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Solarized IPM Module for Biocontrol of Root-knot Nematode on Tomato at Nursery Level in District G.B Nagar, Uttar Pradesh

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ABSTRACT

Background: The role of soil solarization in suppression of soil borne pathogens and weeds has been established by several researchers around the globe It involves capturing solar radiations when the soil receives the maximum sunlight in May-June using a polythene mulch. Its effectiveness depends on ambient temperature, duration of the treatments and soil moisture. This not only acts as a soil disinfectant but also as soil decontamination. It includes various changes in the soil like physical, chemical and biological properties.

Methods: The field to lab and vice-versal based investigations were carried during 2021-2022 at Amity Centre for Biocontrol and Plant Disease Management, Amity University, Uttar Pradesh, Noida and identified tomato nurseries of district G B Nagar where heavy infestation (10-12 J2/cc soil) of root knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood was recorded. The treatments comprised of sustainable components *viz*. deoiled seed cake of neem, a Arbuscular Mycorrhizal fungus *Glomus intraradices* and indigenous fungal strain of *Trichoderma harzianum,* (Th7) alone and together applied for evolving IPM module at solarized and unsolarized sets. Under microplot trials, the entire solarized treatments were carried out measuring 3 × 1 sq. meter each in which one set of all the treatments including control covered with clear transparent polythene sheet (400 µ gauge) for solarization. The treatments were replicated thrice in randomized block design.

Result: The observations of solarized and unsolarized treatments clearly revealed that the soil solarization in treatments where the sun radiant energy was trapped by 400 µ transparent polysheets significantly reduced the root knot nematode *Meloidogyne incognita* population both in root and soil in comparison to unsolarized treatments where no solar energy trapping was done. The combined application of locally isolated *Trichoderma harzianum* (Th7) and VA mycorrhiza, *Glomus intraredices* enhanced germination and plant growth in nurseries. In the present investigation, the solarized IPM module- 4 comprising of other sustainable components *viz*. neem oil-seed cake, *T. harzianum* (Th-7) and Arbuscular Mycorrhizal (AM) fungus *G. intraredices* is proved to be an ideal one in root-knot nematode pest management in tomato nurseries.

Key words: *Glomus intraradices,* IPM module, *Meloidogyne incognita*, Neem oilseed cake, Solarized, *Trichoderma harzianum.*

INTRODUCTION

The phasing out of methyl bromide and the ban on, or withdrawal of, other toxic soil fumigants and non-fumigant nematicides belonging to the organophosphate and carbamate groups are leading to changes in nematode-control strategies (Kaanan *et al.,* 2018; Goswami and Mittal, 2004). Among several approaches, soil solarization is an approach for disinfection of soil for management of nematodes, fungi and weeds that boosts involves low-risk management for farmers that could also boost crop yield (Chellemi, 1997; Singh *et al*., 2015) through which farmers can manage the pests and pathogens in an eco-friendly, non-chemical manner. Soil solarization is one of the non-chemical method that induces natural soil suppressiveness and acts as a potential component of environmentally sustainable management option for of soilborne plant pathogens (Baker, 1962; Katan, 1981; Abdel-Rahim *et al.,* 1988; Oka *et al*., 2002; Gupta *et al.,* 2017). This pre planting method is used for controlling soil borne pathogens (Fungi, bacteria and nematodes) and weeds in different field crops. (Horowitz and Herzlinger, 1983; Katan, 1981; Nanjappa *et al.*, 2005). It is one of the most effective methods and compatible with many other soil disinfestation strategies.

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The role of soil solarization in reduction of soil borne pathogens *viz*. fungi, bacteria, nematodes and weeds has been by established by several researchers in more than 50 countries including India (Katan, 1981; Stapleton *et al.*, 1993; Singh *et al.*, 2015). It involves capturing solar radiations for 4-6 weeks during the summer months May-

June when the soil receives the maximum sunlight using a polythene mulch. Its effectiveness depends on ambient temperature, duration of the treatments and soil moisture. This not only acts as a soil disinfectant but also as soil decontamination. It includes various changes in the soil like physical, chemical and biological properties. In soil solarization, the thickness of plastic sheet and color are important considerations.

A transparent or clear plastic is more effective for solarization, as the incident rays from the sun passes through the sheet and are trapped to heat the soil below. A black plastic which is less effective because it absorbs and deflects part of the heat, rather than trapping as clear plastic does (Stapleton *et al*., 1993). Soil intercepts the energy radiated from the sun and its temperature rises to the level which results in mortality of soil-borne pathogens. It also improves soil texture and the nutrients availability in the soil which are essential for plant growth and development. Besides the reduction in soil-borne pathogens, soil solarization also leads to increased plant growth. It integrates well with other techniques such as soil amendments to enhance its overall effectiveness against pests to increase crop yield (Gamliel and Stapleton, 1993).

The objective of this study was to evaluate soil solarization as a component in IPM packages. In the present investigation, the effect of solar solarization with other IPM components *viz*., neem oil-seed cake, locally isolated biopesticide *Trichoderma harzianum* (Th7) and Arbuscular Mycorrhizal fungus (AM) *Glomus intraredices* alone and in combination was evaluated for combating root-knot nematode on tomato at nursery level. which was carried out at “hot spots” in district G.B Nagar U.P. Soil solarization with organic amendment of neem cake for three weeks followed by application of biopesticide and biofertilizer showed significant reduction in root knot nematode *M.incognita* population as compared to non-solarized nurseries. The mechanism of action is based on increased soil temperature (commonly in the range of 45°C-55°C) at soil depth of 5 cm underneath transparent polysheets and the decomposition of oil seed cake also releases the nematicidal and fungicidal compounds which causes mortality of soil borne pathogens (Katan, 1981; Chellemi, 1997). In the present investigation, the resultant solar assisted IPM module-4 constitutes other sustainable components, local strain of biocontrol agent, *Trichoderma harzianum* (Th7) and AM fungus *Glomus intraradices* showed promising results in biocontrol of root knot nematode *M. incognita* at tomato nurseries in district G.B Nagar.

MATERIALS AND METHODS

The field to lab and vice-versal based investigations were carried out at Amity Centre for Biocontrol and Plant Disease Management, Amity University, Uttar Pradesh, Noida during the hot summer months (May to June) 2021-2022 at identified tomato nurseries in district G B Nagar where heavy infestation (10-12 J2/cc soil) of root knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood was recorded. The treatments comprised of sustainable components *viz*. deoiled seed cake of neem, a Arbuscular Mycorrhizal fungus *Glomus intraradices* and indigenous fungal strain of *Trichoderma harzianum,* (Th7) alone and together applied at solarized and unsolarized sets. The treatments were replicated thrice in randomized block design. Under microplot trials, the entire solarized treatments were carried out measuring 3 × 1 sq. meter each in which one set of all the treatments including control covered with clear transparent polythene sheet (400 μ gauge) for solarization. The neem cake @ 500 g/m^2 was also applied for a period of 3 weeks prior to sowing of seeds in treatments 1, 2 and 4 while for the other set uncovered as unsolarized treatments (Chauhan *et al.*, 1998). The sheets were removed one day prior to application of the treatments with other components like *T. harzianum* @ 50 g/m^2 and *G. intraradices* 50 ml/m^2 respectively.

Following this, sowing of highly susceptible desi variety of tomato cv. Pusa Ruby after surface sterilization with 0.01% $Hgcl_2$ was done in each plot of the nursery. The treatments were:-

1) *Glomus intraradices* (AM) + Neem Cake (T1) - IPM Module1.
2) *Trichoderma harzianum* (Th7) + Neem Cake (T2) - IPM module 2.
3) *Glomus intraradices* (AM) + *Trichoderma harzianum* (T3) IPM module 3.
4) Neem Cake + AM fungus *Glomus intraradices* + *T. harzianum* - (T4) - IPM module 4.
5) Control (C).

The observations were also recorded in respect to germination, plant biomass, root knot nematode population in both soil and root after 45 days in respect to each of the above treatments after termination of the field experiment prior to transplantation to the main field. The data were statistically analyzed by using two factorial analysis of variance (ANOVA). The critical difference (CD) values at 0.05 P were used to determine significance of treatment mean differences.

RESULTS AND DISCUSSION

Effect on plant growth parameters

The present field based investigation was carried out at ‘hot spot’ or naturally infested tomato nurseries located at Birampur village in district G.B Nagar during 2021-2022. The field based investigation was initiated in hottest months ‘May to June’ for solarization at tomato nurseries and the average high temperature lies in the range of 29.4°C to 42.2°C.

Observations of the experiments in respect to plant growth parameters *i.e* germination percentage and biomass in addition to that soil and root population of root knot nematode M. *incognita* were recorded after 45 days from the solarized nursery bed and also unsolarized ones separately. In general, soil and root population of root knot nematode were reduced significantly in solarized treatments as compared to unsolarized ones. The plant growth parameters *i.e*. germination percentage and biomass were recorded high in IPM module-4 where soil solarization with neem cake amendment three weeks before seed sowing and followed by application of AM fungus (*Glomus intraradices*) and local strain of biocontrol agent *T.harzianum* (Th7) (Table1). The root knot nematode population in both soil and root were also reduced significantly in solarized sets as compared to unsolarized ones (Table2).

Effect on soil and root population of root knot nematode *M. incognita*

The performance of IPM-3 module was also noteworthy where *T. harzianum* (Th7) and AM fungus *G. intraredices* were applied together in reducing *M. incognita* population and enhancing plant growth. Among all the solarized and unsolarized IPM modules, however, the solarized IPM-4 module showed significant results and outstanding performance in reducing *M. incognita* population in both soil and roots where both the sustainable components *T. harzianum* and *G. intraredices* were applied together in neem cake amended soil than that of corresponding unsolarized ones. In all the treatments, excepting control, the soil is amended with neem cake which is known to possess nematicidal properties (Goswami *et al.*, 2007) and rich in manural contents which is attributed to enhance the tolerance of the tomato plant against root knot nematode and enriching the soil as well in the present investigation which is advisable for farmers to be included in the amendment for better health of the soil and plant also.

Regarding the performances of the treatments taken up in the present investigation, two solarized treatments *i.e*. IPM module 2 where locally isolated *T. harzianum* (Th-7) is applied to neem cake amended soil and IPM module 1 in which AM fungus *G. intraredices* was used alone showed almost at par or same performance in which the former helped in suppressing the root knot nematode population while the latter helped in making the host more tolerant with some role in protecting root against maladies (Subhashini and Ramakrishnan, 2011). The reduction in number of galls in mycorrhizal plants were also observed by (Jalaluddin *et al.*, 2008).

However the best performance of higher percentage germination, more biomass of the seedlings and also outstanding reduction in both nematode population and root population by adding biocontrol agent and biofertilizer in the solarized IPM module-4 is proposed for tomato nurseries due to the cumulative effect of nematicidal and fungicidal properties of neem cake and fungal bioagent that of biofertilizer being responsible as a 'root protectant' through

Table 1: Effect of solarized and unsolarized IPM modules on plant growth parameters at nursery level.

Treatments	Germination percentage		Plant biomass (g)	
	(S)	(US)	(S)	(US)
IPM module-1	58.3^{c} (7.66)	42.3^{d} (6.54)	27.0^{b} (5.24)	24.3^{b} (4.97)
IPM module-2	55.0^{c} (7.44)	50.0^{c} (7.10)	22.3^{c} (4.77)	20.7^{c} (4.60)
IPM module-3	73.4^{b} (8.59)	61.7^{b} (7.85)	34.0^{b} (5.87)	23.6^{b} (4.90)
IPM module-4	80.3^{a} (8.98)	72.3^{a} (8.53)	37.2^{a} (6.14)	28.7^{a} (5.40)
Control	35.6^{d} (6.00)	27.3^{e} (5.22)	22.1^{c} (4.75)	16.2^{d} (4.08)
S.Em±	1.57	1.44	1.08	0.95
CD (P=0.05)	4.99	3.28	4.26	2.85

Mean value (Average of three replicates).

Means values followed by same letter(s) along the same column indicate statistically *at par.*

Mean values followed by different letters indicate significant at 5% level (P=0.05).

Figures in parentheses are square root transformed values: √X+0.5.

Table 2: Effect of solarized and unsolarized IPM modules on root knot nematode (*M. incognita*) population at nursery level.

Treatments	No. of galls/plant		No of egg masses/plant		No of larvae/egg mass		Larval population/500 cc soil)	
	(S)	(US)	(S)	(US)	(S)	(US)	(S)	(US)
IPM module 1	25.0^{b} (5.04)	30.0^{bc} (5.52)	19.0^{b} (4.85)	34.0 (5.87)	204.3^{c} (14.3)	224.3^{c} (14.99)	1271.3^{c} (35.66)	1396.3^{c} (37.37)
IPM module 2	27.6^{b} (5.30)	35.7^{b} (6.01)	21.3^{b} (4.66)	29.3^{c} (5.45)	234.1^{b} (15.3)	259.6^{b} (16.12)	1427.2^{b} (37.78)	1428.2^{b} (37.79)
IPM module 3	17.0^{c} (4.18)	22.6^{cd} (5.57)	12.0^{c} (3.53)	13.7^{d} (3.76)	115.4^{d} (10.76)	168.3^{d} (12.98)	1257.4^{c} (35.46)	1257.1^{d} (35.46)
IPM module 4	4.0^{d} (2.12)	16.7^{d} (4.14)	2.33^{d} (1.54)	6.3^{e} (2.60)	65.1^{e} (8.09)	90.1^{e} (9.51)	511.6^{d} (22.62)	589.4^{e} (24.18)
Control	43.3^{a} (6.61)	54.0^{a} (7.38)	35.0^{a} (5.95)	52.0^{a} (7.24)	314.2^{a} (17.7)	338.4^{a} (18.40)	2079.5^{a} (45.60)	2034.7^{a} (45.11)
S.Em±	1.90	2.46	1.79	1.32	2.54	3.68	5.91	7.12
CD @ 0.05%	5.72	7.38	5.39	3.97	7.62	11.06	17.75	21.37

Mean value (Average of three replicates).

Means values followed by same letter(s) along the same column are at par.

Mean values followed by different letters indicate significant at 5% level (P=0.05).

Figures in parentheses are square root transformed values: √X+0.5.

occupying the cortical regions of the root particularly in the zone of elongation by 'Vesicles and Arbuscules' (Bhagwati *et al.,* 2000; Goswami *et al.*, 2007; Goswami *et al*., 2008).

The biocontrol potential of *Trichoderma harzianum* through rhizosphere competence against root-knot nematode in soil has also been reported by earlier workers (Babu and Kamara, 2021). The soil solarization in integrated management practices is recorded to aggravates beneficial microflora which is antagonistic to soil borne pathogens through reducing the infestation of soil by these organisms besides increasing plant growth and yield in nurseries and fields. (Chen *et al*., 1981; Katan, 1979, 1981, 1988). Similar findings with organic amendments aggravated by soil solarization have been demonstrated to have reduced the disease incidences with increased plant vigour (Gaur and Dhingra, 1991; Kim, 1988; Stapleton *et al.*, 1993). Solarization works like a "solar hot panel" and shows catalytic properties with amendments for disinfecting soil within three weeks and preserves soil fertility also (Nanjappa *et al.*, 2005).

CONCLUSION

In the present findings, soil-solarization has been observed in enhancing the potentiality of integrated pest management against root-knot nematode infesting tomato. In our country, most of the rural farmer are not aware about the utilization of soil solarization and other sustainable components, oil seed cakes and locally available antagonistic bioagents/plants in their premises for soil borne pest and disease management. The present investigation is non-chemical cost-effective integrated approach for quality production of disease free tomato seedlings. Capacity building programs will be conducted for popularizing the evolved IPM module for combating root knot nematode among the farmers and rural communities in and around G.B Nagar in near future.

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Conflict of interest: None.

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