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Effect of metrological factors on the sheath rot development in rice

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Abstract
Sheath rot (*Sarocladium oryzae*) is an important fungal disease of rice following blast, brown spot and sheath blight in the Union Territory of Jammu and Kashmir. The disease development is highly influenced by environmental conditions, especially the temperature (maximum and minimum) and relative humidity (morning and evening). Hence, effect of various meteorological factors on the sheath rot development was studied in rice variety Pusa Basmati 1509 at the experimental Farm of Division of Plant Pathology, SKUAST-J, Chatha, during cropping seasons 2019 and 2020 under artificial epiphytotic conditions. The terminal disease severity of 37.64 and 35.24 per cent was recorded during 2019 and 2020, respectively. Sheath rot disease showed negative and highly significant correlation with maximum and minimum temperature, evening relative humidity and rainfall. It had negative and non-significant correlation with morning relative humidity, and non-significant & positive correlation with bright sunshine during 2019. During the cropping season 2020 the disease had a negative and highly significant correlation with maximum and minimum temperature, and evening relative humidity whereas it showed positive correlation with morning relative humidity, and negative and non-significant correlation with sunshine hours. Coefficient of determination (R^2) revealed that selected weather variables contributed upto 96 and 98 per cent towards disease severity during the cropping season 2019 and 2020, respectively.

Keywords: Sheath rot, disease severity, correlation, regression, weather variables

Introduction
Rice is inflicted by various fungal diseases out of which blast (*Pyricularia grisea*), brown spot (*Bipolaris oryzae*), sheath blight (*Rhizoctonia solani*) and sheath rot (*Sarocladium oryzae*) take a heavy toll of the crop (Pushpam *et al*., 2020) [20]. Sheath rot is emerging as a major disease in almost all rice-growing ecosystems (Mahadevaiah *et al*., 2016) [8]. The pathogen primarily affects the boot leaf sheath enveloping young panicles, which delays or prevents panicle emergence. Seeds from infected panicles become sterile and discolored, resulting in a considerable reduction in yield (Pushpam *et al*., 2020; Peeters *et al*., 2020) [12, 11]. Rice sheath rot has become a major production constraint with the introduction of high-yielding, semi-dwarf and dwarf rice cultivars in comparison to tall cultivars resulting in yield losses of 3-85 per cent depending upon the disease severity (Amin *et al*., 1974; Ou, 1985; Mahadevaiah *et al*., 2016; Peeters *et al*., 2020) [1, 9, 8, 11]. The pathogen produces phytotoxins (cerulenin and helvoic acid) causing a grayish-brown necrotic lesion in the flag leaf sheath and prevent photosynthates to reach the developing panicles, resulting in quantitative and qualitative yield loss (Pushpam *et al*., 2020; Peeters *et al*., 2021) [12, 10]. Environmental factors temperature (maximum and minimum) and relative humidity play an important role in development of sheath rot (Dhal *et al.*, 1998) [4] an mean temperature of 20-30°C and relative humidity (RH) of 65-85 per cent were congenial for the disease development (Bigirimana *et al*., 2015) [3]. However, no information is available on effect of weather factors on disease development in Jammu division. Keeping this in view, the effect of temperature (maximum and minimum), relative humidity (morning and evening), rainfall and sunshine hours was studied on disease development in rice variety Pusa Basmati 1509 and the results are discussed here in.

Material and Methods
The experiment was conducted at the experimental area of the farm of Division of Plant Pathology, SKUAST-J, Chatha, during the cropping seasons 2019 and 2020 under artificial epiphytotic conditions following standard grain inoculation technique (Hazarika and Phookan, 1998) [5].

The relationship between abiotic factors *viz.*, maximum and minmum temperature, relative humidity, rainfall and sunshine with disease severity of sheath rot, was determined in rice variety Pusa Basmati 1509. The trial was raised in four line plot of variety Pusa Basmati 1509 with three replications following standard agronomical practices (Anonymous, 2007) [2]. The observations on disease severity were recorded at 3 days interval right from disease initiation till the maturity of the crop using 0-9 scale (IRRI, 1996) [6]. The metrological data was procured from the Agromet Research Centre, SKAUST, Chatha. The relation among the disease severity and weather variables (maximum and minimum temperature, morning and evening relative humidity, rainfall and sunshine) was established by determining the simple correlation, R^2 and regression coefficient using OPSTAT online statistical packages. Moreover correlation between disease severity and weather parameters was also calculated and graphically represented using R-Studio software.

Results

The progress of sheath rot severity in rice variety Pusa Basmati 1509 in relation to weather variables was studied during two crop seasons i.e. *Kharif* 2019 and 2020 under field conditions. The data on disease severity is given in Table 1. It showed the disease progress in term of disease severity and various weather parameter *viz.*, temperature: maximum and minimum, relative humidity: morning and evening, rainfall and sunshine during *Kharif* 2019 and 2020. The initial disease severity of 4.83 and 6.23 per cent was recorded on 1st October with corresponding weather variables *viz.*, temperature; maximum (31.25 and 33.65 ºC), and minimum (18.55 and 19.95 ºC), relative humidity; morning (88.00 and 74.00%) and evening (61.00 and 38.0%), rain fall (12.80 and 0.00 mm) and bright sunshine (6.60 and 8.60 hrs), during 2019 and 2020, respectively (Table 1). A gradual increase in disease severity showed progression from 6.74-9.85 and 8.16-11.05 per cent during the period of 4th to 7th October during *Kharif* 2019 and 2020, respectively. Maximum terminal disease severity of 37.64 and 35.24 per cent was recorded during October 31st of 2019 and 2020, respectively, at maximum temperature (29.25 and 28.75 ºC), minimum temperature (15.10 and 11.50 ºC), morning relative humidity (90.00 and 84.00%), evening relative humidity (46.00 and 26.00%), rainfall (0.00 and 1.40 mm) and bright sunshine (6.60 and 8.00hrs) were recorded (Fig. 1 and 2).

Table 1: Disease severity of sheath rot on rice variety Pusa Basmati 1509 and weather factors during 2019 and 2020

Date of observation	Disease severity (%)		Temperature (ºC)				Relative Humidity (%)				Rainfall (mm)		Sunshine (Hours)	
	2019	2020	Max. temp		Mini. temp		Morn.		Evn.		2019	2020	2019	2020
			2019	2020	2019	2020	2019	2020	2019	2020				
1-Oct	4.83	6.23	31.25	33.65	18.55	19.95	88.00	74.00	61.00	38.00	12.80	0.00	6.60	8.60
4-Oct	6.74	8.16	29.45	32.95	18.80	18.65	85.00	79.00	75.00	39.00	8.60	0.00	2.80	8.80
7-Oct	9.85	11.05	30.65	33.10	19.95	18.70	94.00	78.00	53.00	42.00	0.00	0.00	5.60	8.80
10-Oct	12.64	14.43	30.90	32.70	16.55	18.65	78.00	82.00	54.00	47.00	0.00	0.00	8.40	7.70
13-Oct	16.14	18.12	31.10	32.25	17.50	17.35	88.00	81.00	55.00	39.00	0.00	0.00	7.90	8.00
16-Oct	19.95	20.32	30.55	31.75	18.05	15.40	93.00	88.00	56.00	33.00	0.00	0.00	4.00	8.30
19-Oct	24.95	23.76	29.70	31.45	15.50	14.90	83.00	90.00	51.00	33.00	0.00	0.00	9.30	9.10
22-Oct	29.75	26.05	29.60	30.40	14.20	13.80	88.00	87.00	42.00	31.00	0.00	0.00	9.00	8.40
25-Oct	31.75	28.35	29.70	30.00	14.65	13.55	83.00	93.00	45.00	40.00	0.00	0.00	9.30	8.40
28-Oct	35.32	32.55	29.70	29.70	14.15	12.20	86.00	92.00	42.00	36.00	0.00	0.00	9.00	8.30
31-Oct	37.64	35.24	29.25	28.75	15.10	11.50	90.00	84.00	46.00	26.00	0.00	1.40	6.60	8.00
Average	20.87	20.39	30.17	31.52	16.64	15.88	86.91	84.36	52.73	36.73	1.95	0.13	7.14	8.40

Max. Temp= maximum temperature, Mini. Temp= minimum temperature, RH. Mrng= relative humidity morning, Rh. Evn = relative humidity evening

A gradual increase in disease severity showed progression from 6.74-9.85 and 8.16-11.05 per cent during the period of 4th to 7th October during *Kharif* 2019 and 2020, respectively. Maximum terminal disease severity of 37.64 and 35.24 per cent was recorded during October 31st of 2019 and 2020, respectively, at maximum temperature (29.25 and 28.75 ºC), minimum temperature (15.10 and 11.50 ºC), morning relative humidity (90.00 and 84.00%), evening relative humidity (46.00 and 26.00%), rainfall (0.00 and 1.40 mm) and bright sunshine (6.60 and 8.00 hrs) were recorded (Fig. 1 and 2).

Simple correlation coefficients (2019 and 2020)

The disease severity was correlated with weather parameters and correlation coefficients were calculated. The simple correlation between disease severity and weather factors *viz.*, maximum and minimum temperature, morning and evening relative humidity, rainfall and sunshine were calculated for both the years. It was observed that disease severity had negative and highly significant correlation (-0.675) with maximum temperature, minimum temperature (-0.885), evening relative humidity (-0.826) and rainfall (-0.630) whereas, it had negative and non-significant correlation (-0.030) with morning relative humidity, non-significant and positive correlation with bright sunshine (0.544) during *Kharif* 2019 (Fig. 3). During *Kharif* 2020, disease severity showed negative and highly significant correlation with maximum temperature, minimum temperature and evening relative humidity with corresponding values of -0.980, -0.983 and -0.619, respectively. It had positive correlation with morning relative humidity (0.805) and negative and non-significant correlation with bright sunshine (-0.280) and non-significant and positive correlation with rainfall (0.505) (Fig. 4).

Multiple linear regression (*Kharif* 2019 and 2020)

A multiple linear regression equation was fitted for sheath rot to the data recorded during both the years. The best fit regression equation found to be $Y=139.150-2.300X_1-4.623X_2+0.554X_3-0.235X_4-0.416X_5-0.973X_6$, and $Y=46.074+1.539X_1-4.203X_2+0.026X_3+0.236X_4+6.438X_5-2.204X_6$, during the cropping season of *Kharif* 2019 and 2020, respectively.

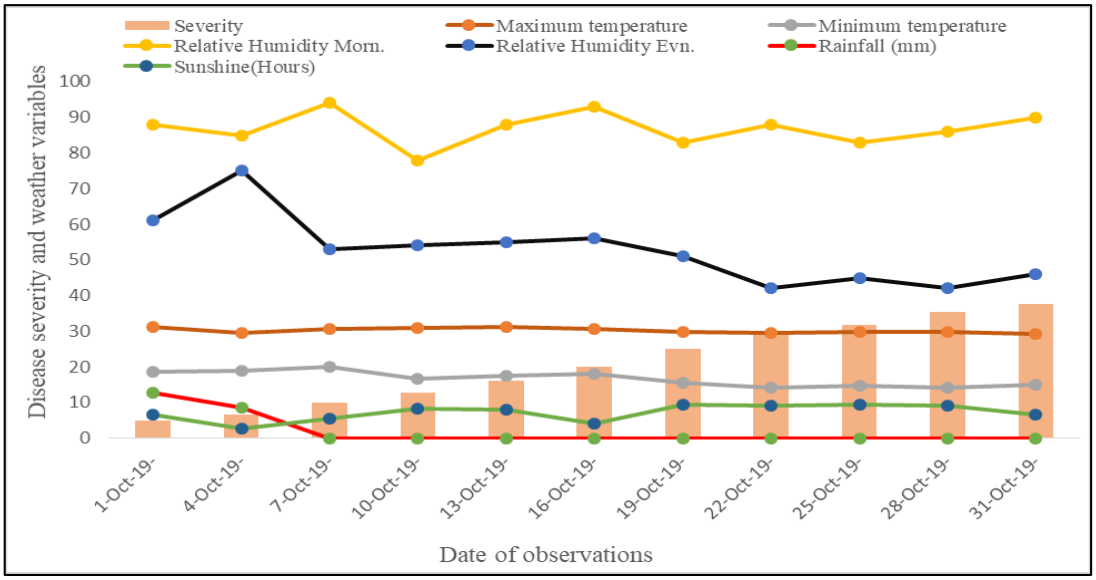


Fig 1: Disease progression of sheath rot of rice in relation to weather parameters during the cropping season of 2019

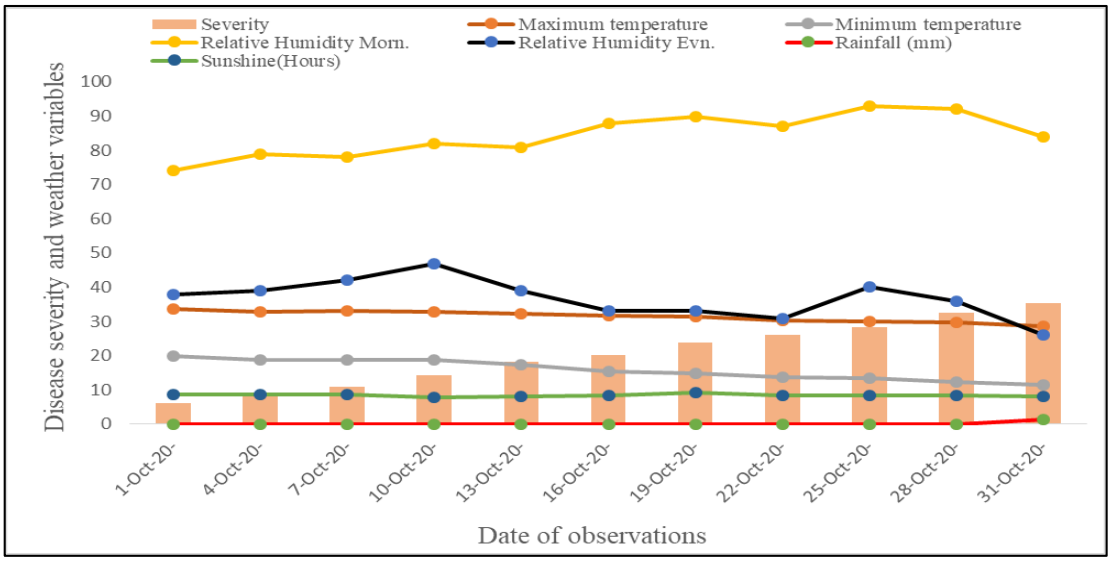


Fig 2: Disease progression of sheath rot of rice in relation to weather factors during the cropping season of 2020

Coefficient of determination (R^2) revealed that selected weather variables contributed upto 96 and 98 per cent towards disease severity during *Kharif* 2019 and 2020, respectively.

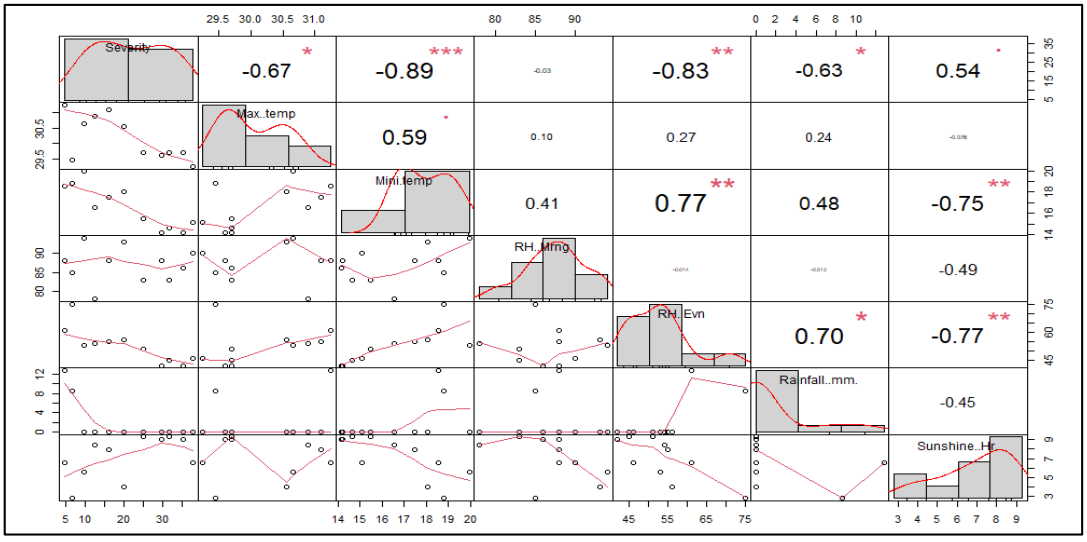
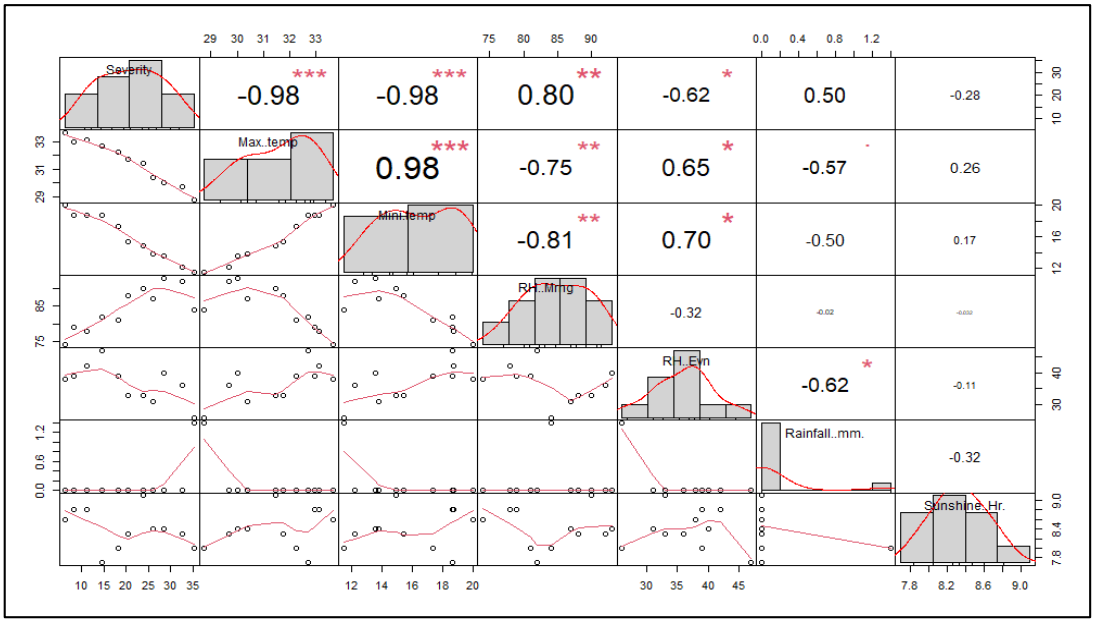


Fig 3: Correlation chart of disease severity with weather parameters during 2019



(Max. temp= maximum temperature, Mini. Temp= minimum temperature, RH. Mrng= relative humidity morning, Rh. Evn.= relative humidity evening)

Fig 4: Correlation chart of disease severity with weather parameters during 2020

Discussion

Weather factors *viz.*, temperature, relative humidity, rainfall and sunshine played a significant role in the progression of rice sheath rot on variety Pusa Basmati 1509. The unit increase or decrease in disease was predicted using regression models.

Weather conditions existing at a specific location for a specific period of time, could impact disease severity. The impact of temperature and relative humidity in the present studies, corroborated the findings of Reddy and Subbaya (1988) [13], who attributed the higher disease incidence to the low temperature and high relative humidity that prevailed during the flowering stages of the crop.

It was observed that the severity of sheath rot had negative and highly significant correlation with maximum and minimum temperature, evening relative humidity and with rainfall during 2019 whereas, during 2020 the relationship between disease severity and weather factors indicated a negative and highly significant correlation with maximum and minimum temperature and evening relative humidity and positive correlation with morning relative humidity. The current findings are in accordance with those of Reddy *et al*. (2001) [14], who reported that relative humidity had a positive correlation with disease index, whereas temperature and sunshine had a negative relationship. In simple correlation, Titaria (2020) [16] found that the disease index of sheath rot was negatively correlated with mean temperature, relative humidity, and rainfall, however in partial correlations, it was positively correlated. The disease development during both the years was due to the prevalence of mean minimum temperature of 16.64 and 15.88 °C, maximum temperature of 30.17 and 31.52 °C, morning relative humidity of 86.91 and 84.36 percent and evening relative humidity of 52.73 and 36.73 per cent, rainfall of 1.95 and 0.13 mm and sunshine hours of 7.14 and 8.40 mm, during 2019 and 2020, respectively. The present results are corroborated by the studies of Sakthivel (2001) who reported that sheath rot thrived well under temperature of 20-30 °C and relative humidity levels of 65-85 percent. Kumar *et al*. (2010) [7] also found that in Bihar, moderate temperature (23-30°C), high relative humidity (85-90%), and light precipitation favoured sheath rot development and spread. In the present study it was concluded that maximum temperature more than 25ºC, minimum temperature more than 15ºC and relative humidity ranging from 80-90 per cent were optimum for the sheath rot development.

Conclusion

The development of sheath rot disease in rice cultivar Pusa Basmati 1509 is greatly influenced by different weather variables like temperature (maximum and minimum), relative humidity (morning and evening), amount of rainfall received at panicle initiation stage during the cropping seasons of *Kharif* 2019 and 2020. Disease severity had negative and highly significant correlation with maximum and minimum temperature and evening relative humidity during both the years. The developed model exhibited that 96 and 98 per cent variation in the disease severity of sheath rot of rice was influenced by selected weather variables.

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