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A Non-chemical Approach to the Management of Root Rot Disease Complex of Tomato Concomitantly Caused by *Rhizoctonia solani* and *Meloidogyne javanica*

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ABSTRACT

Background: Tomato (*Solanum lycopersicum* L.) is an important vegetable crop not only for its economic importance but also for its nutritional value. It remained prone to various diseases and amongst them, root rot disease complex caused by concomitant occurrence of *R. solani* and *M. javanica* has been key problem in Haryana resultantly reduces yield and production to great extent.

Methods: Present study was carried out with the aim to evaluate the effect of organic amendments and biocontrol agents on root rot disease complex in tomato cv. Hisar Arun (Selection 7). Tomato seeds were sown @ 10 seeds/pot filled with sterilized sandy loam soil having 1000 mg/kg soil (*Rhizoctonia solani* inoculum level) and 1000 J2/kg soil (*M. javanica* inoculum level).

Result: The minimum mortality of 33.3 and 36.6 per cent was observed when the soils were incorporated with mustard cake @ 2 g/kg soil followed by cotton cake @ 2 g/kg soil in comparison to total mortality of 63.3 per cent in control pots and the soil application of mustard cake protected 47.4 per cent plants from mortality. The application of *Glomus mosseae* (VAM) at 200, 150, 100 sporocarps/kg soil managed disease to the extent of 36.8% 21.0% and 10.4% respectively. Incorporation of *T. harzianum*@ 5 g/kg soil and 10 g/kg soil managed the disease to the extent of 21% and 42% respectively. The minimum mortality of 33.3% was recorded when seeds were dressed with Carbendazim 50WP whereas 36.6 per cent with Carboxin 37.5WP + Thiram 37.5WP in comparison to 63.3 per cent in control pots. Systemic approach to manage the root-rot disease complex with the help of organic amendments, bioagents and fungicides can prevent the losses caused to the crop.

Key words: Carbendazim, *Glomus mosseae, Meloidogyne javanica,* Organic amendments, *Rhizoctonia solani*, Tomato, *Trichoderma harzianum.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an important vegetable crop not only for its economic importance but also for its nutritional value. India ranks second in the area as well as production of tomato after China. In India Andhra Pradesh ranked first for tomato production (Rizvi *et al*., 2015 b). The estimated production of tomato in India is about 19.759 Lakh MT with productivity of 25.04 MT/ha and Haryana contributed 7.53 Lakh MT with productivity of 21.54 MT/ha (www. indiastat. com). The productivity of tomato in India is comparatively lower than many other countries, presumably due to disease prevalence, improper and inadequate supply of nutrients and lack of adoption of new improved production technologies. Tomato is prone to attack by fungal, bacterial, nematode and viral diseases and among biotic stresses root-rot disease complex caused by concomitant occurrence of *R. solani* and *M. javanica* has been key problem and leads to more severe damage in tomato than their individual effect. (Kumar and Haseeb, 2009).

Root rot complex caused by *Rhizoctonia solani* and *Meloidogyne javanica* is considered as destructive disease of nursery as well as transplanted crop of tomato. *Rhizoctonia solani* causes pre-emergence and post-emergence plant mortality in seedlings, black lesions in root and stem rot. The disease is characterized as complete rotting of seeds or rotting of emerging radical before it come and out at ground level, these symptoms are grouped as pre-emergence while in post-emergence, there is breakdown of host cell walls by pectinase enzyme and the lesion increases in size more towards downward than upward and the root tissues disintegrate at the latter stages resultantly the bark wither away. The sclerotia produced by fungus are barrel shaped and clearly visible on the surface of infected roots. The lower leaves start drying from lower parts of the plant and entire plant get dried off prematurely, whereas, other symptoms are stunting, yellowing, defoliation and premature death of plants in severe form particularly when

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in combination with nematode, hence, the pernicious effects of *R. solani* become more pronounced in the presence of *M. incognita* (Abuzar, 2013).

It is much difficult to manage *Rhizoctonia solani* by virtue of its presence in soil or plant debris, polyphagous nature and its vast distribution. The association of *Meloidogyne* sp. makes the situation more complex for successful economical control of root rot disease complex of tomato. It is quite difficult to manage the disease complex through chemicals alone. Fungicides and nematicides both being costly have undesirable effect on the environment when applied regularly; encourage development of resistance in pathogen. In addition to the target pest, they are harmful to the beneficial micro-organisms in the rhizosphere, contaminate soil, water and accumulate in plant parts (Rizvi *et al*., 2015 b). There is a need to explore and exploit other methods for disease management in an integrated manner. The present study was carried to find out the effect of organic amendments, fungicides and biocontrol agents on root rot disease complex of tomato (*Solanum lycopersicum* L.) caused by concomitant occurrence of *Rhizoctonia solani* and *Meloidogyne javanica.*

MATERIALS AND METHODS

The present study was carried out in Department of Plant Pathology, Chaudhary Charan Singh Haryana Agricultural University, Hisar during 2018-19.The experiment was conducted on most popular and moderately resistant variety Hisar Arun (Selection 7).

Two bio control agents *viz. Glomus mosseae,* vesicular arbuscular mycorrhiza (VAM) and *Trichoderma harzianum* were applied in sandy loam soil for evaluation against *R. solani* and *M. javanica* causing root rot disease complex in tomato. These biocontrol agents were thoroughly mixed in each pot seven days before sowing in soil.

The vesicular-arbuscular mycorrhizal fungus *viz. Glomus mosseae* procured from Department of Plant Pathology, CCS HAU, Hisar was raised and maintained in earthen pots of 30 cm diameter having 5 kg sterilized sand on wheat (*Triticum aestivum*) and pearl millet (*Pennisetum typhoides*). one hundred gram inoculum of mycorrhizal fungus having 450-500 extramatrical chlamydospores was incorporated in upper 5 cm soil layer per pot and then ten seeds of wheat or pearl millet per pot were sown. The pots were irrigated regularly. The shoot portions of the growing plants were cut at soil level after 90 days and soil in pots was left undisturbed to get air dried. The soil was fragmented into small particles and rootlets cut into 1 cm pieces. The mixture of soil and root segments was used as inoculum.

Extraction of sporocarps from soil

The sporocarps were extracted by wet sieving and decantation technique (Gerdemann and Nicolson, 1963). 250 g of soil was suspended in one liter of water two hundred fifty heavier particles were allowed to settle down for 30 min and the liquid was decanted through 20 mesh sieve, fine enough to remove larger particles or organic material but coarse enough to allow the desired sporocarps to pass through. The sieved suspension was stirred to resuspend all the particles. The heavier particles were allowed to settle down for 10 min and the suspension was then passed through a 60-mesh sieve. Resultant suspension was sieved serially through 100, 150, 200 and 240 mesh sieves. The maximum sporocarps were retained on 100 mesh sieve. These sporocarps were washed 2-3 times with water in order to free them from soil and organic material. The volume was made to 50 ml and one ml of this spore suspension taken in a watch glass was examined under stereoscopic microscope for sporocarps count. The VAM was used at three different doses *viz.* 100, 150 and 200 sporocarps per kg soil based on the criteria of Borah *et al.* (2018).

The culture of *T. harzianum* was procured from the Department of Plant Pathology, CCS HAU, Hisar and maintained on wheat bran saw dust medium (WBSD). For this wheat bran, saw dust and water (WBSD) (3:1:3.5 w/w/v) were mixed thoroughly, filled in a polypropylene bag (100g/bag), sealed on flame and autoclaved at 15 lbs pressure per square inch for 30 minutes for two consecutive days (Mukhopadhyay *et al.,* 1986). The sterilized bags were inoculated separately with the three days old culture of *T. harzianum* under aseptic conditions and incubated at 25±2°C for about 10 days. The bags were shaken thoroughly at three days' interval to allow the uniform growth in the bag till 10 days. Two different treatments *viz.* 5 and 10g/kg soil of *T. harzianum* were tested against root rot disease complex of tomato.

The culture of root knot nematode *Meliodogyne javanica* was collected from tomato plants showing galling and multiplied on tomato crop. The egg masses were collected from roots by using forceps and transferred to double fold tissue paper put on molded pieces of aluminium wire net plated in Petri plates. Egg masses were submerged in plates by adding sufficient amount of water. The water containing J_2 larvae was collected next day and hatched J_2 larvae were used as pathogen inoculum.

Earthen pots of 15 cm diameter were filled with sterilized sandy loam soil (autoclaved at 22 psi for 2 h). The inocula were added @ 1000 mg/kg soil (*Rhizoctonia solani* inoculum level) and @ 1000 J_2/kg soil of *M. javanica* The inocula were mixed thoroughly upto 5 cm depth of the pot. Tomato seeds were sown in the pots @10 seeds/pot immediately after adding the inocula.

Effect of organic amendments on root rot disease complex of tomato

The organic amendments *viz.* farm yard manure, poultry manure, spent mushroom compost@ 5 g/kg soil and vermicompost, cotton cake, mustard cake, neem cake @ 2 g/kg soil were thoroughly mixed in each pot.

Effect of seed dressing of fungicides on root rot disease complex of tomato

The seeds were dressed with five different fungicides *viz.*, Carbendazim 50WP, Captan 50WP, Thiram 75WP,

Mancozeb 75WP, Carboxin 37.5WP +Thiram 37.5WP @ 2.0 g/kg seed against root-rot disease complex causing pathogens *Rhizoctonia solani* and *Meloidogyne javanica* in tomato cv. Hisar Arun (Selection 7).

Untreated seeds sown in inoculated and uninoculated soils served as checks. The check without any pathogen inoculum was also maintained to compare the seeds germination. The pots were irrigated at regular interval to maintain proper moisture level. Observations were recorded on per cent pre-emergence and post-emergence mortality (30 DAS) for all the treatments.

$$\text{Per cent plant mortality} = 100 - \frac{\text{Plants stand in inoculated treatment}}{\text{Plants stand in uninoculated control}} \times 100$$

The experiment was conducted in completely randomized design (CRD) with three replications for all treatments under screen house conditions. Statistical analysis was carried out through opstat (https://www.hau.ac.in/page/o-p-stat).

RESULTS AND DISCUSSION

Effect of different organic amendments on root rot disease complex of tomato

The application of organic amendments increases population of resident bacteria and fungi which decrease the disease incidence of *R. solani* (Cohen *et al.,* 2005). The application of organic amendments improves the soil and plant health that in turn reduces the disease incidence. Organic manures increase the water holding capacity, porosity and soil aeration thus help in rapid root extension and improved plant vigour. The results regarding effect of soil incorporation of six organic amendments on root rot disease complex of tomato are presented in Table 1. Minimum mortality of 33.3 per cent was recorded when mustard cake was used as organic amendment followed by cotton cake with 36.6% total mortality as compared to the highest mortality of 63.3 per cent in control pots (*R. solani* and *M. javanica* inoculated simultaneously). Application of mustard cake could manage disease by 47.4 per cent, that was 42.2 and 42.0 per cent with cotton cake and vermicompost.

Soil application of four organic amendments *viz.,* mustard cake, cotton cake, vermicompost and neem cake significantly reduced pre-emergence plant mortality as compared to control in which no soil application of organic amendments were done, whereas, all the seven organic amendments significantly decreased post-emergence plant mortality as compared to control. The disease control on amendment with neem cake, spent mushroom compost, FYM and poultry manure was 31.6, 26.2, 26.2 and 10.6% respectively, as compared to control. The findings of present work are in corroboration with those of other investigations. Rizvi *et al*. (2015 a); Shafique *et al*. (2015); Choudhary and Ashraf (2019) and Parveen *et al.* (2019) also observed that organic amendments reduced the root rot disease complex in tomato.

Effect of different concentrations of *Glomus mosseae* (VAM) on root rot disease complex of tomato

The per cent disease control was directly proportional to the concentration of VAM (Table 2). A maximum of 36.8 per cent disease control was recorded with soil application of 200 sporocarps/kg soil followed by 21 per cent disease control by soil application of 150 sporocarps/kg soil and least disease control of 10.4 per cent was recorded at 100 sporocarps/kg soil.

Table 1: Effect of different organic amendments on root rot disease complex of tomato cv. Hisar Arun (Selection 7) under screen house conditions.

Organic amendments	*Disease Incidence		Total mortality (%)	Disease control (%)
	[1]PEM	[2]POEM		
FYM	20.0 (26.6)	26.7 (31.0)	46.7	26.2
Poultry manure	23.3 (28.8)	33.3 (35.2)	56.6	10.6
Spent mushroom compost	20.0 (26.6)	26.7 (31.0)	46.7	26.2
Vermicompost	16.7 (23.9)	20.0 (26.6)	36.7	42.0
Cotton cake	13.3 (21.1)	23.3 (28.8)	36.6	42.2
Mustard cake	10.0 (18.4)	23.3 (28.8)	33.3	47.4
Neem cake	13.3 (21.1)	30.0 (33.2)	43.3	31.6
Check-1 (*R. Solani* and *M. javanica* inoculated simultaneously)	23.3 (28.8)	40.0 (39.2)	63.3	0.0
Check-2 (No pathogen)	0.0(4.05)	0.0(4.05)	0.0	-
CD at 5%	(5.6)	(4.9)	-	-
CV	(14.7)	(9.8)		
SE(m)	(1.9)	(1.6)		

*(Mean of 3 replications).

Figures in parentheses are angular transformed values.

[1]PEM = Pre-emergence mortality [2]POEM = Post-emergence mortality.

Pre-emergence plant mortality was 13.3, 16.7 and 20.0 per cent with application of 200, 150, 100 sporocarps/ kg soil, respectively as compared to check 1 (23.3 per cent). Post-emergence plant mortality was 26.7 per cent when soil was incorporated with 200 sporocarps/kg soil followed by post emergence plant mortality of 33.3 and 36.7 per cent when soil was incorporated with 150 and 100 sporocarps/ kg soil respectively as compared to control. These observations are in agreement with the findings of Kareem and Hassan (2014), Abo-Korah (2017) and Borah *et al.* (2018) who also reported that root rot disease complex incidence was significantly suppressed by *Glomus mosseae.*

Effect of different concentrations of *Trichoderma harzianum* on root rot disease complex

Root rot disease complex was managed to the extent of 42.0 per cent when *T. harzianum* was applied in the soil @10 g/kg soil and that was 21 per cent when *T. harzianum* was applied in soil @ 5 g/kg soil indicating better disease control at higher concentration of *T. harzianum* (Table 3).

Pre-emergence mortality was 16.7 per cent when *T. harzianum* was incorporated in soil @ 5 g/kg soil and it was reduced significantly to 10.0 per cent when *T. harzianum* was used @ 10 g/kg soil, whereas, maximum pre-emergence mortality of 23.3 per cent was observed in control (*R. solani* and *M. javanica* inoculated simultaneously). Post-emergence mortality was also reduced to 26.7 per cent at 10 g/kg soil as compared to control (40.0 per cent).

The findings of present study are in accordance with results of El-Nagdi and Abd-El-Khair (2008), Archana and Shweta (2014) and Singh *et al*. (2015) who observed the use of soil incorporation of *T. harzianum* for the management of *R. solani* and *M. javanica* disease complex in various crops.

Effect of seed dressing of fungicides on root rot disease complex of tomato

All fungicides were found significantly efficient over control in reducing per cent disease incidence 30 days after sowing. A minimum mortality of 33.3 and 36.6 per cent was achieved when seeds were dressed with Carbendazim 50WP and Carboxin 37.5 WP + Thiram 37.5 WP, respectively as compared to the highest mortality of 63.3 per cent in control pots (Table 4). Carbendazim 50 WP provided 47.4 per cent disease control and Carboxin 37.5 WP + Thiram 37.5 WP protected 42.2 per cent plants from mortality. Thiram 75 WP provided 31.6 per cent disease control and least disease control of 10.6 per cent was provided by Mancozeb 75WP as compared to control.

Pre-emergence plant mortality was 16.7 per cent by seed dressing with Captan 50 WP , whereas, pre-emergence plant mortality of 13.3 per cent was observed when seed dressing was done with Carbendazim 50 WP and Carboxin 37.5 WP + Thiram 37.5 WP , however, both the treatments did not differ significantly in reducing pre-emergence plant mortality. There was no significant difference in pre-

Table 2: Effect of different concentrations of *Glomus mosseae* (VAM) on root rot disease complex of tomato cv. Hisar Arun (Selection 7) under screen house conditions.

Glomus mosseae (sporocarps/kg soil)	*Disease incidence		Total mortality (%)	Disease control (%)
	PEM	POEM		
100	20.0 (26.6)	36.7 (37.2)	56.7	10.4
150	16.7 (23.9)	33.3 (35.2)	50.0	21.0
200	13.3 (21.1)	26.7 (31.0)	40.0	36.8
Check 1 (*R. solani* and *M. javanica* inoculated simultaneously)	23.3 (28.8)	40.0 (39.2)	63.3	0.0
Check 2 (No pathogen)	0.0 (4.05)	0.0 (4.05)	0.0	-
CD at 5%	(6.3)	(5.1)	-	-
CV	(16.4)	(9.5)		
SE (m)	(1.9)	(1.6)		

Table 3: Effect of different concentrations of *Trichoderma harzianum* on root rot disease complex of tomato cv. Hisar Arun (Selection 7) under screen house conditions.

Trichoderma harzianum	* Per cent disease incidence		Total mortality (%)	Disease control (%)
	[1]PEM (%)	[2]POEM (%)		
5 g/kg soil	16.7 (23.8)	33.3 (35.2)	50.0	21.0
10 g/kg soil	10.0 (18.4)	26.7 (31.0)	36.7	42.0
Check 1(*R. solani* and *M. javanica* inoculated simultaneously)	23.3 (28.8)	40.0 (39.2)	63.3	0.00
Check 2 (No pathogen)	0.0 (4.05)	0.0 (4.05)	-	-
CD at 5%	(5.79)	(4.9	-	-
CV	(16.1)	(9.5)		
SE(m)	(1.7)	(1.5)		

Table 4: Effect of seed dressing of different fungicides on root rot disease complex of tomato cv. Hisar Arun (Selection 7) under screen house conditions.

Fungicides	*Disease incidence		Total	Disease
	PEM	POEM	mortality (%)	control (%)
Carbendazim 50WP	13.3 (21.1)	20.0 (26.6)	33.3	47.4
Captan 50WP	16.7 (23.9)	30.0 (33.2)	46.7	26.2
Thiram 75WP	20.0 (26.6)	23.3 (28.8)	43.3	31.6
Mancozeb 75WP	23.3 (28.8)	33.3 (35.2)	56.6	10.6
Carboxin 37.5WP + Thiram 37.5 WP	13.3 (21.1)	23.3 (28.8)	36.6	42.2
Check-1 (*R. solani* and *M. javanica* inoculated simultaneously)	23.3 (28.8)	40.0 (39.2)	63.3	0.0
Check (No pathogen)	0.0(4.05)	0.0(4.05)	0.0	-
CD at 5%	(6.6)	(4.0)	-	-
CV	(16.7)	(8,7)		
SE (m)	(2.1)	(1.4)		

emergence plant mortality observed between Captan 50WP (16.7%) and Carboxin 37.5WP + Thiram 37.5WP (13.3%) but post-emergence planmortality was significantly less in Carboxin 37.5WP + Thiram 37.5WP (23.3%) seed dressing as compared to Captan 50WP seed dressing (30%). The experimental results regarding disease management of root rot disease complex with Carbendazim were in agreement of the results of Emad Abd (2015) and Devi *et al.* (2016) who observed Carbendazim as the most effective seed dressing fungicide which effectively reduced the pre and post emergence mortality of seedlings caused by *R. solani*.

CONCLUSION

The results of present study indicate that application of organic amendments and biocontrol agents significantly reduced the root rot complex disease of tomato caused by concomitant occurrence of *R. solani* and *M. javanica* which can further be exploited along with chemical control for suitable integrated disease management.

Conflicts of interest

All authors declare that they have no conflict of interest.

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