *Meloidogyne* spp. have typical root galling. Some infected plants also express nutrient deficiency symptoms, particularly for nitrogen Good[4].

The intensive growing of vegetable crops in greenhouses promotes for their reproduction. The applied chemical products are not always with adequate effectiveness and often their use cause serious ecological problems. New ecological alternative methods are tried to be found. Currently, the most commonly used soil fumigants for nematode management in vegetables are 1,3-D[5-8], DMDS[9-11] and a 3-way combination of 1,3-D+metam sodium or metam potassium+chloropicrin[12-14]. Generally, the root-knot nematode-fungus complex is considered to be one of the important factors responsible for the crop reduction under field and polyhouse conditions. However, very little work has been done on the management of nematode-fungus disease complex in cucumber under polyhouses conditions. This research wasp proposed to study the management nematode-fungus disease complex in cucumber under protected conditions by using different fumigants.

MATERIALS AND METHODS

Propagation of pure culture of *Meloidogyne incognita* for obtaining egg masses and second stage juveniles (J_2): Identification of root-knot nematode *M. incognita* was done prior to its propagation in pure culture. For this purpose, galled cucumber roots were collected from the naturally infested polyhouses during a random survey and brought to the laboratory. Egg masses were separated in sodium hypochlorite solution after continuous striation for five minutes, for detachment of egg masses from the roots[15]. Eggs were collected on 500 mesh sieve after proper washing with water to remove the excess sodium hypochlorite. The contents of 500 mesh sieve were taken in a beaker and placed on Modified Baermann's funnel for 24 h. After identification, a pure culture was propagated with the egg masses collected from root-knot nematode infected roots. About 40-50 earthen pots were filled with steam sterilized soil and 4 weeks old brinjal seedlings were raised in that pots and inoculated with *M. incognita* juveniles. After 65 days of inoculation, wilted plants showed heavy galling in the roots.

Some plants were selected and brought to the laboratory and the same process was repeated for identification of *M. incognita* females through perineal patterns[16]. Egg masses and juveniles from these plants were used in inoculation for further experimentation during the course of present investigations. The culture was periodically sub-cultured for multiplication and purity. The desired number of egg masses collected by sodium hypochlorite method was transferred to double folded tissue paper, held on a moulded piece of aluminium wire net and placed on petri plate at 28±20°C temperature. Sufficient amount of water was added to keep the egg masses just submerged. On the next day, water from these petri plates containing second stage juveniles was collected in beakers. The number of juveniles was counted per mL solution with three replications. These freshly hatched juveniles were used for inoculation for further experimentation.

Isolation of fungus from plant material collected during a random survey: Infected cucumber roots showing symptoms of the disease were obtained from polyhouses during a random survey. The roots were cut into small sections (0.5-1.0 cm), washed thoroughly under tap water, surface sterilized with sodium hypochlorite (5%) solution (NaOCL) for 5 minutes, rinsed three times in changes of sterilized distilled water and dried on sterilized filter papers. The sterilized roots sections were plated at the rate of five sections/plate onto potato dextrose agar (PDA) in 9 cm Petri dishes. The Petri dishes were incubated at 27±1°C. After incubation for 7 days, isolated fungi were subcultured on PDA. The pure culture of isolated fungus was maintained on PDA slants and renewed after every 10 days. Burgess *et al*.[17] Further microscopic examinations were carried out for mycelia and conidia structure using the pure culture of *F. oxysporum* f. sp. *cucumerinum* was obtained by using Hyphal Tip technique. A sample of the obtained colonies was sub cultured by transferring small mycelia from the colony margins. Pure cultures were obtained by sub-culturing three times and slides were prepared and examined microscopically to confirm *Fusarium oxysporum* due to the occurrence of typical macroconidia with foot-shaped basal cells, microconidia borne in false heads only on monophialides and chlamydospores.

Propagation of pure culture of *F. oxysporum* f. sp. *cucumerinum*: A pure culture of *F. oxysporum* f. sp. *cucumerinum*, isolated from the infested plants during the random survey of polyhouses was maintained on PDA in petri plates at (27±1)°C. In order to produce a mass-culturing pure culture of the fungus were grown on sand maize meal medium (700 g sand+maize meal 300 g+150 mL distilled water). The flasks and polypropylene bags were incubated in a BOD (Biological Oxygen Demand) incubator at a temperature of 27±1°C for 15 days. During incubation, the flasks were shaken three times in a day, to ensure proper growth of the fungal mycelium on the sand maize meal medium.

Experimental procedure: The experiment was conducted in pots (1 kg capacity). A fungus was grown on sand maize meal medium. The soil was autoclaved and infested with root-knot nematode (1000 J2 kg^{-1} soil) and fungus (50 g kg^{-1} soil). The potted soil was treated with fumigants as per treatment. The pots were covered with polythene bags for 15 days. Each pot was uncovered after 15 days of treatment. A waiting of 10 days was given between removal of polythene bags and sowing of cucumber seeds at 5 seeds per pot in the month of March. Besides the fumigants, other chemical checks were incorporated before sowing. One plant per pot was retained after 30 days. The experiment was terminated 60 days after germination. Usual polyhouse care was given.

Statistical analysis: The data were subjected to two factorial completely randomized design (CRD) using OPSTAT programme available on-line at CCS HAU, Hisar University website. The comparisons in treatments were made by critical difference (CD) at the 5% level of significance. Necessary transformations of data were done where applicable.

RESULTS

Effect of fumigants on the plant growth parameters: The data (Table 1) indicated that shoot length in all the treatments was significantly better over untreated inoculated checks viz., nematode alone (91.1 cm), fungus alone (87.2 cm) and nematode+fungus simultaneously (84.9 cm). Among the various treatments, maximum shoot length was observed in

Table 1: Effect of soil treatment with fumigants on shoot length (cm) of cucumber infested with *M. incognita* and fungus

	Shoot length (cm)			
Treatments	Nematode alone	Fungus alone	Nematode+fungus	Pooled mean
T1: Fumigation with formalin at 5% i.e., 1.25 mL/pot	136.2	140.1	131.6	136.0
T2: Fumigation with formalin at 10% i.e., 2.5 mL/pot	144.8	150.8	141.1	145.6
T3: Fumigation with formalin at 30% i.e., 5.0 mL/pot	159.0	167.5	154.1	160.2
T4: Fumigation with dazomet at 0.3 g/pot	129.9	134.4	128.4	130.9
T5: Fumigation with dazomet at 0.6 g/pot	139.4	144.5	136.8	140.2
T6: Fumigation with dazomet at 0.9 g/pot	155.9	161.3	149.6	155.6
T7: Carbofuran 3 G at 0.1 g/pot	150.1	116.6	145.6	137.4
T8: Drenching with bavistin at 2 g L^{-1} water	118.9	157.8	121.6	132.8
T9: Untreated (inoculated)	91.1	87.2	84.9	87.7
T10: Untreated (uninoculated)	164.2	168.1	167.9	166.7
Pooled mean	138.9	142.8	136.1	

CD at 5% level, Treatment: 2.2, Sub treatment: 4.0, Treatment X Sub treatment: 7.0

Table 2: Effect of soil treatment with fumigants on dry shoot weight (g) of cucumber infested with *M. incognita* and fungus

	Dry shoot weight (g)			
Treatments	Nematode alone	Fungus alone	Nematode+fungus	Pooled mean
T1: Fumigation with formalin at 5% i.e., 1.25 mL/pot	18.49	18.95	12.26	16.56
T2: Fumigation with formalin at 10% i.e., 2.5 mL/pot	21.10	23.03	15.01	19.71
T3: Fumigation with formalin at 30% i.e., 5.0 mL/pot	24.66	26.74	22.10	24.49
T4: Fumigation with dazomet at 0.3 g/pot	17.42	18.43	11.53	15.79
T5: Fumigation with dazomet at 0.6 g/pot	19.70	20.58	13.35	17.87
T6: Fumigation with dazomet at 0.9 g/pot	23.00	23.99	19.01	21.99
T7: Carbofuran 3 G at 0.1 g/pot	22.14	14.81	17.26	18.06
T8: Drenching with bavistin at 2 g L^{-1} water	12.46	25.59	11.01	16.35
T9: Untreated (inoculated)	6.91	5.74	5.18	5.94
T10: Untreated (uninoculated)	26.86	28.06	26.60	27.17
Pooled mean	19.27	20.58	15.32	

CD at 5% level, Treatment: 1.27, Sub treatment: 2.32, Treatment X Sub treatment: 4.02

Table 3: Effect of soil treatment with fumigants on dry root weight (g) of cucumber infested with *M. incognita* and fungus

	Dry root weight (g)			
Treatments	Nematode alone	Fungus alone	Nematode+fungus	Pooled mean
T1: Fumigation with formalin at 5% i.e., 1.25 mL/pot	6.43	5.45	3.14	5.00
T2: Fumigation with formalin at 10% i.e., 2.5 mL/pot	6.99	5.72	3.74	5.48
T3: Fumigation with formalin at 30% i.e., 5.0 mL/pot	8.55	8.72	6.68	7.98
T4: Fumigation with dazomet at 0.3 g/pot	5.64	4.74	2.96	4.44
T5: Fumigation with dazomet at 0.6 g/pot	6.77	4.52	3.41	4.89
T6: Fumigation with dazomet at 0.9 g/pot	8.00	6.63	5.65	6.76
T7: Carbofuran at 0.1 g/pot	7.89	3.78	4.01	5.22
T8: Drenching with bavistin at 2 g L^{-1} water	3.57	7.52	3.22	4.76
T9: Untreated (inoculated)	1.72	2.18	1.51	1.80
T10: Untreated (uninoculated)	9.29	9.21	9.49	9.32
Pooled mean	6.48	5.84	4.38	

CD at 5% level, Treatment: 0.73, Sub treatment: 1.34, Treatment X Sub treatment: 2.32

formalin at 30% (160.2 cm), followed by dazomet at 0.9 g kg^{-1} soil (155.6 cm) irrespective of whether nematode or fungus inoculated individually or concomitantly. However, in plants inoculated with nematode alone, shoot length was maximum in case of formalin (159 cm) followed by dazomet (155.9 cm) as compared to untreated inoculated check (91.1 cm). In plants inoculated with fungus alone, shoot length was maximum in case of formalin (167.5 cm) followed by dazomet (161.3 cm) as compared to untreated inoculated check (87.2 cm). In plants inoculated with nematode and fungus concomitantly, shoot length was maximum in case of formalin (154.1 cm) followed by dazomet (149.6 cm) as compared to untreated inoculated check (84.2 cm). In general, shoot length was significantly less in all the treatments compared to untreated uninoculated check irrespective of whether inoculated individually or concomitantly with nematode and fungus.

The data in Table 2 expressed that in the dry shoot weight in all the treatments was significantly better over untreated inoculated checks viz., nematode alone (6.91 g), fungus alone (5.74 g) and nematode+fungus simultaneously (5.18 g). Among the various treatments, maximum dry shoot weight was observed in formalin at 30% (24.49 g), followed by dazomet at 0.9 g kg^{-1} soil (21.99 g) irrespective of whether nematode or fungus inoculated individually or concomitantly. However, in plants inoculated with nematode alone, dry shoot weight was maximum in case of formalin (24.66 g) followed by dazomet (23.0 g) as compared to untreated inoculated check (6.91 g). In plants inoculated with fungus alone, dry shoot weight was maximum in case of formalin (26.74 g) followed by dazomet (23.99 g) as compared to untreated inoculated check (5.74 g). In plants inoculated with nematode and fungus concomitantly, dry shoot weight was maximum in case of formalin (22.1 g) followed by dazomet (19.01 g) as compared to untreated inoculated check (5.18 g).

Data (Table 3) revealed that dry root weight in all the treatments was significantly better over untreated inoculated checks viz., nematode alone (1.72 g), fungus alone (2.18 g) and nematode+fungus simultaneously (1.51 g). Among the various treatments, maximum dry root weight was observed in formalin at 30% (7.98 g), followed by dazomet at 0.9 g kg^{-1} soil (6.76 g) irrespective of whether nematode or fungus inoculated individually or concomitantly. However, in plants inoculated with nematode alone, dry root weight was

Table 4: Effect of soil treatment with fumigants on number of galls per plant of cucumber infested with *M. incognita* and fungus

	Number of galls per plant		
Treatments	Nematode alone	Nematode+fungus	Pooled mean
T1: Fumigation with formalin at 5% i.e. 1.25 mL/pot	60 (7.8)	53 (7.4)	56 (7.6)
T2: Fumigation with formalin at 10% i.e., 2.5 mL/pot	46 (6.8)	40 (6.4)	43 (6.6)
T3: Fumigation with formalin at 30% i.e., 5.0 mL/pot	30 (5.5)	23 (4.9)	26 (5.2)
T4: Fumigation with dazomet at 0.3 g/pot	68 (8.3)	63 (8.0)	65 (8.1)
T5: Fumigation with dazomet at 0.6 g/pot	53 (7.3)	46 (6.8)	49 (7.1)
T6: Fumigation with dazomet at 0.9 g/pot	35 (6.0)	30 (5.5)	32 (5.7)
T7: Carbofuran 3 G at 0.1 g/pot	120 (11.0)	102 (10.2)	111 (10.6)
T8: Drenching with Bavistin at 2 g L^{-1} water	215 (14.7)	196 (14.0)	205 (14.4)
T9: Untreated (inoculated)	330 (18.2)	321 (17.9)	325 (18.0)
T10: Untreated (uninoculated)	0 (1.0)	0 (1.0)	1.0
Pooled mean	8.6	8.2	

Figures in parenthesis are the (√n+1) transformed values, CD at 5% level, Treatment: 0.06, Sub treatment: 0.15, Treatment X Sub treatment: 0.21

Table 5 Effect of soil treatment with fumigants on final nematode population of cucumber infested with *M. incognita* and fungus

	Final nematode population per 200cc soil		
Treatments	Nematode alone	Nematode+fungus	Pooled mean
T1: Fumigation with formalin at 5% i.e., 1.25 mL/pot	160 (12.7)	151 (12.3)	155 (12.5)
T2: Fumigation with formalin at 10% i.e., 2.5 mL/pot	146 (12.1)	142 (12.0)	144 (12.0)
T3: Fumigation with formalin at 30% i.e., 5.0 mL/pot	126 (11.3)	119 (11.0)	122 (11.1)
T4: Fumigation with dazomet at 0.3 g/pot	293 (17.2)	281 (16.8)	287 (16.9)
T5: Fumigation with dazomet at 0.6 g/pot	154 (12.4)	150 (12.8)	152 (12.4)
T6: Fumigation with dazomet at 0.9 g/pot	134 (11.6)	127 (11.3)	130 (11.4)
T7: Carbofuran 3 Gat 0.1 g/pot	177 (13.3)	157 (12.7)	167 (12.9)
T8: Drenching with Bavistin at 2 g L^{-1} water	486 (22.3)	464 (21.6)	475 (21.8)
T9: Untreated (inoculated)	655 (25.6)	641 (25.3)	648 (25.4)
T10: Untreated (uninoculated)	0 (1.0)	0 (1.0)	0 (1.0)
Pooled mean	13.9	13.6	

Figures in parenthesis are the (√n+1) transformed values, CD at 5% level, Treatment: 0.05, Sub treatment: 0.12, Treatment X Sub treatment: 0.17

maximum in case of formalin (8.55 g) followed by dazomet (8.00 g) as compared to untreated inoculated check (1.72 g). In plants inoculated with fungus alone, dry root weight was maximum in case of formalin (8.72 g) followed by dazomet (6.63 g) as compared to untreated inoculated check (2.18 g). In plants inoculated with nematode and fungus concomitantly, dry root weight was maximum in case of formalin (6.68 g) followed by dazomet (5.65 g) as compared to untreated inoculated check (1.51 g).

Effect of fumigants on the nematode reproduction: The data (Table 4) indicated that the number of galls per plant in all the treatments was significantly reduced over untreated inoculated checks viz., nematode alone (330) and nematode+fungus simultaneously (321). Among the various treatments, a minimum number of galls per plant was observed in formalin at 30% (26), followed by dazomet at 0.9 g kg^{-1} soil (32) irrespective of whether nematode inoculated individually or concomitantly. However, in plants inoculated with nematode alone, the number of galls per plant was minimum in case of formalin (30) followed by dazomet (35) as compared to untreated inoculated check (330). In plants inoculated with nematode and fungus concomitantly, the number of galls per plant was minimum in case of formalin (23) followed by dazomet (30) as compared to untreated inoculated check (321).

The data (Table 5) revealed that nematode population J_2/200 cc soil in all the treatments was significantly reduced over untreated inoculated checks viz., nematode alone (655) and nematode+fungus inoculated simultaneously (641). Among the various treatments, minimum nematode population J_2/200 cc soil was observed in formalin at 30% (122), followed by dazomet at 0.9 g kg^{-1} soil (130) irrespective of whether nematode was inoculated individually or concomitantly. However, in plants inoculated with nematode alone, nematode population J_2/200 cc soil was minimum in case of formalin at 30% (126) followed by dazomet (134) as compared to untreated inoculated check (655). In plants inoculated with nematode and fungus concomitantly, nematode population J_2/200 cc soil was minimum in case of formalin at 30% (119) followed by dazomet (127) as compared to untreated inoculated check (641).

Table 6: Effect of soil treatment with fumigants on fungal incidence (%) of cucumber infested with *M. incognita* and fungus

Treatments	Fungal incidence (%)		
	Pre emergence damping off (after 15 days)	Pre emergence damping off (after 30 days)	Pooled mean
T1: Fumigation with formalin at 5% i.e., 1.25 mL/pot	5 (13.6)	15 (23.0)	10.0 (18.3)
T2: Fumigation with formalin at 10% i.e., 2.5 mL/pot	5 (13.6)	15 (23.0)	10.0 (18.3)
T3: Fumigation with formalin at 30% i.e., 5.0 mL/pot	0 (4.1)	5 (13.6)	2.5 (8.8)
T4: Fumigation with dazomet at 0.3 g/pot	5 (13.6)	20 (26.9)	12.5 (20.2)
T5: Fumigation with dazomet at 0.6 g/pot	5 (13.6)	15 (23.0)	10.0 (18.3)
T6: Fumigation with dazomet at 0.9 g/pot	5 (13.6)	15 (23.0)	10.0 (18.3)
T7: Carbofuran at 0.1 g/pot	25 (30.3)	55 (48.2)	40.0 (39.2)
T8: Drenching with Bavistin at 2 g L^{-1} water	5 (13.6)	10 (18.6)	7.5 (16.1)
T9: Untreated (inoculated)	45 (42.4)	80 (63.8)	62.5 (53.1)
T10: Untreated (uninoculated)	0 (4.1)	0 (4.1)	0.0 (4.1)
Pooled mean	16.2	26.5	

Figures in parenthesis are the angular transformed values, CD at 5% level, Treatment: 0.8, Sub treatment: 1.9, Treatment X Sub treatment: 2.7

Effect of fumigants on the disease incidence: The data (Table 6) indicated that disease incidence in case of nematode and fungus concomitantly was reduced significantly in all treatments on cucumber as compared to untreated inoculated checks. Data were recorded 15 and 30 days after sowing. After 15 days of sowing, disease incidence was minimum (0.0%) in case of soil treated with formalin at 30% followed by 5%, in case of bavistin at 2 g L^{-1} water or dazomet at 0.9 g kg^{-1} soil as compared to untreated inoculated check (45%) while it was maximum (25%) in case of carbofuran at 0.1 g kg^{-1} soil treated soil. After 30 days at sowing, disease incidence was minimum (5%) in case of soil treated with formalin followed by (10%) in case of bavistin and (15%) in case of dazomet as compared to untreated inoculated check (80%) while it was maximum (55%) in case of carbofuran at 0.1 g kg^{-1} soil treated soil.

DISCUSSION

The present investigation showed that the fumigants i.e., formalin at 30% and dazomet at 0.9 g kg^{-1} soil were highly effective in reducing *M. incognita* infection, disease incidence (%) and increasing plant growth parameters as compared to untreated inoculated checks. The relative nematicidal effectiveness of the chemicals used in our tests agrees with those of other workers[5,18,19]. The soil is treated before planting and the chemicals either make plants unattractive for nematodes or the nematodes are immobilised and therefore cannot find their host. Moreover, minimum number of galls per plant was observed in formalin at 30%, followed by dazomet at 0.9 g kg^{-1} soil as compared to inoculated checks this finding are in agreement with the Radwan *et al.*[20], who reported that the efficacy of five nematicides (cadusafos, carbofuran, ethoprop, fosthiazate and oxamy) against root-knot nematode on tomato under glasshouse conditions. Plants treated with nematistatics such as aldicarb and carbofuran (carbamates) or ethoprophos (an organophosphate), retain their ability to induce nematode eggs to hatch (such as some cyst nematodes and *Meloidogyne* spp.) but juveniles become either immobilized or disoriented and cannot find their food source, the plant roots[21]. Treatment of plants with nematistatics delays nematode penetration into the roots and results in a certain fraction of the root system escaping nematode attack and thus remaining healthy.

At 15 and 30 days after sowing, disease incidence was minimum in case of soil was treated with formalin followed by bavistin and dazomet as compare to untreated inoculated check of fungus alone. These results cope with the Widmer and Abawi[22] and Rahman[23], who reported that management of root-knot nematode and fungus in various crops under field conditions. Management will require the logical use of effective control methodologies in combinations that are economically acceptable to the grower[24]. In contrast, soil fumigation alone is likely to be detrimental to integrated nematode management. Soil fumigants kill large numbers of nematodes and models of infectious disease in pest populations suggest that the use of such pesticides lengthens the time required for a pathogen to control a pest[25].

In the summary of the current findings for the using of the different fumigants has been very effective for the management of the both pathogens, when we applied that fumigants at appropriate time and methods should be used for their application under the protected cultivation.

CONCLUSION

Results presented in this study address a strong correlation between the fumigants for the cucumber to enhanced plants growth by applying as soil application, reduction in the nematode reproduction and fungus colonization attacking on cucumber plants resulting in production of higher yield, quality cucumber fruits.

SIGNIFICANCE STATEMENT

This study showed the role of fumigants in controlling root knot nematode and soil-borne fungi attacking cucumber plants. Also, direct the attention to use the fumigants for controlling the root knot nematode and soil borne fungus diseases complex with the fumigants mentioned here to produce healthy cucumber fruits.

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