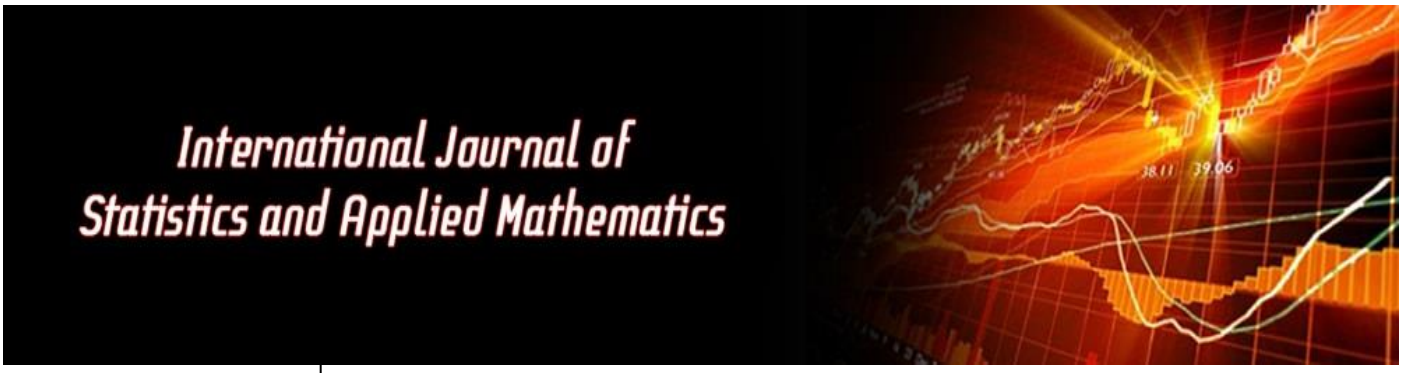

ISSN: 2456-1452
Maths 2023; SP-8(5): 01-05

https://www.mathsjournal.com
Received: 02-06-2023
Accepted: 05-07-2023

Pradeep Kumar Verma
Banda University of Agriculture & Technology, Banda, Uttar Pradesh, India

HS Negi
Banda University of Agriculture & Technology, Banda, Uttar Pradesh, India

Annu
Banda University of Agriculture & Technology, Banda, Uttar Pradesh, India

Gurvinder Kaur
RIMT University, Mandi Govindgarh, Fatehgarh Sahib, Punjab, India

Vivek Singh
Banda University of Agriculture & Technology, Banda, Uttar Pradesh, India

Rohit Kumar
Banda University of Agriculture & Technology, Banda, Uttar Pradesh, India

Corresponding Author:
HS Negi
Banda University of Agriculture & Technology, Banda, Uttar Pradesh, India

Effect of weather variables on white rust disease of Indian mustard

Pradeep Kumar Verma, HS Negi, Annu, Gurvinder Kaur, Vivek Singh and Rohit Kumar

Abstract
The work carried out in Banda of UP, India during 2020-21 investigates the progression of white rust disease of Indian mustard in relation to weather factors and sowing dates on per cent disease index (PDI), area under disease progress curve (AUDPC) and apparent infection rate (r) of the disease and yield of the crop. Coefficient of determination (R^2) explained that 98, 97, 98 and 97% white rust development was influenced by the maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall in Indian mustard varieties Ganga, Varuna, Giriraj and RH-0749, respectively. Multiple linear regression model was developed to find out the expected PDI of the disease based on the predictor weather variables. Lowest average PDI, minimum AUDPC, minimum apparent infection rate (r) and maximum yield was resulted from 1st sown mustard crop.

Keywords: Indian mustard, white rust, weather parameters, AUDPC, apparent infection rate, yield

1. Introduction
Indian mustard (*Brassica juncea* (L.) Czern. and Coss.) is the third most important oilseed crop in the world after soybean and palm oil. Indian mustard is an important source of edible oil especially in northern India containing one of the lowest amounts of saturated fats. India produced 11.75 million tonnes of rapeseed-mustard with productivity of 14.58 q/ha (Anonymous, 2022) [1] which is quite lesser than the world average productivity. One of the main reasons behind low productivity of the rapeseed-mustard in the country is white rust caused by *Albugo candida* (Pers.) Kuntze. Therefore, the work was carried out to study the influence of weather factors and sowing dates on white rust disease of Indian mustard.

2. Materials and methods
The experiment was conducted in the Agricultural Research Farm of Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India during *Rabi* season of 2020-21.

2.1 Effect of weather variables
To analyze the relationship between PDI of white rust and weather variables *viz.*, maximum and minimum temperature (°C), maximum and minimum relative humidity (%) and average rainfall (mm) on four Indian mustard varieties (Ganga, Varuna, Giriraj and RH-0749), the PDI was calculated using standard scale and method (AICRP, 2019) [2] and formula McKinney (1923) [3].

$$\text{Disease index (\%)} = \frac{\text{Sum of all disease ratings}}{\text{Total number of samples observed} \times \text{Maximum disease grade}} \times 100$$

Data on weather parameters was taken from the meteorological observatory of BUAT Banda. Correlation coefficient (r), coefficient of determination (R^2) and multiple linear regression equation was analyzed using R software. Multiple linear regression equation was formulated using equation as below.

$Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5$

Where
Y = PDI
α = Intercept (Constant)
βi = Regression coefficient associated with each Xi
i =1, 2, 3, 4, 5 are the weather variables
X_1 = Maximum temperature (ºC)
X_2 = Minimum temperature (ºC)
X_3 = Maximum relative humidity (%)
X_4 = Minimum relative humidity (%)
X_5 = Rainfall (mm)

2.2 Effect of sowing dates

For determining the relationship between different dates of sowing and severity of white rust, two susceptible varieties of Indian mustard i.e. Varuna and Ganga were sown in four different dates at 10 days intervals (October 27th, November 7th, 17th and 27th) in randomized block design with three replications in uniform plots of 5×3 m^2 size. Standard package of practice was followed for the spacing, fertilizer and irrigation applications. Area under disease progress curve (AUDPC) is the area between curve and the X- axis. AUDPC was calculated to know the comparative effect of different sowing dates on progression of the disease using the formula given by Wilcoxson *et al*. (1975) [4].

$$AUDPC = \sum_{i=1}^{n-1} \left(\frac{y_i + y_{i+1}}{2} \right) (t_{i+1} - t_i)$$

Where
"t"- time of each reading
"y" - PDI at each reading
"n" - Number of readings

Apparent infection rate (r) of the disease development is a rate of the speed at which an epidemic develops. To interpret the epidemic rate in all the sowing dates, readings of PDI was noted at weekly intervals and subjected to the formula given by Vanderplank (1963) [5].

$$r = \frac{2.3}{t_2 - t_1} \left\{ \log \frac{x_2}{1 - x_2} - \log \frac{x_1}{1 - x_1} \right\}$$

Where
r is the apparent infection rate
t_1 is the time of the first measurement
t_2 is the time of the second measurement
x_1 is the proportion of infection measured at time t_1
x_2 is the proportion of infection measured at time t_2
Yield of oilseeds of both the varieties was calculated in q/ha.

3. Results and discussion

First symptom of white rust in Ganga, Varuna, Giriraj and RH-0749 appeared on 2nd meteorological weak i.e. 12th weeks after sowing during which the average maximum temperature recorded was 20.28 ºC, average minimum temperature was 7.57 ºC, average maximum RH was 99.57%, average minimum RH was 66.28% and total weekly rainfall of 9.75 mm was received. White rust in all varieties progressed exponentially from 14th WAS up to 17th WAS during which the maximum temperature was ranging 21.71-29.48 °C, minimum temperature ranged 9.4-14.0 °C, maximum RH > 90% up to 16th WAS and minimum RH between 36.14-56.42% with 12.30 mm rainfall which favoured the development of white rust (Figure 1.). Chattopadhyay *et al*. (2011) [6] also concluded that the severity of white rust on leaves of mustard Cv. Varuna was favoured by >40% minimum relative humidity, >97% maximum RH and 16–24 °C of maximum daily temperature. Sangeetha and Siddamaiah (2007) [7] also reported 20–29 °C maximum daily temperature with >12 °C minimum daily temperature and >97% morning RH favourable for development white rust in mustard.

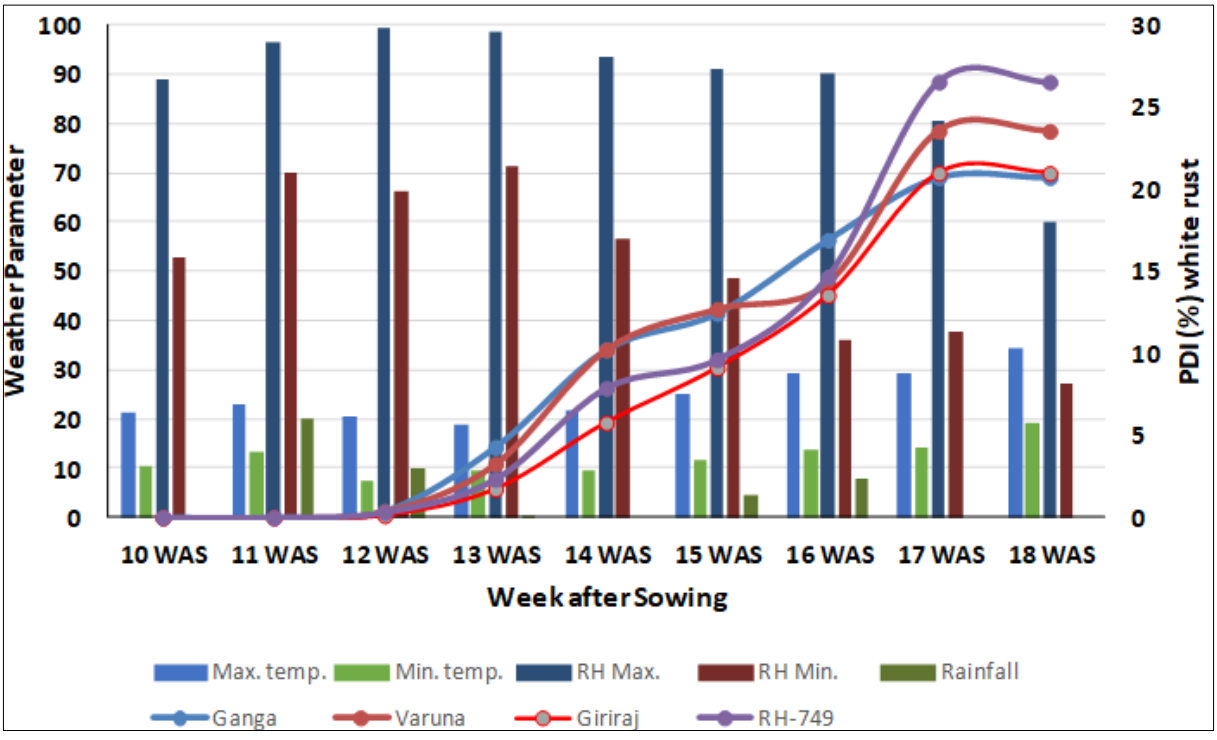

Fig 1: Effect of weather variables on white rust in mustard (Ganga, Varuna, Giriraj and RH-0749)

PDI of white rust of mustard was significant and positively correlated with the average maximum and minimum temperature whereas, it exhibited significantly negative correlation with the average maximum and minimum relative humidity in all the four varieties whereas, rainfall was non-significant and negatively correlated with development of white rust (Table 1). Coefficient of determination (R^2) was statistically significant for all the four varieties and explained that 98, 97, 98 and 97% white rust development was influenced by the maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall in varieties Ganga, Varuna, Giriraj and RH-0749, respectively (Table 2). Multiple linear regression equation developed interprets how much a unit change in weather variables could influence the PDI of white rust (Table 2). Bal and Kumar (2014) [8] who also reported highly significant positive correlation between disease severity of white rust and maximum as well as minimum temperature. Sangeetha and Siddamaiah (2007) [7] also found positive correlation of per cent disease index of the white rust disease with maximum temperature whereas, found negative correlation with minimum temperature, maximum and minimum relative humidity and rainfall. Several other workers have also reported correlation between different climatic factors and disease progression of white rust in Indian mustard and developed multiple linear regression models, Kaur *et al.* (2006) [9]; Chattopadhyay *et al.* (2011) [6]; Biswas *et al.* (2011) [10].

Table 1: Correlation between weather variables and PDI of white rust

Weather variables	Correlation coefficient 'r'			
	PDI of White rust			
	PDI Ganga	PDI Varuna	PDI Giriraj	PDI RH-0749
Maximum Temperature (°C)	0.875**	0.887**	0.927**	0.913**
Minimum Temperature (°C)	0.704*	0.733*	0.782*	0.779*
Maximum Relative Humidity (%)	-0.728*	-0.790*	-0.814**	-0.833**
Minimum Relative Humidity (%)	-0.885**	-0.880**	-0.905**	-0.885**
Rainfall (mm)	-0.443	-0.462	-0.405	-0.43

Table 2: Linear regression equation for development of white rust in relation to weather variable

Variety	Regression equation	Coefficient of determination (R^2)
Ganga	Y= - 166.123 + 4.031** (Tmax) - 0.271 (Tmin) + 0.690** (RHmax) + 0.436* (RHmin) - 1.012** (Rainfall)	0.98
Varuna	Y= - 161.882 + 4.609** (Tmax) - 0.894 (Tmin) + 0.462 (RHmax) + 0. 620* (RHmin) - 1.044** (Rainfall)	0.97
Giriraj	Y= - 131.938 + 3.805** (Tmax) - 0.642 (Tmin) + 0.376* (RHmax) + 0.457* (RHmin) - 0.782** (Rainfall)	0.98
RH- 0749	Y= - 159.048 + 4.922** (Tmax) - 1.094 (Tmin) + 0.323 (RHmax) + 0. 696* (RHmin) - 1.009* (Rainfall)	0.97

* Significant at 5%, and ** Significant at 1% level

Dates of sowing and white rust of Indian mustard

Lowest mean PDI of white rust (8.57% and 8.79%) was recorded from the 1st sown plots on 27th October and were statistically at par whereas, the highest mean PDI of 17.82% and 18.74% was recorded from 4th sowing on 27th November in variety Ganga and Varuna, respectively and differed significantly (Table 3). The PDI of the disease reached to maximum of 34.91% in 4th sowing on 17th WAS in Ganga and it reached 34.89% in 4th sowing on 15th WAS in Varuna. The results depict that mean PDI of disease increased with delay in sowing in both the varieties which may be attributed to late appearance of disease (12th WAS) in first sowing as compare to early appearance of disease on 9th WAS in 3rd and 4th sowing. Subasinghe *et al.* (2009) [11] also reported significantly lesser disease severity of white rust in mustard crop sown on 15th October as compared to the crop sown on 30th November and it increased with delay in sowing dates in both cropping seasons. Kumar (2009) [12] recorded lowest severity of white rust on leaves (12.5%) in crop sown on 19th Oct and found that infection of the disease increased with the delay in sowing time.

Table 3: Per cent disease index of white rust on different dates of sowing

Week after sowing	PDI on different dates of sowing										Overall mean
	Ganga					Varuna					
	1st	2nd	3rd	4th	Mean	1st	2nd	3rd	4th	Mean	
9 WAS	0.00 (0.00)	0.00 (0.00)	0.41 (2.98)	0.04 (0.66)	0.11 (0.91)	0.00 (0.00)	0.00 (0.00)	0.57 (4.30)	0.18 (1.92)	0.18 (1.55)	0.15 (1.23)
10 WAS	0.00 (0.00)	0.00 (0.00)	5.4 (13.42)	0.48 (3.87)	1.47 (4.32)	0.00 (0.00)	0.00 (0.00)	3.92 (11.40)	0.46 (3.80)	1.09 (3.80)	1.28 (4.06)
11 WAS	0.00 (0.00)	0.33 (3.18)	10.96 (19.32)	1.01 (5.74)	3.07 (7.06)	0.00 (0.00)	0.55 (4.12)	7.25 (15.60)	1.31 (6.53)	2.27 (6.56)	2.67 (6.81)
12 WAS	0.37 (3.46)	3.18 (10.25)	13.56 (21.58)	2.34 (8.79)	4.86 (11.02)	0.36 (2.81)	2.5 (9.07)	9.85 (18.28)	3.88 (11.34)	4.14 (10.37)	4.50 (10.70)
13 WAS	4.29 (11.94)	7.85 (16.27)	16.67 (24.08)	12.19 (20.42)	10.25 (18.18)	3.27 (10.41)	8.43 (16.86)	17.26 (24.53)	16 (23.56)	11.24 (18.84)	10.74 (18.51)
14 WAS	10.23 (18.64)	10.96 (19.32)	21.78 (27.80)	25.23 (30.13)	17.05 (23.97)	10.22 (18.63)	15.03 (22.80)	25.4 (30.25)	26.04 (30.67)	19.17 (25.58)	18.11 (24.78)
15 WAS	12.45 (20.64)	14.82 (22.62)	25.56 (30.35)	32.22 (34.57)	21.26 (27.05)	12.7 (20.86)	17.78 (24.92)	28.56 (32.29)	34.89 (36.18)	23.48 (28.56)	22.37 (27.81)
16 WAS	16.92 (24.28)	21.54 (27.64)	25.56 (30.35)	34.91 (36.19)	24.73 (29.61)	14.28 (22.19)	20.08 (26.61)	28.56 (32.29)	34.89 (36.18)	24.45 (29.32)	24.59 (29.46)
17 WAS	20.74	25.78	25.56	34.91	26.74	23.56	27.08	28.56	34.89	28.52	27.63

	(27.07)	(30.50)	(30.35)	(36.19)	(31.03)	(29.02)	(31.34)	(32.29)	(36.18)	(32.21)	(31.62)
18 WAS	20.74 (27.07)	25.78 (30.50)	25.56 (30.35)	34.91 (36.19)	26.74 (31.03)	23.56 (29.02)	27.08 (31.34)	28.56 (32.29)	34.89 (36.18)	28.52 (32.21)	27.63 (31.62)
Mean	8.57 (13.31)	11.02 (16.03)	17.1 (23.06)	17.82 (21.27)	13.63 (18.42)	8.79 (13.29)	11.85 (16.71)	17.84 (23.35)	18.74 (22.25)	14.31 (18.90)	

Figures in parentheses are angular transformed values

Factors	$CD_{(0.05)}$	$SE_{(m)}$	Factors	$CD_{(0.05)}$	$SE_{(m)}$
Variety	0.245	0.081	Interval	0.441	0.158
Date of sowing	0.346	0.114	Variety x Interval	0.623	0.223
Variety x Date of sowing	0.489	0.161	Date of sowing x Interval	0.881	0.315
			Variety x Date of sowing x Interval	1.246	0.446

Minimum AUDPC of 527.64 cm^2 and 533.24 cm^2 for white rust was resulted in 1st sown crop in varieties Ganga and Varuna, respectively. AUDPC increased with the delay in sowing with maximum AUDPC of 1125.52 cm^2 and 1189.97 cm^2 in 4th sown crop of Ganga and Varuna, respectively showing increase in progress of white rust with successive sowing of mustard crop. The AUDPC was lower in Ganga as compared to Varuna in all four sowing dates, illustrating comparatively slow progress of white rust in Ganga as compared to Varuna (Fig 3).

Apparent infection rate (r) of white rust revealed that in 1st sown crops the both varieties were under infection for only five growing weeks that too late in the season whereas, 3rd and 4th sown crop remained infected for eight growing weeks ultimately resulting in comparatively more white rust.

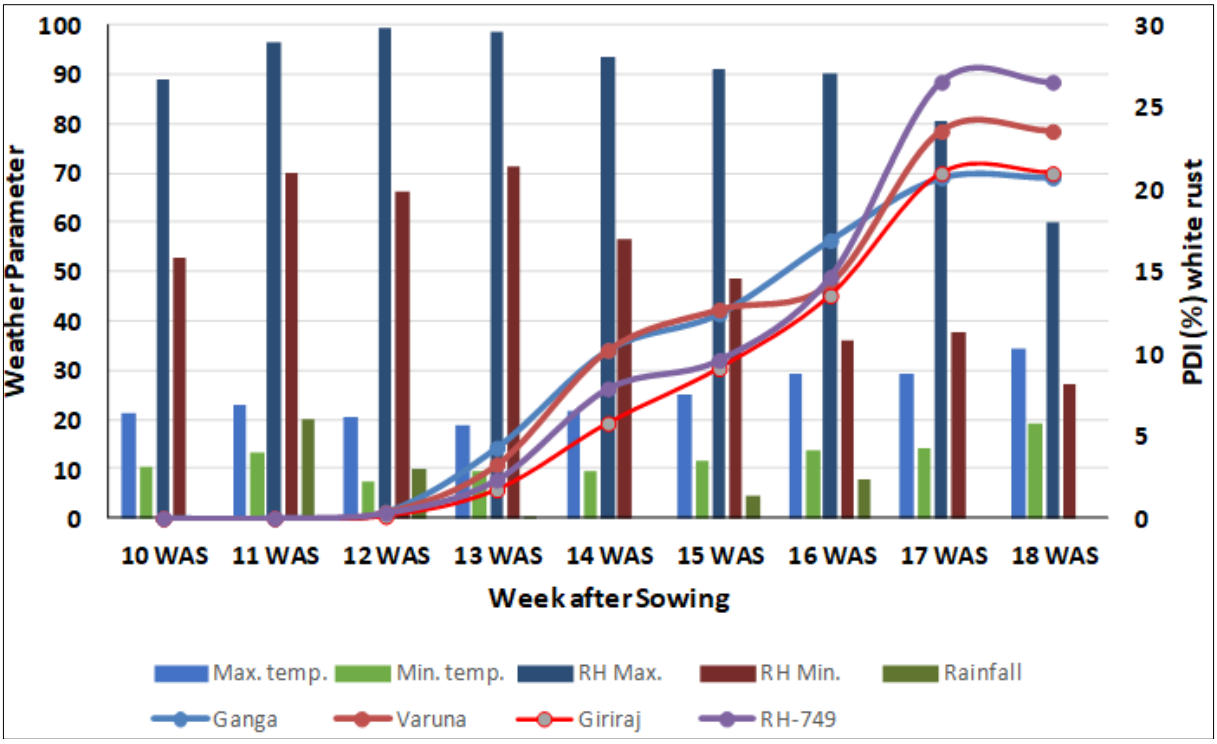

Fig 3: Area under disease progress curve of white rust on different sowing dates

epidemic and lesser yield. Maximum r was noticed in the 1st week of infection in all sowing dates of both the varieties except for 4th sowing in Varuna where rate of disease development was highest (0.2214) during 12 WAS (Table 4).

Similar findings on relation of AUDPC and r on development of white rust of Indian mustard on different sowing dates has also been reported by Yadav *et al.* (2023) [13]; Wangkhem *et al.*, (2019) [14].

Table 4: Apparent infection rate of white rust on different sowing dates

	PDI (Ganga)				PDI (Varuna)			
WAS	1st Sowing	2nd Sowing	3rd Sowing	4th Sowing	1st Sowing	2nd Sowing	3rd Sowing	4th Sowing
9 WAS	-	-	0.3740	0.3562	-	-	0.2800	0.1364
10 WAS	-	-	0.1096	0.1059	-	-	0.0928	0.1489
11 WAS	-	0.3274	0.0346	0.1218	-	0.2180	0.0478	0.1583
12 WAS	0.3541	0.1361	0.0347	0.2507	0.3179	0.1824	0.0923	0.2214
13 WAS	0.1331	0.0523	0.0472	0.1267	0.1731	0.0932	0.0699	0.0877
14 WAS	0.0316	0.0494	0.0299	0.0489	0.0349	0.0287	0.0229	0.0599
15 WAS	0.0513	0.0650	-	0.0172	0.0193	0.0214		
16 WAS	0.0357	0.0336	-	-	0.0878	0.0558	-	-

In variety Ganga, the maximum oilseed yield of 21.18 q/ha and 19.85 q/ha was obtained from 1st sown plots i.e. 27th October which significantly reduced with the delay in sowing and was minimum in 4th sowing (13.49 q/ha and 13.06 q/ha), respectively (Figure 2). Kumar (2009) [12] also reported highest seed yield of 16.39 q/ha, 15.93 q/ ha and 12.50 q/ha from crop sown on 15th Oct., 1st Oct. and 15th Oct. in year 2001-02, 2002-03 and 2003-04, respectively as compared to late sown crop. Alam *et al*. (2014) [15] also reported that first sowing date (25th October) produced a good yield than the later sown crop of mustard.

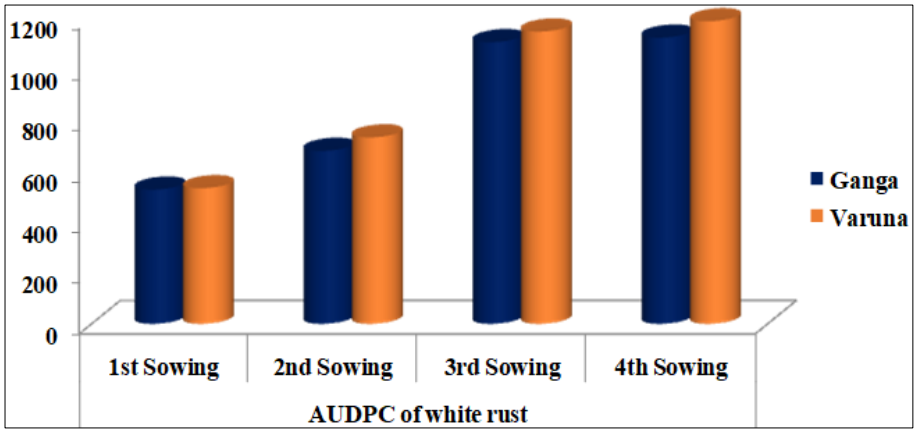

Fig 2: Yield of mustard at different sowing dates

	Variety	Date of sowing	Variety x date of sowing
$CD_{(0.05)}$	0.91	1.00	N/S
$SE_{(m)}$	0.14	0.32	0.29

4. Conclusion

This study concludes that the moderate temperature, higher relative humidity and intermittent rains contributed to the development of white rust on Indian mustard therefore disease prediction model may develop by utilizing the findings of the study. Timely sowing of Indian mustard resulted in least PDI, AUDPC and apparent infection rate with highest yield as compared to late sown crops. As disease development is directly correlated with the favorable environmental conditions, therefore timely sowing can minimize the adverse effect of white rust disease on Indian mustard.

5. References

1. Anonymous. Economic Survey of India. Govt. of India, Economic and Statistics, Ministry of Agriculture (Department of Agriculture and Co-operation), New Delhi; c2022.
2. AICRP. Proceedings of 26th Annual Group Meeting of All India Coordinated Research Project on Rapeseed-Mustard, Aug. 3-5, 2019 at Birsa Agricultural University, Kanke, Jharkhand; c2019. p. 55.
3. McKinney HH. Influence of soil temperature and moisture on infection of wheat seedling by Helminthosporium sativum. J Agric. Res. 1923;26:195-218.
4. Wilcoxson RD, Skovmand B, Atif AA. Evaluation of wheat cultivars for the ability to retard development of stem rust. Ann. Appl. Biol. 1975;80:275–287.
5. Vanderplank JE. Plant Diseases: Epidemics and Control. Academic Press, USA; c1963. p. 366.
6. Chattopadhyay C, Agrawal R, Kumar A, Meena RL, Faujdar K, Chakravarthy NVK, *et al*. Epidemiology and development of forecasting models for white rust of *Brassica juncea* in India. Arch. Phytopathol. Plant Prot. 2011;44(8):751-763.
7. Sangeetha CG, Siddaramaish AL. Epidemiological studies of white rust, downy mildew and Alternaria blight of Indian mustard (*Brassica juncea* (L.) Czern. and Coss. African. J Agric. Res. 2007;2(7):305-308.
8. Bal RS, Kumar A. Studies on the epidemiology of white rust and Alternaria leaf blight and their effect on the yield of Indian mustard. African J. Agril. Res. 2014;9(2):302-306.
9. Kaur N, Kaur GR, Manshi GD. Effect of date of sowing and weather parameters on development of staghead in Raya due to white rust. Pl. Dis. Res. 2006;21(1):51-52.
10. Biswas C, Singh R, Kumar PV. Dynamics of white rust disease in mustard (*Brassica juncea*) in relation to date of sowing and weather parameters Ind. J Agric. Sci. 2011;81(12):1187-1190.
11. Subasinghe AHMP, Bains GS, Chander M. Effect of sowing date and meteorological parameters on development of white rust disease in Indian mustard (*Brassica juncea* L.). Pl. Dis. Res. 2009;24(2):166-169.
12. Kumar A. Ecofriendly option for the management of white rust in Indian mustard under mid hill conditions of north-western India. Indian Phytopathol. 2009;62(1):44-48.
13. Yadav JK, Singh HK, Singh SK, Sharma NK, Kumar S, Yadav VK, *et al*. Correlation of sowing dates and weather factors on the infection and severity of Alternaria blight and white rust of Indian mustard (*Brassica juncea* (L.) Czern and Coss.) in eastern Uttar Pradesh of India. Acta Scient. Agri. 2023;7(6):09-17.
14. Wangkhem B, Rana M, Jackson KS. Exploring the control measures of white rust- organic amendments, botanicals, biocontrol agents and chemicals. J. Pharma. Phytochem. 2019;8(3):4413-4419.
15. Alam MM, Begum F, Roy P. Yield and yield attributes of rapeseed–mustard (*Brassica*) genotypes grown under late sown condition. Bangladesh J Agril. Res. 2014;39(2):311-336