



## Dynamics and management of *Alternaria* blight disease of Indian mustard (*Brassica juncea*) in relation to weather parameters

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### Abstract

*Alternaria* blight incited by *Alternaria brassicae* (Schw.) Wiltshire. is a major devastating disease of Indian mustard [*Brassica juncea* (L.) Czern & Coss], causing significant reduction in seed yield. The crop grown in Jharkhand usually suffers seriously from this disease. Considering the economic importance of the disease, present investigation was under taken to study the effect of weather on disease progression and dynamics of *Alternaria* blight. Maximum *Alternaria* blight severity on leaves and siliqua was observed during 12-18 February, 2013. Mancozeb spray at 40 and 60 days after sowing (das) reduced the disease upto 31 % over control under field conditions. Maximum temperature positively correlated with disease index. Maximum temperature of 23.2°C and maximum and minimum relative humidity (RH) of  $\geq 80$  %, and 66 % respectively, with correlation co-efficient of (r) =0.735 for minimum temperature and r=0.515 of minimum RH respectively, favoured the development of the disease. Forewarning models are expected to guide the farmer's timely application of fungicidal sprays.

**Key words:** *Alternaria* blight, disease incidence, weather parameters, forewarning.

### Introduction

Indian mustard (*Brassica juncea* (L.) Czern. & Coss.) is an important oilseed crop which occupies almost 80 per cent of the 7 million hectares (m ha) cropped under oilseed Brassica crops in India. The estimated area, production and productivity during 2011-12 of rapeseed-mustard in the world were 33.1 m ha, 60.7 million tonnes (mt), and 1832 kg/ha, respectively (Agricultural Statistics Division, GOI, 2012). Globally, India accounts for 20.2 per cent and 10.7 per cent of the total acreage and production (USDA, 2012). India ranks second in the world in acreage, and production after China. Although, rapeseed-mustard acreage and production fluctuate from year to year, the all time high production of 8.17 mt from 6.69 mha were recorded in 2010-11. Rapeseed-mustard contributed around 22.4 per cent and 22.6 per cent of the total oilseed area and production in India (Agricultural Statistics Division, GOI, 2012). The average yield of rapeseed-mustard during 2011-12 was 1145 kg/ha as compared to 1135 kg/ha of total oilseeds

(Agricultural Statistics Division, GOI, 2012). The crop is predominantly cultivated in Rajasthan, Jharkhand, Uttar Pradesh, Haryana, Gujarat, Madhya Pradesh and West Bengal states of the country, which accounts to about 87 per cent of the total national production.

A wide gap exists between the potential and the realized yield at the farmers' field, which is largely due to a number of biotic and abiotic stresses to which the rapeseed-mustard crop is exposed. Therefore, aim of the future research should be more on higher productivity per unit area, rather than on expansion in area. Indian mustard is convenient as monoculture because one crop is easier to plant, harvest, and market than mixtures of other crop (s) with low water requirement.

*Alternaria brassicae* infects host species at all growth stages and affects seed germination and both quality and quantity of oil (Meena *et al.*, 2010). Generally, disease is appears on 45 old plants and severe on 75 days old plants (Meena *et al.*, 2004).

Symptoms first appear on lower leaves as black points, which later enlarge into round, conspicuous spots (1-10mm) also on silique and stem. These small spots may coalesce leading to complete blackening of silique and weakening of the stem with the formation of elongated lesions. Late infection on older leaves does not reduce yield significantly, and can even be controlled through intensive removal of infected leaves (Chupp and Sherf, 1960). Infection on leaves and siliques results in pre-mature pod-ripening and shedding of seeds, thus, adversely affecting the normal seed development, colour and quality of seed, seed weight, and per cent oil content (Meena *et al.*, 2010).

The incidence and severity of *Alternaria* blight in rapeseed-mustard fields is greatly influenced by temperature, relative humidity, soil conditions at the time of planting, splashing rain, wind velocity, leaf wetness, and inoculum density available in the soil (Humpherson-Jones, 1992; Sandhu *et al.*, 1985; Ansari *et al.*, 1988; Chahal and Kang, 1979; Awasthi and Kolte, 1989; Chattopadhyay *et al.*, 2005; Saharan, 1991; Sangeetha and Siddaramaiah, 2007; Meena *et al.*, 2002, 2004, 2011). Depending on the prevailing weather conditions, *Alternaria* blight is a very serious disease in all rapeseed-mustard growing areas, reducing yield from 10 to 70 per cent (Kolte, 1985). The main objectives of the present investigations were to study the effect of

environmental factors on temporal progression of the disease, develop regression equation models for predicting outbreak, and determine most appropriate time of fungicide sprays to control *Alternaria* blight effectively.

### Material and Methods

Study on epidemiology and management of *Alternaria* blight disease of Indian mustard were carried out in the experimental plots, and laboratory of the Department of Mycology and Plant Pathology, Birsa Agriculture University, Kanke, Ranchi during rabi, 2012-13. Ranchi situated between 23°17'N latitude and 85°19'E longitudes in the plateau region of Jharkhand. The data on weather conditions during the period of investigation were collected from meteorological observatory of the Department of Agriculture Physics to support the results. Various weather elements viz., rainfall, relative humidity and temperature were recorded.

An extensive survey programme was conducted during rabi season 2012-13 in BAU, Ranchi in Jharkhand. For field experiment, observation on disease severity was recorded at 15 days intervals starting from 45 days after sowing on the basis of 25 randomly selected from each plot, till the maturity of the crop. Leaves were rated as per the Conn *et al.* (1990) scales and the percent severity was calculated according to following formula :

$$\text{Disease intensity (\%)} = \frac{\text{Sum of all disease ratings}}{\text{Total no. of leaves examined} * \text{Maximum disease rating}} \times 100$$

Characteristic symptoms appearing on different plant parts were observed and described. To confirm the identity and detailed studies on the morphological features of the pathogen, the organism was cultured *in vitro* on PDA under proper sterilized conditions. To confirm identity of the pathogen it was necessary to determine colour, shape and dimension of the fungal structures. Therefore, they were observed under binocular compound microscope calibrated with stage and ocular micrometer.

### Management of *Alternaria* blight

An experiment was conducted in randomized block

design using cultivar Varuna of Indian mustard using 10x30 cm plant to row spacing with three replications. Total thirteen treatments were taken of fungicides viz., Tebuconazole, Propiconazole, Iprodione+Cabendazim and Mancozeb alone or in combination as seed treatment and or foliar spray. Crop was seeded on 15 October 2012 with recommended doses of fertilizers. Disease severity on leaves was undertaken at 90 days after sowing using Conn *et al.* (1990) scale. Two fungicidal spray were applied at 40 and 70 days after sowing.

### Effect of weather factors on disease development

Weather parameters like temperature (maximum and minimum), relative humidity (maximum and minimum), total rain fall and number of rainy days upto 70 days corresponding to the disease, observation were obtained from the Department of Agricultural physics and correlated with percent disease intensity. Regression analysis (RA) was done to determine the effect of individual as well as combined weather factors for disease development. Disease intensity was recorded on the basis of 25 leaves selected randomly from each location using Conn *et al.* (1990) pictorial scale.

## Results and Discussion

### Symptomatological studies

*Alternaria* blight symptoms appears initially on the lower leaves of the *Brassica* plants, as minute black dots which gradually increased in circular fashion with light grey brown to dark brown followed by a yellow halo in the beginning. Symptoms first appeared on 15 January 2013 on lower leaves. The pathogen produce two types of symptoms viz., light grey leaf spot (caused by *Alternaria brassicicola* (Schw.) Wiltshire) and dark black leaf spot (*A. brassicae* (Berk) Sacc. The spot soon increased in size from 0.5 to 12.0 mm and remained light to dark brown with conspicuous black concentric rings at the centre light target board which is a typical symptom to identify the *Alternaria* blight disease. The closely situated spots coalesced and covered the entire leaf surface with blighted appearance.

The disease was observed on siliquae as dark black dots which later became circular to oval, rarely linear, with grayish white centre. In severe cases, the disease was observed to cause premature drying, shrinkage and shattering of siliqua. The seeds inside the severely infected siliqua did not develop properly and developed a shriveled texture with grey colour.

### Morphological studies

Based on morphological characteristics, the causal fungus was identified as *Alternaria brassicae* (Berk) Sacc. Colonies of *A. brassicae* were amphigenous effused rather pale olive, hairy and immersed mycelium. Conidia were produced in chains of up to 4 with average 3.8 transverse septa

and 1.8 longitudinal septa, pale olive and the beak about 1/3 to 1/2 the length of the conidia which confirmed with earlier studies (Ellis, 1971).

Table 1: Morphological features of conidia of *A. brassicae*

Morphological characteristics	Measurement (µm)
Conidial length	106.7 - 285.9 (152.3)
Conidial width	33.5 - 57.0 (47.5)
Beak length of conidia	41.4 - 180.0 (47.3)
No. of Septa/ conidia	
Horizontal septa	3.8
Vertical septa	1.8

Average values of conidial length of *A. brassicae* conidia varied from 106.7 to 285.9 µm observed under light microscope at 40x magnification. However, conidial width of *A. brassicae* conidia varied from 33.5 to 57.0 µm (table 1). Results indicated the wide variation on conidial beak length from 41.4 to 180.0 µm of *A. brassicae*. Average number of horizontal septa varied from 3.2 to 8.0 while vertical septa were 0.1 to 1.8 for *A. brassicae* observed under light microscope at 40 x magnification (table 1).

### Efficacy of fungicides against *Alternaria* blight

From the result of the experiment it may be

Table 2: Effect of different fungicidal treatments on *Alternaria* blight severity

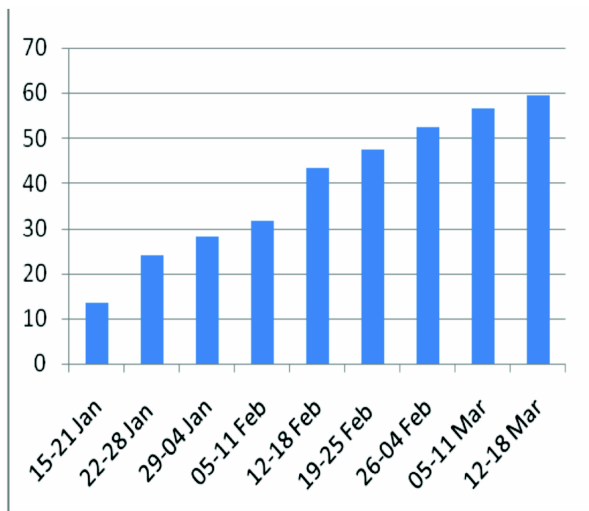
Treatments	% ABL
Tebuconazole-ST	28.4 (35.6)
Propiconazole-ST	27.6 (34.5)
Iprodione+Cabendazim-ST	20.8 (31.7)
Mancozeb-ST	26.4 (34.3)
Tebuconazole-FS	27.0 (31.0)
Propiconazole-FS	24.4 (33.0)
Iprodione+Cabendazim-FS	25.2 (32.6)
Mancozeb-FS	22.8 (33.1)
Tebuconazole-FS+ST	24.8 (34.5)
Propiconazole-ST+FS	23.5 (32.7)
Iprodione+Cabendazim-ST+FS	21.8 (32.4)
Mancozeb-ST+FS	20.3 (27.7)
Control	38.7 (42.9)
CD at 5 %	2.5

concluded that spraying Mancozeb (recommended) @ 2.5 g L at 40 and 70DAS is well adjusted to reduce disease severity significantly over control. This finding is also supported by the reports on Meah *et al.* (1992).

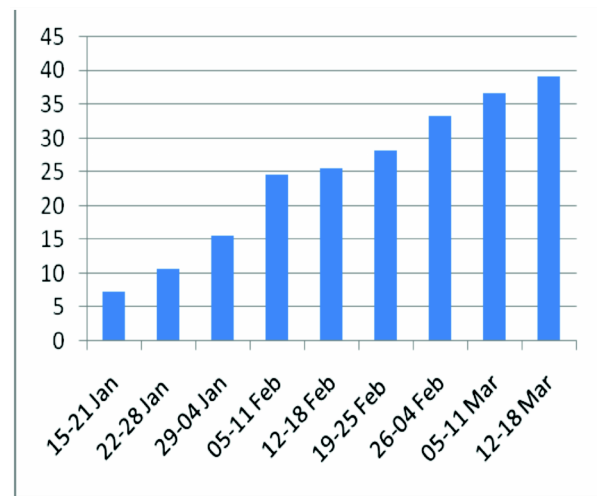
However, all the treatments in the present investigation showed better performance compared with control. Among tested fungicides, the lowest disease severity (20.3%) was recorded in mancozeb seed treatment (ST) along with foliar spray (FS) @ 0.25% followed by Iprodione + carbendazim ST + FS treatments (21.8%) over control 38.7%.

### Effect of meteorological factors on disease epiphytotics

It is evident from the results that the disease appeared during second week of January in the field. Disease intensity increased in both leaves and siliqua gradually upto January – February (29-18). The temperature was recorded as 10.3 to 23.2°C, relative humidity 66 to 83 percent and total rainfall 7mm from 12<sup>th</sup> February 2013 to 18<sup>th</sup> February, 2013 which favoured the development of Alternaria blight disease.



a. Per cent disease intensity on leaves



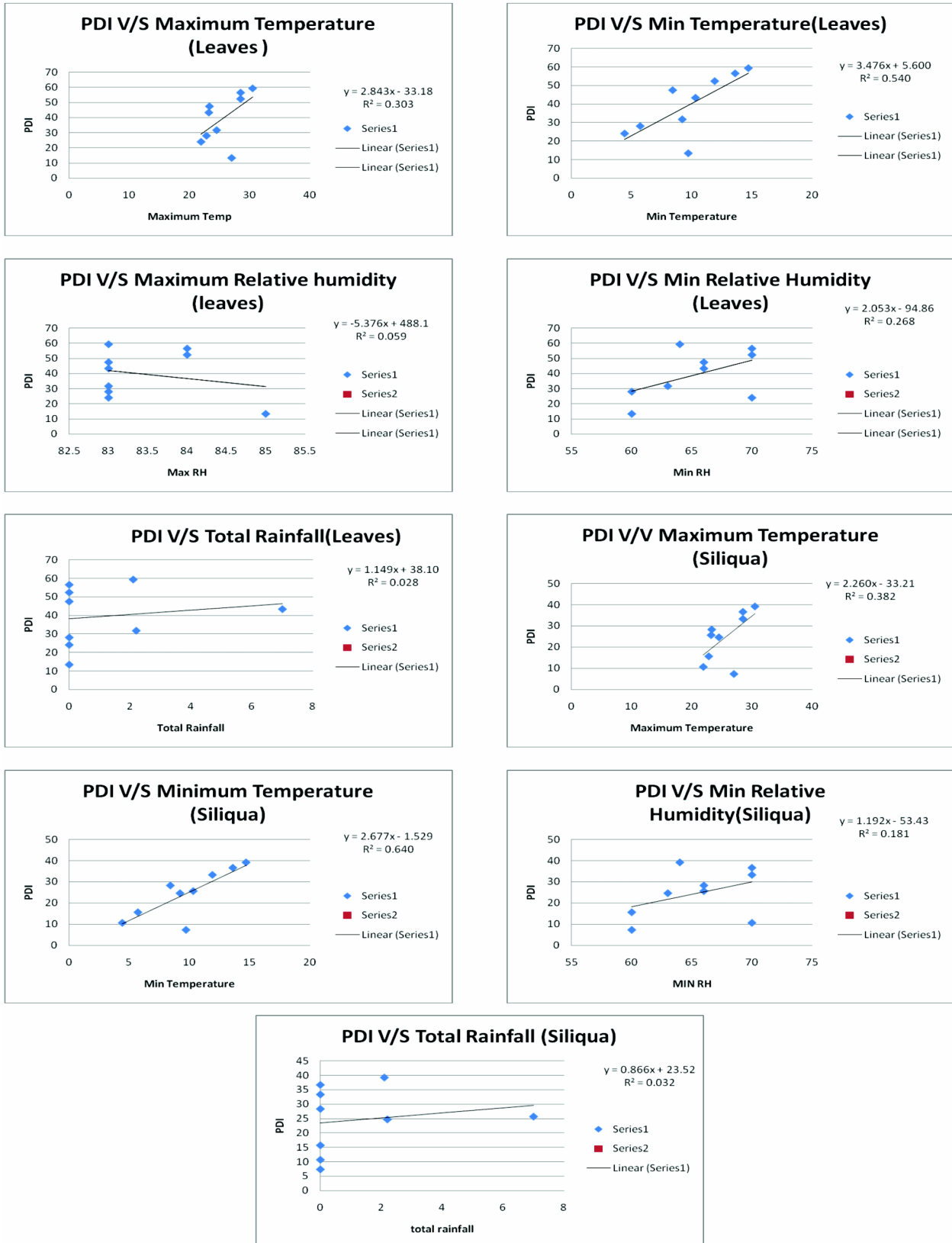
b. Per cent disease intensity on siliqua

Fig. 1: Percent disease incidence on leaves (a) and siliqua (b) at weekly interval

**Table 3: Effect of different environmental factors on Alternaria blight disease development in Indian mustard**

Year 2013 Months	Weeks /Dates	Temperature (°C)		Relative humidity (%)		Total Rainfall (mm) (x <sub>5</sub> )	Disease intensity on leaves % (y <sub>1</sub> )	Disease intensity on siliqua % (y <sub>2</sub> )
		Min. (x <sub>1</sub> )	Max. (x <sub>2</sub> )	Min. (x <sub>3</sub> )	Max. (x <sub>4</sub> )			
January	15-21	9.7	27	60	85	0	13.3	7.3
January	22-28	4.4	21.9	70	83	0	24.0	10.7
January	29-04	5.7	22.8	60	83	0	28.0	15.7
February	05-11	9.2	24.5	63	83	2.2	31.7	24.7
February	12-18	10.3	23.2	66	83	7	43.3	25.7
February	19-25	8.4	23.3	66	83	0	47.5	28.3
February	26-04	11.9	28.5	70	84	0	52.3	33.3
March	05-11	13.6	28.5	70	84	0	56.5	36.7
March	12-18	14.7	30.5	64	83	2.1	59.3	39.2

Fig. 2 : Correlation equation between per cent disease incidence on leaves and siliqua and weather parameters



**Table 4: Regression equation for different weather parameters on PDI of leaves**

GRAPH NAME	EQUATION	R <sup>2</sup>
MAX TEMP - PDI	$y_1 = 2.843x_1 - 33.2$	0.303
MIN. TEMP - PDI	$y_1 = 3.476x_2 + 5.6$	0.540
MAX. R.H. - PDI	$y_1 = -5.376x_3 + 488.1$	0.059
MIN. R.H. - PDI	$y_1 = 2.053x_4 - 94.9$	0.268
TOTAL RAINFAL - PDI	$y_1 = 1.149x_5 + 38.1$	0.028

**Table 5: Regression equation for different weather parameters on PDI of siliqua**

GRAPH NAME	EQUATION	R <sup>2</sup>
MAX TEMP - PDI	$y_2 = 2.260x_1 - 33.21$	0.382
MIN. TEMP - PDI	$y_2 = 2.677 x_2 - 1.529$	0.640
MAX. R.H. - PDI	$y_2 = -3.27x_3 + 297.4$	0.044
MIN. R.H. - PDI	$y_2 = 1.192x_4 - 53.43$	0.181
TOTAL RAINFAL - PDI	$y_2 = 0.866x_5 + 23.52$	0.032

**Table 6: Correlation co-efficient (R) between weather factors and diseases intensity on leaves/siliqua**

Weather factors	R between weather and DIL	R between weather and DIS
Maximum Temperature (°C)(x <sub>1</sub> )	0.550	0.618
Minimum Temperature (°C)(x <sub>2</sub> )	0.735	0.800
Maximum RH (%) (x <sub>3</sub> )	0.243	0.209
Minimum RH (%) (x <sub>4</sub> )	0.518	0.425
Total rainfall (mm)(x <sub>5</sub> )	0.167	0.179

The correlation between disease intensity on leaves and weather factors (viz., maximum and minimum temperature, maximum and minimum relative humidity and total rainfall) were established and found that minimum temperature, maximum relative humidity and total rainfall were significantly positively correlated with disease intensity but other factors were non – significantly positively correlated with disease intensity (Table 4, 5; Fig 2).

Regression equation between PDI and weather factors exhibited strong relationship among different components of the epiphytotics during the crop season. The co-efficient of multiple determinations (R<sup>2</sup>) indicated that the combined effect of different weather factors minimum temperature, maximum relative humidity and total

rainfall favoured the disease development on both leaves and siliqua (Table 6). Weather factors viz., minimum temperature, maximum relative humidity and total rainfall were significant contributing in the prediction of disease development in field.

Regression equation of minimum temperature, maximum temperature and minimum relative humidity on Alternaria blight disease development in mustard leaves.

$$Y_1 = -47.388 + 5.114 T_{\min} - 2.371 T_{\max} + 1.492 R_{\min}$$

$$R^2 = 0.7376$$

Where, Y<sub>1</sub> = PDI on leaves; R<sup>2</sup> = Co-efficient of Determination

Regression equation of minimum temperature and maximum temperature on *Alternaria* blight disease development in mustard siliqua.

$$Y_2 = 31.524 + 4.225 T_{\min} - 1.883 T_{\max}$$

$$R^2 = 0.69203$$

Where,  $y_2$  = PDI on siliqua;  $R^2$  = Co-efficient of Determination

The disease intensity increased gradually with some variations. Maximum percent disease intensity (53.3 %) and (25.7 %) on leaves and siliqua respectively was observed during January – February.

Positive relationships of temperature in the given range, long hours of leaf wetness (Hong *et al.*, 1996) and high r.h. (Chahal and Kang, 1979) with *Alternaria* blight severity have been reported earlier. The information on conditions favouring severity of *Alternaria* blight on leaves and pods could be useful while providing predictions related to the disease. Higher severity of *Alternaria* blight on leaves (Meena *et al.*, 2002) and pods (Sandhu *et al.*, 1985) in later sown crops were reported earlier. Disease intensity is reported to increase with plant age (Meena *et al.*, 2011), which could be the reason for higher frequencies of first appearance of blight on leaves and pods observed in older plants. Higher frequencies for first appearance of blight on leaves in this study matched with earlier report (Meena *et al.*, 2004). The role of weather variables in the disease progress over time was established by determining correlation coefficient and multiple regression analysis among different parameters of epiphytotic. Minimum temperature, maximum relative humidity and total rainfall showed significant effect but other variables showed non-significant effect on *Alternaria* blight (Table 6). Significant positive correlation was observed between *Alternaria* blight disease intensity on leaves and minimum temperature (0.540), and minimum relative humidity (0.258).

Significant positive correlation was observed between *Alternaria* blight disease intensity on siliqua and minimum temperature (0.640), maximum temperature (0.382), and maximum relative

humidity (0.044). The coefficient of determination ( $R^2$ ) indicated that the combined effect of different weather variables (minimum temperature, maximum relative humidity and total rainfall) favoured the disease development in both leaves and siliqua. Correlation co-efficient ( $R$ ) between disease intensity on leaves and minimum temperature ( $x_2$ ) was 0.735 and minimum RH ( $x_4$ ) was 0.518. Most of the models saw entry of variables maximum daily temperature and/or minimum daily temperature with morning r. h., afternoon r. h., total rainfall also getting entered in some cases. Proper monitoring of disease progress could provide accurate forecasts of crop age at first appearance, crop age at highest severity and highest level of disease severity to within one week.

This is expected to guide growers efficiently for making timely fungicidal sprays more effective. The forecasters need to take into consideration the other findings, viz., boundary and favourable conditions for disease severity on leaves and pods. In years of appearance of *Alternaria* blight on crop before the decision week, growers may be advised about the risk expected. Further, the forecasts need to account for the margin of error in order to maintain the confidence of resource-poor rapeseed-mustard farmers of Jharkhand in the forecast system. More study in this direction to improve the models with more information from similar and other new experiments on pathogen inoculum and spore biology for real-time forecasts of outbreaks of the *Alternaria* blight disease based on climatic variables is needed.

## Discussions

Our results indicated that the temperature and relative humidity plays crucial role apart from other parameters in development of disease. *Alternaria* blight is favoured by low temperature, high humidity, and splashing rain (Humpherson- Jones, 1992). Results matched with the earlier report in India, a temperature range of 15-25°C, RH of 70-90 %, intermittent winter rains, and wind velocity around 2-5 Km per hr has been reported to be most conducive to *Alternaria* blight development

in mustard (Ansari *et al.*, 1988; Chahal and Kang, 1979; Awasthi and Kolte, 1989; Chattopadhyay *et al.*, 2005). Awasthi and Kolte (1989) reported the best development of *Alternaria* blight during rosette to flower stages; relative humidity from 67-73 %, rainfall > 70 mm, 5-7 h of sunshine/day, and a minimum temperature range of 7-10°C with the maximum temperature range of 20-23°C have been found to be positively correlated ( $r=0.511 - 0.805$ ) with the severity of disease. A minimum period of 4-hour leaf wetness is essential, but the longer periods of leaf wetness at 25°C, increases the infection frequency on the leaves (Saharan, 1991; Sangeetha and Siddaramaiah, 2007). Infections increases with age of leaf, and the interaction between temperature and leaf age was highly significant (Meena *et al.*, 2011). Meena *et al.*, (2004) reported 45-d.a.s. and 75-d.a.s. as critical stages for *Alternaria* blight development. Severity of *Alternaria* blight on leaves (Meena *et al.*, 2002), and pods (Sandhu *et al.*, 1985) were higher in later sown crops. A delayed sowing results in coincidence of the vulnerable growth stage with warm weather. Results concluded that the farmer's should be aware about the crucial weather for disease development to protect the crop by spraying suitable fungicides.

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