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Field management of *Corynespora cassiicola* in cotton under close spacings

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ABSTRACT

A field trial was conducted to evaluate the efficacy of different fungicides against Corynespora leaf spot in variety, LHDP Cotton – 5 at Regional Agricultural Research Station, Lam, Guntur during *Kharif* 2021-22 in a split-plot design with four main plots *viz*., 75 cm x 30 cm; 75 cm x 45 cm; 60 cm x 30 cm and 60 cm x 45 cm; and six subplots *viz*., T1-Hexaconazole@ 0.2%; T2-Carbendazim @ 0.1%; T3- Propiconazole @ 0.1%; T4-Metiram + pyraclostrobin@ 0.3%; T5-Fluxapyroxad + pyraclostrobin @ 0.06% and T6-Untreated Control and replicated twice. Three sprays were given at 15 days interval with the first spray initiated as soon as the disease was observed. Disease was scored by adopting a standard scale of 0 to 4 in ten plants tagged randomly. Significant difference was found among different fungicides tested over all spacings, however interaction effect was non significant. Least area under disease progress curve (413.91) was observed with fluxapyroxad + pyraclostrobin @ 0.06%indicating maximum efficacy of fluxapyroxad + pyraclostrobin @ 0.06% in controlling cotton Corynespora leaf spot. Highest reduction of disease (58.2%) and highest yield (30.20 q/ha) were recorded with fluxapyroxad + pyraclostrobin @ 0.06%. Highest benefit:cost ratio of 3.0 was obtained with propiconazole @ 0.1% followed by fluxapyroxad + pyraclostrobin @ 0.06% (2.95).

Key words: Corynespora leaf spot, cotton, fungicides, closer spacing, efficacy

Cotton is an important fibre crop worldwide. Cotton is referred to as "King of Fibres" and also as "White Gold". India is the largest country in the world cultivating cotton on an area of 130.49 lakh ha with a production of 337.23 lakh bales of 170 kg lint in 2022-2023. However, productivity is 439 kg ha^{-1}, which is far behind the leading countries. Andhra Pradesh ranks sixth in position both in cultivated area (6.95 Lakh ha) and production (18.85 Lakh bales) and fourth in productivity with 461kg lint ha^{-1} in India (Anonymous 2023). Corynespora target spot caused lint yield loss in susceptible cotton cultivars as high as 224-448 kg ha^{-1} equivalent to 5% to 40% (Conner *et al*., 2013; Hagan *et al*., 2015). Foliar diseases in cotton (fungal, bacterial and viral boll rot) were estimated to cause yield losses up to 20 to 30% in India. Among all the fungal foliar diseases, Corynespora leaf spot caused by *Corynespora cassiicola* has been increasing its prevalence and severity (Salunkhe *et al*., 2019). Corynespora leaf spot has been observed in Andhra Pradesh since 2017 and emerged as major leaf spot in cotton (Anonymous, 2021).

Increasing plant density is a promising approach for improving cotton yields and net profits. High density planting system (HDPS) is advocated to improve the productivity in light soils under rainfed conditions by increasing the plant population and decreasing the crop duration, cost of picking besides suitability for mechanical picking. Higher plant density under narrow plant spacing ensured higher seed cotton yield in all cotton genotypes and lesser CLCV infestation in MNH-886 and MNH-814 (Iqbal *et al*., 2012) and in IUB 13 (Iqbal *et al*., 2021). Alternaria leaf spot disease was found with significant intensity in closer spacing (2.2 lakh ha^{-1}) over wider spacing (1.11 lakh ha^{-1}) whereas, different HDP spacing(s) didn't influence the incidence of bacterial blight and grey mildew. However, higher density with closer row spacing recorded greater PDI of these diseases (Pandagale *et al*., 2020). Keeping in view of the regular occurrence of Corynespora leaf spot as major leaf spot disease in recent years, assessment of area under disease progress curve (AUDPC) under different spacing(s) revealed the

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highest AUDPC of 645.0 in 60 cm × 30 cm while the least AUDPC (585) in 75 cm × 45 cm at boll maturity and bursting stage (Mounika *et al*., 2023). The present investigation reports management of the disease under different spacing (s) and assess the best spacing for cost effectiveness.

MATERIALS AND METHODS

Field trial was conducted at Regional Agricultural Research Station, Lam, Guntur district, Andhra Pradesh during *Kharif* 2021-22. The experiment was laid out with variety, LHDP Cotton-5 in a split-plot design with four main plots *viz*., 75 cm x 30 cm; 75 cm x 45 cm; 60 cm x 30 cm and 60 cm x 45 cm; and six subplots *viz*., T1-Hexaconazole @ 0.2%; T2-Carbendazim @ 0.1%; T3-Propiconazole @ 0.1%; T4-Metiram + pyraclostrobin @ 0.3%; T5-Fluxapyroxad + pyraclostrobin @ 0.06% and T6-Untreated control which were replicated twice. Three sprays were given at 15 days interval with the first spray initiated as soon as the disease was observed. Ten plants were randomly selected per replication and tagged in each treatment. Border rows were excluded from observations. In each plant 10 leaves, three from bottom, four from middle and three from top portion were scored for Corynsora leaf spot by using 0-4 scale given by Shoe Raj (1988).

Disease scale for fungal leaf spot diseases of cotton

Scale	Per cent leaf area covered
0	No infection
1	Few spots of less than 2 mm size, leaf area covering less than 5%
2	Spots of 3 mm size, covering 6-20% of leaf area
3	Spots of 3-5 mm size, irregular in shape coalesce and covering 21-40% of leaf area.
4	Spots covering more than 40% of leaf area

Disease severity was recorded at seven day interval before and after spraying and PDI was calculated by using the formula of Wheeler (1969):

$$PDI = \frac{\text{Sum of numerical ratings}}{\text{Total number of leaves scored} \times \text{maximum rating}} \times 100$$

Plot wise yield data from two replications of each treatment were recorded. The data obtained were statistically analyzed following the standard procedures (Gomez and Gomez, 1984). To know the effective and economically feasible fungicide, benefit cost was calculated by dividing gross returns with gross expenditure for each treatment in comparison to untreated control.

RESULTS AND DISCUSSION

Prior to imposing treatments, *i.e*., in unsprayed plots, significant difference was found among different spacings tested when two factorial analysis was done. However, no significant difference was found in mean per cent disease index (PDI) among different fungicides tested over all spacings (Table 1). This indicated that at the initial stages, variation was observed among different spacings in predisposing the crop to Corynespora leaf spot in cotton. Interaction effect also gave non-significant difference which further indicated difference among the treatments was due to spacings (Table 1).

First spray was done at 70 DAS and disease severity was recorded at 15 days after first spray (*i.e.,* 85 DAS). The result indicated that difference among spacings was non-significant when mean PDI over all the fungicides tested was observed. However, significant difference existed among the fungicides when mean PDI was calculated over all spacings. Further, variation existed among the test fungicides in affecting the PDI of Corynespora leaf spot in cotton. Mean PDI values with fluxapyroxad + pyraclostrobin @ 0.06% (13.3), metiram+ pyraclostrobin @ 0.3% (14.4), hexaconazole @ 0.2% (14.7) and propiconazole @ 0.1% (14.8) were lowest (Fig. 1). Other test fungicides recorded significantly lesser effect. Among the test fungicides carbendazim @ 0.1% (16.1) spray resulted in highest PDI (Table 1). When interaction effect of test treatments was analysed, non-significant difference was observed among the treatments indicating effect of a particular fungicide on the disease is uniform irrespective of spacings tested, *i.e.,* the control of the disease was uniform in all the spacings tested after 15 days of treatment imposition.

As the disease progressed from 13.6 PDI (prior to first spray) to 20.9 PDI (15 days after first spray), a second spray was given and observations were recorded 15 days after second spray to see the impact of second spray on disease development. Data on PDI (15 days after second spray), indicated that difference in mean PDI in different spacings over all the fungicides was non-significant. It may

Table 1. Efficacy of fungicides on cotton Corynespora leaf spot under field conditions vis-a-vis crop geometry

Treatments	PDI before Spray				PDI after 1st Spray				PDI after 2nd Spray				PDI after 3rd Spray			
	75 cm × 30 cm	75 cm × 45 cm	60 cm × 30 cm	60 cm × 45 cm	75 cm × 30 cm	75 cm × 45 cm	60 cm × 30 cm	60 cm × 45 cm	75 cm × 30 cm	75 cm × 45 cm	60 cm × 30 cm	60 cm × 45 cm	75 cm × 30 cm	75 cm × 45 cm	60 cm × 30 cm	60 cm × 45 cm
T1	12.1 (20.4)	11.0 (19.3)	15.9 (23.5)	13.8 (21.7)	14.3 (22.2)	13.6 (21.6)	16.4 (23.9)	14.5 (22.4)	16.4 (23.9)	16.9 (24.2)	18.9 (25.7)	17.6 (24.8)	19.4 (26.1)	19.1 (25.9)	22.0 (27.9)	20.6 (27.0)
T2	11.5 (19.7)	11.5 (19.8)	13.6 (21.7)	14.5 (22.3)	15.3 (23.0)	14.3 (22.1)	18.4 (25.4)	16.5 (23.9)	18.9 (25.7)	18.0 (25.1)	20.9 (27.2)	19.4 (26.1)	21.0 (27.2)	22.3 (28.1)	25.1 (30.1)	21.0 (27.2)
T3	10.8 (19.1)	12.0 (20.3)	14.4 (22.2)	12.3 (20.5)	14.0 (21.9)	13.4 (21.3)	16.8 (24.1)	15.0 (22.8)	16.0 (24.8)	15.0 (22.7)	18.0 (25.1)	15.6 (23.3)	17.1 (24.4)	17.5 (24.7)	19.4 (26.1)	17.8 (24.9)
T4	13.4 (21.4)	11.9 (20.1)	14.9 (22.6)	12.0 (20.2)	13.6 (21.6)	13.1 (21.2)	16.3 (23.8)	14.8 (22.6)	15.9 (22.2)	14.9 (22.7)	17.9 (24.9)	16.0 (23.6)	17.9 (25.0)	15.9 (23.5)	19.1 (25.9)	16.9 (24.2)
T5	12.5 (20.7)	10.5 (18.9)	15.3 (23.0)	13.6 (21.6)	12.9 (21.0)	12.6 (20.8)	14.5 (22.3)	13.0 (21.1)	13.4 (21.4)	12.6 (20.7)	15.3 (23.0)	14.1 (22.0)	13.5 (21.5)	13.0 (21.1)	16.0 (23.5)	14.5 (22.2)
T6	13.0 (21.1)	12.3 (20.5)	15.0 (22.8)	14.0 (21.9)	20.5 (26.9)	19.1 (25.9)	22.9 (28.6)	21.3 (27.4)	26.8 (31.1)	24.8 (29.8)	31.6 (34.2)	29.4 (32.8)	33.1 (35.1)	31.4 (34.0)	37.4 (37.7)	34.4 (35.8)

	Before Spray			After 1st Spray			After 2nd Spray			After 3rd Spray		
	Spacings	Fungicides	Spacings × Fungicides	Spacings	Fungicides	Spacings × Fungicides	Spacings	Fungicides	Spacings × Fungicides	Spacings	Fungicides	Spacings × Fungicides
SEm±	0.32	0.62	1.23	0.75	0.52	1.04	0.80	0.59	1.17	0.87	0.59	1.17
CD (p≤0.05)	1.45	NS	NS	NS	1.54	NS	NS	1.73	NS	NS	1.73	NS
CV (%)	5.30	8.29	-	11.11	6.40	-	11.01	6.55	-	11.09	6.12	-

T1-Hexaconazole @ 0.2%; T2-Carbendazim @ 0.1%; T3-Propiconazole @ 0.1%; T4-Metiram + pyraclostrobin @ 0.3%; T5-Fluxapyroxad + pyraclostrobin @ 0.06% and T6-Untreated control.

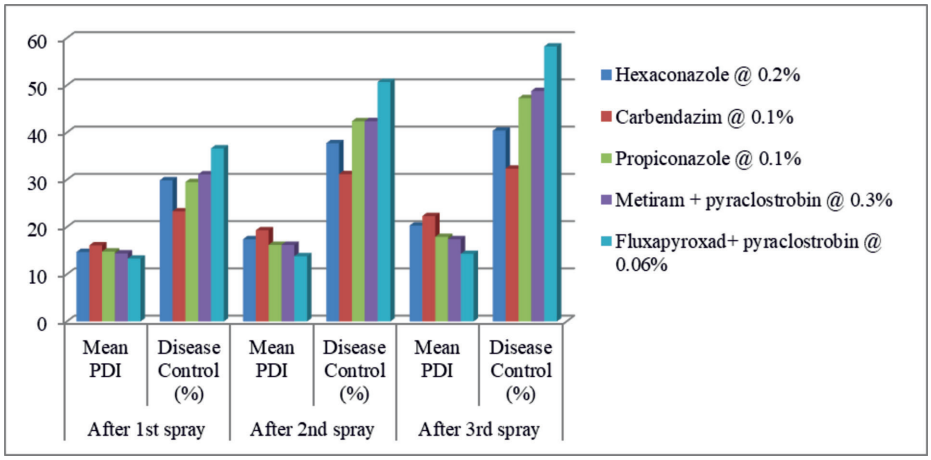

Fig. 1. Mean PDI and control of Corynespora leaf spot (%) in cotton under field conditions

be observed that similar trend of non significant difference was observed among different spacings in their effect on PDI even after second spray. This indicated that disease progression was uniform and not dependent on spacings evaluated. However significant differences were observed in mean PDI of different fungicides over all spacings tested. Similar result was also obtained after first spray. Further interaction effect was also found non-significant indicating that fungicidal efficacy was uniform among the spacings tested (Table 1).

Among the fungicides tested, fluxapyroxad + pyraclostrobin @ 0.06% (13.8 PDI) was found significantly superior over all other fungicides followed by metiram+ pyraclostrobin @ 0.3% (16.2 PDI), propiconazole@ 0.1% (16.2 PDI) and hexaconazole@ 0.2% (17.4 PDI) with insignificant difference among them. Among the test fungicides carbendazim @ 0.1% (19.3) gave least effect in controlling the disease (Table 1).

The disease *i.e.*, cotton Corynespora leaf spot continued to progress from 20.9PDI, 15 days after first spray, to 28.1PDI 15 days after second spray in control plot indicating continued disease development. Hence a third spray was given. When observations were recorded 15 days after third spray and analysed the result was in similar lines as observed earlier with first and second spray *i.e.*, non-significant difference in the

Table 2. Impact of different fungicide treatments on AUDPC of Corynespora leaf spot in cotton

Treatments	AUDPC				
	75 cm × 30 cm	75 cm × 45 cm	60 cm × 30 cm	60 cm × 45 cm	Mean AUDPC
T1-Hexaconazole@ 0.2%	497.81	498.75	570.94	527.81	523.83^{bc}
T2-Carbendazim @ 0.1%	555.00	543.75	639.38	571.88	577.50^{c}
T3-Propiconazole@ 0.1%	473.44	456.56	540.94	480.00	487.73^{b}
T4-Metiram + pyraclostrobin @ 0.3%	474.38	440.63	533.44	477.19	481.41^{b}
T5-Fluxapyroxad+ pyraclostrobin @ 0.06%	398.44	381.56	457.50	418.13	413.91^{a}
T6-Untreated Control	803.44	750.00	926.25	857.81	834.38^{d}

	Spacings	Fungicides	Spacings × Fungicides
SEm±	28.05	19.44	38.87
CD (p≤0.05)	NS	57.34	NS
CV (%)	17.57	9.90	-

Table 3. Seed cotton yield in different fungicide treatments during 2021-22

Treatment	Yield (q/ha)			
	75 cm × 30 cm	75 cm × 45 cm	60 cm × 30 cm	60 cm × 45 cm
T1-Hexaconazole @ 0.2%	20.35	16.85	27.56	20.00
T2-Carbendazim @ 0.1%	18.32	15.90	24.32	16.50
T3-Propiconazole @ 0.1%	23.15	18.32	28.60	20.10
T4-Metiram + pyraclostrobin @ 0.3%	24.20	20.25	30.00	22.82
T5-Fluxapyroxad+ pyraclostrobin @ 0.06%	25.16	22.00	30.20	23.40
T6-Untreated Control	15.50	14.50	20.80	14.23

mean PDI among different spacings tested, significant difference in PDI among different fungicides and non significant difference in PDI of interaction effect. Further, among different fungicides mean PDI over all spacings tested was significantly least in fluxapyroxad + pyraclostrobin @ 0.06% (14.3) which continued to show maximum reduction over control after three sprayings, followed by metiram+ pyraclostrobin @ 0.3% (17.4) and propiconazole @ 0.1% (17.9). Hexaconazole with 20.3 PDI stood after propiconazole. Maximum PDI was obtained with carbendazim @ 0.1% (22.3) among the fungicides tested indicating its lesser efficacy in controlling the disease compared to other test fungicides (Table 1 and Fig. 1)

The present result was in accordance with Molina *et al.* (2019), who reported that based on per cent decrease over the control, fluxapyroxad + pyroxystrobin (76.2%) and epoxiconazole + pyroxystrobin + fluxapyroxad (75.7%) were the most effective fungicides against target spot and the lowest levels of efficiency were observed for mancozeb (49.6%), azoxystrobin + benzovindiflupyr (46.7%) and carbendazim (32.4%). Significant control of fungal leaf spots caused by *Myrothecium*, *Alternaria* and *Cercospora* in upland cotton was reported with fluxapyroxad+pyroxystrobin @ 0.05% (Butter *et al*., 2022)

Teramoto *et al.* (2017) observed that fluxapyroxad and prothioconazole prevented an epidemic of target spot in soybean by 45% to 55% respectively, as against carbendazim (26% to 29%). The least PDI and highest per cent decrease over control was reported with 0.2% hexaconazole (Yamuna *et al*., 2020). Roshan Baba *et al*. (2022) obtained highest reduction of Corynespora leaf spot with propiconazole @ 0.1% (85.9%) and zineb + hexaconazole @ 0.2% (85.6%).

In the present investigation, analysis of PDI data in response to different HDP spacings and fungicides revealed non-significant difference of mean PDI among different spacings and interaction effect (spacings × fungicides). In order to further confirm, we

Table 4. Effect of fungicides on seed cotton yield (q/ha) of effective spacing (60 cm × 30 cm) and benefit cost ratio during *Kharif* 2021-22

Treatments	Conc. (%)	Yield (q/ha)	Gross expenditure (Rs)	Gross returns (Rs)	Net returns (Rs)	Benefit cost ratio
T1-Hexaconozole@ 0.2%	0.20	27.56	69000	234260	173260	2.84
T2-Carbendazim @ 0.1%	0.10	24.32	68175	206720	146545	2.43
T3-Propiconazole@ 0.1%	0.10	28.60	68700	243100	182400	3.00
T4-Metiram + Pyraclostrobin@ 0.3%	0.30	30.00	76500	255000	186500	2.72
T5- Fluxapyroxad + Pyraclostrobin@ 0.06%	0.06	30.20	72900	256700	191800	2.95
T6-Untreated Control	-	20.80	60500	176800	120300	2.12

have calculated AUDPC of cotton Corynespora leaf spot in different treatments. As seen earlier AUDPC analysis also revealed non-significant difference in the mean AUDPC as affected by different spacings over all the fungicides. However significant difference was obtained in mean AUDPC values of different fungicides over all spacings. Further, interaction effect was also found non-significant. Highest AUDPC was found in carbendazim @ 0.1% *i.e.,* 577.50 indicating its lesser efficacy. Least AUDPC was observed with fluxapyroxad + pyraclostrobin @ 0.06% *i.e.,* 413.91 indicating maximum efficacy of fluxapyroxad + pyraclostrobin @ 0.06% in controlling cotton Corynespora leaf spot (Table 2).

The highest yield (30.20q/ha) was recorded in 60 cm × 30 cm treated with fluxapyroxad + pyraclostrobin @ 0.06% followed by metiram + pyraclostrobin @ 0.3% (30.0q/ha) and propiconazole @ 0.1% (28.60 q/ha) (Table 3).The fungicides pyraclostrobin + fluxapyroxad and trifloxystrobin + prothioconazole increased whole plant yield and reduced the severity of target spot (De Souza *et al*., 2020).

Highest benefit: cost ratio was obtained with propiconazole @ 0.1% (3.00) followed by fluxapyroxad + pyraclostrobin @ 0.06% (2.95) (Table 4). Therefore, it is concluded that spacing of 60 cm × 30 cm and management of Corynespora leaf spot with fluxapyroxad + pyraclostrobin @ 0.06% helps to realize higher yields in cotton varieties.

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