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Research Paper

Bioefficacy of propiconazole alone or in combination with other fungicides against *Alternaria alternata* causing leaf blight in cowpea

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ABSTRACT

In the present study, the bioefficacy of propiconazole alone or in combination with other fungicides was evaluated for the management of Alternaria leaf blight in cowpeas under *in vitro* and field conditions. For this, propiconazole was employed in different fungicidal combination (*viz*., propiconazole 25 EC + chlorothalonil 75WP, propiconazole 25 EC + propineb 70 WP and propiconazole 25 EC + metiram 60 WG) with standard fungicidal check (*viz*., propiconazole 25 EC, tebuconazole 50 + trifloxystrobin 25 WG, pyraclostrobin 5 + metiram 55 WG and carbendazim 25 + mancozeb 50 WS) along with native isolate of *Trichoderma* spp. and untreated control. Among all fungicides, the mean colony diameter observed ranged from 0.00 to 31.68 mm at different concentrations of different fungicides with the mean growth inhibition ranging from 63 to 100%. The maximum 100% mean growth inhibition was recorded in propiconazole 25 EC, while a minimum 63% mean growth inhibition was recorded in carbendazim 25 + mancozeb 50 WS with 31.7 mm colony diameter under *in-vitro* condition. Among all the treatments, the highest reduction in disease incidence was observed in tebuconazole 50 + trifloxystrobin 25 WG with 71.6% disease reduction which was at par with propiconazole 25 EC + metiram 60 WG and propiconazole 25 EC + chlorothalonil 75WP with 70 and 62% disease reduction, respectively. The least effective treatment recorded pyraclostrobin 5 WG + metiram 55 WG with 33% disease reduction but effective over the control.

Key words: *Alternaria alternata*, Cowpea, Leaf blight, Propiconazole

INTRODUCTION

Cowpea [*Vigna unguiculata* (Linnaeus) Walper] is one of the most ancient crops, known since Vedic times. Being a member of the family '*Fabaceae/ Papilionaceae*', it can perform multi-functional activities from food and feed supplements to soil and plant health management (Anish *et al*. 2017). It is highly rich in protein; thus, extensively used in inhuman dietary and animal feed. Further, it can fix the atmospheric nitrogen and increase soil nitrogen. It can easily be included in crop rotations to generate quick income for farmers (Omomowo and Babalola 2021). Nevertheless, when added as green manure to soil, it improves soil health. However, the cultivation of the cowpea crop is very challenging, especially in the scenario of climate change (Singh *et al*. 2002). In India, it is grown in the arid and semi-arid regions of the country, especially, Gujarat and Rajasthan (Kimiti *et al*. 2009). Due to climate change, erratic rainfall and frequent droughts are most common in this region. In recent years, heavy rainfall during September-October has led to considerable yield losses in arid legume crops. The cowpea becomes highly prone to various biotic and abiotic stresses. Of them, problems of foliar pathogens become very serious, especially Alternaria blight, Cercospora leaf spot, Anthracnose, etc. Nowadays, different species of Alternaria become very prevalent affecting different crops including cowpea. In cowpea, it causes severe foliar blight during warm-humid conditions, thus resulting in havoc yield loss and different *Alternaria* spp. *viz*., *A. cassiae* (la Grange and Aveling 2008, Van Den Berg *et al*. 2003), and *A. alternata*, *A. malorum* (Atashi Khalilabad and Fotouhifar 2022) were reported from different locations. To avoid such loss, it was necessary to find suitable disease management strategies.

Among different disease management strategies, fungicides are still the best option for disease management in cowpeas (van den Berg *et al*. 2002), despite the significant residue problems with the agriproducts as well as in the environment, water, and soil. To avoid such issues, the identification and use of safer fungicides are the best options. Propiconazole is one such good option, especially against *Alternaria* sp. Previously, propiconazole was found to be one of the most effective fungicides for the management of Alternaria leaf blight in chilli (Thejakumar and Devappa 2016), Indian Mustard (Choudhary *et al.* 2018), tomato (Yadav *et al*. 2020), chrysanthemum (Kharbadkar *et al*. 2022) and *Carya illinoinensis* (Achilonu *et al*. 2023). But, the excessive use of propiconazole leads to the resistance development to this DMI fungicide in different pathogen populations, *viz*., *Monilinia fructicola* (Cox *et al*. 2007), *Microdochium nivale* (Gourlie and Hsiang 2022) and *Ustilaginoidea virens* (Zhou *et al*. 2003). Thus, there is a need to change the strategy of fungicide use against *Alternaria* sp., and combining the use of two fungicides with different modes of action is the one of best strategies. Thus, the efficacy of propiconazole was evaluated in combination with three contact fungicides, *viz*., chlorothalonil, propineb, and metiram having different modes of action under *in vitro* as well as in field conditions to find out a suitable chemical combination for the efficient management of disease

MATERIALS AND METHODS

Fungicides and fungal culture

The experiment was conducted during *Kharif* 2021 (July to September 2021) to evaluate the bioefficacy of propiconazole alone or in combination with other fungicides for the management of Alternaria leaf blight in cowpea under *in vitro* and field conditions. An experiment on the *in vitro* bioefficacy of propiconazole against *A. alternata* was conducted under laboratory conditions at the Department of Plant Pathology, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, India. Further, a field trial was conducted at Agronomy Instructional Farm of the college. The following fungicides were tested against *A. alternata*. The fungal culture was isolated from cowpea-infected leaves in the Pulses Research Station of the university.

In vitro bio-efficacy of propiconazole alone and in combination with different contact fungicides

The bio-efficacy of propiconazole was studied in combination with different contact fungicides at various concentrations (Table 1). Whereas, Tebuconazole 50 + Trifloxystrobin 25 WG, Pyraclostrobin 5 WG + Metiram 55 WG, Carbendazim 25 WS + Mancozeb 50 WS were used for comparison. The poisoned food technique (Nene and Thapliyal, 2000) was used for evaluation of their *in vitro* efficacy. The measured quantities of different fungicides were incorporated separately in melted sterilized PDA medium in conical flasks aseptically to obtain the desired concentrations of the fungicides at the time of pouring the medium. The medium was shaken well to give uniform dispersal of the fungicides and then poured into sterilized Petri plates under aseptic conditions. The Petri plates were inoculated in the center by placing a 5 mm seven-day-old mycelial disc and then incubated at 24±1^{o}C temperature for seven days. Simultaneously, control was also maintained by growing the fungus on a fungicide-free PDA medium. The mycelial growth of the pathogen was measured as colony diameter when the controlled treatment with the pathogen reached full growth.

Table 1. List of fungicides tested against *A. alternata* under *in vitro* condition

S. No.	Treatments	Concentration (ppm)			
1	Propiconazole 25 EC	50	100	250	500
2	Propiconazole 25 EC + Chlorothalonil 75WP (1:1 w/w)	50	100	250	500
3	Propiconazole 25 EC + Propineb 70 WP (1:1 w/w)	50	100	250	500
4	Propiconazole 25 EC + Metiram 60 WG (1:1 w/w)	50	100	250	500
5	Tebuconazole 50 %+ Trifloxystrobin 25%WG	50	100	250	500
6	Pyraclostrobin 5% + Metiram 55% WG	50	100	250	500
7	Carbendazim 25 %+ Mancozeb 50 % WS	50	100	250	500
8	Control	-	-	-	-

Note: In 2, 3, and 4, combinations were made by mixing equal concentrations (50%) of both.

The growth inhibition (%) of the fungus was calculated by the following equation as suggested by Bliss (1934).

$$GI = \frac{C-T}{C} \times 100$$

Where, GI = Growth inhibition (%), C = Colony diameter in control (mm), and T = Colony diameter in treatment (mm)

Bio-efficacy of propiconazole alone and in combination with different contact fungicides in the field

Fungicides that were used in *in vitro* studies, the same fungicides with a native isolate of *Trichoderma* spp. were evaluated under field conditions. Two sprays of each fungicide were done at an interval of ten days with 0.1% concentration. The observations on disease severity were recorded using the standard 0-5 disease rating scale before the first spray (observation 1), before the second spray (observation 2), and ten days after the second spray (observation 3). The disease intensity (PDI) was calculated by adopting the following equation (Mckinney 1923).

Scale/grade	Leaf area infected (%)
0	No infection
1	1 to 10 % leaf area infected
2	11 to 25 % leaf area infected
3	26 to 50 % leaf area infected
4	51 to 75 % leaf area infected
5	76 % above leaf area infected

$$PDI = \frac{\text{Sum of all individual rating}}{\text{Total no. of leaf assessed} \times \text{Maximum rating}} \times 100$$

RESULTS AND DISCUSSION

In-vitro bio-efficiency of propiconazole alone and in combination with different fungicides against A. alternata

In the present investigation, seven different fungicides were tested at different concentrations *in vitro* for their comparative efficacy against the growth of *Alternaria* spp. Among them, propiconazole at different concentrations and another three treatments is a combination of contact fungicides, *i.e*, chlorothalonil, propineb, and metiram along with propiconazole for testing the increase the efficacy of propiconazole to compare with standard fungicidal check, *i.e*, tebuconazole + trifloxystrobin, pyreclostrobin + metiram and carbendazim + mancozeb at different concentrations 50, 100, 250, and 500 ppm and control without any fungicide was also included (Fig 1). About 100% growth inhibition with 00.00 mm colony diameter was recorded in propiconazole 25 EC at all concentrations and propiconazole 25 EC + metiram 60 WG at 500 ppm (Table 2). This was more or less similar to the earlier report of Yadav (2020) who reported about 94.00, 100, and 100 % growth inhibition of *A. alternata* in propiconazole 25 EC at 100, 300, and 500 ppm, respectively. Further, Jackson and Kumar (2019) also observed the complete inhibition of the growth of *Alternaria* sp. infecting Indian Mustard at all concentrations of propiconazole 25 EC (tilt) under *in vitro* conditions. Similarly, Berg *et al.* (2001), Valvi *et al.* (2016), Zade *et al.* (2018), Kokare *et al.* (2020) and Ayana and Gabrekiristos (2022) also reported that propiconazole 25 EC is the best fungicide for inhibiting the mycelial growth of different *Alternaria* sp. in laboratory conditions.

Table 2. Effect of different treatments on mycelial growth of *A. alternata*

S. No.	Treatment / Concentration (ppm)	Colony diameter (mm) 50	100	250	500	Mean
1	Propiconazole 25 EC	0.00	0.00	0.00	0.00	0.00
2	Propiconazole 25 EC + Chlorothalonil 75WP	6.67	4.17	4.00	1.50	4.08
3	Propiconazole 25 EC + Propineb 70 WP	6.67	4.83	3.83	1.50	4.21
4	Propiconazole 25 EC + Metiram 60 WG	6.00	3.17	2.00	0.00	2.79
5	Tebuconazole 40 EC + Trifloxystrobin 25 WG	5.50	4.00	3.00	1.33	3.46
6	Pyraclostrobin 5 WG + Metiram 55 WG	21.50	17.50	14.00	10.83	15.96
7	Carbendazim 25 WS + Mancozeb 50 WS	41.50	34.50	28.00	22.67	31.68
8	Control	85.00	85.00	85.00	85.00	85.00
	Mean	21.60	19.15	17.48	15.35	

	C D (p=0.05)	SEm±	CV (%)
Treatments (T)	0.578	0.204	
Concentration (C)	0.409	0.144	3.84
Treatment × Concentration (T×C)	1.156	0.408	

To increase the bioefficacy of propiconazole, it was combined with three contact fungicides, *i.e*, chlorothalonil, propined, and metiram at an equal concentration (1:1 w/w) and compared with standard fungicidal checks, *i.e*, tebuconazole + trifloxystrobin, pyreclostrobin + metiram and carbendazim + mancozeb at different concentrations (50, 100, 250, and 500 ppm). In combination with Propiconazole 25 EC and chlorothalonil 75 WP (1:1 w/w), about 92.17, 95.13, 95.31, and 98.27% growth inhibition with the mean colony diameter of 6.67, 4.17, 4.00, and 1.50 mm was recorded at 50, 100, 250 and 500 ppm, respectively. Here, the combi-product of propiconazole 25 EC + chlorothalonil 75 WP was recorded as superior in inhibiting the growth of *Alternaria* sp. over the solo application of chlorothalonil 75 WP. Previously, Kantwa *et al.* (2014) reported up to 55.37 % mean growth inhibition of *Alternaria alternata* using chlorothalonil 75 WP a solo fungicide; similarly, Garg and Kumhar (2020) also observed only 69.22% and 73.23% growth inhibition of *A. solani* at 1000 ppm and 2000 ppm, respectively when they used chlorothalonil as a solo fungicide.

Likewise, the combination of Propiconazole 25 EC and propineb 70 WP (1:1 w/w) resulted in 92.18, 94.33, 95.50 and 98.27 % growth inhibition of *Alternaria alternata* with 6.67, 4.83, 3.83, and 1.50-mm colony diameter at 50, 100, 250 and 500 ppm concentration, respectively. This combi-product of propiconazole 25 EC + propineb 70 WP was recorded better over the solo application of propineb 70 WP against different *Alternaria* spp. At 500 ppm, only 69.63 and 77.09% growth inhibition were recorded in *Alternaria alternata* infecting tomato (Jewaliya *et al.* 2021) and ber (Chaudhary *et al.*

2021), respectively. Further, this combi-production was found superior over a propineb-based combi-product (i.e., propineb 61% + iprovalicarb 5.25%) at the same concentration (100 ppm). At 100 ppm, propineb 61% + iprovalicarb 5.25% showed only 75.47% growth inhibition of *Alternaria* spp. infecting potato (Murmu *et al.* 2017). This again signifies the enhanced bioefficacy of propineb in combination with propiconazole. In addition, the combination (1:1 w/w) of Propiconazole 25 EC and metiram 60 WG was recorded to cause 92.95, 96.29, 97.67 and 100% growth inhibition with 6.00, 3.17, 2.00, and 00.00 mm colony diameter at 50, 100, 250 and 500 ppm, respectively. The mean growth inhibition was recorded about 97.65% with 2.79 mm mean colony diameter. Hassan *et al.* (2021) reported 71.21% inhibition of *Alternaria* spp. at 100 ppm concentration of metiram 70% DF. The result of the combined product of propiconazole + metiram was recorded as superior to the solo use of metiram. The superior result of the combined product was recorded due to the complementary interaction between two fungicides with different modes of action.

Table 3. *In vitro* evaluation of different fungicides against *A. alternata*

S. No.	Concentration (ppm) Treatment	Growth inhibition (%) 50	100	250	500	Mean
1	Propiconazole 25 EC	90^{a*} (100**)	90^{a} (100)	90^{a} (100)	90^{a} (100)	90^{a} (100)
2	Propiconazole 25 EC + Chlorothalonil 75WP	73.75^{j} (92.17)	77.25^{fg} (95.13)	77.49^{efg} (95.31)	82.45^{bc} (98.27)	77.74^{c} (95.49)
3	Propiconazole 25 EC + Propineb 70 WP	73.76^{j} (92.18)	76.22^{gh} (94.33)	77.75^{ef} (95.50)	82.45^{bc} (98.27)	77.55^{c} (95.35)
4	Propiconazole 25 EC + Metiram 60 WG	74.60^{ij} (92.95)	78.89^{de} (96.29)	81.23^{c} (97.67)	90.00^{a} (100.00)	81.18^{b} (97.65)
5	Tebuconazole 40 EC + Trifloxystrobin 25 WG	75.28^{hi} (93.54)	77.49^{efg} (95.31)	79.21^{d} (96.49)	82.85^{b} (98.45)	78.71^{c} (96.16)
6	Pyraclostrobin 5 WG + Metiram 55 WG	59.81^{n} (74.71)	63.02^{m} (79.42)	66.13^{l} (83.62)	69.12^{k} (87.30)	64.52^{d} (81.49)
7	Carbendazim 25 WS + Mancozeb 50 WS	45.68^{q} (51.18)	50.43^{p} (59.42)	54.98^{o} (67.06)	58.91^{n} (73.34)	52.50^{e} (62.94)
8	Control	0.311^{r} (0.00)	0.311^{r} (0.00)	0.311^{r} (0.00)	0.311^{r} (0.00)	0.311^{f} (0.00)
	Mean (Concentration)	61.65^{c} (77.39)	64.20^{b} (81.01)	65.89^{b} (83.26)	69.51^{a} (87.70)	
			CD (p=0.05)		SEm±	CV (%)
	Treatment(T)		0.680		0.240	
	Concentration (C)		0.481		0.170	1.27
	Treatment×Concentration (T×C)		1.360		0.480	

*Figures out of parentheses are arc-sin transformed values; **Figures in parentheses are original values; Treatment means with the letters in common are not significant by DNMRT at 5% level of significance.

Among the fungicidal checks, Tebuconazole 40 EC + trifloxystrobin 25 WG was most effective and resulted in 93.54, 95.31, 96.49 and 98.45% growth inhibition of *A. alternata* with 5.50, 4.00, 3.00, and 1.33 mm colony diameter at 50, 100, 250 and 500 ppm, respectively. This is followed by Pyraclostrobin 5 WG + metiram 55 WG resulting in about 74.71, 79.42, 83.62, and 87.30% growth inhibition of *A. alternata* with 21.50, 17.50, 14.00, and 10.83 colony diameter at 50, 100, 250 and 500 ppm, respectively. Whereas, carbendazim 25 WS + mancozeb 50 WS was found to be the least effective fungicide with about 51.18, 59.42, 67.06, and 73.34% growth inhibition at 50, 100, 250, and 500 ppm concentration. Previously, Jewaliya *et al.* (2021) reported the better bioefficacy of Tebuconazole 40 EC + trifloxystrobin 25 WG as compared to carbendazim 25 WS + mancozeb 50 WS in inhibiting the mycelial growth of *A. alternata*. Similarly, Kumari *et al.* (2022) also recorded 79.28% growth inhibition of *A. alternata* at 0.35% concentration of Pyraclostrobin 5 WG + metiram 55 WG.

From these findings, it is clear that fungal growth inhibition (%) increases and colony diameter decreases with increasing concentration. All three combinations of propiconazole with contact fungicides are superior over the check fungicides and also at par with propiconazole alone. It indicates that the efficacy of contact fungicide increases when it mixes with propiconazole and also gives a better result than the solo use of contact fungicide due to the complementary interaction between contact and systemic fungicide.

Bio-efficiency of propiconazole alone and in combination with different fungicides in field

All the fungicides used *in vitro* experiments

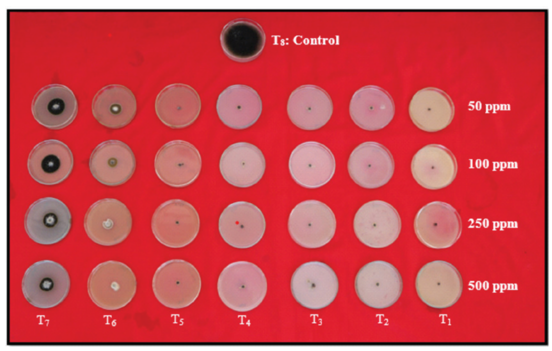

Figure 1. *In-vitro* growth inhibition of Alternaria alternata at 50, 100, 250, 500 ppm concentration of different fungicides.

T_1: Propiconazole 25 EC, T_2: Propiconazole 25 EC + Chlorothalonil 75WP, T_3: Propiconazole 25 EC + Propineb70 WP, T_4: Propiconazole 25 EC + Metiram 60 WG, T_5: Tebuconazole 50 WG + Trifloxystrobin 25 WG, T_6: Pyraclostrobin 5 WG + Metiram 55 WG, T_7: Carbendazim 25 WS + Mancozeb 50 WS, and T_7: Control.

were tested under field conditions for the management of Alternaria leaf spot of cowpea during *Kharif* 2021. Different combined fungicidal treatments with standard fungicidal checks were sprayed at 0.1% concentration. The observation on disease intensity (%) of leaf spot disease was recorded and their percent disease reduction over the control (T_8) was calculated. The highest reduction in disease incidence was observed in tebuconazole 40 EC + trifloxystrobin 25 WG with 71.63% disease reduction which was at par with propiconazole 25 EC + metiram 60 WG and propiconazole 25 EC + chlorothalonil 75WP with 69.90 and 61.95% disease reduction, respectively followed by propiconazole 25 EC + propineb 70 WP with 49.91% disease reduction which was at par with propiconazole 25 EC and Carbendazim 25 WS + Mancozeb 50 WS with 48.56 and 46.69% disease reduction, respectively followed by *Trichoderma* spp. with 35.75% disease reduction (Fig 2). The least effective treatment recorded pyraclostrobin 5 WG + metiram 55 WG with 33.00% disease reduction but effective over control.

Propiconazole 25 EC + chlorothalonil 75 WP, propiconazole 25 EC + propineb 70 WP and propiconazole 25 EC + metiram 60 WG was recorded superior result over propiconazole 25 EC in field condition due to complimentary interaction between systemic and contact fungicides. Propiconazole 25 EC + metiram 60 WG and propiconazole 25 EC + chlorothalonil 75WP were statistically at par with tebuconazole 40 EC + trifloxystrobin 25 WG and also superior over check fungicide combination *viz*., pyraclostrobin 5 WG + metiram 55 WG and carbendazim 25 WS + mancozeb 50 WS. The present results were in accordance with the results obtained by Chaudhary *et al*. (2021) who recorded that two sprays of tebuconazole + trifloxystrobin (0.1%) were most effective in reducing disease intensity with 80.44 % disease reduction. Yadav *et al*. (2020) also recorded 59.16% disease reduction while using tebuconazole + trifloxystrobin @ 0.1%. Also, a similar result was found by Kumar and Singh (2020) who recorded 76.67% disease control while using tebuconazole 25% + trifloxystrobin 50%. Further, Culbreath *et al*. (1995) recorded that leaf spot intensity decreased linearly with increasing rates of chlorothalonil when applied with 63g a.i.

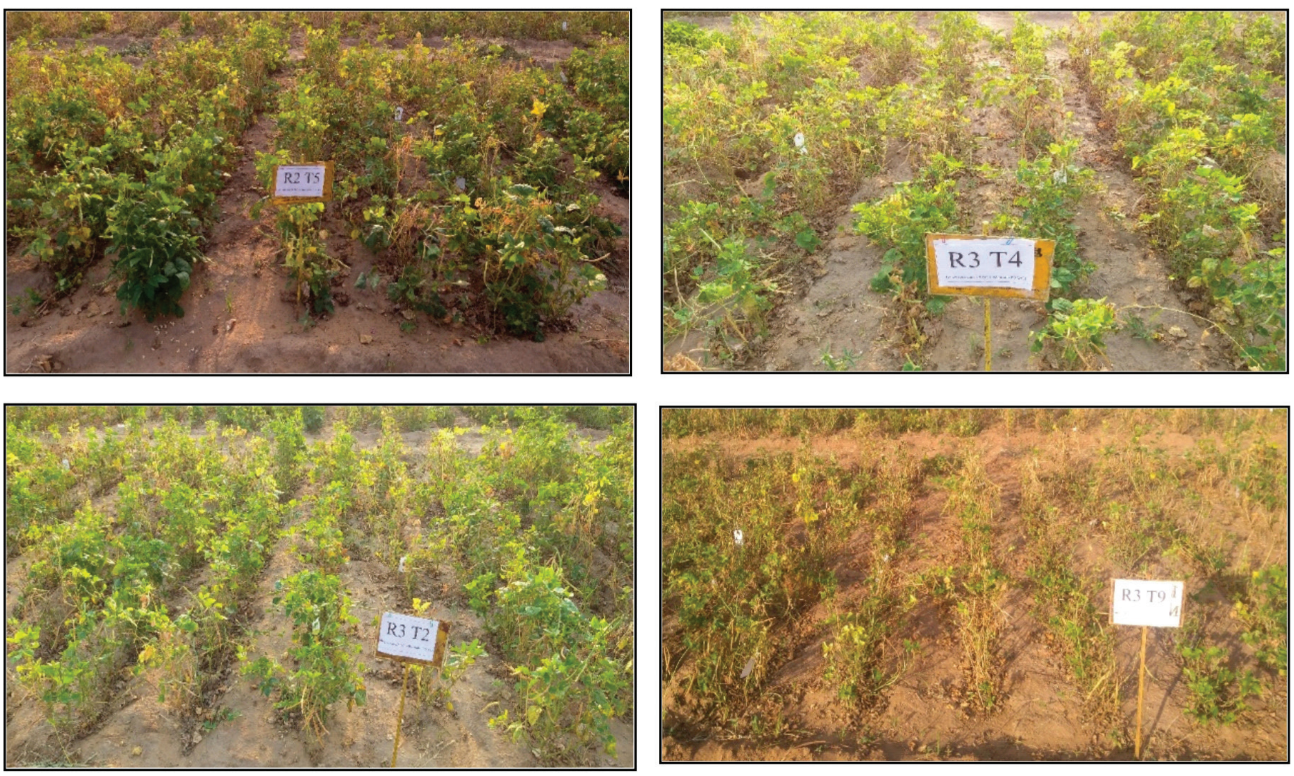

Figure 2. Evaluation of different fungicides against Alternaria leaf spot in cowpea under figufield conditions.

Here, T_5 (Tebuconazole 40 EC + Trifloxystrobin 25 WG) is superior over other treatments, but statistically at par with T_4 (Propiconazole 25 EC + Metiram 60 WG) and T_2 (Propiconazole 25 EC + Chlorothalonil 75WP). Where T_9 represent untreated control.

Table 4. Bio-efficacy of different fungicides against *A. alternata* under field condition

S. No.	Treatment name	Con. (%)	Disease intensity (%)			PDR (%)
			Ob1	Ob2	Ob3	
1	Propiconazole 25 EC	0.1	37.12 (36.60)	29.49 (24.30)	24.94 (17.97)	44.18[bcd*] (48.56[**])
2	Propiconazole 25 EC + Chlorothalonil 75WP	0.1	45.08 (50.13)	37.74 (37.47)	25.78 (18.93)	51.94[ab] (61.95)
3	Propiconazole 25 EC + Propineb 70 WP	0.1	36.38 (35.20)	31.65 (27.53)	25.76 (19.03)	44.95[bc] (49.91)
4	Propiconazole 25 EC + Metiram 60 WG	0.1	33.55 (30.67)	27.83 (22.00)	17.36 (9.00)	56.90[a] (69.90)
5	Tebuconazole 40 EC + Trifloxystrobin 25 WG	0.1	41.82 (44.53)	31.69 (27.65)	20.32 (12.10)	58.02[a] (71.63)
6	Pyraclostrobin 5 WG + Metiram 55 WG	0.1	31.56 (27.47)	28.79 (23.33)	26.22 (19.70)	34.82[d] (33.00)
7	Carbendazim 25 WS + Mancozeb 50 WS	0.1	38.60 (38.93)	34.61 (32.30)	26.81 (20.37)	43.09[bcd] (46.69)
8	*Trichoderma spp.* (native isolate)	0.1	32.44 (28.80)	28.29 (22.47)	25.39 (18.40)	36.65[cd] (35.75)
9	Untreated control	-	39.48 (40.43)	43.06 (46.63)	48.34 (55.80)	-
		SEm±	1.97	1.51	1.36	2.96
		CD (p=0.05)	5.92	4.53	4.08	8.97
		CV (%)	9.15	8.04	8.80	11.06

*Figures out of parentheses are arc-sin transformed values; **Figures in parentheses are original values; Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance.

ha^{-1} of propiconazole and leaf spot intensity ratings were lower on plants treated with mixtures of chlorothalonil and propiconazole compared to those treated with chlorothalonil alone. Kumar and Singh (2017) recorded 53.18% disease control while using metiram 70% alone against *A. solani* and Yadav *et al.* (2020) recorded 63.85% disease control while using propiconazole (0.1%) alone against *A. alternata.* The result of the combination of propiconazole + metiram recorded superior results over the results of both the scientists Kumar and Singh (2017) and Yadav *et al.* (2020).

CONCLUSION

Alternaria blight is a serious issue in cowpea and it occurs in the sporadic form in different cowpea growing areas of north Gujarat. The incidence of this disease may gradually rise as a result of the extreme environmental changes, and it may soon manifest as an epidemic or endemic. Thus, an experiment was carried out to evaluate the bioefficacy of propiconazole 25 EC alone as well as the combinations of propiconazole 25 EC with contact fungicide in comparison with routine fungicidal checks to manage the leaf spot disease. When applied in two sprays of these fungicides @ 0.1% at a 10-day interval, tebuconazole 50 + trifloxystrobin 25 WG was found to be the most effective with the highest percentage of disease reduction. This was comparable to propiconazole 25 EC + metiram 60 WG (1:1 w/w) and propiconazole 25 EC + chlorothalonil 75 WP (1:1 w/w). For the cost-effective management of leaf spot disease in cowpea, farmers can therefore use propiconazole 25 EC + metiram 60 WG (1:1 w/w) or propiconazole 25 EC + chlorothalonil 75 WP (1:1 w/w) in place of tebuconazole 50 + trifloxystrobin 25 WG.

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