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Disease management of fusarium wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici*

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Abstract
Tomato is an important annual vegetable crop grown for its edible fruit which was rich in vitamin C, minerals (Fe and Cu) and antioxidants. India ranks second worldwide in tomato growing with an area, production and productivity of 0.789 M ha, 21.24 Mt and 25 Mt ha^{-1} respectively. In India, tomato is third important vegetable crop grown after potato and onion majorly in states such as Orissa, Madhya Pradesh, Karnataka, Chhattisgarh, Andhra Pradesh and Telangana. As like other crops tomato is also very often affected by several diseases incited by pathogens such as fungi, bacteria, viruses and nematodes. Among the fungal diseases, Fusarium wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici* (Fol), is one of the most destructive diseases across the world causing severe economic losses wherever tomato is grown (Sudhamoy *et al*., 2009). In view of this a field experiment was conducted during *rabi*, 2018-19 to evaluate the best integrated disease management strategies against the Fusarium wilt disease of tomato. The results revealed that, among the different integrated disease management strategies, integration of cultural (Soil application of neem cake @ 250 kg ha^{-1} + FYM @ 1000 kg ha-$^{1)}$ + chemical method (foliar application and soil drenching with (Tebuconazole + trifloxystrobin) @ 0.1 percent and biological method (soil application of *Trichoderma viride* (*Tv*2) @ 10 kg ha^{-1} was found to be effective in managing the Fusarium wilt incidence with recording lowest disease incidence of 8.00 percent along with highest yield of 31.53 t ha^{-1} with C: B ratio 1: 2.30 during *rabi*, 2018-19.

Keywords: Fusarium wilt of tomato, disease management, *F. oxysporum* f. sp. *lycopersici*

Introduction

Tomato, is an annual vegetable crop belonging to family *Solanaceae,* growing to a height of 1-3 meters with having weak woody stem. Due to its tangy flavor contributed to the dish, it is a favorite additive in all the regular cuisines globally. Tomato is cultivated extensively in many countries under both protected and open field conditions. India ranks second to China with an area of 0.789 M ha and production of 21. 24 Mt with productivity 25 Mt ha^{-1}, followed by USA, Turkey and Egypt. In India, it is the third important vegetable crop grown after potato and onion with an area of 0.78 M ha with production and productivity of 19,759 Mt and 25.04 Mt ha^{-1}. Tomato crop is very often affected by several diseases incited by pathogens such as fungi (Fusarium wilt, early blight, anthracnose, verticillium wilt *etc.*) bacteria (wilt and canker), viruses (leaf curl and tomato spotted wilt) and nematodes.

Among all the fungal diseases that infect tomato, Fusarium wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.), Snyder and Hans, is one of the most serious and destructive diseases across the world (Sheu and Wang, 2006) [2] causing severe economic losses, wherever tomato is grown. *Fusarium oxysporum* f. sp. *lycopersici* (*Fol*) is ubiquitous, soil-borne vascular fungal pathogen, surviving by producing two kinds of conidia, *i.e.*, micro and macro and chlamydospores during their challenging conditions. It spreads through short distances mainly through irrigation water and farm equipments, long distances through infected planting material, soils *etc*. (Agrios, 2005) [3]. Once the healthy soil is contaminated with the wilt pathogen, it usually remains indefinitely in the soil until checked with suitable management practices at appropriate time (Animashaun *et al*., 2017 and Prihatna *et al*., 2018) [4-5].

Under these circumstances, integration of cultural, chemical and biological methods have played a major role in managing the Fusarium wilt disease of tomato (Singh *et al*., 2015) [6]. In view of this, a research experiment was formulated by integrating cultural, biological and chemical methods for managing fusarium wilt of tomato.

Material and Methods

This field experiment was conducted with Randomized Block Design (RBD) having 14 treatments with 3 replications at Horticultural Research Station, Kovvur, during *rabi* 2018-2019. Integration of cultural, biological and chemical methods was evaluated against Fusarium wilt disease of tomato. Highly susceptible tomato variety *i.e.*, Pusa Ruby was used for this experiment with spacing of 60 x 45 cm. Regular dosage of fertilizer and irrigation was given to its capacity as per the local agronomical conditions. Under cultural method; FYM was uniformly distributed @ 1000 kg ha^{-1} along with neem cake @ 250 kg ha^{-1} followed by light irrigation. Soil drenching and foliar application with tebuconazole 50% + trifloxystrobin 25% WP at 0.1 percent at 20^{th}, 45^{th} and 70^{th} DAP with a time interval of 25 days under chemical method, and soil application of *Trichoderma viride* @ 10 kg ha^{-1} at basal region of the tomato plant in two split doses with first application on DAP and second application at 30^{th} DAP to encourage good multiplication of bio agent under biological method. Soil drenching with carbendazim @ 0.1 5% as positive check was applied at 20^{th}, 35^{th}, 50^{th} and 65^{th} DAP. Observations on plant height (cm) and percent disease incidence was recorded by using the formula number of plants effected divided by total number of plants x 100, at 30^{th}, 45^{th}, $60^{th}$and 75^{th} DAP and biometrical parameters such as yield per plant (g), fresh and dry weight of shoot (g), were recorded after harvesting to know the effect of different IDM strategies in managing Fusarium wilt. Data was subjected to analysis of variance (ANOVA) at significant levels ($p<0.05$ and $p<0.01$) and treatment means were compared by critical difference (CD).Angular transformation was done as per the requirement.

Results and Discussion

The results revealed that (Table.1), there was significant difference among the treatments pertaining to wilt disease incidence and yield parameters during *rabi* 2018-19 under different IDM strategies. The best effective and significantly superior treatment found promising for management of Fusarium wilt disease of tomato was with integration of cultural, biological and chemical methods.

The results revealed that, at 30 DAP treatment *i.e.*, basal soil application of neem cake @ 250 $kgha^{-1}$ + FYM @ 1000 kg ha^{-1} + soil application of *Trichoderma viride* @ 10 kg ha^{-1} + foliar and soil drenching with tebuconazole 50% WP + trifloxystrobin 25% WP @ 0.1 percent recorded lowest disease incidence of 4.00% compared to inoculated control with recording 16.00%. The least significant treatment observed was under cultural method i.e, soil application of neem cake @ 250 kg q^{-1} + FYM @ 1000 kg ha^{-1} with recording 14.66 percent disease incidence.

Similar trend in results were obtained with integration of cultural, biological and chemical methods at 45, 60 and 75 DAP with recording lowest percent disease incidence of 5.33%, 6.66% and 8.00% compared to control with percent disease incidence of 38.66%, 54.60% and 78.00%.

The positive check under chemical method *i.e.*, soil drenching carbendazim @ 0.1 percent still shows to be promising against Fusarium wilt of tomato during *rabi*,2018-19 with percent disease incidence of 9.33, 13.33, 16.00 and 20.00 percent at 30^{th}, 45^{th},60, and 75 DAP respectively.

With this present investigation, basal soil application of neem cake @ 250 $kgha^{-1}$ + FYM @ 1000 kg ha^{-1} before transplantation (cultural method) + soil application of *Trichoderma viride* @ 10 kg ha^{-1} (biological method) + foliar and soil drenching (Tebuconazole 50% WP + trifloxystrobin 25% WP) @ 0.1 percent (chemical method) was found to be best and significantly superior for managing the Fusarium wilt of tomato with maximum fruit yield of 31.53 t ha^{-1} (table.2).

It is evident from the present investigation that application of FYM + neem cake as cultural method alone was not effective in reducing the wilt disease incidence in tomato which is similar to the findings of Jaiswal *et al.* (2015) [7] and similarly, integration of chemical and biological methods i.e., carbendazim + Neem oil cake recording with 29.17% percent disease incidence followed by *Trichoderma viride* + neem oil cake with 33.33 percent along with good general growth of the tomato plant given by Prasad *et al.* (2002) [8] and Kamdi *et al.* (2012) [9].

Table 1: Effect of different IDM strategies on the incidence of Fusarium wilt of Tomato during *rabi*, 2018-19.

Sl. No.	Treatments	30 DAP	45 DAP	60 DAP	75 DAP
T_1	Soil application of neem cake @ 250 kg q^{-1} + FYM @ 1000 kg ha^{-1}	14.66 (11.01)	29.66 (15.69)	42.60 (19.05)	69.33 (25.34)
T_2	Soil drenching with tebuconazole 50% WP + trifloxystrobin 25% WP @ 0.1%.	8.00 (8.12)	10.66 (9.35)	13.33 (10.49)	14.66 (11.01)
T_3	Foliar application and soil drenching tebuconazole 50% WP + Trifloxystrobin 25% WP @ 0.1%.	8.00 (8.12)	10.66 (9.35)	12.00 (9.97)	13.33 (10.49)
T_4	Soil application of *Trichoderma viride* @10 kg ha^{-1}	12.00 (9.87)	17.33 (11.99)	20.00 (12.87)	24.00 (14.14)
T_5	T_1+ T_2	8.00 (8.12)	10.66 (9.35)	13.33 (10.49)	13.33 (10.49)
T_6	T_1+T_3	8.00 (8.12)	9.33 (8.74)	10.66 (9.26)	12.00 (9.87)
T_7	T_1 +T_4	12.00 (9.87)	14.66 (11.01)	17.33 (11.99)	22.66 (13.75)
T_8	T_2 + T_4	6.66 (7.33)	8.00 (8.12)	10.66 (9.35)	12.00 (9.87)
T_9	T_3 + T_4	6.66 (7.33)	6.66 (7.33)	8.00 (8.12)	10.66 (9.35)
T_{10}	T_1 + T_2 +T_4	5.33 (6.54)	6.66 (7.33)	8.00 (8.12)	9.33 (8.74)
T_{11}	T_1+ T_3 + T_4	4.00 (5.73)	5.33 (6.53)	6.66 (7.33)	8.00 (8.12)
T_{12}	Drenching carbendazim @ 0.1%	9.33 (8.74)	13.33 (10.49)	16.00 (11.47)	20.00 (12.87)
T_{13}	Control (inoculation with *Fol*)	16.00 (11.53)	38.66 (18.08)	54.60 (21.67)	78.00 (27.24)
T_{14}	Control (un inoculated).	10.66 (9.35)	17.33 (11.99)	26.66 (14.89)	34.66 (17.07)
	S.Em (±)	0.31	0.32	0.47	0.55
	C.D.	0.91	0.95	1.38	1.63
	C.V.	17.51	15.95	17.20	15.39

Table 2: Impact of *Fusarium* wilt on yield and other attributes of tomato cv. Pusa Ruby under different IDM strategies during *rabi*, 2018-19.

S. No	Treatments	*Plant height (cm)	Average no. of branches	Yield (tha^{-1})	Shoot fresh weight (g)	Shoot dry weight (g)
1	Soil application of neem cake @ 250 kg q-^{1} + FYM @ 1000 kg ha-^{1}	81.66	7.8	14.70	24.91	5.92
2	Soil drenching with tebuconazole 50% WP + trifloxystrobin 25% WP @ 0.1%.	86.04	12.40	27.30	36.7	7.24
3	Foliar application and soil drenching tebuconazole 50% WP + trifloxystrobin 25% WP @ 0.1%.	89.85	12.8	28.40	38.8	7.52
4	Soil application of Trichoderma *viride* @ 10 kg ha^{-1}.	85.10	11.39	23.30	33.7	6.69
5	T_1+ T_2	93.52	13.23	27.90	36.9	7.86
6	T_1+T_3	95.70	14.41	28.50	37.7	7.88
7	T_1 +T_4	83.80	11.56	24.73	34.8	6.78
8	T_2 + T_4	90.75	13.08	28.40	38.1	8.14
9	T_3 + T_4	91.65	13.7	29.53	37.8	8.41
10	T_1 + T_2 +T_4	103.6	15.09	31.06	38.8	8.68
11	T_1+ T_3 + T_4	104.55	15.41	31.53	41.9	9.62
12	Drenching carbendazim @ 0.1%	85.64	12.96	26.50	38.8	7.24
13	Control (inoculation with *Fol*)	78.64	6.48	9.56	29.2	3.11
14	Control (un inoculated).	80.49	7.80	11.93	29.5	3.71
	S.E(m)$\pm$	1.53	0.3	0.7	2.38	0.33
	C.D.	4.36	1.9	2.04	6.96	0.97
	C.V.	9.08	3.99	5.01	11.56	8.21

Fig 1: healthy plants under best treatment and under control

Fig 2: Tomato crop at harvesting stage

Conclusion

From the studies, it can be inferred that in the absence of resistance in all popular cultivars of tomato against Fusarium wilt, integration of various cultural, biological and chemical methods is suggested for adoption by the farmers for effectively managing this potenatil treat to tomato.

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