Society for Advancement of Wheat and Barley Research
ICAR-Indian Institute of Wheat & Barley Research
Karnal - 132 001, India

Journal of Wheat Research
9(2): 101-107

Research Article

Homepage: http://epubs.icar.org.in/ejournal/index.php/JWR

Influence of phenological growth stages and meteorological parameters on leaf blight infestation of wheat in Gangetic plains of West Bengal

Hijam Meronbala Devi, Sunita Mahapatra*, Subrata Dutta and Srikanta Das

Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, India

Article history

Received: 07 May 2017
Revised : 15 July 2017
Accepted: 12 October 2017

Citation

Devi HM, S Mahapatra, S Dutta and S Das. 2017. Influence of phenological growth stages and meteorological parameters on leaf blight infestation of Wheat in Gangetic plains of West Bengal. *Journal of Wheat Research* 9(2): 101-107. doi.org/10.25174/2249-4065/2017/71803

***Corresponding author**
Email: *sunitamahapatra@yahoo.co.in*

Abstract

Field experiment was conducted for 2012-13 and 2013-14 during winter season at Research Farm of BCKV, Nadia, West Bengal to study the distribution pattern of leaf blight pathogens on wheat at different phenological Zadok's growth stage (GS) and its interaction with various meteorological factors. The result showed that at seedling stage (GS 15), *Alternaria alternata* and *Alternaria triticina* caused maximum infection and continue upto GS49 and *Curvularia lunata*, other pathogens were noticed upto GS33. Whereas, major pathogen, *Bipolaris sorokiniana* infestation started at GS15 and gradually increase and reach to its maximum at GS91. The results pertaining to meteorological factors also demonstrated that increase in maximum temperature (T_{max}), minimum temperature (T_{min}), bright sunsine hours (BSH) and Dew Point morning (DP_{mor}) significantly decreased *A. alternata* infection. Increase in T_{max}, Tmin and DP_{mor} and DP_{eve} reduced *A.triticina* infestation. Whereas infection of *B. sorokiniana* increased with increase in T_{max}, T_{min}, BHS and DP_{mor} although RH_{max} and RH_{min} had a negative correlation with its growth. *C. lunata* and other pathogens showed no significant correlation with these meteorological factors except that RH_{min} significantly effect on disease progression.

Key words: Wheat, leaf blight, distribution pattern, weather factors, growth stage

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops contributing to nearly 20% of the total world's food requirement (Uddin *et al*., 2006). It is considered as the second most important staple food crop next to rice in India. In India, the contribution of wheat to total food grains production has been in the range of 35-37% since last 5 years (Mishra *et al*., 2011). The wheat production in India has improved tremendously with the evolution of high yielding dwarf varieties and better used of inputs. It has been observed that dwarf wheat varieties put forth thick canopy through profuse tillering in response to fertilizers, thus providing a distinct microclimate congenial for the buildup of foliar blight diseases. So, in the recent past with the change in cropping system, foliar blight has now become a major disease far and wide in our country with disease severity ranging between 2.72 to 36.24% (Goel *et al*., 2006).

The wheat scenario in North-Eastern India is more aggravated due to higher intensity of foliar blight and the associated yield losses with it under late sown wheat crops. In Eastern India including West Bengal the fungal diseases appeared as spot blotch caused by *Bipolaris sorokiniana* and leaf blight caused by *Alternaria triticina* may appear alone or together and causing >60% yield loss (Prabhu and Singh, 1974). The disease leaf blight caused by *Alternaria spp* had been noticed in India as early as 1924 (Prasad and Prabhu, 1962), but it did

not cause much concern till 1950's however spreaded widely thereafter. During last decade multilocational surveys for verifying foliar blights incidence on wheat have been conducted in eastern U.P., Bihar, Haryana, Punjab, Delhi, Gujrat and Rajasthan (Singh *et al*., 2001; Saharan *et al*., 2008) found different type of pathogens associated with this disease. According to Chaurasia *et al*. (1999, 2000) *A. triticina* has often been reported as a part of foliar blight disease complex. In recent years Marcado *et al*.(2006), able to identify *A. triticina* among different Alternaria species that isolated from *Alternaria* leaf blight disease from Maxico and South Asian regions and comparing their sporulation,ITS sequencing as well as pathogenicity assays. Systemic work has not been carried out to identify the pathogens cause foliar blight in different crop growth stages and their relation with meteorological parameters. So, an experiment has been conducted to find out the distribution pattern of these pathogens within different crop growth stages in the gangetic alluvial zones of West Bengal.

2. Material and methods

The field experiments were carried out at 'District Seed Farm of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India during 2012-13 and 2013-14. The wheat crop variety DBW 39 was sown on 20th November in each year in the randomized block design with three replications in a plot size of 5 x 5 m^2. The seed rate was 100 kg/ ha with a row to row spacing of 25cm. Normal agronomic practices like preparatory cultivation, fertilizer application, method of sowing intercultural operation were followed. The wheat plants were observed minutely and 90 diseased leaf samples (from three replications) suspected symptoms of foliar blight disease were collected in sterilized polythene bags at different growth stages (Zadok's growth stage at decimal code) GS15 to GS91 and brought to the laboratory. Average infection index (AIDX%) was measured by the method described by Singh *et al*.,(2004). The infected leaves were given numerical rating of 0, 1, 2, 3 and 4 taking into account the leaf area blighted. Leaves with no sign of infection received a score of 0 while those with 1/4, 1/2 and 3/4 area covered with spots received a score of 1, 2, 3 and leaves with highest infection were grouped under score of 4. The average infection index was then calculated by the following formula (Singh *et al*., 2004).

Infection Index = [∑(Class rating x Class frequency) / (Total number of leaves x Maximum class frequency)] x 100

The standard technique for isolation of pathogen was followed as per De Wolf *et al*. (1998). Each pathogen was isolated from the infected leaf samples and pathogenicity test was done as per Koch potulate.The presence of *Bipolaris sorokiniana*, *Alternaria triticina*, *Alternaria alternata* and *Curvularia lunata* were confirmed based on the morphology of those pathogens.

Data on seven weather variables, viz, maximum temperature (T_{max}), minimum temperature (T_{min}), maximum relative humidity (RH_{max}), minimum relative humidity (RH_{min}), bright sunshine hours (BSH), Dew point morning (DP_{morn}) and dew point evening (DP_{eve}) were collected from nearest meteorological observatory (IMD). Weekly mean of weather parameters and disease severity were regressed (multiply regression analysis) by using SPSS16.0 statistical software. The correlation co-efficient values were obsereved for two consecutive years to find out the significant weather parameters in relation to the distribution pattern of these pathogens.

3. Results and discussion

The result revealed that the leaf blight of wheat was caused by several pathogens *viz. A. alternata*, *A. triticina*, *B. sorokiniana* , *C. lunata* and other unidentified pathogens at different stages of crop growth. These pathogens simultaneously attack the crop at different crop growth stages as per the host specificity.

The two years 2012-13 and 2013-14 data revealed that all the above pathogens cause infection at GS15 and cause similar type of symptoms though the infection index was different in different years and the pattern of infection of different pathogens was found similar for both the years. In each year it was observed that at early age of the crop plant *i.e.* at GS21 and also the two years pooled mean indicated that maximum infection index was caused by *A. alternata* (45.83%) significantly followed by *A. triticina* (25%), *B. sorokiniana* (10%) and other unidentified pathogen (12.50%) whereas, minimum infection was caused by *C.lunata* (6.67%).

At GS29, *A. alternata* and *A. triticina* caused maximum infection of 50% and 32.50% respectively followed by *B. sorokiniana* (10%), other pathogens (5%) and *C. lunata* (2.5%) and their differences were statistically significant. Similarly at GS33, maximum infection was caused by *A. alternata* (42.50%) followed by *A. triticina* (40%), *B. sorokiniana* (12.50%) and minimum infection was caused by *C. lunata* (2.5%) which was statistically at par with other unidentified pathogens (2.55%).

At GS45, maximum infection index was noticed by *A. triticiana* (43.33%) followed by *A. alternata* (36.67%), *B. sorokiniana* (20%) and no infection caused by *C.lunata* and other pathogens. At GS49, *A.triticina* caused maximum disease infection (52.50%) followed by *A. alternata* (27.50%) and *B. sorokiniana* (20%). At GS 55, maximum infection was noticed by decrease of *A.triticina* (44.77%) followed by *B. sorokiniana* (31.36%) and decrease of *A. alternata* (23.86%) and their differences were statistically significant. At GS 61 to GS 91 maximum infection was noticed by *B. sorokiniana* (42.05% to 82.50%) followed by *A.triticina* (40.53% to 12.50%) and *A. alternata* (17.42% to 5%) and their differences were statistically significant (Table 1).

The result indicated that average infection index of leaf blight pathogens were different at different growth stage of the plant. The leaf blight pathogens identified were *A. alternata, A.triticina*, *B. sorokiniana* , *C.lunata* and other unidentified pathogens. All the pathogens infest at growth stage GS15 and among the pathogens *A. alternata* cause maximum infection index from GS15 to GS45 (30-40% and 30-43.33%) respectively and later on its population declined with increasing of the plant (35-11.67%) from GS49 to GS 91, respectively. *A.triticina* cause infection at age GS15 and increasing upto GS61 (20% to 60%) and later on it decreased with increasing age of the crop (36% to 20%) upto GS91. The results of two consecutive years and the pooled mean demonstrated that the infection by pathogen *B. sorokiniana* gradually increased from (5 to 10%) at GS15 to 10% at GS33 and later on from 20% to 59% at GS45 to GS61and 48% to 75% at GS69 to GS91, respectively. *C.lunata* and other unidentified pathogens also caused maximum infection at GS15 (15-20%), continuing upto GS21 and were completely disapear finally. The infection of different leaf blight pathogens was different at different age of the crop and these differences were statistically significant. AIDX% at different growth stage within the same pathogen also showed significant differences among themselves. Interaction between different pathogens and the plant growth stage were also statistically significant (Fig 1, 2 and 3).

The experimental results therefore suggested that at seedling stage of wheat *A. alternata, A.triticina* caused maximum infection upto GS59 and later on with increasing age the infection by *Alternaria* were declined. Similarly *C.lunata* and other unidentified pathogens also infected at early stage of crop and were completely absent after GS33. Though, pathogen *B. sorokiniana* infestation initiated at GS15, it increased slowly and significantly reached to a maximum at GS81 till the harvest of the crop. Hence, *B. sorokiniana* was the major pathogen causing leaf blight in wheat. This result was also supported by the results of Singh *et al.* (2001) and Saharan *et al.* (2008) that *B. sorokiniana* is the major leaf blight pathogen in wheat at UP, Mahrashtra, Karnataka and Haryana. Khan *et al.* (2010) also reported the presence of major spot blotch pathogen in wheat *B. sorokiniana* in Punjab and North eastern and eastern plain zones of India.

3.1 Distribution pattern of different leaf blight pathogens and its relation with meteorological parameters : Two years data on distribution of different leaf blight pathogens over the crop growth stages were correlated with seven meteorological parameters to find out how these parameters affect different pathogens. Though the correlation co-efficient values were different in different years and in pooled mean, all the meteorological parameters had significant positive or negative effect on different leaf blight pathogens. In the years 2012-13, T_{max} varied from 20.37 to 36.27^{0}C, T_{min} 7.06 to 20.83^{0}C, RH_{max} 88.86 to 97.57%, RH_{min} 30.86 to 70.57%, BSH 3.21 to 10.04 hrs, DP_{mor} 7.00 to 20.33 ^{0}C, DP_{eve} 9.41 to 18.33^{0}C. It was observed that with increasing T_{max}, T_{min} and BSH there was a significant decreased in *A. alternata* infection whereas, increased in RH_{max} and RH_{min} favoured the growth of this pathogen. In case of *A.triticina* increased in T_{max}, T_{min} and DP_{mor} significantly decreased disease incidence where as with increase in T_{max}, T_{min}, BSH and DP_{mor} there was significant increased in *B sorokiniana* although increasing RH_{max} and RH_{min} did not favour the pathogen's growth and hence caused less infection. With increasing RH_{max}, *C lunata* increased while other weather parameters had no significant effect on it. The other unidentified pathogens had a positive correlation with RH_{max} and RH_{min} (Table 2).

In the year 2012-13, A *alternata* infection was positively and significantly influenced by RH_{min} (0.66) and negatively by T_{max} (-0.75), T_{min} (-0.72), BSH (-0.64), DP_{mor} (-0.68) and DP_{eve} (-0.54), though RH_{max} was positively correlated without any significant effect. In case of *A.triticina* infection, T_{max} (-0.72) and T_{min} (-0.68) had a significant negative influenced whereas RH_{min} (0.68) had a positive effect. *B. sorokiniana* was positively and significantly correlated with T_{max} (0.74), T_{min} (0.76), BSH(0.67) and DP_{mor} (0.74) whereas negatively and significantly correlated with only RH_{min} (-0.66)

and other parameters had negligible effect. In case of *C.lunata* and other leaf blight pathogens the meteorological parameters had no significant effect on disease infection (Table 2).

In 2013-14, T_{max} varied from 22.20 to 35.50^{0}C, T_{min} (9.11 to 19.59^{0}C), BSH (3.13 to 9.20hrs) and DP_{mor} (6.90 to 17.39^{0}C) *A. alternata* infection significantly increased with both RH_{max} and RH_{min} though, the other factors had no significant relation. *A.triticina* infection also increased with decreasing T_{max}, T_{min}, BSH. *B. sorokiniana* infection was increased with increased in T_{max}, T_{min}, BSH and DP_{mor} whereas both maximum and minimum RH had significant negative effect. *C.lunata* showed no significant relation with these weather parameters(Table 3).

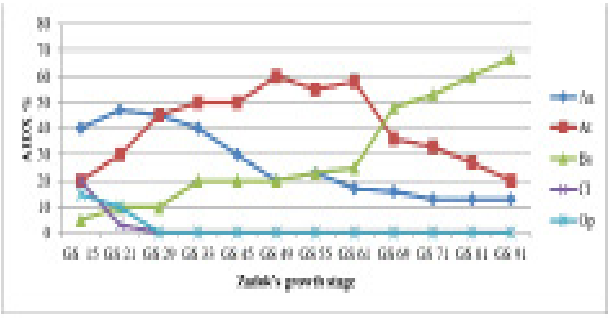

Fig. 1 Distribution of leaf blight pathogen of wheat within the crop growth stage (2012-13)

Two years pooled mean also showed similar observations. *A. alternata* infection was positively and significantly influenced by RH_{max} (0.78) and RH_{min} (0.83) and negatively by T_{max} (-0.85), T_{min} (-0.74), BSH (-0.82) and DP_{mor} (-0.70) and DP_{eve}. In case of *A.triticina* T_{max} (-0.68), T_{min} (-0.79), DP_{mor} (-0.77) and DP_{eve} (-0.67) were negatively and significantly correlated and while RH_{max} (0.54) exhibited positive correlation.

RH_{min} had no significant effect on its growth. *B. sorokiniana* was positively and significantly correlated with T_{max} (0.87), T_{min} (0.80), BSH (0.83) and DP_{mor} (0.77) where as negatively and significantly correlated with only RH_{max} (-0.80) and RH_{min} (-0.87) though DP_{eve} was negligible effect. In case of *C lunata*, infection had no significant relation with the above meteorological factors. Other leaf blight pathogens were positively and significantly correlated with RH_{min} (0.59) while other factors had negligible effect (Table 4).

The two year's pooled mean showed that with increased in T_{max} (22.66 to 35.81^{0}C), T_{min} (8.43 to 20.21^{0}C), BSH (4.16 to 8.58 hrs) and DP_{mor} (7.28 to 18.86^{0}C) there was a significant decreased in *A alternata* infection while positive and significant correlation was found with RH_{max} (61.72 to 86.00%) and RH_{min} (37.64 to 66.36%). In case of *A.triticina*, with increased in T_{max}, T_{min} and DP_{mor} and DP_{eve} (within the range of 12.66 to 17.80^{0}C) disease severity decreased significantly. Here also RH_{max} had a positive significant effect. In case of *B. sorokiniana* with increased in T_{max}, T_{min}, BSH and DP_{mor} there was a significant increased in disease whereas RH_{max} and RH_{min} had negative effect. *C.lunata* showed no significant relation with the meteorological data and other pathogen showed the positive relation with RH_{min}. Similar type of result was observed by Singh and Tewari (2001) that longer sunshine duration and temperature range between 26 to 28^{0}C caused rapid development and associated infection of *B. sorokiniana* and *A.triticina*. Prates and Fernandes (2001) reported that minimum temperature of 23^{0}C and maximum temperature of 30^{0}C was most

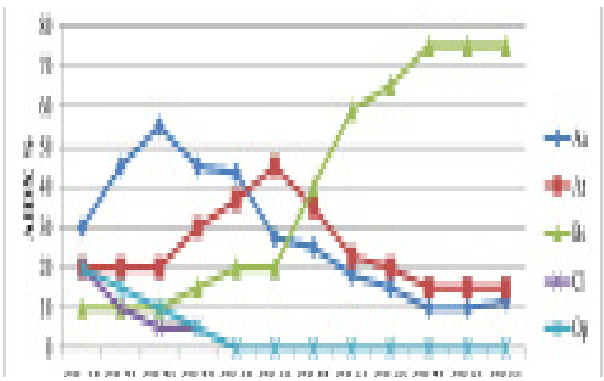

Fig. 2 Distribution of leaf blight pathogen of wheat within the crop growth stage (2013-14)

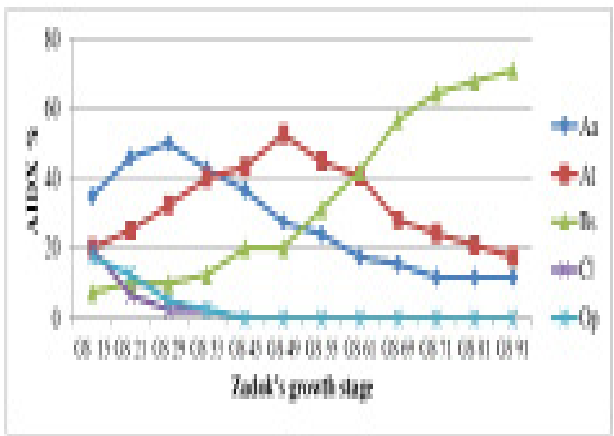

Fig. 3 Distribution of leaf blight pathogen of wheat within the crop growth stage (Pooled)

Table 1. Distribution patterns of leaf blight pathogens (AIDX %) at different growth stages of wheat in 2012-13, 2013-14 and Pooled mean

Growth Stage	2012-13					2013-14					Pooled				
	Aa	At	Bs	Cl	Op	Aa	At	Bs	Cl	Op	Aa	At	Bs	Cl	Op
(GS 15)	40.00 (39.52)	20.00 (26.92)	5.00 (13.56)	20.00 (26.92)	15.00 (23.18)	30.00 (33.52)	20.00 (26.52)	10.00 (18.91)	20.00 (26.92)	20.00 (26.92)	35.00 (36.57)	20.00 (26.92)	7.50 (16.43)	20.00 (26.92)	17.50 (25.10)
GS 21	46.67 (43.67)	30.00 (33.52)	10.00 (18.91)	3.33 (11.29)	10.00 (18.91)	45.00 (42.42)	20.00 (26.52)	10.00 (18.91)	10.00 (18.91)	15.00 (23.18)	45.83 (42.90)	25.00 (30.33)	10.00 (18.91)	6.67 (15.53)	12.50 (21.13)
GS 29	45.00 (42.42)	45.00 (42.42)	10.00 (18.91)	0.00 (4.05)	0.00 (4.05)	55.00 (48.16)	20.00 (26.92)	10.00 (18.91)	5.00 (13.56)	10.00 (18.91)	50.00 (45.29)	32.50 (35.06)	10.00 (18.91)	2.50 (9.97)	5.00 (13.56)
GS 33	40.00 (39.52)	50.00 (45.29)	20.00 (26.92)	0.00 (4.05)	0.00 (4.05)	45.00 (42.42)	30.00 (33.52)	15.00 (23.18)	5.00 (13.56)	5.00 (13.56)	42.50 (40.98)	40.00 (39.52)	12.50 (21.13)	2.50 (9.97)	2.50 (9.97)
GS 45	30.00 (33.52)	50.00 (45.29)	20.00 (26.92)	0.00 (4.05)	0.00 (4.05)	43.33 (41.46)	36.67 (37.56)	20.00 (26.92)	0.00 (4.05)	0.00 (4.05)	36.67 (37.56)	43.33 (41.46)	20.00 (26.92)	0.00 (4.05)	0.00 (4.05)
GS 49	20.00 (26.92)	60.00 (51.06)	20.00 (26.92)	0.00 (4.05)	0.00 (4.05)	27.50 (31.95)	45.00 (42.42)	20.00 (26.92)	0.00 (4.05)	0.00 (4.05)	27.50 (31.95)	52.50 (46.72)	20.00 (26.92)	0.00 (4.05)	0.00 (4.05)
GS 55	22.73 (28.81)	54.55 (47.90)	22.73 (28.81)	0.00 (4.05)	0.00 (4.05)	25.00 (30.33)	35.00 (36.57)	40.00 (39.52)	0.00 (4.05)	0.00 (4.05)	23.86 (29.58)	44.77 (42.29)	31.36 (34.37)	0.00 (4.05)	0.00 (4.05)
GS 61	16.67 (24.48)	58.33 (50.09)	25.00 (30.33)	0.00 (4.05)	0.00 (4.05)	18.18 (25.61)	22.73 (28.81)	59.09 (50.53)	0.00 (4.05)	0.00 (4.05)	17.42 (25.05)	40.53 (39.83)	42.05 (40.71)	0.00 (4.05)	0.00 (4.05)
GS 69	16.00 (23.97)	36.00 (37.17)	48.00 (44.14)	0.00 (4.05)	0.00 (4.05)	15.00 (23.18)	20.00 (26.92)	65.00 (54.03)	0.00 (4.05)	0.00 (4.05)	15.50 (23.58)	28.00 (32.27)	56.50 (49.02)	0.00 (4.05)	0.00 (4.05)
GS 71	13.33 (21.83)	33.33 (35.57)	53.33 (47.20)	0.00 (4.05)	0.00 (4.05)	10.00 (18.91)	15.00 (23.18)	75.00 (60.33)	0.00 (4.05)	0.00 (4.05)	11.67 (20.41)	24.17 (29.78)	64.17 (53.53)	0.00 (4.05)	0.00 (4.05)
GS 81	13.33 (21.83)	26.67 (31.42)	60.00 (51.06)	0.00 (4.05)	0.00 (4.05)	10.00 (18.91)	15.00 (23.18)	75.00 (60.33)	0.00 (4.05)	0.00 (4.05)	11.67 (20.41)	20.83 (27.51)	67.50 (55.55)	0.00 (4.05)	0.00 (4.05)
GS 91	13.33 (21.83)	20.00 (26.92)	66.67 (55.04)	0.00 (4.05)	0.00 (4.05)	11.67 (20.41)	15.00 (23.18)	75.00 (60.33)	0.00 (4.05)	0.00 (4.05)	11.67 (20.41)	20.83 (27.51)	70.83 (57.63)	0.00 (4.05)	0.00 (4.05)
		Pathogen (P)	GS (G)	P x G			Patho-gen (P)	GS (G)	(PxG)			Patho-gen (P)	GS (G)	P x G	
SEM (±)	0.065	0.110	0.245	0.245		SEM (±)	0.068	0.114	0.254		SEM (±)	0.064	0.107	0.240	
CD at 5%	0.183	0.306	0.685	0.685		CD at 5%	0.190	0.318	0.711		CD at 5%	0.179	0.300	0.671	

(Figure within the paranthesis is angular transformed value) Aa: Alternaria *alternata*, At: Alternaria triticina, Bs: Bipolaris sorokiniana, Cl: Curvularia lunata, Op: Other pathogen

Table 2. Correlation between distribution patterns of leaf blight Pathogens of wheat disease complex pathogens in relation to weather parameters (2012-2013)

Pathogens	Weather parameters						
	Tmax	Tmin	RHmax	RHmin	BSH	DPmor	DPeve
Alternaria alternata	-0.76**	-0.72**	0.20	0.66*	-0.64*	-0.68**	-0.54*
Alternaria triticina	-0.72**	-0.68**	0.41	0.68**	-0.48	-0.57	-0.54
Bipolaris sorokiniana	0.74**	0.76**	-0.11	-0.66**	0.66**	0.74**	0.49
Curvularia lunata	-0.17	-0.32	-0.38	0.15	-0.35	-0.42	-0.03
Other pathogen	-0.19	-0.32	-0.29	0.18	-0.35	-0.41	-0.02

*Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level

Table 3. Correlation between distribution patterns of leaf blight Pathogens of wheat disease complex pathogens in relation to weather parameters (2013-2014)

Pathogens	Weather parameters						
	Tmax	Tmin	RHmax	RHmin	BSH	DPmor	DPeve
Alternaria alternata	-0.87 **	-0.62*	0.95**	0.84**	-0.78**	-0.52	-0.23
Alternaria triticina	-0.57*	-0.74**	0.22	0.23	-0.32	-0.76**	-0.47
Bipolaris sorokiniana	0.89**	0.73**	-0.87**	-0.82**	0.79**	0.66*	0.22
Curvularia lunata	-0.14	0.16	0.54*	0.49	-0.37	0.23	0.51
Other pathogen	-0.31	0.08	0.63*	0.66**	-0.51	0.17	0.41

*Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level

Table 4. Correlation between distribution patterns of leaf blight Pathogens of wheat disease complex pathogens in relation to weather parameters (Pooled)

Pathogens	Weather parameters						
	Tmax	Tmin	RHmax	RHmin	BSH	DPmor	DPeve
Alternaria alternata	-0.85**	-0.74**	0.78**	0.83**	-0.82**	-0.70**	-0.45
Alternaria triticina	-0.68**	-0.74**	0.54*	0.46	-0.39	-0.77**	-0.67**
Bipolaris sorokiniana	0.87**	0.79**	-0.79**	-0.87**	0.83**	0.77**	0.42
Curvularia lunata	-0.22	-0.08	0.26	0.47	-0.48	-0.08	0.27
Other pathogen	-0.22	-0.14	0.39	0.59*	-0.57	-0.12	0.28

*Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level

References

1. Chaurasia S, AK Joshi, R Dhari, R Chand. 1999. Resistance to foliar blight of wheat: a search. *Genetic resources and crop evolution* **46**:469–75.
2. Chaurasia S, R Chand, AK Joshi. 2000. Relative dominance of *Alternaria triticina* Pras.et Prab. & *Bipolaris sorokiniana* (Sacc.) Shoemaker in different growth stages of wheat (*T. aestivum* L.). *Journal of Plant Diseases and Protection* **107**:176-81.
3. De Wolf, ED, RJ Effertz, S Ali and LJ Francl. 1998. Vistas of tan spot research. *Canadian Journal of Plant Pathology* **20**:349-444.
4. Goel P, SS Pal, K Srivastava and JP Jaiswal. 2006. Assessment of losses by spot blotch (*Bipolarissorokiniana*) with reference to resistance in wheat in Tarai region of Uttaranchal. *Indian Phytopathology* **59**(1): 36-40.
5. Khan H, SMS Tomar and S Chowdhury. 2010. Inheritance studies on spot blotch of wheat caused by Bipolarissorokiniana. *Indian Journal of Genetics and Plant Breeding* **70**(3): 229-233.
6. Mercado D Vergnesa, ME Renarda, E Duveiller and H Maraitea (2006).Identification of *Alternaria spp.* on wheat by pathogenicity assays and sequencing. *Plant Pathology* **55**: 485–493.
7. Mishra VK, SK Biswas, M Rajik. 2011. Biochemical mechanism of resistance to Alternaria blight by diffrent varieties of wheat. *International Jounral of Plant Pathology* **2**:72-80.
8. Mohd. Akram and Amerika Singh. 2003. Determination of wheat varieties tolerant to spot blotch disease. *Bipolaris sorokiniana* (Sacc.) *Shoem. Annals of Plant Protection Science* **11**(1):75-78.
9. Prabhu AS and A Singh. 1974. Appraisal of yield losses in wheat due to foliage diseases caused by *Alternariatriticina* and *Helminthosporiumsativum. Indian Phytopathology* **27:** 632-634.
10. Prabhu AS and R Prasada. 1966. Pathological and epidemiological studies on leaf blight of wheat caused by Alternariatriticina. *Indian Phytopathology* **19**:95-111.
11. Prasada R and AS Prabhu. 1962. Leaf blight of wheat caused by a new species of Alternaria. *Indian Phytopathology* **15**:292–293.
12. Prates LG and JMC Fernandes. 2001. Evaluating expansion rate of lesions of *Bipolaris sorokiniana* in wheat. *Fitopatol. Bras.* 26(2):185-191.
13. Saharan MS, DP Singh, PK Chauhan and SS Karwasara. 2008. Genetic variability in Bipolaris sorokiniana isolates causing spot blotch of wheat in India. *Indian Phytopathology* **61**(2): 268-272.
14. Singh RV, AK Singh, SP Singh and BN Singh. 2001. Prevalence and distribution foliar blight pathogens attacking wheat in India. *Indian Phytopathology* **54**(2):175-178.
15. Singh SK, KD Srivastava and DV Singh. 2004. Pathogenic behaviour of leaf blight organisms on wheat. *Indian Phytopathology* **57**(3):319-322.
16. Singh TB and AN Tewari. 2001. Role of weather conditions in the development of foliar diseases of wheat under tarai conditions of north-western India. Plant. *Disease Resistance* **16:**173-178.
17. Uddin SA, KM Khalequzzaman and AQMB Rashid. 2006. Effect of relative humidity on the development of head blight by *Bipolaris sorokiniana* in wheat. *Journal of Agriculture and Rural Development Gazipur* **4**(1/2):61-65.