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Influence of Integrated Nematode Management Modules against *Meloidogyne incognita* Infecting Cucumber in Poly-house

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Nematodes management in poly-house through a single practice is a very typical task in present agricultural scenario so, an integrated nematode management trial was conducted for the management of *Meloidogyne incognita* on cucumber in poly-house. In the investigation different combinations of physical, cultural and chemical treatments were applied for effective management of hidden enemy of cucumber, *M. incognita*. The combinations of hot water at 1 litre per poly bag, organic amendment (tea waste, tobacco churi, poultry manure, water hyacinth powder and lantana leaf powder at 20 g/plant) and carbofuran (0.25 g a.i./plant and 0.50 g a.i./plant) were applied.

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Standard (Hot water at 1 litre + Neem cake 50 g/plant + phorate at 0.5 g a.i./plant) and untreated checks were also maintained to compare experimental findings. The results of investigation shows that all the applied treatments significantly reduced nematode infection and increase plant growth over untreated check. Among all treatment combinations, Highest yield of cucumber (4.171 kg/plant) was obtained with integration of Hot water at 1 litre + Neem cake 50 g/plant + phorate at 0.5 g a.i./plant followed by Hot water + Tobacco churi + carbofuran at 0.5 g a.i./plant (3.924 kg/plant) and Hot water + Tea waste + carbofuran at 0.5 g a.i./plant (3.781 kg/plant) as compared to untreated check (1.092 kg/plant).

Keywords: Cucumber; poly-house; Meloidogyne incognita; hot water; organic amendments; chemicals.

1. INTRODUCTION

Cultivation of cucumber under protected cultivation known as a hot spot for the plant parasitic nematodes due to favourable environmental conditions and monocropping. Multiplication of insect pest and pathogens including plant parasitic nematodes are very high and significantly reduce the quantity and quality of production [1,2]. Among plant parasitic nematodes some specific species of root-knot nematode like *Meloidogyne incognita, Meloidogyne javanica* and *Meloidogyne enterolobii* are most serious and causing great damage to crops grown under poly-houses including cucumber [3,4]. Plant parasitic nematode causes approximately 21.3% losses in crops, it's amounting to Rs.102,039.79 million (1.58 billion USD) annually in India. Among nematodes, root-knot nematode, *Meloidogyne* spp. is responsible for 75.83% of the estimated losses. It causes 12.00% losses on cucumber with estimated monetary loss of Rs. 110.46 million per annum in open field recorded by Kumar et al. [5] and cause 66.84% losses on cucumber in poly-house [6]. Agri-horticultural production was adversely affected greatly by plant parasitic nematodes in present scenario due to climate change. Variety of cultural, physical, biological and chemical methods of nematode management have been tested individually and found effective to some extent but all the methods have their own merits and demerits. With this view, in present investigation integration of hot water, organic amendment and carbofuran have been tried for the management of root-knot nematode, *M. incognita* on cucumber in poly house.

2. MATERIALS AND METHODS

This experiment was conducted at naturally infested poly-houses of progressive farmers during 2016 and 2017.

2.1 Selection of Experimental Site

Survey was under taken to identified and locates the *M. incognita* infested poly-house before preparation of experimental trial. Two cucumber growing progressive farmers of two different locations was selected which have well established poly house naturally infested with *Meloidogyne incognita* having an initial nematode population of 1350 and 1360 larvae/100 cc soil during 2016 & 17, respectively. Plant protection, irrigation and other required facilities have been fully ensured for planning, monitoring and layout of experimental trials.

2.2 Identification of Root-Knot Nematode Species

Root samples of plants were collected from the trial and washed carefully in running tap water for removal of soil particles. The egg masses of nematode were separated from infected roots. Fresh egg masses were kept in cavity block filled with water for 24 hrs for emergence of juveniles and females were collected from roots for identification of nematode species. Perineal patterns of these females were cut and observed. The nematode species was identified as *M. incognita* [7].

2.3 Sowing

After layout and proper treatment, sowing of cucumber variety "Mini-angle" which is highly susceptible and used by poly-house growers was done in the month of July with dibbling method and labelled properly. Spacing for each poly bag was maintained according to drip line for appropriate growth of the plants under protected cultivation. Some seeds also sown in pro trays for gap filling, if required.

2.4 Application of Treatments

The experiment was carried out to find out the suitable eco-friendly nematode management

module for root-knot nematode, *Meloidogyne incognita* on cucumber under protected cultivation. The boiled hot water (100^0C) treatment at 1.0 litre/plant applied in light ploughed soil before sowing, used for quick reduction in initial population of nematodes and temperature of soil measured through pocket thermometer. To make waste material useful, the organic amendments *i.e.* tea waste, tobacco churi, poultry manure, water hyacinth powder, lantana leaf powder tested against *M. incognita* at 20 g/plant as soil application before sowing for improve soil properties and plant tolerance along with carbofuran (0.25 and 0.50 g a.i./plant) were used in combinations. A treated check (Hot water 1.0 litre/polybag + Neem cake 50g/plant + phorate at 0.50 g a.i./plant) and untreated check was also taken and maintained for comparison of various treatments.

2.5 Observations

Initial nematode population/100 cc soil was determined just before treatments application. Observations on number of galls/5 g root, egg masses/5 g root, eggs & larvae/egg mass, final nematode population/100 cc soil, vine length (m), vine weight (kg) were recorded. Yield (kg/plant) was recorded from first picking to till harvest of experiment. Picking was done time to time whenever required and collected separately treatment wise in well labeled cloth bags and weighed to obtained yield record data.

2.6 Statistical Analysis

All the experiments in poly-house were conducted in a completely randomized design. All the experiments were conducted twice using the same treatments and data of the two trials were pooled for presentation. After completion of experiments, data were statistically analysed for interpretation of findings using regression analysis with Excel 2016. The critical difference was found out for comparison of treatments where the 'F' test was found significant at 5 per cent level of significance. Summary tables along with SEm± and CD were worked out and presented.

3. RESULTS AND DISCUSSION

Integrated nematode management refers to controlling the nematodes using two or more methods. Now a days looking to climate change, it is very difficult to control nematodes by any one method, so in present scenario integrated nematode management is very important. With this view, in present investigation, integration of hot water, organic amendments and carbofuran have been tried for the management of root-knot nematode, *M. incognita* on cucumber in poly house. A standard check and untreated check were also maintained to compare experimental findings. Observations on galls/5 g roots, egg masses/5 g roots, eggs and larvae/egg mass, final nematode population/100 cc soil, vine length (m), vine weight (kg) and yield (kg/plant) were recorded. The results are presented in Tables 1 and 2.

Experimental results exhibited that all the integrated nematode management treatments significantly reduced number of galls/ 5 g roots as compared to untreated check. Among various combinations, minimum number of galls per 5 g roots (9.00) was recorded with Hot water + Tobacco churi + carbofuran at 0.5 g a.i./plant followed by Hot water + Tea waste + carbofuran at 0.5 g a.i./plant (10.80) and Hot water + Poultry manure + carbofuran at 0.5 g a.i./plant (13.00) in comparison to untreated check (70.10). These treatments found significantly better with regards to decrease galls on cucumber over check. On the whole, minimum galls per 5 g roots (7.80) were obtained with standard check (Hot water at 1 litre + Neem cake 50 g/plant + phorate at 0.5 g a.i./plant) but it was found at par with Hot water + Tobacco churi + carbofuran at 0.5 g a.i./plant. Almost similar trend was obtained pertaining to other nematode parameters *viz.* egg masses/5g roots, eggs and larvae/egg mass and final nematode population/100 cc soil.

Results of present findings are in accordance with the findings of earlier workers who reported that integration of different management options proved better over individual method of nematode management. Parvatha Reddy and Khan [8] tested oil cakes at 1.0 t/ha as single and 0.5 t/ha with combined application of carbofuran (2 kg a.i./ha as single and 1.0 kg a.i./ha as combined application) against *M. incognita* infecting okra. Results revealed that plots treated with karanj cake, neem cake + carbofuran, groundnut cake + carbofuran gave highest yield of okra. However, all the oil cakes in combination with carbofuran gave least root-knot index as compared to control followed by single application of neem cake (1 t/ha) and carboruan (2 kg a.i./ha). Mishra et al. [9] reported that seed treatment with bio-pesticides (neem seed powder, latex of *Calotropis procera* and Neemark), chemicals (dimethoate, triazophos,

chlorpyriphos and carbofuran) and bio-agents (*Trichoderma viride, Aspergillus niger* and *Paecilomyces lilacinus*) found effective against root-knot nematode and increased plant growth and yield of chickpea. Soil treatment with carbofuran at 2 kg./ha was found equally effective as neem seed powder (50 kg/ha), but plant growth parameters were better under neem seed powder treatment.

Haseeb and Kumar [10] reported the effect of bio-agents (*P. fluorescens* and *T. viride* at 10 g/kg seed), neem seed powder at 10 g/kg seed and carbosulfan at 3.0% w/w as seed treatment alone and in combination against root-knot nematode, *M. incognita* on lentil. Highest improvement in grain yield and lowest root-knot index was observed with P*. fluorescens* + *T. viride* + neem seed powder + carbosulfan. An experiment under protected cultivation and observed that soil fumigation with metham sodium alone and in combined application with neem cake (enriched with bio-agents *Paecilomyces lilacinus, Pseudomonas fluorescence*) found very effective against root-knot nematode infecting tomato, capsicum and carnation [11]. Bhati et al. [12] tested different combinations of hot water, organic amendments and bio-agents against *M. incognita* on cucumber in polyhouse and found maximum yield (3.865 kg/plant) with combination of hot water (1 lit./polybag) + tobacco churi (20 g/plant) + *Paecilomyces lilacinus* (5.0 g/plant).

Experimental findings showed that vine length of cucumber increased significantly with the application of integrated treatments over untreated check. Results showed that maximum increase in the vine length was recorded with the application of Hot water + Tobacco churi + carbofuran at 0.5 g a.i./plant (3.406 m.) followed by Hot water + Tea waste + carbofuran at 0.5 g a.i./plant (3.262 m.) and Hot water + Poultry manure + carbofuran at 0.5 g a.i./plant (3.126 m) over untreated check (1.386 m.). However, it was registered 3.550 m. with Hot water at 1 litre + Neem cake 50 g/plant + phorate at 0.5 g a.i./plant and it was found at par with Hot water + Tobacco churi + carbofuran at 0.5 g a.i./plant. The similar trend was found with other parameters *i.e.* vine weight (kg) and yield (kg/plant) of cucumber in protected cultivation.

A field experiment conducted on chickpea against root-knot nematode using seed treatment of carbosulfan 25 SD at 0.75% with soil application of organic amendments. Results revealed that seed treatment and organic amendments had no adverse effect on germination and significantly enhanced plant growth and reduced root-knot index as well as final population in soil [13]. Begum and Sivakumar [14] conducted an integrated study on carbofuran at 3 kg/ha (as soil application), *Pseudomonas fluorescens* (seed treatment) + neem cake (soil application) and *Trichoderma viride* (seed treatment) + neem cake (soil application) for the management of disease complex involving *Heterodera cajani* and *Macrophomina phaseolina* on green gram. Highest reduction in the nematode population was recorded with carbofuran at 3 kg a.i./ha followed by combined application of *P. fluorescens* + neem cake and *T. viride* + neem cake. The organic amendments also helps to improve plant defense mechanism against plant parasitic nematodes [15].

Goswami et al. [16] studied on the effect of fungal bio-agents along with mustard cake and furadan against root-knot nematode *Meloidogyne incognita* infecting tomato under greenhouse condition. Bio-agents *viz*., *Paecilomyces lilacinus* and *Trichoderma viride* alone or in combination with mustard cake or furadan boost up plant growth and exhibited least nematode reproduction as compared to untreated check. Yucel et al. [17] carried out greenhouse experiments to found the effectiveness of a combination of soil solarization with low doses of metham-sodium (500, 750, 1000 and 1250 lha^{-1}) and dazomet (400 g ha^{-1}) against plant parasitic nematodes. Results showed that treatments reduced disease incidence and considered to be applicable for soil disinfestation and crop growth increased with all the treatments tested in both of the greenhouses. Divya et al. [18] conducted a field experiment to study the comparative effect of bio agents (*Purpureocillium lilacinum* and *Stenotrophomonas maltophilia*) and organic amendment (neem cake) in comparison with chemicals fluopyram and carbosulfan for the management of *M. incognita* in cowpea [19].

Table 1. Effect of integrated nematode management on multiplication of root-knot nematode, *M. incognita* infecting cucumber in poly-house

Treatments		Galls/5 g root			Egg masses/5 g roots			Eggs and larvae/egg mass			Final Nematode population/100 cc soil		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T1	Hot water at 1 litre/poly bag+Tea Waste at 20 g/plant + Carbofuran 0.25 g a.i./plant	20.00	19.40	19.70	15.40	15.00	15.20	186.80	179.80	183.30	616.40	612.00	614.20
T2	Hot water at 1 litre/poly bag+Tea Waste at 20 g/plant + Carbofuran 0.5 g a.i./plant	11.40	10.20	10.80	07.20	6.40	6.80	168.60	161.40	165.00	510.60	502.40	506.50
T3	Hot water at 1 litre/poly bag+Tobacco churi at 20 g/plant + Carbofuran 0.25 g a.i./plant	18.40	17.80	18.10	13.00	12.20	12.60	181.80	175.60	178.70	596.00	584.20	590.10
T4	Hot water at 1 litre/poly bag+ Tobacco churi at 20 g/plant + Carbofuran 0.5 g a.i./plant	09.20	8.80	9.00	05.20	04.60	4.90	161.20	158.40	159.80	494.80	486.80	490.80
T5	Hot water at 1 litre/poly bag+ Poultry Manure at 20 g/plant + Carbofuran 0.25 g a.i./plant	21.00	20.40	20.70	16.60	15.60	16.10	191.00	184.20	187.60	640.60	628.60	634.60
T6	Hot water at 1 litre/poly bag+ Poultry Manure at 20 g/plant + Carbofuran 0.5 g a.i./plant	13.40	12.60	13.00	09.20	08.80	9.00	172.40	169.20	170.80	538.20	526.60	532.40
T7	Hot water at 1 litre/poly bag+ Water Hyacinth Powder at 20 g/plant + Carbofuran 0.25 g a.i./plant	25.00	24.60	24.80	17.80	16.20	17.00	191.80	188.40	190.10	668.00	660.40	664.20
T8	Hot water at 1 litre/poly bag+ Water Hyacinth Powder at 20 g/plant + Carbofuran 0.5 g a.i./plant	15.00	14.20	14.60	10.40	09.80	10.10	175.20	171.60	173.40	560.20	556.80	558.50
T9	Hot water at 1 litre/poly bag+ Lantana Leaf Powder at 20 g/plant + Carbofuran 0.25 g a.i./plant	25.80	25.40	25.60	19.00	18.40	18.70	195.00	191.20	193.10	682.20	675.20	678.70
T10	Hot water at 1 litre/poly bag+ Lantana Leaf Powder at 20 g/plant + Carbofuran 0.5 g a.i./plant	15.60	15.20	15.40	12.20	11.60	11.90	178.40	173.60	176.00	577.80	564.60	571.20
T11	Hot Water 1 litre/poly bag + Neem Cake 50 g/plant + Phorate 0.50 g a.i./plant	08.00	7.60	7.80	04.40	03.80	4.10	153.80	146.20	150.00	480.20	472.40	476.30
T12	Check	67.80	72.40	70.10	59.60	63.20	61.40	238.20	242.40	240.30	1826.8	1842.4	1834.6
	SEm ±	0.937	0.752	0.845	0.883	0.591	0.737	7.655	2.776	5.216	28.692	14.086	21.389
	CD at 5%	2.671	2.143	2.407	2.518	1.683	2.101	21.818	7.911	14.865	81.777	40.147	60.962

Data are the average value of five replications

Table 2. Effect of integrated nematode management on plant growth characters of cucumber infected with *Meloidogyne incognita* under poly-house

Treatments		Vine length (m)			Vine weight (kg)			Yield kg/plant		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T1	Hot water at 1 litre/poly bag+Tea Waste at 20 g/plant + Carbofuran 0.25 g a.i./plant	2.604	2.664	2.634	0.684	0.695	0.689	2.664	2.738	2.701
T2	Hot water at 1 litre/poly bag+Tea Waste at 20 g/plant + Carbofuran 0.5 g a.i./plant	3.252	3.272	3.262	0.810	0.828	0.819	3.744	3.818	3.781
T3	Hot water at 1 litre/poly bag+Tobacco churi at 20 g/plant + Carbofuran 0.25 g a.i./plant	2.746	2.840	2.793	0.707	0.718	0.712	2.800	2.880	2.840
T4	Hot water at 1 litre/poly bag+ Tobacco churi at 20 g/plant + Carbofuran 0.5 g a.i./plant	3.390	3.422	3.406	0.840	0.854	0.847	3.902	3.946	3.924
T5	Hot water at 1 litre/poly bag+ Poultry Manure at 20 g/plant + Carbofuran 0.25 g a.i./plant	2.434	2.402	2.418	0.655	0.665	0.660	2.396	2.460	2.428
T6	Hot water at 1 litre/poly bag+ Poultry Manure at 20 g/plant + Carbofuran 0.5 g a.i./plant	3.096	3.156	3.126	0.782	0.796	0.789	3.504	3.564	3.534
T7	Hot water at 1 litre/poly bag+ Water Hyacinth Powder at 20 g/plant + Carbofuran 0.25 g a.i./plant	2.318	2.292	2.305	0.642	0.656	0.649	2.250	2.376	2.313
T8	Hot water at 1 litre/poly bag+ Water Hyacinth Powder at 20 g/plant + Carbofuran 0.5 g a.i./plant	2.962	3.042	3.002	0.758	0.764	0.761	3.220	3.340	3.280
T9	Hot water at 1 litre/poly bag+ Lantana Leaf Powder at 20 g/plant + Carbofuran 0.25 g a.i./plant	2.312	2.242	2.277	0.629	0.648	0.638	2.200	2.260	2.230
T10	Hot water at 1 litre/poly bag+ Lantana Leaf Powder at 20 g/plant + Carbofuran 0.5 g a.i./plant	2.912	2.942	2.927	0.712	0.724	0.718	2.910	2.970	2.940
T11	Hot Water 1 litre/poly bag + Neem Cake 50 g/plant + Phorate 0.50 g a.i./plant	3.538	3.562	3.550	0.860	0.872	0.866	4.146	4.196	4.171
T12	Check	1.326	1.446	1.386	0.390	0.374	0.382	1.104	1.080	1.092
	SEm ±	0.087	0.042	0.065	0.021	0.016	0.019	0.099	0.104	0.102
	CD at 5%	0.248	0.119	0.184	0.059	0.046	0.053	0.281	0.297	0.289

Data are the average value of five replications

4. CONCLUSION

These studies advocates the use of integrated nematode management in high value crops in poly-houses. Integration of hot water as pre-sowing application bring down the nematode population quickly and economically, while addition of organic amendment helps to increase in activity of beneficial microbes. The production and release of nematicidal compounds by the organic amendment in soil was able to reduce the nematode population and ultimately improved plant growth of agro-horticultural crops. The main objective of integrated nematode management is to manage the population of nematodes below ETL level by keeping the safe environment for long time. The resistant against chemicals in nematodes and toxicity on plants by excessive use of agrochemicals can also be avoided with INM and the farmer's income can be increased by reducing cost of cultivation. Integration of different treatments when used at reduced dose as compare to their higher dose as sole application, effectively manage the root-knot nematode in poly house and enhance yield of cucumber in protected cultivation.

DISCLAIMER

The data is original. The datasets generated andanalysed during the current study are available in the krishikosh repository, available:https://krishikosh.egranth.ac.in/handle/1/5810157235.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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