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ROLE OF ABIOTIC FACTORS ON THE DEVELOPMENT OF RICE BROWN SPOT CAUSED BY *Bipolaris oryzae* (BREDA DE HAAN) SHOEMAKER

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ABSTRACT

An attempt was made to study the role of environmental factors on the development of rice brown spot under the agro-ecological condition of red and lateritic belt of West Bengal during the winter season of 2013-2014. The severity of brown spot was increased at a faster rate during the initial period and reached at a maximum level of 5.18% PIPDI (periodical increment in percentage disease index) and 12.7% CIPDI (cumulative increment in percentage disease index) during 3rd and 4th week of September in both of the season. Thereafter, disease was progressed at a lower rate and came down at 0.35% PIPDI during 1st week of November. When maximum average temperature ranged from 32.6 to 34.21°C, minimum average temperature maintained between 23.61°C to 26.18°C, average relative humidity varied between 80.71 to 85.81%, having moderate rainfall, average sunshine of 4.63 to 6.16 kmh^{-1} and moderate wind speed from 1.0 to 1.57 kmh^{-1} persist in rice field maximum periodical increment in PDI might be expected. From the R^2 value it can be stated that, these six meteorological factors are responsible up to the extent of 85.2% for the development of the disease (cumulative). Similarly, meteorological factors that were regressed on PIPDI could explain the variation up to the extent 53.7%. The present investigation highlighted the actual severity level of brown spot of winter rice. It may also help the farmers for predicting the actual time of disease management and for decision making.

Keywords: Brown spot, *Oryza sativa,* disease severity, environmental factors.

INTRODUCTION

Rice (*Oryza sativa* L.) has been regarded as one of the most important cereal crops and a major food grain contributor to the total world food grain basket and feeds more than a third of the world's population (Khush 1997, Burgos 2013). Agriculture in West Bengal is the means of livelihood of about 65% of the population of the state living in villages with over 95% as small and marginal farmers. The percentage share of rice (total) alone in West Bengal in the case of area and production was 91 and 93 respectively. Out of different biotic stresses which influence the performance of rice crop, brown spot of rice caused by *Bipolaris oryzae* (Breda deHaan) Shoemaker; Synonym- *Helminthosporium oryzae* (Breda de

Haanyashi) Drechsler; Telomorph (*Cochliobolus miyabeanus* (Ito & Kuribaex Dastur) is the disease that impairs grain quality and results in about 67% yield reduction (Kohls 1987, Jones 1993). Rice brown spot was responsible for the "Bengal Famine" in India in 1942 and 1943 (Padmanabhan 1973). It is one of the most important seed borne diseases of rice (Ou 1985). This disease is associated with low soil fertility and often referred as 'poor man's disease' (Lee 1992). The disease especially occurs in environments where water supply is scarce and it is often combined with imbalances in plant mineral nutrition, especially the lack of nitrogen. These factors are commonly associated with resource poor farmers' fields (Ou 1985; Zadoks 2002). Brown spot is becoming more frequent and severe as drought is becoming more frequent (Savary *et al.,* 2005). The pathogen of brown spot disease produces multi-septated conidia generally curved, boat or club-shaped, with 6 to 14 transverse septa or cross walls (Ou 1985). Optimal temperatures for conidial germination (25–30°C) and hyphal growth (27–30°C) correspond to optimum temperatures for infection and lesion expansion (Dasgupta and Chattopadhyay 1977). Changes to the architecture of a crop, due to increasing CO2, may lead to increased humidity within the canopy and more favorable condition for pathogen survival (Chakraborty and Datta 2003, Pangga 2011). Increased photosynthetic rate under elevated CO2 levels (Fuhrer 2003) could lead to the availability of new growth flushes earlier in the season for pathogens to colonize and the subsequent increase in plant biomass will result in a larger reservoir for pathogens to colonize and multiply in. The major climate-change factors likely to influence plant disease severity and spread include: increased atmospheric CO2, heavy and unseasonal rains, increased humidity, drought, cyclones and hurricanes and warmer winter temperatures (Cannon, 1998; Chakraborty *et al.*, 2000; Rosenzweig *et al.*, 2001). They also found an increased conidial multiplication and higher development of the brown spot disease during maturity of crop. Holt two parameter linear model was reported to be best fitted model in predicting productivity rice efficiently (Prity *et al.,* 2014). The existing information is inadequate particularly in eastern India. Considering the potentiality of the disease in lateritic belt of west Bengal and its annual recurrent, the present investigation was undertaken with a view to find out the appropriate relationship between the meteorological factors and disease development which not only help to formulate a forecasting model but, also help the farmers for prediction of peak time of spread of disease.

MATERIALS AND METHODS

Field experiments were conducted at farmer's field of village Binuria, District Birbhum, West Bengal, on rice (*O. sativa*) during winter season of 2013 - 2014. The experimental areas are under the sub-humid and sub- tropical climatic conditions. The texture of soil was sandy loam, with high percentage of sand and low percentage of clay. Wet nursery bed was prepared for raising seedlings. Pre germinated seeds of rice were sown on the seed bed and covered with soil-FYM (1:1) mixture. The land was properly prepared with one deep ploughing by tractor followed by subsequent ploughing by power tiller and was labeled with one laddering. After the land preparation, the soil was enriched with recommended doses of N: P: K in a ratio of 75:35:35 kg/ha. Transplanting was done by maintaining the distance 6" (Plant to plant) x 8" (Row to row) by taking 2 to 3 seedlings per hill. The age of seedlings at transplanting was 15 to 20 days. Check basin method of irrigation was followed for irrigating the crop. One irrigation was given to the crop one at 75 DAT. After transplanting, one inch depth of water level was maintained and at later stages two inches water depth was maintained up to 15 days before harvest of the crop. The most widely accepted local variety of rice Swarna (MTU-7029) was selected for the study. The experimental field was divided into eight sub-plots. Data were collected from different locations of the field. The percentage severity index of the disease was measured at every seven days interval till the full maturity of crops. The data on environmental variables was obtained from India meteorological station, Sriniketan, Birbhum, W.B. Weekly average of maximum, minimum temperature, relative humidity, rainfall, sunshine hours and wind speed were symbolized as X^1, X2, X3, X4, X5, and X^6 respectively. The PDI recorded periodically was symbolized as Y^1 (cumulative progress) and Y^2 (periodical increments). The pooled data of three years were analyzed statistically by taking Y^1 and Y^2 as dependent variables and X^1, X2, X3, X4, X5, and X^6 as independent variables using stepwise multiple regression analysis (Gomez and Gomez 1984).

Identification and characterization of the disease and pathogen

Diseased leaves were collected and associated pathogen was isolated by standard tissue culture technique (Rangaswami and Bagyaraj 1998). Identification of the pathogen was carried out according to the cultural, morphological and microscopic characteristics described by Mew and Gonzales (2002). The smaller spots are dark brown to reddish-brown. The larger spots have a dark brown margin and a light reddish-brown or gray center with a gold halo (Plate 1). The pathogen also attacks the coleoptiles, branches of the panicle, glumes and grains (Sparks *et al.*, 2012). The fungus causes brown, circular to oval spots on the coleoptile leaves of the seedlings (Plate 2).

Pathogenicity Test

Pathogenicity test was carried out in plastic cups. In each of these two cups

Symptom at seedling stage

Plate 1.

Symptom at adult stage

Plate 2.

Table 1. Relationship between progress of brown spot disease (cumulative and periodical increments in PDI) and meteorological factors

Sl. No.	Standard week	Observation periods	Cumulative increase in disease (PDI) %	Periodical increment in disease (PDI) %	Temperature (^{0}C) Max.	Temperature (^{0}C) Min.	Average Relative Humidity %	Rainfall (mm)	Sunshine Hours /day	Wind speed (km/h.)
1.	29	24th - 30th July	0.0	0.0	33.93	26.64	80.57	16	5.57	3.14
2.	30	31st July - 6th August	0.0	0.0	31.34	25.71	89.14	115.4	2.6	2.4
3.	31	7th -13th August	0.0	0.0	33.28	26.11	83.71	30.1	6.56	2.0
4.	32	14th -20th August	0.0	0.0	32.10	25.70	89.43	93.1	1.99	2.0
5.	33	21st -27th August	0.27	0.27	32.71	26.06	84.00	55.7	5.43	2.0
6.	34	28th August - 3rd September	0.86	0.59	32.45	26.04	85.71	96.6	5.61	3.57
7.	35	4th -10th September	3.5	2.64	32.6	25.92	85.81	128.5	4.63	1.0
8.	36	11th -17th September	7.52	4.02	33.66	25.96	80.71	28.7	4.67	1.28
9.	37	18th -24th September	12.7	5.18	34.21	26.18	81.71	2.6	6.14	1.00
10.	38	25th September-1st October	15.66	2.96	33.12	25.7	83.42	7.8	6.16	1.57
11	39	2nd – 8th October	16.67	1.01	32.9	25.36	83.14	37.8	5.03	0.33
12	40	9th -15th October	18.02	1.35	31.7	24.01	89.14	175.9	3.16	2.14
13	41	16th -22nd October	19.3	1.28	31.34	24.33	83.43	39.6	5.2	3.0
14	42	23rd -29th October	20.95	1.65	32.01	23.61	85.57	68.7	6.76	1.14
15	43	30th October-5th November	21.3	0.35	28.57	22.21	91.0	95.3	3.27	1.71

(Treatment and control) 5 seeds of susceptible variety (Basmati-370) were placed containing sterilized soil. The spore suspension of the *B. oryzae*/ *H. oryzae* (1 × 105 spores/ml) was sprayed on the seedlings at two leaves stage and evaluation for the symptoms so developed was carried out after 7 days of inoculation.

Assessment of Percent Disease Index (PDI)

The percent disease index was assessed on rice crop by recording the number of leaf showing brown spot disease symptoms such as elliptical brown spot, proportion of plant parts showing symptom. In each plot 20 hills were selected randomly and from each hill three leaves were taken at random from the basal middle and top portion of plants and severity of the disease was recorded on the basis of 0 to 9 (Aluko, 1975).

Disease scoring was done at 7 days interval. Per cent disease index (percent infection) was recorded on the basis of 0 to 9 scales using the following formula

Percent Disease Index =

$$\frac{\text{Sum of all numerical ratings}}{\text{Maximum rating x Total number of observations}} \times 100$$

To study the role of environmental factors on disease development in field, progress of disease was measured in terms of Cumulative Increment in Percent Disease Index (CIPDI) and periodical increments in Percent Disease Index (PIPDI).The disease was measured at every seven days interval till the full maturity of crops. Similarly, meteorological observations on various parameters i.e. maximum temperature, minimum temperature, average relative humidity, rain falls, sunshine hour and wind speed were also recorded. The data recorded on different parameters in different years were pooled and are presented in above Table 1.

RESULTS AND DISCUSSION

Disease Progression

The symptoms of brown spot of rice were appeared in the field at about 27 to 30 days after the transplanting i.e. 4th week of July. The severity of disease was increased at a faster rate during the initial period and reached at a maximum level of 5.18% PIPDI and 12.7% CIPDI during the period from 18th September to 24th September. Thereafter, disease was progressed at a lower rate and reached at a lower level of 0.35% PDI during 30th October-5th November when the terminal severity of the disease was recorded 21.3% CIPDI and finally, no increment in disease severity was noticed from that date to harvesting of crop Fig. 1.

Influence of Environmental Factors on Disease Development

Maximum Temperature

Maximum temperature was found to be an important factor for disease development. Highest increment in PDI (5.18%) was recorded in between 18th September to 24th September, when the average maximum temperature was 34.21°C. While, a declining pattern in PIPDI was noticed with the decreasing maximum temperature and finally, it came to minimum level of increment (0.35% PDI) in between 30th October-5th November at 28.57°C. The periodical increment in disease was not reduced with the proportions of maximum temperature. Eventually, besides maximum temperature, other factor also had role to play in this context. The relationship between average maximum temperature and average PIPDI and CIPDI was found to be non-significant. But, it may be concluded that maximum disease progress may be expected when maximum temperature ranged from 32.6 to 34.21°C in field (Fig. 2).

Minimum Temperature

The severity of brown spot disease was also found to be influenced by minimum temperature in field. Maximum periodical increment in PDI (5.18%) was noticed in between 18th September to 24th September'2013 when average minimum temperature was 26.18°C. while, it was 22.21°C when minimum PIPDI was observed (Fig. 2). Significant negative correlation between average minimum temperature and CIPDI was observed. However, it was found non-significant with PIPDI (Table-2). A range of minimum average temperature from 23.61°C to 26.18°C was found suitable for disease development.

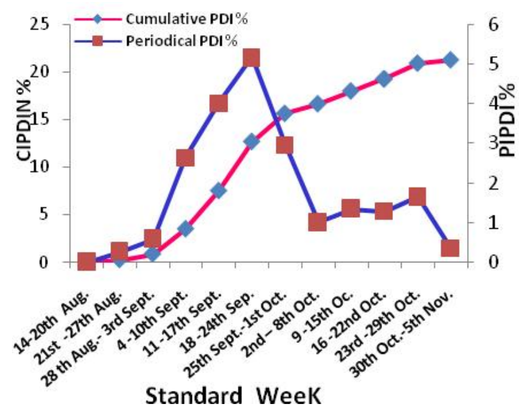

Fig. 1. Relationship between CIPDI and PIPDI

Relative humidity

It was indicated from the Table 3 that maximum PIPDI (5.18%) was observed when the average relative humidity was 81.71%. When average relative humidity had increased, considerable reduction in PIPDI was noticed. Average relative humidity was found to be significantly and negatively correlated with periodical increment of PDI (- 0.580*). However, it was just reverse with cumulative increment of

environment for disease development. Higher temperature, unseasonal rains, warmer winter temperatures increased the brown spot disease (Cannon 1998; Chakraborty 2000).

CONCLUSION

Brown spot of rice caused by *Bipolaris oryzaeis* a major disease of rice in West Bengal and appeared about 27 to 30 f days after transplantation. The disease was increased at a faster rate during initial stage and reached its maximum level during 3rd week of September. Aterminal disease incidence of 21.3 percent was noticed in this region. Environmental factors are the most decisive factor for epidemic development of brown spot disease. Arrange of maximum temperature 32.6 to 34.21°C, a range of average minimum temperature 23.61 to 26.18°C, maximum relative humidity of 80.71 to 85.81 percent were found most suitable for the disease development. Wind speed and sunshine hours have a positive effect on disease development. An average sunshine of 4.63 to 6.16 hours per day and moderate wind speed from 1 to 5 kilometer per hour were found to be most appropriate for faster multiplication and spread of the pathogen. All the meteorological factors were responsible up to the extent of 85.2 percent for the development of the disease under field conditions. The above mentioned information are very useful for the farmers involved in rice cultivation. Through this information farmers can predict the most appropriate time of application of management strategies. They also can take their decision in time of sowing of crop and enhance their profitability by proper management of disease.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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