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Effect of Weather Parameters on Infestation of Blast Disease (*Pyricularia oryzae*) in Rabi Season Rice (*Oryza sativa* L.) in East & South Eastern Coastal Plain of Odisha

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A B S T R A C T

An investigation was carried out at Agrometeorological field, Central Research Farm, Odisha University of Agriculture and Technology, Bhubaneswar in *rabi* season, 2017 in natural condition on study of various aspects of effect of weather (maximum temperature, minimum temperature, rainfall, maximum relative humidity, minimum relative humidity, wind velocity, bright sunshine hours and evaporation) on infestation of *P. grisea* in rice (in the varieties Khandagiri and Lalat). In *rabi* season among the two varieties, Lalat variety showed the higher blast incidence (2.17%) whereas Khandagiri variety showed lowest blast incidence (1.32%). The incidence of blast disease in variety Khandagiri was significant and high positively correlated with Minimum Temperature, Wind velocity, Evaporation. The blast disease incidence was positively correlated with Maximum Temperature, Minimum Relative humidity. The incidence of blast disease in variety Lalat was significant and high positively correlated with Minimum Temperature. The blast disease incidence was positively correlated with Maximum Temperature, Wind velocity, Evaporation and negatively correlated with Maximum Relative humidity. Rainfall, Minimum Relative humidity and BSH have no effect on the disease incidence. Weather parameters played a major role in disease incidence in *rabi* season and in this location, among the two different varieties Lalat variety is very susceptible to blast disease than Khandagiri.

Keywords

Rice, Rice blast disease, Variety, Weather parameters, *Pyricularia oryzae*

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Introduction

Rice (*Oryza sativa* L.) is the staple food for more than 60% of the world's population and more than 90% of the rice produced in the world is consumed in the Asian countries. Globally during 2011-12, rice crop occupied an area of about 159.22 million hectares with 465.81 million tonnes of production and productivity of 4.36metric tonnes per hectare (USDA, 2013). The major rice producing countries are China, India, Indonesia, Bangladesh, Vietnam, Thailand, Myanmar, Philippines, Brazil and Japan.

Rice cultivation is the major activity and source of income for millions of households round the globe. Several countries of Asia and Africa are highly dependent on rice as source of foreign exchange earnings and government revenue. Rice production is geographically concentrated in Western and Eastern Asia and Asia is the biggest rice producer, accounting for 90% of the world's production. The per capita consumption of rice in Asian countries is 200-400lb (90-181 kg) per person. China and India produce half of the world's rice production (FAO, 1999).

Rice is the staple food of over half the world's population and a vital nutritional source for rural poor of most of the countries in the world providing 20% of their dietary energy. The demand of rice as staple food for about 3 billion people is expected to increase further with increase in population. In India it occupies an area of 43388 thousand ha producing 104317 thousand tonnes with an average productivity 2404 kg/ha. In Odisha occupies an area of 3943 thousand ha producing 5878 thousand tonnes with an average productivity of 1491 kg/ha (Directorate of Economics & Statistics, DAC & FW, 2015-16).

Agro-climatic conditions prevailed in a region are most important factors contributing towards build up diseases. The crop is attacked by number of fungi, bacteria, viruses and nematodes besides non-parasitic disorders. Among them, fungi alone account for more than thirty diseases, of which rice blast caused by *Pyricularia oryzae* (*Magnaporthe grisea*) is one of the most prevalent disease found in India which is a major limiting factor in rice productivity of the country and in several parts of the world.

The blast disease was first recorded from Tanjore district of Tamil Nadu in 1918. The blast disease remains a threat to rice production because of its apparently unpredictable outbreaks and the resulting economic losses depending on weather. Rice blast is devastating and the pathogen can cause yield loss ranging from 30-61% depending upon the stage of infection. In severe cases, losses amounting to 70-80% in South-East Asia and India. The disease results in yield loss as high as 70-80% when predisposing factors (high mean temperature, relative humidity higher than 85-89%, presence of dew, drought stress and excessive nitrogen fertilization) favour epidemic development. Subtropical or temperate environment where canopy wetness is frequent along with moderate temperature are inductive to blast.

A systematic study on the effect of weather on infestation of blast disease in rice in Odisha is necessary and information pertaining to screening of rice varieties for this region is yet to be generated. Keeping these points in view, the present investigation was undertaken to generate information on identification of blast resistance varieties in rice in natural condition.

Materials and Methods

A field experiment was conducted during the rabi season 2017 at Agrometeorological field, Central Research Farm, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar situated at an elevation of 25.9 m above mean sea level, 20^{o} 15' N latitude and 85^{o} 52' E longitude. During this time period, the average maximum temperature ranged between 31.9 -37^{0}c, minimum temperature 16.7-26.7^{0}c, total rainfall 74.6mm, maximum RH 86.3-94.1%, minimum RH 35.4-55.1%, wind velocity 2.1-11.1km/hr, bright sunshine hours 7.5-8.7 hrs, evaporation 3.7-7.8mm. Rice varieties Khandagiri and Lalat were transplanted with a spacing of 10cm x 20 cm with replication two in RBD.

Ten diseased plants were selected randomly in "Z" pattern from each plots and tagged. The diseased leaves of rice plants collected from farmers' fields were used for the isolation of the pathogen. The pathogen was isolated by following standard tissue isolation procedure (Tuite, 1969). Small bits of diseased leaves along with some healthy tissue were cut with help of a sterile scalpel and surface sterilized with one per cent sodium hypochlorite solution for 1 min. and rinsed aseptically in three changes of sterilized distilled water. Such surface sterilized leaf bits were transferred aseptically into sterilized Petri dishes containing solidified oat meal agar medium and incubated at 28 ± 1^0C for two weeks in a BOD incubator.

Per cent disease index (PDI) was calculated after scoring the per cent disease severity of leaf blast disease, following standard formula given by Mckinney (1923).

$$\text{PDI} = \frac{\Sigma \text{Sum of all numerical ratings}}{\text{Total no.of leaflets observed} \times \text{maximumrating}} \times 100$$

The data obtained from all the experiments were statistically analyzed by the following standard methods of Panse and Sukhatme (1984) and Gomez and Gomez (1984). The simple correlation and multiple linear regression analysis were done as per the standard methods to work out the relationship between weather factors and disease development by using statistical analysis programme like SAS, Pearson Correlation Coefficient.

Results and Discussion

In rabi season 2017 the per cent disease index (PDI) and mean weather parameters like maximum temperature, minimum temperature, total rainfall, maximum relative humidity (RH), minimum RH, wind velocity, Bright sunshine hour and evaporation of the two varieties Khandagiri and Lalat were worked out at weekly interval and presented in Table 1 and 4. Two simple correlation matrices were worked out by taking PDI and eight weather variables *viz.*, maximum temperature (X_1), minimum temperature (X_2), total rainfall (X_3), maximum RH (X_4) and minimum RH (X_5), wind velocity (X_6), Bright sunshine hour (X_7) and evaporation (X_8) in consideration (Table 1 and 4).

During rabi season 2017, the blast disease incidence started 7^{th} standard meteorological week (SMW) (15 Feb, 2017) 0.48% to a maximum incidence of 1.32% in 16^{th} standard meteorological week (SMW) (19 Apr, 2017) in variety khandagiri and in variety lalat, incidence occurred in 7^{th} standard meteorological week (SMW) (15 Feb, 2016) to a highest range 2.17% in 17^{th} standard meteorological week (SMW) (26 Apr, 2017). This supports the findings of Gowda and Gowda (1985) who found that rice crop sown fortnightly in January to June developed not more than 5% of leaf blast and 1% neck blast. Chaudhary and Vishwadhar (1988) reported that rice crop sown at the earliest date (15^{th} March) showed the lowest levels of foliage blight caused by *P. oryzae* (34.6%).

In both of the varieties (Khandagiri and Lalat), the PDI was gradually increasing with the advancement of dates of observation and the maximum disease severity observed at 16^{th} and 17^{th} SMW, when the maximum temperature (37^0c), minimum temperature (25.2^0c), total rainfall (29.2mm), maximum RH (87.4%) and minimum RH (50.3%), wind velocity (7.9km/hr, Bright sunshine hour (8.7hrs) and evaporation (7.4mm) were recorded.

Maximum and minimum temperature

Rises of temperature cause blast disease (2.17%) in rice. Blast disease is directly significant to both maximum and minimum temperature. During the blast disease occurrence period the maximum temperature ranged between 31.9 -37^{0}c and minimum temperature 16.7-26.7^{0}c. Both the maximum & minimum temperature influences the disease severity in both the verities. Similar findings also found by the work of Ramakrishnan (1948), Chakrabarti and Padmanabhan (1968), Kato and Kozaka (1974), Kapoor and Singh (1977), Gouramanis (1994), Shafaullah *et al.*, (2011**)** and Rajput *et al.*, (2017).

Rainfall

During this period rainfall was less so the disease severity was less. Pal *et.al* (2017) found that due to scanty rainfall scanty in 2014 and in general, the disease severity was less as compared to 2013.

Relative humidity

During this period the maximum and minimum RH ranged between RH 86.3-94.1% and 35.4-55.1% respectively. Relative humidity influences the disease incidence. It is as same as the findings of Gouramanis (1994), Castejon-Munoj (2008), Shafaullah *et al.*, (2011**)** and Syakira *et al.*, (2016).

Wind velocity

During the growing period wind velocity ranged 2.1-11.1km/hr. Wind velocity playes an important role in the blast disease incidence during this period. Studies have been carried out on air mycoflora around Jabalpur by Verma Khare (1987, 1988) and in Gulbarga by Bhat and Rajasab (1988). On pathogenic and non-pathogenic mycoflora in the air and phylloplane of *Triticum aestivum* L. by Uddin and Chakraverty (1996).

Bright sunshine hours

BSH have no interaction with blast disease incidence because during this growing period the BSH is required for the disease incidence is not as par.

Evaporation

Evaporation is optimal for the growth and development for the incidence of blast disease.

Table.1 Influence of weather parameters on Blast disease of Khandagiri variety during *rabi*, 2017

WEEK NO.	MET. WEEK	PDI	Temperature(^{0} C)		Rain fall	Relative Humidity %		Wind velocity	BSH	Evapo
			Max	Min	Daily (mm)	7 hr	14 hr	km/hr	hrs	(mm)
6	08.02.2017	0	32.3	16.7	0.0	94.1	37.4	2.1	7.5	3.7
7	15.02.2017	0.48	33.6	18.4	0.0	93.7	35.4	2.2	7.9	3.7
8	22.02.2017	0.80	34.7	20.2	0.0	93.4	36.4	4.0	8.5	3.8
9	01.03.2017	0.80	34.8	21.5	0.0	93.6	42.7	3.9	7.5	3.8
10	08.03.2017	1.08	35.9	22.5	16.8	91.9	39.4	4.8	7.1	4.6
11	15.03.2017	1.08	31.9	21.5	28.6	93.9	49.0	4.3	5.6	4.6
12	22.03.2017	1.09	34.1	21.9	0.0	89.7	39.9	4.0	7.5	5.1
13	29.03.2017	1.22	36.5	24.8	0.0	88.7	38.7	7.4	8.0	5.6
14	05.04.2017	1.23	35.8	25.7	0.0	86.3	44.3	11.0	7.5	6.1
15	12.04.2017	1.31	36.7	26.3	0.0	88.4	48.3	8.6	5.9	7.1
16	19.04.2017	1.32	37.0	25.2	29.2	87.4	50.3	7.9	8.7	7.4

Table.2 Simple correlation matrix between Blast and weather parameters for Khandagiri variety during *rabi* 2017

Variables	BLAST	Tmax	Tmin	Rainfall	RHI	RHII	Wind vel.	BSH	Evapo
BLAST	1								
Tmax	0.693*	1							
Tmin	0.931**	0.809**	1.000						
Rainfall	0.349	-0.021	0.193	1.000					
RHI	-0.744**	-0.761**	-0.873**	-0.026	1.000				
RHII	0.631*	0.270	0.655*	0.628*	-0.463	1.000			
windvel.	0.772**	0.740**	0.923**	0.077	-0.910**	0.576	1.000		
BSH	-0.169	0.295	-0.141	-0.172	-0.123	-0.436	-0.057	1.000	
Evapo	0.767**	0.721*	0.879**	0.288	-0.896**	0.724*	0.848*	-0.070	1.000

** Correlation is significant at the 0.01 level * correlation is significant at the 0.05 level

Table.3 Multiple Regression Analysis of influence of weather parameters on blast severity for Khandagiri variety during *rabi* 2017

Weather Parameters	Regression Coefficient (b)	Standard Error	t Calculated	P - Value	Intercept (a)	R^2
X_1- Tmax	-0.119	0.110	-1.081	0.393	-2.683	0.97
X_2- Tmin	0.283	0.093	3.034	0.094		
X_3- Rainfall	0.007	0.006	1.054	0.403		
X_4- RHI	0.026	0.099	0.264	0.816		
X_5- RHII	-0.027	0.032	-0.850	0.485		
X_6-Windvel.	-0.074	0.059	-1.252	0.337		
X_7- BSH	0.069	0.107	0.647	0.584		
X_8- Evapo	0.022	0.191	0.114	0.920		
Equation	$Y = -2.683 - 0.119\ \mathbf{X_1} + 0.283\ \mathbf{X_2} + 0.007\ \mathbf{X_3} + 0.026\ \mathbf{X_4} - 0.027\ \mathbf{X_5} - 0.074\ \mathbf{X_6} + 0.069\ \mathbf{X_7} + 0.022\ \mathbf{X_8}$					

Table.4 Influence of weather parameters on Blast disease of Lalat variety during *rabi*, 2017

WEEK NO.	MET. WEEK	PDI	Temperature deg C		Rainfall	Relative Humidity %		Windvel.	BSH	Evapo
			Max	Min	Daily (mm)	7 hr	14 hr	km/hr	hrs	(mm)
6	08.02.2017	0	32.3	16.7	0.0	94.1	37.4	2.1	7.5	3.7
7	15.02.2017	1.52	33.6	18.4	0.0	93.7	35.4	2.2	7.9	3.7
8	22.02.2017	1.63	34.7	20.2	0.0	93.4	36.4	4.0	8.5	3.8
9	01.03.2017	1.63	34.8	21.5	0.0	93.6	42.7	3.9	7.5	3.8
10	08.03.2017	1.71	35.9	22.5	16.8	91.9	39.4	4.8	7.1	4.6
11	15.03.2017	1.71	31.9	21.5	28.6	93.9	49.0	4.3	5.6	4.6
12	22.03.2017	1.81	34.1	21.9	0.0	89.7	39.9	4.0	7.5	5.1
13	29.03.2017	1.97	36.5	24.8	0.0	88.7	38.7	7.4	8.0	5.6
14	05.04.2017	1.97	35.8	25.7	0.0	86.3	44.3	11.0	7.5	6.1
15	12.04.2017	2.00	36.7	26.3	0.0	88.4	48.3	8.6	5.9	7.1
16	19.04.2017	2.17	37.0	25.2	29.2	87.4	50.3	7.9	8.7	7.4
17	26.04.2017	2.17	36.9	26.7	0.0	88.0	55.1	11.1	7.7	7.8

Table.5 Simple correlation matrix between Blast and weather parameters for Lalat variety during *rabi* 2017

Variables	BLAST	Tmax	Tmin	Rainfall	RHI	RHII	Windvel.	BSH	Evapo
BLAST	1								
Tmax	0.698*	1							
Tmin	0.821**	0.832**	1.000						
Rainfall	0.202	-0.075	0.107	1.000					
RHI	-0.649*	-0.784**	-0.882**	0.025	1.000				
RHII	0.525	0.403	0.720**	0.394	-0.531	1.000			
windvel.	0.664*	0.769**	0.931**	-0.022	-0.897**	0.705**	1.000		
BSH	0.021	0.305	-0.095	-0.183	-0.142	-0.296	-0.005	1.000	
Evapo	0.641*	0.753**	0.896**	0.153	-0.884**	0.808**	0.889**	-0.015	1.000

** Correlation is significant at the 0.01 level * correlation is significant at the 0.05 level

Table.6 Multiple regression analysis of influence of weather parameters on blast severity for Lalat variety during *rabi* 2017

Weather Parameters	Regression Coefficient (b)	Standard Error	t Calculated	P - Value	Intercept (a)	R^2
X_1- Tmax	-0.226	0.301	-0.748	0.509	-14.537	0.84
X_2- Tmin	0.498	0.260	1.914	0.152		
X_3- Rainfall	0.002	0.015	0.107	0.922		
X_4- RHI	0.137	0.240	0.569	0.609		
X_5- RHII	-0.034	0.089	-0.386	0.725		
X_6-Windvel.	-0.118	0.156	-0.760	0.502		
X_7- BSH	0.305	0.265	1.151	0.333		
X_8- Evapo	0.071	0.495	0.143	0.895		
Equation	$Y = -14.537 - 0.226\,\mathbf{X_1} + 0.498\,\mathbf{X_2} + 0.002\,\mathbf{X_3} + 0.137\,\mathbf{X_4} - 0.034\,\mathbf{X_5} - 0.118\,\mathbf{X_6} + 0.305\,\mathbf{X_7} + 0.071\,\mathbf{X_8}$					

Correlation between the disease incidence and the weather parameters

The incidence of blast disease was correlated with the weather parameters and is presented in Table 2 and 5.

Correlation within the variety Khandagiri

The incidence of blast disease in variety Khandagiri was significant and high positively correlated with Minimum Temperature (r= 0.931), Wind velocity (r= 0.772), Evaporation (r= 0.767) and high negatively correlated with Maximum Relative humidity (r= 0.744). The blast disease incidence was positively correlated with Maximum Temperature (r= 0.693), Minimum Relative humidity (r= 0.631) and there is no significant effect of both Rainfall (r= 0.349), BSH (r= 0.169).

Correlation within the variety Lalat

The incidence of blast disease in variety Lalat was significant and high positively correlated with Minimum Temperature (r= 0.821).

The blast disease incidence was positively correlated with Maximum Temperature (r= 0.698), Wind velocity (r= 0.664), Evaporation (r= 0.641) and negatively correlated with Maximum Relative humidity (r= 0.649). Rainfall (r= 0.202), Minimum Relative humidity (r= 0.525) and BSH (0.021) have no effect on the disease incidence.

Multiple regression analysis

To handle eight independent weather variables and to identify critical and much contributing weather variable (s) separately towards the dependent variables *i.e.,* blast disease (Table 3 and 6). Multiple regression analysis was performed. In variety Khandagiri, the multiple regression for blast disease severity revealed that R^2 is 97% and the best fitted multiple regression equation is,

$$Y = -2.683 - 0.119 X_1 + 0.283 X_2 + 0.007 X_3 + 0.026 X_4 - 0.027 X_5 - 0.074 X_6 + 0.069 X_7 + 0.022 X_8$$

And in variety Lalat, the multiple regression for blast disease severity revealed that R^2 is 84% and the best fitted multiple regression equation is,

$$Y = -14.537 - 0.226 X_1 + 0.498 X_2 + 0.002 X_3 + 0.137 X_4 - 0.034 X_5 - 0.118 X_6 + 0.305 X_7 + 0.071 X_8$$

In rabi season among the two varieties Khandagiri and Lalat varieties, Lalat variety showed the higher blast incidence (2.17%) and Khandagiri variety was showed lowest blast incidence (1.32%). The incidence of blast disease in variety Khandagiri was significant and high positively correlated with Minimum Temperature (r= 0.931), Wind velocity (r= 0.772), Evaporation (r= 0.767) and high negatively correlated with Maximum Relative humidity (r= 0.744). The blast disease incidence was positively correlated with Maximum Temperature (r= 0.693), Minimum Relative humidity (r= 0.631) and there is no significant of both Rainfall (r= 0.349), BSH (r= 0.169). The incidence of blast disease in variety Lalat was significant and high positively correlated with Minimum Temperature (r= 0.821). The blast disease incidence was positively correlated with Maximum Temperature (r= 0.698), Wind velocity (r= 0.664), Evaporation (r= 0.641) and negatively correlated with Maximum Relative humidity (r= 0.649). Rainfall (r= 0.202), Minimum Relative humidity (r= 0.525) and BSH (0.021) have no effect on the disease incidence. Weather parameters played a major role in disease incidence in *rabi* season. In east & south eastern coastal plain of Odisha location among the two varieties Lalat variety is very susceptible than Khandagiri.

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