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

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Abstract
Experiments were conducted at Sartingal farm of Regional Horticulture Research Sub- station (RHRSS) Bhaderwah, Doda, SKUAST-Jammu in randomized block design with fifteen treatments in three replications to assess the losses caused due to fusarium wilt of tomato using a susceptible variety. Different fungicides, bio-agents and cultural practices, alone and in possible combinations gave the significant reduction in tomato wilt disease incidence caused by *Fusarium oxysporum* f.sp. *lycopersici* and also significantly increased the yield over the check. Among the treatments, seedling treatment with carbendazim @ 0.1% + Soil drenching with carbendazim @ 0.1% three times was most effective, recording the lowest disease intensity (11.33%), recording 70.27% reduction in disease severity over the check. Accordingly, tomato fruit yield was also highest in T_9 (133.65 q/ha), which recorded 91.61% increase in fruit yield over T_{15} check (69.75 q/ha). This was followed by T_{10} (Seedling treatment with carbendazim @ 0.1% and soil drenching with carbendazim @ 0.1% two times at 15 days interval starting at the age of 21 days after transplanting), that recorded 13.69% wilt incidence and fruit yield of 119.95 q/ha and T_{13} (T1 + T2 + T4 + T6), which too recorded fruit yield at par with T_{10} (118.18 q/ha).

Keywords: Tomato wilt, *Fusarium oxysporum* f.sp. *lycopersici*, Carbendazim

1. Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular and important commercial vegetable crop grown all over the world. It is excellent source of various micronutrients and antioxidants. Hence are often recommended by dieticians and nutritionists for controlling cholesterol and weight reduction (Lenucci *et al*. 2006, Keswani 2015) [18, 22]. It is grown in 0.458 M ha area with 7.277 M mt production and 15.9 mt/ha productivity. The major tomato producing states are Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh and West Bengal. In the Year 2014-15 tomato production in Jammu & Kashmir is 136.59 Mt. **(**Source: National Horticulture Board (NHB). In India, tomato has wider coverage in comparison to other vegetables. It is adopted in wide range of climatic condition. In hilly region it grown only in summer and fresh local tomatoes are one of the most popular items during summer (Thamburaj and Singh, 2005) [16].

In Jammu & Kashmir specially Regional Horticultural Research Sub-Station (RHRSS), Bhaderwah, district - Doda comes under the hill and temperate region also. This crop is mainly grown in this region for main vegetable next to knoll khol. This vegetable crop suffers from various diseases that significantly affect its growth and yield. A number of economically important tomato diseases caused by fungi are transmitted by seed or transplants. Tomatoes are parasitized by a number of pathogens, including *Fusarium oxysporium* f. sp. *lycopersici* (Sacc.) (W.C. Snyder *et al*., 2003) [14] the causal agent of fusarium wilt, which is one of the most important pecies as tomato pathogen (Jones *et al*., 1982; Agrios, 1988; Smith *et al*., 1988) [2, 5, 7]. Out of these, tomato wilt is one of the most serious diseases affecting its yield. Yield loss due to this disease is 25.14-47.94% in Uttar Pradesh (Enespa and Dwivedi 2014) [20]. The causal agent of *Fusarium* wilt is soil borne pathogen which can persist many years in the all type of soil without a host throughout world. *Fusarium* spp. are saprophytes and are able to grow on soil organic matter for a prolonged period. Most infections originate from the population associated with infected tomato debris. Healthy plants can become infected by *F. oxysporum* if the soil in which they are growing is infested with the pathogen (Farr *et al*., 1989) [8]. However, pathogenic fungi of the genus *Fusarium* that is the causal agents of tomato wilt cause root and basal stem deterioration and result in the wilting of vegetable plants. Browning of the vascular tissue is strong evidence of *Fusarium* wilt (Snyder and Hans, 2003) [14].

Like many other plant diseases, control of fusarium wilt is achieved by application of systemic fungicides and use resistant cultivars (Cook 1993, Agrios 2005) [10, 17]. Fungicides are main management tool of plant diseases but bio agents specially Trichoderma species also success to control pathogenic activities of plant pathogenic fungi (Taran, 2000) [13]. To adopt a suitable management strategy for managing fusarium wilt of tomato is therefore of paramount importance. Considering these facts, experiments were planned to assess different management techniques alone as well as in various combinations against tomato wilt.

2. Materials and Methods

Experiments were conducted during the kharif-2012, 2013 and 2014 at Sartingal farm of Regional Horticulture Research Sub- station (RHRSS) Bhaderwah, Doda, SKUAST-Jammu in randomized block design with fifteen treatments in three replications to assess the losses due to fusarium wilt of tomato using a susceptible variety. All the treatments were imposed with different combinations viz. FYM, seedling treatment with carbendazim, soil drenching with carbendazim solution three times, soil drenching with carbendazim solution two times, seed treatment with *Trichoderma harzianum*, soil drenching with *Trichoderma harzianum* two times, FYM+ soil drenching with carbendazim two times, FYM+ seed treatment with *Trichoderma harzianum*, Seedling treatment with carbendazim + Soil drenching with carbendazim solution three times, seedling treatment with carbendazim+ soil drenching with carbendazim solution two times, FYM+ soil drenching with carbendazim solution two times + soil drenching with *Trichoderma harzianum* two times, seedling treatment with carbendazim+ soil drenching with carbendazim solution two times + soil drenching with *Trichoderma harzianum* two times, FYM + Seedling treatment with carbendazim + soil drenching with carbendazim solution two times+ soil drenching with *Trichoderma harzianum* two times, FYM + Seedling treatment with carbendazim + seed treatment with *Trichoderma harzianum* + soil drenching with *Trichoderma harzianum* two times and check. The optimum dose of bio-agents was found to be 4-8 g/lt and increase yield were reported (Khan and Sinha, 2007). To get the maximum disease intensity, during the three years research experiment disease sick plot was used for transplant.

The total population of casual agent was 10^7/g in the soil of sick plot before transplanting. The percent disease index (PDI), percent disease control (PDC) was calculated as per the standard formula (Mayee and Datar, 1986) [5]. Disease intensity was recorded after 12 days of every spraying and yield were also recorded after picking edible tomato fruits. The percentage of wilt disease of tomato was observed visually. The data were subjected to analysis of variance (ANOVA) in a Completely Randomized Design after appropriate transformations as suggested by Gomez and Gomez (1984) [4] before statistical analysis. The difference of two means between treatments exceeding Critical Difference (CD) value is significant (Panse & Sukhatme, 1978) [1].

3. Results and Discussions

Per cent wilt incidence and yield data recorded for all the three years were pooled and analyzed and the data is presented in Table 1. Fungicide, bio-agents, and cultural practices, alone and in different possible combinations gave significant reduction in the severity of wilt disease of tomato caused by *Fusarium oxysporum* f.sp. *lycopersici* and also significantly increased the yield over the check, as evident from Table 1. Treatment (T_9), seedling treatment with carbendazim @ 0.1 for thirty minutes before transplanting + soil drenching with carbendazim @ 0.1% solution three times at 15 days interval, started with age of 25 days after transplanting was most effective treatment in which the severity of fusarium wilt disease of tomato was 11.33%, thus recording 70.27% reduction in disease incidence over the check (clearly depicted in Fig. 1). Accordingly, tomato fruit yield was also highest in T_9 (133.65 q/ha), which recorded 91.61% increase in fruit yield over T_{15} check (69.75 q/ha). This was followed by T_{10} (Seedling treatment with carbendazim @ 0.1% and soil drenching with carbendazim @ 0.1% two times at 15 days interval starting at the age of 21 days after transplanting), that recorded 13.69% wilt incidence and fruit yield of 119.95 q/ha and T_{13} (T_1 + T_2 + T_4 + T_6), which too recorded fruit yield at par with T_{10} (118.18 q/ha). The bio-agent (*Trichoderma harzianum*) and cultural practices alone and other different possible combinations were less effective in managing the fusarium wilt disease of tomato. In accordance with our results, Quadri *et al*. (1982) [3] reported that difolatan (0.2%), Thiram (0.2%) carbendazim (0.2%) and mancozeb (0.2) were effective against *Fusarium oxysporium f.sp. lycopersici* causing wilt of tomato. Etenbarian (1992) [9], Singh *et al*. (1993) [11], Narnawar and Kalekar (1997) [12] reported that carbendazim was effective against tomato wilt caused by *Fusarium oxysporium f. sp. lycopersici.* Poddar *et al*. (2004) found that use of systemic fungicides viz. carbendazim, Propiconazole, thiophanate methyl and Tubeconazole was effective against *Fusarium oxysporium* in chickpea. Similar finding was also reported by Amin *et al* (2010) [19], Maria *et al* (2015) and Al-Saeedi SS. and Al-Ani B M (2015)

The results of the experiments from the three years data clearly indicated that seedling treatment with carbendazim @ 0.1% for thirty minutes before transplanting + soil drenching with carbendazim @ 0.1% solution three times at 15 days interval, started with age of 25days after transplanting is very effective in reducing the tomato wilt disease severity, thereby increasing fruit yield. Similar views were put forth by several other workers (Etabarian 1992, Singh *et al*., 1993 and Poddar *et al.,* 2004**)** [9, 11, 15].

Table 1: Tomato wilt disease intensity and yield as affected by various treatments and its combinations (Pooled data of three years)

Treatments	Wilt Intensity (%)	Yield (q / ha)
T1 - FYM @ 30 ton / ha,	35.94	72.26
T2 - Seedling treatment with carbendazim @ 0.1%	33.47	75.88
T3 - Soil drenching with carbendazim @ 0.1% three times at 15 days interval starting at 21 days after transplanting	26.62	89.89
T4 - Soil drenching with carbendazim @ 0.1% two times at 15 days interval starting at 21 days of transplanting	27.73	88.61
T5 - Seed treatment with *Trichoderma harzianum* @ 5 g / Kg of seed	29.25	84.11
T6 - Soil drenching with *T. harzianum* @ 5 g / lit two times at 15 days interval	31.10	75.67

starting at 21 days after transplanting		
T7 - $T_1 + T_4$	25.33	92.35
T8 - $T_1 + T_5$	31.14	79.08
T9 - $T_2 + T_3$	11.33	133.65
T10 - $T_2 + T_4$	13.69	119.95
T11 - $T_1 + T_4 + T_6$	20.62	99.71
T12 - $T_2 + T_4 + T_6$	17.44	115.01
T13 - $T_1 + T_2 + T_4 + T_6$	14.60	118.18
T14 - $T_1 + T_2 + T_5 + T_6$	21.83	95.75
T15 - Check	38.11	69.75
CD at 5%	0.87	3.79

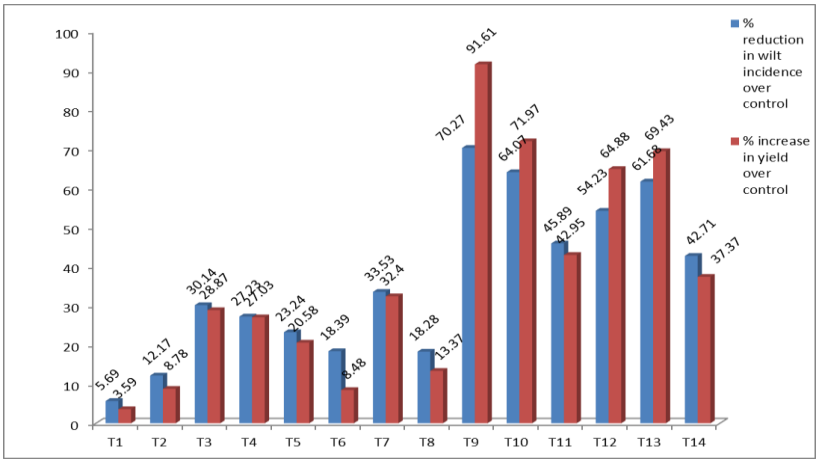

Fig 1: Per cent reduction in wilt incidence and per cent increase in yield over control (calculated on the basis of three years pooled data)

4. Conclusion

Seedling treatment with Carbendazim @ 0.1% + soil drenching with Carbendazim @ 0.1% (thrice) at every fortnight interval significantly lowered the disease intensity (11.33%). The reduction in disease severity over control in this treatment was 70.27%. Consequently, the fruit yield in tomato was 133.65 q/ha, recording a percent increase of 91.61% over control. This may be an effective module for the integrated management of tomato wilt.

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