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Management of Powdery Mildew in Cluster Bean using Fungicides, Botanicals and Bioagents

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ABSTRACT

Background: Cluster bean crop is affected by various biotic and abiotic stresses which are responsible for its poor quality and low yield resulting in severe economic losses. Among the foliar diseases, powdery mildew caused by *Leveillula taurica* is an important disease causing the yield losses ranging from 50-55 per cent. So, there is a need to formulate suitable management practices against powdery mildew.

Methods: Field experiment was laid-out in a randomized complete block design with three replications at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad to determine the efficacy of economically viable and effective fungicides, botanical and bioagent against powdery mildew of cluster bean. Observation on intensity of disease was recorded using 0-9 scale. The per cent disease index and yield per hectare were taken into consideration for statistical analysis.

Result: Among the thirteen combinations, two sprays of hexaconazole @ 0.1 per cent was found to be statistically significant in reducing the disease severity (11.75%) and enhancing pod yield (138.46%) upto 6.20 t ha^{-1} with C: B ratio of 1:3.23. The combined application of nimbecidine and *Bacillus subtilis* also showed significant impact on disease reduction as well as on yield of cluster bean. Relatively, the chemical, hexaconazole gave a higher benefit with minimum production cost and this approach is proposed to the cluster bean growing farmers to mitigate the powdery mildew.

Key words: Benefit cost ratio, Cluster bean, Hexaconazole, PDI.

INTRODUCTION

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] is an important legume crop belonging to family Fabaceae. It is a drought tolerant crop suitable for cultivation under rainfed conditions in arid and semi-arid regions of India. The sweet and tender young pods are consumed as a vegetable or snacks in north-western and southern India and the mature seeds can be eaten during food shortages (Pachundkar *et al.,* 2013). The green and tender pods are cooked as favorite vegetables in many parts of the country including South India. The green pods serve as a nutritious vegetable which contains water (82.5%), protein (3.7%), carbohydrate (9.9%), fat (0.2%), fibre (2.3%), other minerals (1.4%) *viz.* calcium (0.13%), phosphorus (0.25%), iron (5.8 mg/100 g) and vitamins (49 mg/100 g) (Deore *et al*. 2004). Young pods, fresh or dry forage are used as livestock feeds. The plant is also used as a green manure and cover crop. It yields up to 45.00 t ha^{-1} of green fodder, 6.00-9.00 t ha^{-1} of green pods and 0.70-3.00 t ha^{-1} of seeds (Anonymous, 2010). India is the largest producer of guar seeds with 80 per cent of total production in the world and Rajasthan is leading state producing 75 per cent of total production of India. In India, area under cluster bean cultivation is 5.15 million hectares and production of 2.46 million tonnes with a productivity of 478 kg ha^{-1} (Anonymous, 2017). In Karnataka it is cultivated round the year in limited area in districts like Dharwad, Belagavi, Vijayapura, Haveri *etc*. for tender vegetable pods.

The cluster bean crop is affected by various biotic and abiotic stresses which are responsible for its poor quality and low yield resulting in severe economic losses to the country as it is an important cash crop with a great potential for foreign exchange. Among biotic stresses, the damage caused by fungal foliar diseases is one of the major constraints. Among the foliar diseases, powdery mildew caused by *Leveillula taurica* is an important disease causing the yield loss upto 50-55 per cent (Channamma *et al.*, 2015a).The disease manifests mainly on leaves and pods. Severely affected plants are defoliated and weakened by premature drying and death of infected leaves. The incidence of powdery mildew is more observed in the regions where crop season is prolonged. Warm temperature (33°C or above), high humidity (more than 80 per cent) and bright sunshine are congenial conditions for disease development (Channamma *et al.,* 2015b).

Though there is large area under cluster bean cultivation in India, the productivity levels are low because of incidence of diseases in general and powdery mildew in particular.

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The studies carried on cluster bean are very few and as such there is no information related to powdery mildew disease. By considering the seriousness of disease and the economic losses caused by the disease, the present investigation was carried out to formulate suitable management practices against powdery mildew.

MATERIALS AND METHODS

The experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *Rabi* 2017. The recommended package of practices *viz*., Farm yard manure at the rate of 20 t ha^{-1} and fertilizers Urea, SSP (Single Super Phosphate), MOP (Muriate of Potash) at the rate of 25, 75 and 60 kg ha^{-1}, respectively were used. The whole amount of SSP and MOP; half amount of urea were applied as basal dose before sowing of seeds. The rest amount of urea was applied at 30 days after sowing (DAS). The experiment was laid out in a randomized complete block design (RCBD). The seeds of cluster bean cv. Pusa Navbahar were sown on the main field by following spacing of 30 × 15 cm and with plot size of 3 m × 3 m. Light irrigation was given immediately after sowing.

Based on the studies of Vijaykumar *et al*. (2021), Wettable sulphur (Sulfex 80% WP), hexaconazole (Contaf 5 EC), tebunconazole 50% + trifloxystrobin 25% WG (Nativo75% WG), nimbecidine (Azadirachtin 0.03%) and *Bacillus subtilis* (MT383652.1) were selected for field experiment.

Two sprays were given as per the combination and schedule along with unsprayed control to know their efficacy in managing the powdery mildew under natural epiphytotic condition. The first spray was done immediately after the onset of disease (35 DAS) followed by second spray at 15 days interval. The disease severity was recorded at 15 days after second spray on five randomly selected plants per plot. In each plant, 5 leaves from lower, middle and upper part of the plant were graded by using 0-9 scale (Mayee and Datar, 1986) and expressed as per cent disease index (PDI). Per cent reduction of disease over control and per cent increase in yield over control were also computed and presented in the Table 1.

Disease scoring scale

Score	Description
0	No symptom of powdery mildew on leaves.
1	Small scattered powdery mildew specks covering 1% or less leaf area.
3	Small powdery lesions covering 1-10 % of leaf area.
5	Powdery lesions enlarged covering 11-25 % of leaf area.
7	Powdery lesions coalesce to form big patches covering 26-50 % leaf area.
9	Big powdery patches covering 51 % or more leaf area and defoliation occur.

Per cent disease index was calculated by using formula given by Wheeler (1969).

$$PDI = \frac{\text{Sum of the all individual disease ratings}}{\text{Total number of leaves observed} \times \text{Maximum grade}} \times 100$$

Green tender pods harvested at different intervals from each plot and pod yield per plot was converted into tonnes per hectare. Finally the cost of production was analyzed in order to find out the most economic treatment of different management practices. Cost and return analysis were done according to the procedure of Kushwah *et al*. (2017) and Bhupender *et al*. (2020). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benifit cost ratio} = \frac{\text{Gross return per ha}}{\text{Total cost of production per ha}}$$

For analyzing the experimental data, arcsine angular transformations were made and the data analyzed with ANOVA in randomized completely block design using IBM SPSS statistics 21 to test for significant difference among the treatments. In the study, observed significant differences at 5% level of significance (P value>0.05) for per cent disease index and yield at different treatments (Walter, 1967).

RESULTS AND DISCUSSION

The results of the experiment are presented in Table 1. From the experimental results it was very clear that all the treatments significantly reduced the disease development compared to the unsprayed plot after two sprays in combination. Among the thirteen combinations, two sprays of hexaconazole (T_4) recorded the least PDI (11.75%) with highest yield of 6.20 t ha^{-1}, per cent disease reduction was upto 62.53 per cent and 138.33 per cent increase yield, which was significantly superior and found on par with two sprays of tebuconazole 50% + trifloxystrobin 25% WG (T_5) (14.27 PDI) with an yield of 5.98 t ha^{-1}. Least disease control was recorded with two sprays of *Bacillus subtilis* (T_1) (32.74 PDI) which yielded 3.65 t ha^{-1} as compared with unsprayed control 2.60 t ha^{-1}.

The cost benefit ratio has been worked out for different spray schedules and presented in the Table 2. The highest B:C ratio was obtained with spray schedule involving two sprays of hexaconazole (3.23) which is followed by two sprays of wettable sulphur (2.89) and two sprays of tebuconazole 50% + trifloxystrobin 25% WG (2.86). However lowest B: C ratio was observed in unsprayed control (1.48).

Fungicides still constitute the predominate part of the control measures used against powdery mildew. Use of newer chemicals has become more popular in recent years because of their quick results, especially in absence of resistant varieties. Foliar spray of hexaconazole, tebuconazole 50% + trifloxystrobin 25% WG and wettable sulphur provided 81.77, 77.86 and 65.52 per cent reduction of powdery mildew in cluster bean, respectively. Hexaconazole is sterol inhibiting fungicide effectively managed the powdery mildew disease. The triazole fungicide, hexaconazole at 0.1 per cent effectively managed the powdery mildew disease and it is sterol inhibiting fungicide where ergosterol was essential to the structure of cell wall and its absence causes irreparable damage to the cell wall and fungus dies off (Ramesh *et al*., 2013). They will also interfere in conidia and haustoria formation (Bademiyya and Ashtaputre, 2019). They change the sterol content and saturation of the polar fatty acids leading to alterations in membrane fluidity and behaviour of membrane bound enzymes. They affect the cytochrome P-450 enzymes the inhibitors of sterol C-14 demethylation (Nene and Thapliyal, 1993).

Sangani *et al*. (2015) studied the effect of different fungicides against powdery mildew on cluster bean under the field condition during two seasons in 2013-2014 and found that wettable sulphur and hexaconazole were effective in managing the disease by recording least disease intensity of 22.42 and 22.86 per cent and higher disease reduction of 65.69 and 65.02 per cent over control, respectively. Raju *et al.* (2017) conducted an field experiment to know the effect of different fungicides against powdery mildew disease of capsicum (F1 hybrid 'Indra') and found that hexaconazole (0.1%) proved to be the best for the management of powdery mildew with minimum per cent disease index (15.86%) and maximum fruit yield (92.15 t/ha) as compared to untreated control (76.33%) with lower fruit yield (45.83 t/ha). Daunde *et al*. (2018) also reported that foliar application of hexaconazole (0.1%) has resulted in minimum disease severity of 19.94 per cent with 73.44 per cent control of powdery mildew in chilli as compared to untreated control. Gorak (2017) who conducted a field evaluation of fungicides against powdery mildew of chilli and his study revealed that, there was continuous reduction in powdery mildew severity in the treatment hexaconazole (0.1 %) with mean PDI 16.79.

Hingole and Kurundkar (2011) also reported that triazoles were most effective in reducing the powdery mildew intensity of chilli (*Leveillula taurica*). Among them, penconazole, propiconazole, hexaconazole and difenconazole reduced the disease effectively and enhanced the yield. However, treatment with three sprays of hexaconazole (0.1%) recorded higher net returns compared to other treatments. Several workers reported that, hexaconazole and propiconazole were found to be effective in reducing powdery mildew severity in different crops (Naik and Nagaraja, 2000; Pramod Prasad and Dwivedi, 2007; Akhileshwari *et al*., 2012; Channamma, 2015 and Jahir Basha *et al*., 2017).

Table 1: Field evaluation of spray schedule involving fungicides, botanical and bioagent for the management of cluster bean powdery mildew.

Treatments	Spray schedule	PDI	Per cent disease reduction over control	Yield tonnes /ha	Per cent increase in yield over control	B:C ratio
T_1	Two sprays of *Bacillus subtilis* @ 1% at 15 days interval	32.74 (34.90)*	49.19	3.65	40.38	1.95
T_2	Two sprays of Nimbecidine @ 10% at 15 days interval	29.97 (33.19)	53.49	4.37	68.08	2.10
T_3	Two sprays of Wettable sulphur @ 0.3% at 15 days interval	22.22 (28.12)	65.52	5.56	113.85	2.89
T_4	Two sprays of Hexaconazole @ 0.1% at 15 days interval	11.75 (20.05)	81.77	6.20	138.46	3.23
T_5	Two sprays of Tebunconazole 50% + Trifloxystrobin 25% WG @ 0.2% at 15 days interval	14.27 (22.19)	77.86	5.98	130.00	2.86
T_6	Sprays of *Bacillus subtilis* @ 1% followed by Nimbecidine @ 10% at 15 days interval	30.71 (33.65)	52.34	4.12	58.46	2.17
T_7	Sprays of *Bacillus subtilis* @ 1% followed by Wettable sulphur @ 0.3% at 15 days interval	29.68 (33.01)	53.94	4.45	71.15	2.35
T_8	Sprays of *Bacillus subtilis* @ 1% followed by Hexaconazole @ 0.1% at 15 days interval	27.50 (31.63)	57.32	4.84	86.15	2.55
T_9	Sprays of *Bacillus subtilis* @ 1% followed by Tebunconazole 50% + Trifloxystrobin 25% WG @ 0.2% at 15 days interval	26.07 (30.70)	59.54	5.25	101.92	2.64
T_{10}	Sprays of Nimbecidine @ 10% followed by Wettable sulphur @ 0.3% at 15 days interval	31.11 (33.90)	51.72	3.84	47.69	2.01
T_{11}	Sprays of Nimbecidine @ 10% followed by Hexaconazole @ 0.1% at 15 days interval	26.52 (31.00)	58.85	5.07	95.00	2.64
T_{12}	Sprays of Nimbecidine @ 10% followed byTebunconazole 50% + Trifloxystrobin 25% WG @ 0.2% at 15 days interval	25.18 (30.12)	60.92	5.34	105.38	2.65
T_{13}	Unsprayed Control	64.44 (53.39)	-	2.60	-	1.48
S.Em. ±		1.06		0.27		
C.D. (P = 0.05)		3.10		0.80		

* Figures in the parenthesis are arc sine transformed values

Table 2: Economic analysis of different powdery mildew management practices in cluster bean cultivation.

Treatments	Spray schedule	Yield (kg/ha)	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs.)	Benefit cost ratio
T_1	Two sprays of *Bacillus subtilis* @ 1% at 15 days interval	3,650	91,250	46,792	44,458	1.95
T_2	Two sprays of Nimbecidine @ 10% at 15 days interval	4,037	1,00,925	48,046	52,879	2.10
T_3	Two sprays of Wettable sulphur @ 0.3% at 15 days interval	5,560	1,39,000	48,156	90,844	2.89
T_4	Two sprays of Hexaconazole @ 0.1% at 15 days interval	6,200	1,55,000	48,012	1,06,988	3.23
T_5	Two sprays of Tebunconazole 50% + Trifloxystrobin 25 % WG @ 0.2% at 15 days interval	5,980	1,49,500	52,324	97,176	2.86
T_6	Sprays of *Bacillus subtilis* @ 1% followed by Nimbecidine @ 10% at 15 days interval	4,120	1,03,000	47,560	55,440	2.17
T_7	Sprays of *Bacillus subtilis* @ 1% followed by Wettable sulphur @ 0.3% at 15 days interval	4,450	1,11,250	47,412	63,838	2.35
T_8	Sprays of *Bacillus subtilis* @ 1% followed by Hexaconazole @ 0.1% at 15 days interval	4,840	1,21,000	47,368	73,632	2.55
T_9	Sprays of *Bacillus subtilis* @ 1% followed by Tebunconazole 50% + Trifloxystrobin 25 % WG @ 0.2% at 15 days interval	5,250	1,31,250	49,732	81,518	2.64
T_{10}	Sprays of Nimbecidine @ 10% followed by Wettable sulphur @ 0.3% at 15 days interval	3,840	96,000	47,718	48,282	2.01
T_{11}	Sprays of Nimbecidine @ 10% followed by Hexaconazole @ 0.1% at 15 days interval	5,070	1,26,750	48,010	78,740	2.64
T_{12}	Sprays ofNimbecidine @ 10% followed by Tebunconazole 50% + Trifloxystrobin 25% WG @ 0.2% at 15 days interval	5,340	1,33,500	50,318	83,182	2.65
T_{13}	Unsprayed control	2,600	65,000	43,972	21,028	1.48

Price: Rs. 25/kg pods.

CONCLUSION

The severity of powdery mildew in cluster bean can be significantly reduced by the foliar spray of hexaconazole or tebuconazole 50% + trifloxystrobin 25% WG @ 0.1 per cent at two times after the initiation of disease symptoms and later at 15 days interval. It also recorded higher grain yield and higher economic return.

Conflict of interest: None.

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