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Field evaluation of fungicides for the management of powdery mildew disease (*Erysiphe polygoni* DC) of black gram and assessment of yield loss under Saurashtra condition

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Abstract
Powdery mildew caused by *Erysiphe polygoni* DC is a common constraint prevalent in Saurashtra region of Gujarat especially during late *Kharif* season. Considering the moderate to severe losses in yield caused by the disease, it is very necessary to have some information on effective fungicides for the management of the disease under field condition. In this context, an experiment was conducted at the Research Farm of the Department of Plant Pathology, College of Agriculture, JAU, Junagadh during *Kharif* 2021 to evaluate the efficacy of different fungicides for the management of powdery mildew disease of black gram. The results indicated that, two sprays of captan 70% + hexaconazole 5% WP at 0.15 per cent concentration first at initial appearance of symptoms and thereafter at twelve days interval remained the most effective treatment with minimum per cent disease intensity (18.12%), maximum disease control (74.49%), maximum seed yield (1238 kg/ha) and 80.20 per cent yield increase over control followed by wettable sulphur 80% WP (20.15 and 1216), hexaconazole 5% EC (21.20 and 1184), kresoxim-methyl 15% + chlorothalonil 56% WG (23.58 and 1108) and propiconazole 25% EC (24.50 and 1058), respectively with per cent disease intensity and seed yield kg/ha. Further, it was also revealed that the loss in seed yield of black gram due to powdery mildew disease was 35.18 per cent when no any control measures are adopted. Whereas, water sprayed control treatment exhibited avoidable yield loss of 5.40 per cent.

Keywords: Fungicides, powdery mildew, *Erysiphe polygoni*, black gram

Introduction
Black gram (*Vigna mungo* (L.) Hepper) locally known as ‘urd’, ‘biri’ or ‘mash’, originated in India belong to the family *Fabaceae*. India produces about 22.29 lakh tones of black gram annually from about 41.42 lakh hectares of area, with an average productivity of 538 kg per hectare (Anon., 2021) [3]. Powdery mildew has recognized as a pivotal disease of crops in all parts of the world from ages. Linnaeus (1767) [13] established the genus *Erysiphe* and De Candolle (1802) [6] described many species of this genus. Powdery mildew of black gram caused by *Erysiphe polygoni* DC is one of the major constraints in the production particularly late *Kharif* season, which causes both qualitative and quantitative loss of seeds. Abbaiah (1993) [1] noticed powdery mildew in black gram in 45 days old crop. It is the polycyclic disease that interferes in photosynthetic activity and causes significant physiological changes in plants eliciting stunted growth and senescence of host tissue. This results in 20 to 40 per cent reduction in yield depending on the stage and time at which the disease appears (Legapsi *et al*., 1978) [12]. Channaveeresh and Kulkarni (2014) [5] stated 40 to 90 per cent decrease in black gram yield due to powdery mildew infection under Dharwad condition of Karnataka. In Saurashtra region of Gujarat, the powdery mildew disease is emerging as a serious problem since last few years. Keeping in view the importance of black gram and the severity of the disease, the present work was carried out to know the effective fungicides and results obtained were documented in this paper.

Materials and methods
Field evaluation of fungicides for the management of powdery mildew disease of black gram: A field trial was conducted during *Kharif*-2021 at Research Farm, Department of Plant Pathology, Junagadh Agricultural University, Junagadh, Gujarat, India to find out the effective fungicide against powdery mildew disease.

The experiment was laid out in randomized block design with three replications. Certified seed of black gram variety (Gujarat Black gram-2) was sown at the rate of 20 kg/ha evenly in each of the gross plot size of 5.00 m × 2.70 m and net plot size of 4.00 m × 1.80 m, manually at a depth of 2-3 cm in the fertilized (20:40:00 NPK kg/ha) furrows at 45 cm × 10 cm spacing on July 06, 2021 and the rows was covered by light planking. All agronomical practices were followed as and when required. The efficacy of two non-systemic fungicides namely, wettable sulphur 80% WP and mancozeb 75% WP, two systemic fungicides, *viz.*, propiconazole 25% EC and hexaconazole 5% EC and three ready-mix fungicides *viz.*, captan 70% + hexaconazole 5% WP, kresoxim-methyl 15% + chlorothalonil 56% WG and tebuconazole 50% + trifloxystrobin 25% WG were tested with untreated control. Required concentrations of fungicidal solution for foliar spray of each fungicide were prepared on the basis of active ingredient available in the formulation. Measured quantities of respective fungicide were added in required quantity of water so as to get the desired concentration. The spraying of fungicides was carried out at onset of disease followed by one additional spray at 12 days interval. Seed yield of net plot area 4.00 m ×1.80 m having 4 rows of each treatment was recorded after harvest of the crop. Finally, yield in kg/ha was worked out by multiplying yield of net plot area with multiple factor. Data were analyzed statistically at 5 per cent level of critical difference.

Disease Assessment

The assessment of disease was recorded by following the 0-9 scale (Mayee and Datar, 1986) [15] as mentioned in the Table 1. Observations on disease intensity were recorded from ten plants randomly selected from each treatment and five leaves from each plant was evaluated for their disease intensity from top, middle and lower portion of the plant after seven days of last spray. The first date on which powdery mildew symptoms observed in each treatment was considered as disease onset. Per cent disease intensity (PDI) was calculated by using the following formula given by Wheeler (1969) [20].

$$PDI = \frac{\text{Sum of total rating}}{\text{Total plants observed} \times \text{Maximum disease rating}} \times 100$$

The percentage disease control and the percentage deviation in yield were calculated with the help of formula given by Mathur *et al*. (1971) [14].

$$\text{Disease control \%} = \frac{\text{P.D.I in check} - \text{P.D.I in treatment}}{\text{P.D.I in check}} \times 100$$

$$\text{Yield increase \%} = \frac{\text{Yield in treatment} - \text{Yield in check}}{\text{Yield in check}} \times 100$$

Table 1: Assessment of powdery mildew

Scale	Description
0	No symptoms on leaves
1	Small powdery spots on leaves covering less than 1% of leaf area
3	Powdery lesions on leaves small, scattered, covering 1-10% of leaf area.
5	Powdery lesions bigger, covering 11-25% of leaf area.
7	Powdery patches bigger, coalescing covering 26-50% of leaf area. Also on petioles, flowers and pods.
9	Powdery growth covering 51% or more of the leaf area. White coating on petioles, flowers and pods resulting in its shedding. Reduced pod set.

Assessment of yield loss under Saurashtra condition

For assessment of yield loss, black gram variety, GU-2 was sown following large plot technique in three strips of the size 24.0 m × 2.7 m at a distance of 45 cm × 10 cm. One strip was sprayed with propiconazole 25 EC at 0.025 per cent concentration first at the time of initiation of the disease and subsequent spray at ten days interval to maintain disease free condition. The remaining two strips were kept as control (with and without water spray). Spraying of water was done as suggested by Yarwood (1939) [21] that water also control powdery mildew, therefore, one such treatment was kept as control. Observations on disease intensity were recorded from ten plants randomly selected from each treatment after seven days of last spray using 0-9 scale (Mayee and Datar, 1986) [15] as given in Table 1. Five leaves from each plant was evaluated for their disease intensity from top, middle and lower portion of the plant. The seed yield was recorded from each treatment from eight subplots made in each strip. The seeds from each eight samples of the size 2.0 m × 1.8 m was drawn from all the three strips at maturity of crop and loss was estimated on the basis of yield obtained in different treatments in terms of percentage according to formula given below (Gupta and Singh, 1981) [8].

$$\text{Yield loss (\%)} = \frac{\text{Yield of protected plot} - \text{Yield of unprotected plot}}{\text{Yield of protected plot}} \times 100$$

Results and Discussion

Evaluation of fungicides *in vivo*

The efficacy of different seven fungicides *viz.*, wettable sulphur 80% WP, mancozeb 75% WP, propiconazole 25% EC, hexaconazole 5% EC, captan 70% + hexaconazole 5% WP, kresoxim-methyl 15% + chlorothalonil 56% WG and tebuconazole 50% + trifloxystrobin 25% WG were tested against *E. polygoni* causing powdery mildew disease in black gram variety Gujarat Urd-2 under field condition during late *Kharif*-2021.

The first spray of fungicides was given after the onset of the disease and second at 12 days interval. Observation on per cent disease intensity was recorded from ten plants randomly selected from each treatment after seven days of last spray using 0-9 scale as described in Materials and Methods. The data were subjected to statistical analysis after using arc sine transformation for calculating per cent disease incidence. The yield was recorded from each plot and computed to yield in kg/ha.

Effect of fungicides on percent disease intensity

The data presented in Table 2 disclosed that all the fungicides were effective in reducing the disease intensity as compared to control. Among different treatments, captan 70% + hexaconazole 5% WP 0.15% found to be the most effective fungicidewith 18.12 per cent disease intensity and was remained statistically at par with wettable sulphur 80% WP,

hexaconazole 5% EC, kresoxim-methyl 15% + chlorothalonil 56% WG and propiconazole 25% EC with per cent disease intensity of 20.15, 21.20, 23.58 and 24.50, respectively. Tebuconazole 50% + trifloxystrobin 25% WG remained the next effective treatment with 28.54 per cent disease intensity, but it was remain statistically at par with mancozeb 75% WP with 30.56 per cent disease intensity. The control treatment recorded the maximum per cent disease intensity of 71.01. The per cent disease control observed were as low as 56.97 per cent in case of mancozeb 75% WP to as high as 74.49 per cent with captan 70% + hexaconazole 5% WP as compared to control.

Fig 1: Unsprayed (A) and sprayed (B) with captan 70% + hexaconazole 5% WP in black gram crop

The results obtained in this study are in close agreement with several researchers who reported management of powdery mildew disease in various crops through fungicides. The effectiveness of captan 70% + hexaconazole 5% WP in black gram powdery mildew caused by *E. polygoni* was accounted by Balol *et al*. (2020) [4] in one of his literatures showing a disease intensity of 15.85 per cent. Similar observation was also made by Sharma *et al*. (2017) [17] with very low per cent disease intensity of 1.48 when sprayed at a concentration of 750g/ha. The effectiveness of hexaconazole alone was given by Dhruj *et al*. (2000) [7] in managing fenugreek powdery mildew caused by *E. polygoni* and Khunti *et al*. (2005) [10] while working with management of mung bean powdery mildew disease.

Effect of fungicides on seed yield (kg/ha)

The data presented in Table 2 indicated that all fungicidal treatments were effective in increasing the seed yield of black gram as compared to control. The maximum seed yield of 1238 kg/ha was observed in the treatment of captan 70% + hexaconazole 5% WP, but it was remained statistically at par with wettable sulphur 80% WP, hexaconazole 5% EC, kresoxim-methyl 15% + chlorothalonil 56% WG and propiconazole 25% EC with 1216, 1184, 1108 and1058 kg/ha of seed yield, respectively. The next effective fungicide observed was tebuconazole 50% + trifloxystrobin 25% WG with seed yield of 1014 kg/ha, butit was remained at par with mancozeb 75% WP with 989 kg/ha seed yield.The control treatment produced a seed yield of 687 kg/ha.

The corresponding per cent increase in seed yield was also recorded higher in the treatment of captan 70% + hexaconazole 5% WP (80.20%) followed by wettable sulphur 80% WP (76.95%), hexaconazole 5% EC (72.34%), kresoxim-methyl 15% + chlorothalonil 56% WG (61.23%), propiconazole 25% EC (54.05%), tebuconazole 50% + trifloxystrobin 25% WG (47.60%) and mancozeb 75% WP (43.91%).

Table 2: Field evaluation of fungicides for the management of powdery mildew disease of black gram

Sr. No.	Fungicide	Concentration (%)	Per cent disease intensity (%)	Disease Control (%)	Seed yield (kg/ha)	Yield increase over control (%)
1.	Wettable sulphur 80% WP	0.20	26.67 (20.15)	71.63	1216	76.95
2.	Mancozeb 75% WP	0.20	33.56 (30.56)	56.97	989	43.91
3.	Propiconazole 25% EC	0.025	29.67 (24.50)	65.50	1058	54.05
4.	Hexaconazole 5% EC	0.005	27.42 (21.20)	70.14	1184	72.34
5.	Captan 70% + Hexaconazole 5% WP	0.15	25.19 (18.12)	74.49	1238	80.20
6.	Kresoxim-methyl 15% + Chlorothalonil 56% WG	0.14	29.05 (23.58)	66.79	1108	61.23
7.	Tebuconazole 50% + Trifloxystrobin 25% WG	0.05	32.29 (28.54)	59.81	1014	47.60
8.	Control		57.42 (71.01)		687	
S. Em. ±			2.05		66.32	
C.D at 5%			6.21		194	
C.V.%			10.86		10.82	

*****Values in parentheses are re-transformed values while outside were transformed with arcsine transformation before analysis

The effectiveness of fungicides can be perhaps attributed to the efficiency of triazole group that interfere with the biosynthesis of fungal sterols and inhibit ergosterol biosynthesis. The reason behind is the fact that ergosterol is essential for the structure of cell wall and its absence causes irreparable damage to the cell wall thus fungus dies. Apart from this also interfere in conidia and haustoria formation. These changes in a sterol content and saturation of the polar fatty acids leading to alterations in membrane fluidity and behaviour of membrane bound enzymes (Nene and Thapliyal, 1993) [16].

The present findings are in close proximity with the similar kind of results obtained by Akhtar *et al*. (2014) [2] while working with powdery mildew in black gram. Kunkalikar and Padaganur (1990) [11], Dhruj *et al*. (2000) [7] and Balol *et al*. (2020) [4] have also reported efficacy of fungicides against powdery mildew disease in green gram, fenugreek and black gram, respectively.

Yield loss assessment

To assess the seed yield loss of black gram due to powdery mildew disease, an experiment was conducted during *Kharif*-2021 with three treatments including a water spray strip and an untreated control strip. In the treated strip, the foliar application of propiconazole 25% EC (0.025%) was first given at the time of initiation of disease and subsequently at ten days interval to maintain a disease free condition. The per cent disease intensity was recorded after seven days of last spray using the 0-9 scale. The seed yield was recorded after harvesting of the crop from each strip having eight subplots

and analyzed statistically.

The data presented in Table 3 indicated that treated strip with propiconazole 25% EC 0.025% resulted in 22.19 per cent disease intensity. Whereas, water spray and without water spray (untreated control) strips recorded 67.57 and 70.66 per cent disease intensity, respectively. Consequently, a maximum disease control of 68.59 per cent and a maximum seed yield of 1026 kg/ha was recorded in the treated strip. Corresponding yield in water spray and untreated control treatment gave seed yield of 703 and 665 kg/ha. The per cent disease control observed in water spray was only 4.37 per cent.

Table 3: Yield loss assessment due to powdery mildew disease in black gram

Sr. No.	Treatment	Per cent disease intensity (%)	Per cent disease control (%)	Seed yield (kg/ha)	Avoidable seed yield loss (%)
1.	Propiconazole 25% E (0.025%)	28.10 (22.19)	68.59	1026	35.18
2.	Control (water spray)	55.28 (67.57)	4.37	703	5.40
3.	Control (Absolute)	57.20 (70.66)		665	
	S.Em.±	1.49		30.90	
	C.D at 5%	4.37		91.00	
	C.V. %	8.96		10.96	

*Values in parentheses are re-transformed values, while outside were transformed with arcsine transformation before analysis.

It can also be inferred that the loss in seed yield of black gram due to powdery mildew disease was 35.18 per cent when no any control measures are adopted including other diseases present in the field such as Cercospora leaf spot and anthracnose. Therefore, timely application of fungicides can avoid a loss in yield upto 35.18 per cent. Whereas in water sprayed control, the avoidable yield loss is only 5.40 per cent. More or less similar kinds of results of decrease in yield were also obtained by Teshome and Tegegn (2017) [18] and Jha *et al* (2019) [9] in field pea powdery mildew caused by *E. pisi* and Vekariya *et al.* (2020) [19] during yield loss assessment in green gram due to powdery mildew disease.

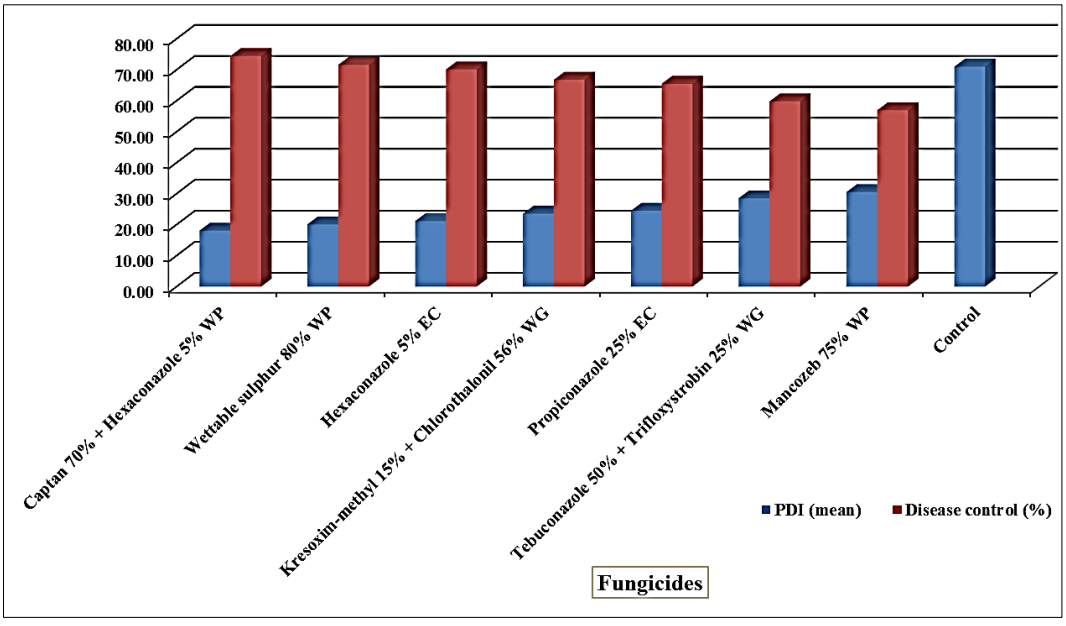

Fig 2: Per cent disease intensity (PDI) and disease control (%) under field evaluation of fungicides for the management of powdery mildew disease of black gram

Conclusion

All fungicidal application found effective in reducing the disease intensity and improving the yield of black gram. Two sprays of captan 70% + hexaconzole 5% WP at 0.15 per cent concentration first at initial appearance of symptoms and thereafter at twelve days interval remained the most effective treatment with minimum per cent disease intensity (18.12%), maximum disease control (74.49%), maximum seed yield (1238 kg/ha) and 80.20 per cent yield increase over control. Further, it was also revealed that the loss in seed yield of black gram due to powdery mildew disease was 35.18 per cent when no any control measures are adopted.

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