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EFFECTIVENESS OF SOIL-SOLARIZATION IN COMBINATION WITH *TRICHODERMA VIRIDE* FOR MANAGING DAMPING-OFF DISEASE IN TOMATO NURSERIES

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Abstract: *Soil solarization is a pre-planting, non-chemical dis-infestation technique which not only controls the soil-borne plant pathogens, weeds and nematodes but also frequently promotes plant growth, a phenomenon termed as increased growth response (IGR). Trichoderma species are commonly used as biological control agents (BCA) against phytopathogenic fungi and some isolates are able to improve plant growth. In this study, conducted at Krishi Vigyan Kendra, Jagatsinghpur, Odisha, the soil-solarization method was used along with the bio-agent Trichoderma viride for managing soil-borne plant pathogens responsible for seedling damping-off disease. Research findings revealed that, the damping-off disease incidences were minimum (17 % pre-emergence and less than 2 % post-emergence) in the treatment where, the soil was solarized for 8 weeks followed by pre-sowing soil and seed treatment with Trichoderma viride as compared to the control plots where the pre and post-emergence damping-off disease incidences were 37 % and 19 %, respectively. Moreover, in the same treatment, the length, fresh and dry weights of tomato seedlings were found to be significantly higher than other treatments.*

Key words: *Tamato, Damping off, Trichoderma viride, Soil solarization.*

Introduction

Soil contains a multitude of plant pathogenic micro-organisms, which cause various deadly diseases resulting in serious crop loss. In Odisha, solanaceous vegetables like Tomato, Brinjal and Chilli are being grown widely, which suffer from damping-off disease in their early stages. This disease sometimes destroys the nurseries completely and forces the farmers to re-sow their crop. The epidemiology says that, during moist and warmer condition, this disease flair up to a higher proportion. Many soil-borne pathogenic fungi like *Pythium*, *Phytophthora*, *Sclerotinia*, *Sclerotium*, *Rhizoctonia*, *Fusarium*, *Glomerella*, *Phoma*, *Thielavia*, *Botrytis* etc. are responsible for this disease (Rasanjalie and Ranaweera, 2009). These either solely or in combination infect the emerging seedlings resulting in pre or post-emergence damping-off. The seed either does not sprout at all or does not come out or even if it comes out the soil-surface, a water soaked lesion is developed at the collar region which soon becomes necrotic and shrunken. Then the seedling topples down and dies.

The farmers often practice chemicals either as seed dressing and/or spraying, which significantly lower the disease incidence. However, the chemicals are toxic to even the beneficial microbes and can have drastic effects on environment. Also repeated use of these chemicals will lead to the development of resistance in target organisms. Therefore, it is necessary to reduce chemical use as less as possible in agriculture and apply novel and alternate technologies which are proven to be very promising in managing harmful diseases like damping off of vegetable seedlings.

Soil solarization is an alternative and effective method to control these soil-borne pathogens (Raj and Kapoor, 1993). It is an eco-friendly and hydro-thermal process which was established for the first time in Israel to control many plant pathogenic pests, diseases and weeds and involves the use of 25 µm transparent polythene mulch for capturing the solar

energy and heating the soil to minimize the pests present in the soil (Katan, 1981). This method is done by mulching the moist soil by transparent polythene sheets during summer months for 4 to 6 weeks (Akhtar *et al*., 2006).

Another promising mean for reduction of the pathogen load in the rhizosphere is the use of biological control agents (BCAs). The most prominent and viable BCA for the vegetable nurseries is *Trichoderma* sp. which is a soil-borne fungi belongs to phylum Ascomycota. It exerts bio-control against fungal phytopathogens either indirectly by competing for nutrients as well as space, modifying the environmental conditions or promoting the plant growth and plant defense mechanisms and antibiosis or directly by mechanisms such as myco-parasitism (Benitez *et al*., 2004).

The present investigations were carried out with an objective to establish an eco-friendly and viable method for managing the soil-borne phyto-pathogens as well as the damping off disease incidence so as to obtain disease free healthy vegetable seedlings.

Materials and Methods

The experiment was carried out in seedling production unit of Krishi Vigyan Kendra, Jagatsinghpur of Odisha with naturally infested nursery beds where the vegetable seedlings were grown for last eight years. A history of severe seedling blight disease incidence was recorded for the last 4 years in these nurseries during tomato seedling production in the months of August and September. The nurseries were prepared in the dimension of 1 x 2 m^2. The solarization process was carried out in the months of May and June of 2015 and 2016 by covering the beds tightly with 200 gauge thick transparent polythene sheets after watering them to saturation level. The experiment consists of eight treatments and three replications. The first three treatments (T1, T2, T3) i.e., solarization for 4, 6 and 8 weeks along with application of farm yard manure (FYM) @ 0.2 kg per m^2; the next three treatments (T4, T5, T6) were solarization for 4, 6 and 8 weeks along with application of FYM fortified with *Trichoderma viride* for 21 days @ 0.2 kg per m^2 and seed treatment with *T. viride* @ 10g per kg seed; the seventh treatment (T7) was application of only FYM fortified with *Trichoderma viride* along with seed treatment with *T. viride* in non-solarized beds and the control treatment (T8) was non-solarized beds with application of normal FYM.

The experimental nurseries were having almost uniform topography and the soil was sandy loam, deep and well drained with pH 6.3. The crop tomato (Hyb. JK Desi) was taken for the study. The experiment was laid in RBD and the data were evaluated by using appropriate statistical method. The parameters like a) pre emergence damping-off incidence (%) at 5 days after sowing and post emergence damping-off incidence (%) at 30 days after sowing, b) length (cm) of the seedlings (Shoot + Root length) and c) fresh and dry weight (g) of the seedlings were studied in the trial after uprooting them at 30 days after sowing. Dry weights were obtained by placing 20 seedlings in a hot air oven at 60^0C for 48 hours. The disease incidence was calculated by using the following formula.

$$\text{Per cent Disease Incidence (PDI)} = \frac{\text{Numbers of diseased/wilted seedlings or not emerged}}{\text{Total numbers of seeds sown per unit area}} \times 100$$

Results and Discussion

The trial nursery beds were sufficiently irrigated during the experiment so as to create conducive environment for disease development. In both the years, other epidemiological parameters like atmospheric temperature and humidity were also found to be conducive. The experimental results of disease incidence and seedling growth parameters in

different treatments used were depicted in Table 1 and Table 2.

Pre and Post-emergence Damping-off

Experimental results revealed that, with the increase in duration of solarization, there was a decreasing trend of pre and post-emergence damping-off disease incidence in the treatments. It may be due to the decrease of natural population or inocula load of phytopathogens causing this disease in the soil by solarization (Akhtar *et al.,* 2012). The decrease in population of soil-borne phytopathogenic microbes is due to their prolonged exposure to very high temperature which is resulted by mulching the soil with polythene sheets. The rhizospheric temperature can be raised up to 15^0C more than the non-solarized soil during summer months of the year (Raj *et al*., 1997). It was also observed that, soil solarization in integration with FYM amendment along with seed and soil treatment by using BCA *Trichoderma viride* showed even better results as compared to solarized plots amended with only FYM.

It was seen from the observations that, the per cent decrease in disease incidence was highest in the treatments with solarization period of 8 weeks as compared to 4 and 6 weeks. Moreover, when it is integrated with the application of BCA, the disease incidence was again minimized. In Table 1, it can be seen that, the pre and post-emergence damping-off incidences were minimum in T6 where the soil was solarized up to 8 weeks and there was a pre-sowing seed and soil application with BCA. The pre and post emergence damping-off disease incidences were 17 and 1.83 per cent, respectively in T6 which is significantly lower than all other treatments. In the same treatment, the pre-emergence damping-off disease incidence was decreased up to 54.1 per cent and post-emergence damping-off was decreased up to more than 90 per cent over check. This study corroborates the findings of Hazarika (2004) and Akhtar *et al*., (2008) which showed that, soil solarization resulted in higher germination of seeds and lowered damping-off disease incidence.

Growth of the Seedlings

The study was also directed towards assessing the effect of soil solarization and application of *T. viride* on growth and development of seedlings. Apart from lowering the damping-off disease incidence, the hydro-thermal soil solarization process was found to be responsible for vigorous growth of the seedlings. This phenomenon is called increased growth response (IGR) and is happened due to considerable increase in the water extractable N, K, Ca, Cl, Mg and Na (Grunzweig *et al*., 1999). From this study it was observed that, in non-solarized plots, the average seedling length was 15.21 cm (T8 – control) where in the plots with 8 weeks of solarization, the length of the seedlings was 22.47 cm (T3) which is around 48 per cent more over control (Table 2). Similarly the fresh and dry weight of the seedlings were also significantly increased by 55 and 64 per cent respectively over check, in the treatment where the soil was solarized for 8 weeks (T3). The duration of solarization had also a positive correlation with the increased level of water extractable nutrients and thereafter increase in the growth of the seedlings, for which it was seen that, when the duration of solarization was increased from 4 weeks to 8 weeks, there was an increasing trend of seedling growth in form of length, fresh and dry weight (Table 2).

In this study, it was also revealed that, there was an increase in the growth of tomato seedlings by the application of *Trichoderma viride* (Table 2). When the bio-control agent *Trichoderma viride* was applied in non-solarized plots (T7), the average length, dry and fresh weight of the seedlings were significantly increased to 16, 33 and 32 per cent respectively, over control (T8). The maximum seedling growth (length, fresh and dry weight) was recorded in the plots solarized up to 8 weeks and applied with the bio-control agent *Trichoderma viride* (T6). The plant growth promoting activity of *Trichoderma* was an established fact as this fungus colonizes the roots and helps in mobilizing various important nutrients like Ca, Mg, P and K into the plant system (Azarmi *et al*., 2011). This study corroborated the findings of Rasanjalie and Ranaweera (2009) where they found

that, the chemical seed dressing gave disease free seedlings but the seedling vigor was non-significant, where as the application of *Trichoderma* could make the nurseries disease free as well as yielded more vigorous seedlings. Therefore, these two factors like soil solarization and application of *Trichoderma viride* complement each other and their combination not only suppresses the soil-borne phytopathogens, but also makes seedlings healthy and vigorous.

It may be concluded from this study that, the eco-friendly management of seedling damping-off disease in tomato nurseries can very well be done by solarizing the nurseries for 8 weeks and pre sowing seed and soil application with BCA like *Trichoderma viride*.

Table 1: Effect of Soil solarization in combination with *Trichoderma viride* on Pre and Post emergence damping off disease incidence

Treatments	Pre-emergence Damping-off incidence				Post-emergence Damping-off incidence			
	2015-16	2016-17	Average	% decrease over check	2015-16	2016-17	Average	% decrease over check
T1 : Solarization for 4 weeks + FYM	25.67	27.00	26.34	28.8	6.33	6.67	6.50	65.8
T2 : Solarization for 6 weeks + FYM	23.67	24.33	24.00	35.1	5.67	6.00	5.83	69.3
T3 : Solarization for 8 weeks + FYM	21.67	21.33	21.50	41.9	4.33	3.67	4.00	78.9
T4 : Solarization for 4 weeks + FYM + *T. viride*	21.67	22.33	22.00	40.5	5.00	4.67	4.83	74.6
T5 : Solarization for 6 weeks + FYM + *T. viride*	20.33	21.00	20.67	44.1	3.67	3.33	3.50	81.6
T6 : Solarization for 8 weeks + FYM + *T. viride*	16.67	17.33	17.00	54.1	2.00	1.67	1.83	90.4
T7 : No solarization + FYM + *T. viride*	30.67	32.00	31.34	15.3	7.67	8.33	8.00	57.9
T8 : No solarization + FYM (Check)	35.33	38.67	37.00	0.0	18.67	19.33	19.00	0.0
S.E.M.±			0.54				0.43	
C.D.(P=0.05)			1.63				1.28	

Table 2: Effect of Soil solarization in combination with *Trichoderma viride* on Length, Fresh and Dry weight of tomato seedlings

Treatments	Seedling Length (cm)			Fresh Weight (gm)			Dry Weight (gm)		
	2015-16	2016-17	Average	2015-16	2016-17	Average	2015-16	2016-17	Average
T1 : Solarization for 4 weeks + FYM	18.28	18.88	18.58	4.50	4.44	4.47	1.48	1.46	1.47
T2 : Solarization for 6 weeks + FYM	19.01	19.55	19.28	4.58	4.63	4.61	1.51	1.53	1.52
T3 : Solarization for 8 weeks + FYM	22.67	22.27	22.47	4.96	4.99	4.98	1.62	1.65	1.64
T4 : Solarization for 4 weeks + FYM + *T. viride*	19.38	20.05	19.72	5.40	5.26	5.33	1.78	1.74	1.76
T5 : Solarization for 6 weeks + FYM + *T. viride*	21.67	22.78	22.23	6.21	6.32	6.27	2.11	2.14	2.12
T6 : Solarization for 8 weeks + FYM + *T. viride*	23.33	23.10	23.22	6.95	7.05	7.00	2.28	2.33	2.30
T7 : No solarization + FYM + *T. viride*	17.05	18.16	17.61	3.98	4.03	4.01	1.31	1.33	1.32
T8 : No solarization + FYM (Check)	15.55	14.87	15.21	3.04	2.97	3.01	1.02	0.98	1.00
S.E.M.±			0.22			0.06			0.02
C.D.(P=0.05)			0.65			0.18			0.06

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