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Research Article

Effect of Microclimate Modifications on Alternaria Blight Severity

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ABSTRACT

Field experiment was conducted on *Brassica juncea* during *rabi* season of 2019-20 at the Research Farm, Department of Climate Change and Agricultural Meteorology, PAU, Ludhiana. Two *Brassica juncea* varieties (PBR 91 and PBR 357) sown on 30th October under two row directions i.e. North-South (N-S) and East-West (E-W) during *rabi* season 2019-20. The defoliation treatment was done at flowering and pod filling stage of the crop. Effect of microclimate modification on the alternaria blight severity was worked out. Disease severity data were collected from 2017 to 2019. Maximum and minimum temperatures, evening relative humidity and rainfall showed a significant positive correlation with alternaria blight severity and morning relative humidity and bright sunshine hours were negatively correlated with disease severity. Alternaria blight severity was higher (39.8%) in E-W row direction compared to N-S direction (33.3%). The highest area under disease progress curve was recorded in E-W direction (246) compared to N-S direction (220). First defoliation (at flowering stage) proved effective against alternaria blight than second defoliation (Pod formation). Maximum area under disease progress curve was recorded under control treatment (234) followed by 2nd defoliation (215) and 1st defoliation (210). Regression equations developed between meteorological parameters and disease severity may be useful in weather-based disease models/ decision support systems. Farmers can reduce yield losses due to alternaria blight by adapting these microclimate modifications.

Key words: Defoliation, Row direction, Microclimate modification, Alternaria blight

Introduction

Rapeseed and mustard is the second most important oilseed crop in India and belongs to family *Cruciferеae* under genus *Brassica* with a large number of species and subspecies cultivated in India. A wide gap exists between the potential and the realized yield at the farmers's field, which is largely due to number of abiotic and biotic stresses to which the rapeseed-mustard crop is, exposed (Jha *et al*., 2013). Diseases and insect pests are the main limiting factors, which decrease the productivity of the mustard crop (Jain *et al.,* 2019). The occurrence, development and spread of mustard diseases are influenced by different meteorological parameters. The moisture and temperature play a vital role in germination of spore, incidence and spread of diseases. The severe attack of different diseases in mustard deteriorates the quality as well as reduces the oil content. Alternaria blight occurs between 15-25°C temperature and relative humidity of more than 75 per cent. The alternaria pathogen infects the crop at all growth stages and affects the quality and quantity of oil (Meena *et al.,* 2010). The yield losses due to alternaria blight are 10 to 71 per

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cent (Chattopadhyay *et al*., 2005). Under Punjab conditions, the alternaria blight disease caused by *Alternaria brassicae* is an important disease. The harmful effect of organism reduces both the quality and quantity of seed yield. Microclimate modification viz. row spacing, row direction, defoliation and debranching etc. is practiced in rapeseed-mustard crops to increase yield. Little work has been reported to study the effect of microclimate modification on different diseases. The row direction in winter crops affects the growth, yield and disease incidence in crops. In some crops, the row orientation reduces the incidence of diseases/insect by modifying the microclimate thereby resulting in higher seed yield and good economic return (Kaul and Singh, 1995). Defoliation i.e. the removal of leaves is also practiced in these crops. The 75 per cent removal of leaves in mustard makes essentially more translocation of assimilates to inflorescence than controlled conditions. Keeping all this in view, the field experiment was conducted to study the effect of microclimate modification on alternaria blight disease.

Material and methods

Field experiment

The field experiment was conducted with two *Brassica juncea* varieties (PBR 91 and PBR 357) sown on 30th October under two row directions i.e. N-S and E-W during *rabi* season 2019-20. The defoliation was done at flowering and pod formation stage. The experiment was laid out in factorial split plot design with four replications. Crop was raised as per the recommendations of Punjab Agricultural University package of practices.

Meteorological Data

Meteorological data of Ludhiana were collected from the Agrometeorological Observatory, Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana which is situated at 30°54′N latitude and 75°48′E longitude and altitude of 247 m from mean sea level.

Disease data: Under natural conditions, disease severity data were recorded at weekly intervals under field conditions. The alternaria blight severity data were collected at Oilseed Farm, Punjab Agricultural University, Ludhiana from 2017 to 2019.

Disease Severity (%)

Leaf area infected was observed at weekly intervals randomly from ten plants per plot under different treatments by using rating scale (Bal and Kumar 2013) and per cent disease severity was calculated on the basis of following formulae:

$$\text{Disease severity} = \frac{\text{Sum of all disease rating}}{\text{Total no. of rating} \times \text{Maximum disease grade}}$$

Area under disease progress curve (AUDPC)

Area under disease progress curve (AUDPC) gives a quantitative measure of disease development and disease intensity. The AUDPC was estimated using the following formula as given by Campbell and Madden (1990).

$$\text{AUDPC} = \sum_{i=1}^{n-1} (Yi + 1 + Yi)\ 0.5\ (Ti + 1 - Ti)$$

Where,

Yi – Alternaria blight disease severity on the ith date

Ti - Date on which the disease was scored

n - Numbers of dates on which disease was scored

Statistical analysis

Correlation and regression analysis was conducted between alternaria blight severity and different meteorological parameters viz; temperature, relative humidity, sun shine hours and rainfall.

Results and Discussion

The alternaria blight incidence was first observed on 6th standard meteorological week (SMW) and its peak was recorded on 10th SMW. During this week, total rainfall of 18.6 mm was recorded, which may be responsible for its peak. The average maximum and minimum temperatures were 20.4 and 5.6°C during the alternaria blight incidence period. Disease severity was more in variety PBR 91 compared to variety PBR 357 (Fig.1).

Most of the diseases are influenced by prevailing weather conditions for incidence and development. But the crop micro-environment which is represented by temperature and relative humidity profiles within the canopy may alter the level of disease infection. The E-W row direction showed more disease severity than N-S row direction, because in the E-W row direction there is less penetration of light so the relative humidity was more in this direction which is favourable for the disease development as presented in Fig.2

The first defoliation was done at flowering stage in both the directions (N-S and E-W) which results in low disease severity compared to control (no defoliation). In fact alternaria blight was recorded 90 days after sowing but the severity was low in defoliated plots than control. After 2nd defoliation (90 days after sowing), the severity of disease was more than 1st defoliation treatment (Fig.3). Defoliation management of legume seedlings helps to minimize stresses (disease and drought) as reported by Sanderson *et al.* (1997).

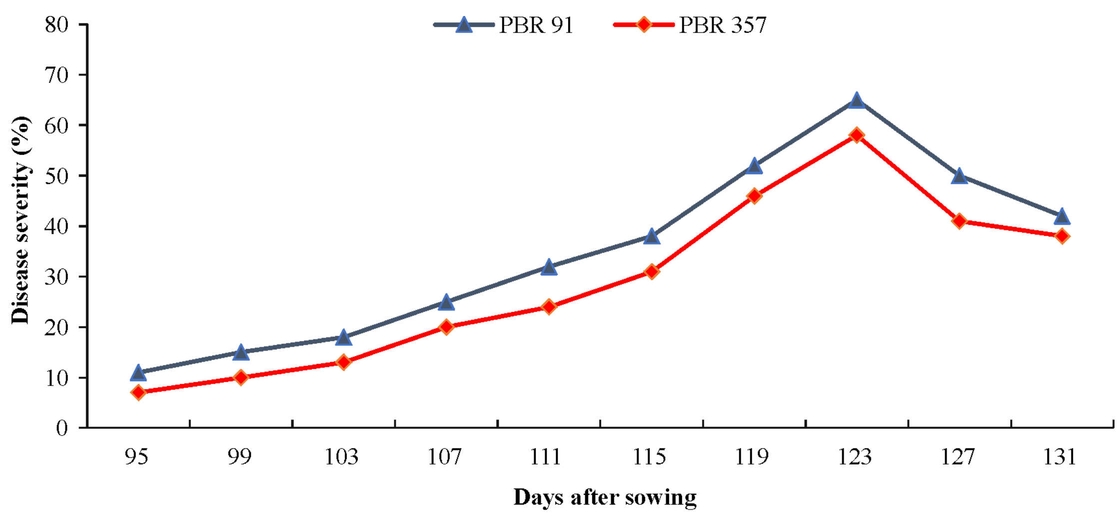

Fig. 1. Alternaria blight severity in *Brassica juncea* varieties during *rabi* 2019-20

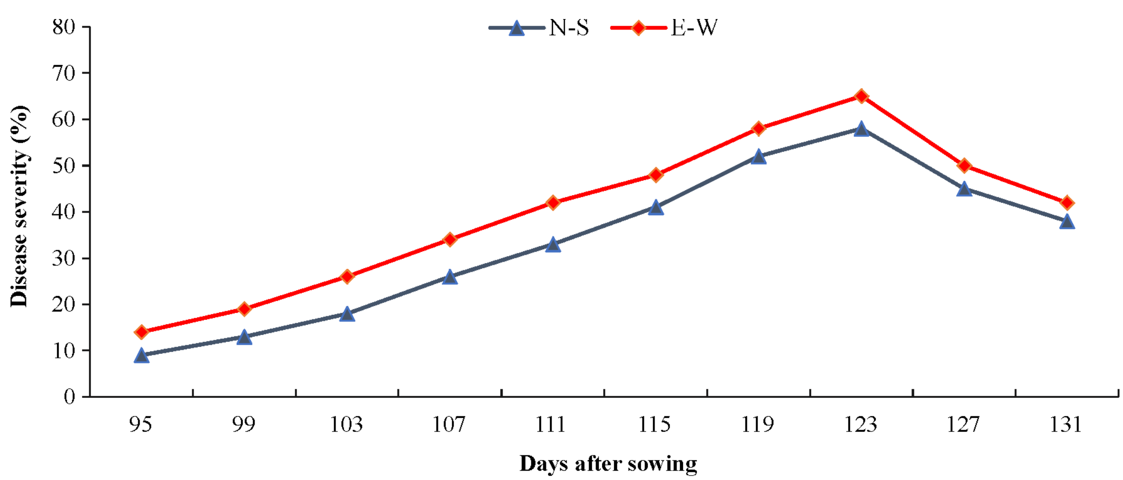

Fig. 2. Effect of row direction on alternaria blight severity during *rabi* 2019-20

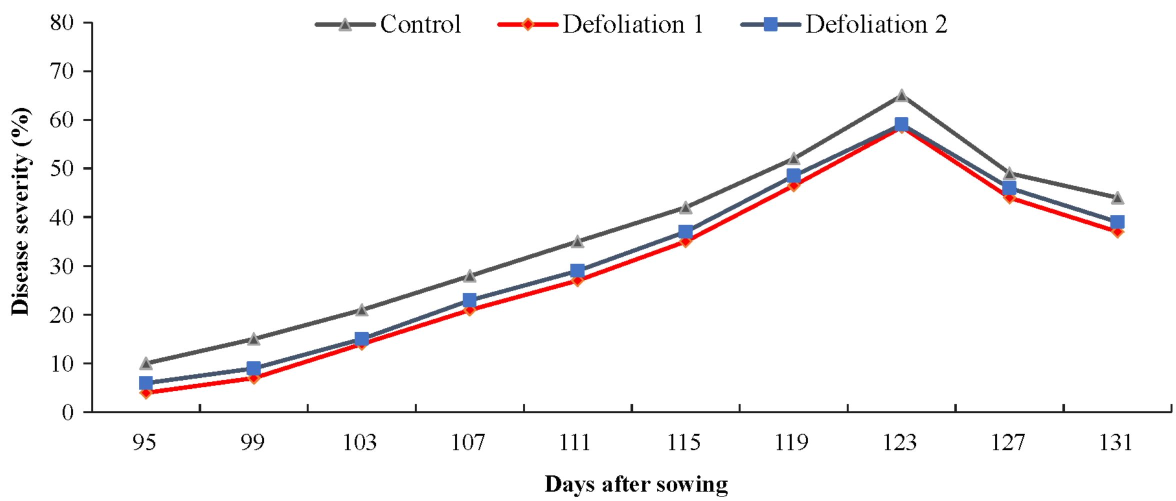

Fig. 3. Effect of defoliation on alternaria blight severity during *rabi* 2019-20

Correlation coefficients between alternaria blight severity and different meteorological parameters

Disease severity is mainly dependent on the weather conditions prevailing during the crop season. Generally temperature and relative humidity are the most important meteorological parameters that affect incidence and further development of different diseases. Correlation coefficients between disease severity and different meteorological parameters viz. maximum and minimum temperatures, morning and evening relative humidity, sunshine hours and total rainfall were worked out and presented in Table 1. It was found that the maximum temperature, minimum temperature, evening relative humidity and rainfall showed a significant positive correlation with the alternaria blight severity. Morning relative humidity and bright sun shine hours (SSH) were negatively correlated with alternaria blight severity. Similarly Bal and Kumar (2013) reported that the maximum and minimum temperatures had a significant and positive correlation with disease severity. Mahapatra and Das (2015) also reported that the maximum

Table 1. Correlation coefficients between alternaria blight severity and different meteorological parameters

Treatments	T_{max} (°C)	T_{min} (°C)	RH_m (%)	RH_e (%)	BSSH (hr/day)	RF (mm)
$V_1R_1T_0$	0.85 ð	0.80*	-0.52 ð	0.55*	-0.42	0.63*
$V_1R_1T_1$	0.72 ð	0.68 ð	-0.48	0.58*	-0.32	0.62*
$V_1R_1T_2$	0.75 ð	0.70*	-0.29	0.62*	-0.35	0.66*
$V_2R_2T_0$	0.66 ð	0.58 ð	-0.28	0.52*	-0.48	0.59*
$V_2R_2T_1$	0.76*	0.61 ð	-0.21	0.61*	-0.49	0.62*
$V_2R_2T_2$	0.58 ð	0.50*	-0.30	0.55*	-0.28	0.62*

*Significant at 5 per cent level of significance

Where,

T_{max}: Maximum temperature (°C)
T_{min}: Minimum temperature (°C)
RH_m: Morning relative humidity (%)
RH_e: Evening relative humidity (%)
BSSH: Bright sun shine hours (hr/day)
RF: Rainfall (mm)

V_1: PBR 91
V_2: PBR 357
T_0: Control
T_1: Defoliation at flowering stage
T_2: Defoliation at pod formation

R_1: East-West row direction
R_2: North-South row direction

temperature and rainfall had a positive correlation with intensity of alternar.ia blight. Manjhi *et al.* (2018) also observed that the rainfall had significantly association with alternaria blight intensity.

Step wise regression analysis between alternaria blight severity and different meteorological parameters

Regression analysis is a set of statistical process to estimate the relationships between a dependent variables (often called the 'outcome variable') and one or more independent variables. Disease severity which is usually depends upon the meteorological parameters. So the stepwise regression analysis between alternaria blight severity and different meteorological parameters viz. maximum and minimum temperatures, morning and evening relative humidity, bright SSH and rainfall were worked out. From the R^2 values (Table 2), it is clear that most of the meteorological parameters were the major determinants for alternaria blight severity. The R^2 value was observed in the range of 0.31 to 0.95 indicating that most of the meteorological parameters contributed significantly in the incidence and development of this disease under different treatments. The maximum and minimum temperatures, evening relative humidity, bright SSH and rainfall can be used as predictor variables for prediction of alternaria blight disease. Similar results were reported by Razdan *et al.* (2012) who found that maximum temperature, morning relative humidity and rainfall influence the disease incidence/severity. Talukdar *et al.* (2017) also concluded that decrease in evening relative humidity and bright sunshine hours during the growing period aggravated the disease incidence/ severity in late sown crops.

Area under disease progress curve (AUDPC) under different treatments

The area under the disease progress curve (AUDPC) is a valuable tool for measuring harvest losses due to pathogen attack and in epidemiological studies of polycyclic diseases, especially those regarding quantitative resistance studies (Jeger and Viljanen, 2001). Area under disease progress curve (AUDPC) of alternaria blight was computed for mustard varieties (PBR 91 and PBR 357). The maximum AUDPC (234) at 119 days after sowing was recorded in variety PBR 91 compared to variety PBR 357 (208) (Fig 4). Number of studies have been demonstrated that more compact growth and closed plant canopy was favorable for enhancing the disease severity and AUDPC (Andrea *et al.,* 2006 and Ahmed *et al.,* 2011).

Solar radiation is one of the major meteorological parameter which influences the yield as well as disease severity of the crop. Row orientation can help to intercept maximum radiation. Crop sown in E-W row direction experiences less warm and more humid weather conditions due to lower penetration of solar radiation in E-W row direction than that of N-S oriented crop (Goyal *et al.,* 2017).

The highest area under disease progress curve was recorded in E-W row direction compared to N-S row direction (Fig.5) This may be due to the reason that in E-W direction light interception was low so the relative humidity was more which was favorable for development of alternaria blight.

Leaves play a significant role in determining photosynthetic potential and have a major effect on yield (Lawlor, 2001). The removal of leaves (defoliation) is common practice in mustard for higher radiation interception. The results of this study shows that the defoliated crop showed more PAR interception than control from flowering to pod filling stage. The maximum area under disease progress curve was recorded under control treatment followed by 2nd defoliation and 1st defoliation (Fig.6). This may be due to the reason that in defoliated plots more PAR interception was recorded than the control plots which makes the unfavourable conditions for the pathogen.

Comparison of different meteorological parameters during highest and lowest disease years

Different meteorological parameters viz. maximum temperature, minimum temperature, morning and evening relative humidity, bright

Table 2. Step wise regression analysis between alternaria blight severity and different meteorological parameters

Treatments	Regression equations	R^2 value
$V_1R_1T_0$	$Y= -30.60 + 2.95\ T_{max} + 1.77\ T_{min}$	0.68*
	$Y= -40.33 + 2.89\ T_{max} - 1.92\ T_{min} + 0.10\ RH_m$	0.68*
	$Y= -1.54 + 5.16\ T_{max} - 0.79\ T_{min} - 1.48\ RH_m + 1.63\ RH_e$	0.90*
	$Y= -138.37 + 5.62\ T_{max} - 0.18\ T_{min} -1.10\ RH_m + 2.54\ RH_e + 5.26\ SSH$	0.94*
	$Y= -133.39 + 5.24\ T_{max} - 0.01\ T_{min} - 0.80\ RH_m + 2.09\ RH_e + 4.63\ SSH + 0.25\ RF$	0.94*
$V_1R_1T_1$	$Y= -30.60 + 2.95\ T_{max} - 1.77\ T_{min}$	0.68*
	$Y= -40.33 + 2.89\ T_{max} +1.92\ T_{min} + 0.10\ RH_m$	0.68*
	$Y= -1.54 + 5.16\ T_{max} - 0.79\ T_{min} - 1.48\ RH_m + 1.63\ RH_e$	0.90*
	$Y= -138.37 + 5.62\ T_{max} - 0.18\ T_{min} - 1.10\ RH_m + 2.54\ RH_e + 5.20\ SSH$	0.94*
	$Y= -133.40 + 5.72\ T_{max} - 3.31\ T_{min} - 1.81\ RH_m + 1.90\ RH_e + 4.09\ SSH - 0.27\ RF$	0.96*
$V_1R_1T_2$	$Y= -23.32 + 3.29\ T_{max} + 0.26\ T_{min}$	0.54*
	$Y= 5.31 +3.48\ T_{max} - 0.16\ T_{min} - 0.31\ RH_m$	0.60*
	$Y= 44.11 + 5.76\ T_{max} - 2.88\ T_{min} - 1.91\ RH_m + 1.63\ RH_e$	0.70*
	$Y= -132.79. + 6.35\ T_{max} - 2.10\ T_{min} - 1.41\ RH_m + 2.80\ RH_e + 6.80\ SSH$	0.78*
	$Y= -127.61 + 5.95\ T_{max} - 1.92\ T_{min} - 1.10\ RH_m + 2.34\ RH_e + 6.15\ SSH + 0.26\ RF$	0.79*
$V_2R_2T_0$	$Y= -10.42 + 2.09\ T_{max} + 0.43\ T_{min}$	0.31
	$Y= -39.71 + 1.76\ T_{max} - 1.19\ T_{min} + 0.55\ RH_m$	0.32
	$Y= -2.58 + 3.93\ T_{max} - 1.40\ T_{min} - 0.97\ RH_m + 1.56\ RH_e$	0.65*
	$Y= -75.10 + 4.18\ T_{max} - 1.08\ T_{min} - 0.77\ RH_m + 2.04\ RH_e + 2.78\ SSH$	0.67*
	$Y= -73.25 + 4.04\ T_{max} - 1.02\ T_{min} - 0.66\ RH_m + 1.88\ RH_e + 2.56\ SSH + 0.08\ RF$	0.68*
$V_2R_2\ T_1$	$Y= -4.97 + 2.41\ T_{max} + 0.94\ T_{min}$	0.35
	$Y= -52.90 + 2.09\ T_{max} - 1.66\ T_{min} + 0.52\ RH_m$	0.36
	$Y= 1.67 + 5.29\ T_{max} - 2.15\ T_{min} - 1.72\ RH_m + 2.30\ Rh_e$	0.75*
	$Y= -125.2 + 5.72\ T_{max} - 1.59\ T_{min} - 1.36\ RH_m + 3.14\ RH_e + 4.88\ SSH$	0.75*
	$Y= -127.27 + 5.87\ T_{max} - 1.66\ T_{min} - 1.48\ RH_m + 3.531\ RH_e +5.12\ SSH - 0.09\ RF$	0.76*
$V_2R_2\ T_2$	$Y= 2.01 + 3.44\ T_{max} - 1.40\ T_{min}$	0.27
	$Y= 46.02+ 3.74\ T_{max} - 2.06\ T_{min} - 0.48\ RH_m$	0.28
	$Y= 81.23 + 5.80\ T_{max} - 4.52\ T_{min} - 1.93\ RH_m + 1.48\ Rh_e$	0.66*
	$Y= -134.95 + 6.53\ T_{max} - 3.57\ T_{min} - 1.33\ RH_m + 2.91\ RH_e + 8.31\ SSH$	0.77*
	$Y= -131.72 + 6.28\ T_{max} - 3.46\ T_{min} - 1.13\ RH_m + 2.62\ RH_e + 7.90\ SSH + 0.16\ RF$	0.77*

* Significant at 5% level

T_{max}: Maximum temperature (°C)
T_{min}: Minimum temperature (°C)
RH_m: Morning relative humidity (%)
RH_e: Evening relative humidity (%)
BSSH: Bright sun shine hours (hr/day)
RF: Rainfall (mm)

V_1: PBR 91,
V_2: PBR 357,
T_0: Control
T_1: Defoliation at flowering stage
T_2: Defoliation at pod formation

R_1: East-West row direction
R_2: North-South row direction

SSH and total rainfall during disease development period (4 SMW to 11 SMW) from 2017 to 2019 were compared. The lowest and highest disease years were 2018 and 2019.The maximum temperature remained below normal except 7th, 8th and 9th standard meteorological weeks during the highest disease year. There was a rapid infestation of alternaria blight in between 6th to 11th standard meteorological weeks (SMW) when the average maximum temperature was 18.9°C. (Fig.7). The minimum temperature was below normal temperature during 5th to 7th SMW and above normal during 8th and 9th SMW in highest disease year (Fig.7). The average minimum temperature during alternaria blight development period ranged between 5.7 to 11.8°C during 6th to 11th standard meteorological week (SMW). This range of minimum temperature proved most

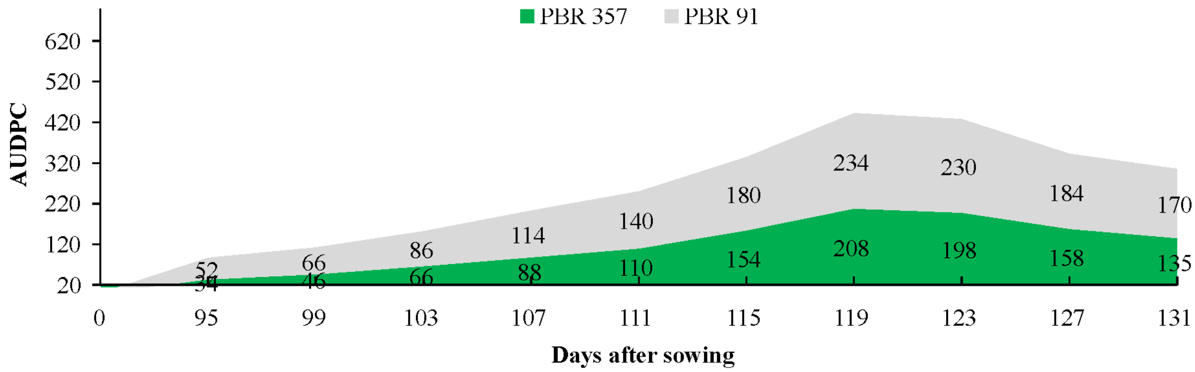

Fig. 4. Area under disease progress curve of alternaria blight in *Brassica juncea* varieties during *rabi* 2019-20

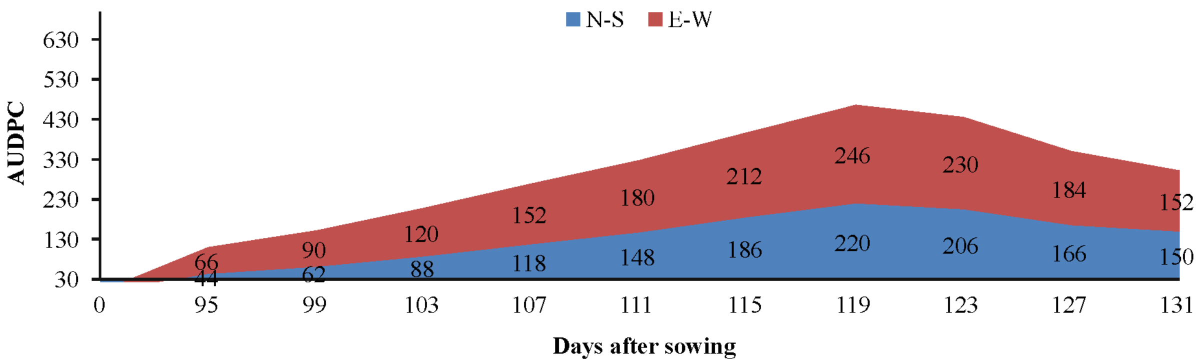

Fig. 5. Area under disease progress curve of alternaria blight under row direction during *rabi* 2019-20

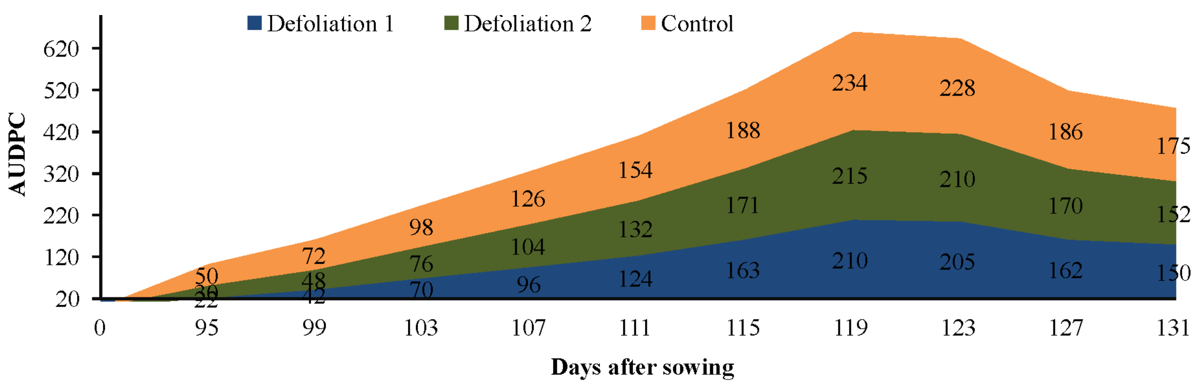

Fig. 6. Area under disease progress curve of alternaria blight under defoliation treatments during *rabi* 2019-20

suitable for alternaria blight incidence and severity. Shrestha *et al*. (2005) reported that the minimum temperature range between 10-14°C was favourable for increased the disease severity. The morning relative humidity was above normal during the 5th, 6th and 9th standard meteorological week and below normal during 4th, 8th, 10th and 11th SMW (Fig.8). Banerjee *et al.* (2010) also reported that with increase in morning relative humidity the intensity of alternaria blight was increased. The evening relative humidity remained above normal during the entire crop period except 7th SMW. Which favoured growth and activity of alternaria blight development and spread.(Fig.8). The bright SSH were below the normal except 7th SMW. The below normal sun shine hours may be responsible for development of alternaria blight (Fig.9). Similar results were

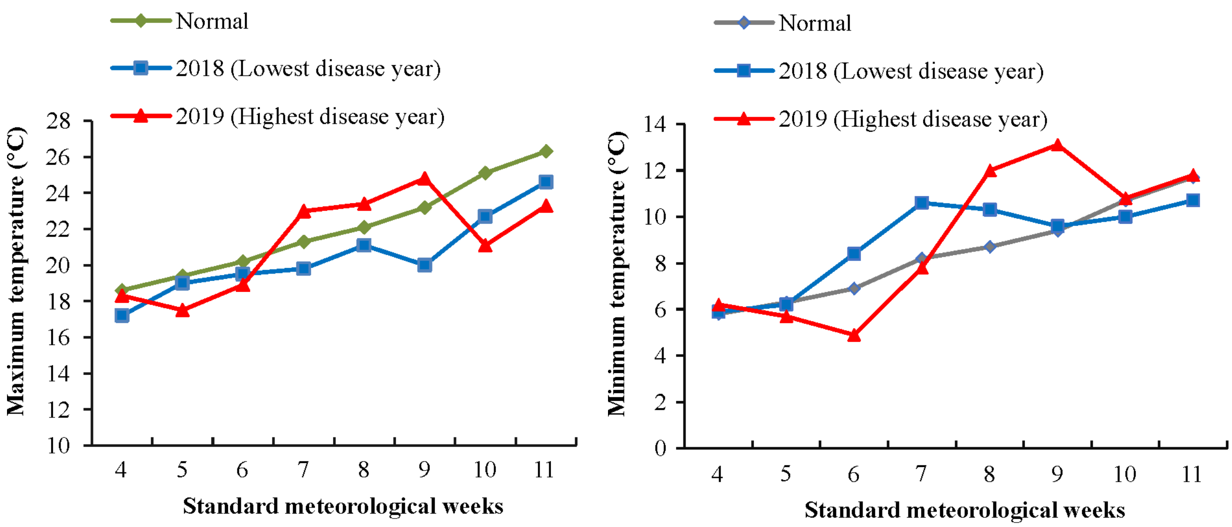

Fig. 7. Comparison of maximum and minimum temperatures during highest and lowest disease years

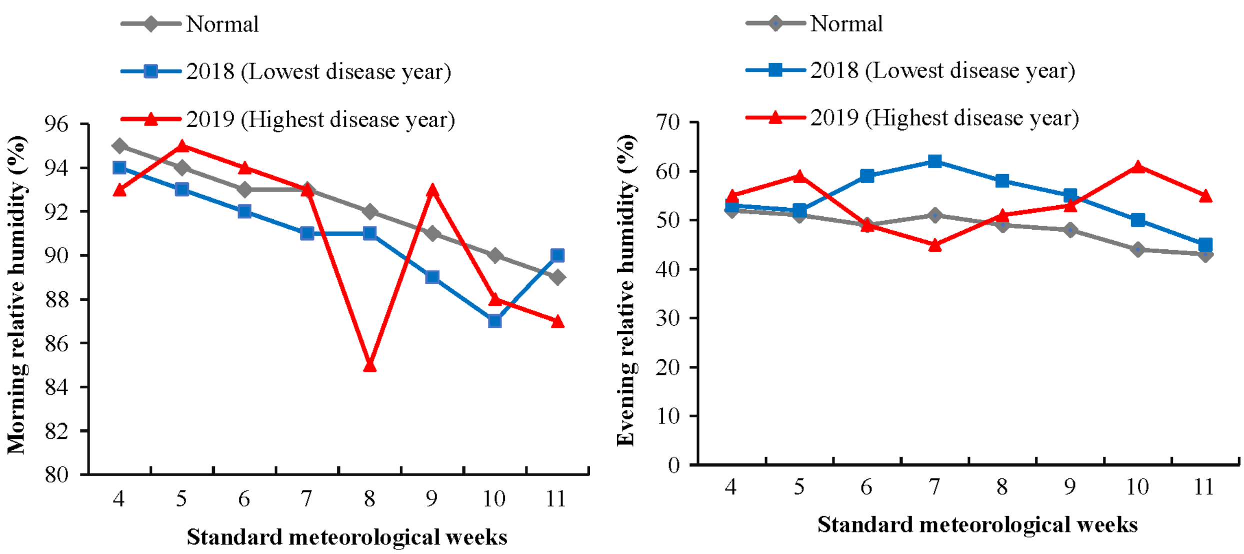

Fig. 8. Comparison of morning and evening relative humidity during highest and lowest disease years

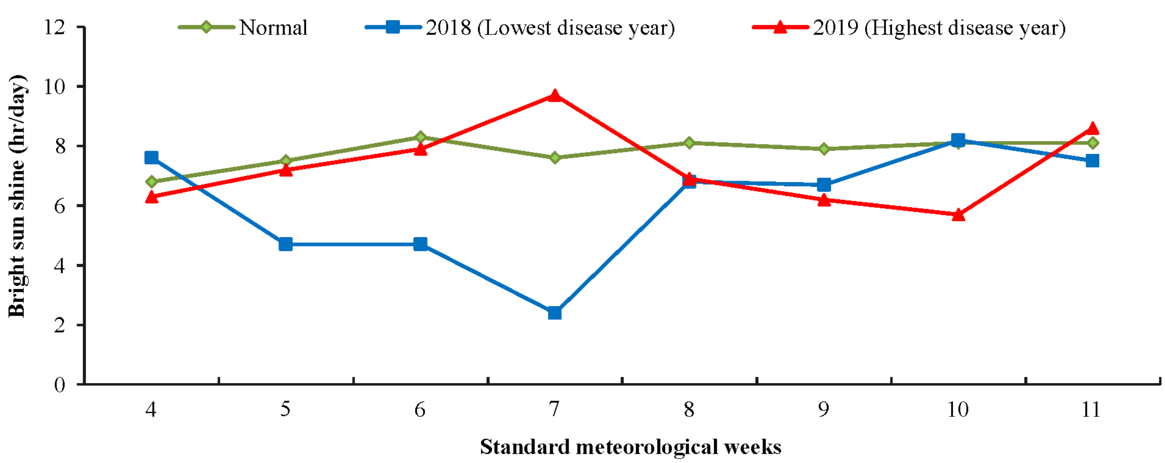

Fig. 9. Comparison of bright sun shine hours during highest and lowest disease years

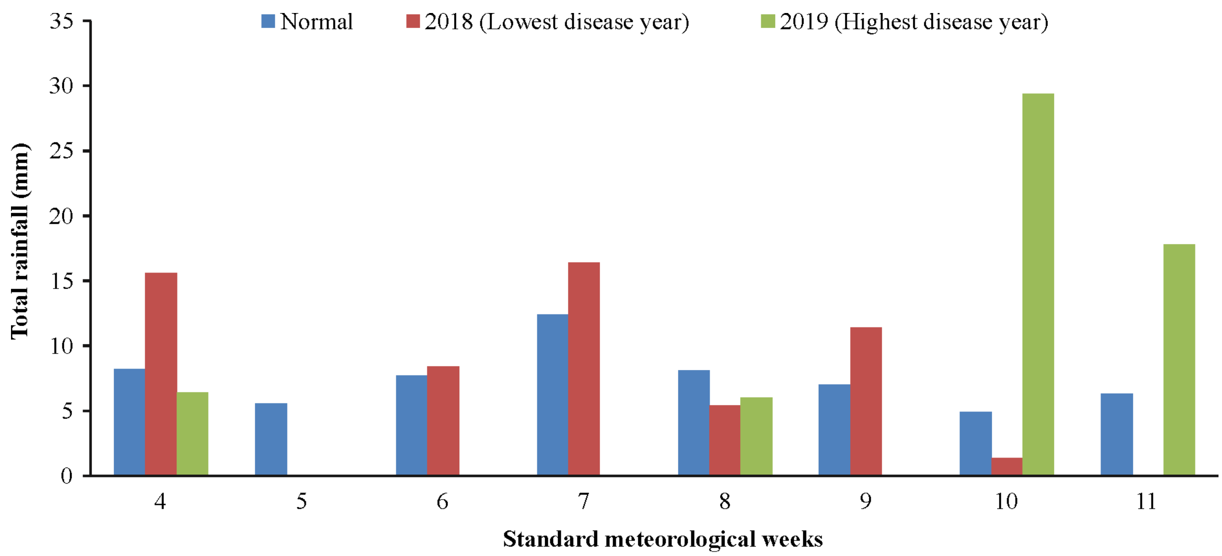

Fig. 10. Comparison of total rainfall during highest and lowest disease years

also reported by Sandhu *et al.* (2017). The total rainfall recorded during the crop season was comparatively higher than normal except during 8th SMW (Fig.10). During the period of disease spread i.e. from 5th to 11th standard meteorological week, 29.4 mm of rainfall was recorded which increased the severity of alternaria blight.

Conclusion

Low temperature and higher humidity in E-W row direction was more conducive for alternaria blight severity. The N-S direction may be beneficial in reduction of disease incidence in mustard crop. Early defoliation (Flowering stage) proved effective than late defoliation (Pod formation). Regression equations developed between meteorological parameters with disease severity may be useful in weather based disease models/ decision support systems.

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