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# Effect of different meteorological parameters on the development and progression of rice leaf blast disease in western Odisha

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ABSTRACT

Blast disease is one of the most destructive diseases of rice. Epidemiological factors affect greatly on the disease establishment, development and severity resulting in huge crop losses. A field experiment was conducted at All India Co-ordinated Rice Improvement Project, Regional Research and Technology Transfer Station, Chiplima, Sambalpur, Odisha to find out the effect of weather parameters on severity of leaf blast disease during the growing season 2013-14 and 2014-15. The result revealed that both relative humidity and rainfall were positively correlated with leaf blast severity. On the contrary, the temperature and disease severity was found to be negatively correlated which indicated that the disease increased with the decrease of temperature. A maximum relative humidity of 90-95 per cent and total rainfall of more than 280 mm accompanied by $28^0$C temperature were found favourable for disease development and spread. However, still more epidemiological studies are required to strengthen the forecasting and prediction mechanism of the disease which will ultimately minimize the yield losses caused by the disease.

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## INTRODUCTION

Rice is an economically important food crop in India. Among different biotic stresses that limit rice production, blast disease is a major one. The fungus *Magnaporthe grisea* (Hebbert) Barr [anamorph: *Pyricularia grisea* (Cooke) Sacc] is responsible for blast disease and results in a significant yield loss as high as 70-80 per cent during an epidemic (Ou and Nuque, 1985). The fungus can attack the rice plant at all the stages on the leaves, nodes and panicles though leaf infection is more common. Castejon-Munoz (2008) reported the first symptom of blast infection on the leaves and the number of lesions increased as the plant developed. In western Odisha, which is considered as the rice bowl of Odisha, blast is one of the major constraints in rice production. Though the disease can be managed to some extent by using fungicides (Dubey, 2005 and Pal and Mandal, 2015) but chemicals will certainly have some deleterious effect on the soil and environment. Hence, an alternative to chemical control is a must under present scenario. Environmental factors play a key role in blast disease development. Sharma *et al.* (1993) reported that the variation in the intensity of leaf blast disease was correlated with weather parameters. In recent years lot of emphasis are given on the weather based disease prediction models to save the crop from sudden outbreak of the disease. Keeping all these points in view, the present experiment was carried out to find out the most critical weather parameters responsible for the development of leaf blast in western Odisha condition and also to work out prediction equation to facilitate easy forecasting of the disease in order to reduce crop loss.

## MATERIAL AND METHODS

A field experiment was conducted during the *Kharif* season of 2013 and 2014 at the research farm of AICRIP, RRTTS, Chiplima (20° 21'N latitude and 80° 55'E longitude with an elevation of 178.8 m above mean sea level). Rice variety Swarna (MTU 7029) was sown in a plot size of 50 $m^2$ with a spacing of 15 x 20 cm and replicated twice. All the recommended agronomic practices were followed. Natural development of the disease was permitted in the field. Three sampling units of 1$m^2$ was selected in each plot and disease severity was recorded at weekly interval for ten randomly selected plants from each sampling units following 0-9 SES scale (Anonymous, 2002) starting from the initial infection of the disease till terminal disease severity. After scoring the per cent disease severity of leaf blast disease, per cent disease index (PDI) was calculated following standard formula given by Mckinny (1923).

$$PDI = \frac{\text{Sum of all numerical ratings}}{\text{No. of observations x maximum rating}} \text{x100}$$

The weather parameters like maximum and minimum temperature, maximum and minimum relative humidity percentage and rainfall in mm were also recorded from the meteorological station of AICRPWM, RRTTS,Chiplima for the entire period of experimentation. Data were arranged according to standard meteorological weeks and simple correlation co-efficient among any pair of the weather variables was worked out. Multiple regression analysis for prediction of disease severity was also done to find out the most critical weather parameter(s) contributing much towards the disease severity. All data were statistically analyzed using SPSS software version 19.

## RESULTS AND DISCUSSION

The per cent disease index (PDI) and mean weather parameters like maximum temperature, minimum temperature, maximum relative humidity (RH), minimum RH and total rainfall of 2013 and 2014 were worked out at weekly interval and presented in Table 1 and 3. Taking PDI and five weather variables *viz.*, maximum temperature ($X_1$), minimum temperature ($X_2$), maximum RH ($X_3$), minimum RH ($X_4$) and total rainfall ($X_5$) in consideration, two simple correlation matrices were worked out (Table 2 and 4).

During 2013, disease development and spread was observed between 37th to 44th standard meteorological week (SMW). During this period, the average

**Table 1: Development of leaf blast in relation to weather parameters during 2013**

| SMW | PDI | Max. temp | Min. temp | Max. RH | Min. RH | Total rainfall |
|---|---|---|---|---|---|---|
| 36 | 0 | 32.86 | 25.57 | 93.14 | 87.00 | 20.00 |
| 37 | 3.33 | 33.71 | 26.00 | 92.00 | 86.71 | 64.70 |
| 38 | 8.89 | 32.71 | 24.86 | 94.29 | 88.00 | 53.20 |
| 39 | 15.56 | 33.14 | 26.29 | 92.86 | 80.86 | 20.20 |
| 40 | 20.00 | 31.14 | 26.86 | 92.57 | 84.71 | 25.30 |
| 41 | 26.67 | 29.71 | 24.00 | 94.29 | 87.00 | 42.10 |
| 42 | 30.00 | 28.00 | 22.57 | 92.00 | 85.43 | 31.00 |
| 43 | 35.56 | 27.29 | 23.43 | 95.43 | 89.71 | 26.10 |
| 44 | 37.78 | 28.86 | 20.29 | 92.14 | 79.57 | 0 |

temperature ranged between 27 - 33°C and maximum RH reached 95 per cent with a total rainfall of 282.6 mm. During 2014, the disease severity was recorded within the max temperature range of 31-35°C with a maximum RH of 91 per cent during 42nd to 48th SMW. Rainfall was scanty in 2014 and in general, the disease severity was less as compared to 2013.

During both the years of study (2013 and 2014), PDI values exhibited gradual increasing trend with the advancement of dates of observation and maximum PDI was recorded after 40th SMW when maximum temperature was in the range of 27- 35°C and maximum RH was more than 90 per cent.

**Correlation with weather factor :**

From Table 2 it was evident that, during *Kharif*, 2013 max RH (r = 1.161**) was positively and significantly correlated with PDI but max temp (r = - 0.918*) and min temp (r = - 0.747*) were significantly but negatively correlated with PDI. Moreover, max temp (r = 0.742*) exhibited significant positive relationship with min temp. During 2014 also (Table 4), almost similar trend was noticed where max temp (r = -0.877**) and min temp (r = - 0.947**) had significant negative correlation with PDI whereas a non-significant positive correlation between max RH and PDI was observed. A significant positive relationship between rainfall and min RH (r = 0.714*) was also observed which indicated that increment of rainfall increase the RH. So, it can be said that, increase in rainfall leads to increase in RH and ultimately increasing the PDI value. This finding is in conformity with Lee *et al*. (2005) who also reported high humidity and frequent rainfall create environmental conditions conducive for rice blast infection.

Correlation co-efficients of different weather factors with leaf blast disease development revealed that, the max temp had significant negative correlation with disease severity whereas max RH had significant positive correlation with disease severity in 2013 but in 2014, a non-significant positive correlation was observed between max RH and disease severity.

**Multiple correlation co-efficients :**

Multiple correlation co-efficients during 2013 and 2014 indicated strong relationship between disease and some weather variables. Multiple regression analysis was performed to handle five independent weather variables and to identify critical and much contributing weather variable (s) separately towards the dependent variables *viz*., PDI of leaf blast disease. During 2013, results of the multiple regression analysis for prediction of leaf blast disease severity was accounted for the linear function

**Table 2 : Simple correlation matrix between environmental variables and per cent disease index (PDI) of leaf blast disease during 2013**

| | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | Y |
|---|---|---|---|---|---|---|
| $X_1$ | 1.000 | | | | | |
| $X_2$ | 0.742* | 1.000 | | | | |
| $X_3$ | -0.260 | 0.013 | 1.000 | | | |
| $X_4$ | -0.069 | 0.252 | 0.642 | 1.000 | | |
| $X_5$ | 0.414 | 0.445 | 0.136 | 0.614 | 1.000 | |
| Y | -0.918** | -0.747* | 1.161** | -0.242 | -0.511 | 1.000 |

$X_1$ =Maximum temperature, $X_2$ = Minimum temperature, $X_3$=Maximum relative humidity, $X_4$= Minimum relative humidity, $X_5$=Total rainfall, Y = Per cent disease index. * and ** indicate significance of values at P=0.05 and 0.01, respectively

**Table 3: Development of leaf blast in relation to weather parameters during 2014**

| SMW | PDI | Max. temp | Min. temp | Max. RH | Min. RH | Total rainfall |
|---|---|---|---|---|---|---|
| 41 | 0 | 36.00 | 17.43 | 84.57 | 68.71 | 6.00 |
| 42 | 5.56 | 35.29 | 17.14 | 87.71 | 69.71 | 19.10 |
| 43 | 8.89 | 34.57 | 14.57 | 91.14 | 62.29 | 0 |
| 44 | 10.00 | 32.57 | 13.14 | 91.00 | 60.00 | 6.00 |
| 45 | 16.67 | 32.29 | 9.71 | 90.57 | 47.71 | 0 |
| 46 | 21.11 | 33.57 | 11.71 | 90.14 | 56.29 | 0 |
| 47 | 25.56 | 31.57 | 6.43 | 89.71 | 47.14 | 0 |
| 48 | 25.56 | 31.29 | 5.43 | 90.57 | 44.71 | 0 |

involving a positive relation with max RH and rainfall and a negative correlation with max temp (Table 5).

So the representative best fitted multiple regression equation during 2013 was :

$$Y^* = 131.635 - 6.208\ X_1^{**} + 0.720\ X_2 + 3.314\ X_3^{**} - 2.966\ X_4^{**} + 0.205\ X_5^{**}$$

Out of five weather parameters considered for studying their influence on the increment of disease severity, maximum RH, rainfall and maximum temperature were identified as critical parameters through multiple regression analysis and had their significant positive or negative contributions towards the PDI increment. Max RH and rainfall had significant positive correlation with PDI which means that increment of maximum RH and rainfall predicts higher disease severity taking care of 97.6 per cent variation out of total variation of 99.1 per cent. A maximum RH of 90-95 per cent and total rainfall of more than 280 mm was found favourable for disease development. Tiwari and Chaure (1997) also found significant positive correlation between leaf blast disease and rainfall.

Maximum temperature was found to have significant negative correlation with PDI. This could be possibly due to the agro ecological zone of the study area as the ambient temperature of the zone was in the range of 34-35°C during the earlier months of the experiment which was not favourable for disease development. And afterwards due to continuous rainfall, the temperature gradually decreased to 28°C which was found suitable for the disease. This finding about the role of max temperature on disease severity has similarities with the findings of Lou *et al.* (1995) who reported that increase of temperature resulted in greater risk of blast epidemic in cool sub tropical zones where as the situation was found opposite in case of humid tropics and warm humid sub tropics where lower temperature resulted in greater risk of blast epidemics. Shafaullah *et al.* (2011) also indicated that blast disease incidence increases with the decrease of temperature. Neetam *et al.* (2014) revealed that average minimum and maximum temperatures of 21°C and 29 °C, respectively and 70-81 per cent relative humidity were the most important factors favouring blast disease development. They also indicated that decrease in temperature and increase in humidity favour the disease development and may cause epidemic of leaf blast which collaborate with the present findings. Minimum temperature of 20°C or below to 22.3°C depending on locations along with high relative humidity had been reported for maximum blast development by a number of other scientists (Govindaswamy, 1964; Murlidaran and Venkata Rao, 1980 and Sharma *et al.*, 1993).

During 2014, results of the multiple regression analysis for prediction of leaf blast disease severity along with the calculation of co-efficient of multiple determination ($R^2$) revealed that, 90.5 per cent of total

**Table 4 : Simple correlation matrix between environmental variables and per cent disease index (PDI) of leaf blast disease during 2014**

| | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | Y |
|---|---|---|---|---|---|---|
| $X_1$ | 1.000 | | | | | |
| $X_2$ | 0.446 | 1.000 | | | | |
| $X_3$ | -0.701 | -0.576 | 1.000 | | | |
| $X_4$ | 0.937** | 0.978** | -0.605 | 1.000 | | |
| $X_5$ | 0.570 | 0.655 | -0.498 | 0.714* | 1.000 | |
| Y | -0.877** | -0.947** | 0.617 | -0.914** | -0.613 | 1.000 |

$X_1$ =Maximum temperature, $X_2$ = Minimum temperature, $X_3$=Maximum relative humidity, $X_4$= Minimum relative humidity, $X_5$=Total rainfall, Y = Per cent disease index * and ** indicate significance of values at P=0.05 and 0.01, respectively

**Table 5 : Multiple regression equation for prediction of leaf blast disease severity**

| Year | Regression equation | COD-$R^2$ | Adj $R^2$ | Multi R | SEE |
|---|---|---|---|---|---|
| 2013 | $Y^{**}=131.635-6.208X_1^{**}+0.720X_2+3.314X_3^{**}-2.966X_4^{**}+0.205X_5^{**}$ | 0.991 | 0.976 | 0.995 | 2.143 |
| 2014 | $Y_2^{*}= -174.485+3.550X_1-3.126X_2^{*} +1.194X_3+0.181X_5$ | 0.930 | 0.837 | 0.964 | 3.840 |
| | $Y_3^{**}= -130.934+2.769X_1-2.734X_2^{*} +0.954X_3$ | 0.923 | 0.865 | 0.961 | 3.502 |
| | $Y_4^{**} = -3.684-1.864X_2^{**}+0.449X_3$ | 0.905 | 0.867 | 0.951 | 3.476 |

COD = Co-efficient of determination, $R^2$ = R squared, Adj $R^2$ = Adjusted $R^2$, Multi R = Multiple regression, SEE = Standard error of estimate
* and ** indicate significance of values at P=0.05 and 0.01, respectively

93.0 per cent variations existing in the regression analysis of disease severity can be accounted for the linear function involving minimum temperature and maximum RH (Table 5). The combined effect of these two weather parameters, identified as critical, contributed much towards the PDI increment. The representative and best fitted multiple regression equation appeared in 2014 was:

$$Y_4^{**} = -3.684 - 1.864X_2^{**} + 0.449X_3$$

The non-significant positive correlation between max RH and disease severity during 2014 could be possibly due to adverse effect of other factors like less total rainfall (31.1 mm) and high temperature (31-35$^{o}$C) during the experimental period.

It was evident from the studies of simple correlation co-efficient between weather parameters and PDI that, maximum RH and rainfall were positively and significantly correlated with PDI *i.e.*, the increment of rainfall and max RH enhanced leaf blast disease. Whereas, maximum temperature was found to be significantly negatively correlated with the PDI value which means that augmentation of maximum temperature have negative effect on disease development and as the temperature gradually decreases from 35$^{o}$C to 28$^{o}$C, the disease progresses. Vishwanath and Channamma (1988) also explained that the blast pathogen prefers low temperature with high humidity and heavy rainfall for outbreaks. Bhatt and Chauhan (1985) observed that minimum temperature, more number of rainy days, higher rainfall and relative humidity were the most important factors favouring blast development. An average minimum and maximum temperature of 22$^{o}$C and 29$^{o}$C, respectively with 85 - 99 per cent RH was favourable for disease development in Madhya Pradesh, India (Patel and Tripathi 1998 and Pall, 1988). Jain *et al.* (1994) also reported that moderate temperatures between 21$^{o}$C to 29$^{o}$C with more than 80 per cent mean atmospheric relative humidity during reproductive period favoured the disease development which is in conformity with the present finding.

The equations can be considered as prototype model rendering a baseline for future improvement in leaf blast disease forecasting. Calvero *et al.* (1996) analyzed that regression equations can be used as empirical model to predict rice blast disease caused by *Pyricularia oryzae*. Thus, the prediction equations of both the year of investigation can be used for forecasting leaf blast disease severity in the zone and can be utilized as a component of integrated disease management programme by minimizing chemical spray for the control of the disease. However, its practical utility in other area needs further investigation since such predictions cannot be utilized across its limitations. For more accurate prediction, other meteorological and biological variables of host and pathogen need to be considered.

Thus, it can be concluded from the experimental results that, out of five independent weather variables considered for prediction of disease severity *i.e.*, dependent variable, maximum RH, rainfall and maximum temperature were identified as critical weather parameters following multiple regression analysis. The five selected independent variables were positively, negatively or partially correlated with disease severity. Maximum RH and rain fall exhibited significant positive effect on disease severity but maximum temperature increment caused significant negative contribution towards the disease.

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