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Influence of weather parameters on *Alternaria* blight of cotton

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Abstract
Cotton is one of the most important commercial crops as it directs the destiny of large part of the farming community as well as that of the flourishing textile industry and is called by various names such as king of fibres, natural fibre, white gold, etc., it plays a vital role in the economy of India. Blight of cotton infected by *Alternaria macrospora* cause huge losses in the economic yield. Therefore, a study was conducted on influence of weather variables (temperature, relative humidity, rainfall and rainy days) on cotton *Alternaria* blight disease intensity at Main Agriculture Research Station (MARS), Raichur during 2022-23. The outcomes revealed that, for disease development positive correlation was found in between rainfall and rainy days, morning relative humidity and evening relative humidity with minimum temperature, between rainfall and rainy days, likewise, morning relative humidity and evening relative humidity on disease development. Interaction between sunshine hours with minimum temperature, rainy days, morning relative humidity and evening relative humidity have a significant negative correlation for disease development.

Keywords: *Bt cotton*, Alternaria blight, epidemiology, temperature, rainfall, humidity, sunshine hours

Introduction
Cotton is a significant crop that brings in a respectable living for millions of farmers in both developed and developing countries. Cotton is known to be susceptible to several diseases of bacterial, viral and fungal origins. Over the past two decades, there has been a shift in the relative significance of the several diseases that impact cotton in India. These alterations may be a result of changeover from the cultivation of Asiatic or Desi (*Gossypium herbaceum* and *Gossypium arboreum*) to American cottons (*Gossypium hirsutum*) and hybrids most of them, even though high yielding are susceptible to diseases (Hong-Bin *et al*., 2008) [4]. Since the beginning of time, India is the only nation recognised for its cotton textiles; the rest of the globe is primarily covered in wool, flax and silk. This was particularly from Asiatic *Gossypium arboreum* and *Gossypium herbaceum*. India is responsible for 22% (5.4 million tonnes) of global cotton production and 33% (10.7 mha) of the world's cotton acreage. About 70% of India's land is covered by hybrids, 20% by upland types, and 10% by diploid cultivars. There are only two states where *G. herbaceum* is found: Gujarat and Karnataka. All the nine cotton growing states in India cultivate two species *viz*., *G. hirsutum* and *G. arboreum*. Blight of cotton caused by *A. macrospora* cause numerous losses in the yield. Not much information is however available regarding effect of weather on the development of disease (Amaresh and Nargund, 2003) [1]. Therefore, a study was undertaken to determine the impact of weather conditions on the development of *Alternaria* blight disease of cotton. An understanding of the impact of environmental factors on infection, development and spread of the pathogen/diseases is necessary to formulate sustainable disease management practices.

Materials and Methods
The influence of weather variables (temperature, relative humidity, rainfall and rainy days) on cotton *Alternaria* blight disease intensity was studied at Main Agriculture Research Station (MARS), Raichur during 2022-23. For the purpose, observations regarding the severity of the *Alternaria* blight illness were made beginning with its initial appearance and continuing every week after that on RCH- 659 *Bt* cultivar of cotton. The data on weather parameters of the corresponding meteorological weeks during experimental year was obtained from the Meteorological department, MARS, Raichur and correlated with *Alternaria* blight disease intensity.

Further percent disease index was calculated by using the formula given by Wheeler (1969) [8].

$$PDI = \frac{\text{Sum of the numerical ratings}}{\text{Total no. of leaves scored}} \times \frac{100}{\text{Maximum disease grade}}$$

Correlation co-efficient between disease severity and different weather parameters was determined by Karl Pearson's formula and tested individually for their significance at 5 percent probability level, at the end of the experiment weather parameters which are favourable for disease development can be known using following formula.

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

Where,
t = test of significance
r = correlation co-efficient
n = number of observations

Results and Discussion

According to the meteorological data (Table 1), weather during the *kharif* of 2022–2023 was generally conducive for the development of *Alternaria* blight in terms of temperature, relative humidity, and sunshine hours. The maximum and minimum temperature ranged between 27.34 to 35.09 °C and 13.17 to 21.77 °C, respectively, while the morning and evening relative humidity were in the ranges of 71.14 to 91.14 and 41.00 to 78.00 percent, rainfall was between 0 to 21.09 mm, sunshine hours ranged between 0.14 to 9.24 (hrs/day) respectively. The disease progression was significantly impacted by the weather. Crop was sown on June 18th, 2022 (25th standard week). Initial *Alternaria* blight symptoms appeared on 32th standard meteorological week on cotton crop. Observations were made at weekly intervals from the 25th SMW of 2022 to 4th SMW of 2023. Disease progression was continuous from the 32th to 4th SMW. First disease symptoms appeared in the second week of August 2022 (32th SMW) with maximum and minimum temperatures of 29.69 °C and 20.49 °C, with leaf blight intensity (5.00%), was gradually increased week by week until the end of crop season, maximum severity (48.50%) was recorded in the last week of January, 2023 (4th SMW) (Fig. 1). Correlation coefficient study presented in table 2 reveals that, maximum temperature (r = -0.135) was non-significant, minimum temperature (r = -0.674), morning relative humidity (r = - 0.542), evening relative humidity (r = - 0.707) was highly significant at 1 percent with negative effect. Sunshine hours (r = 0.456) was significant at 5 percent with positive effect. While rain is another component that contributes to the monsoon season, its uneven, heavy, and occasionally dry spells have less of an impact on the development of disease. Rainfall (r = - 0.404) had a significant relation at 5 percent with negative effect on *Alternaria* blight disease during crop season. The data on weather parameters revealed that, there was a significant positive correlation between rainfall and rainy days (r = 0.727), minimum temperature and morning relative humidity (r = 0.610), rainfall and morning relative humidity (r = 0.573), rainy days and morning relative humidity (r = 0.664), minimum temperature and evening relative humidity (r = 0.752), rainfall and evening relative humidity (r = 0.590), rainy days and evening relative humidity (r = 0.715), morning relative humidity and evening relative humidity (r = 0.802) on disease development. However, interaction between sunshine hours and minimum temperature (r = 0.476), sunshine hours and rainy days (r = 0.561), sunshine hours and morning relative humidity (r = 0.441), sunshine hours and evening relative humidity (r = 0.735) have a significant negative correlation for disease development. The PDI of *Alternaria* blight was analysed using multiple linear regression to determine how weather parameters would affect it in 2022–2023. The results showed that the regression coefficients for maximum temperature (X1), minimum temperature (X2), rainfall (X3), rainy day (X4), morning relative humidity (X5), evening relative humidity (X6), and sunshine hours (X7) were + 0.396, + 0.328, + 0.541, - 3.716, + 0.444, - 1.154 and + 0.917 (Table 3). The multiple linear regression equation was fitted to the data and the equation arrived for the weather parameters is Y = 81.051 + 0.396 + 0.328 + 0.541 – 3.716 + 0.444 – 1.154 + 0.917. This analysis showed that, when there was increase in one unit of rainy day and evening relative humidity the percent disease severity was decreased by 3.716 and 1.154 units. Whereas increase in one unit of maximum temperature, minimum temperature, rainfall, morning relative humidity and sunshine hours, the percent disease severity was increased by 0.396, 0.328, 0.541, 0.444 and 0.917 units, respectively.

Our findings are in agreement with Venkateshwarlu *et al.* (2006) [7] and (Gowdar *et al.* 2007) [3] carried out a study to assess the epidemiology of farmer's and experimental fields for *Alternaria* leaf spot (*A. macrospora*). In experimental plots, the leaf spot first appeared in the first week of October (the 40th standard week) with a disease index of 0.7%. From there, it gradually climbed to 44.40 percent in the first week of December (the 49th standard week). Disease incidence in Farmer's fields peaked (45.8%) in the 47th standard week, having steadily grown from 1.28 percent in the 39th standard week. The proportion of disease incidence was found to be significantly positively connected with both morning relative humidity and rainfall, but negatively correlated with both maximum and minimum temperatures (Amaresh and Nargund, 2004) [2]. Perane *et al.* (2007) [5] revealed that all weather variables, with the exception of rainfall and hours of strong sunshine, had a negative correlation with the severity of the condition. Weather parameters such as temperature range of 21.40 (min.) to 29.40 ºC (max.), RH of 62.70 (afternoon) to 86 percent (morning), rainfall (47.10 mm) and bright sunshine hrs (3.57 hrs.) etc. favoured the disease development. There was significant negative correlation (-0.620) between the blight intensity and minimum temperature. Therefore, maximum blight disease growth was promoted by heavy rains (47.10 mm), moderate temperatures (21 to 29 ºC), high relative humidity (62-28%), and moderate bright sunshine hours (3.57 hrs/day). (Vamsi Krishna *et al.* 2018) [6].

Table 1: Influence of weather factors on progress of *Alternaria* blight of cotton during *kharif* 2022-23

Sl. No.	Standard meteorological week	Date	Temp. (^{0}C)		RH (%)		Rainfall (mm)	Rainy days	Sunshine hours (hrs/day)	PDI (%)
			Max.	Min.	Morning	Evening				
1	25	18.06.2022 to 24.06.2022	34.89	21.37	78.71	41.71	0.11	0.00	3.20	0
2	26	25.06.2022 to 01.07.2022	35.09	21.77	76.00	41.14	0.29	0.00	1.47	0
3	27	02.07.2022 to 08.07.2022	32.74	21.23	85.86	62.86	6.71	0.43	0.59	0
4	28	09.07.2022 to 15.07.2022	27.34	20.23	89.14	78.00	6.09	0.57	0.14	0
5	29	16.07.2022 to 22.07.2022	32.80	20.74	85.43	52.14	2.37	0.14	4.80	0
6	30	23.07.2022 to 29.07.2022	30.91	20.51	89.86	60.86	8.40	0.71	2.36	0
7	31	30.07.2022 to 05.07.2022	32.06	20.69	90.71	62.43	10.94	0.71	5.66	0
8	32	06.08.2022 to 12.08.2022	29.69	20.46	87.00	65.00	3.31	0.29	1.46	5
9	33	13.08.2022 to 19.08.2022	30.69	20.09	85.14	61.71	5.71	0.43	5.43	7.50
10	34	20.08.2022 to 26.08.2022	31.91	20.11	84.57	55.86	0.31	0.00	5.14	10.00
11	35	27.08.2022 to 02.09.2022	31.46	20.74	88.43	62.29	5.34	0.43	4.49	12.00
12	36	03.09.2022 to 09.09.2022	31.63	21.00	89.57	65.00	21.09	0.29	5.46	18.50
13	37	10.09.2022 to 16.09.2022	29.74	19.97	89.29	69.29	1.17	0.14	2.59	22.50
14	38	17.09.2022 to 23.09.2022	30.43	19.40	84.29	56.29	0.09	0.00	5.43	25.00
15	39	24.09.2022 to 30.09.2022	30.83	19.60	91.14	63.86	7.17	0.43	4.13	27.50
16	40	01.10.2022 to 07.10.2022	29.40	16.94	91.14	66.33	15.17	0.71	2.47	32.00
17	41	08.10.2022 to 14.10.2022	30.06	20.00	90.71	68.14	3.37	0.14	3.74	34.50
18	42	15.10.2022 to 21.10.2022	31.71	20.41	88.57	65.29	6.23	0.29	5.27	36.50
19	43	22.10.2022 to 28.10.2022	30.43	17.26	86.29	45.14	0.00	0.00	8.36	37.00
20	44	29.10.2022 to 04.11.2022	30.23	19.20	80.00	44.14	0.00	0.00	6.04	37.00
21	45	05.11.2022 to 11.11.2022	30.97	19.86	83.86	38.14	0.00	0.00	7.10	37.50
22	46	12.11.2022 to 18.11.2022	30.60	17.43	78.29	40.00	0.00	0.00	5.13	38.50
23	47	19.11.2022 to 25.11.2022	29.20	17.63	78.43	47.43	0.06	0.00	3.89	39.00
24	48	26.11.2022 to 02.12.2022	31.00	17.80	72.71	47.14	0.00	0.00	5.23	40.00
25	49	03.12.2022 to 09.12.2022	30.74	17.14	71.14	37.57	0.00	0.00	4.16	41.50
26	50	10.12.2022 to 16.12.2022	28.71	18.94	85.00	59.29	1.91	0.43	2.31	42.00
27	51	17.12.2022 to 23.12.2022	30.97	15.23	84.57	35.86	0.00	0.00	6.06	42.50
28	52	24.12.2022 to 31.12.2022	31.55	18.20	83.63	41.75	0.00	0.00	6.26	43.50
29	1	01.01.2023 to 7.01.2023	30.66	18.86	82.00	41.00	0.00	0.00	4.87	45.00
30	2	08.01.2023 to 14.01.2023	30.31	13.17	74.00	25.29	0.00	0.00	8.39	46.00
31	3	15.01.2023 to 21.01.2023	31.06	16.00	75.57	29.43	0.00	0.00	9.24	47.50
32	4	22.01.2023 to 28.01.2023	30.43	17.49	77.71	31.14	0.00	0.00	7.94	48.50

Table 2: Pearson's correlation matrix for percent disease index as influenced by different weather variables

Parameter	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y PDI	1.000							
X_1 maximum temperature (°C)	-0.135	1.000						
X_2 minimum temperature (°C)	-0.674**	0.175	1.000					
X_3 rainfall (mm)	-0.404*	0.097	0.348	1.000				
X_4 rainy days	-0.471*	0.229	0.359	0.727**	1.000			
X_5 Morning relative humidity (%)	-0.542**	-0.021	0.610**	0.573**	0.664**	1.000		
X_6 Evening relative humidity (%)	-0.707**	-0.138	0.752**	0.590**	0.715**	0.802**	1.000	
X_7 sunshine hours (hrs/day)	0.456*	0.470*	-0.476*	-0.296	-0.561**	-0.441*	-0.735**	1.000

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 3: Multiple regression analysis for *Alternaria* blight severity in relation to weather parameter

Location	Constant	X_1	X_2	X_3	X_4	X_5	X_6	X_7	R	R^2
MARS, Raichur	81.051	0.396	0.328	0.541	-3.716	0.444	-1.154	0.917	0.757	0.572
Multiple linear regression equation										
$Y = 81.051 + 0.396X_1 + 0.328X_2 + 0.541X_3 – 3.716X_4 + 0.444X_5 – 1.154X_6 + 0.917X_7$										

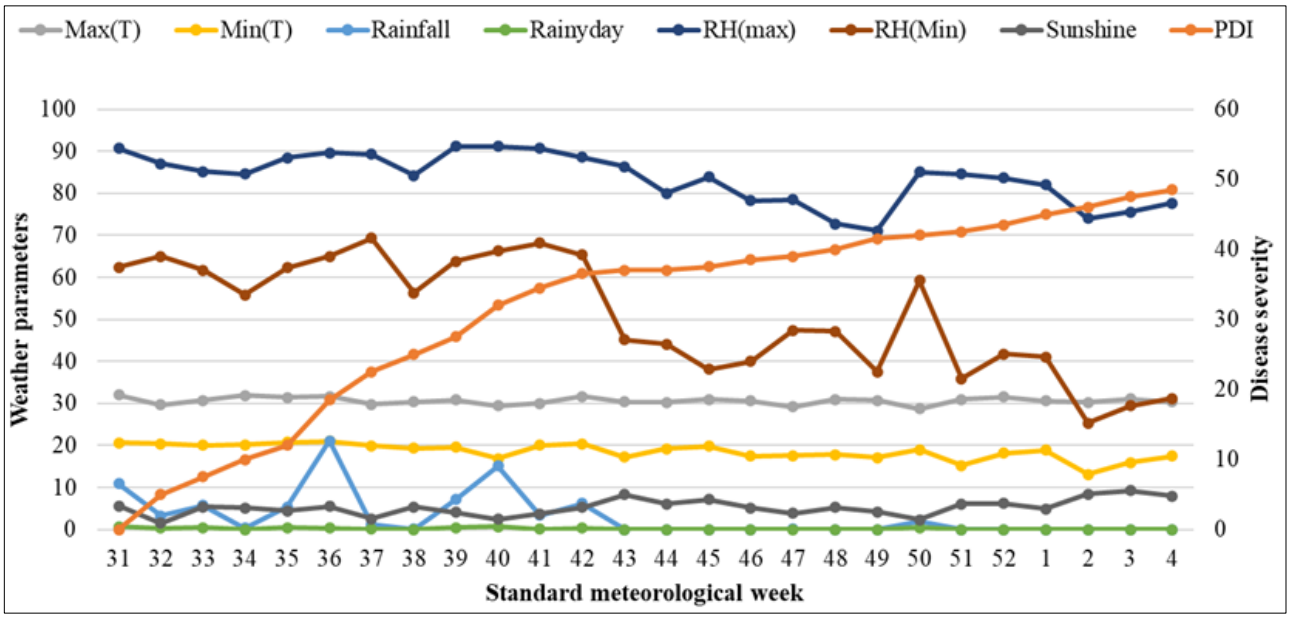

Fig 1: Influence of weather factors on progress of *Alternaria* blight of cotton during *kharif* 2022-23

Conclusion

For disease development positive correlation was found in between rainfall and rainy days, morning relative humidity and evening relative humidity with minimum temperature, between rainfall and rainy days, likewise, morning relative humidity and evening relative humidity on disease development. Interaction between sunshine hours with minimum temperature, rainy days, morning relative humidity and evening relative humidity have a significant negative correlation for disease development.

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