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Dual-action fungicide: A breakthrough in the management of fungal foliar diseases of greengram (*Vigna radiata* L.)

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Abstract
Greengram cultivation is severely constrained by destructive foliar diseases, often causing yield losses of up to 60%. To address this challenge, a field trial was conducted during *kharif* 2021 at UAS, Dharwad to evaluate the efficacy of Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L 500 SC (Priaxor® 500 SC) against the major fungal foliar diseases of greengram (*Vigna radiata* L. Wilczek). Priaxor 500 SC effectively reduced Cercospora leaf spot, Anthracnose and Powdery mildew incidence. Application of this combi fungicide at 300 ml/ha recorded the lowest mean PDI values (15.84, 13.61 and 12.71) with corresponding yield improvement of 60.97 per cent over control which was closely followed by 200 ml/ha, which was statistically on par with higher dosage. No phytotoxic effects were observed even at higher doses. The superior efficacy is attributed to the complementary action of fluxapyroxad (SDHI) and pyraclostrobin (QoI), providing both preventive and curative protection. Priaxor 500 SC @ 200 ml/ha emerged as a highly effective, economically viable and safe option for managing foliar fungal diseases and enhancing productivity in greengram.

Keywords: Fluxapyroxad, greengram, priaxor 500 SC, pyraclostrobin

Introduction
Greengram also known as mungbean [*Vigna radiata* (L.) Wilczek] is vital legume in India, valued for its short duration, nitrogen-fixing ability and high nutritional content. It consists of 25-28% protein, 62-65% carbohydrates, essential amino acids and minerals, forming an essential part of vegetarian diets (Ali and Gupta, 2012) [1]. In India it is cultivated in area of 5 million ha with 2.5 million tonnes production (Singh *et al*. 2016) [14] and it is extensively grown in Dharwad, Belagavi, Gadag and Haveri districts of Karnataka.

Although India is leading producer of greengram, there is gap in productivity owing to diseases such as Cercospora leaf spot (*Cercospora canescens*), Anthracnose (*Colletotrichum truncatum*) and Powdery mildew (*Erysiphe polygoni*) (Pathak and Ram, 2013) [10], which can cause yield losses upto 30-60% (Balol *et al*., 2020) [2].

Effective chemical management becomes essential for safeguarding crop health and ensuring stable yields. Modern fungicides that combine strobilurin (QoI) and carboxamide (SDHI) molecules offer one of the most reliable approaches for managing these diseases. Pyraclostrobin inhibits mitochondrial respiration, while fluxapyroxad blocks succinate dehydrogenase (Bartlett *et al*., 2002) [5], and their premix formulation (Priaxor®) delivers both preventive and curative protection along with added physiological benefits. Therefore, this study evaluated the efficacy and crop safety of Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L 500 SC (Priaxor 500 SC) against major foliar fungal diseases of greengram under field conditions at UAS Dharwad.

Materials and Methods
A field experiment was conducted during *kharif* 2021 at Main Agricultural Research Station (MARS), University of Agricultural Sciences (UAS) Dharwad, Karnataka, to evaluate the bioefficacy and phytotoxicity of Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L 500 SC (Priaxor 500 SC) against major foliar fungal diseases of greengram.

The experimental site lies at an elevation of 678 m above mean sea level (15°26′ N latitude and 75°07′ E longitude) in the Northern Transitional Zone (Zone 8) of Karnataka, characterized by a semi-arid climate with an average annual rainfall of about 750-800 mm and the mean maximum temperature ranged between 27.2°C and 30.0°C with relative humidity ranging from 74-87% during the experiment period.

Experimental details: The experiment was laid out in a Randomized Block Design (RBD) with seven treatments and three replications. The greengram variety DGGV-2, moderately susceptible to foliar diseases, was sown at a spacing of 30 cm × 10 cm in plots of 5 m × 4 m (20 m²) under rainfed conditions. Standard agronomic practices recommended by UAS Dharwad for the region were followed for raising a healthy crop. Two sprays were applied at 14 days interval.

The details of treatments were as follows

Tr. No.	Treatments
T_1	Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L SC (Priaxor 500 SC) @ 100 ml/ha
T_2	Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L SC (Priaxor 500 SC) @ 200 ml/ha
T_3	Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L SC (Priaxor 500 SC) @ 300 ml/ha
T_4	Fluxapyroxad 300 g/L SC @ 166 ml/ha
T_5	Pyraclostrobin 20% WG @ 500 g/ha
T_6	Metiram 55% + Pyraclostrobin 5% WG @ 1500-1750 g/ha (Market check)
T_7	Untreated control

Disease assessment

Three major foliar fungal diseases, namely Cercospora leaf spot (*Cercospora canescens*), Anthracnose (*Colletotrichum* spp.) and Powdery Mildew (*Erysiphe polygoni*), were monitored. Disease severity was recorded on ten randomly selected plants per plot before spraying and 14 days after each spray.

The following rating scales were used

Powdery mildew: 0-5scale (Gawande and Patel, 1987) [6]

Cercospora leaf spot and Anthracnose: 0-9 scale (Mayee and Datar, 1986) [7]

The Per cent Disease Index (PDI) was calculated as per formula given by Wheeler (1969) [16]:

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

Phytotoxicity observation

Phytotoxic effects of Priaxor 500 SC were evaluated at 300, 375 and 600 ml/ha. Ten plants were randomly selected in each plot and observations were recorded at 1, 3, 5, 7 and 10 days after each spray for symptoms such as leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty, using a 0-10 scale (0 = no effect; 10 = 91-100% injury).

Yield estimation

At maturity, the crop was harvested and yield from each net plot was recorded and converted to quintals per hectare (q/ha). The per cent increase in yield over control was calculated to assess the economic advantage of fungicidal treatments.

Statistical Analysis

The data was subjected to analysis of variance (ANOVA) for RBD as per Panse and Sukhatme (1985) [8]. Treatment means were compared using the critical difference (CD) at 5% level of significance and standard error of mean (SEm±) was computed for reliability of comparison.

Results and Discussion

Efficacy against Cercospora leaf spot

All fungicidal treatments significantly reduced Cercospora leaf spot severity compared to the untreated control. The mean PDI varied from15.84 to 31.35% across treatments. The lowest disease severity (15.84 PDI) was recorded in Priaxor 500 SC @ 300 ml/ha (T_3), closely followed by T_2 (Priaxor 500 SC @ 200 ml/ha) with disease severity of 16.19%, which was statistically on par with higher dosage (T_3). These treatments (T_2 and T_3) achieved 49.45 per cent and 48.34 per cent reduction in PDI over control (31.35). Metiram + Pyraclostrobin (1750 g/ha) (T_6) also provided effective control (18.44 PDI; 41.15% reduction). Single active ingredient treatments such as Pyraclostrobin 20% WG (T_5) and Fluxapyroxad 300 g/L SC (T_4) showed moderate efficacy with Per cent disease severity of 20.12 and 20.85%. Significant difference was observed among treatments (Table 1). The superior performance of Priaxor 500 SC can be attributed to the dual-site action of fluxapyroxad (SDHI) and pyraclostrobin (QoI), which interferes with fungal respiration and energy production. Similar synergistic effects were reported earlier by Bartlett *et al*. (2002) [5], and Pathak and Ram (2013) [10].

Efficacy against Anthracnose

The Similar trend was followed in Anthracnose severity. The mean PDI was lowest with Priaxor 500 SC @ 300 ml/ha (13.61), followed by T_2 (13.92), both T_3 and T_2 were statistically on par and significantly superior to other treatments. Consequently there was 64.86% and 64.06% reduction in disease severity over control (38.72 PDI). Metiram + Pyraclostrobin (1500-1750 g/ha) was next best treatment with 16.24 PDI and 58.05% reduction over control. Pyraclostrobin 20% WG (18.38 PDI) and Fluxapyroxad 300 g/L SC (18.78 PDI) provided moderate control. The untreated control recorded the maximum PDI of 38.72%. Statistical analysis revealed significant differences among treatments (Table 1). The combination formulation exhibited higher efficacy than single-molecule fungicides due to the complementary mechanisms of SDHI and QoI components that inhibit pathogen respiration at different sites in the mitochondrial electron transport chain.

Efficacy against powdery mildew

The results presented in Table 1 indicate that Priaxor 500 SC effectively suppressed powdery mildew (*Erysiphe polygoni*). The mean PDI of 12.71 at 300 ml/ha and 13.04 at 200 ml/ha showed 49.68% and 48.39% reduction over untreated control (25.26 PDI). Both doses were statistically

on par with each other. Metiram + Pyraclostrobin (1750 g/ha) also provided considerable protection (15.35 PDI; 39.25% reduction). Pyraclostrobin 20% WG (17.17 PDI) and Fluxapyroxad 300 g/L SC (18.21 PDI) were less effective. The strong curative and translaminar properties of Priaxor 500 SC ensured rapid inhibition of fungal growth and sustained control. These findings are consistent with earlier reports of Sharma (1999), Balol *et al*. (2021) [3] and Singh *et al*. (2016) [14], who noted superior performance of strobilurin-based mixtures in managing powdery mildew of greengram. Similar results have been reported on other crops such as chickpea Sangeeta *et al.,* 2022) [11], urdbean (Balol *et al.,* 2020) [2], Onion (Shilpahumari *et al*., 2011) [13], Mango (Vamshika *et al.*, 2023) [15] and greengram (Rengima *et al.,* 2025) where fungicide application has reduced the disease and increased the yield.

Table 1: Effect of different treatments on fungal foliar diseases of greengram

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 @ 100 ml/ha	25.46 (30.32)	17.19 (24.51)	13.10 (21.23)	18.58 (25.55)	20.75 (27.11)	16.45 (23.94)	13.45 (21.52)	16.88 (24.27)	18.89 (25.77)	14.84 (22.67)	13.14 (21.26)	15.62 (23.29)
T_2	Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L SC @ 200 ml/ha	25.88 (30.59)	14.16 (22.11)	8.53 (16.99)	16.19 (23.74)	20.12 (26.66)	12.19 (20.45)	9.44 (17.9)	13.92 (21.91)	18.64 (25.59)	12.02 (20.29)	8.45 (16.9)	13.04 (21.18)
T_3	Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L SC @ 300 ml/ha	25.72 (30.49)	13.83 (21.84)	7.98 (16.42)	15.84 (23.47)	20.68 (27.06)	11.52 (19.85)	8.61 (17.08)	13.61 (21.66)	18.75 (25.67)	11.55 (19.88)	7.82 (16.25)	12.71 (20.9)
T_4	Fluxapyroxad 300 g/L SC @ 166 ml/ha	25.64 (30.43)	20.07 (26.63)	16.85 (24.25)	20.85 (27.19)	20.08 (26.64)	18.72 (25.65)	17.54 (24.77)	18.78 (25.69)	18.75 (25.67)	16.06 (23.64)	19.83 (26.46)	18.21 (25.28)
T_5	Pyraclostrobin 20% WG @ 500 g/ha	25.81 (30.55)	18.21 (25.28)	16.33 (23.85)	20.12 (26.66)	20.58 (26.99)	17.59 (24.81)	16.97 (24.34)	18.38 (25.4)	18.74 (25.66)	15.75 (23.39)	17.03 (24.38)	17.17 (24.49)
T_6	Metiram 55% + Pyraclostrobin 5% WG @ 1500-1750 g/ha	25.77 (30.52)	16.94 (24.31)	12.62 (20.82)	18.44 (25.45)	20.20 (26.72)	15.84 (23.46)	12.69 (20.88)	16.24 (23.78)	18.82 (25.73)	14.52 (22.41)	12.69 (20.88)	15.35 (23.07)
T_7	Untreated control	25.62 (30.43)	29.97 (33.21)	38.44 (38.34)	31.35 (34.06)	20.48 (26.92)	40.03 (39.27)	55.65 (48.27)	38.72 (38.5)	18.64 (25.59)	25.06 (30.06)	32.09 (34.52)	25.26 (30.19)
	CD at 5%				0.98				0.76				0.86
	S. Em.±				0.32				0.24				0.28

Effect on grain yield

Application of Priaxor 500 SC significantly increased grain yield (Table. 2). Maximum yields were obtained in T_3 with dosage of 300 ml/ha (8.66 q/ha) and T_2 with dosage of 200 ml/ha (8.45 q/ha), representing 60.97% and 57.13% increase over the untreated control (5.38 q/ha). These were statistically on par with each other and superior to all other treatments. Metiram+ Pyraclostrobin produced 7.42 q/ha, while Pyraclostrobin 20% WG and Fluxapyroxad 300 g/L SC recorded 7.1 and 7.11 q/ha, respectively (Fig. 1). The yield increase under Priaxor 500 SC treatments is attributed to reduced foliar disease incidence, enhanced green leaf area, improved photosynthetic activity and delayed senescence (Bartlett *et al*. 2002) [5].

Table 2: Effect of different treatments on yield of greengram

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 @ 100 ml/ha	18.58 (25.55)	40.70	16.88 (24.27)	56.40	13.14 (21.26)	38.15	7.31	35.87
T_2	Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L SC @ 200 ml/ha	16.19 (23.74)	48.34	13.92 (21.91)	64.06	8.45 (16.9)	48.39	8.45	57.13
T_3	Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L SC @ 300 ml/ha	15.84 (23.47)	49.45	13.61 (21.66)	64.86	7.82 (16.25)	49.68	8.66	60.97
T_4	Fluxapyroxad 300 g/L SC @ 166 ml/ha	20.85 (27.19)	33.46	18.78 (25.69)	51.50	19.83 (26.46)	27.89	7.11	32.22
T_5	Pyraclostrobin 20% WG @ 500 g/ha	20.12 (26.66)	35.81	18.38 (25.4)	52.53	17.03 (24.38)	32.02	7.14	32.71
T_6	Metiram 55% + Pyraclostrobin 5% WG @ 1500-1750 g/ha	18.44 (25.45)	41.15	16.24 (23.78)	58.05	12.69 (20.88)	39.25	7.42	37.86
T_7	Untreated control	31.35 (34.06)		38.72 (38.5)		32.09 (34.52)		5.38	35.87
	CD at 5%	0.98		0.76			0.86	1.12	
	S. Em.±	0.32		0.24			0.28	0.36	

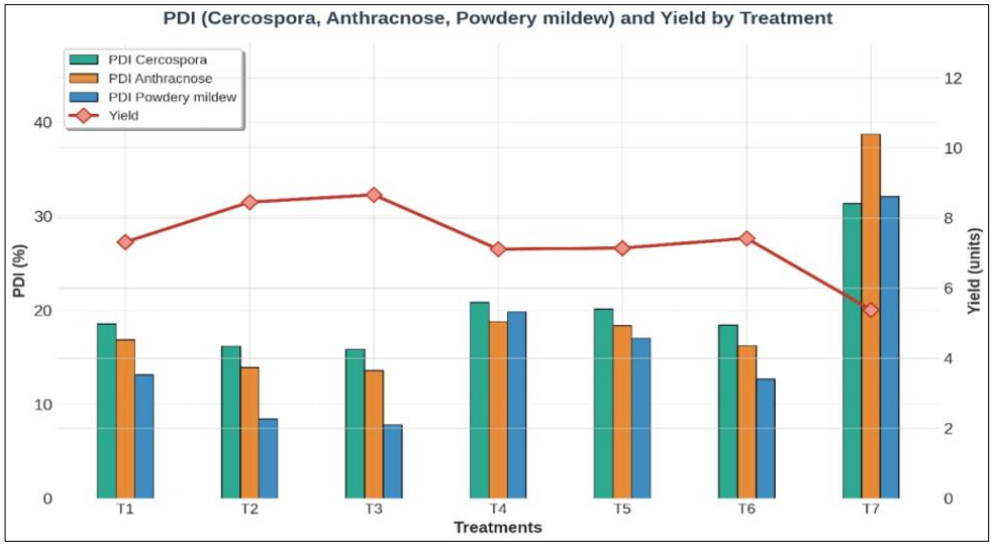

Fig 1: Effect of different treatments on PDI and yield of greengram

Phytotoxicity

No visible phytotoxic symptoms such as leaf injury, necrosis, vein clearing, wilting, epinasty or hyponasty were observed at any observation period or dose level (300, 375, and 600 ml/ha). All treated plots recorded 0% phytotoxicity throughout the study (Table 5). The results confirm that Priaxor 500 SC is safe for greengram even at higher than recommended doses, which aligns with earlier findings that fluxapyroxad + pyraclostrobin combinations exhibit excellent selectivity on legume crops (Ali and Gupta 2012) [1].

Conclusion

Fluxapyroxad 167 g/L + Pyraclostrobin 333 g/L 500 SC (Priaxor 500 SC) proved highly effective in managing Cercospora leaf spot, Anthracnose and Powdery Mildew of greengram. Application @ 200 ml/ha provided excellent disease control, increased yield and showed no phytotoxicity. The formulation is recommended as a reliable component in integrated disease management of greengram for higher productivity and sustainability.

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