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Integrated SDHI-QoI Fungicide Strategy for Effective Foliar Disease Management in Blackgram

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Abstract
Blackgram (*Vigna mungo* L. Hepper) is a vital pulse crop often affected by foliar fungal diseases like Cercospora leaf spot, Anthracnose and Powdery Mildew. A field study was conducted at MARS, UAS Dharwad, during *Kharif* 2021 to evaluate the efficacy of Fluxapyroxad + Pyraclostrobin (Priaxor 500 SC) against these diseases. The fungicide applied at dosage of 300 and 200 ml/ha significantly reduced disease severity, recording mean disease severity of 15.06 and 15.58 % for Cercospora leaf spot, 15.68 and 16.34 % for Anthracnose and 18.21 and 18.60 % for powdery mildew, with 55-60% reduction over control. The highest yield (9.07 q/ha) and no phytotoxic effects were observed with Priaxor 500 SC @ 300 ml/ha. The dual-action SDHI and QoI chemistry provided both protective and curative benefits. Thus, Priaxor 500 SC @ 200 ml/ha is recommended for effective and sustainable management of foliar diseases of blackgram.

Keywords: Blackgram, Disease management, Fluxapyroxad, Foliar diseases, Priaxor 500 SC, Pyraclostrobin

Introduction
Blackgram (*Vigna mungo* (L.) Hepper) is an important short-duration pulse crop belonging to the family Fabaceae. It plays a significant role in Indian agriculture due to its nutritional richness, ability to fix atmospheric nitrogen and soil fertility improvement. It consists of around 24% protein, along with carbohydrates, vitamins and essential minerals such as calcium, phosphorus and iron, making it a vital component of vegetarian diets (Ali and Gupta 2012) [1]. India is the leading producer of blackgram, cultivating nearly 3.5 million hectares and producing about 2.0 million tonnes annually (Singh *et al*. 2016) [16]. In Karnataka, it is widely grown in the northern transitional zone including Dharwad, Belagavi, Gadag and Haveri districts, where it forms an integral part of the rainfed cropping system. Although India is the leading producer of Blackgram, there is gap in its productivity due to several foliar fungal diseases that cause considerable yield losses. Among these, Cercospora leaf spot (*Cercospora canescens*), Anthracnose (*Colletotrichum truncatum*) and Powdery mildew (*Erysiphe polygoni*) are the most destructive diseases, often reducing yield by 30-60% under favorable weather conditions (Sharma, 1999; Pathak and Ram, 2013; Balol *et al*., 2020) [14, 6]. The co-formulated product Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L 500 SC (Priaxor 500 SC) offers both protective and curative activity. In addition to disease suppression, this formulation promotes plant vitality through improved photosynthetic efficiency, delayed senescence and enhanced yield potential. Considering the recurring incidence of foliar diseases in blackgram, the present investigation was undertaken to evaluate the field efficacy and crop safety of Priaxor 500 SC under the conditions of northern Karnataka.

Materials and Methods
A field investigation was carried out during the *Kharif* 2021 season at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, Karnataka (15°28′N, 75°00′E, 678 m above MSL). The location experiences a semi-arid tropical climate with moderate rainfall and warm temperatures, receiving an annual precipitation of about 730 mm.

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Experimental design and layout

The experiment was laid out in a Randomized Block Design (RBD) comprising seven treatments, each replicated three times. Individual plots measured 5 m × 4 m (20 m²), maintaining a spacing of 30 cm between rows and 10 cm between plants. Standard cultivation practices such as recommended seed treatment with Rhizobium inoculant, basal fertilizer application, weeding and intercultivation were uniformly adopted in all plots to ensure normal crop growth. No insecticides were used during the experimental period to avoid interaction with fungicidal treatments.

Treatment details

Tr.no	Treatments
T_1	Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC @ 100 ml/ha
T_2	Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC @ 200 ml/ha
T_3	Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC @ 300 ml/ha
T_4	Fluxapyroxad 300 g/l SC
T_5	Pyraclostrobin 20% WG
T_6	Captan 70 & + Hexaconazole 5% WP
T_7	Control/ Untreated check

Disease recording and assessment

The incidence and severity of Cercospora leaf spot, Anthracnose and Powdery mildew were recorded before the first spray, 14 days after each spray and at harvest. Disease severity was scored visually using standard rating scales:

- Cercospora leaf spot and Anthracnose were rated on a 0-9 scale (Mayee and Datar, 1986) [12].
- Powdery mildew was scored on a 0-5 scale (Gawande and Patel, 1987) [9].

The Percent Disease Index (PDI) was computed using the formula given by wheeler (1969) [19]:

$$\text{PDI} = \frac{\text{sum of the individual disease ratings}}{\text{no of leaves observed} \times \text{maximum disease grade}} \times 100$$

Ten plants per replication were randomly selected for scoring and the mean PDI values were calculated for each treatment before subjecting them to statistical analysis.

Phytotoxicity evaluation

Phytotoxicity of Priaxor 500 SC was assessed at higher concentrations of 300, 375, and 600 ml/ha, along with an untreated control. Ten plants from each plot were tagged and examined for possible injury symptoms such as leaf burn, wilting, vein clearing, necrosis, epinasty and hyponasty at 1, 3, 5, 7 and 10 days after spraying. Observations were recorded using a 0-10 scale, where 0 represented no visible symptoms and 10 denoted complete damage. The absence of any phytotoxicity symptoms indicated the crop safety of the tested formulation.

Yield assessment

At harvest, the grains from each plot were collected, dried and weighed to obtain plot-wise yields, which were then converted to quintals per hectare (q/ha). The percentage increase in yield over the untreated check was computed to determine the productivity advantage associated with each treatment.

Statistical analysis

All the experimental data was subjected to analysis of variance (ANOVA) suitable for RBD. Treatment means were compared using the critical difference (CD) at 5% probability level ($p = 0.05$) as described by Gomez and Gomez (1984) [10]. Percentage data was transformed to arcsine values before analysis to normalize variance. Statistical interpretation was based on significant differences among treatments and their relative efficacy.

Results and Discussion

Effect on Cercospora leaf spot

Priaxor 500 SC significantly reduced Cercospora leaf spot severity compared to control. The minimum mean PDI (15.06 and 15.58) was recorded in T_3 and T_2 (300 and 200 ml/ha doses) respectively, corresponding to 59.5% and 57.2% reduction over control. These treatments were statistically on par with each other and superior to standard fungicides Captan + Hexaconazole (17.49 PDI) and Pyraclostrobin 20% WG (19.07 PDI). The lowest yield (5.08 q/ha) was recorded in the untreated control (T_7) (Table 1). The enhanced control could be attributed to the dual-action mode of the SDHI and QoI components that inhibit fungal respiration and spore germination (Fisher *et al*., 2018).

Effect on Anthracnose

Similarly, Priaxor 500 SC @ 300 and 200 ml/ha doses (T_3 and T_2) recorded the least mean PDI of 15.68 and 16.34 respectively, with 57.0% and 55.2% reduction over control. Both treatments were superior to Captan + Hexaconazole (18.11 PDI) and Pyraclostrobin 20% WG (19.47 PDI) (Table 1). The results corroborate earlier findings of Balol *et al*., 2021 and Balasubramanian *et al*., 2019 [3, 2] who reported effective control of *Colletotrichum* spp. in pulses using fluxapyroxad-based formulations.

Effect on Powdery Mildew

The application of Priaxor 500 SC at 300 and 200 ml/ha doses (T_3 and T_2) reduced powdery mildew severity to 18.21 and 18.60 % respectively, compared to 33.25 % in the untreated check (T_7). Both treatments recorded over 44% reduction in disease intensity (Table 1). The superiority of Priaxor is due to its translaminar movement and systemic protection providing both preventive and curative effects (Venugopal *et al*., 2020; Channaveeresh *et al*., 2013) [18, 7]. Similar results have been reported on other crops such as chickpea (Basamma *et al*., 2021: Sangeeta *et al*., 2022) [13], urdbean (Balol *et al*., 2020) [4], Onion (Shilpakumari *et al*., 2011), Mango (Vamshika *et al*., 2023), Rice (Balol *et al*., 2022) [5, 15, 17] and Greengram where fungicide application has reduced the disease and increased the yield.

Table1: Effect of different treatments on fungal foliar diseases of blackgram

Tr.no	Treatments	PDI (Cercospora Leaf spot)				PDI (Anthracnose)				PDI (Powdery mildew)			
		(Before Spray)	14 days After 1st spray	14 days After 2nd spray	Mean	(Before Spray)	14 days After 1st spray	14 days After 2nd spray	Mean	(Before Spray)	14 days After 1st spray	14 days After 2nd spray	Mean
T_1	Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC	23.77 (29.2)	16.45 (23.94)	12.63 (20.82)	17.62 (24.83)	24.29 (29.54)	17.11 (24.45)	12.63 (20.82)	18.01 (25.12)	28.35 (32.19)	17.85 (25.00)	15.47 (23.17)	20.56 (26.98)
T_2	Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC	23.46 (28.98)	13.13 (21.26)	10.15 (18.58)	15.58 (23.26)	23.97 (29.33)	14.09 (22.06)	10.95 (19.33)	16.34 (23.85)	28.31 (32.16)	15.36 (23.09)	12.14 (20.4)	18.60 (25.56)
T_3	Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC	22.7 (28.47)	12.84 (21.01)	9.64 (18.1)	15.06 (22.85)	23.17 (28.79)	13.59 (21.64)	10.29 (18.72)	15.68 (23.34)	28.21 (32.1)	14.84 (22.67)	11.60 (19.92)	18.21 (25.28)
T_4	Fluxapyroxad 300 g/l SC	23.98 (29.33)	19.42 (26.16)	16.52 (23.99)	19.97 (26.56)	23.89 (29.27)	20.02 (26.6)	16.54 (24.01)	20.15 (26.69)	28.45 (32.25)	20.15 (26.69)	19.83 (26.46)	22.81 (28.54)
T_5	Pyraclostrobin 20% WG	23.36 (28.92)	17.87 (25.02)	16.00 (23.59)	19.07 (25.91)	23.79 (29.21)	18.53 (25.51)	16.07 (23.65)	19.47 (26.19)	28.29 (32.15)	19.53 (26.24)	17.03 (24.38)	21.62 (27.72)
T_6	Captan 70 & + Hexaconazole 5% WP	22.76 (28.51)	16.88 (24.27)	12.82 (20.99)	17.49 (24.73)	23.17 (28.79)	18.13 (25.22)	13.03 (21.17)	18.11 (25.2)	28.28 (32.14)	18.09 (25.18)	15.69 (23.34)	20.68 (27.07)
T_7	Control/ Untreated check	23.77 (29.2)	31.37 (34.08)	36.38 (37.12)	30.51 (33.55)	24.21 (29.49)	35.14 (36.38)	50.13 (45.1)	36.50 (37.18)	28.40 (32.22)	34.97 (36.27)	36.38 (37.12)	33.25 (35.23)
	CD at 5%				1.35				0.84				0.84
	S. Em.±				0.44				0.27				0.27

Effect on yield

Significant difference in grain yield was observed among treatments. The highest yield was recorded in Priaxor 500 SC @ 300 ml/ha (9.07 q/ha) followed by 200 ml/ha (8.83 q/ha) doses both statistically on par with each other and showing yield increase of 78.5% and 73.9% over control. Standard checks showed comparatively lower yields (7.66-7.88 q/ha) (Table 2; Fig. 1). The yield advantage may be attributed to prolonged disease control, improved leaf greenness, and enhanced photosynthetic efficiency (Kumar *et al*., 2021) [11].

Table 2: Effect of different treatments on yield of blackgram

Tr.no	Treatments	Cercospora leaf spot		Anthracnose		Powdery mildew		Yield (q/ha)	% yield Increase
		Mean PDI	Reduction over control (%)	Mean PDI	Reduction over control (%)	Mean PDI	Reduction over control (%)		
T_1	Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC	17.62 (24.83)	51.58	18.01 (25.12)	50.65	20.56 (26.98)	38.16	8.00	57.41
T_2	Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC	15.58 (23.26)	57.18	16.34 (23.85)	55.23	18.60 (25.56)	44.03	8.83	73.88
T_3	Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l SC	15.06 (22.85)	59.49	15.68 (23.34)	57.02	18.21 (25.28)	45.20	9.07	78.54
T_4	Fluxapyroxad 300 g/l SC	19.97 (26.56)	45.10	20.15 (26.69)	44.78	22.81 (28.54)	31.38	7.48	47.24
T_5	Pyraclostrobin 20% WG	19.07 (25.91)	47.57	19.47 (26.19)	46.66	21.62 (27.72)	34.96	7.66	50.79
T_6	Captan 70 & + Hexaconazole 5% WP	17.49 (24.73)	51.93	18.11 (25.2)	50.37	20.68 (27.07)	37.77	7.88	55.18
T_7	Control/ Untreated check	30.51 (33.55)		36.50 (37.18)	-	33.25 (35.23)	-	5.08	--
	CD at 5%	1.35		0.84		0.84		0.88	
	S. Em.±	0.44		0.27		0.27		0.28	

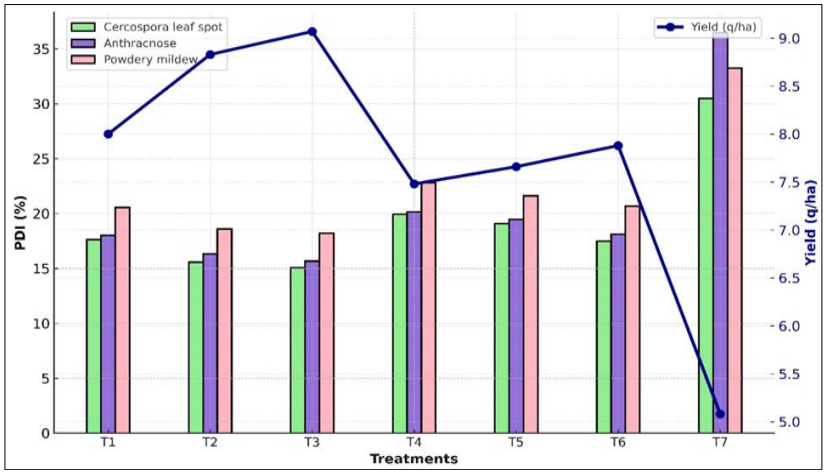

Fig 1: Effect of different treatments on PDI and yield of blackgram

Phytotoxicity

No phytotoxic symptoms such as leaf injury, wilting or necrosis were observed at any tested concentration of Priaxor 500 SC, confirming the crop safety of the formulation.

Conclusion

The study clearly demonstrated that Priaxor 500 SC (Fluxapyroxad 167 g/l + Pyraclostrobin 333 g/l) @ 200 ml/ha is optimum for effective management of major foliar fungal diseases of blackgram including Cercospora leaf spot, Anthracnose and Powdery mildew. The product not only reduced disease incidence significantly but also enhanced grain yield without showing any phytotoxic symptoms, thereby ensuring sustainable urdbean production.

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