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Progression of Powdery Mildew, Alternaria Blight and Bacterial Leaf Blight of Cluster Bean in Relation to Weather Parameters

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A research was performed to assess the effect of weather parameters along with different date of sowing. Disease progress was influenced by different weather factors *viz*., temperature, relative humidity, sunshine and rainfall. For powdery mildew and Alternaria blight, maximum AUDPC (Area under disease progress curve) value were 333.9 and 378.3, respectively in the plants sown on 1st July and the lowest 191.4 and 205.1 in plants sown on 21st July 2014, respectively. However, effect of weather parameters on development of bacterial leaf blight resulted in abrupt increase in AUDPC from 289.4 to 444.5 in 4th to 5th week of inoculation, reaching its maximum 455.3 in 6th week of inoculation, due to fluctuating in rainfall and relative humidity. Lowest AUDPC 82.6 was observed in last sowing done on 21st July.

Keywords: Powdery mildew, Alternaria blight, Bacterial leaf blight, Disease progression, AUDPC (area under disease progress curve).

Cluster bean (Cyamopsis tetragonoloba) is an important leguminous herb, highly adapted to arid and semi-arid parts of the world requiring low inputs and care. The seeds are highly valued for industrial gum. It is cultivated mainly in rainy season as a rainfed crop in arid zones of India and various other parts of the world (Pathak *et al*. 2009). Sustainable cluster bean cultivation is continuously challenged by diseases that cause quantitative and qualitative losses in yield. The crop is suffering from number of fungal, bacterial, viral and mycoplasmal diseases. Among them the fungal diseases like *Alternaria cyamopsidis* causing blight, *Leveillula taurica*, causing powdery mildew, *Macrophomina phaseolina* causing dry root rot, *Cercospora canescens* causing cercospora leaf spot and *Curvularia lunata* causing curvularia leaf spot and *Xanthomonas axonopodis* pv *cyamopsidis* causing bacterial blight. Apart from this a number of fungi *viz*. *Collectotrichum capsici* f.sp. *cyamopsicola*, *Fusarium moniliforme*, *Pseudomonas cyamopsicola,* and *Ascochyta* are known to be carried by seeds and pathogenic to cluster bean and causes reduction in seed germination and loss of early seedling vigour. Bacterial blight has become a serious problem in many cluster bean production areas, during monsoon season i.e. July-October (Patel *et al* 1953; Srivastava and Rao 1963). Early infection may reduce the yield to a great extent (Gandhi and Chand 1985). Management of these infecting pathogens is difficult due to unavailability of commercial resistant varieties to these diseases. The disease progress curve, referred to as the signature of an epidemic, represents the integration of all the host, pathogen and environmental effects

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during the epidemic (Campbell and Madden 1990). The Area under Diseased Progress Curved (AUDPC) was decreased significantly for all different weather parameters. The correlation between AUDPC and weather parameters was varied. AUDPC was strongly correlated with all the meteorological attributes. The value of AUDPC was negatively correlated to different weather attributes proving that the pathogen had a damaging effect on the crop attributes of cluster bean.

The natural epidemics of blights are strongly influenced by environmental conditions and severe disease appears every year in India. Hence, the present study was confined on the epidemiological aspects of blights and powdery mildew of cluster bean was undertaken. In spite of a lot of work done on the chemical management of these diseases, invariably it was found ineffective in its economic management. One of the reasons would be insufficient information in the epidemiological aspects of the diseases.

MATERIALS AND METHODS

To understand the effect of various weather factors on development of powdery mildew, Alternaria blight and bacterial leaf blight of cluster bean, disease development was studied on plants by staggered weekly sowing. Based on disease severity, area under disease progress curve (AUDPC) was calculated. The experiment was conducted to find out the effect of weather conditions on development of Powdery mildew, Alternaria blight and Bacterial leaf blight on susceptible cluster bean cultivar. Pot experiments were laid out in completely randomized design (CRD) with five replications separately for each of the three diseases i.e., powdery mildew, Alternaria blight and bacterial leaf blight to find out the effect of environmental factors on the development of the three diseases on susceptible local cultivar in Kharif, 2014 in the cage house, at Department of Plant Pathology, RCA Udaipur. Cluster bean plants were raised in 25 cm earthen pots having soil: FYM (3:1) mixture from organic field where organic farming is practiced for past six years. Staggered sowings for each of the three diseases was done from 1stJuly and dates were as followed 7th, 14th and 21st July, 2014, after germination, 20-days-old plants were inoculated on 21st July, 27th July, 3rd Aug. and 10th Aug. in year 2014 respectively for each of the sowings. Inoculations were made with a spore suspension of inoculum concentration of 1×103 conidia ml-1 for Alternaria cyamopsidis and 2.5x108cfu/ml for X. axonopodis pv. cyamopsidis, and L. taurica was studied under un-inoculated natural conditions.

Powdery mildew naturally infected plants, Alternaria blight and bacterial leaf blight inoculated plants were periodically observed for disease severity and area under disease progress curve (AUDPC) calculation. Considerable variations were observed in AUDPC in four different dates of sowing and correlation with weather factors on disease development. To know the relationship between the dependent variable i.e., disease severity (s) and six independent variables weather factors (max. temp., min. temp., max. RH, min. RH, sunshine and rainfall) multiple regression analysis was done starting with 1stJuly and dates were as followed 7th, 14th and 21st July, 2014. By fitting equations, the contribution of weather factors in the development of powdery mildew, Alternaria blight and bacterial leaf blight was observed.

Periodical observation on disease progress of Pm, Alt. and Bac. Blight was recorded during disease prevailing period using five-point rating scale as described by Adinarayana *et al*., 2012, Pandey *et al*. 2003. Weather variables *viz*., temperature, RH, sunshine hours and rainfall *etc*. were also recorded for crop season and correlation was worked out.

Per cent disease index (PDI) was calculated based on each reading till physiological maturity of crop. The per cent infection index described by (Chester, 1959 and Wheeler, 1969) Weekly meteorological data on maximum and minimum temperature morning and evening relative humidity, rainfall and duration of sunshine hours were obtained from agro met observatory, Agronomy farm, RCA, Udaipur for the period between disease recordings to establish their correlation with disease development. Multiple regression equation, correlation coefficient and coefficient of multiple determination (R2) were calculated as per the standard statistical formula $Y = a + b1X1 + b2X2 + b3X3 + b4X4 + b5X5$ where Y = Percent disease index, a is intercept/ constant value, b1… b5 are regression coefficient of

corresponding independent weather variables, X1 …X5 are independent weathers variables. Area under disease progress curve (AUDPC) was calculated as described by Campbell and Madden (1990) as follows:

$$AUDPC = \sum_{i=1}^{n-1} \left(\frac{y_i + y_{i+1}}{2} \right) (t_{i+1} - t_i)$$

Where,

Y_i = The cumulative disease index expressed as a proportion at the i^{th} observation

t_i = Time (days after planting) at the i^{th} observations.

n = Total number of observations

RESULTS AND DISCUSSION

The area under disease progress curve (AUDPC) is a quantitative measure of disease intensity with time. It is used in plant pathology to indicate and compose level of resistance to disease among, effect of weather factors and different date of sowing. Lower AUDPC represented slower disease progression and the high AUDPC represents faster disease progression

Powdery mildew

The cluster bean grown in kharif season indicated that powdery mildew incidence started in the month of September. In the present study, powdery mildew AUDPC values were lower during 21st July to 16th September when temperature ranges in 21.4-28.7°C and relative humidity 63.0-92.4 per cent. The AUDPC values were moderate during 17th September to 30th September 2014. While increase in temperature (20.0- 33.9°C) during 1st October to 6th November 2014 period, the disease progression was much faster and high AUDPC values were obtained. It appeared that despite different ages of the cluster bean plants, the temperature of 19.4- 31.8°C and 16.6 to 33.2°C were the most confined during 24th September to 29th October 2014. These observations are useful for timely application of organic pesticides for checking further spread of the disease. This seems to be crucial stage when prophylactic control measures may be applied to suppress the disease. Manipulation of sowing time has some effect on the incidence and severity of many diseases. Many field crops can escape various diseases with the shifting of sowing time (Sud and Singh, 1984). This was supported by (Hedge and Anahosur, 1994). The multiple regression equation was Y = 92.13 - 0.166 X1 - 2.248 X2 + 0.255 X3 - 0.715 X4 - 1.514 X5 + 0.008 X6, and coefficient of multiple determination (R2), 1.0 mean 100 per cent these six independent weather variables are contributing for disease development. R2 were 0.97 (97%). It indicated that there was 97 % influence of six meteorological factors and the remaining 3 % variations were unexplained (Table-1).

Alternaria blight

Alternaria blight AUDPC values were low during 22nd July to 3rd September when temperature ranges in 22.8-29.1°C and relative humidity 76.1-89.3 per cent. The AUDPC values were moderate during 10th September to 30th September 2014. While increase in temperature (20.0-33.9°C and 18.4-31.4°C) during 1st October to 6th November 2014, the disease progression was much faster and high AUDPC values were obtained. It appeared that despite different date of sowings of the cluster bean, the temperature of 18.1- 34.4°C and 18.4 to 31.4°C were the most confined during 8th October to 6th November 2014. Some of the workers have studied various weather factors for disease development of A. solani (Gupta & Paul 2001, Dragomir 1995, Tong *et al*. 1994). The multiple regression equation was = 124.545 - 0.421X1 - 3.387 X2 + 0.126 X3** - 0.505 X4 - 1.170 X5 + 0.025 X6** Multiple correlation coefficients (R2) were 0.95 (95 %). It indicated that there was 95 % influence of six meteorological factors and the remaining 5 % variations were unexplained (Table-2). The period between 17th Sept. to 6th Nov. (2014) was found to be highly favorable for disease development and more severity during this period was observed in comparison to progressive phase. The minimum and maximum temperature range was 16.6 -20.0°C and 31.4-34.4°C accompanied with minimum and maximum relative humidity i.e. between 21.5 - 52.0 and 71.4 - 84.1 % respectively in progress phase AUDPC value range from 206.1 - 378.3% disease was found almost stable (Table-2). Meteorological conditions have a great effect on the development and severity of the disease (Humpherson-Jones & Phelps 1989, Marchegay *et al*. 1990, Hong & Fitt 1995, Hong *et al*. 1996, Shrestha *et al*. 2005).

Table 1. Progression of Powdery Mildew on cluster bean in relation to weather parameters in different dates of sowing under natural conditions during *Kharif* 2014

S. No.	Standard Weeks	Meteorological weeks	Temp.(°C)		Relative Humidity (%)		Sunshine (Hours)	Rainfall (mm)	AUDPC* Dates of sowing			
			Max	Min	Max	Min			1st July	7th July	14th July	21st July
1	29	16-22 July 14	31.9	24.3	80.7	63.0	2.9	95.6	0	0	0	0
2	30	23-29 July 2014	30.1	24.2	86.0	76.6	0.6	51.6	0	0	0	0
3	31	30 July-5 Aug.14	30.3	23.7	89.9	77.3	2.4	109.0	0	0	0	0
4	32	6-12 August 14	27.8	23.9	86.6	76.0	0.4	47.2	0	0	0	0
5	33	13-19 August-14	29.6	23.5	80.0	65.4	3.4	0.2	5.2	0	0	0
6	34	20-26 August 14	32.9	23.4	86.1	66.6	6.6	40.8	7.0	0	0	0
7	35	27 August-2 Sept.14	31.8	23.0	87.4	67.3	6.4	31.6	1.7	0	0	0
8	36	3-9 September 14	29.1	22.8	89.3	76.1	3.1	165.2	0	0	0	0
9	37	10-16 September 14	28.7	21.4	92.4	82.9	3.0	94.8	0	0	0	0
10	38	17-23 September 14	32.5	19.8	84.1	52.0	8.8	0.0	88.5	37.1	25.2	14.7
11	39	24-30 September 14	31.8	19.4	80.1	48.4	8.9	0.0	194.2	109.9	57.0	38.1
12	40	1-7 October 14	33.9	20.0	80.7	38.4	8.0	0.0	225.7	172.2	95.2	52.5
13	41	8-14 October 14	34.4	18.1	79.0	34.0	8.3	0.0	261.8	210.0	144.5	86.4
14	42	15-20 October 14	32.5	17.6	75.6	32.4	8.4	0.0	293.6	242.9	184.4	131.2
15	43	21-29 October 14	33.2	16.6	69.6	21.5	7.0	0.0	313.2	272.6	220.8	159.6
16	44	30-6 November 14	31.4	18.4	71.4	31.9	4.7	0.0	333.9	287.7	240.4	191.4

*Mean of five replications.
Inoculation started 20 days after sowing of each dates.
Observation started 7 days after inoculation at weekly intervals.
Dates are 21st July, 27th July, 3rd Aug. and 10th Aug. respectively

Table 2. Progression of Alternaria blight on cluster bean in relation to weather parameters in different dates of sowing under epiphytotic conditions during *Kharif* 2014

S. No.	Standard Weeks	Meteorological weeks	Temp.(°C)		Relative Humidity (%)		Sunshine (Hours)	Rainfall (mm)	AUDPC* Dates of sowing			
			Max	Min	Max	Min			1st July	7th July	14th July	21st July
1	29	16-22 July 14	31.9	24.3	80.7	63.0	2.9	95.6	0	0	0	0
2	30	23-29 July 2014	30.1	24.2	86.0	76.6	0.6	51.6	15.4	0	0	0
3	31	30 July-5 Aug.14	30.3	23.7	89.9	77.3	2.4	109.0	35.7	9.8	0	0
4	32	6-12 August 14	27.8	23.9	86.6	76.0	0.4	47.2	45.1	21.0	7.7	0
5	33	13-19 August-14	29.6	23.5	80.0	65.4	3.4	0.2	53.9	23.8	13.3	5.6
6	34	20-26 August 14	32.9	23.4	86.1	66.6	6.6	40.8	61.2	26.9	14.0	10.8
7	35	27 August-2 Sept.14	31.8	23.0	87.4	67.3	6.4	31.6	72.8	36.0	17.5	11.5
8	36	3-9 September 14	29.1	22.8	89.3	76.1	3.1	165.2	98.3	50.4	24.1	13.6
9	37	10-16 September 14	28.7	21.4	92.4	82.9	3.0	94.8	149.8	64.7	37.4	18.5
10	38	17-23 September 14	32.5	19.8	84.1	52.0	8.8	0.0	206.1	89.2	52.8	26.2
11	39	24-30 September 14	31.8	19.4	80.1	48.4	8.9	0.0	242.9	141.0	71.0	36.7
12	40	1-7 October 14	33.9	20.0	80.7	38.4	8.0	0.0	277.5	186.5	114.8	55.3
13	41	8-14 October 14	34.4	18.1	79.0	34.0	8.3	0.0	307.6	212.1	165.5	98.7
14	42	15-20 October 14	32.5	17.6	75.6	32.4	8.4	0.0	327.9	237.3	198.1	147.3
15	43	21-29 October 14	33.2	16.6	69.6	21.5	7.0	0.0	352.4	278.6	220.8	179.5
16	44	30-6 November 14	31.4	18.4	71.4	31.9	4.7	0.0	378.3	330.4	254.4	205.1

*Mean of five replications.
Inoculation started 20 days after sowing of each dates.
Observation started 7 days after inoculation at weekly intervals.
Dates are 21st July, 27th July, 3rd Aug. and 10th Aug. respectively

Table 3. Progression of Bacterial blight on cluster bean in relation to weather parameters in different dates of sowing under epiphytotic conditions during *Kharif* 2014

S. No.	Standard Weeks	Meteorological weeks	Temp.(°C)		Relative Humidity (%)		Sunshine (Hours)	Rainfall (mm)	AUDPC* Dates of sowing			
			Max	Min	Max	Min			1st July	7th July	14th July	21st July
1	29	16-22 July 14	31.9	24.3	80.7	63.0	2.9	95.6	42.7	0	0	0
2	30	23-29 July 2014	30.1	24.2	86.0	76.6	0.6	51.6	113.0	57.7	0	0
3	31	30 July-5 Aug.14	30.3	23.7	89.9	77.3	2.4	109.0	169.4	151.5	34.3	0
4	32	6-12 August 14	27.8	23.9	86.6	76.0	0.4	47.2	220.1	218.4	73.5	30.4
5	33	13-19 August-14	29.6	23.5	80.0	65.4	3.4	0.2	259.3	278.2	109.9	66.1
6	34	20-26 August 14	32.9	23.4	86.1	66.6	6.6	40.8	289.8	337.0	289.4	100.4
7	35	27 August-2 Sept.14	31.8	23.0	87.4	67.3	6.4	31.6	310.4	381.8	444.5	234.5
8	36	3-9 September 14	29.1	22.8	89.3	76.1	3.1	165.2	320.6	402.1	455.3	342.6
9	37	10-16 September 14	28.7	21.4	92.4	82.9	3.0	94.8	309.0	384.3	437.5	320.2
10	38	17-23 September 14	32.5	19.8	84.1	52.0	8.8	0.0	274.7	321.6	390.6	268.4
11	39	24-30 September 14	31.8	19.4	80.1	48.4	8.9	0.0	236.9	260.7	340.9	224.0
12	40	1-7 October 14	33.9	20.0	80.7	38.4	8.0	0.0	202.3	233.8	291.2	184.1
13	41	8-14 October 14	34.4	18.1	79.0	34.0	8.3	0.0	167.6	193.2	242.5	149.4
14	42	15-20 October 14	32.5	17.6	75.6	32.4	8.4	0.0	139.9	151.9	203.3	117.6
15	43	21-29 October 14	33.2	16.6	69.6	21.5	7.0	0.0	120.4	137.5	173.2	96.2
16	44	30-6 November 14	31.4	18.4	71.4	31.9	4.7	0.0	105.3	118.3	138.9	82.6

*Mean of five replications.
Inoculation started 20 days after sowing of each dates.
Observation started 7 days after inoculation at weekly intervals.
Dates are 21st July, 27th July, 3rd Aug. and 10th Aug. respectivel

Bacterial leaf blight

Bacterial leaf blight AUDPC values were low during 16th to 22nd July when temperature ranges in 24.3-31.9°C. The AUDPC values were high during 23rd July to 20th August 2014, when temperature range 23-30.10C and relative humidity 76.6-86.0 per cent. While decrease in temperature (23.0-31.8°C and 21.4-28.7°C) during 27st August to 10th September 2014, the disease progression was much faster and high AUDPC values were obtained. In 17th September to 1st October 2014 AUDPC constantly declined. From, 8th October to 6th November 2014 AUDPC sharply decreased due to increase in temperature, sunshine and decrease in RH & rainfall. These observations are useful for timely application of organic pesticides for checking further spread of the disease. The multiple regression equation = 76.56- 4.4212X1 + 1.6873X2** - 0.04743X3 + 0.3028X4** + 7.348X5**+1.1303 X6. Multiple correlation coefficients (R2) were 0.72 (72 %). It indicated that there was 72 % influence of six meteorological factors and the remaining 28 % variations were unexplained (Table- 3). In the pots having plants sown on 14th July and inoculated on 3rd August exhibited maximum bacterial blight and the disease recorded was higher as compared to other dates of sowing. The AUDPC abruptly increased from 4th to 5th week of inoculation from 289.4 to 444.5 reaching to its maximum 455.3 in 6th week of inoculation, due to increase and fluctuating in rainfall and relative humidity. The disease thereafter started gradually declining (Table- 3). However, The disease progress curve, referred to as the signature of an epidemic, represents the integration of all the host, pathogen and environmental effects during the epidemic (Campbell and Madden 1990).

CONCLUSION

Powdery mildew severity increased with increasing in temperature (16.6-33.2°C) & Sunshine hours, during 21st Oct. to 6th Nov., the disease progression was much faster and AUDPC values of 313.2 – 333.9 were observed due to dry spell. Alternaria blight severity increased with increasing in temperature (19.8-32.5°C) & Sunshine hours, decreasing in rainfall & RH during 17th Sep. to 6th Nov. period, the disease progression was much faster and AUDPC values of 206.1-378.3 were observed. Bacterial blight severity increased with decreasing in maximum temperature (22.8-29.1°C) AUDPC abruptly increased from 289.4 to 444.5 reaching its maximum 455.3 due to fluctuations in rainfall and relative humidity.

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