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Original Research Article

Field Evaluation of Different Seed Treatments for the Management of Early Blight and Fusarium Wilt of Tomato (*Solanum lycopersicum* Mill.)

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A B S T R A C T

Tomato (*Solanum lycopersicum* Mill.) is one of the most popular vegetable crops grown in the world. Many of the tomato diseases are seed borne in nature, among these early blight and fusarium wilt are economically important diseases and affecting both quality and quantity of the seed and reduction of fruit yield under field level. These diseases can be managed by different strategies like fungicides, bioagents and bioprimings. Seed treatment with seed dressing fungicides like carbendazim + mancozeb (Sprint) along with foliar spray of hexaconazole was found to be most effective as it exhibited maximum benefit cost ratio for the management of both early blight and fusarium wilt. Among bioagents, *Pseudomonas fluorescens*+ foliar spray with hexaconazole was found effective for control of these diseases. Seed treatment with bioagent along with priming agent (*i.e.* biopriming) like, Jelly + *Pseudomonas fluorescens*+ foliar spray with hexaconazole (0.1%) was found to be effective for the control of both fusarium wilt as well as early blight of tomato. Foliar spray with hexaconazole (0.1%) alone was found inferior compared to seed treatment along with foliar spray, indicating the efficacy of seed treatment along with foliar spray for the management of these diseases.

Keywords

Bioagents, Biopriming, Fungicides, Seed-borne, Tomato

Introduction

Several diseases affecting tomato and many of them are seed-borne in nature such as early blight and Fusarium wilt is economically important seed-borne diseases. Tomato is the most popular vegetable crop grown in the world, crop offers significant nutritional advantages, as it contains significant source of dietary lycopene, β-carotene, vitamin C and antioxidant properties in a low energy dense food (Britt and Kristin, 2011). At present, the total tomato cultivation is 46.16 lakh hectares in the world with the production of 1279.93 lakh tonnes (Anon., 2015). In India, area under cultivation is 7.77 lakh hectares with the production of 182.86 lakh tonnes (Anon., 2015). In Karnataka, tomato with a production of 20.34 lakh tonnes (Anon., 2015).

Seed-borne infections or infected seed is very important discouraging factor, which possess a serious problem in seed certification. Although infected seeds which may otherwise be viable with prescribed germinability as per certification standards, may not be acceptable as seed because of poor physical appearance, high incidence of seed-borne fungi and mycotoxin such as aflatoxin. Fungal pathogens may be externally or internally seed-borne, extra- or intra-embryal, or associated with the seeds as contaminants (Singh and Mathur, 2004).These seed-borne diseases lead to cause heavy reduction in fruit yield. The infected seeds may fail to germinate, or transmit disease from seed to seedling and/or from seedling to growing plant. Thus, the disease control programme is important at each stage of growth. Seed treatment with bio-control agents along with priming agents may serve as an important means of managing many of the soil and seed-borne diseases, the process often known as 'bio-priming". The bio-priming seed treatment developed for control of *Pythium* seed rot of sweet corn (Callan *et al*., 1990). The priming agents along with bioagents can protect the seeds from biotic as well as abiotic stresses like moisture stress and thereby they can protect the seeds and the seedlings for extended periods. Good seed is a basic input in agricultural production. Successful agriculture depends on quality of seed used for sowing. Thus the seed producer holds a greater responsibility in producing genetically pure but viable seed, besides preserving its quality from harvest to next one or two planting seasons. Hence there is a need to screen the new and the available seed dressing molecules including fungicides, bio agents and bio agents along with priming agents for their efficacy in overcoming the seed-borne fungal infections in tomato.

Materials and Methods

An experiment was conducted during *Rabi* 2015-2016 at Bailhongal in the farmer′s field. Two best seed dressing fungicides, bioagent and biopriming agents were selected for the management of seed-borne fungal diseases of tomato. Tomato variety PKM-1 was used for the study. Seedlings were transplanted after 25 days after sowing (DAS) to the main field and common foliar spray of hexaconazole @ 0.1% at 45DAS was given to all the treatments except control.

Seed treatment with fungicides

Seeds were treated with fungicides by following dry seed treatment at 0.3 per cent concentration of the fungicide was prepared and treated with seeds by sprinkling the water. Then the seeds were dried under shade after that seed are used for the study.

Bioagents

The powder formulations of antagonists' *viz.*, *Trichoderma harzianum* Rifai, *Pseudomonas fluorescens* Migula, bioagents were pacured from IOF ((Institute of Organic Farming), UAS, Dharwad. Seeds of moderately infected tomato variety PKM-1 were treated with these bioagents at the rate 0.8 per cent concentrations. The seeds were shaken along with bioagents for 20 minutes in mechanical shaker for uniform application and then stored in separate boxes for 24 hours. The treated seeds were used for an experiment.

Bio-priming

In bio-priming, two grams of tomato seeds were treated with bacterial bio-control agent *Pseudomonas fluorescens* with priming agentof coco peat. Same treatment was followed for fungal biocontrol agent *Trichoderma harzianum.* After pre-soaking of seeds in sterile distilled water, seeds were coated with powder formulations of *P. fluorescens and T. harzianum.*at 0.8 per cent concentration along with moist coco peat in the proportion of 2:1 (2 parts of coco peat and 1 part of seed) and mixed thoroughly to give uniform coating. These seeds were dried in shade and stored at 25± 2°C for 24 h in a self– sealing plastic bags. The treated seeds were used for study.

For bio-priming in jelly, (a commercial preparation containing water absorbent organic polymer which absorbs, stores and then keeps releasing the moisture slowly). 10 g of jelly was poured into 500ml of cold sterilized water and kept in water 5 to 6 hours till the small pieces turned into sparkling jelly cubes. After pre-soaking of seeds in sterilized water, seeds were coated with powder formulations of *P. fluorescens* and *T. harzianum* at 0.8 per cent concentration along with the jelly cubes in 2:1 proportion as stated earlier. Such treated seeds were tested against seed-borne fungi of tomato.

Design and layout

The experiment was laid out in randomized block design (RBD) with three replications. The treatments were randomly allotted to the plots.

Plot size : 3.6 × 6 m
Treatments : 8
Spacing : 60×45 cm
Variety : PKM-1

Treatments details

T_1 – ST with carbendazim + mancozeb @ 0.3% + Hexaconazole @ 0.1% spray
T_2–ST with carboxin + thiram @ @ 0.3% + Hexaconazole @ 0.1% spray
T_3 – ST with *Trichodermaharzianum*@ 0.8% + Hexaconazole @ 0.1% spray
T_4 - ST with *Pseudomonas fluorescens*@ 0.8% + Hexaconazole @ 0.1% spray
T_5 – ST with Jelly + *Pseudomonas fluorescens* @ 0.8% + Hexaconazole @ 0.1% spray
T_6 – ST with coco peat + *Trichoderma harzianum* @ 0.8% + Hexaconazole @ 0.1% spray
T_7 – Hexaconazole @ 0.1% spray alone
T_8 – Control
(ST = Seed treatment)

Observations were recorded after 45DAS, 60DAS and 90DAS, per cent disease index of early blight and wilt incidence

Alternaria leaf spot (early blight)

0-5 disease rating scale (Mayee and Datar, 1986)

Scale	Description
0	No symptoms on the leaf
1	0-5 per cent leaf area infected and covered by spot, no spot on petiole and branches
2	6-20 per cent leaf area infected and covered by spot, some spots on petiole
3	21-40 per cent leaf area infected and covered by spot, spots also seen on petiole, branches
4	41-70 per cent leaf area infected and covered by spot, spots also seen on petiole, braches, stem
5	>71 per cent leaf area infected and covered by spot, spots also seen on petiole, branch, stem, and fruit.

Further, the PDI was calculated with the above scales using the formula given by Wheeler (1969).

$$\text{Per cent disease index (PDI)} = \frac{\text{Sum of the individual disease ratings}}{\text{Number of leaves observed}} \times \frac{100}{\text{Maximum disease grade}}$$

$$\text{Wilt incidence} = \frac{\text{No of wilted plants in a microplot}}{\text{Total no of plants in a microplot}} \times 100$$

Yield

Crop was harvested at fruit ripening stage from randomly selected 5 plants from each replication and after harvest fruit weight of each plant in kilograms were recorded and yield per each treatment from each replication of 4 pickings in kilograms were recorded. Yield per hectare was computed by using net plot yield data and it was then converted to tonnes per hectare.

Benefit cost ratio (B:C ratio)

Total cost (Rs. ha^{-1}) incurred for the application of each treatment including cost of cultivation, cost of chemicals and labour was worked out. Gross return (Rs. ha^{-1}) was calculated on the basis of market price of the produce during harvest period. Net returns (Rs. ha^{-1}) were calculated by deducting the total cost (Rs. ha^{-1}) from the gross return (Rs. ha^{-1}). Benefit cost ratio was calculated by using the formula.

$$\text{B:C ratio} = \frac{\text{Net returns (Rs. ha}^{-1}\text{)}}{\text{Total cost (Rs. ha}^{-1}\text{)}}$$

Results and Discussion

A field experiment was conducted during *Rabi* season 2015-16 at the farmer′s field in Bailhongal (of Belagavi districts) to assess the efficacy of fungicides, bioagents and bioagent with priming agent (biopriming) as seed dresser against seed-borne fungal diseases of tomato. Variety PKM-1 is used for the study. Observations were recorded on per cent disease index of early blight, per cent disease incidence of wilt and yield. Results are presented in Table 1.

In case of *Fusarium* wilt seed treatment with carbendazim + mancozeb (Sprint) @ 0.3% + foliar spray with hexaconazole @ 0.1% was found to be on par with seed treatment with carboxin + thiram (Vitavax Power) @ 0.3% + foliar spray with hexaconazole (0.1%) with respect to per cent disease incidence at 45 days (8.24% and 9.17%), 60days (10.18% and 11.23%), 90 days (15.11% and 15,74%) and fruit yield (20.74 and 19.26t/ha). In case of earlyblight seed treatment with carbendazim + mancozeb (Sprint) @ 0.3% + foliar spray with hexaconazole @ 0.1% was found to be on par with seed treatment with carboxin + thiram (Vitavax Power) @ 0.3% + foliar spray with hexaconazole (0.1%) with respect to per cent disease index at 45 days (9.97% and 10.73%), 60days (12.73% and 13.07%), 90 days (16.13% and 17.23%) and fruit yield (20.74 and 19.26t/ha).

With respect to benefit cost ratio seed treatment with carbendazim + mancozeb (Sprint) @ 0.3% + foliar spray with hexaconazole (0.1%) exhibited maximum benefit cost ratio (3.39). Hence this treatment is considered as effective for the management of Fusarium wilt and early blight of tomato. Similar results were obtained by Singh *et al*. (2000) they reported that the seed treatment of tomato variety Pusa Ruby with seed dressing fungicides, carbedazim, vitavax, thiram, and carbendazim + mancozeb at 0.2 per cent concentration significantly reduced the incidence of early blight caused by *Alternaria solani* and increased the fruit yield.

Thippeswamy *et al.*, (2006) suggested that among all the fungicides, seed treatment with Mancozeb, Carbendazim and Captaf at 0.20 per cent concentration was effective against *Phomopsis* blight and leaf spot in brinjal caused by *Phomopsis vexans* and *Alternaria solani*.

Table.1 Field evaluation of different seed treatments for the management of early blight and Fusarium with of tomato

Sl. No.	Treatments	Fusarium wilt incidence (%)			Early blight (PDI)			Fruit yield (t/ha)	B:C ratio
		45 DAS	60 DAS	90DAS	45 DAS	60 DAS	90DAS		
1	Seed treatment with Carbendazim + mancozeb @ 0.3% + Hexaconazole @ 0.1% spray	8.24 (16.65) *	10.18 (18.60)	15.11 (22.87)	9.97 (18.34)	12.73 (20.85)	16.13 (23.64)	20.74	3.39
2	ST with Carboxin + thiram @ 0.3% + Hexaconazole @ 0.1% spray	9.17 (17.62)	11.23 (19.57)	15.74 (23.36)	10.73 (19.04)	13.07 (21.15)	17.23 (24.47)	19.26	3.15
3	ST with *Trichodermaharzianum*@ 0.8% + Hexaconazole @ 0.1% spray	14.96 (22.75)	19.65 (26.31)	24.24 (29.49)	18.07 (25.15)	20.03 (26.59)	26.53 (31.00)	14.59	2.39
4	ST with *Pseudomonas fluorescens*@ 0.8% + Hexaconazole @ 0.1% spray	13.60 (21.63)	17.19 (24.49)	22.06 (28.00)	17.13 (24.45)	18.43 (25.43)	24.17 (29.44)	15.04	2.46
5	ST with Jelly +*P. fluorescens*@ 0.8% +Hexaconazole @ 0.1% spray	11.11 (19.47)	13.33 (21.41)	18.26 (25.30)	14.90 (22.71)	15.03 (22.78)	20.07 (26.61)	17.78	2.91
6	ST with Coco peat +*T.harzianum*@ 0.8% +Hexaconazole @ 0.1% spray	11.38 (19.71)	14.04 (22.00)	19.44 (26.17)	13.27 (21.36)	15.23 (22.97)	19.17 (25.90)	17.04	2.79
7	Hexaconazole @ 0.1% alone	18.04 (25.13)	21.05 (27.30)	28.33 (32.13)	19.57 (26.25)	21.10 (27.34)	29.13 (32.67)	12.00	1.96
8	Control	18.98 (25.83)	21.75 (27.77)	28.44 (32.23)	22.20 (28.11)	24.20 (29.45)	34.57 (36.01)	10.37	1.70
S.Em±		**0.42**	**0.50**	**0.51**	**0.73**	**0.64**	**0.80**	**0.86**	
CD at 5%		**1.29**	**1.53**	**1.56**	**2.20**	**1.94**	**2.41**	**2.61**	

*Figures in parentheses indicate arcsine transformed values DAS - days after sowing PDI – Per cent Disease Index

Among the bioagents, *Pseudomonas fluorescens@* 0.8 per cent + foliar spray with hexaconazole (0.1%) and *Trichoderma harzianum@* 0.8 per cent + foliar spray with hexaconazole (0.1%) was found to be on par with respect to per cent disease incidence at 45days (13.60 and 14.96%) and 90dasy (22.06 and 24.24 %) in case of wilt incident. With respect to per cent disease incidence these treatments were found to be on par at 45days, 60days, 90dasy and fruit yield. Seed treatment with *Pseudomonas fluorescens@* 0.8 per cent + foliar spray with hexaconazole (0.1%) considered to be effective for the control of tomato diseases has it exhibited higher benefit cost ratio (2.46).Similar results were obtained by Vandna and Priya (2014) studied the efficiency of *Trichoderma harzianum* as seed treatment against wilt disease of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici* showed maximum seed germination (78.33%) and disease control (66.53%).

Seed treatment with Jelly + *Pseudomonas fluorescens* @ 0.8 per cent + foliar spray with hexaconazole (0.1%) were found to be effective for the control of Fusarium wilt and early blight even though it found to be on par with seed treatment with coco peat +*Trichoderma harzianum@* 0.8 per cent + foliar spray with hexaconazole (0.1%) because itrecorded maximum benefit cost ratio.Seed treatment with bioagents alone (without priming agent) were found inferior, seed treatment with bioagents along with priming agent with reference to per cent wilt incidence, early blight index and fruit yield clearly indicate the significance of priming agent along with bioagent. The successe of biocontrol dependence on the survival of bioagents under varied climatic conditions. Similar observation was made by Ravindra *et al.,* (2014) evaluate the effect of bio priming with bacterial strains of *Enterobacter* spp. on seed germination and seedling growth of tomato. Ananthi *et al.,* (2014) reported increased efficacy of biocontrol agents along with priming agent.

Results of this field trail clearly indicated the significance of seed treatment along with foliar spray for the management of diseases like early blight and Fusarium wilt. Foliar spray with hexaconazole (0.1%) alone was found inferior compared to seed treatment + foliar spray indicating the efficacy of seed treatment + foliar spray for the management of such diseases for which the primary source comes from seed and soil and secondary spread of inoculum takes place by air. Foliar spray with hexaconazole (0.1%) cannot control fusarium wilt as the pathogen is soil and seed-borne in nature.

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