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Epidemiology of alternaria leaf blight of cluster bean caused by *Alternaria cucumerina var. cyamopsidis*

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Abstract
*Alternaria*sps are economically important pathogens widely distributed throughout the world and cause devastating disease on field crops. Alternaria leaf blight is a common disease in guar-growing area of western India and Pakistan. Severe Alternaria blight of cluster bean was also reported from Pusa and Madras. The Alternaria blight of Cluster bean was negatively correlated with maximum and minimum average temperature, whereas significant and positive correlation was observed with maximum and minimum average relative humidity and total rainfall. The regression equation also indicates the the Alternaria blight disease was negatively correlated with the maximum tempratature and positively influenced by average relative humidy and total rainfall. In epidemiological studies, it was concluded that meteorological parameters *viz;* maximum and minimum average temperature showed negatively correlation with the disease incidence. While maximum and minimum average relative humidity and total rainfall were positively and significantly correlated with the disease intensity. Temperature and relative humidity play a crucial role apart from the other parameters in the development of the disease. Alternaria blight is favoured by low temperature, high humidity and rainfall.

Keywords: the environmental parameters favoring of Alternaria blight in Cluste bean

Introduction
Clusterbean is being grown in India since ancient time. Although believed to be of African origin (Vavilov, 1951), Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] belongs to the family Fabaceae. It is an important dry land, drought hardy, annual Kharif crop grow widely under rainfed (barani) condition for grain, green fodder, vegetable, green manuring and for seed purposes. The major world suppliers are India, Pakistan and the United States with smaller acreages in Australia and Africa.The disease appears year after year in mild to severe form since the pathogen is seed- borne in nature (Sowell, 1965) [16]. In early stages of infection, the water soaked spots appear on leaf blade which later turn greyish to dark brown with concentric zonations, demarcated with light brown lines inside the spot on the under surface. The lesions are light to grayish brown. Higher yield losses (43-78 %) were recorded when leaves were infected at seedling stage than at old stage (Sharma, 1981) [9]. For the assessment of nature of damage, caused by the pathogen, survey is essential. It also helps in identification of the specific pathogen species and its aggressiveness prevailing in a particular area. During favourable weather conditions for disease development very meager work has been carried out on weather parameters, which are responsible for disease development. There is a positive correlation between weather parameters favourable for progressive development of disease in the crop (Gupta, 1997) [5].

Materials and Methods
The experiment was laid out at experimental field of Department of Plant Pathology on nine dates of sowing starting from June 23, 30, July 7, 14, 21, 28, August 4, 11 and 18 during 2016 and 2017. The meteorological data on temperature, relative humidity (RH) and rainfall were also recorded separately at weekly interval during the crop season in 2016 and 2017 from the Meteorological Department, College of Agriculture, Gwalior After emergence 10 plants from each plot were randomly selected tagged and inoculated with conidial suspension of *A. cyamopsidis*. The inoculated plants were covered by big polythene bags for three days. The initiation and progress of the disease was recorded on tagged plants at weekly interval starting from the first appearance of the symptoms. Simultaneously the meteorological parameters *viz*-temps. (Max and Mini), RH (Max. and Mini), and rainfall were also recorded. (Plate- 1)
After germination, the crop was regularly watched for first appearance of disease. The observation on disease intensity was recorded using a progressive 0-5 scale, (McKinney, 1923)

In the Numerical rating grade was given on the basis of percentage of area covered by pathogen on the leaves.

$$PDI = \frac{\text{Sum of all individual rating}}{\text{Total no. of leaf assessed x Maximum rating}} \text{x } 100$$

Plate 1: Effect of different date of sowing on the Alternaria blight intensity

Results and Discussion

Effect of environmental factors (temperature, relative humidity and rainfall) on the development of Alternaria blight of Cluster bean was studied in *Kharif* 2016 and 2017. Data was summarized in Table 01 and Figure 5-6 that the maximum average temperature (-0.1073^{NS}) and minimum average temperature (-0.0965*****) were negatively correlated whereas maximum average relative humidity (0.5708*****) and minimum relative humidity (0.6249*****) and total rainfall (0.6352*****) were positively correlated with the disease intensity.

The disease intensity on 23rd June 2016 sown crop, showed the negative correlation with maximum and minimum average temperature whereas positively correlated withall other parameters. The disease intensity was 2.2 % when the maximum temperature (34.22 ^{0}C) and minimum temperature (25.91 ^{0}C) was negatively correlated with the disease intensity while the maximum and minimum relative humidity were 90.57 % and 76.57 % and total rainfall was 17.28 mm respectively. In the next year i.e. 2017 the meteorological parameters have the same correlation with the disease intensity which was 6.2 %.

In the crop which was sown on 30th June 2016, the weather parameters were similarly correlated with the crop sown on 1st date i.e. 23 June. The disease intensity was 10.5 % when the maximum and minimum temperature were negatively correlated while maximum and minimum relative humidity and total rainfall was positively correlated. The maximum and minimum temperature were 32.08°C and 25.02°C, maximum and minimum relative humidity per cent were 94.85% and 73.14% and rainfall was 16.85 mmrespectively. In the next year i.e. 2017 the maximum and minimum temperature were 34.54 ^{0}C and 26.62^{0}C which were negative correlated. The maximum and minimum relative humidity and rainfall showed positive corelation with the PDI which was 1.2 %.

In 7th July 2016, the highest PDI i.e. 12.3 % and positively correlative with all the meteorological parameters except maximum and minimum temperature. The maximum and minimum temperature were 32.4 ^{0}C and 26.4 ^{0}C while the maximum and minimum RH were 92.42 and 76.0 % and rainfall was 11.6 mm. The same sown crop date in 2017 also showed the same relationship with 9.4 % disease intensity.

In 14th July 2016 sown crop showed the negative correlation with maximum temperature (32.14 ^{0}C) and minimum temperature(27.8 ^{0}C) while positive correlation with maximum RH (90.28 %) and minimum RH (73.57 %)and total rainfall(10.42 mm) with disease intensity of 6.7 % was recorded. In the next year 2017, the same date of sowing, all the weather parameters also showed the same correlation with the PDI. The maximum temperature was 34.67 ^{0}C and minimum temperature was 27.31 ^{0}C while the maximum and minimum RH was 78.99 % and 58.00 %. The PDI was 2.1 % when there was no rainfall was recorded.

In 21st July 2016 sown crop, the maximum and minimum average temperaturewas negatively correlated while other parameters were positively correlated with PDI. The maximum and minimum temperature were 30.94 ^{0}C and 29.8 ^{0}C whereas the maximum and minimum RH was 88.71 % and 70.00 % with the total rainfall of 3.42 mmerspectivel with 3.2 % disease intnesity. In next year, the sowing date 21st July 2017, revealed that the correlation was same as previous year when the maximum and minimum temperature were 35.68 ^{0}C and 27.11 ^{0}C respectively and the maximum and minimum RH were 85.12 % and 56.71 % at 2.71 mm total rainfall with 7.3 % disease intensity.

In the crop which was sown on 28th July 2016, the correlation data showed that all the meteorological parameters except maximum and minimum temperature, was significantly and positively correlated with the PDI value of 6.4 %. In next year i.e. 28th July 2017, when the maximum and minimum temperature were 31.12 ^{0}C and 24.92 ^{0}C and maximum and minimum RH were 94.98 and 74.71 % and total rainfall 30.60 mm, the highest PDI was recorded 11.4.

The crop sown on 4th August 2016, the maximum temperature (33.4 ^{0}C) and minimum temperature (25.51 ^{0}C) were negatively correlated. The maximum and minimum average RH and total rainfall weresi gnificantly and positively correlated with the PDI (4.3 %). In 2017, the same sowing date showed the 4.7 per cent disease intensity.

In the sowing date of 11th August 2016, the per cent disease intensity was negatively correlated with the maximum and minimum temperature but significantly and positively correlated with all the other parameters with 2.1 % disease intensity. In the year 2017, the same sowing date sowed 3.5

per cent disease intensity when there was no rain fall. Maximum and minimum temperature were 36.3 ^{0}C and 26.18 ^{0}C and maximum and minimum RH were 80.28 and 52.71 % respectively.

Table 01: Influence of meteorological parameters in the Progressive development of Alternaria blight of Cluster bean during *Kharif of* 2016 and 2017.

Date of sowing	Date of observation	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	PDI
		Max.	Min.	Morning	Noon		
23 Jun. 2016	23 Jul. 2016	34.22	25.91	90.57	76.57	17.28	2.2
30 Jun. 2016	30 Jul. 2016	32.08	25.02	94.85	73.14	16.85	10.5
07 Jul. 2016	06 Aug. 2016	32.40	26.40	92.42	76.00	11.60	12.3
14 Jul. 2016	13 Aug. 2016	32.14	27.80	90.28	73.57	10.42	6.7
21 Jul. 2016	20 Aug. 2016	30.94	29.80	88.71	70.00	3.42	3.2
28 Jul. 2016	27 Aug. 2016	34.00	26.01	86.71	70.85	1.42	6.4
04 Aug. 2016	03 Sept. 2016	33.40	25.51	74.14	57.71	0.14	4.3
11 Aug 2016	10 Sept. 2016	34.62	25.10	78.42	55.28	0.00	2.1
18 Aug. 2016	17 Sept. 2016	35.05	23.60	86.55	61.00	1.31	3.2
23 Jun. 2017	23 Jul. 2017	31.97	25.71	87.14	66.00	0.60	6.2
30 Jun. 2017	30 Jul. 2017	34.54	26.62	81.71	58.28	0.00	1.2
07 Jul. 2017	06 Aug. 2017	32.45	26.40	79.57	77.28	13.17	9.4
14 Jul. 2017	13 Aug. 2017	34.67	27.31	78.99	58.00	0.00	2.1
21 Jul. 2017	20 Aug. 2017	35.68	27.11	85.12	56.71	2.17	7.3
28 Jul. 2017	27 Aug. 2017	31.12	24.92	94.98	74.71	30.60	11.4
04 Aug. 2017	03 Sept. 2017	34.52	25.47	82.82	56.42	0.22	4.7
11 Aug. 2017	10 Sept. 2017	36.30	26.18	80.28	52.71	0.00	3.5
18 Aug. 2017	17 Sept. 2017	33.90	24.71	85.57	59.57	10.31	4.1

The last sowing date 18th August 2016, showed the same correlation as with the previous sowing dates. The maximum and minimum temperature were negatively correlated while the other parameters were significantly and positively correlated with plant disease intensity. At the last date of sowing, 3.2 per cent disease intensity was recorded. In the next year i.e. 2017 the same date of sowing revealed 4.1 per cent disease intensity with maximum and minimum temperature of 33.90 ^{0}C and 24.71 ^{0}C, maximum and minimum RH were 85.57 % and 59.57 % and total rainfall 10.31 mm

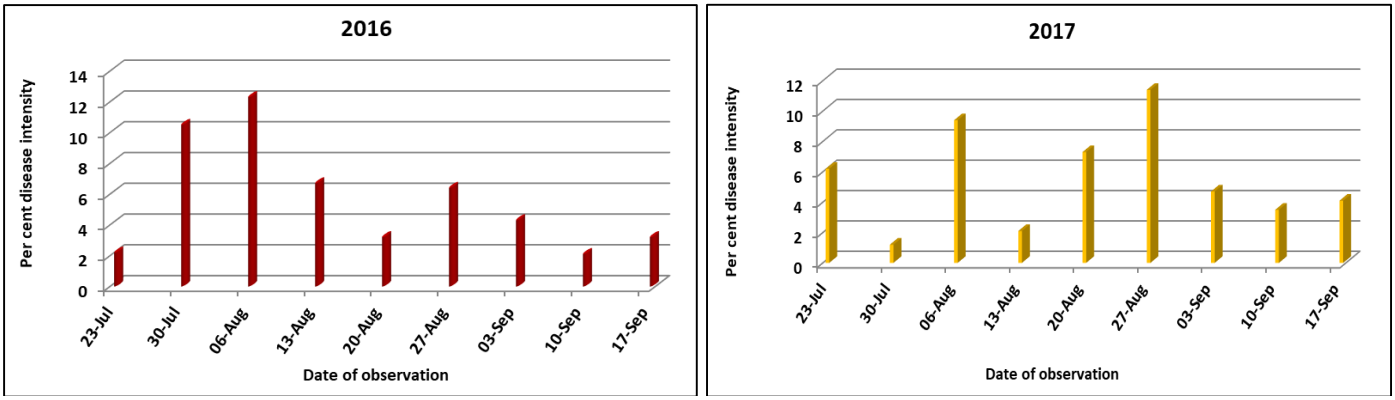

Fig 1: Role of meteorological parameters in the Progressive development of PDI of Cluster bean during *Kharif of* 2016 and 2017.

Further the regression equation between meteorological data and PDI during *Kharif* were analysed (Table 02). The regression equation (y = 34.463 - 2.471x) between average maximum temperature and PDI for the sowing date in the *Kharif* 2016 reveals that the average maximum temperature should be less than 34.46^{0}C for the initiation of the disease and thereafter with the decrease in 1 ^{0}C the PDI would increase by 2.47 %. Similarly the regression equation (y = 25.513 + 0.0678x) with average minimum temperature and PDI reveals that the minimum temperature should be less than 25.51^{0}C for the initiation of the disease and thereafter with the unit increase would result and increase in PDI by 0.06^{0}C.

Table 2: Correlation coefficient of individual meteorological parameters with progressive development of Alternaria blight of Cluster bean of 2016 and 2017

S. No.	Meteorological parameter	Correlation coefficient	Regression equation
1.	Maximum Temp. (^{o}c), x_1	-0.1073 ^{NS}	y = 34.463 - 2.4710x
2.	Minimum Temp. (^{o}c), x_2	- 0.0965*	y = 25.5130 + 0.0678x
3.	Maximum R.H. (%) x_3	0.5708*	y = 81.355 + 0.6599x
4.	Minimum R.H. (%) x_4	0.6249*	y = 58.276 + 1.1067x
5.	Rainfall (mm) x_5	0.6352*	y = 2.5035 + 1.4590x

* Significant at 5% and NS-Non significant at 5%

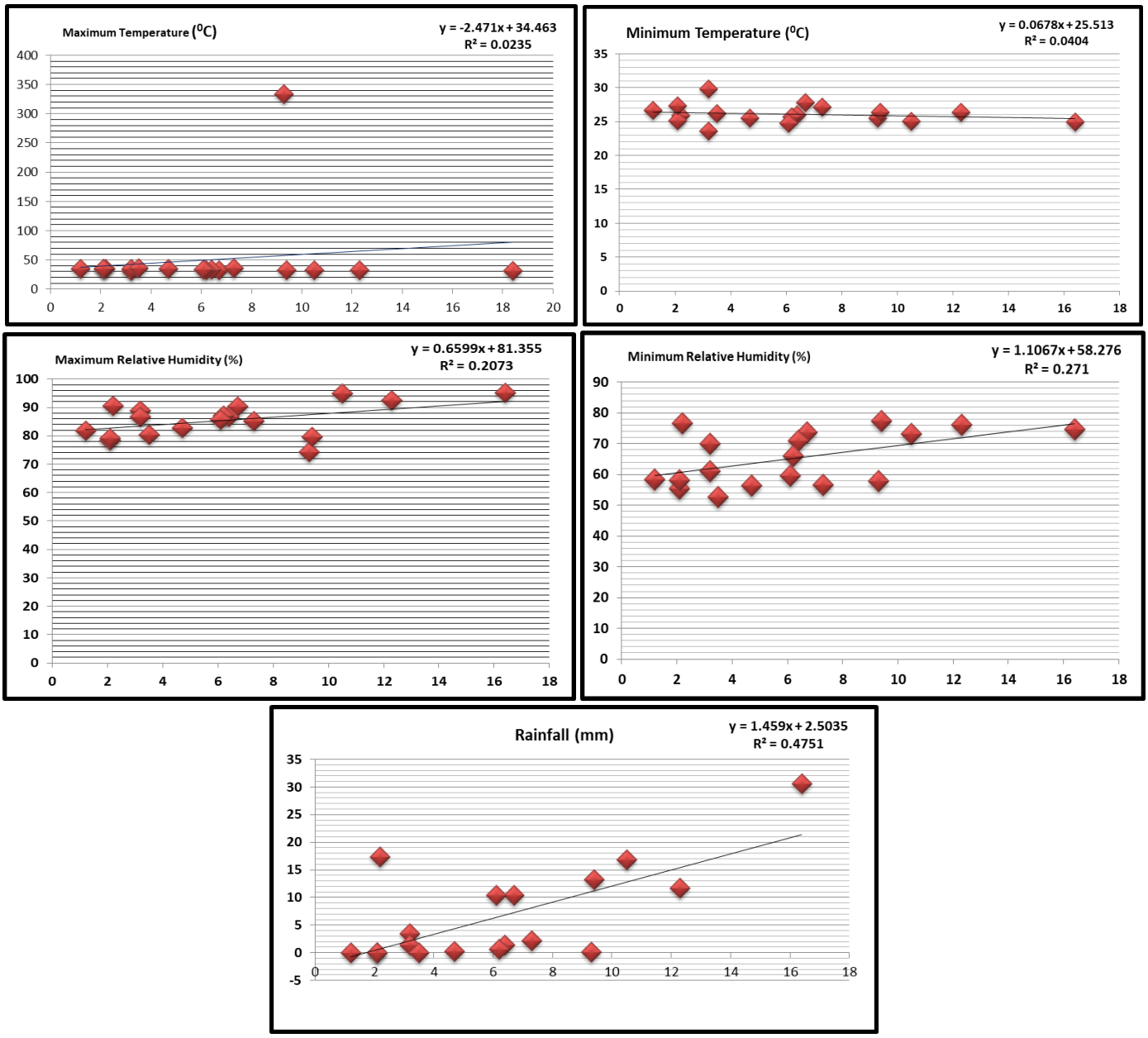

Fig 2: Role of meteorological parameters in the Progressive development of Alternaria blight of Cluster bean during *Kharif season of* 2016 and 2017.

The regression equation between average maximum relative humidity and PDI (y = 81.355 + 0.6599x) indicate that at least 81.355 % average maximum relative humidity is essential for the development of the disease and thereafter with a unit increase in the relative humidity the PDI would increase by 0.6599 %. Similarly the regression equation with minimum average relative humidity and PDI (y = 58.276 + 1.1067x) indicate that the average minimum relative humidity should not be less than 58.276 % for the initiation of the disease and thereafter it's a unit increase would result and increase in PDI by 1.1067 %.

In epidemiological studies, results of two consecutive cropping *Kharif* seasons (2016 and 2017) with respect to weather parameters revealed that Alternaria blight of Cluster bean is greatly favoured by relative humidity and rainfall. Significant and positive correlation was recorded with maximum and minimum average relative humidity and total rainfall. Negative correlation with maximum average temperature was observed which is supported with results obtained by earlier workers (Saharan and Saharan, 2004)

In an attempt to see the effect of date of sowing on intensity of Alternaria blight of guar the M-83 variety was sown at nine different dates. Disease development was favored by temperature ranging from 27^0C – 29^0C and by RH of 78 – 80%. Disease intensity was highest in the last week of July after then there was a gradual decline in disease severity (Kumar *et al.*, 1996) [6].

In epidemiological studies, maximum and minimum average relative humidity and total rainfall showed significant and positive correlation coefficient with the disease intensity which indicate that the disease increased with the increase in maximum relative humidity, minimum relative humidity and rainfall. Rainfall showed significant correlation in compared to other meteorological parameters. Maximum and minimum average temperature showed negative correlation with disease intensity which indicates that there was increase in disease with decrease in maximum temperature and minimum temperature.

Disease development was correlated with weather average parameters including temperature, relative humidity, total rainfall, average wind velocity and sunshine hours per day.

The plants were susceptible to blight at all growth stages, with 30 days old plant being least susceptible. Late sowing favoured the development of the disease, whereas early sowing reduced the intensity of the disease and increased the crop yield (Dubey 2002) [4].

Rangaswami and Rao (1957) [8] and Singh and Prasad (1972) [7] reported maximum disease intensity in years of more than normal rainfall. The results of this present study are in agreement with the above observation since there was more progress in disease intensity during 2017 where more rainfall was received.

The same findings were reported by Singh *et al*., (1995) [15] that maximum disease intensity of leaf spot of cluster bean (*A. cyamopsidis*) when the temperature was ranging from 25 ^{0}C to 30 ^{0}C and relative humidity was 80 per cent with high rainfall.

Another worker, Patel (2003) observed relative humidity related significantly and negatively while maximum temperature and sunshine hours related significantly and positively with the leaf spot intensity in green gram (*A. alternata*) during *Kharif* season. He also noted that the leaf spot intensity was negatively correlated 6with minimum temperature and relative humidity in the crop grown in late *Kharif.*

Similar result was also presented by Amaresh, (2000) [1] that the highest incidence of Alternaria leaf blight was observed in crop sown in first and second fortnight of July and first fortnight of August. The least incidence and significantly the highest yield were obtained when sunflower crop was sown during the first and second fortnight of September. Negative correlation between Alternaria leaf blight, maximum temperature and yield was observed while positive correlation was observed with rainfall and relative humidity.

Conclusion

Alternaria blight intensity on six varieties of cluster bean. They reported a significantly positive correlation between the disease severity and certain weather parameters (cumulative rainy days and cumulative rainfall) whilst maximum temperature was significantly negatively associated (pooled basis). The step-wise multiple regression analysis of data revealed that minimum temperature, relative humidity in the evening, sunshine and cumulative rainfall played a major role in disease development.

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