Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 24, No. (2) : 2022 : 335-340
© Global Science Publications
ISSN-0972-3005

DOI No.: http://doi.org/10.53550/AJMBES.2022.v24i02.020

EFFECT OF AGRO-MET CONDITIONS ON THE PROGRESSION OF BROWN LEAF SPOT DISEASE IN BASMATI-370 RICE

SONALI ABROL[1], S. K. SINGH[1], V. B. SINGH[1], UMER BASU*, RANBIR SINGH[1], A. K. SINGH[1],SHAFAT AHMAD AHANGER[2], AMRITPAL MEHTA[1], SARDAR SINGH KAKRALIYA[3], DEVANSHI PANDIT[1], SONALI BHAGAT[1] AND SHEIKH SAIMA KHUSHBOO[3]

[1]Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, 180 009, India
[2]Division of Plant Pathology, FoA, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura Sopore, 193 201, India
[3]Council of Scientific and Industrial Research–Indian Institute of Integrative Medicine (CSIR–IIIM) Jammu and Kashmir, India
*Correspondence: Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, 180 009, India

(Received 13 February, 2022; Accepted 17 March, 2022)

Key words : *Standard Meteorological Week, Disease severity, Brown leaf spot, Correlation, Kharif, Infection rate*

Abstract– Basmati-370 rice variety was used for the present investigation that has a distinct flavor and aroma, along with fine quality and moderately resistant to brown leaf spot. The primary emphasis of the research had been on the impact of climatic variables on brown leaf spot disease progression. The infection was initially identified in the late vegetative stage of each cropping season, *viz*., 2019 and 2020, and reached its peak during the maturity phase. In *Kharif,* 2018 the maximum infection rate (r) was observed during 43rdMSW, whereas, in 2019 maximum infection rate (r) was observed during 39th MSW. The relation between weather factors and disease severity during 2018 designated a significantly negative correlation of -0.928 and -0.903 with maximum and minimum temperature, respectively. Relative humidity (morning) had a significant positive correlation (0.640), but relative humidity (evening), rainfall, and sunlight hours exhibited non-significant negative correlations of -0.505, -0.418, and -0.362, respectively. In 2019, a substantial negative association was found between illness severity and meteorological conditions. A significantly negative correlation of -0.917 and -0.937 with maximum and minimum temperature respectively, was observed. During the kharif, 2019 until the end of agricultural seasons, correlation study of disease progression with relative humidity (morning), relative humidity (evening), sunlight (hr), and rainfall revealed non-significant and negative correlations.

INTRODUCTION

Rice cultivation in Jammu and Kashmir region is mostly monocropped, with a far higher consumption and importance as a staple grain than other Indian states. Rice is highly essential in the lives of people in the state, despite the fact that the area under the crop cultivation is quite small relative to other Indian states, and hence is very significant in the state economy. Rice is susceptible to a variety of fungal infections, many of which can manifest themselves in a severe form and result in significant crop output loss. Brownleaf spot is one of the most common rice fungal infections caused by *Bipolaris oryzae* (teleomorph=*Cochliobolusmiyabeanus*) occupies not only an important position, but is also of historical interest (Abrol *et al*., 2022). The disease has spread throughout the world's rice-growing regions. It has been discovered to be pandemic in locations with high rainfall, such as the Assam, West Bengal, the Malabar Coast and Himalayas. The disease has been also recorded in Africa, Asia, South America and US.

Brown spot in rice, is known to cause major qualitative and quantitative losses (upto 90%) in rice crop, especially when the leaf spotting phase reaches epiphytic dimensions, as it did during the Great Bengal Famine of 1942 (Ghose *et al*., 1960).

Brownleaf spot is more common in situations where water is scarce, and is frequently associated with mineral nutrition deficiencies in plants, particularly nitrogen. Experiments have revealed that the environmental factors have a direct impact in brownleaf spot disease, various epidemiological elements support the survival of causative fungus in soil and seed. The temperature and humidity at which the seeds are stored also effect the viability of the pathogen and significantly affect the disease progress (Mia and Safeeulla, 1998; Dallagnol *et al.*, 2011). However, it has been seen that disease development was suppressed after prolonged exposure to a saturated atmosphere before and after inoculation (Dasgupta and Chattopadhyay, 1977). Brown leaf spot is seldom found in years with enough rainfall, but times with low rainfall but heavy dew becomes prone for outbreaks (Sherf *et al.*, 1947). Pannu *et al*. (2005) found that disease severity was considerably lower in high-rainfall years compared to low-rainfall years, higher leaf wetness spans in the rice canopy have been linked to higher lesion densities (Percich *et al*., 1997).A relative humidity of >89% at 25°C leads to successful inoculation by conidia and infection can be vigorous upon free water on leaf surface. The disease outburst can be recorded to be the maximum in dry soil, least in wet soil and average in moist soil (Ou, 1985). It has been found that brown leaf spot disease can be vigorous lead to enormous yield losses during water shortage/rainfed conditions (Hegde *et al*., 1999). These issues even in the second decade of 21st century are quiet tilled by majority of resource-poor farmers in the world (Zadoks, 1974; Ou, 1985). So, keeping the facts under consideration, the effect of weather on brownleaf spot of rice disease progression during different crop growth stages, the present study was undertaken using rice variety basmati-370.

MATERIALS AND METHODS

Field experiments were piloted during two cropping seasons of *kharif* (2018 and 2019) at Experiential Research Farm, Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu following standard package and practices. Basmati-370 rice variety was used forpresent investigation that has a distinctflavor and aroma, along with fine quality and moderately resistant to brown spot. The facts and figures were obtained at weekly intervals on per cent disease severity on five randomly labelled plants in each sub-plot (10). Disease severity was recorded using a 0-9 scale (Table 1) Standard Evaluation System (SES) for rice to score the amount of leaf areas affected by brown spot and total disease severity was calculated by formulae as mentioned:

$$\text{Per cent Disease Index (PDI)} = \frac{\text{Sum of all disease ratings}}{\text{Total No. of leaves observed x Maximum grade}} \times 100$$

Relative humidity (%), temperature (^{o}C), rainfall (mm) and sunshine (hrs) data were obtained from the corresponding Metrological Station and was correlated with disease progression. OPSTAT and MS Excel softwares were used to determine the simple, partial, and multiple correlation and regression coefficients between disease severity and several meteorological variables throughout disease development.

RESULTS

Symptomatology of brown spot of rice

The incidence of disease shows various types of symptoms in all the stage of crop growth from the seedling to harvesting stage. The characteristic symptoms of brownleaf spot on leaves and glumes include light reddish-brown lesion or lesions with a grey center surrounded by a dark to reddish-brown margin, and then by a bright yellow halo. Brown spots are visible on leaves, sheaths pseudostems and on grains. Spots formed on leaves, sheaths are isolated, oblong or oval, dark purplish-brown and are scattered. The size of the spots ranges from 0.7-19 mm in length and 0.4-5 mm in width (Figure 1). During heavy incidence of disease leaves dry up and blighted appearance exhibited in rice field. During culms infection, it becomes dark brown with smoky dark growth of the fungus. Panicle (neck) infection shows shrunk and discoloration. The head

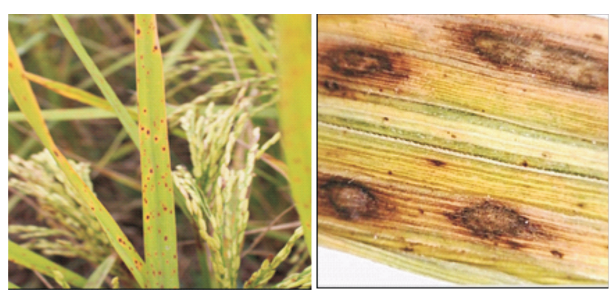

Fig. 1. Symptoms of brown spot disease on leaves of infected rice plant

Table 1. For documenting the severity of brown spots on rice leaves 0-9 scale was used.

Disease score	Description
0	There are no spots
1	On lower leaves, little brown speaks of pin point size
3	A substantial number of small roundish necrotic brown spots, about 1-2 mm in diameter, with a noticeable brown edge, appear on the top leaves
5	Brown patch with a diameter of 3 mm or greater that infects 4-10 per cent of the leaf area
7	Brown spot with a diameter of 3 mm or greater that infects 26-50 per cent of the leaf area
9	A typical susceptible brown spot with a diameter of 3 mm or greater infecting more than 75 per cent of the leaf area

does not emerge completely from the sheath of the boot leaf and bears discoloured, chaffy spikelets. Spikelet infection shows dark brown spots or patches on the lemma and palea. The infected spikelets bear discoloured and shriveled grains. The first appearances of brown leaf spot disease incidence were noted in tested cultivars at 32 DAS in screening nursery. The symptomology studies of the tested cultivars were carried out in the field as well as in laboratory under natural and artificial condition.

Disease development in relation to weather variable

Data presented in Table 2 and Table 3 showed the disease progress in term of severity and infection rate in Basmati-370 on various weather parameter *viz*; relative humidity (morning and evening), temperature (minimum and maximum), rainfall (mm) and sunshine (hr) during cropping season *Kharif,* 2018 and 2019, respectively.

The disease initiated on 38th Standard

Table 2. Effect of weather parameters on disease severity of brown leaf spot of rice during cropping season *Kharif,* 2018.

SMW	Basmati-370		Temperature (ºC)		Relative Humidity(%)		Rainfall (mm)	Bright sunshine (hrs)
	Disease severity (%)	Infection rate(r)	Max.	Min.	Morn.	Even.		
38th	3.81	-	31.31	22.01	86.57	62.57	103.80	6.32
39th	4.91	0.038	31.49	21.61	88.71	60.43	14.80	6.58
40th	6.72	0.047	31.80	18.27	84.00	51.14	0.00	8.30
40th	8.11	0.029	29.94	16.44	73.71	44.00	2.80	5.23
42th	10.33	0.038	30.81	13.89	82.86	36.29	0.80	4.54
43th	16.23	0.074	29.57	12.44	80.86	33.86	0.00	9.11
44th	21.55	0.050	27.87	14.83	88.57	48.57	14.00	4.70
45th	26.76	0.038	26.14	10.03	93.00	44.86	0.00	7.20
46th	33.81	0.051	23.94	9.33	90.29	46.57	0.80	4.84
47th	38.12	0.027	26.63	8.54	94.29	36.14	0.00	4.44

Table 3. Effect of weather parameters on disease severity of brownleaf spot of rice during cropping season *Kharif,* 2019.

SMW	Basmati-370		Temperature(ºC)		Relative Humidity(%)		Rainfall (mm)	Bright sunshine (hrs)
	Disease severity(%)	Infection rate(r)	Max.	Min.	Morn.	Even.		
38th	1.82	-	32.06	22.79	89.00	62.14	57.60	6.89
39th	3.92	0.113	32.10	22.99	89.43	59.86	61.40	7.72
40th	5.21	0.043	29.69	23.13	93.14	75.86	93.40	1.49
40th	7.93	0.064	28.76	18.84	88.57	64.57	21.40	5.36
42th	10.14	0.039	30.53	18.60	86.43	52.86	0.00	8.29
43th	14.54	0.059	29.13	17.33	87.29	52.00	9.20	5.30
44th	19.32	0.049	29.29	14.47	84.57	43.57	0.00	8.89
45th	24.52	0.044	27.99	15.76	89.86	53.71	0.00	4.53
46th	29.72	0.038	25.30	13.04	83.14	51.00	51.80	6.15
47th	33.31	0.024	24.00	13.41	89.86	61.71	2.80	2.78

Meteorological Week (MSW) during both *Kharif* cropping seasons of 2018 and 2019with initial disease severity of 3.81 and 1.82%, respectively. In *Kharif*, 2018 the maximum infection rate (r) was observed during 43rdMSW where it was 0.074 (unit/ day) when weather variables *viz*; temperature; maximum (29.57ºC), minimum (12.44ºC), relative humidity, morning (80.86%), evening (33.86%), rain fall (0.00mm) and sun shine (9.11hr) for the establishment and spread of the disease. Whereas, in 2019 maximum infection rate (r) was 0.113(unit/ day)during 39th when weather variables *viz*; temperature; maximum (32.10), minimum (22.99 and 23.13ºC), relative humidity; morning (89.43%), evening (59.86%), rain fall (61.40mm) and sun shine (7.72hr),was recorded highly promising for the growth, establishment and spread of the pathogen (Figure 2).

Correlation analysis

The effect of individual factors or their combined influence on the progression of brownleaf spot of rice was determined using correlation and regression analysis to determine the association between disease development and meteorological variables.

Simple correlation coefficient

The simple correlation coefficient between disease severity and independent variable *viz*., temperature (maximum and minimum), relative humidity (morning and evening), rainfall (mm) and sunshine (hr) of the time course under investigation were calculated for both the *kharif* seasons of 2018 and 2019. The relation between disease severity and weather factors during 2018 (Table 4) indicated a significantly negative correlation of -0.928 and -0.903 with maximum and minimum temperature, respectively. The significant positive correlation (0.640) was observed with relative humidity (morning), whereas non-significant negative correlation of -0.505, -0.418 and -0.362 was observed with relative humidity (evening), rainfall and sunshine hours, respectively. In 2019 the relationship between disease severity and weather factors (Table 4) indicated a significantly negative correlation of -0.917 and -0.937 with maximum and minimum temperature, respectively. Correlation analysis of disease progression with relative humidity (morning), relative humidity (evening), rainfall and sunshine hours recorded non-significant and negative correlation during *kharif*, 2019 to the end of crop seasons with respective values of -0.379, -0.447, -0.504 and -0.214.

Multiple linear regressions

The multiple linear regression of disease severity with weather parameters *viz*; temperature (maximum and minimum), relative humidity (morning and evening), rainfall (mm) and sunshine (hours) were calculated and the regression coefficients were obtained. The multiple linear regression equation was fitted to the data and the equation derived for the weather parameters are presented in Table 5 during the cropping season of 2018 and 2019. During *kharif*, 2018 and 2019 best fit

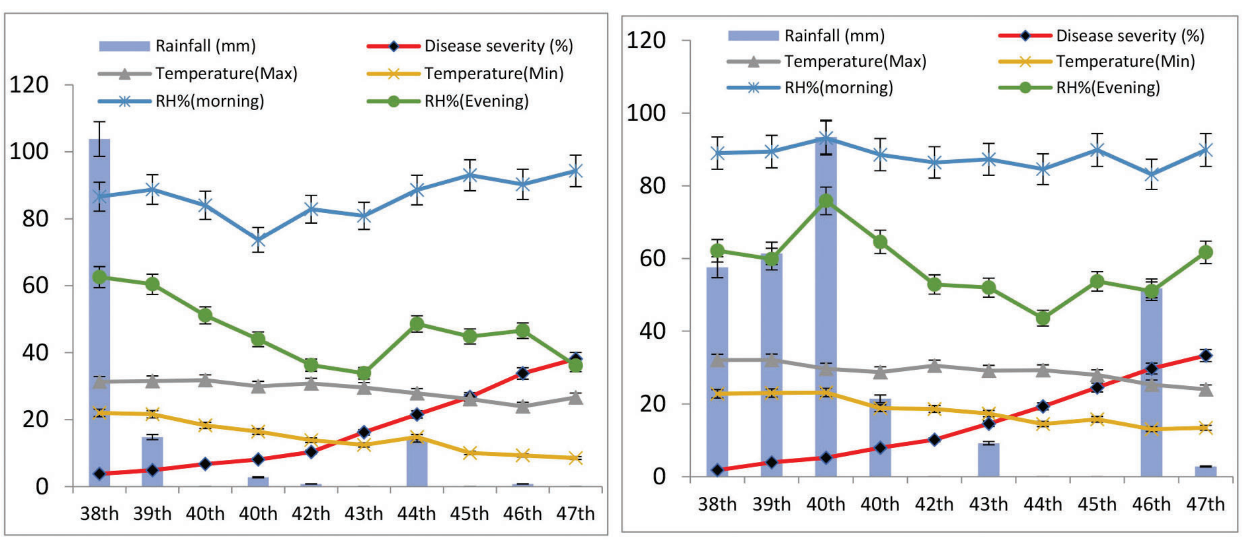

Fig. 2. Variation in disease progression of brown spot of rice due to the effect of weather parameters during cropping season *Kharif*, 2018 (left) and 2019 (right).

Table 4. Correlation between brown leaf spot disease severity and weather parameters during cropping season *Kharif,* 2018 and 2019.

Temperature (°C)		Relative Humidity (%)		Rainfall	Bright Sunshine
Max.	Min.	Morning	Evening	(mm)	(Hrs.)
-0.928**	-0.903**	0.640*	-0.505 ^{NS}	-0.418^{NS}	-0.362^{NS}
-0.917**	-0.937**	-0.379^{NS}	-0.447^{NS}	-0.504^{NS}	-0.214^{NS}

^{Ns} Non-significant values

regression equation for brown leaf spot of rice was found to be $Y=+69.056-3.33X_1+0.517X_2+0.758X_3-0.583X_4-0.001X_5-0.253X_6$ and $Y= -3.388-4.683X_1-0.095X_2+2.286X_3-0.945X_4+0.072X_5+1.101X_6$, respectively. Coefficient of determination (R^2 =0.97) revealed that all the weather variables contributed up to 97 per cent towards disease severity during both cropping seasons of 2018 and 2019.

DISCUSSION

The disease development seemed to depend on prevailing environmental conditions. In general, weather conditions that prevailed during the months of August, September and October were most favorable for the development of brown leaf spot disease. Multiple regression models were fitted for the prediction of disease severity under the given set of environmental circumstances because simple correlation did not show any significant relation between meteorological variables and disease progression.Similar results were observed by Dhaliwal *et al.* (2018) who reported that relative humidity (morning) was positively correlated with brown spot severity. On the contrary, the temperature and disease severity was found negatively correlated with development of brown spot of rice. Furthermore, Biswas *et al.* (2018) studied the role of environmental factors on the development of rice brown spot under the agro-ecological condition of red and lateritic belt of west Bengal during *rabi* season, 2013-2014, and it was observed that environmental factors were most decisive factors for the epidemic development of brown spot disease. They concluded that maximum relative humidity of 80.71 to 85.81% and maximum and minimum temperature from 32.6 to 34.21^{0}C and 23.61 to 26.18^{0}C, respectively were found to be most suitable for the disease development. Similar findings were also reported by Minnatullah and Sattar, and demonstrated that when crop moves from vegetative to reproductive phase, the temperature becomes comparatively cooler and brown spot disease was found to be favored by relatively cooler temperature and wet weather conditions (Minnatullah and Sattar, 2002). Favorable temperatures and relative humidity accompanied by moderate rainfall have been found suitable for maximum increment of PDI in brown leaf spot disease of rice that were similar to our present findings (Biswas *et al*., 2018).

CONCLUSION

It was found that brown leaf spot disease mostly attacks at late vegetative stages and becomes severe from reproductive stage towards maturity affecting the photosynthetic activity where maximum translocation of sugars occurs from leaves to grains and thereby responsible for formation of lightweight shriveled/chaffy grains and reduction in yield. From the present findings it can be concluded that increase in the age of the crop, decrease in maximum and minimum temperatures, and increase in morning and afternoon relative humidity to the end of crop seasons followed by intermittent drizzles will greatly favor the progression of brown leaf spot disease in rice. Data related to meteorological parameters can be used to predict disease epidemic using prediction model and

Table 5. Multiple linear regression of brown leaf spot diseaseduring cropping season *Kharif,* 2018 and 2019.

Regression equation	R^2
$Y=+69.056-3.33X_1+0.517X_2+0.758X_3-0.583X_4-0.001X_5-0.253X_6$	0.97
$Y= -3.388-4.683X_1-0.095X_2+2.286X_3-0.945X_4+0.072X_5+1.101X_6$	0.97

Y= Disease severity, X_1= Maximum Temperature, X_2= Minimum Temperature, X_3=Relative humidity (morning), X_4= Relative humidity (evening), X_5= Rainfall, X_6= Bright Sunshine proper spray scheduling as a disease management practice can be implemented or suggested to farmers to reduce the progression of disease without incurring any extra costs.

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