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RESEARCH ARTICLE

Effect of weather parameters on powdery mildew development of wheat at different location in Himachal Pradesh

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Abstract

Powdery mildew (*Blumeria graminis* f sp. *tritici*) is the most important among diseases of wheat after stripe rust and leaf rust in northern Hill Zone. The disease development is highly affected by environmental conditions, especially the temperature and relative humidity. Keeping this in view, the powdery mildew development was studied in five wheat varieties PBW 343, HPW 155, HD 3086, VL 829 and HS 490 (commercially grown varieties in NHZ and NWPZ) along with susceptible check genotype Lehmi at two nationally important hotspot locations of CSKHPV i.e. HAREC, Kukumseri (Summer 2016) and Rice and Wheat Research Centre, Malan (*Rabi* season 2016–2017). The disease severity was correlated with maximum temperature, minimum temperature and mean relative humidity (RH). The disease development was more at Kukumseri which may be due to the prevalence of conducive mean minimum and maximum temperature of 13.4 °C and 23.6 °C, respectively and moderate RH (45.1%). However, disease development was less at Malan. The prevailing mean minimum and maximum temperature and RH were 7.8 °C, and 28.9 °C and 63.5%, respectively at Malan. It is apparent from the studies that powdery mildew development was favoured by temperature of < 23.6 °C and > 45% RH. Multiple correlation of coefficients between maximum temperature, minimum temperature and RH were significant in both the environments. The coefficient of determination (R^2) revealed that selected weather variables contributed 15–59% and 94–99% towards the terminal disease severity (TDS) at Malan and Kukumseri, respectively. Hence, the crop grown at Kukumseri may be the most vulnerable for disease development under field conditions.

Keywords Wheat · Powdery mildew · Field conditions · Severity · Weather parameters

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important crop in the world. In India, wheat ranks second in production after rice. During the year 2016–2017, it was grown in an area of 30.23 million ha with grain production of 98.38 million tonns and the productivity of 31.72 q/ha. The wheat production this year is one of the highest ever recorded in the country (Anonymous 2017a). Wheat is the main *Rabi* cereal crop of Himachal Pradesh, grown in an area of 3.59 lakh ha with production of 650 lakh tones and productivity of 1811 kg/ha (Anonymous 2017b). Among various factors for low productivity, diseases i.e. rusts, smuts, karnal bunt, powdery mildew etc. take a heavy toll of the crop. Powdery mildew caused by the fungus *Blumeria graminis* (DC.) E.O. Speer f. sp. *tritici* Em. Marchal Bgt (syn. *Erysiphe graminis* DC. f. sp. *tritici* Em. Marchal) is the third most devastating disease causing yield losses ranging from 13–34% and 50–100%, under low and severe infestation, respectively in different wheat growing areas (Alam et al. 2013; Mwale et al. 2014). Environmental factors viz. temperature and relative humidity play an important role in the disease development and causing an epidemic (TeBeest et al. 2008). Keeping this in view, the effect of temperature and relative humidity was studied on six bread wheat varieties released and commercially cultivated in North Hill Zone (NHZ) and the results are discussed here in.

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Materials and methods

The experiments were conducted at High Mountain Research and Extension, Centre, Kukumseri during summer 2016 and Rice and Wheat Research Centre, Malan during *Rabi* season 2016–2017, the hotspot locations for powdery mildew of wheat using genotype Lehmi (universal susceptible check) and varieties PBW 343, HPW 155, HD 3086, VL 829 and HS 490 (commercially released and popular varieties in NHZ). The test varieties were grown in 2 m long rows following standard package and practices (Anonymous 2009). The data were recorded at weekly interval on percent disease severity on five randomly tagged plants in each test line based on the modified scale proposed by Mayee and Datar (1986) starting from 30th July to 02nd September 2016 at Kukumseri and 12–18 Feb to 25 March, 2017 at Malan. Data on temperature and RH under field conditions were procured from the respective research centres and were correlated with the disease development. The relation among the disease severity and various weather variables (mean maximum and minimum temperature and mean RH) during disease development was established by determining the simple, partial and multiple correlation and regression coefficient using OPSTAT or MS software.

Results and discussion

The mean disease severity was correlated with maximum temperature, minimum temperature and mean relative humidity and correlation coefficients were calculated and are given in (Tables 1, 2). The disease development at both the locations was influenced by temperature and RH. The data were recorded periodically on percent mean disease severity and correlated with mean weakly maximum and minimum temperature and RH and are presented in Fig. 1.

Table 1 Partial correlation coefficient of weather factors with mean disease severity (%) at different locations

Cultivar	Partial correlation coefficient of weather factors with disease severity (%) at					
	Malan			Kukumseri		
	MIN T	MAX T	HUM	MIN T	MAX T	HUM
Lehmi	−0.587	0.550	−0.095	0.968	−0.987	−0.985
PBW 343	−0.622	0.590	0.331	0.769	−0.925	−0.911
HPW155	−0.338	0.246	−0.090	0.955	−0.980	−0.978
HD3086	−0.159	0.323	0.087	0.846	−0.932	−0.927
VL829	−0.254	−0.116	−0.072	0.383	−0.749	−0.729
HS490	−0.622	0.590	0.331	−0.977	−0.988	−0.980

MIN T minimum temperature, *MAX T* maximum temperature, *HUM* humidity

Table 2 Multiple regression equations of weather factors with mean disease severity (%) at different locations

Lines	Multiple regression equations of weather factors with disease severity (%) at					
	Malan			Kukumseri		
	Multiple correlation coefficient (R)	Coefficient of determination (r^2)	Regression equation	Multiple correlation coefficient (R)	Coefficient of determination (r^2)	Regression equation
Lehmi	0.6242	0.3897	$\mathbf{Y} = -349.371 - 15.529X_1 + 17.409\ X_2 - 0.121X_3$	0.9781	0.9567	$\mathbf{Y} = 688.251 + 11.542\ X_1 - 24.205\ X_2 - 5.246\ X_3$
PBW 343	0.7701	0.593	$\mathbf{Y} = -265.88 - 10.824\ X_1 + 12.288\ X_2 + 0.291\ X_3$	0.9934	0.9868	$\mathbf{Y} = 568.352 + 7.874\ X_1 - 19.327\ X_2 - 4.072\ X_3$
HPW155	0.3969	0.1575	$\mathbf{Y} = -131.743 - 9.754\ X_1 + 8.529\ X_2 - 0.149\ X_3$	0.9963	0.9925	$\mathbf{Y} = 394.262 + 7.742\ X_1 - 14.33\ X_2 - 3.204\ X_3$
HD3086	0.7711	0.5946	$\mathbf{Y} = -224.466 - 2.77\ X_1 + 7.276\ X_2 + 0.983\ X_3$	0.9847	0.9697	$\mathbf{Y} = 297.762 + 5.534\ X_1 - 10.755\ X_2 - 2.398\ X_3$
VL829	0.6805	0.4631	$\mathbf{Y} = 120.942 - 3.894\ X_1 - 2.006\ X_2 - 0.066\ X_3$	0.9734	0.9475	$\mathbf{Y} = 377.063 + 3.959\ X_1 - 12.15\ X_2 - 2.697\ X_3$
HS490	0.7701	0.5930	$\mathbf{Y} = -265.88 - 10.824\ X_1 + 12.288\ X_2 + 0.291\ X_3$	0.9999	0.9998	$\mathbf{Y} = 163.427 - 2.401\ X_1 - 3.235\ X_2 - 0.566\ X_3$

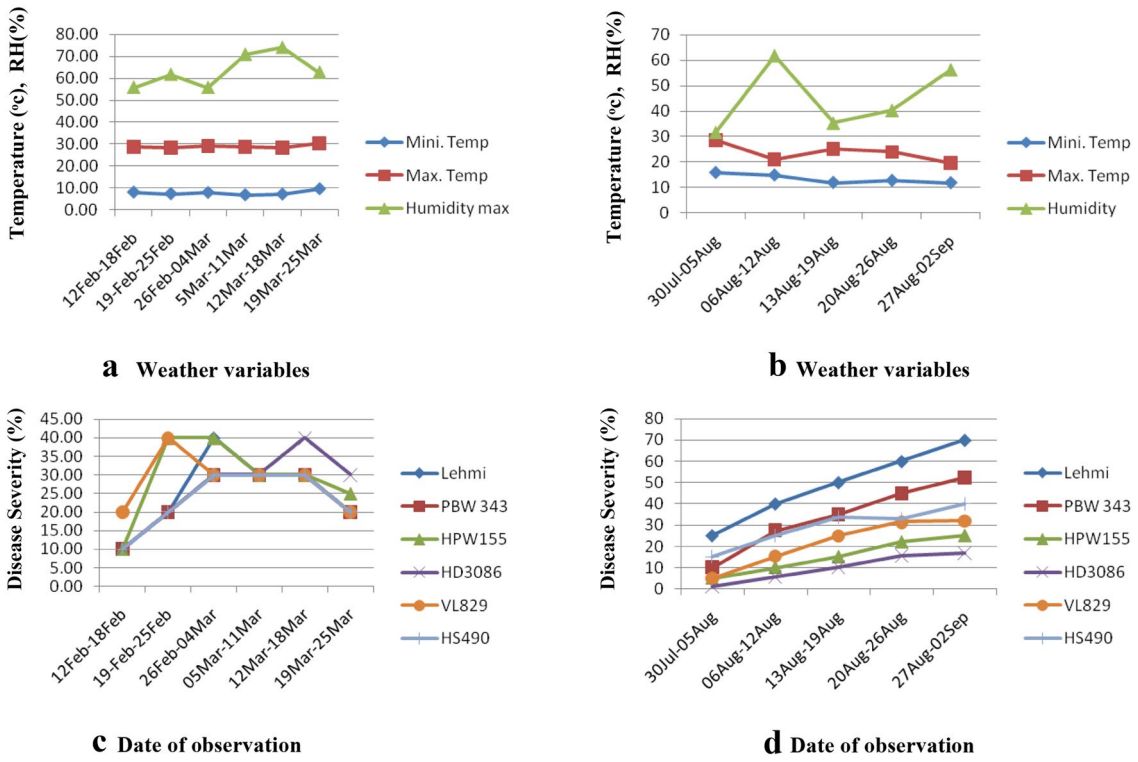

Fig. 1 Weather variables **a** Malan. **b** Kukumseri and disease severity on different dates on different wheat varieties at **c** Malan. **d** Kukumseri

Malan

Mean terminal disease severity (TDS) of 20 and, 20, 25, 30, 20 and 20 percent was recorded on genotype Lehmi and, varieties PBW 343, HPW 155, HD 3086, VL 829 and HS 490, respectively (Fig. 1). The disease progressed slowly at Malan and the mean disease severity decreased by the end of the season. The maximum temperature at Malan ranged between 27.4–30.3 °C during first fortnight of February to the second fortnight of March and the RH ranged between 59.8–62.7%. Present findings of slow and retarded disease by the end of March are in agreement with the findings of Schafer (1987) and Leath and Bowen (1989) inferring that the temperatures above 25 °C can severely retard the growth of powdery mildew resulting in slow progression of the disease as the growing season progresses into hotter months. It was further supported by the studies of Ward and Manners (1974) who observed that production of conidia was optimal at 20 °C and it declined rapidly at lower and higher temperature. Similar findings were also reported by Jacob et al. (2007), based growth chamber experiments, reporting that powdery mildew did not develop at 28 °C. The simple correlation coefficient of disease severity with minimum and maximum temperature and RH were non significant in all the genotypes. Partial correlation of coefficient of disease severity with minimum temperature was negatively correlated whereas; it was positively correlated with maximum temperature in all the cultivars except VL 829. TDS was negatively correlated with RH on Lehmi, HPW 155 and VL 829 (Table 1).

Kukumseri

The data revealed that TDS was more severe at Kukumseri i.e. 70, 53, 25, 17, 32 and 40 percent on genotype Lehmi and varieties PBW 343, HPW 155, HD 3086, VL 829 and HS 490, respectively (Fig. 1). The correlation of TDS with the prevailing environmental conditions revealed that at Kukumseri disease development was more as the mean maximum temperature decreased progressively every week starting from 28.6 °C during 30th July to 5th August, 2016 and it was 19.5 °C during the 27th August to 2nd September, 2016 i.e. and the RH during the period varied from 31.6–61.9%. As has been observed in the present studies, similar results were reported by Last (1953) that variety Red Standard was more susceptible to *Erysiphe graminis* at 14–20 °C than at 7 °C. It is further supported by the studies of Singh and Pannu (2014) that temperature ranging from 9.1 to 22.3 °C and RH of 66–81% favoured the development of disease. The simple correlation of coefficient was negatively correlated with minimum temperature i.e. −0.884, −0.891, −0.926 and −0.963 in case of varieties PBW 343, HD 3043, VL

829 and HS 490, respectively and it was non significant in Lehmi and HPW 155. Maximum temperature and RH were non significant with TDS in case of different varieties. The partial correlation of coefficient of TDS with minimum temperature was positively correlated in all the varieties except HS 490, whereas it was negatively correlated with maximum temperature and RH in all the test cultivars (Table 1). Present studies are supported by Patil et al. (2004), who reported that at high altitudes, maximum temperature of 23.7 °C showed strong significant positive correlation in disease development.

Multiple correlation of coefficients between maximum temperature, minimum temperature and RH were significant in all environments (Table 2). The coefficient of determination (R^2) showed that selected weather variables contributed 15–59 and 94–99% towards TDS at Malan and Kukumseri, respectively. Similar results were reported by Sandhu et al. (2017) in case of stripe rust where coefficient of determination (R^2-value) was highly significant indicating that stripe rust incidence was highly influenced by the weather parameters.

Multiple regression coefficients were positively correlated with maximum temperature, minimum temperature and RH at Kukumseri in all the varieties whereas, it was negative for all the varieties at Malan except in case of VL 829 (Table 2). The regression analysis showed that temperature and RH were the most important factors for the disease development. The disease development was more at Kukumseri due to the prevalence of average minimum, and maximum temperature of 13.4 °C and, 23.6 °C, respectively and moderate RH of 45.1% which remained consistent throughout the season. However, there was decrease in disease development at Malan as the prevailing mean minimum and maximum temperature were 7.8 °C and 28.9 °C, respectively and RH was 63.5% (Fig. 1). Jacob et al. (2007) reported that severity of powdery mildew of tomato was positively correlated with the duration of the temperature ranging from 15 to 25 °C. The studies conducted at prevailing regime of different weather conditions at different hot spot locations suggested that wheat powdery mildew development was favored by temperature of < 23.6 °C and > 45% RH. As has been reported in the present studies, TeBeest et al. (2008) also observed that among various weather factors temperature and RH exhibit the largest impact on the severity of powdery mildew epidemics. Hence, cultivars at Kukumseri were the most vulnerable to the disease showing more severe disease development under field conditions. Kukumseri falls under dry temperate region of the state and the observation of more severe disease development there is in agreement with the findings of Spencer (1978), who found that powdery mildew was more dangerous under drier conditions. The analysis of correlations between minimum and maximum temperatures and disease severity showed that the number of days with temperatures between 17 and 23 °C were approximately the optimal temperatures for powdery mildew development (Prigge et al. 2005).

Conclusion

It is apparent from the correlation and regression analysis that temperature and RH were the most important factors for the disease development. With the use of prevailing weather data during different locations of the state, it is suggested that wheat powdery mildew development was favoured by temperature < 23.6 °C and > 45% RH. Hence, the crop at Kukumseri is more vulnerable to the disease development under field conditions.

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