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Impact of Weather Parameters and Time of Sowing on Severity of Powdery Mildew in Cluster Bean

K.N. Vijaykumar[1], Shripad Kulkarni[2], D.N. Kambrekar[3], T.R. Shashidhar[4], S.M. Hiremath[4], Gurupad Balol[5]

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ABSTRACT

Background: Powdery mildew of cluster bean causes considerable yield loss upto 50-55%. Studies carried on cluster bean powdery mildew are very few and as such there is no information related to epidemiology of the disease. Environmental factors decide the epidemic of the disease and are being used to forecast the disease severity.

Methods: Five different dates of sowing of cluster bean were evaluated in a randomized complete block design with four replications at Main Agricultural Research Station, College of Agriculture, Dharwad. Observations on the first appearance of the disease and severity were recorded at weekly intervals using disease scoring scale 0-9 and along with pod yield were considered for statistical analysis. The weather data was used to correlate with the disease severity and correlation matrix was worked out. Further, the observations were converted to % disease index to calculate rate of infection and area under disease progress curve (AUDPC) for each date of sowing.

Result: Sowing of crop in first fortnight of September recorded the minimum mean disease severity of 19.10% and recorded pod yield of 4.72 t/ha with lower value of area under disease progress curve (1270.50) as against crop sown in first fortnight of November that recorded the 39.39 % of maximum mean disease severity, 3.82 t/ha pod yield and 2583.88 of area under disease progress curve. The mean maximum temperature was positively correlated (0.89) with % disease index whereas, minimum temperature (-0.87), morning relative humidity (-0.81) and evening relative humidity (-0.88) were negatively correlated with % disease index. Disease progression was started at 35 days after sowing and the maximum 'r' value of 0.157 was observed during the II fortnight of September followed by an 'r' value of 0.142 during the I fortnight of September whereas, a lower 'r' value of 0.009 was observed in I fortnight of September sown crop at 63-69 days after sowing.

Key words: AUDPC, Cluster bean, Dates of sowing, Per cent disease index, Rate of infection.

INTRODUCTION

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] is a drought tolerant legume crop grown as green manure, green fodder and vegetable crop for human consumption since ancient times in India. The crop has special importance because of gum content present in its seed (Pachundkar *et al.,* 2013). The major states involved in its production are Gujarat, Haryana, Punjab, Uttar Pradesh, Odisha, Maharashtra, Madhya Pradesh and Karnataka (Vijaykumar *et al*., 2022). The green and tender pods are cooked as favourite vegetables in many parts of the country including South 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. Young pods, fresh or dry forage are used as livestock feeds. The plant is also used as a green manure and cover crop. Like other legumes, cluster bean is an excellent soil-building crop with respect to availability of nitrogen. Root nodules contain nitrogen-fixing bacteria and crop residues, when ploughed under the soil improve the yields of succeeding crops (Pathak *et al*., 2009).

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. Powdery mildew caused by *Leveillula taurica* (Lev.) Arn. manifests mainly on leaves and pods. Severely affected plants are defoliated and weakened by premature drying and death of infected leaves. Environmental factors decide the epidemic of the disease and are being used to

[1]ICAR-Indian Agricultural Research Institute, Regional Research Centre, Dharwad-580 005, Karnataka, India.
[2]Institute of Organic Farming, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India.
[3]ICAR-Krishi Vigyan Kendra, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India.
[4]Department of Horticulture, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India.
[5]AICRP on MULLaRP, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India.

Corresponding Author: Shripad Kulkarni, Institute of Organic Farming, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India. Email: kulkarnish@uasd.in

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forecast the disease severity. The knowledge of weather conditions for the development and spread of disease are important to organize agro-advisory services to the farmers to take up timely management practices (Campbell and Madden, 1990). The studies carried on cluster bean are very few and as such there is no information related to epidemiology of powdery mildew disease. Under favourable conditions, the powdery mildew causes considerable defoliation leading to yield loss upto 50-55% (Channamma *et al.,* 2017). With this background, the present study has been undertaken to study the epidemiology of cluster bean powdery mildew with respect to different dates of sowing.

MATERIALS AND METHODS

The most susceptible genotype (Pusa Navbahar) was sown in 2m×2m area in field condition at Main Agricultural Research Station, College of Agriculture, Dharwad during 2017 to assess the progress of powdery mildew at different dates of sowing. The first date of sowing was undertaken on 1st fortnight of September and subsequent sowings were done at an interval of 15 days till the last sowing was carried on 1st fortnight of November. Totally five different dates of sowings were carried out in the experiment. Observations on the first appearance of the disease and severity of disease was recorded on five plants in each plot for all the dates of sowing using a disease scoring scale 0-9 (Mayee and Datar, 1986). Further, these observations were converted to % disease index (PDI) using the formula given by Wheeler (1969) and compared with all the treatments to find out the best sowing date. The weather data of Main Agricultural Research Station, Dharwad meteorological unit 2017 was used to correlate with the PDI and correlation matrix was worked out to study the impact of weather parameters on powdery mildew of cluster bean in relation to time of sowing.

The rate of infection of disease (r) at weekly intervals was calculated by the formula given by Vander Plank (1963) and the area under disease progress curve (AUDPC) for each sowing was calculated using the formula given by Wilcoxson *et al.* (1975).

Apparent rate of infection (r)

$$\text{Rate of disease spread (r)} = \frac{2.3}{t_2 - t_1} \log_{10}\left[\frac{X_2}{1-X_2} - \frac{X_1}{1-X_1}\right]$$

Where,

r = Apparent rate of infection (units day $^{-1}$).

X_1 = PDI at initial week time (t_1).

X_2 = PDI at subsequent week time (t_2).

$t_2 - t_1$= Time interval in days between the two consecutive observations.

Area under disease progress curve (AUDPC)

$$\text{AUDPC} = \sum_{i=1}^{k}\left[\frac{X_i + X_{i-1}}{2}\right] \times d$$

Where,

X_i =Disease severity at the end of the i^{th} week of evaluation.

k = Number of successive evaluation of powdery mildew.

d = Days interval between two evaluations.

RESULTS AND DISCUSSION

The results on the effect of different dates of sowing of cluster bean on powdery mildew development are presented in Table 1. The results of the experiment revealed that sowing of crop in I fortnight (FN) of September recorded the minimum mean disease severity (19.10%) with maximum pod yield of 4.72 t/ha followed by crop sown in II FN of September recorded disease severity of 25.52 % with pod yield of 4.12 t/ha as against the crop sown in I FN of November recorded maximum disease severity of 39.39 % and minimum pod yield of 3.82 t/ha. In first date of sowing, powdery mildew infection started at 35 days after sowing

Table 1: Effect of date of sowing on severity of powdery mildew in cluster bean.

Treatments	% Disease Index (PDI)								
	35 DAS	42 DAS	49 DAS	56 DAS	63 DAS	70 DAS	77 DAS	Mean	Yield (t/ha)
I Fortnight of September	3.88 (11.36)*	6.84 (15.16)	16.54 (23.99)	20.89 (27.19)	26.76 (31.14)	28.01 (31.94)	31.00 (33.82)	19.10 (25.93)	4.72
II Fortnight of September	6.45 (14.71)	8.84 (14.71)	22.54 (28.33)	24.52 (29.67)	32.76 (34.90)	40.50 (39.51)	43.00 (40.96)	25.52 (30.33)	4.12
I Fortnight of October	10.95 (19.32)	17.16 (24.46)	27.00 (31.29)	29.00 (32.57)	36.65 (37.24)	39.75 (39.07)	45.46 (42.38)	29.42 (32.84)	4.03
II Fortnight of October	11.78 (20.07)	15.86 (23.46)	27.09 (31.35)	31.07 (33.86)	43.44 (41.21)	49.71 (44.82)	54.44 (4.53)	33.34 (35.26)	3.89
I Fortnight of November	15.25 (22.98)	26.76 (31.14)	36.10 (36.91)	39.07 (38.67)	46.90 (43.21)	53.17 (46.80)	58.50 (49.87)	39.39 (38.86)	3.82
S.Em.±	0.474	0.645	0.945	0.86	1.036	1.038	1.119	0.897	0.148
C.D. (P = 0.05)	1.478	2.008	2.945	2.68	3.227	3.235	3.485	2.796	0.461

*Figures in the parenthesis are arc sine transformed value.

Table 2: Effect of date of sowing on severity of cluster bean powdery mildew in relation to weather parameters during 2017.

Date of sowing	Meteorological standard week	% Disease index	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	No. of rainy days
			Max.	Min.	Max.	Min.		
I Fortnight of September	40	3.88	28.60	20.34	94.57	90.85	6.97	1.00
	41	6.84	28.90	21.40	95.90	88.90	1.30	0.00
	42	16.54	29.80	20.50	93.90	82.40	6.00	1.00
	43	20.89	29.60	19.90	93.40	81.90	0.20	0.00
	44	26.76	30.30	16.10	87.70	78.70	0.00	0.00
	45	28.01	29.62	16.40	87.70	78.10	0.00	0.00
	46	31.00	30.12	14.08	77.42	63.85	0.00	0.00
Correlation coefficient	-	1.00	0.89**	-0.87**	-0.81*	-0.88**	-0.71*	-0.58
II Fortnight of September	42	6.45	29.26	20.27	94.28	81.57	5.48	1.00
	43	8.84	29.40	19.50	92.30	82.40	0.20	0.00
	44	22.54	30.02	15.80	87.90	79.30	0.00	0.00
	45	24.52	29.54	16.25	84.71	74.85	0.00	0.00
	46	32.76	29.94	14.35	78.57	64.42	0.00	0.00
	47	40.50	30.01	18.27	87.14	73.00	2.31	0.00
	48	43.00	29.95	14.95	79.57	57.57	0.00	0.00
Correlation coefficient	-	1.00	0.84**	-0.69*	-0.82**	-0.84**	-0.41	-0.59
I Fortnight of October	45	10.95	29.60	16.00	89.60	81.70	0.00	0.00
	46	17.16	29.40	14.90	78.00	68.14	0.00	0.00
	47	27.00	29.80	16.03	84.57	67.14	0.00	0.00
	48	29.00	29.76	17.64	85.57	69.43	2.31	0.00
	49	36.65	29.85	15.4	80.10	58.70	0.00	0.00
	50	39.75	29.62	17.44	83.86	69.43	0.06	0.00
	51	45.96	30.45	14.44	85.29	68.00	0.00	0.00
Correlation coefficient	-	1.00	0.72*	-0.03	-0.14	-0.61	-0.01	0.00
II Fortnight of October	47	11.78	29.69	16.03	84.57	68.14	0.00	0.00
	48	15.86	29.76	16.76	82.43	73.71	0.00	0.00
	49	27.09	28.96	16.18	81.43	60.57	0.00	0.00
	50	31.07	29.60	16.57	82.42	70.00	0.06	0.00
	51	43.44	29.80	14.50	87.30	70.70	0.00	0.00
	52	49.71	29.90	11.70	84.4	76.00	0.00	0.00
	1 week (2018)	54.44	30.60	15.30	83.80	67.70	0.00	0.00
Correlation coefficient	-	1.00	0.55	-0.65	-0.33	-0.16	-0.05	0.00
I Fortnight of November	49	15.25	28.76	16.97	83.86	63.14	0.00	0.00

Table 1: Continue....

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	51	36.10	28.95	14.3	86.90	72.90	0.00	0.00	
	52	39.07	28.64	11.47	84.29	74.14	0.00	0.00	
1 week (2018)		46.90	29.54	11.00	76.00	71.70	0.00	0.00	
	2	53.17	28.86	13.34	84.86	63.14	0.00	0.00	
	3	58.50	30.83	16.21	74.14	55.71	0.00	0.00	
Correlation coefficient	-	1.00	0.54	-0.40	-0.51	-0.30	-0.37	0.00	

*Significant at 5% level of probability; **Significant at 1% level of probability

(DAS) with 3.88% and progressed up to 31% at 77 DAS. In second date of sowing, disease progression was up to 43.00% whereas, third date of sowing recorded 45.46% disease severity. In fourth and fifth date of sowing, disease started earlier and recorded the maximum disease severity of 54.44 and 58.50%, respectively. Irrespective of dates of sowing, the disease initiated at 35 days after sowing and reached the highest disease index at 77 DAS which indicated that pod initiation and pod development stages were highly susceptible to the powdery mildew. From the results it was very clear that disease development was very high if crop is sown in between I fortnight of October to I fortnight of November. The results are in line with the findings of Guzman Plazola *et al*. (2003) whose observations revealed that higher temperature (>32°C) coupled with very low relative humidity positively influenced the development of powdery mildew in tomato.

The powdery mildew severity obtained at different stages of crop growth and different dates of sowing was correlated with weather parameters prevailed during the respective date of sowing. The correlation coefficients are presented in Table 2. The results reveal that powdery mildew severity was significantly positive relation with maximum temperature (0.89**) whereas, minimum temperature (-0.87**), morning relative humidity (-0.81**) and evening relative humidity (-0.88**) showed negative relation with powdery mildew severity. On the other hand, rainfall (-0.71*) and number of rainy days (-0.58) showed significantly negative correlation with powdery mildew severity. The weather parameters *viz*., minimum temperature, morning and evening relative humidity, rainfall and number of rainy days did not play any significant role in powdery mildew disease development.

Ashtaputre (2006) while working with chilli powdery mildew observed maximum temperature had positive correlation while minimum temperature, maximum and minimum relative humidity and rainfall were negatively correlated with disease development. In general, powdery mildew development is most rapid if low relative humidity coincides with warm weather. The ability of the powdery mildew to spread under dry climatic conditions is largely due to the capacity of their conidia to disseminate and germinate at lower humidity than at moist condition. These findings were in conformation with the reports of Reuveni and Rotem (1973) and Clerk and Ayesu-Offei (1967) who worked on sunflower powdery mildew reported that severity of powdery mildew had negative correlation with rainfall.

In the present investigation the apparent rate of infection value varied and at times they did not remain consistent for given date of sowing and also did not show a particular trend which is attributed to weather factors of the locality and results are presented in Table 3. The highest 'r' value of 0.157 was observed at 42-48 DAS during the II FN of September sown crop followed by I FN September sown crop (0.142). The least 'r' value of 0.009 was observed at 63-69 DAS in I FN September sown crop. The AUDPC values were also differed considerably for different dates of sowing. The highest AUDPC value was observed in I FN

Table 3: Apparent rate of infection (r) of powdery mildew and computed values for area under disease progress curve (AUDPC) at different time of sowing in cluster bean.

Time of sowing	Rate of spread (r)/ DAS						AUDPC
	35-41	42-48	49-55	56-62	63-69	70-77	value
I Fortnight of September	0.085	0.142	0.041	0.046	0.009	0.021	1270.50
II Fortnight of September	0.049	0.157	0.016	0.058	0.048	0.015	1679.76
I Fortnight of October	0.074	0.083	0.014	0.050	0.019	0.033	1926.93
II Fortnight of October	0.049	0.097	0.028	0.076	0.036	0.027	2177.60
I Fortnight of November	0.101	0.062	0.018	0.046	0.036	0.031	2583.88

of November sown crop (2583.88) followed by II FN October sown crop (2177.60). The least AUDPC value was observed in I FN of September sown crop (1270.50) followed by II FN September sown crop (1679.76) and results are presented in Table 3. The timing of sowing can impact the severity and incidence of many diseases. Shifting the sowing time can prevent many diseases from attacking crops (Sud and Singh, 1984; Hedge and Anahosur, 1994). Harshraj *et al.* (2016) also recorded lower AUDPC values for powdery mildew during 21st July to 16th September, when temperature ranged between 21.4 to 28.7°C and relative humidity levels between 63.00 to 92.40%. The disease progressed much more rapidly and recorded the maximum AUDPC value due to higher temperature prevailed during the I FN of November. The environmental factors decide epidemic of powdery mildew of various crops. The weather parameters like temperature, relative humidity, rainfall and wind speed are important for disease development and these factors are being used to forecast the disease severity.

CONCLUSION

First fortnight of November sown crop recorded maximum disease severity of 58.50 PDI, whereas September sown crop recorded the least disease severity of 31.00 PDI. The severity of the disease was increased with increase in temperature, but decreased with the change in other parameters. The disease progression was much faster during first fortnight of November sown crop and recorded AUDPC value of 2583.88 due to dry spell. First fortnight of September sown crop had the highest 'r' value of 0.157 at 42-48 DAS followed by second fortnight of September (0.142). The natural epidemics of powdery mildew are strongly influenced by environmental conditions and severe disease appears every year in India. Hence, the weather parameters are important for disease development and these factors are being used to forecast the disease severity.

Conflict of interest

The authors have no conflict of interest to declare.

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