*Journal of Oilseed Brassica*, 4(2): 66-74, July 2013

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

Priyanka Jha[1], Manoj Kumar, PD Meena[*] and HC Lal

*Department of Environmental Science and Engineering Group, BIT Mesra, Ranchi, Jharkhand, India*

[*]*Directorate of Rapeseed-Mustard Research, Bharatpur 321 303 Rajasthan, India*

[1]*Corresponding author: priya@drpjha.com*

(*Received: 29 April 2013; Revised: 5 May 2013; Accepted: 20 May 2013*)

## 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 23.2ºC 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 siliaue results in pre-mature pod-ripening and shedding of seeds, thus, adversely effecting 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, leafwetness, 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 $23^0 17'$N latitude and $85^0 19'$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 :

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

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 using10x30 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 ½ 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* condia 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**

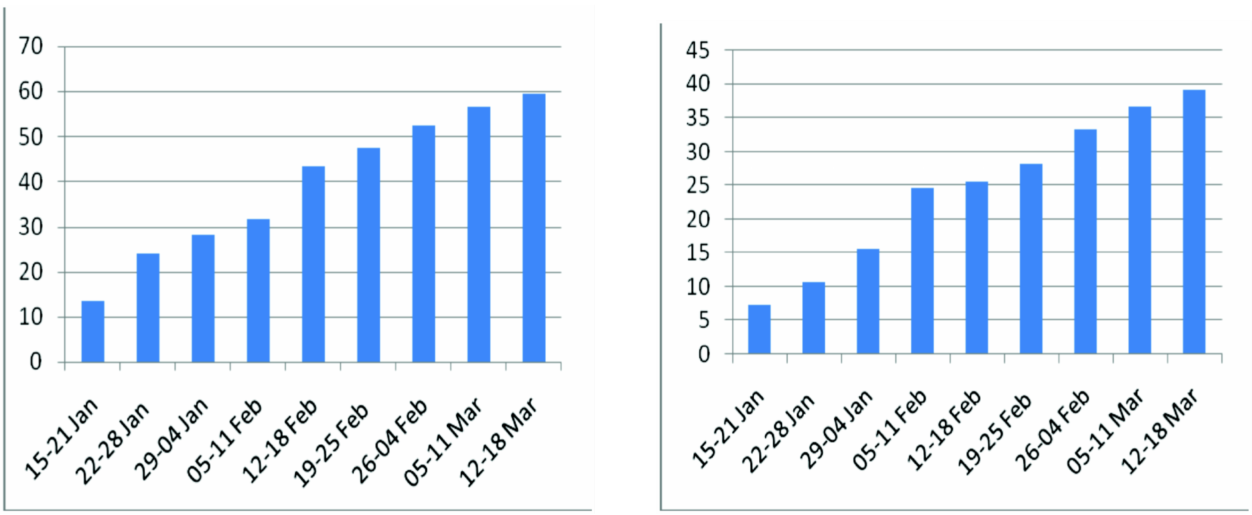
| **Treatments** | **% ABL** |
|---|---|
| Tebuconazole-ST | 28.4 (35.6) |
| Propiconazole-ST | 27.6 (34.5) |
| Iprodione+Cabendazim-ST | 20.8 (31.7) |
| Mancozeb-ST | 26.4 (34.3) |
| Tebuconazole-FS | 27.0 (31.0) |
| Propiconazole-FS | 24.4 (33.0) |
| Iprodione+Cabendazim-FS | 25.2 (32.6) |
| Mancozeb-FS | 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$^0$C, relative humidity 66 to 83 percent and total rainfall 7mm from 12th February 2013 to 18th 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 ($^0$C) | | Relative humidity (%) | | Total Rainfall (mm) | Disease intensity on leaves | Disease intensity on siliqua |
|---|---|---|---|---|---|---|---|---|
| | | Min. ($x_1$) | Max. ($x_2$) | Min. ($x_3$) | Max. ($x_4$) | ($x_5$) | % ($y_1$) | % ($y_2$) |
| 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

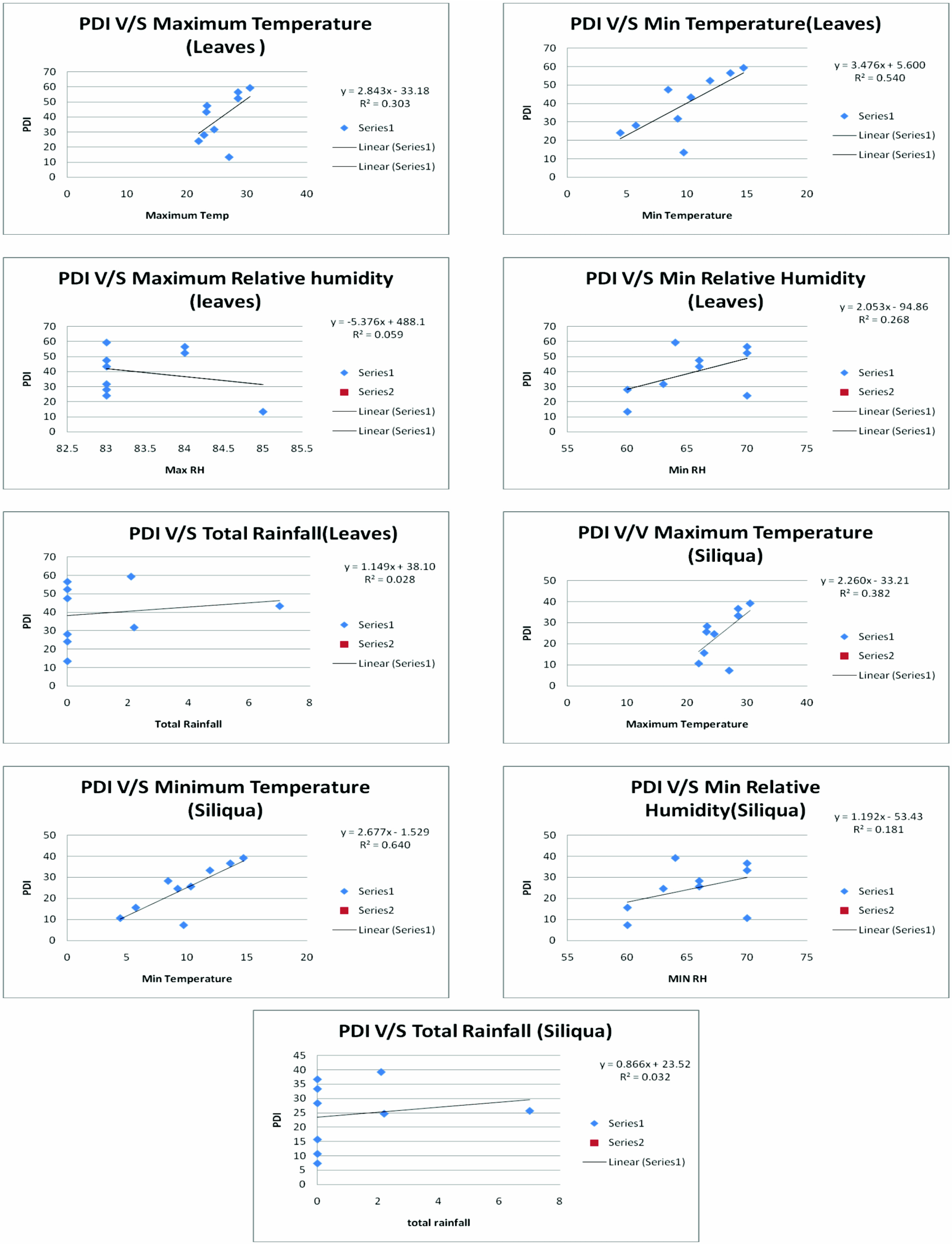


**Table 4: Regression equation for different weather parameters on PDI of leaves**

| GRAPH NAME | EQUATION | $R^2$ |
|---|---|---|
| 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 | $R^2$ |
|---|---|---|
| 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 ($^0$C)($x_1$) | 0.550 | 0.618 |
| Minimum Temperature ($^0$C)($x_2$) | 0.735 | 0.800 |
| Maximum RH (%)($x_3$) | 0.243 | 0.209 |
| Minimum RH (%)($x_4$) | 0.518 | 0.425 |
| Total rainfall (mm)($x_5$) | 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 ($R^2$) 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 Tmin-2.371Tmax+ 1.492 Rhmin

$R^2 = 0.7376$

Where, $Y_{1=}$ PDI on leaves; $R^2$ = Co-efficient of Determination

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

Y2= 31.524+ 4.225 Tmin- 1.883 Tmax

$R^2 = 0.69203$

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 progess over time was established by determining correlation coefficient and multiple regression analysis among different parameters of epiphytotics. 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 determinations ($R^2$) 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 (x2) was 0.735 and minimum RH (x4) 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 aprt 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$^0$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$^0$C with the maximum temperature range of 20-23$^0$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$^0$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.

## Reference


Agriculture Statistics Division. 2012. Agriculture Statistics at a Glance 2003. Agriculture Statistics Division, Dept. Agril. & Coop., Ministry Agriculture, GOI, New Delhi.

Ansari, NA, Khan, MW and Muheet, A. 1988. Effect of temperature and relative humidity on spore germination of *Alternaria brassicae* and development of Alternaria blight on oilseed crucifers *Rev Trop Plant Pathol*, **5**: 79-84.

Awasthi, RP and Kolte, SJ. 1989. Effect of some epidemiological factors on occurrence and severity of Alternaria blight of rapeseed-mustard. *Proc. IDRC (Canada) Oil Crops*: meeting held at Pantnagar and Hyderabad, India, Jan.4-17: 49-55.

Chahal, AS and Kang, MS. 1979. Influence of the metrological factors on the development of Alternaria blight of rape and mustard in Punjab. *Indian Phytopath*, **32**: 171. (Abstr.).

Chattopadhyay C, Agrawal R, Kumar A, Bhar LM, Meena PD, Meena RL, Khan SA, Chattopadhyay, AK, Awasthi RP, Singh, SN, Chakravarthy, NVK, Kumar, A, Singh, RB, Bhunia, CK. 2005. Epidemiology and forecasting of Alternaria blight of oilseed *Brassica* in India – a case study. *J Plant Dis Prot*, **112**: 351-365

Chupp, and Sherf, AF. 1960. Vegetable diseases and their control. *The Ronald Press Company. New York. pp* 693.

Conn, KL and Tewari, JP. 1990. Survey of Alternaria blackspot and Sclerotinia stem rot in central Alberta in 1989. *Can Plant Dis Surv*, **70**: 66-67.

Ellis MB. 1971. Dematiaceous Hyphomycetes. Commonwealth Mycological Institute, Kew. London.

Hong, CX and Fitt, BD. 1995. Effect of inoculum concentration, leaf age and wetness period on the development of dark leaf and pod spot (*Alternaria brassicae*) on oil seed rape (*Brassicae napus). Annals Applied Bio* **127**: 283-295.

Humpherson-Jones, FM. 1992. The development of weather-related disease forecasts for vegetable crops in the UK. Problems and prospects. *OEPP/EPPO Bulletin* **21**: 425-429.

Kolte, SJ. 1985. Diseases of Annual Edible Oilseed Crops, Vol. II, CRC Press Inc. London.

Meena, PD, Awasthi, RP, Chattopadhyay, C, Kolte, SJ and Kumar, Arvind. 2010. Alternaria blight: a chronic disease in rapeseed- mustard. *J Oilseed Brassica*, **1**: 1-11.

Meena, PD, Chattopadhyay, C, Meena, SS and Kumar, Arvind. 2011. Area under disease progress curve and apparent infection rate of Alternaria blight disease of Indian mustard (*Brassica juncea*) at different plant age. *Arch Phytopath Pl Protect*, **44**: 684–693.

Meena, PD, Chattopadhyay, C, Singh, F, Singh, B and Gupta, A. 2002. Yield loss in Indian mustard due to white rust and effect of some cultural practices on Alternaria blight and white rust severity. *Brassica*, **4**: 18-24.

Meena, PD, Meena, RL, Chattopadhyay, C and Kumar, Arvind. 2004. Identification of critical stage for disease development and biocontrol of Alternaria blight of Indian mustard (*Brassica juncea*). *J Phytopath,* **152**: 204-209.

Meah, MB, Kabir, H, Huda, T, Howlider, MAR and Shahjahan, M. 1992. Minimization of chemical sprays for control of Alternaria blight of mustard. *Thai J Agric Sci,* **25**: 251-161.

Saharan, GS. 1991. Assessment of losses, epidemiology and management of black spot disease of rapeseed-mustard. Proc. GCIRC 8th Intl. Rapeseed Congr. July 9-11, Saskatoon, Canada: 84 (Abstr). **2**: 465-470.

Sandhu, KS, Singh, H and Kumar, R. 1985. Effect of different nitrogen levels and dates of planting on Alternaria blight and downy mildew diseases of radish seed crop. *J Res Punjab Agric Univ* **22**: 285–290.

Sangeetha, CG and Siddaramaiah, AL. 2007. Epidemiological studies of white rust, downy mildew and Alternaria blight of Indian mustard (*Brassica juncea* (Linn.) Czern. and Coss.). *African J Agril Res* **2**: 305–308.