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Eco-Friendly Management of Collar Rot Disease of Tomato Caused by *Sclerotium rolfsii* (Sacc.)

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ABSTRACT

The collar rot disease of Tomato (Solanum lycopersicon L.) caused by Sclerotium rolfsii (Sacc.) is a severe soil born disease, particularly in the undulating red and lateritic zone of West Bengal causing considerable crop loss. An experiment was carried out to develop a sustainable management strategy against the collar rot disease at Agricultural Farm of Palli Siksha Bhavana during the winter season of 2014-16.Various treatments of different approaches viz. (1) Mulching by transparent polythene (25 micro m) (2) Mulching + Neem Seed Cake@ 150 kg/ ha. (3) Mulching + Tricoderma harzianum @ 2.5 kg/ha. (4) Mulching + Garlic Extract @ 20 % (5.) Mulching + Vermicompost @ 5 t/ha. (6) Mulching + Gypsum @ 4 tone/ ha. (7) Mulching + salicylic acid @ 10 ppm. (8) Mulching + Neem Seed Cake @ 150 kg/ ha. + Tricoderma harzianum @ 2.5 kg/ha. (9.) Mulching + Garlic Extract @ 20 % + Tricoderma harzianum @ 2.5 kg/ha. (10) Mulching + Gypsum @ 4 tone/ ha. + Tricoderma harzianum @ 2.5 kg/ha. (11) Mulching + Vermicompost @ 5 t/ha + Tricoderma harzianum @ 2.5 kg/ha. (12) Mulching + Tricoderma harzianum @ 2.5 kg/ha. + Salicylic acid @ 10 ppm were evaluated against the disease under field condition. All the treatments performed well in terms of reducing the disease incidence and resulted in higher fruits yield compared to untreated control. Least disease incidence (4.17 %) and highest fruits yield (250.67 Q/ha) was observed in treatment with mulching by transparent polythene + Neem Seed Cake @ 150 kg/ha (soil application) + Tricoderma harzianum @ 2.5 kg/ha (soil application) followed by mulching + gypsum @ 4 tonne/ ha. + Tricoderma harzianum @ 2.5 kg/ha treated field with 5.56% disease incidence in comparison to disease incidence (27.78 %) and fruits yield (200.67 Q/ ha) in untreated control. The combination of different approaches had an edge over individual approaches.

Key words: *Tomato, Collar rot, Sclerotium rolfsii, Sustainable, Management.*

INTRODUCTION

Tomato is one of the most widely cultivated crops in the world. Due to its extensive cultivation in non-traditional areas, several biotic and abiotic factors have emerged as a major constraint in its successful cultivation. *Sclerotium rolfsii* is one of the important fungal pathogens that cause collar rot resulting in substantial yield losses. It causes up to 30 % of crop loss of tomato[1].

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The pathogen is a soil inhabitant, very aggressive nature, attacks the collar portion of plant, which ultimately leads to its death. The infection leads to the drying of lower leaves and eventually the whole plant dries giving a typical symptom of wilting. Efficient and effective management of the disease is generally achieved by using synthetic pesticides which are known to pollute the environment, soil and water besides causing deleterious effects on human health and biosphere. Thurston and Abawi[2] stated that soil amendments lead to competition for nutrients, particularly iron and nitrogen. *T. harzianum* or *T. virens* significantly reduced the collar rot caused by *S. rolfsii* of mint under greenhouse condition[3] . Application of *Trichoderma* spp. in soil significantly reduced the disease incidence of stem rot of caused by *S. rolfsii* in tomato[4,5.] Application of *Trichoderma* spp. to pine seedlings brought about 57% reduction in damping-off in pine seedlings caused by *S. rolfsii* under greenhouse conditions[5]. Gunes *et al*. [6] reported that salicylic acid acts as endogenous signal molecule involved in induction of tolerance to abiotic stresses in plants and exogenous application of salicylic acid increased plant growth significantly both under saline and non saline conditions. Mandal, *et al*.[7] observed that application of Salicylic acid at 200 mM, through root feeding and foliar spray, led to reduced vascular browning and leaf yellowing caused by *Fusarium oxysporum* f. sp. *lycopersici* on tomato plants. Considering the above, an attempt was made to develop a sustainable management strategy against the collar rot disease through an integrated approach by combining different environmentally sustainable treatments like plastic mulching, organic and inorganic amendments, antagonistic biological agents, plant extract and inorganic anti oxidant compound.

MATERIALS AND METHODS

A comprehensive experiment was carried out with different combination of mulching by transparent polythene (25 micro m), bio agent, organic and inorganic soil amendments and inorganic anti oxidant compounds to find out a proper disease management strategy under *in vivo* condition at Agricultural farm of Palli siksha Bhavana during the winter season of 2014-16. One month old tomato seedling (var- Punjab Chuhara) grown in plastic seed germination tray was used for the experiments. Mass multiplication of biological agents was done in wheat grain for further used in field experiments[8]. The Garlic extract was prepared by collecting fresh samples and washed in tap water and washed thrice using sterilized distilled water. The excess water was wiped out with tissue paper and weighed. The sample was crushed in a sterilized pestle and mortar by adding sterile distilled water at a ratio of 1:1 (w/v) to get the standard extract. Filtered through muslin cloth and the filtrate was centrifuged at 5000 rpm for 15 min. Twenty percent standard solution was prepared by adding required quantity of sterile water into the stock solution. The experiment was designed as Randomized Complete Block design with 3 replications. The soil amendments like Neem Seed Cake, Vermicompost and Gypsum or Plaster of Paris (CaSO4.1/2 H2O) were applied in soil 10 days before transplanting of seedlings where as antagonistic biological agents i.e. *T. harzianum* (10gm/plant) were applied two times, during transplanting and at 25 days after transplanting (DAT). For second application, some upper surface soil from the root zone of the plant removed gently and 10gm of bio-agent was applied followed by covering up the soil layer. Inorganic anti oxidant compound salicylic acid was sprayed two times, during transplanting and at 25 DAT. The Garlic Extract was soil drenched at collar region in two times, during transplanting and at 25 DAT. The treatment details were as follows:

T-1: Mulching by transparent polythene (25 micron).

T-2: Mulching + Neem Seed Cake @ 150 kg/ ha (Soil Application).

T-3: Mulching + *Tricoderma harzianum* @ 2.5 kg/ha (Soil Application).

T-4: Mulching + Garlic Extract @ 20 % (Soil Drenching).
T-5: Mulching + Vermicompost @ 5 t/ha (Soil Application).
T-6: Mulching + Gypsum or Plaster of Paris @ 4 tone/ ha (Soil Application).
T-7: Mulching + Salicylic acid @ 10 ppm (Foliar Spray).
T-8: Mulching + Neem Seed Cake @ 150 kg/ ha.+ *Tricoderma harzianum* @ 2.5 kg/ha.
T-9: Mulching + Garlic Extract @ 20 % + *Tricoderma harzianum* @ 2.5 kg/ha.
T-10: Mulching + Gypsum @ 4 tone/ ha. + *Tricoderma harzianum* @ 2.5 kg/ha.
T-11: Mulching + Vermicompost @ 5 t/ha + *Tricoderma harzianum* @ 2.5 kg/ha.
T-12: Mulching + *Tricoderma harzianum* @ *2.5 kg/ha.* + Salicylic acid @ 10 ppm.
T-13: Untreated Control.

Data on the incidence of collar rot were recorded at 35, 45, 55 and 65 days after transplanting by visual observation of symptoms. Number of infected plants plot^{-1} and yield plot^{-1} were recorded.

Per cent disease incidence (PDI) was calculated by using the following formula:

$$PDI = \frac{\text{No. of Infected Plant}}{\text{Total No of Plant}} \times 100$$

Per cent disease control (PDC) was calculated by using the following formulae:

$$PDC = \frac{\text{PDI in control plot- PDI in treated plot}}{\text{PDI in control plot}} \times 100$$

The data were subjected to statistical analysis following RBD as per Gomez and Gomez[8]. Necessary transformations were made whenever required. Data were analyzed using Statistical Analysis Systems software STPR.3.

RESULTS AND DISCUSSION

The result of percent disease incidence at 35, 45, 55 and 65 days after transplanting (DAT) are presented in table 1. In general all the treatments had substantial positive effect on the reduction of percent disease incidence over control at all the dates of data collection. The symptom appeared as early as 35 DAT in all treatments except in treatments with Mulching + salicylic acid (T7), Mulching + Neem Seed Cake + *T. harzianum* (T8) and Mulching + Gypsum + *T. harzianum* (T10). The higher disease incidence 11.11 % was recorded in untreated control plot (T-13) at 35 DAT. The incidence of the disease gradually increased with the increase of age of the plant. Consequently the lowest disease incidence 2.78% and 4.17% was recorded in plants grown in the plot treated with Mulching + Neem Seed Cake + *T. harzianum* (T8) followed by 4.17% and 5.56% in Mulching + Gypsum + *T. harzianum* (T10), Mulching + *T. harzianum* + Salicylic acid (T12) and 5.56 % and 6.94% was observed in the treatment of Mulching + Garlic Extract + *T. harzianum* (T9) at 55 and 65 DAT.

Table-1: Effects of Sustainable Management strategy on Collar Rot Disease of Tomato

S. No.	Treatments	Percent Disease Incidence				PDC after 65 DAT
		35 DAT	45 DAT	55 DAT	65 DAT	
1	Mulching by transparent polythene (25 micro m)	5.55 (2.22)*	9.72 (3.09)	12.50 (3.57)	16.66 (4.07)	40.03
2	Mulching + Neem Seed Cake @ 150 kg/ ha.	2.78 (1.68)	6.94 (2.70)	9.72 (3.09)	11.11 (3.25)	60.01
3	Mulching + *Tricoderma harzianum* @ 2.5 kg/ha.	1.39 (1.19)	2.78 (1.68)	6.94 (2.70)	9.72 (3.09)	65.01
4	Mulching + Garlic Extract @ 20 %.	4.17 (1.95)	4.17 (1.95)	8.33 (2.91)	12.50 (3.48)	55.00
5	Mulching + Vermicompost @ 5 t/ha	6.94 (2.43)	9.72 (3.09)	11.11 (3.25)	13.89 (3.73)	50.00
6	Mulching + Gypsum @ 4 tone/ ha.	4.17 (1.67)	8.34 (2.82)	11.11 (3.25)	12.50 (3.46)	55.00
7	Mulching + salicylic acid @ 10 ppm.	0.00 (0.71)	2.78 (1.68)	6.94 (2.43)	8.33 (2.91)	70.01
8	Mulching + Neem Seed Cake @ 150 kg/ ha+ *Tricoderma harzianum* @ 2.5 kg/ha.	0.00 (0.71)	1.39 (1.19)	2.78 (1.68)	4.17 (1.95)	94.99
9	Mulching + Garlic Extract @ 20 % + *Tricoderma harzianum* @ 2.5 kg/ha.	1.39 (1.19)	2.78 (1.46)	5.56 (2.16)	6.94 (2.43)	75.02
10	Mulching + Gypsum @ 4 tone/ ha. + *Tricoderma harzianum* @ 2.5 kg/ha.	0.00 (0.71)	1.39 (1.19)	4.17 (2.95)	5.56 (2.43)	79.99
11	Mulching + Vermicompost @ 5 t/ha + *Tricoderma harzianum* @ 2.5 kg/ha.	2.78 (1.68)	5.55 (2.22)	6.94 (2.43)	8.33 (2.91)	70.01
12	Mulching + *Tricoderma harzianum* @ 2.5 kg/ha. + Salicylic acid @ 10 ppm.	1.39 (1.19)	2.78 (1.46)	4.17 (1.95)	5.56 (2.16)	79.99
13	Control	11.11 (3.39)	15.28 (3.96)	20.83 (4.60)	27.78 (5.31)	
	SEM±	0.46	0.50	0.48	0.46	
	CD at 5%	1.35	1.45	1.40	1.35	

PDI-Per cent disease incidence, PDC- Per cent disease control, DAT-Days after transplanting, *Figures in parentheses are angular transformed values.

The effects of sustainable management strategies on yield of tomato are presented in table-2. It was evident from the table that all tested treatments increased the yield of tomato significantly over untreated control. Highest increase in yield (24.92 %) was recorded in plants received the treatments of mulching with the integration of neem seed cake and *T. harzianum* followed by 19.77 % from mulching of transparent polythene + *T. harzianum* as soil amendment + Salicylic acid as foliar application (T12) and 18.60 % from mulching of transparent polythene + *T. harzianum* +Gypsum as soil amendment (T-10). Lowest increase in yield (9.80 %) recorder in plants received the treatments of transparent polythene mulching only in respect of untreated control plots where plants received only agronomic practices.

Table-2: Effects of Sustainable Management Strategy on Yield of Tomato

S. No.	Treatments	Yield (Q/Ha)	Percent Increase in Yield Over Control
1	Mulching by transparent polythene (25 micron)	220.33	9.80
2	Mulching + Neem Seed Cake @ 150 kg/ ha.	227.00	13.12
3	Mulching + *T. harzianum* @ 2.5 kg/ha.	224.67	11.96
4	Mulching + Garlic Extracts @ 20 %.	222.33	10.80
5	Mulching + Vermicompost @ 5 t/ha	229.67	14.45
6	Mulching + Gypsum @ 4 tone/ ha.	228.00	13.62
7	Mulching + salicylic acid @ 10 ppm.	223.33	11.30
8	Mulching + Neem Seed Cake @ 150 kg/ ha.+ *T. harzianum* @ 2.5 kg/ha.	250.67	24.92
9	Mulching + Garlic Extracts @ 20 % + *T. harzianum* @ 2.5 kg/ha.	232.67	15.95
10	Mulching + Gypsum @ 4 tone/ ha. + *T. harzianum* @ 2.5 kg/ha.	238.00	18.60
11	Mulching + Vermicompost @ 5 t/ha + *T. harzianum* @ 2.5 kg/ha.	235.67	17.44
12	Mulching + *T. harzianum* @ 2.5 kg/ha. + Salicylic acid @ 10 ppm.	240.33	19.77
13	Control	200.67	
	SEM±	1.78	
	CD at 5%	5.20	

The Present study accomplished that incorporation of different organic, inorganic and biological antagonistic materials along with soil mulching with transparent polythene significantly reduced the collar rot disease and increase the yield of tomato. The reduced disease incidence can be attributed to several factors including soil temperature, moisture, organic and inorganic amendments as these affect both pathogen and bio agent. Soil mulching by transparent polyethylene save the soil temperature and enhances both of vegetative growth and crop yield, as well as, reduce the incidence of collar rot disease[9,10]. Stapleton and De Vay[11] indicated that the soil mulched with polyethylene sheeting significantly reduced actinomycetes and fungi counts. Incidence and losses on tomato plants incited with root rot and wilt caused by several species of *Fusarium, R. solani and S. rolfsii*, which greatly reduced crop yield and quality were minimized by solarization[12,13,14.] Organic amendments increase the availability of nutrients besides improving physical condition of soil, increase the yield and reduce the soil-borne diseases[15]. The superiority of this amendment may be due to release of some inhibitory substances like nimbicidin, nimbin or azadirachtin on the decomposition, effecting the population of pathogen. Besides the nutrient content of these amendments may have a possible role in enhancing the host growth and vigor, increasing antagonistic microbial activity and enabling them to resist the attack of pathogen. The production of volatile and non-volatile toxic compounds during the decomposition of organic amendments suppresses root diseases though he also stated that though the organic matter has been shown to generally suppress root diseases, but in some cases, organic matter mulches have increased the severity of root diseases. Mulches and organic amendments have been shown to stimulate the germination of fungal propagules of soil-borne pathogens. Bulluck and Ristaino[16] reported the reduction of the viability of sclerotia after the mixing of compost or manure to natural soils. The effect of the manure on the sclerotia in a natural soil can be explained by some actions of the soil

micro-flora. In fact, many types of manure have been reported to harbor antagonistic fungi and bacteria[17]. The manure inhibited the mycelial growth of *S. rolfsii* and affected the viability of its sclerotia.[18]. The suppressive ability of neem organic amendments in inhibiting growth of soil-borne pathogens has been demonstrated to be through competition, antibiosis or due to the increase of saprophytic soil microbial populations[19].

In the Present study it was found that soil mulching + neem seed cake and biological antagonist *T. harzianum* as soil amendments gave maximum effects in terms of reduction of disease and in enhancing the yield. Neem plant possesses biologically active compounds mainly alkaloids such as isoprenoids that control various pest and diseases. Singh *et al.*[20] reported that the neem cake has ability to influence the secondary metabolites in soil borne phytopathogenic fungus *Sclerotium rolfsii*. Several *Trichoderma spp*. suppress the soil-borne pathogens by diversified mechanisms viz., production of a wide range of broad spectrum antifungal metabolites, mycoparasitism, competition with the pathogen for nutrient and for occupation of infection court, induced resistance, production of protease and fungal cell wall degrading enzymes[21]. The present study highlights the immunity development effect of Gypsum and Vermicompost against the collar rot disease of Tomato. Gypsum is efficacious may be due to its absorbent nature that may absorb moisture from the fungal structures including sclerotia followed by its desiccation. Garren[22] first reported that high rates of gypsum resulted in a reduction of rotted peanut pods. Mondal and Khatua[23] reported the strong adverse effect of Plaster of Paris on mycelial growth and survival of sclerotia of *Sclerotium rolfsii* under field condition. Thilagavathi *et al*[24] reported that Vermicompost-based bioformulations of fungal biocontrol agents *Trichoderma spp.* performed better in reducing root rot disease of sugarbeet caused by *Sclerotium rolfsii* and also enhancing yield. The present study also highlights the protective effect of salicylic acid against the collar rot disease of Tomato. On the other hand, an important finding from this study revealed that salicylic acid had positive effects on plant growth, yield and fruit quality of tomato plants grown under field conditions. These increases in growth, yield quantity and quality may be attributed to elicitors effect on physiological processes in plant such as ion uptake, cell elongation, cell division, enzymatic activation and protein synthesis [25,26]. Similar results were reported by Pandey and Gupta[27] where, foliar application of Salicylic acid @ 10 ppm, led to completely checked upto 21 days of incubation and only 10 % wilt incidence after 28 days of incubation of *Fusarium oxysporum* f. sp. *Lycopersici* on tomato plants. Inhibition of pathogenic fungi by garlic bulb extract might be due to the presence of antimicrobial compounds in the extract. It has been reported that the antibiotic substance present in garlic is the allyl compound of allyl thiosulphate[28]. It is also reported that garlic contains an amino acid alliin which on crush transferred into allicin by the action of allicinase enzymes and this allicin is toxic to the microorganism (http//www.gourmetgarlicgardens.com/ pill.htm).

CONCLUSION

The results obtained in this study revealed that mulching in integration with soil amendment i.e. neem seed cake and *Trichoderma harzianum* attributed the synergistic and additive growth effects that enhanced the plant vigour and yield as well as substantial antagonistic activity of bio antagonistic against collar rot pathogen. This is highly advantageous in light of the fact that the use of mulching in combination with antagonistic bio agents and organic soil amendment is not only safe for the farmers and consumers but is also environmentally friendly.

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