PROGRESSION OF *ALTERNARIA* BLIGHT ON DIFFERENT VARITIES OF CLUSTERBEAN IN RELATION TO WEATHER PARAMETERS

***A. K.Meena[1], S.L. Godara[2], S. Gangopadhyay[3], R.S. Jatav[4] and V.R. Meena[5]**

[1, 2,& 3] *Department of Plant Pathology, College of Agriculture,Swami Keshwanand Rajasthan Agricultural University, Bikaner –India – 334 006*
[4] *Department of Plant Pathology, RCA, MPUA&T,Udaipur (Raj.)313001*
[5] *Department of Ag. Entomology, RCA, MPUA&T,Udaipur (Raj.)313001*
Email: ak_patho@rediffmail.com

Abstract : Progression of *Alternaria* blight of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] caused by *Alternaria cucumerina* var. *cyamopsidis* (Rangaswami and Rao) Simmmons,was found to be greatly influenced by environmental factors prevalent conditions. The pooled data for both the years (2006 and 2007) revealed that there was periodical increase in blight intensity on all three varieties of clusterbean. However, this increase was more in susceptible variety, RGC-936 followed by moderately resistant, RGC-1003 and resistant, RGC-986. Relative humidity (morning and evening) were found significantly correlated with the progression of blight intensity.

Keywords : *Alternaria cucumerina* var. *cyamopsidis*, Clusterbean, Disease progression, Environment

INTRODUCTION

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] is an important leguminous crop of kharif season in arid and semi-arid region of India. Cluster bean is also popularly called as "Guar". It is a very hardy and drought tolerant crop. Its deep penetrating root enables plant to utilize available moisture more efficiently and thus find better scope for rainfed cropping. The crop survives best even at moderate salinity and alkalinity. There is no other legume crop so hardy and drought tolerant as clusterbean, and hence suitable for cultivation in arid and semi arid tracts of Rajasthan. Tender green guar pods are important source of nutrition to human being and animals.The production and productivity of Clusterbean in term of grain and fodder is limited mostly due the destructive fungal disease caused by *Alternaria cucumerina* var. *cyamopsidis* (Rang. and Rao), is a major foliar disease of Clusterbean in northern India (Rangaswami and Rao (1957).

This disease alone has been reported to be responsible for reduction in yield by 56-59 per cent under artificial epiphytotic conditions (Gupta 1994). Since the pathogen is seed-borne in nature. The disease appears year after year in mild to severe form (Sowell 1965). In early stages of infection, the water soaked spots appear on leaf blade which later turn grayish 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. In severe infection several spots coalesce together involving a major portion of the leaf blade. In such cases the leaflet becomes chlorotic and usually drops off. If the plants are infected in the early stages of the growth then there may not be any flowering and pod formation. This disease ultimately results in sever defoliation, which is a direct loss of seed yield. Therefore, present investigation was under taken to specific activity of peroxidase, polyphenol oxidase, catalase and phenylalanine ammonia lyase.

MATERIAL AND METHOD

Progression of disease

Three varieties of clusterbean *i.e*., RGC-936 Highly Susceptible (HS), RGC-1003, Moderately Resistance (MR) and RGC-986 Resistance (R) were selected to record the influence of genotype on the progression of the disease under field conditions. The progress was measured in terms of per cent area covered by the disease. It is measured on different varieties in relation to prevailing environmental conditions during *kharif* seasons 2006 and 2007. Five leaves were marked at random of each variety and disease progression was measured on alternate days for two weeks (Meteorological week 36 and 37).

The data on environmental variables was obtained from Meteorological Laboratory, Agricultural Research Station (ARS), Rajasthan Agricultural University, Bikaner, Rajasthan. Means of maximum temperature, minimum temperature, relative humidity (morning), relative humidity (evening), sunshine hours, rainfall and number of rainy days were symbolized as X_1, X_2, X_3, X_4, X_5, X_6 and X_7, respectively. The per cent disease intensity was calculated on different varieties (RGC-936, RGC-1003 and RGC-986) and symbolized as Y_1, Y_2 and Y_3, respectively. Disease index on foliage was calculated using the formula of McKinney (1923).

$$\textit{Alternaria}\text{blight index }(\%) = \frac{\text{Sum of all numerical ratings}}{\text{Total number of leaves observed X Maximum disease grade}} \times 100$$

*[1]*Part of Ph.D. thesis submitted to College of Agriculture, SKRAU, Bikaner , Rajasthan 334 006*
[1]*Assistant Professor, KVK, Jalore 343 001 (Rajasthan)* [**2&3] *Assoc. Prof. & ZDR and Prof.,* [***4&5] *Ag. Sup.& T.A. , A.R.S.,Ummedganj (MPUAT) Kota Raj.*

Disease rating /grade	Per cent leaf area affected	Disease reaction
0	-	Highly Resistant (HR)
1	0-5.0	Resistant (R)
2	5.1-10.0	Moderately Resistant (MR)
3	10.1-25.0	Moderately Susceptible (MS)
4	25.1-50.0	Susceptible (S)
5	>50.0	Highly Susceptible (HS)

Rating Scale

Before analysis, the data on per cent *Alternaria* blight intensity were subjected to angular transformation as advocated by Fisher and Yates (1956).

The data were analysed statistically by taking Y_1, Y_2 and Y_3 as dependent variables and X_1, X_2,……………X_7 as independent variables using stepwise multiple regression analysis

RESULT AND DISCUSSION

The progress of *Alternaria* blight intensity in three cultivars of clusterbean in relation to weather variables were studied in two crop seasons i.e. *Kharif* 2006 and 2007 under field conditions. The first observation on disease severity was recorded on 4th September of each crop season and continued up to 26th September at 48 hours interval. Thus, a total 12 observations on disease severity was recorded during both the crop season 2006 and 2007. The disease incidence was noted at 48 hours interval using standard rating scale and the disease intensity was calculated following McKenny (1923) scale. The weather variables *viz.*, Maximum temperature (X_1), Minimum temperature (X_2), Relative humidity morning (X_3), evening (X_4), Sunshine hours (X_5), Rainfall (X_6) and Number of rainy days (X_7) were recorded periodically from weather station situated near the experimental fields. The data given in table 1 & 2 revealed that *Alternaria* blight intensity was much higher in RGC-936 as compared to other two cultivars i.e. RGC-1003 and RGC-986. The mean disease intensity in RGC-936 ranged 22.64 to 28.18 per cent as compared to 6.83 to 7.31 per cent in RGC-1003 and 3.70 to 3.83 per cent in RGC-986. The blight intensity progressively increased during the observation period *i.e*. 4th September to 26th September in all three varieties in both the crop seasons. However, the perusal of the data revealed that the progression was relatively faster from 14th September onwards in all the three cultivars in two seasons. The two year data of disease progression also indicate that the disease progression was faster during 14th September to 26th September in all three varieties in both the crop seasons (Table 3). The pooled data also showed that the mean disease intensity ranged from 10.78 to 19.67 per cent in three test clusterbean cultivars. During this period i.e. 14th September to 26th September the average maximum and minimum temperature ranges were 35.55 to 38.35^{0}C and 23.60 to 28.05^{0}C.respectively, while the average morning and evening relative humidity prevailed 63.00 to 74.50 and 33.50 to 52.00 per cent respectively. During 2006 crop season the rainfall was scanty as was 1.7 mm and number of rainy days was one day while the rainfall was higher i.e. 53.5 mm and number of rainy days were five days during 2007 crop season.

The correlation coefficient between individual weather variables and disease intensity was determined for two crop seasons. The results given in table 4 indicated that progression of *Alternaria* blight intensity in three varieties was significantly negatively correlated with maximum temperature (X_1). Further the correlation matrix (r-value) was much higher in two years pooled data as compared to individual crop season. Minimum temperature (X_2) was also negatively correlated with disease intensity during 2006 and 2007 crop seasons. Relative humidity morning and evening (X_3, X_4) were found significantly positively correlated with the blight intensity in all the three varieties in both the crop seasons. The data also revealed that morning RH was more correlated with the disease intensity as compared to evening RH in all the three varieties. The pooled data with respect to relative humidity was more correlated with the disease intensity as compared to individual crop season. Sunshine hours (X_5) exhibited positive correlation with disease progression and this relationship was more pronounced in the pooled data as compared to individual crop season. Although the total rainfall (X_6) showed positive correlation with the disease intensity but it was not significant. While, the number of rainy days (X_7) was significantly positively correlated in one crop season i.e. *Kharif* 2007 and also in case of pooled analysis (Table 3).

Based on observations recorded on progression of *Alternaria* blight and weather variables step wise multiple regression equations were developed. These equations were developed variety wise, for both the crop seasons and pooled data basis (Table 5, 6 & 7).

Besides, multiple regression equations were developed on the basis of two years pooled in which the observations recoded on three varieties were also pooled. Regression equation developed in three varieties, two crop seasons indicated that maximum (X_1) and minimum temperature (X_2) explained 54.4 to 80.8 per cent variation of disease intensity (Table 5, 6 & 7). However, the variability in disease intensity could be better explained when two years pooled data with respect to temperature was considered. The trend with respective morning and evening relative humidity (X_3 and X_4) in explaining the variations of disease intensity was similar to that temperature. Two years pooled data of morning relative humidity (X_3) the regression equation developed that based on explain better variations than the individual year. For instance the morning RH (X_3) could explain the variation 81.6 and 74.7 per cent disease intensity in RGC-936 and RGC-986 respectively (Table 5 &7). The results also revealed that sunshine hours (X_5) and total rainfall (X_6) did not show marked effect on the development of *Alternaria* blight intensity in all the three varieties in two crop seasons. However, number of rainy days (X_7) had better impact on disease intensity as compared to total rainfall (X_6). No significant difference was recorded in three varieties with respect to their response to the selected weather variables.

The regression equation developed taking maximum and minimum temperature (X_1 and X_2) in three individual varieties revealed that these two parameters could explain the variability in a better way as compared to either maximum (X_1) or minimum temperature (X_2) individually. It is worthwhile to mentioned that X_1 and X_2 explained 79.0 per cent variability in disease intensity in RGC-1003 during 2007 crop season (Table 6). Morning (X_3) and evening (X_4) relative humidity together explain 74.2, 71.2 and 72.5 per cent in RGC-936, RGC-1003 and RGC- 986 respectively (Table 5, 6 &7). Multiple regression equations developed using five selected weather variables such as maximum temperature (X_1), minimum temperature (X_2), morning RH (X_3), evening RH (X_4) and sunshine hours (X_5) explained 85.1 to 86.5 per cent variability in blight intensity in three crop varieties during 2007 crop seasons. However, during 2006 crop season multiple regression equations developed taking the five parameters together explain 62.9 to 76.5 per cent variability of the blight intensity . The results also indicated that the pooled data of these five weather variables (maximum temperature (X_1), minimum temperature (X_2), morning RH (X_3), evening RH (X_4) and sunshine hours (X_5) when taken together in regression equation explained 92.1,83.7 and 82.9 per cent variability in clusterbean RGC-936, RGC-1003 and RGC-986 respectively ((Table 5, 6 & 7). The results showed 83.8 to 93.6 per cent variability in disease intensity when regression equations were developed taking seven weather parameters (maximum temperature (X_1), minimum temperature (X_2), morning RH (X_3), evening RH (X_4), sunshine hours (X_5), rainfall (X_6) and number of rainy days (X_7)) together. The regression equations developed based on two years over all pooled data on disease intensity recorded in three varieties in two crop seasons clearly indicated that morning RH (X_3) could explain 78.7 per cent variations in disease intensity. Maximum temperature (X_1), minimum temperature (X_2), morning RH (X_3) regressed together could explain 81.2 per cent variability in blight intensity. While, regression equations based on both temperature and relative humidity (Maximum temperature (X_1), minimum temperature (X_2) , morning RH (X_3), and evening RH (X_4) explained 82.8 per cent variability in *Alternaria* blight intensity. The results also indicated that the regression equations developed based on all the seven variables could explain more than 89.2 per cent variations in blight intensity recorded in all the three varieties (Table 8). Very little information is available in the literature on the environmental factors affecting infection and development of *Alternaria* blight of clusterbean caused by *Alternaria cucumerina* var. *cyamopsidis*. In the present investigation, an attempt has been made to study the effect of maximum temperature (X_1), minimum temperature (X_2), relative humidity (morning) (X_3), relative humidity (evening) (X_4), sunshine hours (X_5), rainfall (X_6) and number of rainy days (X_7) for initiation and development of *Alternaria* blight. The results of two consecutive cropping seasons with respect to effect of weather parameters revealed that *Alternaria* blight is greatly favoured by high relative humidity. Significantly and negatively correlation was recorded with maximum temperature (X_1) and minimum temperature (X_2) whereas, positive correlation with sunshine hours (X_5) and number of rainy days (X_7), which is an accordance with the findings of Yogendra *et al.* (1995) from Kanpur (Uttar Pradesh) recorded maximum disease intensity on variety, Pusa Navbahar (PNB) at 25-31^{o}C temperature, 80 per cent relative humidity and high rainfall. Gupta *et al*. (1998) obtained positive and significant correlation of disease index of *Alternaria* blight of clusterbean with temperature, relative humidity and rainfall, whereas with sunshine hours it was negative and non significant. Such attempt would help us in predicting disease incidence in given area. However, information on interaction of disease incidence and weather data of several years will be more reliable. Saharan *et al.* (2001) studied the progress of *Alternaria* blight of clusterbean (*Alternaria cucumerina* var.*cyamopsidis*) under field conditions for two crop seasons. They found that the disease progress was greatly influenced by environmental factors prevalent under the field conditions. The pooled data for both the years (1997 and 1998) revealed that there was periodically increase in lesion number on all the varieties. However, this increase was more in highly susceptible variety, FS-277 followed by susceptible variety, RGC-936 and moderately resistant varieties, HG-365 and HG-75. Relative humidity (morning and evening) was found significantly negatively correlated with the development of lesion number. On the contrary, cumulative number of rainy days and cumulative rainfall were directly significantly associated with the lesion number development. Saharan *et al.* (2003) reported that the fungus survives through seeds and mycelium in infected crop debris. The seed and soil borne inoculum infects the clusterbean seedlings. Such infected plants serve as foci of infection. On availability of favorable environmental condition of the disease development the pathogen infects the large population of the crop. Excessive rainfall and humidity favour the disease incidence. Dubey and Ekka (2004) reported highly significant negative correlation between minimum temperature and disease intensity of bitter gourd blight caused by *Colletotrichum capsici*. Similarly, highly significant negative correlation was established between number of rainy days and disease intensity during both the years. Maximum and minimum relative humidity also showed negatively correlation with disease intensity during first year (1999) whereas only minimum relative humidity was highly significant during second year (2000). Mean rainfall also showed a similar trend. The results of stepwise multiple regression analysis revealed that during 1999 weather altogether accounted 95.2 per cent variation which was highly significant. Of these 92.6 per cent variation was due to relative humidity and number of rainy of days. Number of rainy days alone significantly contributed to 84.7 per cent variation.

Gupta *et al.* (2004) reported that the disease increased with the delay in sowing time. Cultivar Kranti showed significantly more disease severity an all the sowing dates. Maximum temperature 24^0C and minimum 9^0C had significant and negative correlation whereas relative humidity maximum 87-90% and minimum 44-49% had significant and positive correlation with disease severity. The prediction equations for forecasting of the disease were reported at different growth stages of the crop. Sangwan *et al.* (2004) reported that the two varieties of rapeseed-mustard *e.i. Brassica juncea* (RH-30) and *B. campestris* var. yellow sarson (YsPb-24) were monitored for the progression of *Alternaria* blight for two consecutive crop seasons (2001-02 and 2002-03). The stepwise regression analysis of the pooled data for both the years revealed that temperature (maximum) and relative humidity (morning) played significant and positive role in disease progression. The R^2 value was more than 90 per cent in all the cases. The correlation coefficient matrix of weather data with disease progression also revealed that temperature (maximum) and relative humidity (morning) had prominent role in disease progression.

Chattopadhyay *et al.* (2005) reported that the severity of *Alternaria* blight disease on leaves was positively correlated to maximum daily temperature of 18-27^0C, minimum daily temperature of 8-12^0C, daily mean temperature >10^0C , more than 92 percent morning relative humidity (R.H.), more than 40 percent afternoon R.H. and mean R.H. of 70% in the preceding week. Correlation of *Alternaria* blight severity on leaves and pods of the plants was positively correlated with a maximum daily temperature 18-27^0C in the preceding week (R^2:0.9), more so when the range was 24-26^0C (R^2:0.97), minimum daily temperature of 8-12^0C (R^2:0.81), daily mean temperature >10^0C (R^2:0.77),> 92% (R^2:0.83) morning relative humidity R.H. >40% afternoon R.H. (R^2:0.89) and daily mean R.H. of 70% (R^2:0.9). Mehta *et al.* (2008) reported that the prediction model for *Alternaria* blight of rapeseed and mustard was developed for adopting better disease management for cultivars each of *Brassica juncea* (RS-30, RS-8113, RS-8695, RS-8546) and *B. campestris* (YsPb-24, BSH-1, Candle, Shiva) to of *B. carinata* (HC-2, HC-9001), one each of *B. napus* (GSH-1) and *B. alba* (local) were monitored for the development and progression of *Alternaria* blight for three consecutive crop seasons (1998-99 to 2000-01). The data on disease progression in relation to corresponding weather variables were subjected to stepwise multiply regression analysis. There were significant variations in the development of *Alternaria* blight during all three crop seasons. The progression was much less during 2000-01 as compared to other two crop seasons. The rate of disease development was faster on *Brassica juncea* and *B. campestris* as compared to *B. carinata, B. napus* and *B. alba.* Further during the crop year 1998-99, Temp. (min.), RH.(e) and Sun-shine played significant role whereas, Temp. (maxi.), Temp.(min), RH (m) and RH (e) contributed largely towards the disease development during 1999-2000.

Table 1. Progression of *Alternaria* blight intensity on three varieties of clusterbean in relation to weather parameters (*Kharif* - 2006)

Date of observation	Intensity of Alternaria blight (%)				Weather parameters						
	RGC-936	RGC-1003	RGC-986	Mean	X_1 (^{0}C)	X_2 (^{0}C)	X_3 (%)	X_4 (%)	X_5 (h)	X_6 (mm)	X_7 (days)
4 Sept., 2006	12.00 (20.27)**	1.27 (6.47)	0.66 (4.66)	4.64 (10.47)	38.5	28.5	56	34	7.8	0	0
6 Sept.,	14.40	2.87	1.33	6.20	39	27.5	53	33	7.4	0	0

2006	(22.30)	(9.75)	(6.62)	(12.89)							
8 Sept., 2006	16.80 (24.20)	4.06 (11.62)	2.35 (8.82)	7.74 (14.88)	39.5	28.8	56	35	6.3	0	0
10 Sept., 2006	18.80 (25.70)	4.69 (12.50)	2.63 (9.34)	8.71 (15.85)	39.5	28.6	53	41	2.2	0	0
12 Sept., 2006	19.11 (25.92)	6.00 (14.18)	3.10 (10.15)	9.41 (16.75)	39.3	27.6	58	36	8.2	0	0
14 Sept., 2006	20.36 (26.82)	6.98 (15.32)	3.47 (10.73)	10.27 (17.62)	39.2	29.1	56	37	6.6	0	0
16 Sept., 2006	22.40 (28.25)	8.11 (16.55)	3.97 (11.49)	11.49 (18.76)	39.9	26.7	54	32	10.2	0	0
18 Sept., 2006	25.07 (30.04)	8.78 (17.23)	4.42 (12.13)	12.75 (19.80)	35.6	25.6	62	42	9.8	0	0
20 Sept., 2006	26.67 (31.09)	9.50 (17.96)	4.70 (12.52)	13.62 (20.52)	34.5	25	69	42	10.0	0	0
22 Sept., 2006	29.38 (32.82)	11.11 (19.47)	5.38 (13.42)	15.29 (21.90)	34	21.3	80	60	8.6	1.7	1
24 Sept., 2006	32.67 (34.86)	11.82 (20.11)	6.02 (14.20)	16.84 (23.06)	35.5	24.6	75	45	9.0	0	0
26 Sept., 2006	34.04 (35.70)	12.49 (20.70)	6.35 (14.59)	17.63 (23.66)	34.8	24.2	70	68	10.2	0	0
Mean	22.64 (28.16)	7.31 (15.16)	3.70 (10.72)								

CD at 5% Variety = 0.24; Days =0.48; V x D =0.83 X_1 = Maximum temperature, X_2 = Minimum temperature, X_3 = Relative humidity (morning), X_4 = Relative humidity (evening), X_5 = Sunshine hours, X_6= Rainfall,
X_7 = Number of rainy days
**values in parenthesis are angular transformed values

Table 2. Progression of *Alternaria* blight intensity on three varieties of clusterbean in relation to weather parameters (*Kharif* - 2007)

Date of observation	Intensity of Alternaria blight (%)				Weather parameters						
	RGC-936	RGC-1003	RGC-986	Mean	X_1 (^{0}C)	X_2 (^{0}C)	X_3 (%)	X_4 (%)	X_5 (h)	X_6 (mm)	X_7 (days)
4 Sept., 2007	13.42 (21.49)*	1.67 (7.43)	0.95 (5.61)	5.35 (11.51)	38.5	28.8	57	28	6.9	0	0
6 Sept., 2007	15.23 (22.97)	2.74 (9.52)	1.45 (6.92)	6.48 (13.14)	38.5	28	71	28	6.8	0	0
8 Sept., 2007	15.73 (23.36)	3.10 (10.15)	1.74 (7.59)	6.86 (13.70)	36.6	26	64	33	5	0	0
10 Sept., 2007	17.14 (24.45)	3.73 (11.14)	2.30 (8.72)	7.72 (14.77)	39	28.1	65	34	6.0	0	0
12 Sept., 2007	21.47 (27.60)	5.16 (13.12)	2.78 (9.60)	9.80 (16.78)	38.7	25.2	65	34	6.3	0	0
14 Sept., 2007	24.00 (29.33)	6.49 (14.76)	3.40 (10.63)	11.30 (18.24)	37.5	27	70	30	8.4	0	0
16 Sept., 2007	30.34 (33.42)	7.73 (16.15)	4.57 (12.34)	14.21 (20.64)	35.7	25.6	74	32	8.1	15.7	1
18 Sept., 2007	34.40 (35.91)	8.67 (17.12)	4.62 (12.41)	15.89 (21.81)	35.5	24.6	69	38	10.2	2	1
20 Sept., 2007	36.26 (37.03)	9.51 (17.96)	5.08 (13.03)	16.95 (22.67)	37	21.4	71	33	8.9	0	0
22 Sept., 2007	37.42 (37.71)	9.87 (18.31)	6.13 (14.34)	17.81 (23.45)	35.7	20.3	79	35	8.6	2.2	1
24 Sept., 2007	45.86 (42.63)	11.56 (19.87)	6.42 (14.67)	21.28 (25.72)	34.4	21.5	87	49	8.3	33.6	1
26 Sept., 2007	46.87 (43.20)	11.76 (20.05)	6.50 (14.77)	21.72 (26.01)	36.3	23	79	36	5.3	0	1
Mean	28.18 (31.59)	6.83 (14.63)	3.83 (10.89)								

CD at 5% Variety = 0.54; Days = 1.08; V x D = 1.88
X_1 = Maximum temperature, X_2 = Minimum temperature, X_3 = Relative humidity (morning), X_4 = Relative humidity (evening),
X_5 = Sunshine hours, X_6= Rainfall, X_7 = Number of rainy days

*values in parenthesis are angular transformed values

Table 3. Progression of *Alternaria* blight intensity on three varieties of clusterbean in relation to weather parameters (Pooled basis, 2006 and 2007)

Date of observation	Intensity of Alternaria blight (%)				Weather parameters						
	RGC-936	RGC-1003	RGC-986	Mean	X_1 (^{0}C)	X_2 (^{0}C)	X_3 (%)	X_4 (%)	X_5 (h)	X_6 (mm)	X_7 (days)
4 September	12.71 (20.88)	1.47 (6.95)	0.81 (5.13)	5.00 (10.99)	38.50	28.65	56.50	31.00	7.35	0.00	0.00
6 September	14.82 (22.64)	2.80 (9.64)	1.39 (6.77)	6.34 (13.02)	38.75	27.75	62.00	30.50	7.10	0.00	0.00
8 September	16.26 (23.78)	3.58 (10.89)	2.05 (8.21)	7.30 (14.29)	38.05	27.40	60.00	34.00	5.65	0.00	0.00
10 September	17.97 (25.07)	4.21 (11.82)	2.47 (9.03)	8.22 (15.31)	39.25	28.35	59.00	37.50	4.10	0.00	0.00
12 September	20.29 (26.76)	5.58 (13.65)	2.94 (9.88)	9.60 (16.76)	39.00	26.40	61.50	35.00	7.25	0.00	0.00
14 September	22.18 (28.08)	6.73 (15.04)	3.43 (10.68)	10.78 (17.93)	38.35	28.05	63.00	33.50	7.50	0.00	0.00
16 September	26.37 (30.83)	7.92 (16.35)	4.27 (11.91)	12.85 (19.70)	37.80	26.15	64.00	32.00	9.15	7.85	0.50
18 September	29.73 (32.98)	8.72 (17.18)	4.52 (12.27)	14.32 (20.81)	35.55	25.10	65.50	40.00	10.00	1.00	0.50
20 September	31.47 (34.06)	9.51 (17.96)	4.89 (12.78)	15.29 (21.60)	35.75	23.20	70.00	37.50	9.45	0.00	0.00
22 September	33.40 (35.27)	10.49 (18.89)	5.76 (13.88)	16.55 (22.68)	34.85	20.80	79.50	47.50	8.60	1.95	1.00
24 September	39.27 (38.74)	11.69 (19.99)	6.22 (14.44)	19.06 (24.39)	34.95	23.05	81.00	47.00	8.65	16.80	0.50
26 September	40.46 (39.45)	12.12 (20.37)	6.42 (14.68)	19.67 (24.84)	35.55	23.60	74.50	52.00	7.75	0.00	0.50
Mean	25.41 (29.88)	7.07 (14.89)	3.76 (10.80)	12.08 (18.53)							

CD at 5% Variety = 0.30; Days = 0.60; V x D = 1.04

X_1 = Maximum temperature, X_2 = Minimum temperature, X_3 = Relative humidity (morning), X_4 = Relative humidity (evening),

X_5 = Sunshine hours, X_6= Rainfall, X_7 = Number of rainy days

*values in parenthesis are angular transformed values

Table 4. Correlation matrix for *Alternaria* blight per cent disease index progression on clusterbean varieties in relation to weather parameters

Season	Variety	Weather parameters						
		X_1 (^{0}C)	X_2 (^{0}C)	X_3 (%)	X_4 (%)	X_5 (h)	X_6 (mm)	X_7 (days)
Kharif, 2006	RGC-936	-0.789**	-0.806**	0.830**	0.780**	0.516	0.301	0.301
	RGC-1003	-0.830**	-0.836**	0.852**	0.697*	0.729**	0.319	0.319
	RGC-986	-0.834**	-0.822**	0.851**	0.725**	0.686*	0.280	0.280
Kharif, 2007	RGC-936	-0.788**	-0.864**	0.848**	0.702	0.417	0.484	0.795*
	RGC-1003	-0.765**	-0.830**	0.843**	0.513	0.285	0.405	0.707*
	RGC-986	-0.859**	-0.852**	0.879**	0.505	0.256	0.421	0.763**
Pooled	RGC-936	-0.920**	-0.827**	0.899**	0.818**	0.575*	0.433	0.637*
	RGC-1003	-0.928**	-0.844**	0.896**	0.749**	0.671*	0.409	0.663*
	RGC-986	-0.930**	-0.863**	0.918**	0.787**	0.621*	0.428	0.708**

X_1 = Maximum temperature, X_2 = Minimum temperature, X_3 = Relative humidity (morning), X_4 = Relative humidity (evening), X_5 = Sunshine hours, X_6= Rainfall, X_7 = Number of rainy days

*, ** Significant at 5% and 1%, respectively.

Table 5. Regression equation for *Alternaria* blight progression during *kharif*-2006, 2007 and pooled on clusterbean variety RGC-936

Regression equations	R^2			F-cal			F-tab at 5% (1%)		
	2006	2007	pooled	2006	2007	pooled	2006	2007	pooled
$Y_1 = 90.120 – 1.655 X_1$	0.622	0.621	0.787	16.47	16.37	36.96	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_1 = 72.012 – 1.657 X_2$	0.650	0.747	0.757	18.56	29.48	31.15	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_1 = 82.538 – 0.728 X_1 – 1.025 X_2$	0.676	0.805	0.808	9.38	18.58	18.94	4.10 (7.55)	4.10 (7.55)	4.10 (7.55)
$Y_1 = -1.373 + 0.433 X_3$	0.688	0.719	0.816	22.07	25.63	44.43	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_1 = 13.818 + 0.341 X_4$	0.608	0.492	0.746	15.54	9.70	29.32	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_1 = -3.651 + 0.294 X_3 + 0.150 X_4$	0.735	0.742	0.847	12.49	12.95	24.90	4.10 (7.55)	4.10 (7.55)	4.10 (7.55)
$Y_1 = 19.319 + 1.102 X_5$	0.267	0.174	0.361	3.63	2.10	5.66	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_1 = 27.741 + 2.988 X_6$	0.091	0.235	0.233	1.00	3.06	3.05	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_1 = 27.741 + 5.079 X_7$	0.091	0.631	0.510	1.00	17.13	10.42	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_1 = 34.422 – 0.227 X_1 – 0.523 X_2 + 0.260 X_3$	0.703	0.853	0.849	6.31	15.47	15.03	4.07 (7.59)	4.07 (7.59)	4.07 (7.59)
$Y_1 = 18.152 – 0.0206 X_1 – 0.333 X_2 + 0.223 X_3 + 0.139 X_4$	0.739	0.854	0.870	4.96	10.28	11.73	4.12 (7.84)	4.12 (7.84)	4.12 (7.84)
$Y_1 = -11.143 + 0.250 X_1 + 0.05166 X_2 + 0.277 X_3 + 0.183 X_4 + 0.466 X_5$	0.765	0.858	0.921	3.90	7.23	13.90	4.38 (8.74)	4.38 (8.74)	4.38 (8.74)
$Y_1 = 9.825 + 1.070 X_1 – 1.785 X_2 + 0.354 X_3 + 0.140 X_4 –0.175 X_5 – 6.231 X_6$	0.878	0.876	0.926	6.02	5.90	10.35	4.95 (10.67)	4.95 (10.67)	4.95 (10.67)
$Y_1 = 9.825 + 1.070 X_1 – 1.785 X_2 + 0.354 X_3 + 0.140X_4 – 0.175 X_5 – 10.529 X_7$	0.878	0.900	0.936	6.02	5.13	8.37	4.95 (10.67)	6.09 (14.97)	6.09 (14.97)

Table 6. Regression equation for *Alternaria* blight progression during *kharif*-2006, 2007 and pooled on clusterbean variety RGC-986

Regression equations	R^2			F-cal			F-tab at 5% (1%)		
	2006	2007	pooled	2006	2007	pooled	2006	2007	pooled
$Y_3 = 44.131 – 0.892 X_1$	0.474	0.596	0.681	9.00	14.74	21.34	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_3 = 35.365 – 0.931 X_2$	0.537	0.765	0.724	11.62	32.49	26.23	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_3 = 38.744 – 0.234 X_1 – 0.729 X_2$	0.544	0.808	0.737	5.38	18.93	12.64	4.10 (7.55)	4.10 (7.55)	4.10 (7.55)
$Y_3 = -4.194 + 0.241 X_3$	0.559	0.715	0.747	12.65	25.12	29.55	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_3 = 2.848 + 0.187 X_4$	0.480	0.439	0.661	9.23	7.83	19.52	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_3= -3.028 + 0.170 X_3 + 0.007678 X_4$	0.591	0.725	0.761	6.50	11.86	14.85	4.10 (7.55)	4.10 (7.55)	4.10 (7.55)
$Y_3 = 5.641 + 0.633 X_5$	0.230	0.203	0.315	2.99	2.54	4.60	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_3 = 10.477 + 1.731 X_6$	0.080	0.202	0.201	0.87	2.54	2.51	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)

$Y_3 = 10.477 + 2.943 X_7$	0.080	0.613	0.506	0.87	15.84	10.23	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_3 = 7.954 + 0.0864 X_1 – 0.407 X_2 + 0.166 X_3$	0.574	0.856	0.768	3.59	15.86	8.85	4.07 (7.59)	4.07 (7.59)	4.07 (7.59)
$Y_3 = -0.666 + 0.196 X_1 – 0.307 X_2 + 0.147 X_3 + 0.007338 X_4$	0.600	0.856	0.785	2.63	10.42	6.39	4.12 (7.84)	4.12 (7.84)	4.12 (7.84)
$Y_3 = -19.696 + 0.372 X_1 - 0.00565 X_2 + 0.182 X_3 + 0.102 X_4 + 0.303 X_5$	0.629	0.865	0.829	2.03	7.70	5.83	4.38 (8.74)	4.38 (8.74)	4.38 (8.74)
$Y_3 = -7.515 + 0.849 X_1 – 1.124 X_2 + 0.226 X_3 + 0.007755 X_4 - 0.00695 X_5 – 3.620 X_6$	0.729	0.885	0.835	2.24	6.44	4.22	4.95 (10.67)	4.95 (10.67)	4.95 (10.67)
$Y_3 = -7.515 + 0.849 X_1 – 1.124 X_2 + 0.226 X_3 + 0.007755 X_4 - 0.00695 X_5 – 6.154 X_7$	0.729	0.908	0.838	2.24	5.65	2.96	4.95 (10.67)	6.09 (14.97)	6.09 (14.97)

Table 7. Regression equation for *Alternaria* blight progression during *kharif*-2006, 2007 and pooled on clusterbean variety RGC-1003

Regression equations	R^2			F-cal			F-tab at 5% (1%)		
	2006	2007	pooled	2006	2007	pooled	2006	2007	pooled
$Y_2 = 65.483 – 1.344 X_1$	0.502	0.586	0.688	10.08	14.14	22.04	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_2 = 52.695 – 1.419 X_2$	0.582	0.747	0.718	13.95	29.48	25.47	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_2 = 56.823 – 0.285 X_1 – 1.171 X_2$	0.587	0.790	0.736	6.40	16.98	12.55	4.10 (7.55)	4.10 (7.55)	4.10 (7.55)
$Y_2 = -7.082 + 0.360 X_3$	0.580	0.700	0.745	13.79	23.30	29.15	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_2 = 3.645 + 0.274 X_4$	0.479	0.443	0.635	9.19	7.95	17.38	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_2= -5.551 + 0.266 X_3 + 0.101 X_4$	0.606	0.712	0.757	6.91	11.13	14.05	4.10 (7.55)	4.10 (7.55)	4.10 (7.55)
$Y_2 = 7.001 + 1.016 X_5$	0.277	0.216	0.359	3.83	2.76	5.60	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_2 = 14.763 + 2.769 X_6$	0.095	0.195	0.195	1.05	2.43	2.42	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_2 = 14.763 + 4.707 X_7$	0.095	0.570	0.482	1.05	13.24	9.31	4.96 (10.04)	4.96 (10.04)	4.96 (10.04)
$Y_2 = 20.100 – 0.09674 X_1 – 0.787 X_2 + 0.198 X_3$	0.607	0.837	0.767	4.11	13.71	8.77	4.07 (7.59)	4.07 (7.59)	4.07 (7.59)
$Y_2 = 9.918 + 0.226 X_1 – 0.669 X_2 + 0.175 X_3 + 0.08668 X_4$	0.624	0.837	0.776	2.91	9.00	6.06	4.12 (7.84)	4.12 (7.84)	4.12 (7.84)
$Y_2 = 21.294 + 0.514 X_1 - 0.259 X_2 + 0.233 X_3 + 0.134 X_4 + 0.497 X_5$	0.660	0.851	0.837	2.33	6.86	6.18	4.38 (8.74)	4.38 (8.74)	4.38 (8.74)
$Y_2 = -5.029 + 1.151 X_1 – 1.684 X_2 + 0.292 X_3 + 0.101 X_4 + 0.000498 X_5 – 4.834 X_6$	0.743	0.878	0.839	2.41	5.99	4.35	4.95 (10.67)	4.95 (10.67)	4.95 (10.67)
$Y_2 = -5.029 + 1.151 X_1 – 1.684 X_2 + 0.292 X_3 + 0.101 X_4 + 0.000498 X_5 – 8.217 X_7$	0.743	0.888	0.845	2.41	4.53	3.12	4.95 (10.67)	6.09 (14.97)	6.09 (14.97)

Table 8. Regression equation for *Alternaria* blight progression on clusterbean (over all pooled over year and over variety)

Regression equations	R^2	F-cal	F-tab at 5% (1%)
$Y_1 = 103.518 – 2.285 X_1$	0.740	28.40	4.96 (10.04)
$Y_1 = 58.150 – 1.541 X_2$	0.746	29.34	4.96 (10.04)
$Y_1 = 82.534 – 1.140 X_1 – 841 X_2$	0.776	15.57	4.10 (7.55)
$Y_1 = -14.523 + 0.498 X_3$	0.787	36.91	4.96 (10.04)
$Y_1 = -1.777 + 0.533 X_4$	0.699	23.23	4.96 (10.04)
$Y_1= -12.337 + 0.360 X_3 + 0.184 X_4$	0.809	19.07	4.10 (7.55)
$Y_1 = 5.933 + 1.633 X_5$	0.354	5.48	4.96 (10.04)

$Y_1 = 17.574 + 0.414 X_6$	0.216	2.76	4.96 (10.04)
$Y_1 = 16.133 + 9.576 X_7$	0.506	10.25	4.96 (10.04)
$Y_1 = 32.689 – 0.776 X_1 – 0.192 X_2 + 0.296 X_3$	0.812	11.49	4.07 (7.59)
$Y_1 = 28.543 – 0.609 X_1 – 0.243 X_2 + 0.193 X_3 + 0.158 X_4$	0.828	8.40	4.12 (7.84)
$Y_1 = -49.868 – 0.840 X_1 – 0.00497 X_2 + 0.190 X_3 + 0.424 X_4 + 1.253 X_5$	0.881	8.85	4.38 (8.74)
$Y_1 = -38.768 + 0.867 X_1 – 0.275 X_2 + 0.007604 X_3 + 0.458 X_4 + 1.219 X_5 + 0.008924 X_6$	0.885	6.39	4.95 (10.67)
$Y_1 = -37.253 + 0.935 X_1 – 0.440 X_2 + 0.004573 X_3 + 0.508 X_4 + 1.319 X_5 + 0.118 X_6 – 1.987 X_7$	0.892	4.71	6.09 (14.97)

ACKNOWLEDGEMENT

The authors are grateful to Dean, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner for providing necessary facilities.

REFERENCES

Chattopadhyay, C., Agrawal, R., Kumar, A., Bhar, L. M., Meena, P. D., Meena, R. L., Khan, S. A., Chattopadhyay, A. K., Awasthi, R.P., Singh, S.N., Chakravarthy, N.V.K., Kumar, A., Singh, R.B. and Bhunia, C.K. (2005). Epidemiology and forecasting of *Alternaria* blight of oil seed *Brassica* in India a case study, *Zeitschrit-fur-pflanzenkrnkheiten-und-pflanzenschutz.* **112** (4): 351-365.

Dubey, S.C. and Ekka, S. (2004). Influence of weather on development of *Collettrichum* blight of bitter gourd, *Journal of Mycology and Plant Pathology* . **34**(2): 404 - 406.

Fisher, R.A. and Yates, F. (1956). Statistical tables for Biological. Agricultural and Medical Research 5 th ed., Oliver and Boyd. Edinburgh.

Gupta, P.P. (1994). Assessment of yield losses in different genotypes of clusterbean against important diseases, Annual Report of All India Coordinated Research Project of Arid Legumes, pp. 1-14.

Gupta, P. P., Gupta, V., Singh, J.V. and Singh, V.P. (1998). *Alternaria* blight (*Alternaria cucumerina* var. *cyamopsidis*) disease management strategy in clusterbean (*Cymopsis tetragonoloba* (L.) Taub.). (Abstr.) Proc. 7th Int. Cong. PI. Pathol. Edinburgh, Scotland.

Gupta, R., Awasthi, R.P. and Kolte, S.J. (2004). Effect of sowing date and weather on development of white rust (*Albugo candida*) in rapeseed-mustard, *Journal of Mycology and Plant Pathology*. **34**(2): 441-444.

McKinney, H. H. (1923). Influence of soil temperature and moisture on infection of wheat seedling by *Helminthosporium sativum*, *Journal of Agricultural Research*. **26**:195-217.

Mehta, N., Sangwan, M.S., Kumar,R. and Niwash, R. (2008). Progression of *Alternaria* blight on different varieties of rapeseed-mustard in relation to weather parameters, *Plant Disease Research*. **23**(1): 28-33.

Rangaswami, G. and Rao, A .V. (1957). *Alternaria* blight of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub],*Indian Phytopath*ology. **10**: 13-18.

Saharan, M.S., Saharan, G.S. and Singh, J.V. (2001). Inheritance of resistance in clusterbean to *Alternaria* blight (*Alternaria cucumerima* var. *cyamopsidis*) disease, *Journal of Mycology and Plant Pathology*. **31**: 72-75.

Saharan, M.S., Saharan, G.S. and Gupta, P.P. (2003). Conidial germination of *Alternaria cucumerima* var. *cyamopsidis* causing *Alternaria* blight of clusterbean, *Journal of Mycology and Plant Pathology*. **33** (3): 444-445.

Sangwan, M.S., Mehta, N. and Shrivastava, M.P. (2004). Progression of *Alternaria* blight in relation to weather factors on two varieties of rapeseed-mustard, *Journal of Mycology and Plant Pathology*. **34**(3): 1000.

Sowell, P.G. (1965). The effect of seed treatment on seed borne pathogens of guar, *Plant Disease Reporter*. **49**: 895-897.

Yogendra, Singh., Kushwaha, K.P.S., Chauhan, S.S. and Singh, Y. (1995). Epidemiology of *Alternaria* leaf blight of clusterbean caused by *Alternaria cyamopsidis*, *Annual Plant Protection Sciences*. **3** (2): 171-172.