

ARTICLE INFO

Open Access



Date Received:

12/12/2018;

Date Revised:

19/02/2019;

Date Published Online:

25/02/2019;

Comparative analysis of leaf spot disease in Rice Belt of Punjab, Pakistan

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How to Cite:

Choudhury FA, Jabeen N, Haider MS, Hussain R (2019). Comparative analysis of leaf spot disease in Rice Belt of Punjab, Pakistan. Adv. Life Sci. 6(2): 76-80.

Keywords:

Fungal pathogen; Incidence; Meteorological variables; Rice belt; Relative humidity

Abstract

Background: Brown leaf spot (BLS) caused by *Bipolaris oryzae* (Breda de Haan) Shoemaker, is a chronic disease of rice that infects millions of hectares worldwide each year. In this study, a total of 18 rice growing districts of Punjab, Pakistan were surveyed during cropping season in 2014-17 for the incidence of BLS disease.

Methods: The survey method was used to gather the data of BLS incidence during 2014-2017 in 18 districts of rice growing areas of Punjab, Pakistan. Meteorological data was collected from the weather stations of each surveyed district and co-related with BLS incidence.

Results: The findings of the study revealed that quantitative relationship exists between meteorological variables and BLS incidence. The incidence of disease in the field was at peak during the month of October. The disease incidence varied from 1.12% to 14.37% over a period of study i.e. from 2014-2017. However, the role of relative humidity (RH) was highly positively correlated with the incidence of disease. Relative humidity showed a positive correlation with the incidence of disease as indicated by the year in which it was towards the high values. The highest disease incidence was observed in district Sargodha whereas the minimum in district Okara. The highest incidence of BLS disease was found in variety Basmati Super (51.43%) and the minimum in Basmati 386 (6.57%).

Conclusion: Our study revealed that the fluctuations in temperature did not depict an appreciable impact on the incidence of BLS as indicated by the statistical coefficient, whereas RH strongly influenced the incidence of BLS incidence.



Introduction

Agriculture sector has become the backbone of the Pakistan's economy by contributing about 24% to the country's gross domestic product. It feeds almost 45% of the country's population. Almost 63% of country's population resides in the country side and is directly or indirectly linked with agriculture for its source of revenue [1]. Rice (*Oryza sativa L.*) is the staple food crop of more than half of the world's population mainly living in Asia and Africa [2]. Pakistan is among the leading exporters of rice globally by sharing 2 million tons, approximately accounting for the 10% of world trade. Among total rice exported, Basmati rice is known for his unique aroma and has a share of 25% in total rice exports of Pakistan [3].

Pest and diseases pose a continuous threat to rice production. The disease is more generally reported in countries across South and South-East Asia. The disease is responsible for the historic Bengal famine in 1842-43, with reported yield loss of 50- 90%, that lead to the death of nearly 2 million people due to starvation [4].

Brown spot disease is caused by necrotrophic rice leaf fungus *Cochliobolus miyabeanus* (Ito & Kuribayashi) Drechsler ex Dastur, also called *Bipolaris oryzae* (Breda de Haan) Shoemaker [5]. The pathogen is one of the devastating and prevalent in rice growing areas [6,7]. The symptoms of disease occur from seedling to milk stage and appear as small spots on the leaf blade, leaf sheath, coleoptile and glumes. On leaves, leaf sheath and coleoptiles, the spots are oval or cylindrical, brown with whitish or grey center and yellow halo. Under severe conditions, spots give a velvety appearance by the production of dark brown conidia and conidiophores. Severe grain infection has been reported to prevent germination, seed rotting and pre-emergence damping off. The diseased plants are stunted and the diseased field appeared as burnt or scorched [8]. The yield reduction can be as high as 45% in severe infection and 12% in moderate infection [9].

The primary infection of the disease is seed-borne while secondary infection occurs from wind-borne inoculum. Soil, infested debris and weed hosts are the inoculum reservoirs. The optimum conditions for disease development are 25-30°C for conidial germination and 27-30°C for hyphal growth with RH of over 90%. The rapid spread and occurrence of the disease is favored by continuous rains and cloudy

weather with higher day temperature i.e. 25-30°C [10]. For infection to occur the leaf must be wet for 8-24 hours. The disease is favored by temperature stress, water scarcity and nutrient imbalance [10]. Moreover, the disease also comes in epidemic form where soils have poor nutritional profile and low pH [11].

Keeping in view the above stated yield losses caused by the pathogen and disease etiology regarding rice production; the study was planned to calculate disease incidence of BLS in relationship with meteorological factors for rice protection. The study will help the government agencies and agriculturists to direct future efforts in planning strategies to overcome the threat and disseminate necessary information to the rice farming community of Punjab.

Methods

Survey and disease assessment

The study adopted the quantitative methodology using the survey method to derive its findings. A comprehensive survey was conducted during 2014-2017 in the major rice growing areas of Punjab, Pakistan (Figure 1) as defined by the Directorate General, Pest Warning and Quality Control of Pesticides, Agriculture Department, Government of Punjab, Pakistan. Total eighteen districts were regularly scouted for the brown leaf spot disease (Figure 1).



Figure 1: Map showing the location of surveyed districts of rice belt of Punjab.

The scouting was carried out by moving diagonally or in zigzag manner in a field, starting from ten meter inside the field [12]. The disease incidence was recorded by thoroughly examining at ten points in a field. Each site was selected five paces apart. Disease incidence percentage was calculated using the following formula;

$$\text{Disease Incidence (\%)} = \frac{\text{No. of brown spot infected plants} \times 100}{\text{Total No. of plants examined}}$$

The severity of the diseases was recorded by grading the scale (0-3 scale of Standard Evaluation). The following grades were used for disease of brown spots:

- 0 = No incidence,
- 1 = Less than 25%,
- 2 = Less than 50%
- 3 = >50% lesion area.

Meteorological data

Meteorological data was collected from the weather stations of each surveyed districts during the rice season in the years 2014 to 2017. The maximum and minimum temperature, RH indices and rain fall were recorded. Month wise means were calculated and correlated with disease incidence.

Statistical analysis

Analysis of variance (ANOVA) was performed to analyze the significant difference in disease incidence percentage recorded in each of the 18 districts. Pearson's correlation was applied at $P \leq 0.05$ to find the relationships between meteorological variables and the incidence of brown leaf spots using the Statistical Package for Social Sciences (SPSS® version 16.020).

Results

Disease Assessment

BLS disease was predominantly observed on rice during the four growth seasons *i.e.* from 2014 to 2017. The findings of the study reflected that mean disease incidence varied from 1.127 in Okara to 14.37 in Sargodha (Figure 2) during the research period. The average incidence of BLS disease ranged from 6.50 to 8.75 for the period of study from 2014-2017 (Figure 4). There were seemingly no significant differences between incidences of disease in different years.

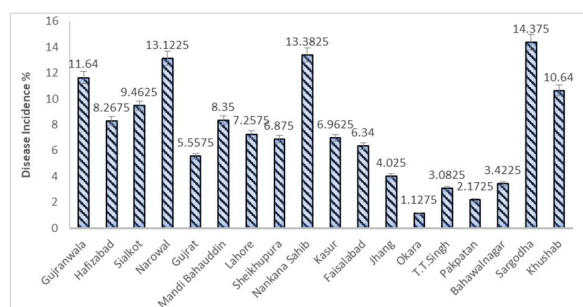


Figure 2: Average disease incidence (%) from 2014-17 in different districts.

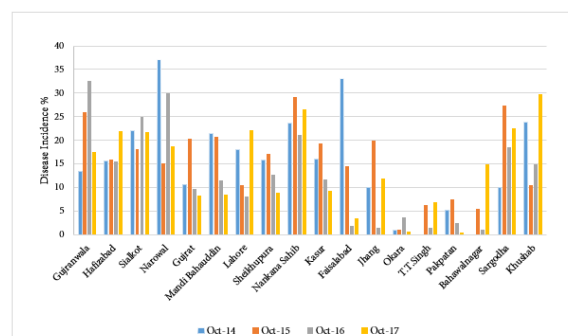


Figure 3: Disease incidence (%) from 2014-17 in different districts of rice belt.

Variety	2014	2015	2016	2017
Basmati Super	50.86	49.80	51.47	51.43*
PS2	32.52	32.48	33.53	33.04*
Basmati 386	7.90	8.35	6.57	7.22*
Basmati 515	8.71	9.37	8.43	8.31

*Significant at $P < 0.05$.

Table 1: Disease incidence (%) of BLS on rice varieties from 2014-2017.

As shown in the figures 2 and 3 variability of the incidence of BLS remained from 1.127 to 14.37% on an average basis during 2014-2017. The severity of the disease varied significantly for each variety (Table 1). Among different varieties of rice planted in the field, the highest severity of brown spot was found in Basmati Super Rice (51.47%) followed by PS-2 (33.53%), Basmati 515 (9.37%) and the minimum in Basmati 386 (6.57%).

Correlation of environmental variables with disease incidence

The data showed that the maximum temperature, RH and rainfall had significant effect on the development of disease in the field while the maximum temperature did not affect disease incidence.

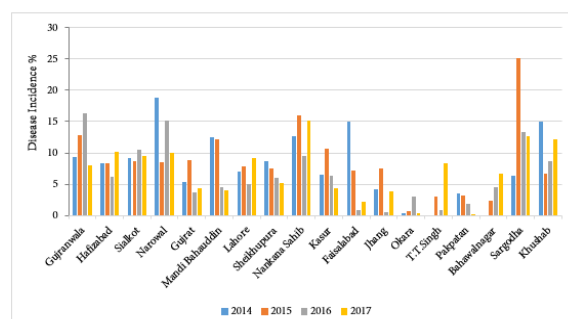


Figure 4: Disease incidence % of BLS on average basis for the years 2014-2017.

The current study has found the association between the incidence of BLS and the meteorological factors including temperature, RH indices and rainfall (Table 2). The results suggested that rainfall and humidity had the highest impact on BLS occurrence. The results showed that the maximum temperature did not show any correlations with BLS disease incidence during 2014-17, with correlation coefficients of -0.235, -0.201, -0.381 and -0.321, respectively. The minimum temperature on the other hand, showed significant negative relationship with disease incidence, with correlation coefficients of -0.469, -0.468, -0.340 and -0.5318 for years 2014 to 2017, respectively. Relative humidity showed a positively correlation disease incidence with a factor load of 0.519, 0.469, 0.611 and 0.483 for years 2014 to 2017, respectively. Rainfall exerted strongest influence on disease incidence and thereby was the major contributing factor towards BLS.

Year	Environmental variables			
	Max. Temperature (°C)	Min. Temperature (°C)	R.H ¹ (%)	Rainfall mm
2014	-0.235	-0.469	0.519	0.594
	0.346	0.049*	0.027*	0.009**
2015	-0.201	-0.468	0.469	0.599
	0.423	0.050*	0.049*	0.008**
2016	-0.381	-0.340	0.611	0.617
	0.118	0.167	0.005**	0.006**
2017	-0.321	-0.531	0.483	0.472
	0.192	0.023*	0.042*	0.048*

*Significant at $P < 0.05$, **Significant at $P < 0.01$, 1R.H= Relative humidity

Table 2: Correlation between disease incidence and climatic factors.

Discussion

Rice is staple food of about two billion people worldwide [14]. It is estimated that rice crop is threatened by almost 50 diseases including 21 fungal, 6 bacterial, 12 viral, 4 nematodes and 7 others diseases and disorders [5,15]. Rice together with wheat (*Triticum aestivum* L.) is as important as gold to the world's economy and enjoys a unique position among cash crops of Pakistan. Rice infestation with pests and disease are among the major causes deteriorating the rice yield. Rice diseases solely account for 5% yield losses [16].

Bipolaris oryzae conidia are multicellular, usually germinate bipolarly at maturity and generate more than one infection points [6]. There are several factors responsible for the occurrence of the disease in the field.

Essentially, all the components interactively influence the disease and relate to each other in a disease pyramid. Rice production and disease development are influenced by climatic conditions. In accordance to our findings, a study also reported the positive correlation of BLS occurrence with the RH [17]. Earlier, Pal and co-workers also correlated the weather parameters with Sheath blight disease in rice [18]. Additionally, it was found that the temperature did not influence the incidence of BLS. The possible explanation is that rise and fall in the mercury column (maximum & minimum temperature) did not differ in the specific months of the years over many decades in Pakistan. Whereas the precipitation and RH are the major variants in the climatic zone as this region lies in the Northern hemisphere of the globe has long been experiencing dry and wet years for several decades.

The disease is prevalent in all the rice growing areas of the world and holds an important position among fungal pathogens of rice crop. The BLS disease incidence was associated with favourable meteorological conditions for the successful infection including undesirably heavy dew periods and moderate temperature [13]. In addition to that nutritional deficiency has also been associated with BLS has been also associated with plant nutrition and soil fertility [19]. The yield losses caused by the brown spot BLS, are in the range of approximately 10 % of the attainable yield [20,21] in tropical and subtropical Asia. Moreover, alterations in the rainfall pattern also add to the increased incidence of BLS [21]. Environmental factors such as temperature and RH interfere with the infection capability of the pathogen [22].

It is concluded that quantitative relationship exists between meteorological variables and BLS incidence. The rise (Maximum) and fall (Minimum) in temperature did not show an appreciable impact on the incidence of BLS. RH showed a strong positive correlation with the incidence of disease. It is suggested that, for an effective BLS control, more consideration should be given to meteorological variables in future.

Acknowledgement

Authors are thankful to the Institute of Agricultural Sciences, University of the Punjab Lahore and Pest warning and quality control of pesticides for providing the facilities to conduct the study.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this paper.

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