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**Research Article**

# Microclimatic Modifications Through Row Direction and Row Spacing for Alternaria Blight and White Rust Diseases of *Raya*

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## ABSTRACT

Field experiment was conducted on *Brassica juncea* during *rabi* season of 2020-21 at the Research Farm, Department of Climate Change and Agricultural Meteorology, PAU, Ludhiana. Two *raya* varieties (PBR 91 and PBR 357) were sown on 3rd November in two row directions i.e. North-South (N-S) and East-West (E-W) under six spacing (30cm×10cm, 30cm ×20cm, 30cm×30cm, 45cm×10cm, 45cm×20cm and 45cm×30cm). The meteorological data for crop season were collected from Agromet Observatory located near the experimental field. Very little work has been reported on these microclimate modifications to reduce the disease losses under Punjab conditions. Main objective was to study the effect of microclimate modification on alternaria blight and white rust severity with simple microclimate modifications. Alternaria blight severity was higher (32%) in E-W row direction compared to N-S row direction (30%). Disease-severity was minimum (15%) in wider spacing (45cm×30cm) and-maximum (30%) in closer-spacing (30cm×10cm). Similarly white rust severity was higher (25%) in East-West row direction and lower (20%) in North-South row direction. Lower disease severity (25%) was observed in wider spacing (45cm×30cm), while higher (18%) in closer-spacing (30cm×10cm). For alternaria blight, area under disease progress curve (AUDPC) was higher in E-W row direction (126) compared to N-S row direction (118). Area under disease progress curve (AUDPC) for alternaria blight was higher (32) in 30cm×10cm spacing and lower (23) in 45cm×30cm spacing. Similarly, for white rust higher AUDPC was recorded in E-W row direction (92) compared to N-S row direction (78). Among row spacing, higher AUDPC (21) was'recorded in 30cm×10cm, while'lower (11) was recorded in 45cm×30cm. Maximum and minimum temperatures showed a significant positive correlation with alternaria blight and white rust severity and morning relative humidity, evening relative humidity were negatively correlated with disease severity. Regression equations developed between different meteorological parameters and disease severity (Alternaria blight and white rust) may be useful in weather-based disease models which helps farmers for reducing yield losses by adapting these simple microclimate modifications. These microclimate modifications (Change in row direction and change in spacing) can play an important role in reducing the disease losses without any extra input cost.

**Key words**: Row direction, Row spacing, Microclimate modification, Alternaria blight and white rust

## Introduction

Rapeseed-mustard crops are the major *rabi* season oilseed crops of India. Rapeseed-mustard is a group comprising of large number of species and subspecies cultivated in India. Increase in maximum temperature from normal (above 25°C temperature) in *brassica,* caused flower abortion and reduction in seed yield (Rao *et al*., 1992). Different biotic stresses like insect, diseases and weeds effect growth and

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production of mustard crop, which decrease the productivity as well as quality of mustard crop (Jain *et al.,* 2019). Alternaria blight mainly occurs when optimum temperature is between 15-25°C and relative humidity is more than 75 per cent (Sinha *et al.,* 1992). Another important disease oftrapeseed-mustard is white rust, which attacks at the early stages of the crop. The causal organism is *Albugo candida* and the incidence of this disease occurr when temperature is between 13-22°C and relative humidity is more than 60 per cent (Lakra and Saharan, 1991).

Microclimate modifications like change in row spacing and row direction may affect the disease development in *raya* crop. The improper row spacing decreased seed yield of mustard by synchronization of silique filling period with increase in temperature, decrease in homogenize production, drought stress occurrence, shortened siliquae period and stimulation of plant maturity (Mendham and Salisbury, 1995). Higher plant height, oil content and oil yield was recorded in 60cm×15cm spacing followed by 45cm×30cm spacing (Singh, 2016). Both alternaria-blight and white rust disease incidence were very low in wider spacing (60cm×30cm) as compared to closer spacing (45cm×15cm) (Gupta *et al.,* 2003). More PAR interception was recorded in N-S row direction as compared to E-W row direction. The seed yield was significantly increased by 5 per cent in crop sown in N-S row direction than that of crop sown in E-W row direction. The growing environment of N-S row direction-becomes unsuitable for the alternaria blight and"white rust occurrence (Jha *et al.,* 2012). The low infestation of pest and disease in the N-S oriented crop was reported by Goyal *et al.* (2017). These microclimate modifications (change in row direction and change in spacing) can play an important role in reducing the losses due to these diseases. Farmers can manage these practices without any extra input cost. Very little work has been reported on these microclimate modifications to reduce the disease incidence under Punjab conditions. Keeping all this in view, the experiment was conducted to study the effect of row direction and row spacing on alternaria blight and white rust severity in two *Brassica juncea* varieties.

## Material and Methods

### *Field experiment*

The field experiment was conducted with two *Brassica juncea* varieties (PBR 91 and PBR 357) sown on 3rd November in two row directions (N-S and E-W) under six spacing (30cm×10cm, 30cm ×20cm, 30cm×30cm, 45cm×10cm, 45cm×20cm and 45cm×30cm) during *rabi* season 2020-21. The experiment was laid out in factorial split plot design with three replications. Crop was raised as per recommendations of Punjab Agricultural University package of practices.

### *Meteorological data*

Meteorology data of Ludhiana were collected from Agrometeorological Observatory, Department of Climate Change and Agricultural/Meteorology, Punjab Agricultural University, Ludhiana. It is situated at 30º-54' N latitude and 75º-48' E longitude and at'altitude of 247 m above mean sea level.

### *Disease severity (%)*

Under natural conditions, disease severity of alternaria blight and white rust data were recorded at weekly intervals under field conditions.

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

$$\text{Disease severity} = \frac{\text{Sum of all disease rating}}{\text{Total no. of rating} \times \text{maximum disease grade}} \times 100$$

### *Area under disease progress curve (AUDPC)*

Area under disease/progress curve, summarize the increase or decrease the area under disease over time for different treatments. The area under the disease progress curve is frequently used to combine multiple observations of disease progress into a single value. A formula/given by Wilcoxson *et al.*(1975) for[calculating AUDPC is:

$$\text{AUDPC} = \sum_{i=1}^{n=1} \left( \frac{\text{Xi} + \text{Xi} + 1}{2} \right) \times (\text{ti} + 1 - \text{ti})$$

where,

X*i* = Alternaria blight and white rust severity on date *i*

ti =time in days between *i* and date *i* + 1

n = number of dates on which disease was recorded

### *Statistical analysis*

Correlation and regression analysis was conducted between alternaria blight and white rust severity with different meteorological parameters viz. temperature, relative humidity, sunshine hours and rainfall.

## Result and Discussion

### *Alternaria blight*

Alternaria blight is caused by fungus *Alternaria brassicae*, which mainly affects the crop production leading to a yield loss upto 70 per cent. The disease attacks on the lower leaves as small circular brown necrotic spots, which slowly increase in size. Moist conditions (more than 70 per cent relative humidity) coupled with warm weather (12-25°C), intermittent rains and wind velocity around 2-5 km/hour favours disease development (Chahal and Kang, 1979).

Incidence of alternaria blight was first observed during $6^{th}$ Standard meteorological week (SMW). Maximum and minimum temperatures ranged between 18 to 25°C and 10 to 14°C and relative humidity above 80 per cent provided favourable conditions for disease occurrence. Higher disease severity was observed in variety PBR 91, due to more susceptibility to the disease as compared to variety PBR 357 (Fig. 1).

Disease severity was more in E-W row direction as compared to N-S row direction (Fig. 2) because the micro-environment of N-S row direction become unfavourable for the disease due to more PAR[interception in N-S row direction as compared to E-W row direction. Temperature and relative humidity in E-W row direction was different from the N-S row direction. Due to higher humidity and lower PAR interception disease occurrence was more in E-W row direction as reported by Goyal *et al*. (2015). Dharmpal (2020) reported that E-W row direction showed more disease severity as compared to N-S row direction, because in the E-W row direction, due to less penetration of light and higher relative humidity provided favourable conditions for the disease. Higher penetration of light in N-S row direction increased the temperature and reduced relative humidity, hence the microclimatic conditions in N-S row direction was not favourable for alternaria blight.

Disease severity was lowest in wider spacing (45cm×30cm) and highest in closer spacing (30cm×10cm) (Fig.3). This may be due to more PAR

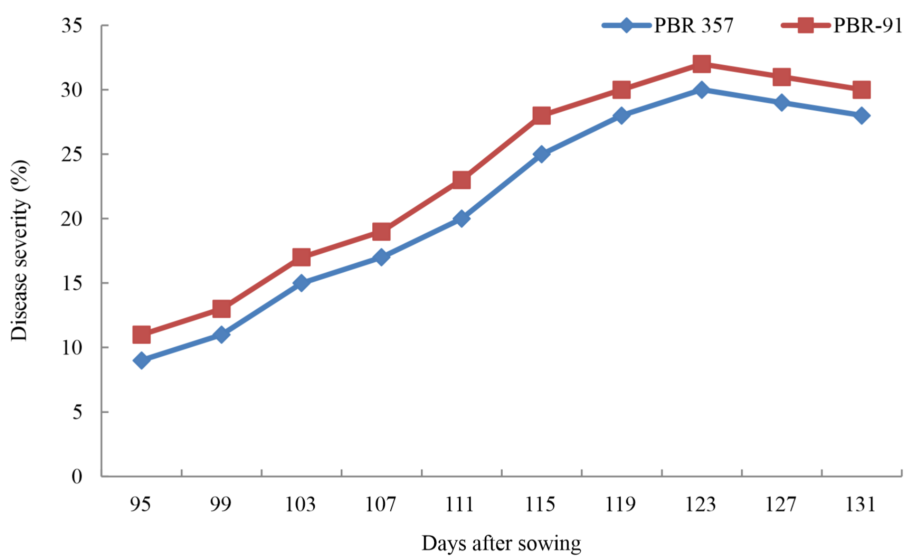


**Fig. 1.** Alternaria blight severity in variety PBR 91 and PBR 357 during *rabi* 2020-21

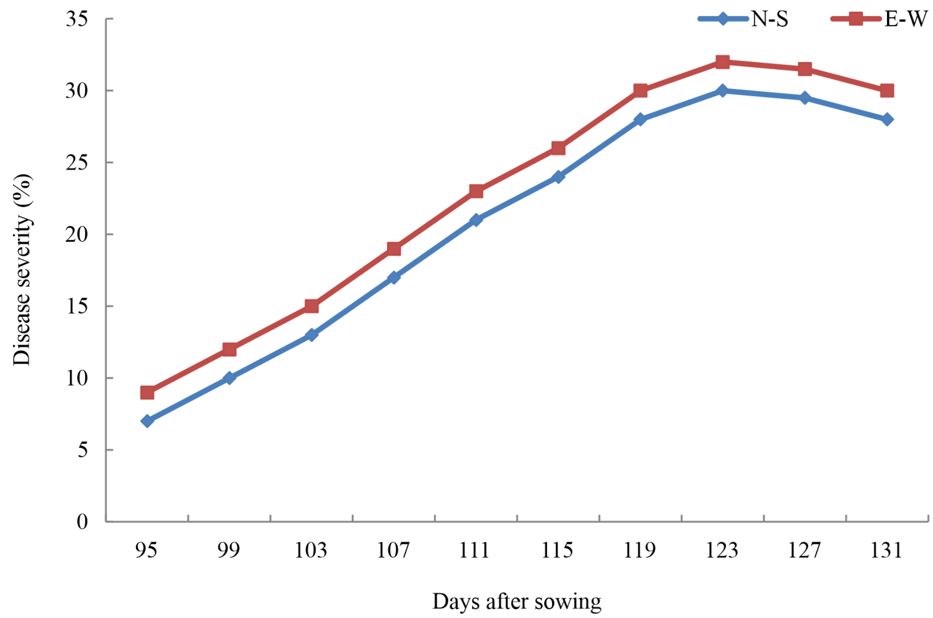


**Fig. 2.** Effect of row direction (N-S and E-W) on alternaria blight severity during *rabi* 2020-21

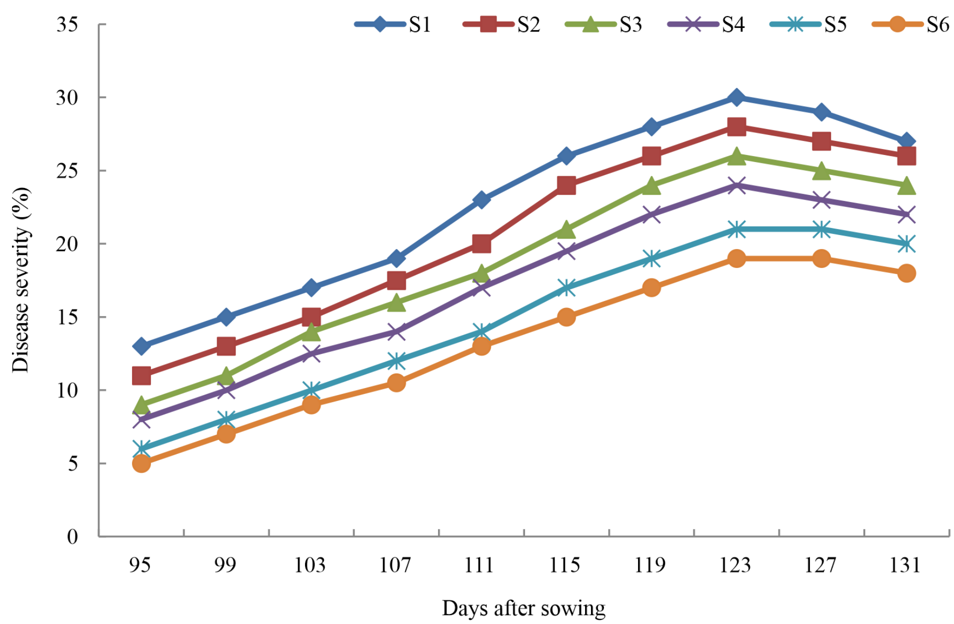


**Fig. 3.** Effect of different spacing on alternaria blight severity during *rabi* 2020-21

interception and low humidity was.unfavourable for disease development and further spread. Beg *et al.* (2007) also found that narrow spacing (20cm) coupled with low plant spacing was more/susceptible to disease incidence as compared to wider spacing (30cm). Manmohan and Mehta (2016) investigated that maximum growth of pustules, spots and speck size (mm) of white rust, alternaria blight and powdery mildew occurred in narrow spacing (30cm×15cm). As maximum temperature and relative humidity contributes maximum in disease progression of white rust, alternaria blight and powdery mildew.

### *White rust*

White rust of mustard is one of the important disease caused by *Albugo candida*. White rust produce small white pustules on the undersides of affected leaves. The pustules may enlarge and grow together to form large, irregular shaped lesions filled with the white spores. Most favourable temperature for occurrence of this disease is 13-22°C and relative humidity more than 60 per cent. The optimum time of disease occurrence is November and February-March. Yield losses due to white rust has been recorded between 23 to 54.5 per cent in India (Saharan *et al.,* 1984).

White rust disease incidence was first observed during 5th SMW and its peak was observed during 11th SMW, when average temperature ranged between 10 to 18°C and average relative humidity more than 65 per cent which were provided most suitable conditions for white rust infestation and spread. White rust increased at a faster rate when mean temperature was 11.5°C to 12.5°C, mean relative humidity was more than 75 per cent. Cloudy weather with precipitation and wind velocity at the rate of 2.6 km/hr also provide favourable conditions (Saharan *et al.,* 1988). The results of experiment indicate that white rust infestation was more in variety PBR 91 as compared to variety PBR 357 (Fig.4). This may be due to the resistance of variety PBR 357 to white rust. Crop sown in N-S row direction was less infected by disease while E-W row direction had more infestation of this disease. Kumar and Chakravarty (2008) found that low disease infestation occurs in N-S row direction, because of high temperature and low humidity as compared to E-W row direction. Temperature and relative humidity in E-W row direction was different from the N-S row direction. Hence due to higher humidity and lower PAR interception, disease occurrence was more in E-W row direction (Goyal *et al*., 2015). Among different row spacing, disease severity was lower in wider spacing (45cm×30cm). This may be due to that in wider spacing due to more PAR interception and low humidity, micro-environment become unfavourable for disease development. Wider row spacing (45cm×15cm) has low relative humidity and higher solar radiation penetration. So under these conditions the diseases like white rust may be reduced (Kumar and Chakravarty, 2008).

### *Correlation coefficients between alternaria blight severity and different meteorological parameters*

Correlation coefficient is the specific measure that quantifies the strength of linear relationship between two variables. The value ranges between -1.0 and 1.0. Correlation coefficients between disease severity and different meteorological parameters

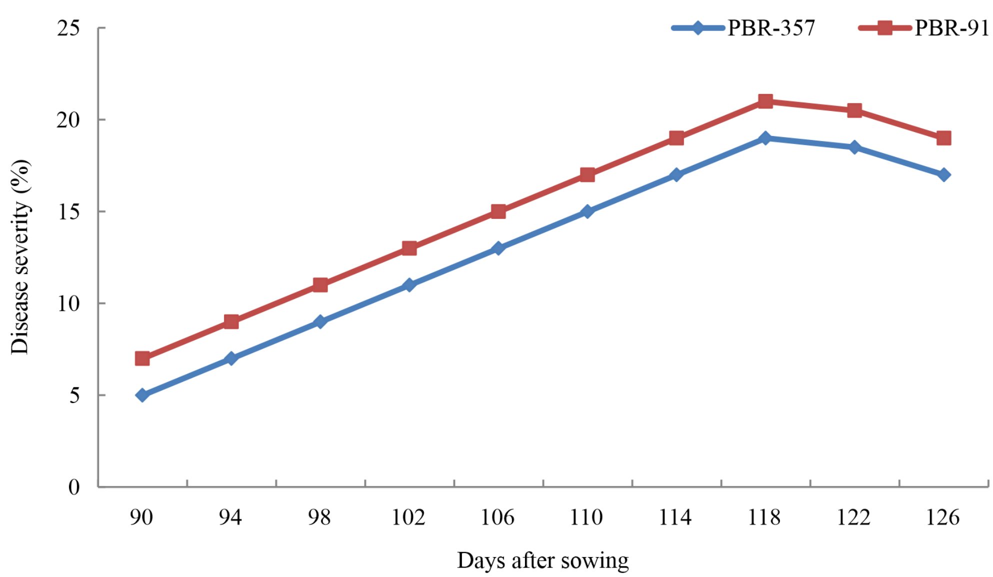


**Fig. 4.** White rust severity in variety PBR 91 and PBR 357 during *rabi* 2020-21

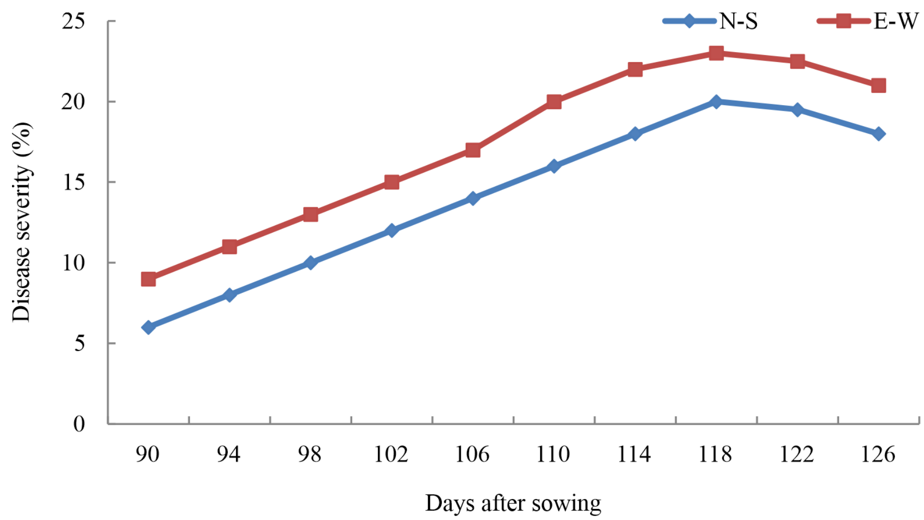


**Fig. 5.** Effect of row direction (N-S and E-W) on white rust severity during *rabi* 2020-21

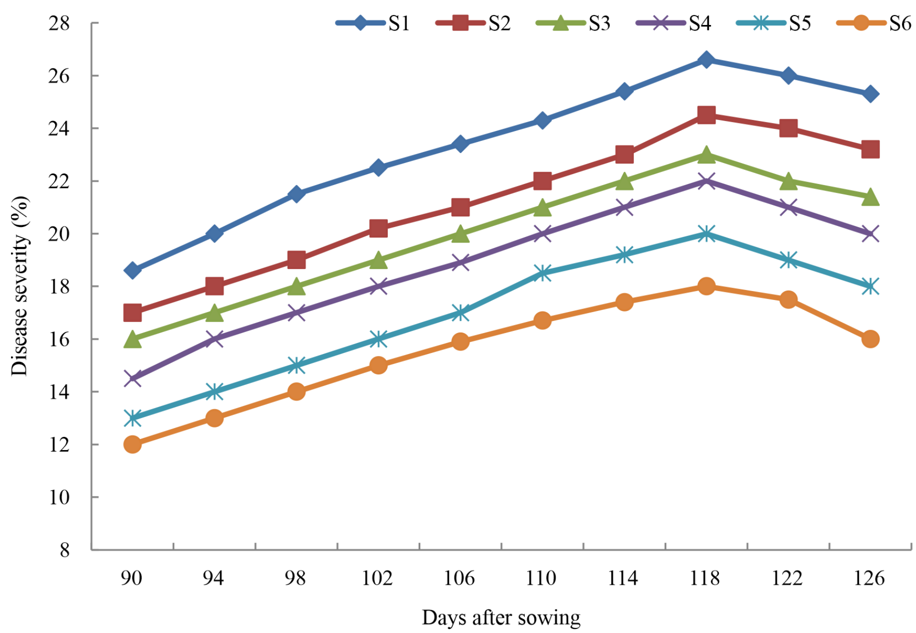


**Fig. 6.** Effect of different spacing on white rust severity during *rabi* 2020-21

(maximum and minimum temperatures, morning and evening relative .humidity, sunshine hours and total rainfall) were calculated and presented in Table 1. The results indicate that both maximum as well as minimum temperatures showed a positive and significant correlation with alternaria blight severity. Similar results were also observed by Mahapatra *et al.* (2015). They reported that maximum and minimum/temperatures were positively correlated with alternaria blight disease. While morning as well as evening relative humidity showed. negative and non-significant correlation with alternaria blight severity. Both sunshine hours and rainfall showed positive correlation,with the disease severity. Manjhi *et al.* (2018) reported that rainfall showed a positive correlation with disease severity. Jha *et al.* (2013) observed the effect of meteorological parameters on the development of *Alternaria blight* of mustard. They conducted correlation coefficient analysis between different meteorological parameters and

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

| Treatments | $T_{max}$ (°C) | $T_{min}$ (°C) | $RH_m$ (%) | $RH_e$ (%) | SSH (hr/day) | RF (mm) |
|---|---|---|---|---|---|---|
| $RD_1V_1S_1$ | 0.69* | 0.58* | -0.06 | -0.13 | 0.43 | 0.23 |
| $RD_1V_1S_2$ | 0.72* | 0.60* | -0.10 | -0.18 | 0.38 | 025 |
| $RD_1V_1S_3$ | 0.65* | 0.56* | -0.01 | -0.06 | 0.39 | 0.27 |
| $RD_1V_1S_4$ | 0.88* | 0.72* | -0.48 | 0.49 | 0.54* | 0.31 |
| $RD_1V_1S_5$ | 0.77* | 0.75* | -0.50* | -0.22 | 0.29 | 0.33 |
| $RD_1V_1S_6$ | 0.35 | 0.27 | -0.26 | -0.20 | 0.48 | 0.20 |
| $RD_1V_2S_1$ | 0.69* | 0.57* | -0.06 | -0.18 | 0.37 | 0.18 |
| $RD_1V_2S_2$ | 0.67* | 0.53* | -0.04 | -0.24 | 0.38 | 0.21 |
| $RD_1V_2S_3$ | 0.66* | 0.52* | -0.01 | -0.23 | 0.37 | 0.56* |
| $RD_1V_2S_4$ | 0.65* | 0.48 | -0.0.1 | -0.25 | 0.46 | 0.24 |
| $RD_1V_2S_5$ | 0.69* | 0.56* | -0.05 | -0.27 | 0.39 | 0.28 |
| $RD_1V_2S_6$ | 0.70* | 0.58* | -0.06 | -0.22 | 0.38 | 0.29 |
| $RD_2V_1S_1$ | 0.63* | 0.50* | -0.04 | -0.13 | 0.42 | 0.25 |
| $RD_2V_1S_2$ | 0.68* | 0.52* | -0.05 | -0.23 | 0.47 | 0.30 |
| $RD_2V_1S_3$ | 0.72* | 0.60* | -0.11 | -0.18 | 0.45 | 0.28 |
| $RD_2V_1S_4$ | 0.66* | 0.52* | -0.03 | -0.23 | 0.51* | 0.27 |
| $RD_2V_1S_5$ | 0.64* | 0.46 | -0.04 | -0.20 | 0.59* | 0.26 |
| $RD_2V_1S_6$ | 0.63* | 0.48 | -0.04 | -0.21 | 0.54* | 0.22 |
| $RD_2V_2S_1$ | 0.69* | 0.60* | -0.06 | -0.12 | 0.38 | 0.24 |
| $RD_2V_2S_2$ | 0.70* | 0.58* | -0.09 | -0.19 | 0.42 | 0.26 |
| $RD_2V_2S_3$ | 0.72* | 0.60* | -0.11 | -0.18 | 0.45 | 0.22 |
| $RD_2V_2S_4$ | 063* | 0.53* | -0.02 | -0.10 | 0.40 | 0.34 |
| $RD_2V_2S_5$ | 0.72* | 0.61* | -0.09 | -0.18 | 0.39 | 0.35 |
| $RD_2V_2S_6$ | 0.71* | 0.58* | -0.08 | -0.24 | 0.43 | 0.33 |

* Significant at 5 per cent level of significance

Where,

$T_{max}$: Maximum temp. (°C)
$T_{min}$: Minimum temp. (°C)
$RH_m$: Morning relative humidity (%)
$RH_e$: Evening relative humidity (%)
RF: Total Rainfall (mm)
SSH: Sun shine hours (hr/day)

$V_1$: PBR 91
$V_2$: PBR 357,
$RD_1$: North-South
$RD_2$: East-West

$S_1$: Spacing (30cm×10cm)
$S_2$: Spacing (30cm×20cm)
$S_3$: Spacing (30cm×30cm)
$S_4$: Spacing (45cm×10cm)
$S_5$: Spacing (45cm×20cm)
$S_6$: Spacing (45cm×30cm)

disease progression. They recorded that maximum temperature, minimum temperature, morning and evening relative humidity were positively correlated with disease index.

### *Correlation coefficients between white rust severity and different meteorological parameters*

Meteorological parameters (maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, sunshine hours and rainfall) play a key role in disease development and spread. Correlation coefficients between disease severity and different meteorological parameters (maximum and minimum temperatures, morning and evening relative humidity, sunshine hours and total rainfall) were computed and presented in Table 2. Positive and significant correlation of white rust severity with maximum and minimum temperatures were observed. Similar results were also reported by Sangeetha and Siddaramaiah (2007). They concluded

**Table 2.** Correlation analysis between white rust severity and different meteorological parameters

| Treatments | $T_{max}$ (°C) | $T_{min}$ (°C) | $RH_m$ (%) | $RH_e$ (%) | SSH (hr/day) | RF (mm) |
|---|---|---|---|---|---|---|
| $RD_1V_1S_1$ | 0.91* | 0.74* | -0.56* | -0.57* | 0.53* | 0.35 |
| $RD_1V_1S_2$ | 0.97* | 0.86* | -0.74* | -0.58* | 0.36 | 0.38 |
| $RD_1V_1S_3$ | 0.94* | 0.82* | -0.64* | -0.50* | 0.42 | 0.30 |
| $RD_1V_1S_4$ | 0.96* | 0.91* | -0.76* | -0.48 | 0.24 | 0.34 |
| $RD_1V_1S_5$ | 0.86* | 0.73* | -0.45 | -0.41 | 0.51* | 0.28 |
| $RD_1V_1S_6$ | 0.80* | 0.71* | -0.31 | -0.27 | 0.46 | 0.29 |
| $RD_1V_2S_1$ | 0.97* | 0.88* | -0.76* | -0.51* | 0.35 | 0.32 |
| $RD_1V_2S_2$ | 0.96* | 0.85* | -0.73* | -0.53* | 0.37 | 0.33 |
| $RD_1V_2S_3$ | 0.82* | 0.69* | -0.37 | -0.32 | 0.53* | 0.30 |
| $RD_1V_2S_4$ | 0.84* | 0.71* | -0.50* | -0.42 | 0.51* | 0.28 |
| $RD_1V_2S_5$ | 0.78* | 0.62* | -0.37 | -0.35 | 0.62* | 0.26 |
| $RD_1V_2S_6$ | 0.92* | 0.80* | -0.62* | -0.48 | 0.48 | 0.27 |
| $RD_2V_1S_1$ | 0.64* | 0.48 | -0.13 | -0.21 | 0.64* | 0.25 |
| $RD_2V_1S_2$ | 0.94* | 0.87* | -0.78* | -0.51* | 0.26 | 0.36 |
| $RD_2V_1S_3$ | 0.96* | 0.83* | -0.59* | -0.51* | 0.40 | 0.32 |
| $RD_2V_1S_4$ | 0.97* | 0.87* | -0.70* | -0.49 | 0.35 | 0.28 |
| $RD_2V_1S_5$ | 0.94* | 0.83* | -0.72* | -0.54* | 0.39 | 0.24 |
| $RD_2V_1S_6$ | 0.78* | 0.60* | -0.40 | -0.48 | 0.61* | 0.31 |
| $RD_2V_2S_1$ | 0.62* | 0.39 | -0.19 | -0.42 | 0.74* | 0.26 |
| $RD_2V_2S_2$ | 0.52* | 0.36 | -0.11 | -0.06 | 0.26 | 0.20 |
| $RD_2V_2S_3$ | 0.97* | 0.88* | -0.75* | -0.53* | 0.34 | 0.38 |
| $RD_2V_2S_4$ | 0.92* | 0.84* | -0.65* | -0.52* | 0.37 | 0.34 |
| $RD_2V_2S_5$ | 0.95* | 0.83* | -0.75* | -0.58* | 0.41 | 0.33 |
| $RD_2V_2S_6$ | 0.90* | 0.74* | -0.50* | -0.49 | -0.53* | 0.30 |

*Significant at 5 per cent level of significance

that both maximum and minimum temperatures were positively correlated with alternaria blight severity. While morning as well as evening relative humidity showed a negative correlation with white rust severity. The sunshine hours and rainfall were positively correlated with white rust severity. Singh and Kumar (2007) reported that temperature (maximum and minimum) had a positive correlation with disease intensity of white rust. Dharmpal (2020) found that temperatures (maximum and minimum) and rainfall had a significant positive correlation with disease severity. Maximum relative humidity and sun shine hours had a negative correlation with disease severity.

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

The stepwise regression analysis between alternaria blight severity and different meteorological parameters *viz*. maximum and minimum temperatures, morning and evening relative humidity, sunshine hours and rainfall were calculated and presented in Table 3. From the $R^2$ values, 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 0.39 to 0.98, indicating that most of the meteorological parameters contributed significantly in the development of disease under different treatments. From the regression equations, it can be concluded that maximum.and minimum temperatures, morning and evening relative humidity, sun shine hours and rainfall can be used as predictor variables in alternaria blight disease. Similar results were also reported by Razdan *et al.* (2012). They found that maximum temperature, morning relative humidity and rainfall influence the disease incidence. Talukdar *et al.* (2017) carried out regression analysis and concluded that

**Table 3.** Step wise regression analysis between alternaria blight severity and different meteorological parameters

| Treatments | Regression equation | $R^2$ value |
|---|---|---|
| $RD_1V_1S$ | $Y= -16.4+1.47\ T_{max}-0.36T_{min}$ | 0.49 |
| | $Y= -122.4+2.12T_{max}-+0.34T_{min}+0.89RH_m$ | 0.90* |
| | $Y= -127.7+3.43T_{max}-1.18T_{min}+0.66RH_m-0.21RH_e$ | 0.94* |
| | $Y= -128.3-3.55T_{max}-1.31T_{min}+0.65RH_m+0.22RH_e-0.05SSH$ | 0.94* |
| | $Y=.-128.7-3.55T_{max}-1.31T_{min}+0.65RH_m+0.22RH_e-0.06SSH+$ lllllll0.07RF | 0.94* |
| $RD_1V_2S$ | $Y= -18.1+1.62\ T_{max}-0.70T_{min}$ | 0.51* |
| | $Y= -106.3+2.17T_{max}-0.11T_{min}+0.74RH_m$ | 0.85* |
| | $Y= -114.4+3.57T_{max}-2.21T_{min}+0.42RH_m+0.29RH_e$ | 0.95* |
| | $Y= -115.7+4.23T_{max}-2.51T_{min}+0.41RH_m+0.31RH_e+0.16SSH$ | 0.95* |
| | $Y= -113.9+4.23T_{max}-2.50T_{min}+0.38RH_m+0.30RH_e-0.11SSH-0.37RF$ | 0.95* |
| $RD_2V_1S$ | $Y= -22.8+2.19\ T_{max}-1.22T_{min}$ | 0.51* |
| | $Y= -131.9+2.86T_{max}-0.48T_{min}-0.92RH_m$ | 0.89* |
| | $Y= -137.4+4.04T_{max}-1.87T_{min}-0.71RH_m+0.19RH_e$ | 0.92* |
| | $Y= -121.7+1.70T_{max}+0.73T_{min}+0.87RH_m+0.02RH_e+1.21SSH$ | 0.93* |
| | $Y=.-123.2+1.78T_{max}+0.73T_{min}+0.89RH_m+0.01RH_e+1.20SSH+$ ppp0.32RF | 0.93* |
| $RD_2V_2S$ | $Y= -26.3+1.99T_{max}-0.68T_{min}$ | 0.51* |
| | $Y= -152.1.0+2.76T_{max}+0.15T_{min}+1.06RH_m$ | 0.90* |
| | $Y= -158.8+4.25T_{max}-1.57T_{min}-0.80RH_m+0.24RH_e$ | 0.94* |
| | $Y= -136.9+0.94T_{max}+2.10T_{min}+1.02RH_m+0.03RH_e+1.71SSH$ | 0.96* |
| | $Y=.-137.5+0.92T_{max}+2.02T_{min}+1.03RH_m+0.01RH_e+1.71SSH+$ ppp0.12RF | 0.96* |

* Significant at 5 per cent level of significance

decrease in evening relative humidity and bright sunshine hours during the growing period aggravated the disease incidence/ severity in late sown crops. Dharmpal (2020) reported that $R^2$ value in the range of 0.31 to 0.95 indicates that the meteorological parameters (maximum and minimum temperatures, morning and evening relative humidity, sunshine hours and rainfall) contributed significantly in the development of disease severity under different treatments.

### *Step wise regression analysis between white rust severity and different meteorological parameters*

The stepwise regression analysis between white rust severity and different meteorological parameters *viz*. maximum and minimum temperatures, morning and evening relative humidity, sunshine hours and rainfall were computed and presented in Table 4. All these weather parameters play an important role in white rust incidence and spread. From the $R^2$ values, it is clear that most of the meteorological parameters had the major determinants in prediction of white rust severity. The $R^2$ value observed in the range of 0.36 to 0.98 indicating, that most of the meteorological parameters contributed significantly in the development of disease under different treatments. From the regression equations, it can be concluded that maximum temperature, minimum temperature and rainfall can be used as disease predictor variables for white rust. Mahapatra *et al.* (2015) reported that maximum temperature, relative humidity and rainfall were best indicators of disease incidence. $R^2$ value in the range of 0.45 to 0.96 indicating that the meteorological parameters play important role in the development of disease severity under different treatments (Dharmpal, 2020).

### *Area under disease progress curve (AUDPC) of alternaria blight severity*

The area under disease progress curve is a useful quantitative summary of disease intensity over time, for comparison across the years for location or management tracts. For measuring harvest losses due

**Table 4.** Step wise regression analysis between white rust severity and different meteorological parameters

| Treatments | Regression equation | $R^2$ value |
|---|---|---|
| $RD_1V_1S$ | Y= -11.3+1. 60$T_{max}$-1.53$T_{min}$ | 0.45 |
| | Y= -140.4+2.39$T_{max}$-+0.66$T_{min}$+1.09$RH_m$ | 0.68* |
| | Y= -145.7+3.76$T_{max}$+2.27$T_{min}$+0.856$RH_m$-0.22$RH_e$ | 0.72* |
| | Y= -111.2-1.54$T_{max}$+3.64$T_{min}$+1.20$RH_m$-0.16$RH_e$-2.76SSH | 0.78* |
| | Y= -109.9+1.54$T_{max}$+3.64$T_{min}$+1.19$RH_m$+0.15$RH_e$+ 2.73SSH-kkk0.26RF | 0.78* |
| $RD_1V_2S$ | Y= -31.8+2.63 $T_{max}$-2.06$T_{min}$ | 0.48 |
| | Y= -117.7+3.17$T_{max}$-1.48$T_{min}$+0.73$RH_m$ | 0.72* |
| | Y= -123.6+4.54$T_{max}$-3.10$T_{min}$+0.48$RH_m$+0.22$RH_e$ | 0.76* |
| | Y= -73.5-31.3$T_{max}$+5.54$T_{min}$+1.00$RH_m$-0.33$RH_e$+3.99SSH | 0.89* |
| | Y= -76.3-3.13$T_{max}$+5.43$T_{min}$+1.04$RH_m$-0.34$RH_e$+3.95SSH+ kkk0.59RF | 0.89* |
| $RD_2V_1S$ | Y= -16.5+2.22 $T_{max}$-2.34$T_{min}$ | 0.28 |
| | Y= -131.2+2.93$T_{max}$-1.57$T_{min}$-0.97$RH_m$ | 0.76* |
| | Y= -138.4+4.54$T_{max}$-3.50$T_{min}$+0.68$RH_m$+0.27$RH_e$ | 0.83* |
| | Y= -100.3-1.22$T_{max}$+2.96$T_{min}$+1.07$RH_m$-0.15$RH_e$+3.11SSH | 0.91* |
| | Y= -99.2-1.22$T_{max}$+2.96$T_{min}$+1.06$RH_m$-0.14$RH_e$+3.02SSH+ kkk0.19RF | 0.91* |
| $RD_2V_2S$ | Y= -19.8-0.38$T_{max}$+0.21$T_{min}$ | 0.38 |
| | Y= -127.3+0.51$T_{max}$+1.20$T_{min}$+1.25$RH_m$ | 0.80* |
| | Y= -135.4+2.43$T_{max}$-1.03$T_{min}$+0.91$RH_m$+0.31$RH_e$ | 0.88* |
| | Y= -156.7+5.69$T_{max}$-4.66$T_{min}$+0.89$RH_m$+0.55$RH_e$-1.69SSH | 0.91* |
| | Y= -157.5+5.62$T_{max}$-4.65$T_{min}$+0.70$RH_m$+0.55$RH_e$-1.70SSH+ kkk0.16RF | 0.91* |

*Significant at 5 per cent level of significance

to pathogen attack and in epidemiological studies of polycyclic diseases, especially those regarding/ quantitative resistance, AUDPC is a variable tool (Jeger *et al*., 2001). The AUDPC values indicate that comparatively higher area under disease (alternaria blight) progress curve was observed for variety PBR 91 as compared to variety PBR 357. The maximum value of AUDPC in variety PBR 91was observed (126) at 122 days after sowing while it was 118 in PBR 357 at 118 days after sowing (Fig. 7).

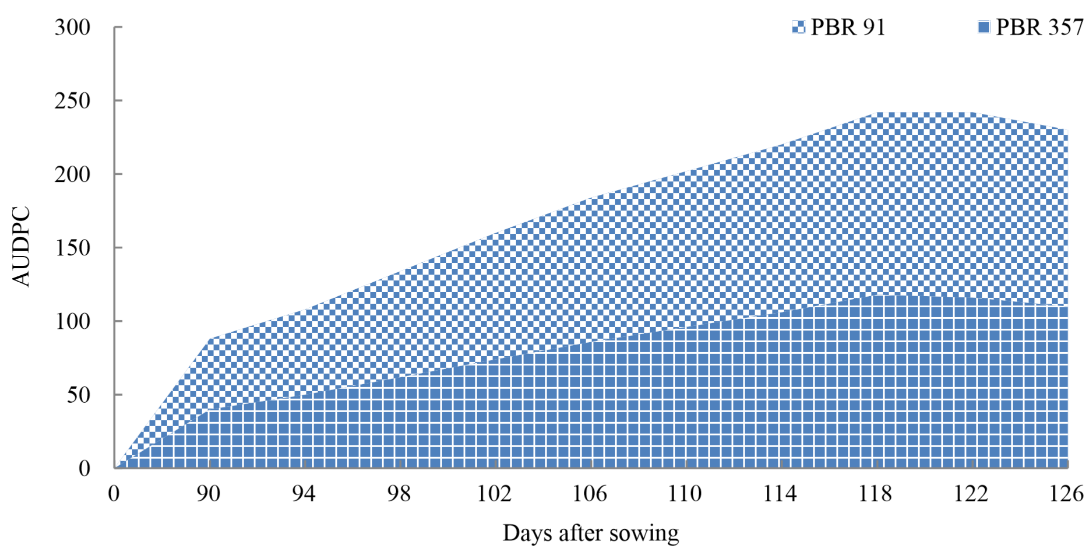


**Fig. 7.** Area under disease progress curve of alternaria blight in *raya* varieties during *rabi* 2020

Maximum area under disease was observed under E-W row direction as compared to N-S row direction (Fig. 8). This was due to low PAR interception and shade during day time, hence provide most favourable conditions for alternaria blight. Maximum area under diseases progress curve for alternaria blight was 126 in E-W row direction and 118 in N-S row direction. Dharmpal (2020) reported that alternaria blight severity was maximum in E-W row direction (246) as compared to N-S row direction (220).

Among different spacing, maximum area under disease progress curve was observed in 30cm×10cm spacing (32) and minimum was recorded in 45cm×30cm row spacing (23) (Fig. 9). It was found that as spacing among the rows increases.disease intensity decreases because in wider spacing, PAR interception was more and relative humidity was less, which was unfavourable conditions for disease development and spread of alternaria blight.

### *Area under disease progress curve (AUDPC) of white rust severity*

In white rust, maximum AUDPC was recorded in variety PBR 91 as compared to variety PBR 357.

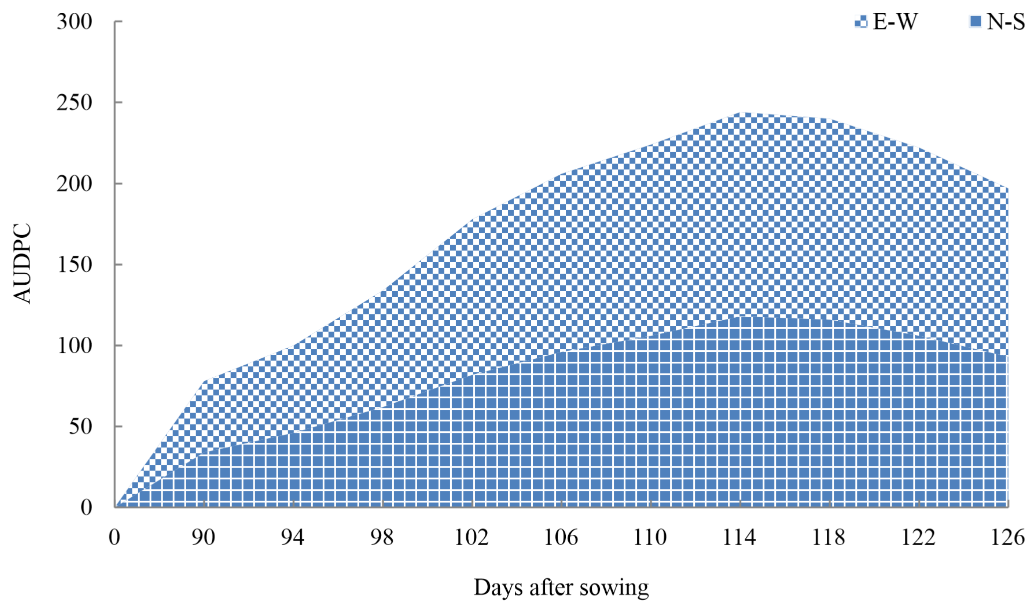


**Fig. 8.** Area under disease progress curve of alternaria blight under different row directions during *rabi* 2020-21

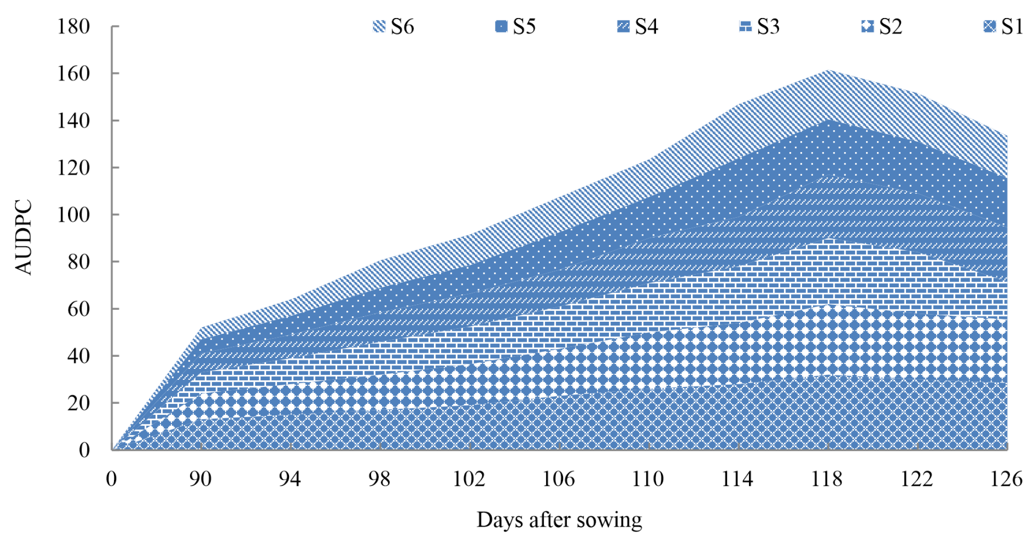


**Fig. 9.** Area under disease progress curve of alternaria blight under different spacing during *rabi* 2020-21

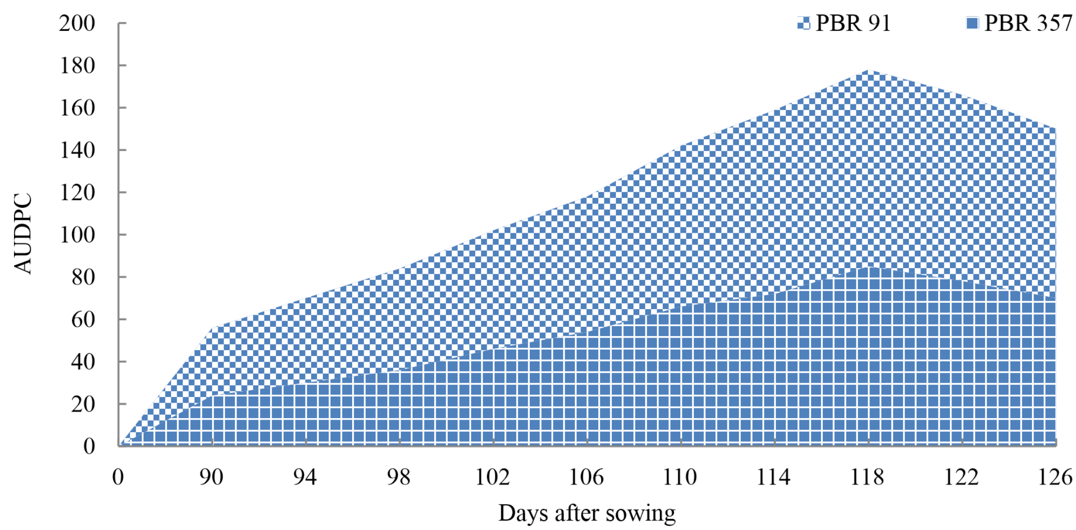


**Fig. 10.** Area under disease progress curve of white rust in *raya* varieties during *rabi* 2020-21

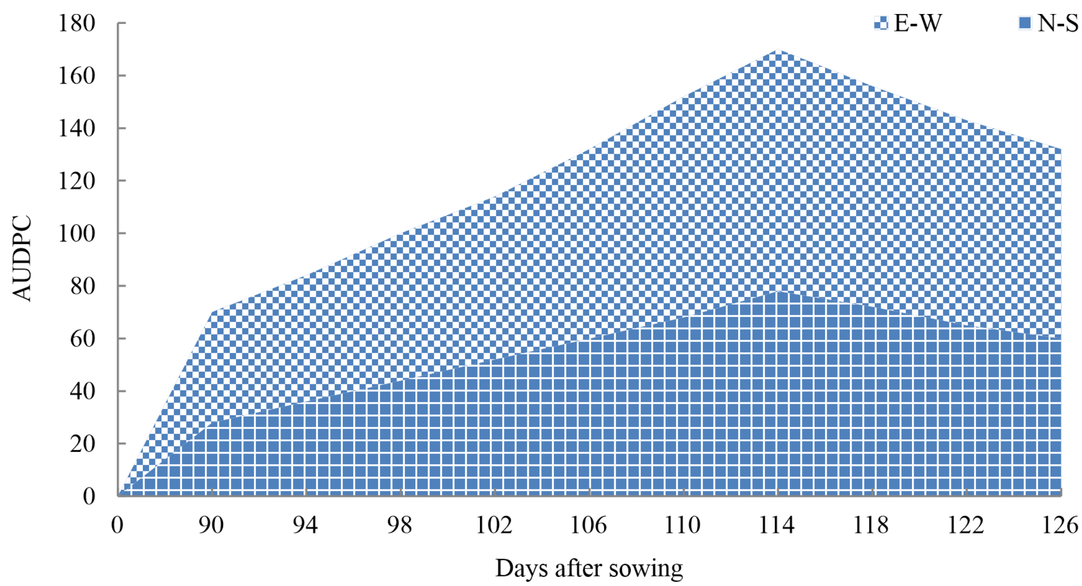


**Fig. 11.** Area under disease progress curve of white rust under different row directions during *rabi* 2020-21

AUDPC was higher in variety PBR 91 (93) as compared to variety PBR 357 (85) (Fig. 10). Maximum area under disease was observed in E-W row direction (92) and minimum in (N-S row direction (78) (Fig. 11). Maximum area under white rust was observed in E-W row direction (138) as compared to N-S row direction (114) (Dharmpal, 2020). The results indicate that maximum disease severity (21) was recorded in closer spacing (30cm×10cm) and minimum severity (11) was observed in wider spacing (45cm×30cm) (Fig.12).

## Conclusions

Disease severity (Alternaria blight and white rust) was higher in E-W row direction than N-S row direction. The N-S row direction may be beneficial in reduction of disease incidence in mustard crop. Both alternaria blight and white rust severity were low in wider spacing (45cm×30cm) and higher in closer-spacing (30cm×10cm). Regression equations developed between disease severity (Alternaria blight and white rust) and different meteorological parameters *viz*., maximum and minimum temperatures,

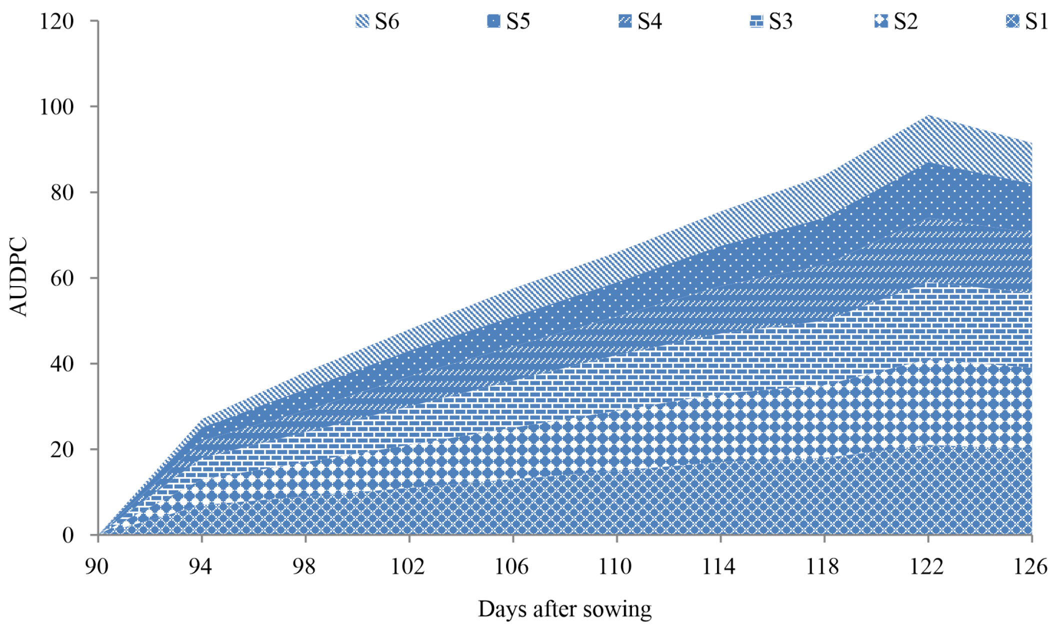


**Fig. 12.** Area under disease progress curve of white rust under different spacingduring *rabi* 2020-21

morning and evening relative humidity, sun shine hours and rainfall can be used as predictor variables in disease incidence. So these simple microclimatic modifications can be used to reduce the losses due to alternaria blight and white rust.

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