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Field evaluation of different fungicides, bio-agent and botanical against early blight of tomato caused by *Alternaria solani*

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Abstract

Tomato is a major horticultural crop in India and particularly in the state of Odisha, which is of prime economic and nutritional importance. Despite its economic significance, tomato cultivation is greatly constrained by early blight, caused by *Alternaria solani* which poses a major challenge in the West Central Table Land Zone of Odisha. Therefore, a field experiment was conducted to know the efficacy of different fungicides, bio-agent and botanical against early blight of tomato caused by *Alternaria solani* under field condition. Among all the treatments, it was found that difenoconazole recorded the lowest disease severity (14.23%) and highest fruit yield (225.10 q/ha), followed by tebuconazole and hexaconazole. *Trichoderma viride* was found least effective in reducing disease severity as well as increasing fruit yield of tomato. Economic analysis showed that difenoconazole yielded the highest benefit-cost ratio (3.68), followed by tebuconazole and hexaconazole.

Keywords: Early blight, *Alternaria solani*, fungicides, bio-agent, botanical, management

Introduction

Tomato (*Solanum lycopersicum*) constitutes one of India's commercially rewarding vegetable crops of major significance. It belongs to the family *Solanaceae*. In India, the tomato is often called "poor man's orange" or *Vilayati Baigan*. Introduced in the early 19th century, it is now the world's third most cultivated vegetable after potato and sweet potato. Widely recognized as a protective food, the tomato is packed with essential nutrients, including minerals, vitamins, organic acids and health-promoting compounds like lycopene, beta-carotene, phenols and flavonoids. Lycopene, in particular, functions as a potent antioxidant associated with a lowered risk of cardiovascular diseases and certain cancers.

In the year 2023–24, India recorded a total tomato production of 21.32 million tonnes cultivated over an area of 854 thousand hectares, resulting in an average productivity of approximately 24.96 tonnes per hectare. (Anonymous, 2024) ^[2]. In 2023–24, Madhya Pradesh recorded the largest tomato-cultivated area at 119.67 '000 ha, followed by Odisha (98.13 '000 ha), Gujarat (66.57 '000 ha), Bihar (63.20 '000 ha) and Karnataka (62.43 '000 ha). Among the major tomato-producing states in India, Odisha ranked fifth, contributing significantly to the national output.

The pathogen responsible for tomato early blight, *Alternaria solani*, was first identified and described by Ellis and Martin (1882). The pathogen survives on infected plant debris (leaves, stems) and soil, and its spores germinate on crop residue or active lesions. The disease spreads through several means—splashing rain, air currents, wind-blown soil particles and irrigation water (Maurya *et al.*, 2022) ^[7]. The disease is particularly aggressive during the fruiting stage of the crop (Chohan *et al.*, 2015) ^[4].

Tomato crops are highly susceptible to various diseases caused by fungal, bacterial, viral, nematode and abiotic factors. Important fungal diseases include late blight (*Phytophthora infestans*), fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*) and septoria leaf spot (*Septoria lycopersici*). Among the various fungal infections affecting tomato crops, early blight stands out as a major concern. The disease is incited by *Alternaria solani* (Ellis and Martin) Jones and Grout, posing a major constraint to tomato production by substantially reducing both yield and

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fruit quality. The disease can affect the crop at any stage of its growth, making it a persistent and challenging threat (Abada *et al.*, 2008) ^[1]. Dense plantings, frequent rains, and long periods of leaf wetness favor epidemics. (Gondal *et al.*, 2012) ^[6]. According to Parvin *et al.* (2021) ^[10], the disease can reduce yield by 50 to 86% and hinder seedling establishment by 20 to 40%. The effective management of early blight disease is crucial to ensure sustainable tomato production in Western Odisha. Fungicides used at present are very costly and are not controlling the disease satisfactorily. Hence, it is necessary to evaluate new fungicides in the field to combat the disease satisfactorily. There is lack of information on the impact of bio-agents and plant products against the pathogen and it is necessary to identify a suitable bio-agent and plant product to prevent health hazards due to fungal toxicants. Therefore, the present work was designed to manage the disease using different fungicides, bio-agent and botanical under field condition in Western Odisha.

Materials and Methods

A field experiment was undertaken during Rabi, 2024–25, at the College of Agriculture, Chiplima, to evaluate the efficacy of different fungicides, bio-agent and botanical against early blight of tomato. The experiment was laid out in a randomized block design with nine treatments and three replications. The variety used was Pusa Rubi. The different treatments used were as follows:

- T₁ – 2 sprays of multineem @ 0.5%
- T₂ – Soil application of *Trichoderma viride* @ 2.5 kg/ha
- T₃ – 2 sprays of tebuconazole @ 0.1%
- T₄ – 2 sprays of difenoconazole @ 0.1%
- T₅ – 2 sprays of carbendazim 12% + mancozeb 63% @ 0.2%
- T₆ – 2 sprays of mancozeb @ 0.3%
- T₇ – 2 sprays of copper oxychloride @ 0.3%
- T₈ – 2 sprays of hexaconazole @ 0.1%
- T₉ – Untreated control.

Twenty one days old tomato seedlings were transplanted into the main field during November 2024, maintaining a spacing of 60 × 45 cm. Recommended doses of fertilizer were applied in each plot and standard agronomic practices were followed to raise the crop. After initiation of the disease, the first spray was applied on the foliage. Two sprayings of each fungicide and botanical were applied at 15-day intervals. *Trichoderma viride* was applied in the soil. Disease intensity was assessed using the 0–5 scale (0= No disease in the foliage, 1= Small irregular spots covering less than 5% leaf area, 2= Small irregular spots covering 5.1 to 10% leaf area, 3= lesions covering 10.1 to 25% leaf area, 4= lesions covering 25.1 to 50% leaf area, 5= lesions covering more than 50% leaf area) proposed by (Mayee and Datar, 1986) ^[8]. Yield data were also collected and all observations were subjected to statistical analysis.

Disease severity was calculated by using the following formula (Chester, 1959; Wheeler, 1969) ^[3,12]

$$PDI = \frac{\text{Sum of individual ratings}}{\text{Number of leaves assessed} \times \text{maximum disease grade value}} \times 100$$

Results and Discussion

A field experiment was carried out during Rabi, 2024–25, at the College of Agriculture, Chiplima, to evaluate the efficacy of different fungicides, bio-agent and botanical against early blight disease of tomato. The data pertaining to disease severity and

yield were recorded and presented in Table 1. The data revealed that all the treatments tested were effective in reducing the severity of early blight disease compared to the untreated control. Among the different fungicides evaluated, difenoconazole 25% EC recorded the lowest PDI of 14.23%, resulting in a maximum disease reduction of 77.34% over the control. This was followed by the fungicide tebuconazole, which also performed well in reducing disease severity with a PDI of 18.10% and 71.18% disease reduction over control. Similarly, plots sprayed with hexaconazole 5% SC showed good results, recording a PDI of 23.20% with 63.06% disease reduction over control. Moderate control was observed with carbendazim 12% + mancozeb 63% WP and mancozeb 75% WP, which recorded PDI values of 28.30% and 32.10%, respectively. Treatments with copper oxychloride gave a PDI of 38.30%. However, the botanical and biological treatments, Multineem (neem oil-based EC) and *Trichoderma viride* 1.5% WP, were comparatively less effective in controlling early blight disease under field conditions, showing higher PDI values of 44.50% and 48.20%, respectively.

Data on effect of different fungicides, bio-agent and botanical on fruit yield of tomato were recorded and presented in Table 1. There has been a significant increase in fruit yield of tomato in all treatments over the control. Plots treated with difenoconazole recorded the highest yield of 225.10 q/ha, which was 87.27% greater than that of the untreated control (120.20 q/ha). This was followed by tebuconazole (210.20 q/ha) and hexaconazole (200.30 q/ha), which showed yield increases of 74.87% and 66.63%, respectively, over control. Carbendazim 12% + mancozeb 63% WP and mancozeb 75% WP also gave good yields of 194.50 q/ha and 188.60 q/ha. On the other hand, the botanical Multineem and the bioagent *Trichoderma viride* recorded comparatively lower yields of 162.20 q/ha and 155.40 q/ha, respectively.

An economic analysis of the benefit–cost ratio for different fungicides, botanical and bio-agent is presented in Table 2. The analysis highlights pronounced differences in profitability among the treatments. Difenoconazole 25% EC delivered the best overall returns, generating a gross income of Rs. 2,25,100, a net income of Rs. 1, 63,964 and the highest B:C ratio of 3.68. This was followed by tebuconazole 25.9 EC, which produced a gross income of Rs. 2,10,200, net returns of Rs. 1,48,200 and a B:C ratio of 3.39. The systemic fungicide hexaconazole 5% SC also performed well, with gross and net incomes of Rs 2,00,300 and Rs. 1,38,504, respectively, yielding a B:C of 3.24. The botanical Multineem and the bio-agent *Trichoderma viride* were less lucrative, with B: C ratios of 2.61 and 2.49, respectively. The untreated control recorded the lowest net return (Rs. 50,721) and the poorest B: C ratio of 1.73.

Our results are in line with the findings of Nagesh, *et al.* (2019) ^[9] who reported that difenoconazole was the most effective fungicide for managing early blight and boosting tomato yield followed by tebuconazole under field condition. Sreenivasulu *et al.* (2019) ^[11] also found that tebuconazole was most effective fungicide in reducing disease severity against early blight of tomato and increasing yield under field condition. Even though *T. viride* and Multineem were found to be less effective in managing early blight, they may play a valuable role in integrated disease management of the disease. Therefore, biological agents and botanicals need to be tried on a larger scale to manage the disease and then recommended to the farmers.

Table 1: Management of early blight of tomato with fungicides, bio-agent and botanical under field conditions

Tr. No.	Trade Name	Chemical Name	Type	PDI (%)	Percent Incidence Reduction Over Control (%)	Yield (q/ha)	Percent Yield Increase Over Control (%)
T ₁	Multineem	Neem oil-Based EC containing 0.03% azadirachtin	Non-systemic (botanical biopesticide)	44.50 (41.84)**	29.15	162.20	34.94
T ₂	Nisarga (Multiplex)	<i>Trichoderma viride</i> – 1.5% WP	Biological (biopesticide)	48.20 (43.96)	23.26	155.40	29.28
T ₃	Folicur	Tebuconazole 25.9 EC	Combination (systemic)	18.10 (25.18)	71.18	210.20	74.87
T ₄	Score	Difenoconazole 25% EC	Systemic	14.23 (22.16)	77.34	225.10	87.27
T ₅	Saaf	Carbendazim 12% + mancozeb 63% WP	Combination (systemic/contact)	28.30 (32.14)	54.94	194.50	61.81
T ₆	Dhanuka M-45	Mancozeb 75% WP	Non-systemic (contact)	32.10 (34.51)	48.89	188.60	56.90
T ₇	Blitox	Copper oxychloride 50% WP	Non-systemic (contact)	38.30 (38.23)	39.02	176.30	46.67
T ₈	Hitazol	Hexaconazole 5% SC	Systemic	23.20 (28.79)	63.06	200.30	66.63
T ₉	Control	—	Untreated	62.81 (52.41)	—	120.20	—
	S.E.m. ±			1.13		1.81	
	C.D. (0.05)			3.39		5.45	

** Figures in parentheses are arcsine transformed values

Table 2: Economics of different treatments for management of early blight of tomato

Treatment No.	Treatment Name	Yield (q/ha)	Gross Income (Rs.)	Cost of Cultivation (Rs.)	Net Income (Rs.)	B:C Ratio
T ₁	Multineem	162.2	162200	62127	100073	2.61
T ₂	<i>Trichoderma viride</i>	155.4	155400	62370	93030	2.49
T ₃	Tebuconazole	210.2	210200	62000	148200	3.39
T ₄	Difenoconazole	225.1	225100	61136	163964	3.68
T ₅	Carbendazim + mancozeb	194.5	194500	61580	132920	3.16
T ₆	Mancozeb	188.6	188600	61234	127366	3.08
T ₇	Copper oxychloride	176.3	176300	61613	114687	2.86
T ₈	Hexaconazole	200.3	200300	61796	138504	3.24
T ₉	Control	120.2	120200	69479	50721	1.73

Conclusion

The overall findings of the study clearly indicated that difenoconazole was the most effective fungicide both in terms of disease management and economic return, followed by tebuconazole and hexaconazole. Even though, botanical and bio-agent were not much effective in reducing disease severity as compare to fungicidal treatment, but they performed better in reducing disease severity as compare to control.

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