



Progress of *Alternaria* leaf spot in cotton as affected by weather parameters, phenological stages and date of sowing

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ABSTRACT: The effect of weather parameters, phenological stages and time of sowing on the development of *Alternaria* leaf spot in *Bt* cotton hybrid, Jaadoo BG II was investigated at Regional Agricultural Research Station, Lam, Guntur, during 2016-2017. Weekly data on disease score at different phenological stages of the crop was recorded on randomly labeled plants and per cent disease intensity (PDI) was correlated with weather parameters. Disease appeared during vegetative stage and reached peak at boll formation to boll bursting stages. Correlation analysis of pooled PDI in three sowings indicated significant negative correlation with minimum temperature, RH II, RH I; significant positive correlation with the number of sun shine hr. Multiple linear regression of pooled PDI revealed that RH II, rain fall, number of rainy days, sun shine hr and evaporation significantly influenced the disease development while minimum temperature, wind speed and RH I showed partial influence on disease progress. It was observed that irrespective of time of sowing, number of rainy days, RH II, sunshine hr, wind speed and evaporation are critical parameters in determining the progress of *Alternaria* leaf spot.

Key words: *Alternaria* leaf spot, cotton, phonological stages, weather parameters

Cotton is an important commercial crop in India with a production of 377 lakh bales of 170 kg lint in 2017-2018 from an area of 122.35 lakh ha with a productivity of 524 kg/ha, which is far behind the leading countries. Andhra Pradesh stood 7th in area (5.44 lakh ha) but 5th in production (22.0 lakh bales) and 3rd in productivity (688 kg/ha) during 2017-2018 (Anonymous, 2018). Cotton crop is affected by fungal, bacterial and viral diseases. In India, foliar diseases have been estimated to cause yield losses up to 20 to 30 per cent. *Alternaria* spp including *A. macrospora* Zimm., *A. alternata* (Fr.) Keissler cause leaf spot/blight. On leaves

dark brown, circular or irregular spots develop concentric ridges with a target board appearance. Mature spots have dry grey centres which may crack and even drop. Occasionally cankers develop on stems leading to cracking and breaking of stem. Circular lesions develop on bolls. The disease under congenial conditions causes severe defoliation and reduction in boll formation. Losses due to *Alternaria* leaf spot/blight were to the tune of 38.23 per cent in cotton variety LRA 5166 (Bhattiprolu and Prasada Rao, 2009) and 33.43 per cent in variety Jayadhar (Chattannavar *et al.*, 2010).

MATERIALS AND METHODS

To know the effect of weather factors, phenological stages and time of sowing on the development of *Alternaria* leaf spot, *Bt* cotton hybrid Jaadoo BG II was sown at three different dates of sowing (01.08.2016; 27.08.2016 and 29.09.2016) with 25-30 days interval in a bulk plot with an area of 150 m² at Regional Agricultural Research Station, Lam, Guntur. In each fixed bulk plot, 10 plants at random, in the middle rows were tagged. Scoring of *Alternaria* leaf spot was done based on the Sheo Raj (1988) scale (0-4), at weekly intervals on randomly labelled plants up to the mid February.

Per cent Disease Index (PDI) was calculated.

$$\text{PDI} = \frac{\text{Sum of all the numerical ratings}}{\text{Total number of leaves scored} \times \text{Maximum disease grade}} \times 100$$

Phenological stage of the crop was also recorded during the study. Meteorological data (maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, sunshine hr, wind speed, evaporation, rain fall and rainy days) were recorded daily from sowing onwards and weekly means were calculated while rainfall during the standard meteorological week (SMW) was totalled. Correlation between progress of *Alternaria* leaf spot severity and weather factors was calculated. The data were subjected to multiple regression analysis to know the factors which influenced the progression of *Alternaria* leaf spot in three different sowings during *kharif* 2016-2017 at RARS, Lam, Guntur.

RESULTS AND DISCUSSION

Alternaria leaf spot appeared during 38th SMW (Sep 17-Sep 23) in the first sown field (DOS: 01-08-2016) at mean maximum temperature 30.8°C, mean minimum temperature 24.1°C, mean morning relative humidity 81.4 per cent, mean evening relative humidity 68.6 per cent, sunshine hr 0.9 h/day, wind speed 5.4 km/h, evaporation 2.5 mm and rainfall 85.9 mm/wk during vegetative stage and reached highest peak of 39.25 per cent during the 1st SMW (Jan 1-Jan 7), with mean maximum temperature 31.3°C, mean minimum temperature 15.9°C, mean morning relative humidity 76.0 per cent, mean evening relative humidity 55.9 per cent, sunshine hr 8.3 h/day, wind speed 2.8 km/h, evaporation 3.7 mm and nil rainfall at the initial boll bursting stage. In second sown field (DOS: 27-08-2016), *Alternaria* leaf spot appeared during 42nd meteorological week (Oct 15-21), with mean maximum temperature 33.9°C, mean minimum temperature 20.7°C, mean morning relative humidity 79.4 per cent, mean evening relative humidity 65.1 per cent, sunshine hr 6.9 h/day, wind speed 3.4 km/h, evaporation 4.4 mm and nil rainfall at the vegetative stage and reached highest peak of 33 per cent during the 1st meteorological week (Jan 1- 7 2017), with mean maximum temperature 31.3°C, mean minimum temperature 15.9°C, mean morning relative humidity 76.0 per cent, mean evening relative humidity 55.9 per cent, sunshine hr 8.3 h/day, wind speed 2.8 km/h, evaporation 3.7 mm and nil rainfall at the boll maturity stage. In third sown field experiment (DOS : 29-09-2016), also *Alternaria* leaf spot appeared during 42nd meteorological week (Oct 15-21), at the

Table 1: Progress of Alternaria leaf spot in Jaadoo BG II hybrid at different dates of sowing along with phenological stages of crop

Std wk	Calendar date	Date of sowing (01-08-2016)		Date of sowing (27-08-2016)		Date of sowing (29-09-2016)	
		Phenological stage	PDI (%)	Phenological stage	PDI (%)	Phenological stage	PDI (%)
38	17-23 Sep	Vegetative stage	5.00	Cotyledonary stage	0.00	-	-
39	24-30 Sep	Initial flowering stage	8.75	Third leaf stage	0.00	Sowing	0.00
40	1-7 Oct	Flowering stage	14.50	Fifth leaf stage	0.00	Germination stage	0.00
41	8-14 Oct	Flowering stage	14.25	Seventh leaf stage-	0.00	Germination stage	0.00
42	15-21 Oct	Flowering stage	15.00	Vegetative stage	16.00	Cotyledonary stage	15.00
43	22-28 Oct	Flowering stage	16.25	Initial flowering stage	18.00	Third leaf stage	15.83
44	Oct 29-Nov 4	Flowering stage	17.50	Flowering stage	18.25	Fifth leaf stage	18.33
45	5-11 Nov	Boll formation stage	10.00	Flowering stage	4.50	Seventh leaf stage	10.00
46	12-18 Nov	Boll formation stage	9.50	Flowering stage	3.00	Vegetative stage	4.50
47	19- 25 Nov	Boll maturity stage	5.50	Flowering stage	2.50	Initial flowering stage	3.25
48	Nov 26-Dec 2	Boll maturity stage	7.25	Flowering stage	4.00	Flowering stage	5.00
49	3-9 Dec	Boll maturity stage	12.75	Boll formation stage	6.00	Flowering stage	7.00
50	10-16 Dec	Boll maturity stage	14.50	Boll formation stage	9.50	Flowering stage	9.50
51	17- 23 Dec	Boll maturity stage	25.25	Boll maturity stage	12.50	Flowering stage	13.25
52	24- 31 Dec	Initial boll bursting stage	28.50	Boll maturity stage	16.75	Flowering stage	17.00
1	1-7 Jan	Initial boll bursting stage	39.25	Boll maturity stage	33.00	Boll formation stage	33.50
2	8-14 Jan	Boll bursting stage	39.00	Boll maturity stage	32.50	Boll formation stage	32.00
3	15-21 Jan	Boll bursting stage	38.75	Boll maturity stage	32.00	Boll maturity stage	32.75
4	22-28 Jan	Harvesting stage	35.00	Initial boll bursting stage	31.25	Boll maturity stage	28.25
5	Jan 29-Feb 4	Harvesting stage	19.00	Initial boll bursting stage	18.25	Boll maturity stage	16.25
6	5-11 Feb	Harvesting stage	12.50	Boll bursting stage	9.50	Boll maturity stage	7.50

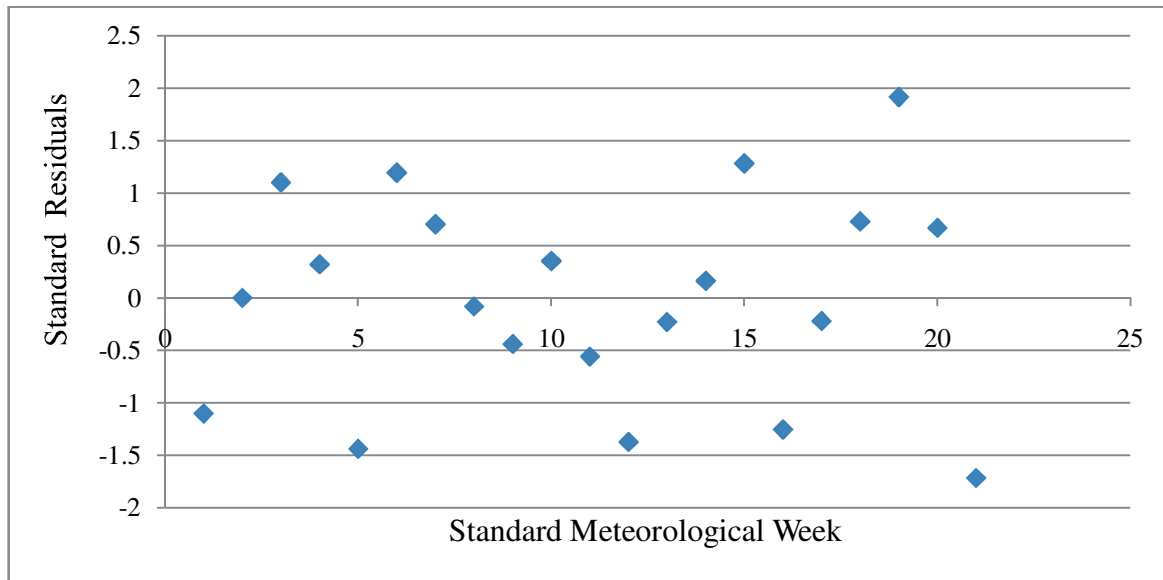


Fig.1: Standard residuals of regression model for Alternaria leaf spot of cotton (2016-2017)

Primary leaf stage and reached highest peak of 32.75 per cent during the 3rd meteorological week (Jan 15-21), with mean maximum temperature 31.9°C, mean minimum temperature 14.1°C, mean morning relative humidity 80.0 per cent, mean evening relative humidity 52.3 per cent, sunshine hr 8.1 h/day, wind speed 4.1 km/h, evaporation 3.6 mm and nil rainfall at the initial boll maturity stage. The progress of Alternaria leaf spot in three different sowings along with phenological stage of the crop is given in Table 1.

In the first sown crop minimum temperature, RH II, RH I and rain fall were negatively correlated with PDI; number of sun shine hr showed positive and significant correlation. Maximum temperature, number of rainy days, wind speed and evaporation were negatively correlated and non significant (Table 2). In second and third sown crops sun shine hr showed positive and significant

correlation with PDI and wind speed was positively non significant; and remaining weather factors expressed non significant negative correlation (Table 2). Correlation analysis of pooled data of three sowings indicated that minimum temperature, RH II and RH I showed significant negative correlation; number of sun shine hr showed positive and significant correlation. Maximum temperature, rain fall and wind speed, number of rainy days were non significant with negative correlation; evaporation was non significant with positive correlation (Table 2).

Sowing wise multiple linear regression analysis revealed that rain fall, number of rainy days, sun shine hr, wind speed and evaporation significantly influenced the disease development in first sown cotton crop; minimum temperature, RH II, RH I showed partial influence on disease progress (Table 3). In second sown crop, number of rainy days, sun shine hr, wind speed and

Table 2. Correlation between severity of *Alternaria* leaf spot and weather factors during *kharif* (2016–2017)

S. No.	Variable	Correlation co-efficient (r)			
		DOS: 01-08-2016	DOS: 27-08-2016	DOS: 29-09-2016	Pooled
1	X ₁ - Maximum temperature (°C)	-0.322NS	-0.088NS	-0.184NS	-0.203NS
2	X ₂ - Minimum temperature (°C)	-0.609**	-0.192NS	-0.299NS	-0.527**
3	X ₃ - Morning relative humidity (%)	-0.482*	-0.268NS	-0.236NS	-0.455*
4	X ₄ - Evening relative humidity (%)	-0.573**	-0.365NS	-0.382NS	-0.530**
5	X ₅ - Rainfall (mm)	-0.391*	-0.01NS	-0.066NS	-0.343NS
6	X ₆ - Rainy days	-0.227NS	-0.07NS	-0.120NS	-0.219NS
7	X ₇ - Sunshine hours (h day ⁻¹)	0.575**	0.741**	0.749**	0.571**
8	X ₈ - Wind speed (km h ⁻¹)	-0.297NS	0.053NS	0.018NS	-0.253NS
9	X ₉ - Evaporation (mm)	-0.006NS	-0.061NS	-0.158NS	0.080NS

DOS= Date of sowing; ** Significant at p dd 1%; *Significant at p dd 5%; NS: Non significant;

'r' table value = 0.369 and 0.503(1st sowing) and 0.412 and 0.558 (2nd and 3rd sowings);

N = 21(1st sowing) and 17 (2nd and 3rd sowings)

evaporation significantly influenced the PDI. In the third sown crop also number of rainy days, sun shine hr, wind speed and evaporation significantly influenced the PDI. Pooled data of PDI in three sowings revealed that RH II, rain

fall, number of rainy days, sun shine hr and evaporation significantly influenced the disease development; minimum temperature, wind speed and RH I showed partial influence on disease progress (Table 3). The standard

Table 3. Regression statistics of weather variables on severity of *Alternaria* leaf spot during *kharif* 2016 in different sowings and pooled PDI

Sowing date	Regression equation	Coefficient of determination (R ²)
1 st (01.08.16)	Y = -8.75039+0.644214 RF** + 0.081128 RD** + 15.8342 S** + 4.385452 W** -26.6018 E**	0.857**
	Y = 56.95388 -2.12603 min T**	0.371**
	Y = 214.926 -2.48252 RH I*	0.233*
	Y = 71.48761 -0.89153 RH II**	0.328**
2 nd (27.08.16)	Y = -78.2061 + 15.25646 RD** + 17.8405 S** + 4.084819 W** -13.3022 E**	0.897**
3 rd (29.09.16)	Y = -59.1081+ 13.19388 RD** + 16.05381 S** + 3.708114 W** -14.3092 E**	0.912**
Pooled	Y = -59.3454 + 1.129749 RH II* + 0.392932 RF** + 0.073905 RD** + 15.82757 S** -26.3152 E**	0.867**
	Y = 54.77632 -2.18132 Min T**	0.397**
	Y = 35.76233 - 5.09196 W*	0.227*
	Y = 192.4422 -2.23975 RH I*	0.193*

**Significant at 1%; * Significant at 5%

Y = PDI of *Alternaria* leaf spot; Max T = Maximum Temperature; Min T = Minimum Temperature; RH I = Morning Humidity;

RH II = Evening Relative Humidity; RD = Rainy Days; S = Sun Shine Hours; E = Evaporation; W = Wind Speed and RF = Rainfall

residuals of PDI showed that the value of deviation was between +2 indicating high degree of accuracy of the model in predicting the intensity of *Alternaria* leaf spot of cotton (Fig. 1)

Temperature regime of 20 - 30°C with prolonged high humidity (>80%) and frequent rains favoured *A. macrospora* infection and disease development in cotton (Johnson *et al.*, 2013). Sumer Singh and Ratnoo (2013) observed that 28.8-31.0°C and 86-93 per cent RH were conducive for *Alternaria* leaf spot (*A. gossypina*) and recorded negative correlation of PDI with minimum temperature and positive correlation with maximum relative humidity. Minimum temperature and afternoon relative humidity were found critical to forecast the *Alternaria* blight disease in cotton genotypes (Venkatesh *et al.*, 2013). Venkatesh *et al.*, (2016) reported significant negative correlation of *Alternaria* leaf spot with maximum temperature and minimum temperature while morning relative humidity and sunshine hr expressed significant and positive correlation in Narasimha variety of cotton. Maximum temperature showed significant and positive correlation where as significant negative correlation with minimum temperature in Abhadita, Bunny *Bt* and Dr. Brent *Bt* genotypes for *Alternaria* blight was observed at Dharwad (Anonymous, 2017). Rainfall and rainy days showed significant and positive correlation where as maximum temperature and sunshine hr showed significant and negative correlation with intensity of *Alternaria* blight in cotton variety, LRA 5166 at Rahuri representing central zone. The incidence of *Alternaria* blight of cotton could be predicted to an extent of 77 per cent accuracy by employing linear

regression model (Monga *et al.*, 2018). Present studies suggest early protection against *Alternaria* leaf spot under the above mentioned weather conditions, especially in late sown crop to prevent economic losses.

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