Biological Forum – An International Journal **15(8): 488-495(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of Weather Parameters in Relation to Occurrence and Development of Leaf Blight (*Alternaria macrospora*) of Cotton

R. J. Chaudhari*, M. M. Talpada, A. C. Detroja and S. N. Galani
Main Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar (Gujarat), India.

(Corresponding author: R. J. Chaudhari)*
(Received: 02 June 2023; Revised: 29 June 2023; Accepted: 18 July 2023; Published: 15 August 2023)
(Published by Research Trend)

ABSTRACT: In the present context, cotton farming in India is far from being a sustainable agricultural system. India is the second-largest producer of conventional cotton after China. More than 90% of the cotton is produced from genetically modified, pest-resistant, high yielding Bt cotton varieties. In relation to weather parameters, impact of different meteorological parameters on development of leaf blight on cotton, first leaf blight (*Alternaria macrospora*) symptoms were appeared on 37th and 39th standard meteorological week during 2020-21 and 2021-22, respectively. In correlation study, maximum temperature was non-significant with negative effect on leaf blight disease development in year 2020-21, while maximum temperature was also non-significant but positive effect leaf blight disease development in year 2021-22. Minimum temperature was non-significant with negative effect in year 2020-21 and 2021-22, respectively. Morning and evening relative humidity was significant and highly significant in both years, respectively and wind speed opposite to RH. Regression study, in year 2020-21 reflect that one per cent increase in morning relative humidity and wind speed led to corresponding decrease in per cent disease index of *Alternaria* blight in 2020-21 and 2021-22. This study focuses on impact of weather parameters on fungal foliar diseases and tackles the problem as well. Weather parameters play vital and crucial role in formation, development and multiplication of new virulence pathogen, so its challenges to researchers for identification of responsible different gene for it.

Key words: Leaf blight, weather parameters, standard week, cotton.

INTRODUCTION

Cotton is one of the most ancient and important commercial crop next only to food grains and is the principal raw material for a flourishing textile industry. Cotton, although under pressure from synthetic fibers, has made resurgence worldwide and remains as the most improved crop species producing lint plus oil and meal from seed (Nosberger *et al.*, 2001). India got first place in the world in cotton acreage with around 120.69 lakh hectares under cotton cultivation *i.e.* around 36% of the World area of 333 lakh hectares. In 2021-22 approximately 67% of India's cotton is produced on rainfed areas and 33% on irrigated lands. In terms of productivity, India (510 kg/ha) ranks poorly compared to the USA (951 kg/ha) and China (1892 kg/ha) (Anon., 2021).

The major cotton growing districts/area in Gujarat is Kutch, Saurashtra and North Gujarat; however, cotton is grown in almost all the districts of Gujarat. In Gujarat, during 2019-20, cotton cultivated in an estimated area of 26.684 lakh ha with a yield of 681.32 kg/ha. All four species, *G. arboreum* and *G. herbaceum* (Asian cotton), *G. barbadense* (Egyptian cotton) and *G. hirsutum* (American Upland cotton) grown in India. *G. hirsutum* represents 88% of the hybrid cotton production in India and all the current Bt cotton hybrids are *G. hirsutum* (Anon., 2019).

Bt cotton hybrids are susceptible to diseases like bacterial blight, *Alternaria* leaf spot and grey mildew. Bacterial blight, *Alternaria* leaf spot and grey mildew were the major diseases on cotton identified in the central and southern parts of the country in 2004 (Ashok, 2005).

Despite the promising scenario in cotton, several factors are responsible for reduction in yield and quality deterioration of cotton in India. A large number of fungal, bacterial, viral and nematode diseases have been reported on cotton crop right from early stage to maturity. Among them, the economically most important ones are bacterial blight, Alternaria leaf spot, grey mildew, rust and vascular wilts which occur throughout the world (Kotasthane and Agrawal 1970). *Alternaria* leaf blight and other leaf spotting fungi pose an alarming situation (Gholve *et al*., 2012). In India, leaf spot of cotton (*Alternaria macrospora* Zimm.) was first reported by in Bombay (Uppal *et al*., 1935) and later it reported in Pune and Ahmednagar (Rane and Patel 1956), however observed it later in large scale and subsequently, many researchers recorded its occurrence from various provinces of India (Dastur *et al*., 1960, Chopra and Sharma 1975; Padmanabhan

and Narayanasamy 1976).

Epidemics of *Alternaria* leaf spot in Israel decreased the yield of Pima-S-5 by 25 per cent (Bashi *et al*., 1983). Disease was serious on three cotton varieties of *G. hirsutum*, the other cultivated species of *Gossypium* being resistant (Dastur *et al*., 1960). *Alternaria* blight (*A. macrospora*) has been reported to cause about 20-30 per cent losses in seed cotton yield (Srinivasan, 1994, Chauhan *et al.*, 1997; Mayee and Mukewar 2007). However, the production potential of the crop has not been fully exploited due to several biotic and abiotic factors. The crop suffers from many fungal diseases, of which foliar diseases take a heavy toll and among the diseases, *Alternaria* leaf spot causes yield losses up to 26 per cent *(*Chattannavar *et al*., 2006).

Alternaria leaf spot of cotton appeared during 37th meteorological week at the seedling stage and reached its peak (31.8%) during the 5th meteorological week at the boll maturity stage (Venkatesh *et al*., 2016). Rainfall, minimum temperature and relative humidity (RH-I and II) had a positive correlation with the development of leaf spot of safflower caused by *A. carthami* and rains received coupled with high humidity above 80% and temperature in the range of 21 to 32 °C favours the primary infection to the crop (Gud *et al*., 2017).

Different weather parameters *viz*., rainfall, temperature and humidity on the development of *Alternari*a leaf spot of safflower caused by *A. carthami* (Wagh *et al*., 2017). studied that maximum, minimum temperatures, number of rainy days and wind speed significantly influenced the development of *Alternaria* leaf spot (R^2 = 0.984) (Bhattiprolu and Monga 2018).

The leaf blight of cotton incited by *A. macrospora* cause heavy losses in the yield. Not much information is however available regarding effect of weather on the development of disease. Therefore, a study was undertaken to observe impact of weather condition on the development of leaf blight disease of cotton.

MATERIAL AND METHODS

Geographically, Kukada is situated at 22.4° N latitude and 71.3° E longitudes under North-Saurashtra Agro-climatic region of Gujarat state and enjoys a typically subtropical climate characterized by fairly cold and dry winter, hot and dry summer and warm and moderately humid monsoon. The rainy season commences in the first fortnight of June and ends by mid of September with an average rainfall of 650 mm (average of last 10 years). July and August are the months of heavy rainfall.

Jamnagar is situated at 22.47° N latitude and 70.05° E longitudes under North-Saurashtra Agro- climatic region of Gujarat state and enjoys a typically subtropical climate characterized, the wet season is oppressive and mostly cloudy, and the dry season is humid and mostly clear, and moderately humid monsoon. The rainy season commences in the first fortnight of June and ends by mid of September with an average rainfall of 677 mm (average of last 10 years). July and August are the months of heavy rainfall.

A trial was conducted to determine the influence of weather conditions on the severity of leaf blight disease in cotton. Highly susceptible cotton cultivar was sown in 5.4 × 9 m (10 Rows) spacing with 90 × 30 cm, during *Kharif* 2020-21 at Cotton Research Station, JAU, Kukada and 2021-22 at Pearl Millet Research Station, JAU, Jamnagar. The data on *Alternaria* leaf blight was weekly examined from 3 leaf stag to up to harvest (Venkatesh *et al*. 2016). Meteorological data such as rainfall, maximum temperature, minimum temperature, relative humidity at morning and evening hours and wind velocity were collected from the Meteorological Weather Station, JAU, Kukada and Jamnagar. Correlation and regression analyses were conducted to determine the influence of weather conditions on the severity of leaf blight disease in cotton.

The disease intensity was recorded from 10 tagged plants on 0-4 scale given by Sheo Raj (1988).

Disease grade	Symptoms
0	Immune, completely free from infection
1	Resistant, infection 0-10 %
2	Moderately resistant, infection 11-20 %
3	Moderately susceptible, infection 21-40 %
4	Susceptible, infection >40 %

The weather parameters were correlated to weekly disease intensity by calculating the Karl Person's correlation coefficient (r). Correlation coefficient values were tested individually for their significance at 5% probability level using following formula;

$$t = \frac{r\sqrt{n-2}}{r\sqrt{1-r}}$$

Where,

t = Test of significance,

r = Correlation coefficient and

n = Number of observations

The per cent disease intensity (PDI) were calculated as per given formula.

$$\text{Disease intensity}(\%) = \frac{\text{Sum of total rating}}{\text{Total number of leaves observed}} \times \frac{100}{\text{Maximum disease rating}}$$

RESULTS AND DISCUSSION

The leaf blight of cotton incited by *A. macrospora* cause heavy losses in the yield. Not much information is however available regarding effect of weather on the development of disease. Therefore, a study was undertaken to observe impact of weather condition on the development of leaf blight disease of cotton.

An understanding of the role of environmental factors and their consequences on infection, development and spread of the pathogen / diseases is needed to develop sustainable disease management practices. Keeping in view, all of the above evidences, present investigations were planned and conducted on cotton leaf blight at Cotton Research Station, JAU, Kukada during the crop season in year 2020-21, the maximum and minimum temperature ranged between 11.0 to 38.5 °C and 6.0 to 27.2 °C, respectively, while the morning and evening relative humidity were in the ranges of 52.29 to 88.57 and 30.29 to 82.71 per cent, respectively, wind speed was ranged from 2.55 to 10.93 km/h and rain was also recorded in the ranges of 0.0 to 327.40 mm.

According to the meteorological data (Table 1, Fig. 1 and Table 2, Fig. 2), weather parameters such as temperature, relative humidity, and wind speed were more or less favourable for the development of cotton leaf blight during Kharif 2020-21 and 2021-22.

The development of the leaf blight disease was greatly influenced by climatic conditions. Crop was sown in the first season on July 16th, 2020-21 (29th standard week) and the second season on July 1st, 2021-22 (26th standard week).

During the year 2021-22 at Pearl Millet Research Station, JAU, Jamnagar, the maximum and minimum temperature ranged between 23.71 to 36.07 °C and 11.14 to 27.86 °C, respectively, while the morning and evening relative humidity were in the ranges of 55.71 to 94.86 and 21.00 to 86.14 per cent, respectively, wind speed was ranged from 2.06 to 16.20 km/h and rainfall was also recorded in the ranges of 0.0 to 244.0 mm.

Disease development under natural conditions was found to be influenced by environmental factors. Initial leaf blight symptom was appeared on 37th standard meteorological week in 2020-21 and 39th standard meteorological week in 2021-22 on cotton crop.

Observations were made at weekly intervals from the 26th SMW to the 9th SMW in 2020-21 and 2021-22. Disease progression was continuous from the 37th to the 5th SMW in 2020-21 and from the 39th to the 3rd SMW in 2021-22.

The first disease symptoms appeared in the second week of September 2020 (37th SMW) with maximum and minimum temperatures of 29.50 0C and 26.20 °C, and the fourth week of September 2021 (39th SMW) with maximum and minimum temperatures of 31.43 °C and 24.79 °C, respectively, with leaf blight intensity (4.00 and 3.50%) in the years 2020-21 and 2021-22. It was gradually increased week by week until the crop season ended. In the years 2020-21 and 2021-22, the maximum leaf blight intensity was measured in the first week of November (45th SMW) at 37.50 and 37.50, respectively.

A. Correlation study

Correlation coefficient study presented in Table 3 and Table 4 revealed that, maximum temperature (r = 0.119) were non-significant with negative effect on leaf blight disease development in year 2020-21, while maximum temperature (r = 0.018) were also non-significant but positive effect on leaf blight disease development in year 2021-22. Minimum temperature (r = 0.246 and r = 0.252) was non-significant with negative effect in year 2020-21 and 2021-22, respectively. Morning relative humidity (r = 0.422) was significant at 5% with negative effect in year 2020-21, while in year 2021-22 morning relative humidity (r = 0.724) was highly significant at 1% with negative effect. Evening relative humidity (r = 0.372) was significant at 5% with negative effect in year 2020-21, while in year 2021-22 evening relative humidity (r = 0.518) was highly significant at 1% with negative effect. Wind speed (r = 0.604) was highly significant at 1% with negative effect in year 2020-21, while in year 2021-22 Wind speed (r = 0.386) was significant at 5% with negative effect. The most significant effect on the scale of the infection of cotton was relative humidity. Rain is another factor responsible in monsoon season but uneven rain, sometimes heavy rain and sometime dry spell less impact on disease development. Rain (r = 0.300 and r = 0.234) had no effect on leaf blight disease in year 2020-21 and 2021-22, respectively.

B. Regression study

The data on per cent disease index was subjected to step up multiple linear regression analysis. Regression study presented in Table 5 and Table 6.

In year 2020-21 following equation was made Y = 73.528-0.994 Morn RH-4.470 WS. The coefficient determination (R^2) was 0.562, which showed that weather factors caused variation in per cent disease index to the extent of 56.2 per cent. It was also observed from the step up regression equation that among the weather factors studied the partial regression coefficient (b) for morning related humidity and wind speed was highly significant and negative correlated with per cent disease index.

It means that for every one per cent increase in relative humidity during morning and wind speed led to corresponding decrease in per cent disease index of *Alternaria* blight of 0.994 and 4.470 per cent, respectively.

It was evident that for every one per cent increase in wind speed led to corresponding decrease in per cent disease index of *Alternaria* blight of 3.690 per cent.

Table 1: Effect of weather parameters on disease development (2020-21).

Std. Week No.	*Alternaria* leaf blight (PDI)	Temperature (^{0}C)		Relative Humidity (%)		Wind speed (km/h)	Rainfall (mm)
		Maximum	Minimum	Morning	Evening		
June-2020							
26	0.00	38.50	25.90	67.29	43.42	9.92	59.80
July-2020							
27	0.00	31.80	27.20	82.57	57.71	10.93	34.00
28	0.00	30.00	26.00	80.43	61.71	10.50	72.00
29	0.00	27.00	23.50	78.43	62.28	10.79	22.00
30	0.00	30.00	27.00	71.76	45.63	9.85	0.00
31	0.00	30.00	26.00	71.14	46.86	7.77	41.80
August-2020							
32	0.00	30.50	24.00	81.29	70.00	9.08	50.20
33	0.00	22.00	24.00	87.14	82.71	10.04	124.40
34	0.00	28.00	25.00	83.71	76.29	10.12	327.40
35	0.00	27.00	24.00	81.71	68.43	8.32	53.40
September-2020							
36	0.00	28.50	25.00	85.29	55.57	4.77	0.00
37	4.00	29.50	26.20	84.57	57.71	4.82	62.60
38	6.00	28.20	26.00	80.57	63.00	5.76	11.40
39	10.00	29.00	24.50	82.29	60.29	6.06	0.00
October-2020							
40	12.00	28.80	23.00	88.57	48.86	5.27	0.00
41	19.00	27.00	22.10	70.14	33.88	4.69	0.00
42	27.00	28.50	20.50	77.14	52.36	5.03	0.00
43	32.00	26.40	15.50	72.00	40.57	4.03	0.00
44	34.00	22.10	15.50	70.57	36.29	3.00	0.00
November-2020							
45	37.50	20.60	15.50	72.43	46.43	2.82	0.00
46	32.50	17.60	13.00	64.86	41.43	3.67	0.00
47	30.50	18.50	13.20	52.29	30.29	4.37	0.00
48	27.00	20.50	16.50	65.29	43.71	5.52	0.00
December-2020							
49	19.50	21.50	13.50	65.14	40.00	2.55	0.00
50	14.00	27.50	14.00	81.85	57.14	4.31	0.00
51	13.50	21.00	11.00	63.43	46.00	4.80	0.00
52**	7.00	14.50	11.00	67.71	35.86	5.34	0.00
January-2021							
1	2.50	12.50	9.50	68.43	43.57	5.60	0.00
2	1.00	13.50	11.00	78.86	51.00	6.33	0.00
3	2.50	17.50	8.00	75.71	45.71	3.84	0.00
4	3.50	15.00	10.50	67.20	39.14	4.53	0.00
5	2.00	11.00	6.00	67.33	36.50	4.95	0.00
February-2021							
6	0.00	17.50	10.50	71.86	35.83	4.34	0.00
7	0.00	14.50	11.50	79.28	40.43	4.93	0.00
8	0.00	22.00	12.50	69.37	37.43	4.68	0.00
9	0.00	21.50	17.00	70.67	36.00	6.91	0.00

** Week No. 52 have an always 8 days

Table 2: Effect of weather parameters on disease development (2021-22).

Std. Week No.	*Alternaria* leaf blight (PDI)	Temperature (^{0}C)		Relative Humidity (%)		Wind speed (km/h)	Rainfall (mm)
		Maximum	Minimum	Morning	Evening		
June-2021							
26	0.00	35.50	27.86	73.43	56.43	13.83	0.00
July-2021							
27	0.00	36.07	27.57	76.00	54.14	13.84	0.00
28	0.00	34.97	27.30	83.29	63.00	9.47	9.00
29	0.00	33.93	27.03	89.29	68.57	12.59	72.00
30	0.00	31.96	27.10	92.71	76.14	15.16	30.00
31	0.00	32.14	26.49	85.29	67.43	16.20	4.50
August-2021							
32	0.00	33.03	25.80	85.43	65.57	9.31	0.50
33	0.00	32.97	25.43	83.57	65.29	10.11	0.00
34	0.00	32.69	25.86	85.86	65.29	9.79	2.00
35	0.00	33.07	25.54	88.57	72.00	8.04	68.50
September-2021							
36	0.00	31.36	25.60	93.00	83.00	8.19	91.00
37	0.00	30.33	24.84	94.86	83.00	7.19	204.00
38	0.00	32.53	26.06	90.71	76.29	7.76	6.50
39	3.50	31.43	24.79	94.29	86.14	4.86	244.00
October-2021							
40	5.00	32.64	25.21	90.43	73.14	5.06	7.00
41	10.50	34.57	25.57	88.14	61.00	3.67	0.00
42	15.00	34.76	23.93	76.57	38.43	3.89	0.00
43	23.50	33.03	22.04	74.57	39.71	4.96	0.00
44	32.00	34.17	20.07	64.86	25.57	3.80	0.00
November-2021							
45	39.00	33.50	19.69	55.71	25.86	5.89	0.00
46	32.50	31.87	19.14	60.86	31.14	8.49	0.00
47	24.00	31.23	20.99	74.71	44.86	7.49	1.00
48	24.00	31.71	18.21	68.71	30.57	4.20	0.00
December-2021							
49	16.00	27.96	17.43	70.86	35.86	2.66	0.00
50	13.50	26.00	13.00	60.00	21.00	2.20	0.00
51	12.50	26.87	12.19	72.14	25.43	2.06	0.00
52**	11.00	27.06	13.89	83.25	37.88	2.26	1.50
January-2022							
1	9.50	26.93	17.14	85.29	50.57	4.09	3.00
2	11.00	23.71	11.14	75.00	32.43	5.53	0.00
3	5.50	26.83	13.80	78.00	36.86	5.60	0.00
4	0.00	24.50	11.43	71.43	32.00	5.73	0.00
5	0.00	27.61	13.73	93.00	37.00	3.16	0.00
February-2022							
6	0.00	28.50	14.36	81.71	35.71	4.81	0.00
7	0.00	29.64	14.64	79.57	27.86	4.57	0.00
8	0.00	32.01	16.71	85.14	24.86	5.77	0.00
9	0.00	32.11	18.11	70.57	24.71	5.51	0.00

** Week No. 52 have an always 8 days

Table 3: Correlation coefficient between weather parameters and *Alternaria* blight per cent disease index for the year 2020-21.

Variable	Weather parameters	Correlation co-efficient 'r' value
X_1	Maximum temperature (ºC)	-0.119
X_2	Minimum temperature (ºC)	-0.246
X_3	Morning relative humidity (%)	-0.422*
X_4	Evening relative humidity (%)	-0.372*
X_5	Wind speed (km/h)	-0.604**
X_6	Rainfall (mm)	-0.300

*Significant at (p = 0.05) level **Significant at (p = 0.01)

Table 4: Correlation coefficient between weather parameters and *Alternaria* blight per cent disease index for the year 2021-22.

Variable	Weather parameters	Correlation co-efficient 'r' value
X_1	Maximum temperature (ºC)	0.018
X_2	Minimum temperature (ºC)	-0.252
X_3	Morning relative humidity (%)	-0.724**
X_4	Evening relative humidity (%)	-0.518**
X_5	Wind speed (km/h)	-0.386*
X_6	Rainfall (mm)	-0.234

*Significant at (p = 0.05) level **Significant at (p = 0.01)

Table 5: Multiple linear regression analysis between weather parameters and *Alternaria* blight per cent disease index for the year 2020-21.

Variable	Weather parameters	Regression co-efficient (b)	Standard error (E)	t-value
X_1	Maximum Temp. (ºC)	0.267	0.524	0.510
X_2	Minimum Temp. (ºC)	0.622	0.628	0.992
X_3	Morning RH (%)	-0.994**	0.331	-3.000
X_4	Evening RH (%)	0.399	0.254	-1.568
X_5	Wind speed (km/h)	-4.470**	0.943	-4.738
X_6	Rainfall (mm)	0.002	0.035	-0.060

**Significant at (p= 0.01)
Intercept (a) = 73.528, Co-efficient of determination (R^2) = 0.562
Multiple Correlation Coefficient (R) = 0.750, Standard Error = 9.008

In year 2021-22 more or less same scenario has been observed compared to previous year. In this year following equation was made Y = 64.339-0.976 Morn RH-1.333 WS. Here, wind speed was common weather factor in both years. The coefficient determination (R^2) was 0.653, which showed that weather factors caused variation in per cent disease index to the extent of 65.3 per cent.

It was also observed from the step up regression equation that among the weather factors studied the partial regression coefficient (b) for morning related humidity was highly significant and wind speed was significant but both were negative correlated with per cent disease index. It means that for every one per cent increase in morning relative humidity and wind speed led to corresponding decrease in per cent disease index of *Alternaria* blight of 0.976 and 1.333 per cent, respectively. These results of correlation are supported by earlier reports of Venkatesh *et al.* (2016), they found that the leaf spot of cotton first appeared during 37th SMW.

Bhattiprolu and Monga (2018) supported the wind speed significantly influenced the development of *Alternaria* leaf spot in Cotton. Gud *et al.* (2017) conferred that the relative humidity significant affect the development of *Alternaria* leaf spot in saffflower. Also same correlation study observed by Thakare *et al.* (2014) in cotton, Selvamani *et al.* (2014) in crucifers and Wagh *et al.* (2017) in safflower.

Table 6: Multiple linear regression analysis between weather parameters and *Alternaria* blight per cent disease index for the year 2021-22.

Variable	Weather parameters	Regression co-efficient (b)	Standard error (E)	t-value
X_1	Maximum Temp. (ºC)	0.659	1.771	0.372
X_2	Minimum Temp. (ºC)	0.080	1.791	0.044
X_3	Morning RH (%)	-0.976**	0.257	-3.795
X_4	Evening RH (%)	0.174	0.373	0.466
X_5	Wind speed (km/h)	-1.333*	0.497	-0.268
X_6	Rainfall (mm)	0.005	0.033	0.141

**Significant at (p= 0.01)
Intercept (a) = 64.339, Co-efficient of determination (R^2) = 0.653
Multiple Correlation Coefficient (R) = 0.808, Standard Error = 7.19

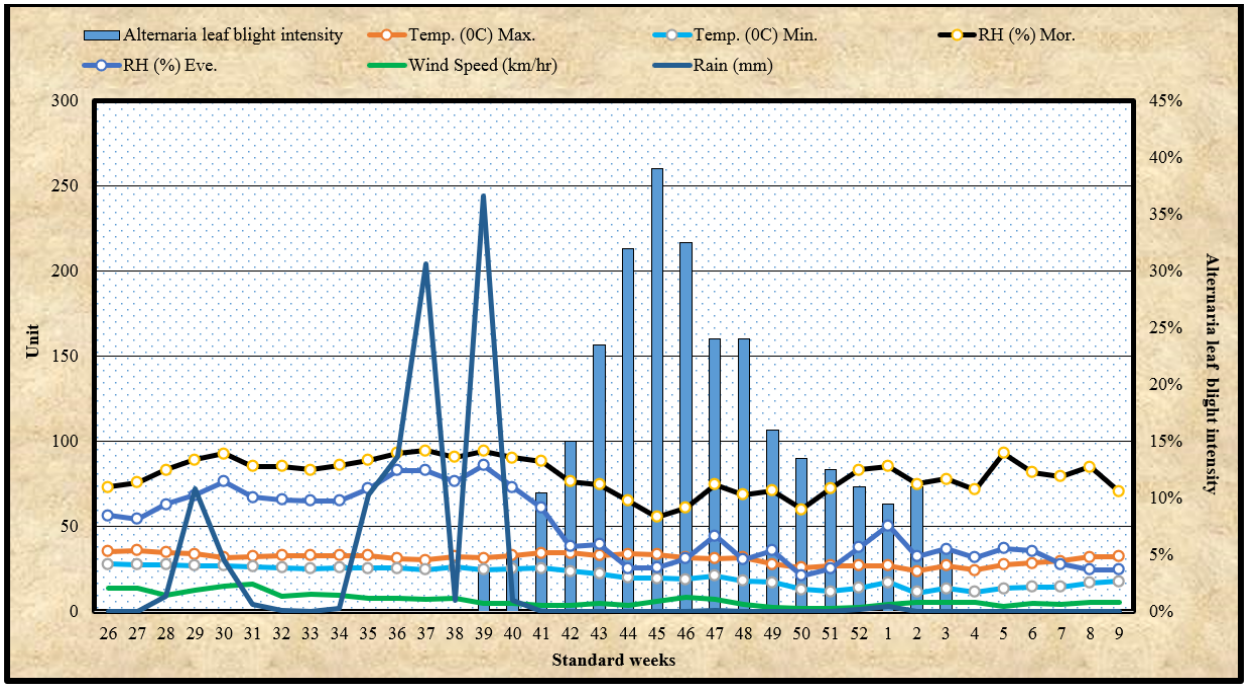

Fig. 1. Impact of weather factors for development of Alternaria leaf blight disease in cotton for the year 2020-21.

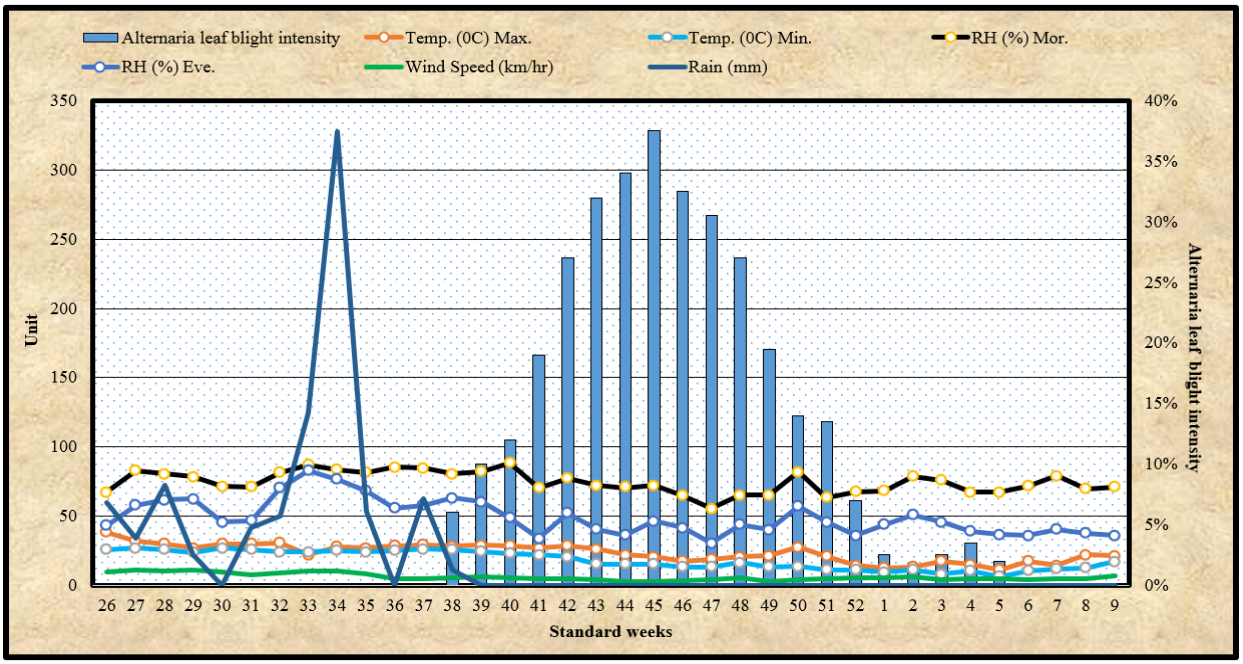

Fig. 2. Impact of weather factors for development of Alternaria leaf blight disease in cotton for the year 2021-22.

CONCLUSION

From the present investigation it is concluded that epidemiology study revealed that, how the climatic condition affects on leaf blight on cotton, weather parameters were checked with late blight disease intensity in year 2020-21 and 2021-22. First leaf blight symptoms were appeared on 37th standard meteorological week in 2020-21 and 39th standard meteorological week in 2021-22 on cotton crop with minimum disease intensity i.e. 4.00 and 3.5 per cent. In year 2020-21 and 2021-22 maximum leaf blight intensity was recorded in First week of November (45th SMW) 37.50 and 39.00 per cents, respectively.

FUTURE SCOPE

This prediction was useful for development and to know changing scenario of *Alternaria* disease development of cotton.

Acknowledgement. I am extremely thankful to Cotton Research Station, JAU, Kukada and Pearl millet research station, JAU, Jamnagar for providing land, inputs and man power for conducting the field trials. I also express my heartfelt thanks to Junagadh Agricultural University, Junagadh for proving financial assistance.
Conflict of Interest. None.

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How to cite this article: R. J. Chaudhari, M. M. Talpada, A. C. Detroja and S. N. Galani (2023). Effect of weather parameters in relation to occurrence and development of leaf blight (*Alternaria macrospora*) of cotton. *Biological Forum – An International Journal*, *15*(8): 488-495.