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Dynamic cumulative weather based index for forewarning of rice blast

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ABSTRACT

An attempt was made to develop disease forewarning model by following a novel approach. Each weather variable is assigned weigtage based on their relative importance to the disease initiation and spread. A new Dynamic Cumulative Weather Based Index (DCWBI) was derived and validated in two locations viz., Palampur and Hyderabad using the available long-term historical data. A multiple linear regression equation was developed for predicting blast severity one week in advance by taking DWBLA and DCWBI as independent variables. The prediction model was validated using independent data sets at two locations.

Key words: Rice blast, weather indices, forewarning.

Rice (*Oryza sativa* L.), the principle staple food crop in India, grown in 44.62 million hectares with annual production of 93.08 million tons. The projected demand for rice is expected to be 100 million tons during 2010 and 140 million tons by 2025 (Mishra, 2002). Therefore, the major challenge in the years to come is to increase the rice productivity from the present level of 2.07 t ha^{-1} to more than 3 t ha^{-1}. To achieve this goal, the losses due to abiotic and biotic stresses have to be tackled. Diseases caused by plethora of microorganisms take a heavy toll of the crop in the humid tropical rice-growing environment. While an average yield loss span from 5 to 15 % over large areas, total crop failure due to pests and disease epidemic is regularly encountered in some or the other part of the country. Of the various diseases of rice, blast caused by *Pyricularia grisea* Sacc. {*Magnaporthe grisea* (Hebert) Barr.} is one of the most destructive diseases and is widely prevalent in India. Further, it is a major limiting factor in stepping up rice yields in plains and hills of the country. It continues to be the enigmatic problem in several rice growing ecosystems of both tropical and temperate regions of the world.

The intensity of blast infection is greatly influenced by the environment and the variety of the rice grown. Extensive studies on the role of temperature and humidity have been made and concomitant occurrence of temperature of 20 to 24°C and a relative humidity of 90 % was considered favourable for the development of blast of rice (Padmanabhan, 1953; Sadasivan *et al.* 1965; Chakrabarti, 1971). According to them resistance to blast is governed not only by genetic factors but also to a large extent by a set of very critical environmental factors including night temperature (20°C) which influence the metabolic pattern of the host. Manibhushanrao and Day (1972) also reported that low temperatures result in partial breakdown of resistance. These findings showed good correlation with field incidences of blast (Govindaswamy, 1964; Padmanabhan, 1965). The occurrence of a minimum temperature ranging from 20 to 25°C along with humidity of 95% and above lasting for a week or more during any of the susceptible growth phases of the crop was found to be associated with the blast epidemic (Padmanabhan *et al.*, 1971). Venkat Rao and Muralidharan (1982) observed rapid development of blast at tillering and heading stages coinciding with low temperature (20°C or less) and high relative humidity (90% or above) at these two vulnerable stages of the crop. According to Kaur *et al* (1977) temperature influenced both penetration and establishment phases, and particularly appeared to be more critical in case of susceptible variety at 25°C. Majority of authors stressed that temperature, humidity, rainfall and cloudiness are major factors for the development of the blast in rice crop. In our study, we have attempted a novel approach to develop simple and dynamic weather indices to forecast the disease incidence one week in advance.

MATERIALS AND METHODS

After an extensive review of literature on the conducive weather factors for rice blast disease, weights ranging from 0-5 were assigned to various weather parameters (except for rainy days for which it is 0-1) depending on the relative importance of each weather variable for disease initiation and development. (Table-1). The total possible weights for each individual weather parameter would be 6 except for rainy day, for which it will be 2. Therefore the total possible weights of all weather parameter put together for a seven days window will be 266 (38*7). The daily weather parameters that were recorded starting from the date of sowing were assigned weightages as described above.

A Dynamic Cumulative Weather Based Index (DCWBI) of Blast of the following form was developed.

DCWBI for jth day

$$= \frac{\Sigma\,(MaxT\_Wj + MinT\_Wj + MRH\_Wj + ERH\_Wj + RF\_Wj + RD\_Wj + SSH\_Wj)}{\text{Total possible weights}}$$

Where,

DCWBI = Dynamic Cumulative Weather

Table 1 : Weights of weather parameters based on their possible ranges

Weight	MaxT (°C)	MinT (°C)	MRH (%)	ERH (%)	RF (mm)	RD	SSH
5	<25.0	<19	> 90	>70	> 20	-	<1
4	25.1-26.0	19-21	85-90	65-70	16-20	-	1-2
3	26.1-27.0	21.1-23	80-84	60-64	10-15	-	2-3
2	27.1-28.0	23.1-24.0	76-79	50-59	6-9	-	3-4
1	28.1-29.0	24.1-25.0	70-75	40-49	1-5	Rain	4-5
0	> 29.0	> 25	<70	< 40	0	No rain	>5

Table 2: Disease initiation and DCWBI at Palampur

Date of Initiation of blast	% Blast	DCWBI up to 3 weeks prior to initiation			
		0	1	2	3
25-Jul-91	0.40	0.49	0.43	0.24	0.15
20-Jul-92	1.00	0.53	0.45	0.32	0.27
23-Jul-93	0.04	0.62	0.62	0.45	0.20
21-Jul-94	0.05	0.55	0.52	0.60	0.51
29-Jul-95	1.00	0.61	0.56	0.61	0.54
22-Jul-96	0.20	0.40	0.54	0.42	0.50
27-Jul-97	2.22	0.61	0.59	0.59	0.27
31-Jul-98	1.95	0.47	0.42	0.48	0.49
22-Jul-99	1.42	0.64	0.49	0.39	0.49
02-Aug-00	0.02	0.52	0.57	0.57	0.50

Based Index amd Wj is weight of weather parameter of J[th] day

where MaxT is maximum temperature, MinT is minimum temperature, MRH is morning relative humidity, ERH is evening relative humidity temperature, RF is rainfall RD is rainy day and SSH is bright sunshine hours

The DCWBI were calculated regularly for each week using the daily weather data from date of sowing. The DCWBI values lies between 0 and 1. This DCWBI was validated with ten years (1991- 2000) of historical blast data from HPKV, Palampur and four years data (2001-2004) form Directorate of Rice Research, Hyderabad.

Then Dynamic Weight of Blast

Table 3: Initiation blast and DCWBI values at DRR, Hyderabad during 2001-2004

Date of Initiation of blast	% Blast	DCWBI up to 3 weeks prior to initiation			
		0	1	2	3
28-8-2004	1.3	0.48	0.26	0.32	0.41
30-8-2003	0.35	0.51	50	0.50	0.35
16-9-2002	0.21	0.53	51	0.43	0.21
19-8-2001	1.9	0.51	52	0.40	0.28

Table 4: Correlation coefficients between blast and DWBLA up to 3 weeks lag

	Blast	DWBLA	DWBLA_1	DWBLA_2	DWBLA_3
Blast	1.00	0.96*	0.92*	0.78*	0.78*
DWBLA	0.96*	1.00	0.87*	0.65*	0.65*
DWBLA_1	0.92*	0.87*	1.00	0.84*	0.83*
DWBLA_2	0.78*	0.65*	0.84*	1.00	1.00*
DWBLA_3	0.78*	0.65*	0.83*	1.00*	1.00

* Significant at 5% level

(DWBLA) was calculated by multiplying blast severity with DCWBI. Correlations were worked out between % blast severity and DWBLA up to three weeks lag.

By using Palampur data (1991-1995) a regression equation was developed for predicting blast severity one week in advance by taking DWBLA and DCWBI as independent variables. The prediction model was validated using independent data set from 1996-2000 from the same location, Palampur and also the same model was validated for DRR, Hyderabad using data sets of the year 2003-2004.

RESULTS AND DISCUSSION

The date of initiation of blast and DCWBI values prior to 3 weeks at Palampur (Table 2) revealed that in 8 years out of 10 years, DCWBI were greater than 0.5 in current and previous week to the first appearance of the disease (disease initiation). A similar trend was noticed at Hyderabad also (Table 3). Hence it is inferred that if the DCBWI is greater than 0.5 for any given week during susceptible stage of the crop, then in the following week the disease incidence is most likely to appear on the crop. Once blast is initiated and DCWBI is greater than 0.5, the disease spread rapidly.

Correlations between % blast severity and DWBLA up to three weeks lag (Table 4) were positively significant at 5% level.

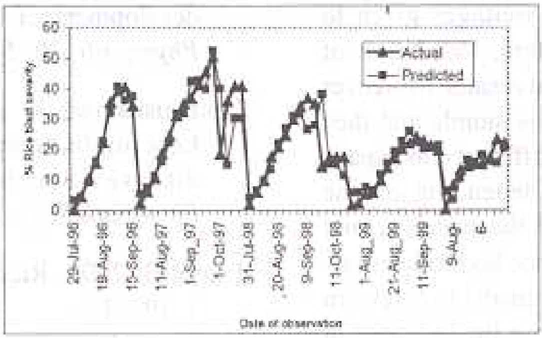

Fig 1: Actual and predicted values of blast severity at Palampur during 1996-2000

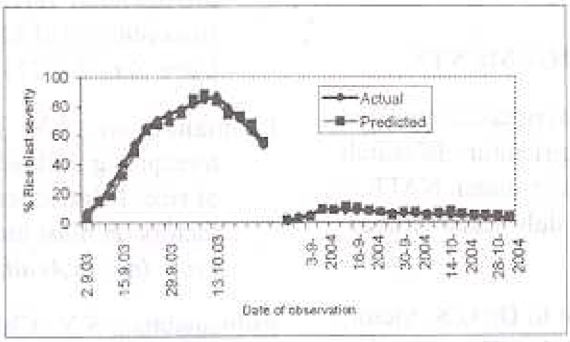

Fig 2: Actual and predicted values of rice blast at DRR, Hyderabad during *kharif* 2003-04

The following equation was developed for prediction of blast severity one week in advance using Palampur data from 1990 to1995.

$$B_N = -0.5 + 1.6\ DWBLA\_1 + 9.5\ DCWBI, \quad R^2 = 85\%$$

Where ,

B_N = Predicted value of % blast in the next week

DWBLA _1 = dynamic weight of blast during previous week and DCWBI = dynamic weather based index for blast during current week

The above equation explains 85% variation in rice blast severity. R^2 is significant at 5% level of probability.

The model was validated with independent data set at Palampur (1996-2000) and DRR 2003-2004. The actual and predicted values were in close agreement throughout the period (Figs 1& 2).

CONCLUSIONS

It is concluded that the blast forewarning models described in this paper are based on weather weitages given to daily weather parameters. Validation of models consistently good results. Moreover calculation of DCWBI is simple and they can be calculated for different time spans like 10, 7 or 3 days depending on the availability of data. Then the models are not location specific and hence find wide usage. Therefore, it is a better model to forewarn rice blast incidence across the locations in the country and enable appropriate agroadvisories.

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