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Research Article

Microclimate-Alternaria Blight Interactions in Mustard under Ludhiana Conditions

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ABSTRACT

A field experiment was conducted to study the effect of microclimate on the severity of Alternaria blight in the mustard crop. Mustard was cultivated with three dates of sowing (10^{th} October, 5^{th} November, 1^{st} December) and two mustard cultivars (RLC-3 and PBR-357) replicated thrice during *rabi* 2017-18. Alternaria blight severity was observed at weekly intervals randomly from ten plants per plot under different treatments. Microclimate parameters viz. relative humidity within the canopy and canopy temperature were measured. Disease development and spread are influenced by the microclimate of a crop so relationships were developed between microclimatic parameters and disease severity under different treatments. Relative humidity within the canopy contributed significantly to the development of Alternaria blight severity (R^2=0.90). Canopy temperature played important role in Alternaria blight development. Relationships between canopy temperature and disease severity gave significantly higher R^2 values (0.87) respectively. Regression models developed by using disease severity and microclimatic parameters gave highly significant R^2 values in both cultivars under different dates of sowing.

Key words: Alternaria blight, Disease severity, Microclimatic parameters, Mustard, Regression models

Introduction

Indian mustard (*Brassica juncea* (L.) Czern. & Cosson) is an important oilseed crop that occupies about 80 per cent of the total cropped area under oilseed crops in India. In the year 2020, India produced more than 33 million metric tons of oilseeds. In Punjab, the mustard crop was grown on an area of 30.5 thousand hectares with production of 46.5 thousand tonnes with average productivity of 15.24 quintals per hectare during 2018-19 (Anonymous 2021). Rapeseed-mustard requires cool temperature below 25°C and adequate supply of soil moisture during the growing season. Its growing season (October to April) coincides with a period of very low to high evaporative demand, abundant sunshine, and moderate to high solar radiation conditions. Indian mustard grows well in areas which are receiving 625 to 1000 mm of annual rainfall. Huang *et al.* (2001) revealed that in mustard crop the base temperature for shoot elongation and leaf appearance is 5.5 and 1.5°C respectively, while the optimum temperature is 24.5 and 27.0°C, respectively.

Mustard is vulnerable to weather variability so any change in climate can effect crop growth and production. From 1997 onwards a reduction in mustard yield was observed due to erratic rainfall pattern, which created water stress (drought and excess rainfall) and temperature increase (Kumar, 2005). Different meteorological parameters influence mustard phenological stages. During early stages of mustard crop establishment high temperature affects

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crop and during flowering to pod formation stage cold, fog and winter rains affect the crop adversely and cause yield losses. Climate change and agriculture are interrelated so any change in climate is influencing agriculture. Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. Projected global GHG emissions from NDCs (nationally determined contribution) announced prior to COP26 would make it likely that warming will exceed 1.5°C and also make it harder after 2030 to limit warming to below 2°C (IPCC, 2022). It is projected that heat waves and heavy rainfall events will become more frequent. Overall effect of climate change is projected as increase in *rabi* temperature and more erratic rainfall. If in winter season temperature rises by 1°C from the normal it may reduce mustard yield by 450 kg/ha and shortened the crop duration (Anonymous, 2010). Kalra *et al.* (2008) studied that in Haryana with every 1°C rise in temperature mustard yield is reduced to the tune of 2.01 q/ha.

Flowering and grain filling are the most sensitive stages for temperature stress probably due to vulnerability during pollen and grain development, anthesis and fertilization leading to reduced crop yield. High temperature in *Brassica* enhanced plant development and caused flower abortion and poor grain filling with appreciable loss in seed yield. A rise of 3°C in maximum daily temperature (21-24°C) during flowering and grain filling caused a decline of 430 kg/ha in Canola seed yield. Whereas floral sterility was observed in canola sarson when temperature raised above 27°C (Morrison and Stewart, 2002).

Sowing time is important non-monetary input to achieve maximum yields in crop. Date of sowing affects different stages of crop growth as with change in sowing time crop is exposed to different thermal environments. Delayed sowing resulted in poor crop growth and oil content (Akhter *et al.,* 2015).

Different biotic stresses like insect-pest, diseases and weeds etc. effect crop growth and production. Diseases and insect pests are important limiting factors, which restrict the fast expansion of cultivation and reduce the productivity of mustard crop. The severe attack of many diseases on mustard crop not only deteriorates the quality of the seeds but also reduces the oil content. Number of diseases attack mustard crop and about 30 diseases are recognized to effect crops in India (Saharan, 1992). Among these, Alternaria blight, white rust, downy mildew, powdery mildew and stem rot or white stem rot are considered economically important. Most of the commercially grown varieties are susceptible or moderately susceptible to these diseases. Occurrence of any disease is influenced by congenial weather conditions. Different meteorological parameters affect the occurrence, development and spread of mustard diseases. Alternaria blight is one of the important disease caused by *Alternaria brassicae* causing 30-70 per cent yield loss of *Brassica* crops (Mishra *et al.,* 2010). The incidence and severity of Alternaria blight in rapeseed-mustard fields is influenced by air temperature, relative humidity, soil conditions at the time of sowing, splashing rain, wind velocity, leaf wetness, and inoculum density available in the soil (Meena *et al.,* 2011). For progression of Alternaria blight the meteorological parameters like temperature 12-25°C and relative humidity more than 70 per cent with intermittent winter rainfall and wind speed around 2-5 km/hr has been reported as favourable (Mehta, 2014). Mamgain *et al.* (2014) studied that *Alternaria brassicae* induced leaf blight has been found to have a drastic effect on members belonging to plant families such as Cucurbitaceae, Brassicaceae and Solanaceae which have nutritional as well as economic importance. Microclimate modification can be useful in management of Alternaria blight as disease is highly influenced by microclimate of the crop. Microclimate of crop influences the disease development, multiplication and spread. As some pathogens require specific leaf temperature to develop and multiply. The knowledge on interaction of microclimate-disease is required to provide important information for developing disease forewarning system. Very little work has been reported regarding the effect of microclimate of crop on the incidence of different mustard diseases. Effect of different micrometeorological parameters viz. canopy temperature and relative humidity within crop canopy were yet to be carried out. So, keeping these aspects in view, this study was planned to know the effect of different micrometeorological parameters on Alternaria blight severity in mustard grown under different dates of sowing.

Materials and Methods

The experiment was carried out during *rabi* season of 2017-18 at the Research Farm, Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana (30°54′N latitude and 75°48′E longitude and at an altitude of 247 meter above mean sea level). The experiment on mustard crop was conducted with three dates of sowing (10th October, 5th November, 1st December) and two mustard cultivars (RLC-3 and PBR-357) replicated thrice under split plot design with dates of sowing in main plot and cultivars in sub plot. Canopy temperature was measured with the help of an infrared thermometer. The infrared thermometer was held at an angle of 45° and one meter above the canopy. The canopy temperature was recorded at 1430 hrs. The observations were recorded at periodic intervals. The relative humidity was measured with the help of Belfort Psychron (Model 566 series) by placing it inside the crop canopy on ground surface, at the middle of crop canopy and the top of crop canopy.

Disease severity (%)

Alternaria blight symptoms appeared 43-45 days after sowing as minute brown to black usually round necrotic spots on older leaves. Leaf area infected was observed at weekly intervals randomly from ten plant per plot under different treatments by using rating scale (Table 1) and per cent disease severity was calculated on the basis of following formulae:

$$\text{Disease severity (\%)} = \frac{\text{per cent leaf area infected}}{\text{Total leaf area}} \times 100$$

Statistical analysis

Correlation matrix was developed by using pooled data of both varieties and three dates of sowing disease severity and corresponding meteorological parameters. Relationships were developed between microclimatic parameters and disease severity under different treatments. Regression models were developed by using disease severity as dependent variable and both microclimatic parameters viz., canopy temperature and relative humidity within canopy as independent variables.

Results and Discussion

Alternaria blight severity and meteorological parameters

The Alternaria blight severity was observed in the mustard crop sown on three different dates i.e. 10th October, 5th November and 1st December. The crop sown on 1st December showed highest disease severity (44.2 %) followed by 5th November (39.7%) and 10th October (31.5 %) sown crop in cultivar RLC-3. Similarly, in cultivar PBR-357, late sown crop (1st December) showed the highest disease severity (51.5%) as compared 5th November (45.5%) and 10th October (40.0%) sown crop as shown in Fig.1. This was due to the reason that the early sown (10th October) crop didn't get congenial weather conditions for Alternaria blight development and spread. Thus, from the results it can be concluded that the early sown mustard crop showed lower disease severity and therefore mustard crop should be sown during first fortnight of October to avoid heavy losses in the yield due to severity of Alternaria blight. These results are in accordance with those reported by Dange *et al.* (2003) that in early sown crop i.e. in the month of October, showed less

Table 1. Rating scale used for scoring Alternaria blight severity (Bal and Kumar, 2013)

Disease rating	Disease severity description
0	No symptoms on leaf
1	Small light brown spots scattered covering <5% leaf area
2	Spots small, brown, with concentric rings, covering 5.1 to 10% leaf area
3	Spots large, brown, irregular, with concentric rings 10.1 to 25% leaf area
4	Large, brown, irregular lesions with typical blight symptoms, covering 25.1 to 50% leaf area
5	Large, brown, irregular lesions with typical blight symptoms, covering more than 50% leaf area

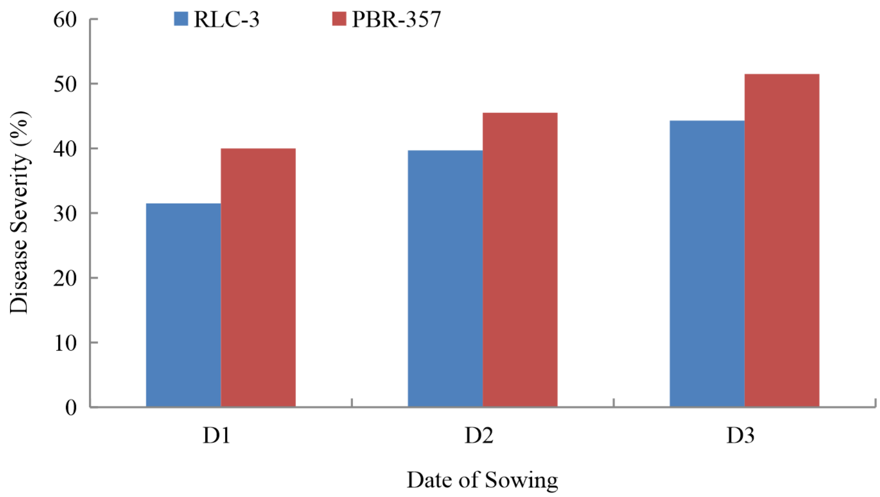

Fig. 1. Terminal Alternaria blight severity in different treatments of mustard

severity as compared to late sown conditions. Every insect, pest or disease has a favourable period during which it flourish well similarly, *Alternaria brassicae* development and progression is influenced by different meteorological parameters. At a specific time period a particular meteorological parameter influences disease occurrence, development and spread. A delayed sowing results in coincidence of the vulnerable growth stage of plants with favourable weather conditions. During disease spread period, maximum temperature was in range of 15.5 to 27.3 ^{o}C, minimum temperature was in range of 5.4-13.1 ^{o}C, morning relative humidity 88-96 per cent and evening relative humidity in range of 38-76 along with total rainfall of 45.4 mm. Sunshine hours were in range of 2.6 to 10.4 hr/day as presented in Table 2. Disease appeared during 52nd standard meteorological week (SMW) and suddenly increased after 4th SMW and terminal disease severity was recorded during 10th SMW. Rainfall is not favourable for development of disease. Disease showed maximum incidence during zero rainfall period. The results are in corroboration with the findings observed by Gupta *et al.* (2003) that meteorological parameters significantly influence mustard diseases. They observed that Eighty five-day old plants showed highest disease severity because maximum temperature in the range of 20.4-31.6°C and

Table 2. Weekly meteorological parameters during Alternaria blight development and spread period in *rabi* 2017-18

SMW	Temperature (°C)			Relative humidity (%)			Rainfall	Sunshine	Disease
	T_{max}	T_{min}	T_{me}	RH_m	RH_e	RH_{me}	(mm)	hours (hrs/day)	severity (%)
51	21.9	7.4	14.6	91.0	47.0	69.0	0.0	7.9	0.0
52	20.7	6.3	13.5	96.0	49.0	72.5	0.0	4.9	0.7
1	15.9	5.4	10.6	96.0	66.0	81.0	0.0	2.6	1.5
2	20.8	5.3	13.0	94.4	42.7	68.6	0.0	7.6	3.1
3	22.0	6.1	14.1	92.0	40.1	66.1	0.0	7.7	5.1
4	15.5	7.6	11.5	93.4	75.6	84.5	18.4	3.6	7.8
5	21.2	7.6	14.4	91.4	45.6	68.5	0.0	8.1	16.4
6	21.1	5.6	13.4	89.0	37.6	63.3	2.4	8.0	23.2
7	21.1	9.3	15.2	89.0	53.0	71.0	21.4	7.4	30.7
8	25.5	11.7	18.6	87.6	48.0	67.8	3.2	7.5	32.7
9	25.8	13.1	19.4	88.7	50.9	69.8	0.0	6.5	34.4
10	27.3	12.2	19.7	87.9	41.7	64.8	0.0	10.4	35.8

Table 3. Correlation matrix between Alternaria blight severity and meteorological parameters

	Disease severity	Tmax	Tmin	RHm	RHe	RF	SSh
Disease severity	1						
Tmax	0.781	1					
Tmin	0.839	0.825	1				
RHm	-0.888	-0.857	-0.811	1			
RHe	-0.376	-0.718	-0.220	0.564	1		
RF	-0.050	-0.455	-0.083	0.076	0.600	1	
SSh	0.556	0.796	0.435	-0.702	-0.879	-0.369	1

minimum temperature in the range of 4.9-14.4°C maximum relative humidity 80-94 per cent and minimum relative humidity 33-56 per cent had significant effect on disease. The correlation matrix was developed between pooled data of disease severity of both varieties and dates of sowing and weather parameters as presented in Table 3. From correlation matrix, it is evident that both maximum and minimum temperatures positively influence disease severity whereas relative humidity negatively influences disease severity. Similarly, Jain and Sandhu (2019) revealed that the maximum, minimum temperature and sunshine hours showed a significant positive correlation with Alternaria blight incidence in mustard.

Relationship between Alternaria blight severity and microclimatic parameters

Microclimate influence disease severity so modification of microclimate can be helpful to manage diseases. Alternaria blight severity is affected by different meteorological and micrometeorological parameters of the mustard crop. Microclimatic parameters viz. canopy temperature and relative humidity with in crop canopy was recorded at periodic intervals. To study the interaction between Alternaria blight severity with canopy temperature and relative humidity with in canopy relationships were developed between these microclimatic parameters and disease observations.

Canopy temperature and Alternaria blight severity

Canopy temperature was higher in the more infested crop in both cultivars under three dates of sowing. Higher relative humidity was more favourable for disease development. The severity of Alternaria blight disease is influenced by canopy temperature. Any change in canopy temperature shows the stress of crop due to occurrence of disease and any other stress. The relationship between disease severity and canopy temperature under different dates of sowing were worked out by using pooled data of both cultivars (Fig. 2). The value of R^2 indicates the variability in disease severity due to canopy temperature within crop canopy and also explained the per cent contribution of canopy temperature in disease severity. In the early date of sowing (10th October), the variability in disease severity due to canopy temperature was 80.0 per cent and in the timely sown crop (5th November), the variability in disease severity due to canopy temperature was 87.0 per cent. While in the late sown crop (1st December), the variability in disease severity due to canopy temperature was 81.0 per cent.

The relationship between the disease severity and canopy temperature under different cultivars were worked out and the relationship gave the per cent contribution of canopy temperature in the development of disease severity which is presented in the Fig 3a and 3b. The value of R^2 indicated the variability in disease severity due to canopy temperature within crop canopy and also explained the percent contribution of canopy temperature in disease severity. In the mustard cultivar RLC-3, the variability in disease severity due to canopy temperature was 85.0 per cent and in PBR-357, the variability in disease severity due to canopy temperature was 79.0 per cent. This difference in per cent variability was mainly due to difference in disease severity within both cultivars. Paveley *et al.* (2000) and Schubert (2005) also reported that

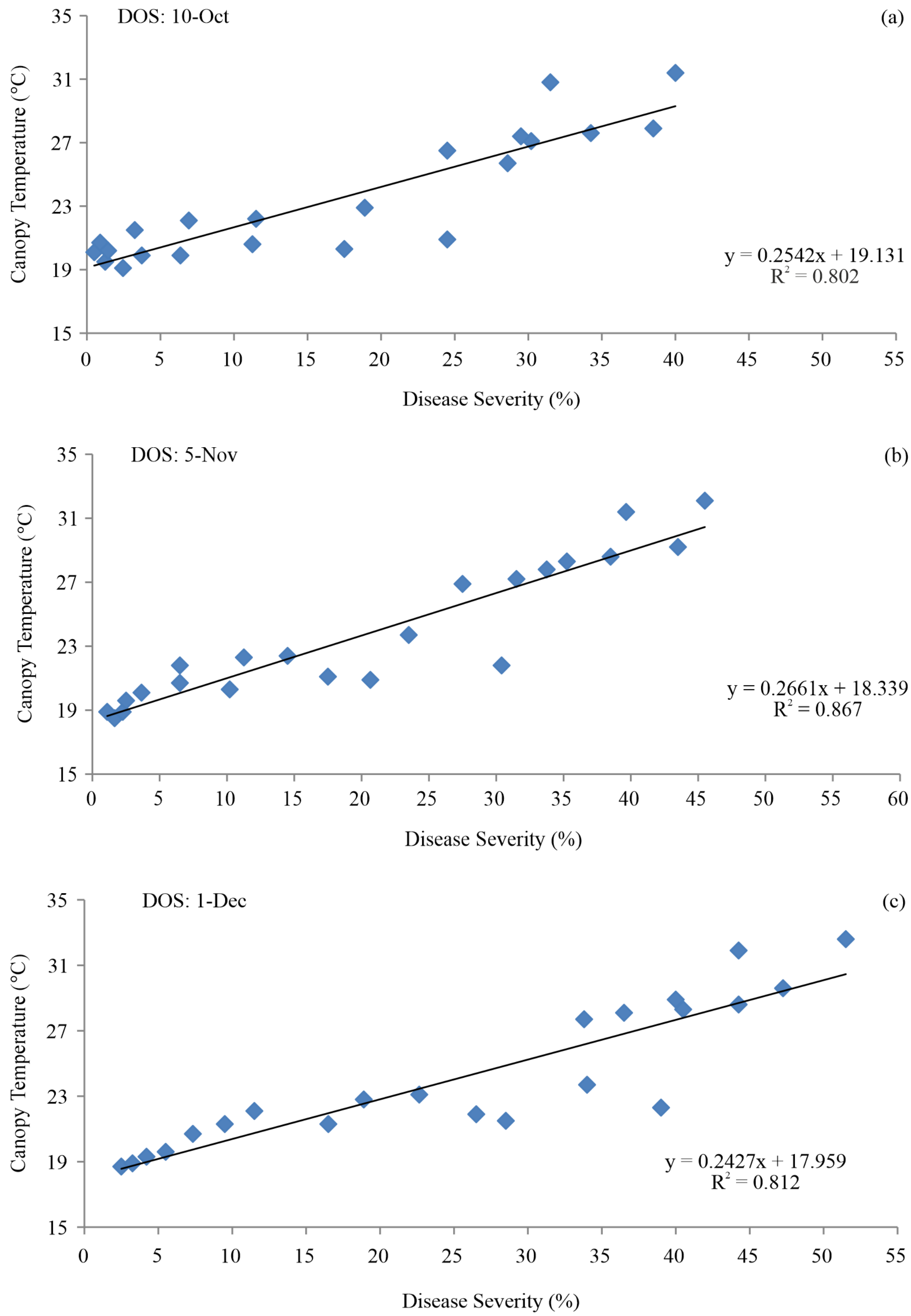

Fig. 2. Relationship between canopy temperature and severity of Alternaria blight in mustard under different dates of sowing

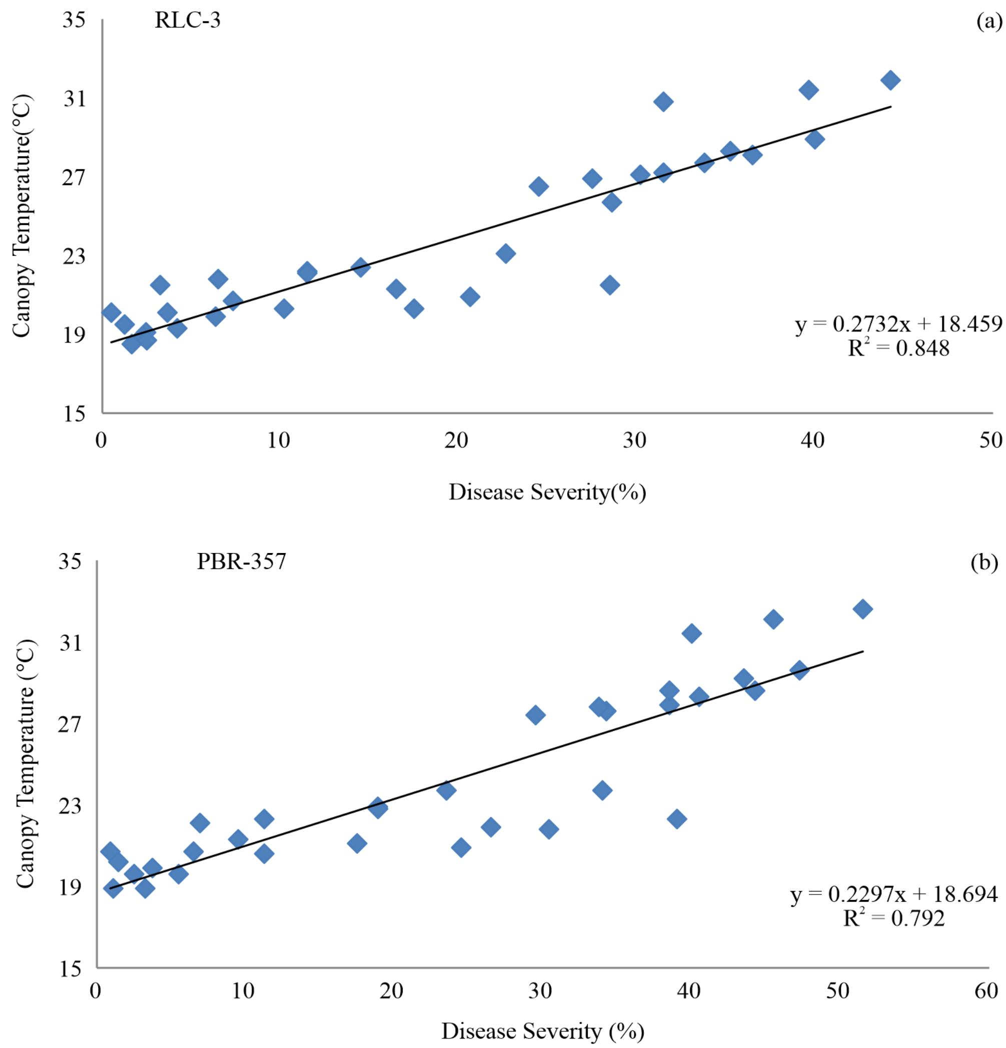

Fig. 3. Relationship between canopy temperature and severity of Alternaria blight in mustard cultivars

microclimate of a crop influence disease incidence and progress significantly.

Relative humidity within canopy and Alternaria blight severity

Relative humidity is one of the important weather parameter playing significantly role in Alternaria blight development. Relative humidity within crop canopy has a direct effect on development and spread of Alternaria blight. So to study the contribution of relative humidity within the crop canopy in development of Alternaria blight, relationships were developed between disease severity with relative humidity with in crop canopy under different treatments. The disease severity was affected greatly by any change in the relative humidity within the crop canopy under different dates of sowing and two cultivars of mustard. So the relationships between relative humidity within the crop and disease severity were worked out (Fig 4). The value of R^2 indicated the variability in disease severity due to relative humidity within crop canopy and also explained the per cent contribution of relative humidity in disease severity. In the first date of sowing (10th October), the R^2 value of 0.82 signifies that the variability in disease severity due to relative humidity within the crop canopy was 82.0 per cent and in the second date sown crop (5th November), the R^2 value of 0.88 signifies that the variability in disease severity due to relative humidity within the crop canopy was 88.0

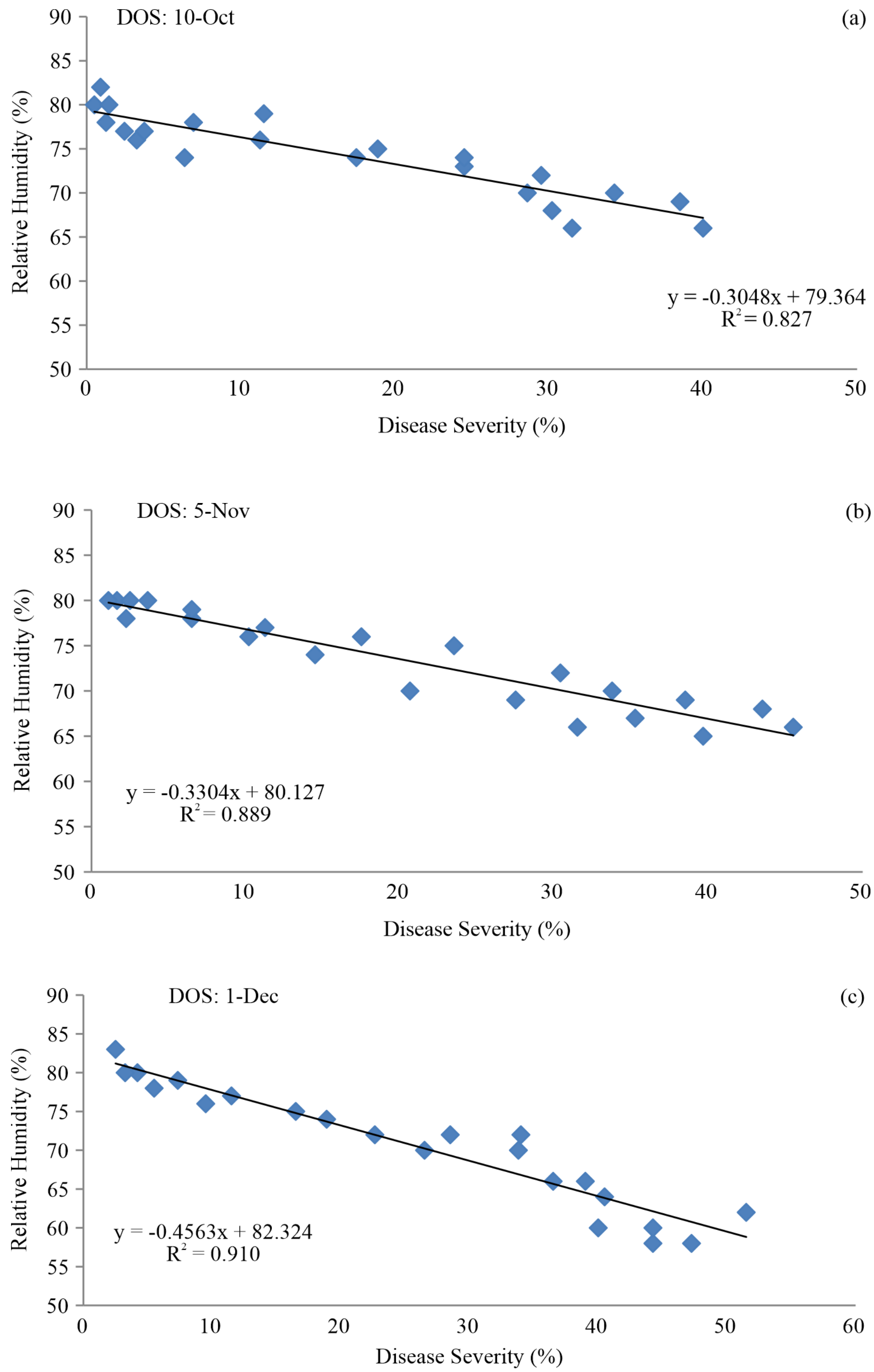

Fig. 4. Relationship between relative humidity within crop and severity of Alternaria blight in mustard under different dates of sowing

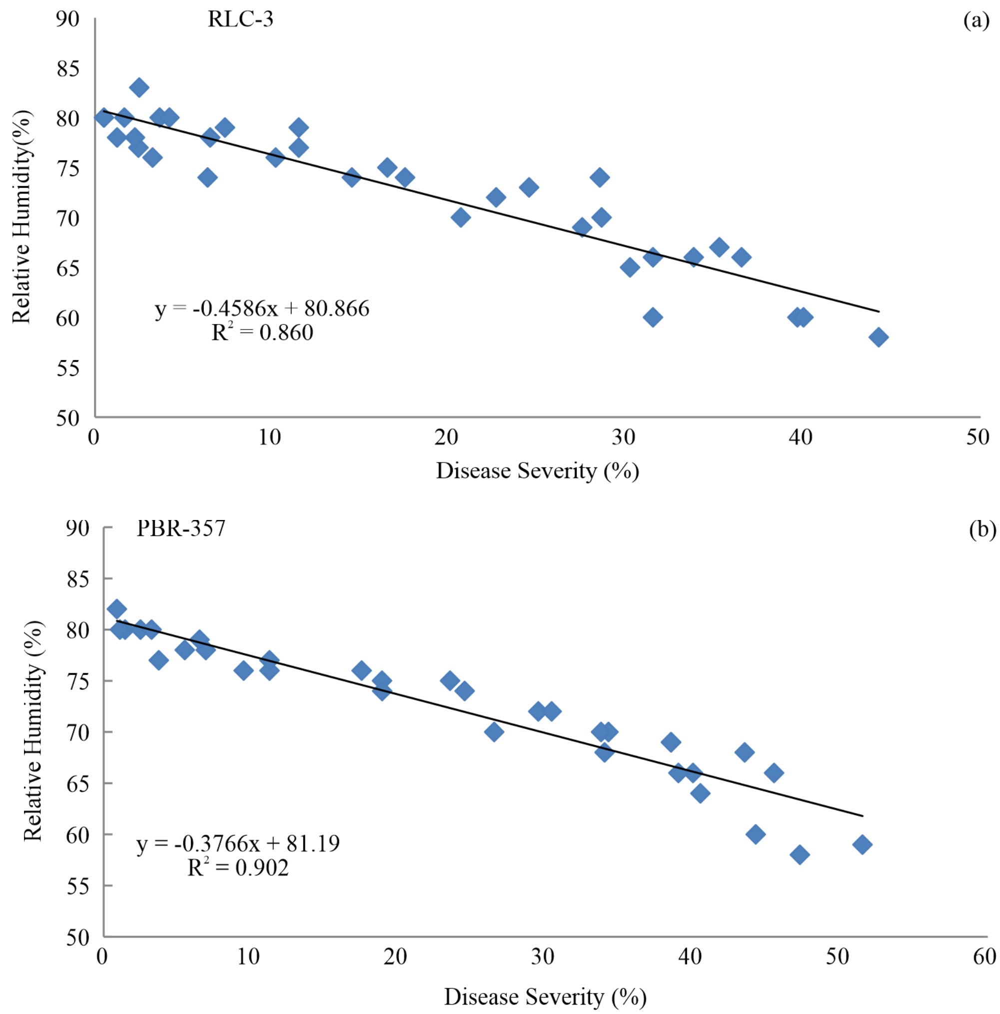

Fig. 5. Relationship between relative humidity within crop and severity of Alternaria blight in mustard cultivars

per cent. While in the third date of sowing (1st December) crop, the R^2 value of 0.91 signifies that the variability in disease severity due to relative humidity within the crop canopy was 91.0 per cent. So the results revealed that the relative humidity with in canopy significantly influenced disease severity under different dates of sowing.

Relationships between relative humidity within the crop and disease severity in both mustard cultivars RLC-3 and PBR-357 were worked out and presented in (Fig 5a and 5b). The value of R^2 indicated the variability in disease severity due to relative humidity within crop canopy and also explained the per cent contribution of relative humidity in disease severity. In mustard cultivar RLC-3, the R^2 value of 0.86 signifies that the variability in disease severity due to relative humidity within the crop canopy was 86.0 per cent and in PBR-357, the R^2 value of 0.89 signifies that the variability in disease severity due to relative humidity within the crop canopy was 89.0 per cent. This difference in R^2 values between two cultivars was mainly due to difference in disease severity level of both cultivars and may be due to difference in relative humidity within canopy of both cultivars.

Regression models

After the development of relationships between disease severity and microclimatic parameters, it was evident that Alternaria blight severity is significantly influenced by canopy temperature and relative humidity within crop. So on the basis of these

Table 4. Regression models between disease severity and microclimatic parameters

Treatment	Regression Model	R^2 Value
D_1 (10-Oct)	y=99.45+1.53CT-1.59RH	0.87*
D_2 (5-Nov)	y=100.3+1.51CT-1.58RH	0.92*
D_3 (1-Dec)	y=126.4+0.66CT-1.65RH	0.91*
RLC-3	y=61.51+1.45CT-1.06RH	0.88*
PBR-357	y=121.5+1.17CT-1.75RH	0.92*

*Significant at 0.01 level of significance
Where,
y= Disease Severity (%)
CT = Canopy Temperature (°C)
RH = Relative humidity within crop (%)

relationships, regression models were developed using disease severity as dependent variable and canopy temperature and relative humidity within crop as independent variable. Five regression models were developed as presented in Table 4. Combination of canopy temperature and relative humidity within crop as independent variables gave highly significant R^2 values like 0.88 in case of RLC-3 and 0.92 in PBR-357.Similarly, Jambhulkar *et al.* (2016) revealed that conidial spore population of Alternaria spp. trapped under the influence of microclimatic conditions during the cropping season from the month of January to May months was better correlated with minimum temperature, maximum temperature, RH and wind speed with the R^2 value of 0.982, 0.885, 0.962, and 0.758, respectively. They observed that conidial spore count was less till March, but in April it was suddenly increased from 50 to 135. During that period, there was sudden decrease of RH from 75 to 55 per cent and minimum temperature increased from 13°C to 21°C.

Conclusion

Alternaria blight an important disease of mustard is significantly influenced by microclimatic parameters viz., canopy temperature and relative humidity within crop. Canopy temperature and relative humidity within crop showed linear relationships with disease severity and more than 90 and 88 per cent variability in Alternaria severity in cultivars PBR-357 and RLC-3, respectively. Regression models developed by using these two microclimatic parameters gave highly significant R^2 values and after validation these models can be further used for forewarning of Alternaria blight severity.

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