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Research Article

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Integrated Management of Alternaria Leaf Spot of Cabbage Caused by *Alternaria brassicicola*

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ABSTRACT

Alternaria leaf spot of cabbage caused by Alternaria brassicicola is one of the most destructive disease of cabbage (Brassica oleracea var. capitata) causing both quantitative as well as qualitative losses all over the kerala. The disease is difficult to manage alone with fungicides or bioagents. Hence the present study was undertaken to manage the disease effectively by utilization of fungicides, bioagents and their combinations. The results from in vivo assay showed that lowest per cent disease index was recorded with the treatment hexaconazole + B. subtilis (10.8%) and the disease suppression over control was 79.4%. This was followed by hexaconazole (16.6%) which was on par with tebuconazole (18.3%) and propiconazole (19.1%). Maximum yield was recorded with the treatment hexaconazole + B. subtilis (0.58 kg/plant) followed by hexaconazole (0.54 kg/plant), tebuconazole (0.52 kg/plant) and propiconazole (0.48 kg/plant).

Key words: *Alternaria, Tebuconazole, Propiconazole, Hexaconazole,*

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) is an economically important vegetable crop belongs to the family Brassicaceae. The total production of cabbage in the world is 73.6 million tonnes. In Kerala, cabbage is grown in an area of 197 ha and major cultivated regions were Idukki and Wayanad districts. Cabbage production is affected by many fungal, bacterial and viral diseases at different stages of growth and development. Among fungal diseases, Alternaria leaf spot of cabbage caused by *A. brassicicola* is a widespread disease affecting the yield of cabbage worldwide[8].

During recent years, most of the research was done on chemicals thus developed fungicides which are target specific with new site of action, easily degradable and can be used at lower concentrations, thereby reduces the residue level of these fungicides and are also environmentally safe. Leaf being the economic part, usage of these new generation fungicides and bioagents will provide good management strategy and also prevents residual effect and the fungicidal resistance.

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In the present study, new generation fungicides, biocontrol agents and their effective combinations were screened to provide an integrated management strategy against Alternaria leaf spot of cabbage. Meena *et al*.[11] reported that foliar spray of *T. viride* (45 DAS) had good effect against Alternaria blight in mustard. Field tests were conducted by Ramegowda *et al*. with two bioagents and the per cent disease suppression over control recorded after second spray was 41.9% with *T. viride* and 37.5% with *T. harzianum*. Kumar *et al*.[9] tested the efficacy of fungicides and bioagents against *A. alternata* and observed that lowest PDI was recorded with hexaconazole (0.1%) was 12.81% and benefit cost ratio was 1:7.16. Mishra *et al*.[12] conducted a field trial with fungicides and bioagents against *A. brassicae* and percentage disease suppression over control recorded after 2 weeks of application of *T. harzianum* was 34.57%.

Sharma *et al*.[18] stated that hexaconazole (0.1%) was effective against *A. burnsii* as the percentage disease suppression over control (52.5%) and yield (6.4 q/ha) was high with this treatment. Shikha and Pandey[19] found that foliar spray of tebuconazole at 0.05% concentration reduced the incidence of Alternaria blight of cumin by 71.9% under field conditions.

Rai *et al*.[14] conducted an field study during two seasons to control *A. brassicae* and reported that the per cent disease reduction with two treatments viz., seed treatment with *T. harzianum* + foliar spray of *P. fluorescens*, seed treatment and foliar spray with *T. harzianum* was 28% and 26.9% respectively. Chavan *et al*.[2] conducted a pot culture experiment with eight treatments against *A. brassicae* and revealed that the maximum disease reduction was recorded with hexaconazole (64.11%) and propiconazole (59.02%). Among bioagents, the disease reduction with *T. viride* and *T. harzianum* was 37.7% and 31.3% respectively. Dabbas and Kumar[4] evaluated the efficacy of fungicides and bioagents in field trial to control Alternaria blight of cabbage and observed that maximum and minimum disease reduction was recorded with acrobat + mancozeb and *T. viride* which was 67.8%, 13.5% respectively.

A field trail was conducted by Chohan *et al*.[3] with five treatments to control *A. solani* and reported that *T. viride* and *T. harzianum* recorded 42.7%, 52.6% disease reduction respectively at spray concentration of 10^8 conidia/ml. The per cent disease index recorded with *T. harzianum* against *A. brassicae* was 41.13% after two weeks of spraying[1].

Khalse *et al*.[7] conducted field trial with fungicides and bioagents to control Alternaria leaf spot of cabbage and observed that disease reduction at 15 days after foliar spray of propiconazole (0.05%) and *T. harzianum* (2%) was 35.8% and 18.3% respectively. Sailaja *et al*.[15] reported that the percentage disease reduction over control recorded with treatments propiconazole and *T. harzianum* against *A. brassicae* was 30.3% and 11.5% respectively.

MATERIAL AND METHODS

a) Integrated management of Alternaria leaf spot of cabbage in field conditions

A pot culture experiment was conducted to determine the efficiency of fungicides, bioagents and their combination against Alternaria leaf spot of cabbage in the Department of Plant Pathology. Cabbage variety selected for the pot culture experiment was NS – 183. The cabbage seeds of this variety were grown in pot trays which is filled with potting mixture. When the seedlings attained three to four leaf stage, they were transplanted to the main pot filled with potting mixture. The potting mixture in the main pot was of sand, soil and dried powdered cow dung in 1:1:1 ratio. The plants were maintained as per Package of Practice Recommendations of KAU[6] to attain proper growth of the plant.

The design followed for conducting this experiment was completely randomised design. Three replications were maintained for each treatment and each pot consists of only one plant. The virulent leaf spot pathogen was

multiplied in the potato dextrose broth. For this, potato dextrose broth was prepared in conical flasks and sterilized. Five mm mycelial disc cuts were taken with the help of cork borer from seven days old culture pathogen and transferred to the potato dextrose broth under aseptic conditions. These flasks were plugged with cotton and incubated at room temperature.

The mycelial mats of the pathogen were harvested from the potato dextrose broth flasks which were kept for incubation. In order to apply the inoculum of pathogen on cabbage, the harvested mycelial mats were mixed with sterile distilled water and homogenised in a blender for one minute. Then inoculum was filtered through two layered muslin cloth. The filtered inoculum was diluted with sterile distilled water and adjusted the concentration as 10^6 conidia per ml. Then this inoculum was sprayed on healthy plants of cabbage using a hand sprayer[5].

Selected treatments were applied as a foliar spray at 15 days interval on the cabbage plants one week after artificial inoculation of the pathogen. Intensity of the disease was determined for all the treatments based on the score chart mentioned in table 1.

Table 1: Score chart to calculate Percent disease index[16]

Score	Percentage area of leaf infected
0	No infection on leaves
1	< 5% leaf area infected
2	5 - 10% leaf area infected
3	10 - 25% leaf area infected
4	25 - 50% leaf area infected
5	>50% leaf area infected

b) Per cent Disease Index

After application of the inoculum and selected treatments over cabbage plants the disease intensity was observed using score chart as mentioned in 3.1 and assessed per cent disease index at ten days intervals by using formula[10].

c) Yield

The yield obtained from each plants in the treatments were individually observed and recorded.

RESULTS AND DISCUSSION

a) Integrated management of alternaria leaf spot of cabbage in field conditions

A pot culture experiment was undertaken with effective fungicides, bioagents and their combination to manage the Alternaria leaf spot of cabbage. The variety of cabbage used for this pot culture study was NS 183.

b) Per cent Disease Index

Effective treatments selected from *in vitro* studies include three fungicides viz., propiconazole, hexaconazole, tebuconazole; three bioagents viz., *T. viride*, *T. harzianum*, *B. subtilis*; one combination hexaconazole + *B. subtilis*. All these treatments were applied as a foliar spray at ten days interval after artificial inoculation of the pathogen on the cabbage plants.

For inoculation of pathogen the conidial suspension of *A. brassicicola* was prepared with concentration 10^6 conidia /ml in sterile water. The dosages used for foliar spray of eight treatments were given in the Table 2. The per cent disease index and the disease suppression over control were calculated for all the treatments by using standard procedures.

Based on the symptoms observed on the treated plants disease intensity was recorded at ten days intervals after the treatment application by using the score chart as mentioned in table 1. The PDI was calculated by using standard formula given by McKinney[10] and mentioned in Table 3 and plate 1.

After ten days of treatment application, the lowest per cent disease index was recorded with hexaconazole + *B. subtilis* (25%) which was on par with hexaconazole (26.6%). This was followed by tebuconazole (29%) which was on par with propiconazole

(31.6%) and *T. viride* (32.5%). The PDI recorded with *T. harzianum* was 34.1% which was on par with *B. subtilis* (35%). The maximum PDI was recorded in control treatment which was 36.6%.

The lowest PDI was recorded in hexaconazole + *B. subtilis* (17.5%) after 20 days of treatment application. This was followed by hexaconazole (20.8%), tebuconazole (24.1%) and propiconazole (26.6%). The PDI recorded with *T. viride* was 31.6% which was on par with *T. harzianum* (33.3%). The PDI recorded with plants treated with *B. subtilis* was 34.1%.

The combination treatment with hexaconazole + *B. subtilis* recorded lowest PDI after thirty days of treatment application. The plants treated with hexaconazole recorded 16.6% disease index which was on par with tebuconazole (18.3%). The treatments *T. harzianum* (30.8%) and *B. subtilis* (32.5%) were on par and PDI recorded with *T. viride* was 28.3%.

The per cent disease suppression over control was calculated for all the treatments and it was maximum in treatment hexaconazole + *B. subtilis* (79.4%) followed by triazolefungicides i.e., hexaconazole (68.3%), tebuconazole (65.1%) and propiconazole (63.6%). The lowest percentage disease suppression was recorded with treatment *B. subtilis* (38%).

Sharma *et al.*[17] observed percentage disease reduction over control was high in integrated module of fungicide and bioagent against Alternaria leaf spot in cauliflower (82.2%) followed by chemicals (79.4%) and less with biological management (69.8%). Mishra *et al.*[12] observed that the maximum percentage disease suppression over control against *A. brassicae* was high with propiconazole (74.65%) and less with *T. harzianum* (53.5%). Propiconazole and tebuconazole fungicides were effective against Alternaria leaf spot of cabbage as they recorded lowest per cent disease index. Lowest percentage disease index against *A. brassicae* was recorded with hexaconazole (54.32%) and propiconazole (31.8%) as described by Patwari[13].

Table 2: Treatments selected for pot culture studies and their dosages

Sl. No.	Treatments	Dosage
1	Propiconazole	0.05%
2	Hexaconazole	0.05%
3	Tebuconazole	0.05%
4	*T. viride*	10^6cfu/ml
5	*T. harzianum*	10^6cfu/ml
6	*B. subtilis*	10^8cfu/ml
7	Hexaconazole + *B. subtilis*	0.05% + 10^8cfu/ml

Table 3: Effect of fungicides, bioagents and their combination against Alternaria leaf spot of cabbage

Treatments	Per cent disease index				Disease suppression over control (%) (30 days after treatment)
	Pre treatment	10 days after treatment	20 days after treatment	30 days after treatment	
Propiconazole	22.5	31.6 (31.61)^{bc}	26.6 (30.32)^{d}	19.1 (25.9)^{d}	63.6
Hexaconazole	22.5	26.6 (30.54)^{de}	20.8 (27.12)^{f}	16.6 (24.03)^{e}	68.3
Tebuconazole	23.3	29 (32.68)^{cd}	24.1 (29.39)^{e}	18.3 (25.32)^{de}	65.1
B. subtilis	23.3	35(35.76)^{ab}	34.1 (35.72)^{b}	32.5 (34.75)^{b}	38.0
T. viride	22.5	32.5 (34.74)^{bc}	31.6 (34.2)^{c}	28.3 (32.13)^{c}	46.0
T. harzianum	23.3	34.1 (35.76)^{ab}	33.3 (35.24)^{bc}	30.8 (33.7)^{b}	41.3
Hexaconazole + *B. subtilis*	22.5	25 (29.98)^{e}	17.5 (24.72)^{g}	10.8 (19.17)^{f}	79.4
Control	23.3	36.6 (36.26)^{a}	44.1 (41.61)^{a}	52.5 (46.43)^{a}	
CD (0.05)		3.5	1.798	1.9	
SE		1.66	0.81	1.12	

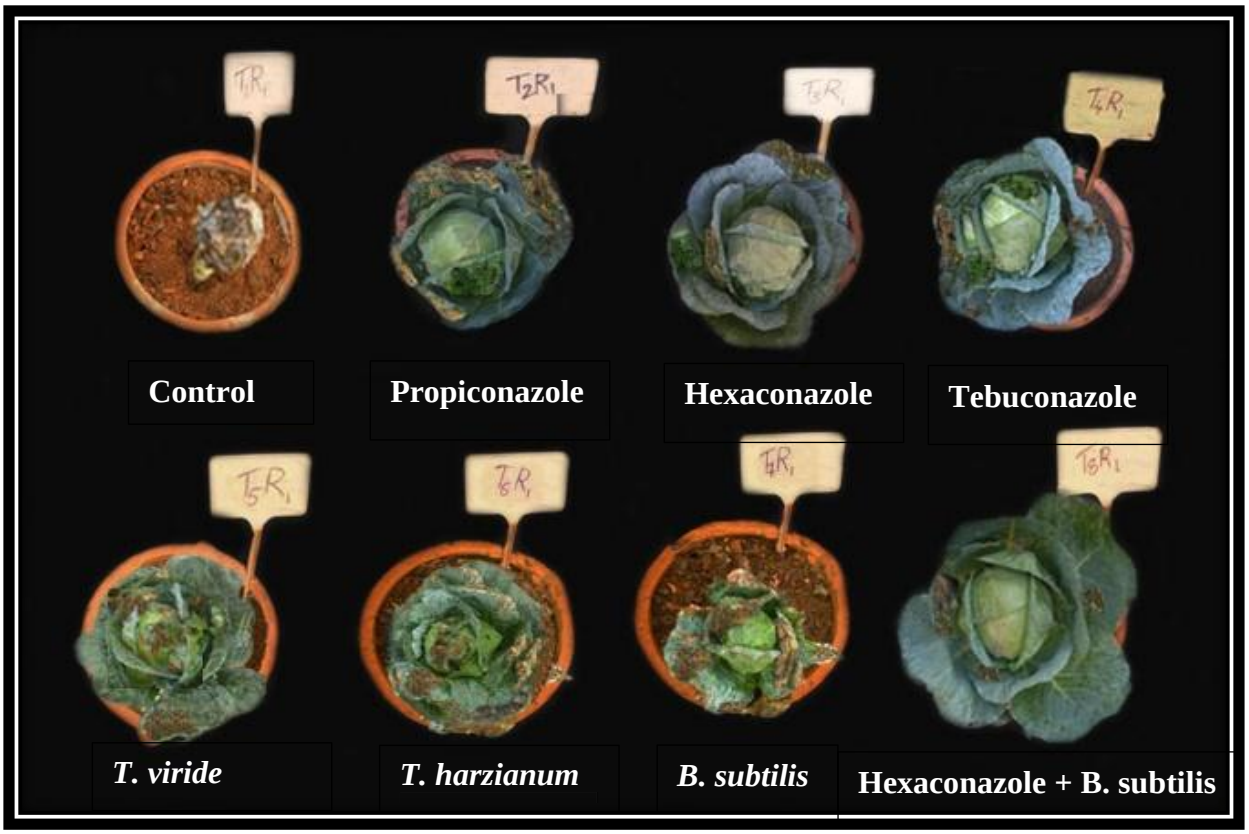

Plate 1: Effect of fungicides, bioagents and their combination against Alternaria leaf spot of cabbage

a) Yield

Based on the yield data obtained from pot culture experiment, the maximum yield per pot was recorded in the treatment hexaconazole + *B. subtilis* which was 590 g/pot followed by hexaconazole (548.3 g/pot) which was on par with tebuconazole (523.6 g/ pot). The yield obtained with propiconazole was 484.6 g/pot. Less yield was obtained in bioagent treatments compared to triazoles and the combination treatment. The lowest yield was recorded in the treatment *B. subtilis* (243.3 g/pot) followed by *T. harzianum* (279.2 g/pot) and *T. viride* (309.6 g/pot) (Table 4).

Yield obtained from each plant was recorded for all the treatments and observed that maximum yield was recorded with the combination treatment hexaconazole + *B. subtilis* (0.58 kg/plant) which differed significantly with remaining treatments. This was followed by hexaconazole (0.54 kg/plant), tebuconazole (0.52 kg/plant) and propiconazole (0.48 kg/plant). Cabbage yield recorded was high with propiconazole and tebuconazole which was 24.97 and 28.01 tonnes/ha. Maximum yield of cabbage was recorded with hexaconazole (18.4q/ha) and propiconazole (16.25q/ha) treatments and C: B ratio was 1:19, 1:4 with hexaconazole and propiconazole respectively[13].

Table 4: Effect of different treatments on the yield of cabbage

Sl. No.	Treatment	Yield/ pot (g)	Yield over control (g)
1	Propiconazole (0.05%)	484.6^{c}	355
2	Hexaconazole (0.05%)	548.3^{b}	418.7
3	Tebuconazole (0.05%)	523.6^{b}	394
4	*B. subtilis*(10^{8}cfu/ml)	243.3^{e}	113.7
5	*T. viride*(10^{6}cfu/ml)	309.6^{d}	180
6	*T. harzianum*(10^{6}cfu/ml)	279.2^{e}	149.6
7	Hexaconazole (0.05%) + *B. subtilis*(10^{8}cfu/ml)	580.5^{a}	450.9
8	Control	129.6^{f}	
CD (0.05)		24.83	
SE		11.6	

Economic analysis on alternaria leaf spot of cabbage using fungicides, bioagents and their combination showed that maximum yield was recorded with hexaconazole + *B. subtilis* which was 29.5 q/ha. This was followed by hexaconazole (27.4 q/ha), tebuconazole (26.1 q/ha) and propiconazole (24.2/ha). The yield recorded with *T. viride* and *T. harzianum* was 15.4 q/ha and 13.9 q/ha. The lowest yield was recorded with *B. subtilis* (12.1 q/ha). The percentage yield increase over control was calculated and it was maximum with hexaconazole + B. subtilis (355.2%) followed by triazole fungicides viz., hexaconazole (322.8%), tebuconazole (303.5%) and propiconazole (264.1%). Percentage yield increase over control recorded with *T. viride*, *T. harzianum* and *B. subtilis* was 138.8%, 115.4% and 87.7% respectively.

Benefit Cost ratio was assessed and showed that it was maximum with treatment hexaconazole + *B. subtilis* which was 2.09: 1.0 (Table 5). This was followed by hexaconazole (2.02:1.0), tebuconazole (1.89:1) and propiconazole (1.76:1.0). The cost benefit ratio noted with *T. viride* was 1.09: 1.0. But the returns obtained with *T. harzianuma* alone (0.98) and *B. subtilis* alone (0.87) was less per each rupee spent.

As the economic part of cabbage is head, frequent use of chemicals for the management of this disease will create residue problems and ecologically not safe. Hence, new generation fungicides and bioagents are required for effective management of this disease. In the present investigation, the combination treatment hexaconazole + *B. subtilis* was found to be best for the management of Alternaria leaf spot of cabbage as it recorded lowest per cent disease index and highest yield with benefit cost ratio 2.09:1. Apart from this, the bioagent (*B. subtilis*) impart protection in the storage as it prevents the post harvest damage and hexaconazole degrades fast as it is a new generation fungicide thereby reduces the residue level of this fungicide.

Table 5: Economic analysis of different treatments evaluated under pot culture study

Sl. No.	Treatment	Yield (kg/ha)	Additional yield over control (kg/ha)	Percentage yield increase over control	Additional income Rs./ha	Plant protection input required /ha	Cost of input Rs./ha	Income Rs./ha	Total cost of cultivation Rs./ha	Benefit cost ratio
1	Propiconazole	24200	17720	264.1	46020	500 ml	900/-	67720	38400	1.76:1
2	Hexaconazole	27400	20920	322.8	54340	500 ml	350/-	76720	37850	2.02:1
3	Tebuconazole	26150	19670	303.5	50960	500 ml	1140/-	73220	38640	1.89:1
4	*B. subtilis*	12165	5685	87.73	14781	20 kg	1600/-	34062	39110	0.87:1
5	*T. viride*	15480	9000	138.8	23400	20 kg	2100/-	43344	39600	1.09:1
6	*T. harzianum*	13960	7480	115.4	19448	20 kg	2100/-	39088	39600	0.98:1
7	Hexaconazole + *B. subtilis*	29500	23020	355.2	59800	500 ml +20 kg	1950/-	82600	39450	2.09:1
8	Control	6480								

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