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Article *in* Journal of Agrometeorology · March 2017

DOI: 10.54386/jam.v19i1.753

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Journal of Agrometeorology 19 (1) : 39-43 (March 2017)

Effect of weather parameters on the initiation and progression of sheath blight of rice

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ABSTRACT

Sheath blight disease is one of the major fungal diseases of rice. Studies on the role of different weather parameters in the initiation and progression of the disease was carried out taking seven weather parameters as independent variables and cumulative and periodical increment in percent disease index as dependent variables. The main aim was to find out the most critical and contributory weather parameter (s) towards development of the disease in west central table land zone of Odisha. The study revealed that a heavy rainfall was conducive for initiation of the disease followed by low and intermittent rainfall of 13 to 38 mm, which was found favourable for progression of the disease. A maximum temperature range of 31^{0}C to 34^{0}C, minimum temperature range of 17^{0}C to 23^{0}C with 70 to 83 per cent evening relative humidity were found favourable for disease development and spread.

Key Words: Rice, sheath blight, weather parameters

Rice (*Oryza sativa* L) is the main food crop of majority of the Indian population. The crop is commonly infected by a number of fungal, bacterial and viral pathogens. Among the fungal diseases sheath blight caused by *Rhizoctonia solani* Kuhn has become one of the important diseases in all the major high yielding rice varieties grown in India. The disease causes enormous loss both in terms of quality and quantity and has a direct effect on yield reduction of rice. The disease is now known to occur in almost all the rice growing states of India causing up to 69% loss in yield (Sivalingham *et al.*, 2006) depending on cultivars, environmental conditions, crop stages at which the disease appears and cultivation practices. Different weather parameters play an important role in initiation and progression of the disease. In recent days, lot of emphasis is being given on weather based forecasting models for prediction of disease outbreak. Hashiba *et al.* (1982) observed that sheath blight disease development was most favourable at a temperature of 28^{0}C and 100% relative humidity with continuous low precipitation during the time of disease development. However the environmental conditions of different regions of the country differ a lot due to their geographical variations. Hence need was felt for thorough understanding on the weather parameters of west central table land zone of Odisha to study the weather relationship of the disease so as to predict, forecast and plan for effective protection measures. Considering the intensity of the disease, the present experiment was undertaken to find out the influence of weather parameters on the initiation and progression of sheath blight disease in west central table land zone of Odisha.

MATERIALS AND METHOD

A field experiment was conducted during two consecutive kharif season (2013 and 2014) at the research farm of All India Coordinated Rice Improvement Project, Regional Research and Technology Transfer Station, Chiplima (20^{0}21'N latitude and 80^{0}55'E longitude with an elevation of 178.8 m above mean sea level), Sambalpur, Odisha.

Sheath blight susceptible variety Swarna (MTU 7029) was sown in a plot size of 50 m^2 with a spacing of 15cm x 20 cm and replicated twice. The recommended dose of fertilizers @ 100: 50: 50 (N: P_2O_5: K_2O) kg ha^{-1} and FYM @ 10 t ha^{-1} were applied. N, P and K were supplied through urea, di-ammonium phosphate and murate of potash, respectively. All the recommended agronomic practices were followed for raising the crop.

Cumulative and periodical disease index

Natural development of the disease was permitted in the field. Three sampling units of 1m^2 was selected in each

Table 1: Development of sheath blight disease (cumulative and periodical increment in PDI) in relation to weather parameters (Pooled of 2013 and 2014)

Standardweek	Crop stage	Cumulative increase in PDI (%)	Periodical increment in PDI (%)	Temperature (^{0}C)		Relative humidity (%)		Total rainfall (mm)	Sunshine hours per day	Daily Wind speed (km h^{-1})
				Max.	Min.	Morning	Evening			
33	Vegetative	0	0	33.6	23.5	92.4	80.1	53.6	4.9	4.9
34	„	0	0	33.7	23.1	91.3	77.9	60.7	4.7	4.1
35	„	0	0	33.5	22.3	92.4	76.6	46.2	4.4	5.6
36	„	0	0	31.8	22.2	94.0	86.4	135.2	3.1	5.1
37	„	2.2	2.2	33.4	22.7	92.0	83.0	100.1	2.6	6.6
38	Reproductive	7.2	5.0	33.7	22.2	93.2	82.0	37.7	4.8	5.1
39	„	12.2	5.0	34.4	22.2	89.7	73.3	23.1	7.0	4.5
40	„	15.0	2.8	33.6	22.3	89.2	75.9	12.7	7.3	4.1
41	„	21.7	6.7	32.7	20.7	89.4	77.9	24.1	5.6	12.6
42	„	25.6	3.9	31.7	19.9	89.9	77.6	25.1	5.1	7.0
43	„	30.6	5.0	30.9	19.0	93.3	76.0	13.1	5.3	4.0
44	Maturity	32.2	1.7	30.7	16.7	91.6	69.8	3.0	7.6	3.0
45	„	32.2	0	30.8	14.5	90.7	67.2	0	9.1	2.0

plot and disease severity was recorded at weekly interval for ten randomly selected plants from each sampling units following SES scale (IRRI, 1996) starting from the initial infection of the disease till terminal disease severity. After scoring the percent disease severity of sheath blight disease, cumulative increase in percent disease index (CIPDI) was calculated following the standard formula

$$\text{CIPDI} = \frac{\text{Sum of all numerical ratings}}{\text{No.of observations X Maxmimum rating}} \text{ X } 100$$

The periodical increment in percent disease index (PIPDI) was also worked out from CIPDI and the weather parameters like maximum and minimum temperature, morning and evening relative humidity percentage, total rainfall in mm, sunshine hours per day and daily wind speed in km h^{-1} were also recorded from the meteorological station of RRTTS, Chiplima for the entire period of experimentation. Data were arranged according to standard meteorological weeks. Multiple regression analysis for prediction of disease severity was worked out to find out the most critical weather parameter(s) contributing much towards the disease severity by taking CIPDI and PIPDI as dependent variables and all the weather parameters as independent variables. All data were statistically analyzed using SPSS software version 21.

RESULTS AND DISCUSSION

Progress of the disease was measured in terms of CIPDI and PIPDI and designated as Y_1 and Y_2 respectively. Mean weather parameters like maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, total rainfall, daily sunshine hours and daily wind speed of 2013 and 2014 were worked out at weekly interval and their pooled values were presented in Table 1.

The data revealed that, disease development and spread was observed from 37th to 45th Standard Meteorological Week (SMW) at average maximum temperature range between 31^{0}C -34^{0}C, morning relative humidity 93 per cent and a total rainfall of 534.5 mm which helped the pathogen infection and further progress of the disease. Bhukal *et al* (2015) reported that a maximum temperature between 31^{0}C to 33^{0}C, minimum temperature between 16^{0}C to 25^{0}C and more than 90 per cent relative humidity play major role in the progression of the disease. The disease initiation was at the later part of vegetative stage i.e., during 37th SMW. PDI values increased significantly and maximum PDI of 32.23 CIPDI was recorded at 44th SMW and disease progression ceased at 45th SMW.

Table 2: Correlation between weather parameters and increment in PDI (cumulative and periodical) in sheath blight disease of rice

Sl.No	Weather parameters	Cumulative increment in PDI	Periodical increment in PDI
1	Maximum temperature	-0.723**	0.124
2	Minimum temperature	-0.873**	0.002
3	Maximum relative humidity	-0.362	-0.347
4	Minimum relative humidity	-0.719**	0.007
5	Rainfall	-0.758**	-0.381
6	Sunshine hours	0.697**	0.076
7	Wind speed	-0.101	0.534

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

Table 3: Multiple regression equation between environmental variables and increment in cumulative and periodical PDI of sheath blight disease of rice

Step	Multiple correlation between	Regression equation	R^2 Value
1	Y_1 and X_1,X_2,X_3,X_4,X_5	$333.695-4.467\ X_1-2.129\ X_2-2.220\ X_3+1.059X_4-0.205\ X_5$	0.949**
2	Y_2 and X_1,X_2,X_4,X_5, X_7	$-51.204+0.856X_1-0.638\ X_2+0.517\ X_4-0.066\ X_5+0.349\ X_7$	0.669*

*Significant at 5% level, ** Significant at 1% level; X_1 =Maximum temperature, X_2 = Minimum temperature, X_3=Morning relative humidity, X_4= Evening relative humidity, X_5=Total rainfall, X_7= Wind speed/day, Y_1= Cumulative increment in PDI, Y_2= Periodical increment in PDI.

Correlation of sheath blight with weather parameters

Different weather parameters played important role in sheath blight development and spread. Correlation between the pooled data of weather variables and disease development presented in Table 2.

Maximum temperature had a significant negative correlation (r= -0.723**) with CIPDI which implies that increase in maximum temperature had a negative influence on progress of the disease and vice versa. During the period the maximum temperature gradually decreased from 34^{0}C to 31^{0}C with the progress of the disease and a maximum CIPDI of 32.23 per cent was recorded on 44th SMW with a maximum temperature of 31^{0}C (Table 1). On the contrary, a non significant positive correlation (r=0.124) was observed between maximum temperature and PIPDI.

A significant negative correlation (r= -0.873**) was observed between minimum temperature and CIPDI. During the period of disease progress i.e., from 37th to 44th SMW, the average minimum temperature gradually decreased from 23^{0}C to 17^{0}C and with the decline of minimum temperature, an increase in CIPDI was noticed. On the other hand, a non significant positive correlation (r= 0.002) was observed between minimum temperature and PIPDI. The highest increment of 6.67% in PIPDI was observed on 41st SMW with an average minimum temperature of 21^{0}C (Table 1).

The relationship of morning relative humidity with CIPDI (r= -0.362) and PIPDI (r= -0.347) was found negative and non significant. A range of 89 per cent to 93 per cent morning relative humidity was found suitable for disease development and spread (Table 1).

Evening relative humidity was found to have a significant negative correlation with CIPDI (r= -0.719**). During initiation of disease at 37th SMW (Table 1), the evening relative humidity was 83 per cent and it declined with advancement of disease. A non significant positive correlation was observed between evening relative humidity and PIPDI (r= 0.007). The maximum PIPDI of 6.67 per cent was recorded with an evening relative humidity of 78 per cent, where as a minimum PIPDI of 1.67 per cent was recorded after reduction of evening relative humidity to 69.8 per cent.

Rainfall was an important factor for sheath blight development. The disease initiated at 37th SMW recording 100 mm rainfall (Table 1) and was preceded by 135 mm total rainfall during 36th SMW which might have made the micro climate more suitable for disease initiation. Therefore, probably heavy rainfall was found favourable for disease initiation. A significant negative correlation (r=-0.758**)

was observed between total rainfall and CIPDI while a non significant negative influence of rainfall was found on PIPDI (r= -0.381) which implies that the cumulative and periodical increment in disease was not increased with the proportion of rainfall. It seems that other weather parameters were also simultaneously responsible for disease progress. A range of 13 to 38 mm of intermittent total rainfall was found favourable for disease spread.

The effect of sunshine hours on CIPDI was significantly positive (r= 0.697**) which means that with increase in daily sunshine hours, the disease also increased due to the production of favourable micro climate within the crop canopy. A non significant positive correlation (r=0.076) was observed between sunshine hours day $^{-1}$ and PIPDI. A range of 2.58 to 7.32 sunshine hour day $^{-1}$ was found suitable for development and spread of sheath blight (Table 1).

Wind speed had non significant negative and positive influence on CIPDI (r=-0.101) and PIPDI (r= 0.534) respectively. The highest periodical increment in PDI (6.67 per cent) was observed when average wind speed was maximum (12.63 km hr^{-1}) during 41st SMW (Table 1). Heavy cyclonic air was blowing at that period coincidentally during both the years of experiment which might facilitated the spread of sclerotia of the fungus and aggravated the disease.

Multiple correlation coefficients

To develop a quantitative relationship between different weather variables and development of sheath blight (CIPDI and PIPDI), coefficient of determination (R^2) was worked out through multiple regression analysis.

Multiple correlation coefficients indicated strong relationship between disease and different weather variables. Multiple regression analysis was performed to handle seven independent weather variables and to identify critical and much contributing weather variable (s) separately towards the dependent variables i.e., CIPDI and PIPDI of sheath blight.

Combined effect of weather variables was found significantly favourable for sheath blight development and spread as indicated by the significant coefficient values of multiple determination. The results of multiple regression analysis for prediction of sheath blight severity was accounted for the linear function involving a negative correlation with all the weather variables except evening relative humidity in case of CIPDI (Table 3). Whereas considering the PIPDI (Table 3), the result of multiple regression analysis revealed a positive correlation with maximum temperature, evening relative humidity and wind speed and negative correlation with other weather factors. The combined effect of these weather parameters had contributed much towards the PDI increment. Highly significant R^2 value (0.949**) was obtained for CIPDI which implies that the weather variables were responsible for up to 94.9 per cent variation in cumulative increase in PDI. Similarly, in case of PIPDI weather variables were responsible for up to 66.9 per cent variation. Out of seven weather parameters, maximum and minimum temperature, evening relative humidity and rainfall were identified as critical parameters through multiple regression analysis and had their positive or negative contributions towards the PDI increment. Maximum and minimum temperature and rainfall had negative correlation with CIPDI. Whereas evening relative humidity had positive correlation with both CIPDI and PIPDI which means that increment of evening relative humidity predicts higher disease severity.

The result of multiple regression analysis indicated that a heavy total rainfall of 135mm and 100mm during 36th and 37th SMW respectively paved the way towards initiation of the disease and a range of 13mm to 38 mm low and intermittent rainfall during the later weeks aggravated the disease. An average minimum temperature of 21^{0}C was found critical for PIPDI. A maximum temperature range of 31 to 34^{0}C and minimum temperature range of 17 to 23^{0}C favoured the disease. Evening relative humidity had a positive contribution towards PDI. PIPDI recorded its minimum value (1.67 per cent) after a sudden fall of evening relative humidity from 76 per cent to 69.8 per cent at 44th SMW and after that with further decrease in evening relative humidity, the increment of the disease ceased at 45th SMW. An average range of 70-83 per cent evening relative humidity was found favourable for disease development and spread. The result is in conformity with Dutta and Kalha (2011) who reported that high and frequent rains with moderate temperature (up to 30^{0}C) coupled with high relative humidity favoured the spread of disease. Biswas *et al* (2012) also identified different agro meteorological parameters responsible for enhancing sheath blight severity in the field and reported that maximum air temperature between 33-34^{0}C and minimum air temperature of 24-26^{0}C coupled with more than 90 per cent relative humidity aggravated the disease development. They also found a strong positive relationship between cumulative rainfall over the season and disease development. Thind *et al* (2008) and Tiwari and Chaure (1997) reported maximum disease development at a temperature range of 25^{0}C to 30^{0}C and relative humidity of more than 80 per cent. Individual

contribution of each environmental factor towards CIPDI and PIPDI played important role on sheath blight development but their combined effect was more likely to help in the process of disease development.

CONCLUSION

So, it can be concluded that heavy rainfall was conducive for initiation of sheath blight disease. Further, a maximum temperature range of 31^{0}C to 34^{0}C and minimum temperature range of 17^{0}C to 23^{0}C coupled with 70% to 83% evening relative humidity were proved to be the critical parameters for disease development.

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Received : July 2016 ; Accepted : January 2017