Statistical weather based forewarning model for rice leaf blast

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ABSTRACT

*Rice is the second largest grown cereal crop in the world and the most commonly consumed main staple meal. Rice blast is the most devastating rice disease, resulting in large annual losses. A pot experiment was conducted at Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore, during 2018-19, 2019-20, 2020-21, and 2021-22 Rabi seasons, with an objective of investigating the possible role of weather variables on rice leaf blast and developing the forewarning model. Research analysis performed in this study through correlation analysis was carried under R studio helped to know the relation between weather parameters and per cent disease index (PDI) of leaf blast, which revealed that minimum temperature (X_2, r = 0.68**), grass minimum temperature (X_2, r = 0.68**), morning dew point temperature (X_4, r = 0.69**) and afternoon dew point temperature (X_5, r = 0.67**) having highly negative significant correlation. The rainfall and afternoon relative humidity were showed highly positively significant correlation (X_7, r = 0.43** and X_9, r = 0.42**). The enter multiple linear and stepwise regression equation was developed for predicting in real-time has R^2 = 0.75 and 0.72 these weather variables can be employed for weather-based disease forewarning against rice leaf blast and helps farmers to minimums the loses.*

Key words: *Rice, Leaf blast, weather variables, forewarning model.*

INTRODUCTION

Rice (*Oryza sativa* L.), is one of the main stable food crops globally after wheat, and more than 50 per cent of world's population depends on it. Paddy cultivation covers almost one-fourth of the total Indian cropped area and almost half of the Indian population are rice consumers. Tamil Nadu, one of the leading paddy growing states in India, out of 59.42 lakh hectares of Gross Cropped area in Tamil Nadu, rice occupied more than 20.5 lakh hectares (29 per cent) per year with an average annual production of 7.18 million tonnes and highest average productivity of 3,494 kg/ha (Anonymous, 2019). Rice blast disease has the potential to cause severe damage in crop losses under favorable environmental conditions (Padmanabhan *et al.*, 1971). Yield reduction due to rice blast disease exceeds 50% over large areas in some parts of the world include India (Zeng *et al.*, 2009) and in individual fields reduction was reported in the range between 20 to 60% in the southern United States and India. The higher sporulation potential of blast occurs at 20 °C with relative humidity of 89 % and above (Kato, 1974; Kato and Kozaka, 1974).

Understanding the influence of weather factors on host-disease stage and development is prerequisite to strategically manage leaf blast disease. In view of the importance of weather influence on rice leaf blast occurrence and spread, the results discussed in this paper.

MATERIAL AND METHODS

Study area

The experimental field study was conducted at Paddy Breeding Station (PBS) (11.0168° N, 76.9558° E), Tamil Nadu Agricultural University, Coimbatore during four *Rabi* seasons *viz.*, 2018-19, 2019-20, 2020-21, 2021-22. The study area receives an average annual rainfall of 694 mm of which more than 80 per cent is received from Northeast monsoonal rainfall. The variety chosen for this study is CO 39. Data on leaf blast disease incidence was recorded during *Rabi* season at weekly interval from the initiation of disease occurrence to till the maturity of crops. The location of study area map is presented in Figure 1.

The random plants were selected to obtain the rice leaf blast disease incidence grade. The observation was made at weekly interval and disease incidence was calculated by using below given formula which suggested by Wheeler's, 1969.

$$PDI = \frac{\text{Sum of numerical ratings}}{\text{Total number of leaves scored} \times \text{maximum rating}} \times 100 \quad \text{----------}$$

Equation 1

Leaf blast disease were scored on 0 to 9 scale, a standard evaluation scale system for rice which is given by International Rice Research Institute, Philippines (IRRI, 2013). The detailed information about the scoring scale is given in Table 1. The daily weather data on meteorological observations measured at the Agrometeorological Observatory were collected from Agro Climate Research Centre, TNU Coimbatore (Table 2)

All necessary weather parameters were recorded on daily basis from sowing day to till panicle emergence and weekly means were calculated and summation weekly rainfall and dew recordings Correlation between Percent Disease Infestation (PDI) and weather variables was computed by using R studio through library corr and regression analysis also performed.

RESULTS AND DISCUSSION

The real time correlation was analysis (Table 3) by using all the four years data from 2018-2022 with 11 weather variables combined showed that the maximum temperature (0.36) and sunshine hours (0.13) was negatively correlated and minimum temperature (0.68**), grass minimum temperature (0.68**), morning dew point temperature (0.69**) and afternoon dew point temperature (0.67**) were showed highly negative significant correlation. The morning relative humidity (0.21), evaporation (0.31), dew (0.09) was positive correlated and afternoon relative humidity (0.43**), rainfall (0.42**) was showed highly positively significant correlation. According to Govindaswamy (1964), minimum temperature is key factor for blast incidence and development, and it is negatively correlated with PDI.

Models for disease forewarning

The statistical model through regression analysis was performed using the per cent disease index data of rice leaf blast disease collected at seven days interval and the weather variables data collected on corresponding days. Perusal of Table 4 indicates that the11 weather variables collectively account for 75 % variability in rice leaf blast disease incidence (R^2: 0.75).

In order to optimize the weather variables, step-wise regression procedure was adopted. It is noticed the selected three variables *viz*., afternoon dew point temperature, morning dew point temperature, evaporation, dew explained the variability in rice leaf blast disease incidence (R^2: 0.72). The dynamic cumulative weather-based index for forewarning of rice blast by DWBLA and DCWBI weather elements has shown R^2 = 85 % (Reddy *et al.*, 2006).

CONCLUSION

The results obtained from the data concluded that the incidence and development of rice leaf blast is mainly influenced by minimum temperature, grass minimum temperature, morning dew point temperature, afternoon dew point temperature, afternoon relative humidity and rainfall like drizzling more than two days with lower temperature leads to outbreak of leaf blast. By looking to close relationship between weather and leaf blast disease. The forwarding model has been developed for timely and effective control of disease.

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Table 1. Rice Leaf Blast Score details

Score Rating	Description
0	No lesions observed
1	Small brown specks of pin-point size or larger brown specks without sporulating center
2	Small roundish to slightly elongated, necrotic gray spots, about 1-2 mm in diameter, with a distinct brown margin. Lesions are mostly found on the lower leaves.
3	Lesion type is the same as in scale 2, but a significant number of lesions are on the upper leaves
4	Typical susceptible blast lesions2 3 mm or longer, infecting less than 4% of the leaf area
5	Typical blast lesions infecting 4-10% of the leaf area
6	Typical blast lesions infection 11-25% of the leaf area
7	Typical blast lesions infection 26-50% of the leaf area
8	Typical blast lesions infection 51-75% of the leaf area and many leaves are dead
9	More than 75% leaf area affected

Table 2. Weather variables used in the analysis

Weather variable	Description	Units
X_1	Maximum temperature	℃
X_2	Minimum temperature	℃
X_3	Grass Minimum temperature	℃
X_4	Morning Dew point temperature	℃
X_5	Afternoon Dew point temperature	℃
X_6	Morning Relative Humidity	%
X_7	Afternoon Relative Humidity	%
X_8	Sunshine hours	hr
X_9	Rainfall	mm
X_{10}	Evaporation	mm
X_{11}	Dew	mm

Table 3. Correlation coefficient matrix between per cent disease index (PDI) of Rice leaf blast and weather parameters.

Weather variable	Real-time correlation
X_1	-0.36
X_2	-0.68**
X_3	-0.68**
X_4	-0.69**
X_5	-0.67**
X_6	0.21
X_7	0.43**
X_8	-0.13
X_9	0.42**
X_{10}	0.31
X_{11}	-0.09

Note: *values are significant at 5 % level of significance and **values are significant at 1 % level of significance.

Table 4. Real time model for rice leaf blast disease

Model	Enter multiple linear regression equations	R^2
Real-time	$Y = 194.86-1.08X_1-0.38X_2-1.15X_3-4.95X_4-0.96X_5+1.37X_6 -0.20X_7+2.14X_8-0.09X_9-21.04X_{10}-10.36X_{11}$	0.75
Stepwise multiple linear regression equations		
	$Y = 298.3-5.80X_4-23.60X_{10}-2.76X_5-9.96X_{11}+2.45X_{10}$	0.72

Where, Y = PDI, X_1 = maximum temperature, X_2 = minimum temperature, X_3 = grass minimum temperature, X_4 = morning dew point temperature, X_5 = afternoon dew point temperature, X_6 = morning relative humidity, X_7 = afternoon relative humidity, X_8 = sunshine hours, X_9 = rainfall, X_{10} = evaporation, X_{11} = dew.

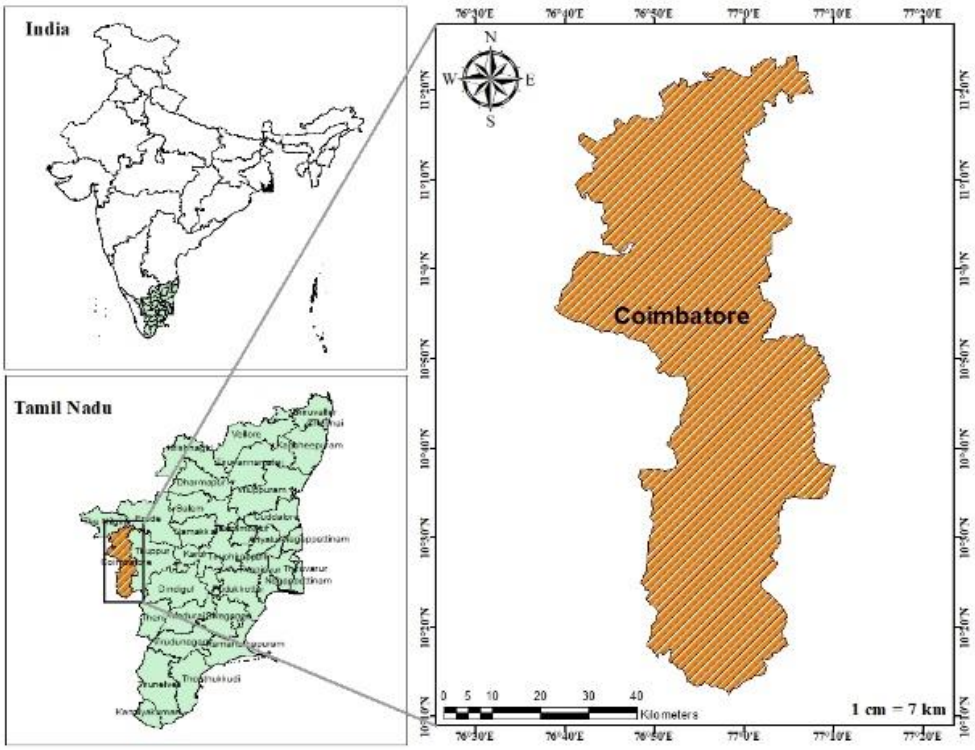

Figure 1: Study area