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Impact of long term observations of climatic factors on incidence of bacterial leaf blight in fine varieties of rice

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ABSTRACT

Bacterial leaf blight (BLB) is becoming major disease in rice crop. However, there is a pressing need to manage the pathogen *Xanthomonas oryzae pv. oryzae* as alternative measures. In this study, the impact of climatic factors was assessed on the incidence of BLB on Basmati Super and PS-2 (PK-1121 (aromatic)). Pearson's correlation analysis showed that temperature and relative humidity played a significant role in flourishing the disease incidence on fine varieties of rice. The disease incidence in Basmati Super recorded strong significant (P<0.01) positive relationship with maximum temperature (0.768) which was at par with PK-1121 (aromatic) (0.751). Likewise, significant (P<0.01) negative relationship was found with humidity in Basmati Super (-0.621) and PK-1121 (aromatic) (-0.603) during 2010. The correlation regarding disease incidence with minimum temperature and rainfall (mm) was non-significant. The correlation showed negative significant (P<0.01) impact (-0.726) with minimum temperature regarding disease incidence on Basmati Super which was at par with PK-1121 (aromatic) (-0.797). The disease incidence in Basmati Super rice was recorded by 10.1% to 18.7% compared to PK-1121 (aromatic) (1.99% to 5.67%). In conclusion, disease incidence changed its regime accordingly with fluctuation in climate change and Basmati Super was found more susceptible against BLB of rice compared to PK-1121 (aromatic).

Introduction

Rice is one of the most important food crops in the world. It is the staple food of about 60% of the world's population. More than 90% of the rice is produced and consumed in Asia [1]. More than half of the world's population depend on rice (*Oryza sativa* L.), one of the most essential staple foods, which is grown on vast tracts of arable land [2]. In Asia, where 90% of the world's land was cultivated for rice, China become the highest global rice output [3]. Pakistan is the fourth largest producer of rice in the World. In Pakistan it is common for *Xanthomonas oryzae pv. oryzae* to produce Bacterial Leaf Blight (BLB) in the fine rice that is grown throughout the country. Numerous studies have demonstrated that biotic and abiotic stresses significantly lower yield. Bacterial leaf blight infection lower the grain quality and usually attack on panicle initiation, booting and milking stage [4]. After the infection of bacteria enter through human hands and wounds into the leaf. Later on the bacteria grow in the xylem and phloem, obstructing the flow of nutrients and water, turning the leaves dusty, and preventing photosynthesis, which reduces harvests and affect grain quality [5].

Climatic factors such as temperature, relative humidity, rainfall etc. affect the incidence and intensity of BLB. The key determinants of bacterial growth are rainfall, temperature and relative humidity. Rice leaf blight caused by bacteria is accelerated by high humidity (>80%), rain, and overcast weather conditions. Moderate amount of evenly dispersed rainfall can start an epidemic during the growing seasons. Temperature showed significant environmental impact on both healthy and infected plant growth. Bacterial Leaf Blight of rice is most serious biotic constraint of rice production in Punjab influenced by environmental conditions resulted to reduce yield [6]. Findings have shown that the incidence of BLB is significantly influenced by weather variables, including temperature (25-34°C), relative humidity (70-84%), and rainfall (>200mm). Rainfall, high temperature, relative humidity were found to be positively correlated with BLB infection [7]. These results are in line with the researchers who reported that bacterial growth flourished in mature rice plants that required optimum temperature (30.1°C-33.1°C) & relative humidity (79.1-91.2%) with un-availability

of rainfall [8].

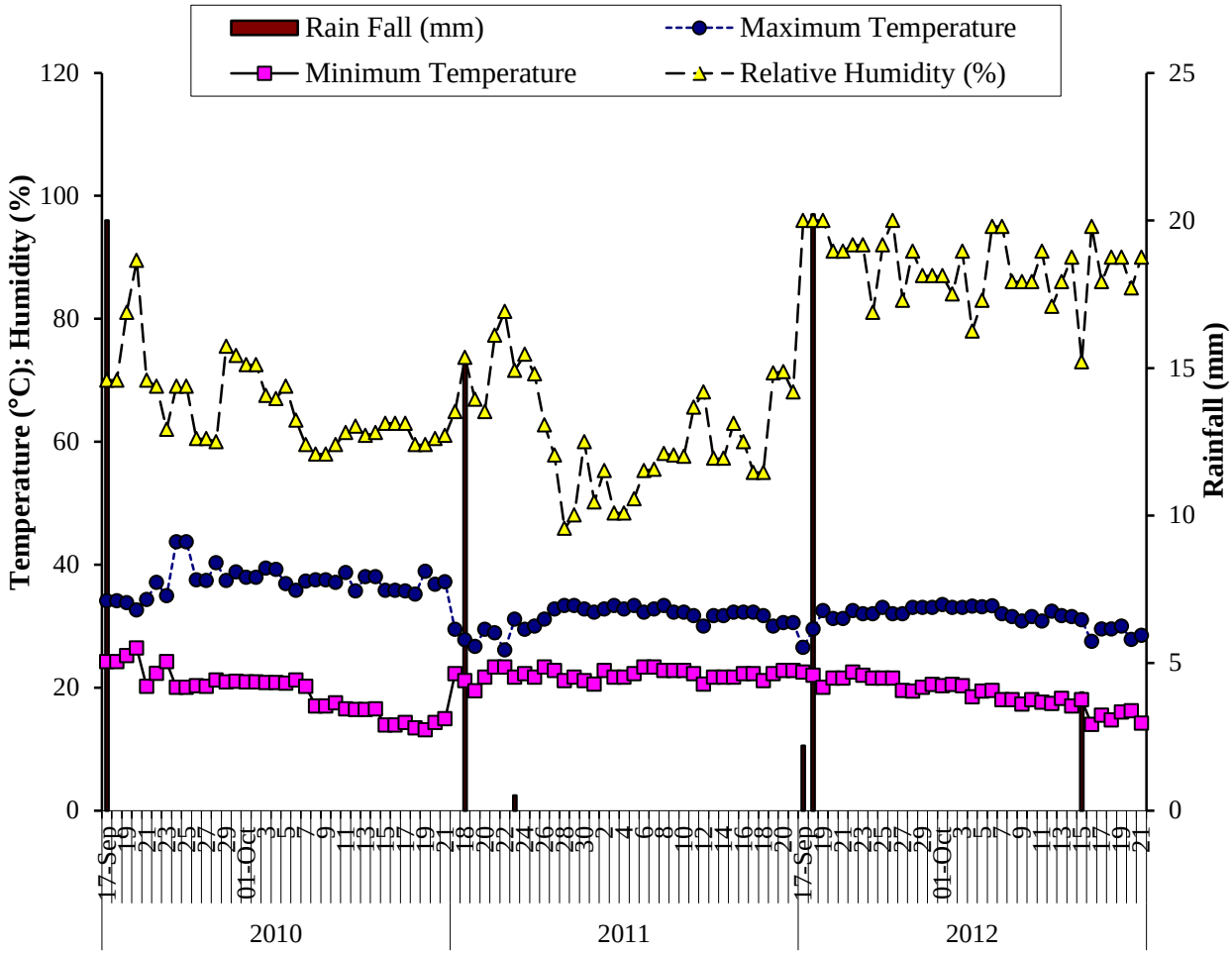
There is a pressing need to manage the pathogen *Xanthomonas oryzae pv. oryzae* as alternative measures due to its high resistance to a variety of antibiotics that cause BLB in rice crop [9]. Hence, alternate management practices such as transplanting time and methods, selection of resistant varieties, optimum fertilization, irrigation and Integrated Pest Management could aid in managing the disease occurrence. However, among these practices the selection of resistant varieties against BLB is more crucial & essential.

Bacterial leaf blight causes tremendous losses in the rice crop. Various climatic factors could affect the incidence and intensity of BLB in rice crop. Therefore, the current research was conducted to investigate the impact of long time observations regarding climatic factors on the disease incidence of BLB of rice crop in rice-wheat cropping system of Gujranwala, Punjab, Pakistan.

Materials and Methods

The study was conducted at Adaptive Research Farm, Gujranwala during Kharif 2010 to 2012. The study was conducted to evaluate the incidence of BLB on the two varieties of rice i.e. Basmati Super and PS-2/PK-1121 (aromatic). The daily values of maximum and minimum temperature (°C), relative humidity (%) and rainfall (mm) were collected from the devices which were already installed at the spot of rice field. The long time observations data were recorded among different environmental factors collected with effect from 17th September to 21st October each year (Figure-1). The crop was transplanted in the month of July and recommended doses of fertilizers were applied in the field each year. No any type of fungicides, micro and macro nutrients were sprayed in the rice field against any disease.

Figure-1 showing long time observations of environmental factors during 2010-2012 at Adaptive Research Farm, Gujranwala



The disease incidence (%) data was collected through said rating scale for assessment of BLB (Table-1) in rice crop [10, 11]. The data was analyzed statistically by Pearson's Correlation matrix through SPSS [11]. The data of disease incidence on two fine rice varieties were recorded randomly and correlated with environmental factors according to pre-designed protocol.

Table 1 showing rating scale regarding incidence of bacterial leaf bight (%) in rice crop

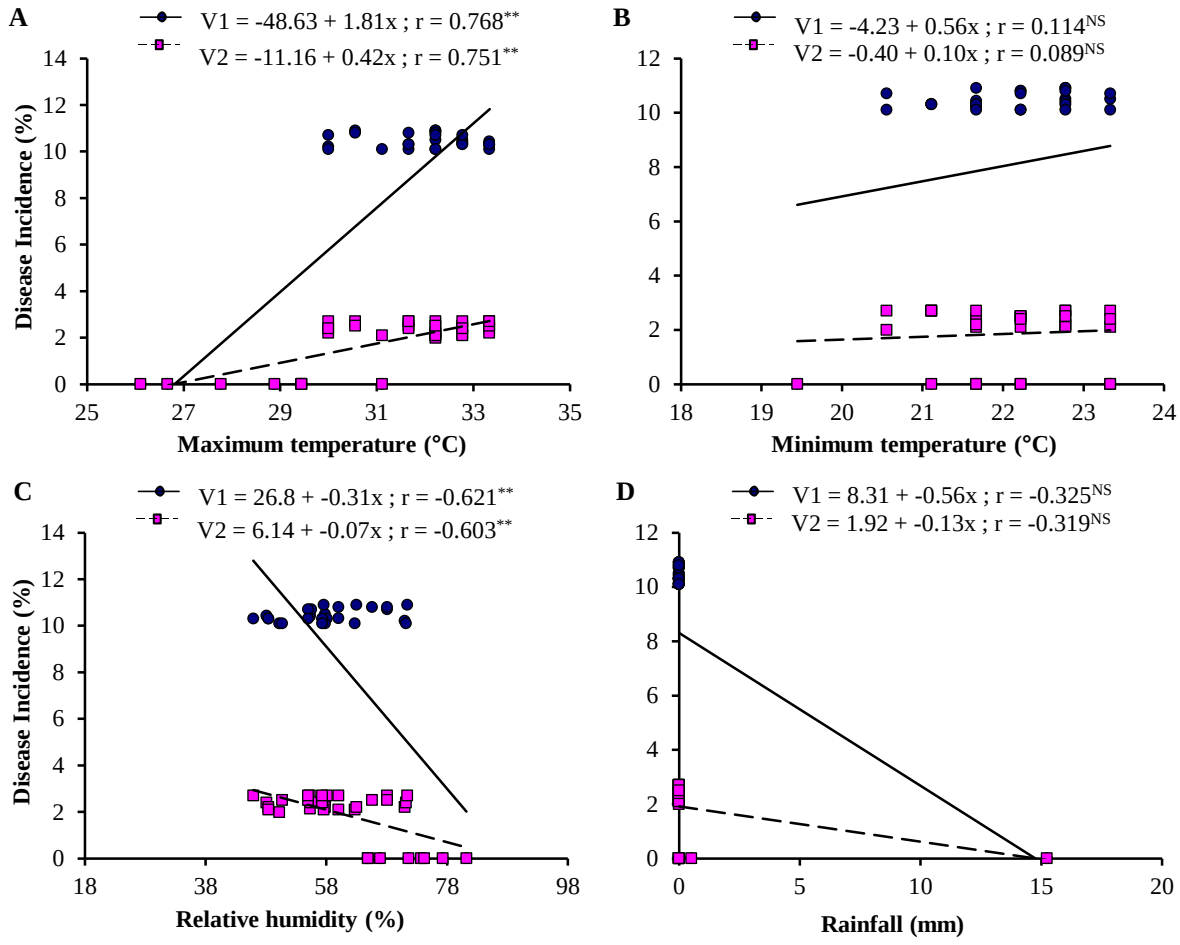
Sr. No.	Bacterial Leaf blight (%)	Description
1	0	Not Seen
2	5	A pale yellow leaf tips seen in patches
3	15	Leaf tips affected & dry in patches
4	25	Every plant affected and about ¼ of the leaf area destroyed
5	50	Every plant affected and about ½ of the leaf area destroyed
6	75	About ¾ of leaf area destroyed by BLB
7	95	Only a few leaves left green but stems were green
8	100	All leaves dead, stem dead or drying

Results and Discussion

The Pearson's correlation showed that temperature and relative humidity (%) range played a highly significant (*P*<0.01) role in flourishing the disease incidence on the fine varieties of rice crop during three years of the study. Strong and highly significant negative correlation was recorded between relative humidity (%) with maximum temperature during 2010. Similarly strong positive highly significant (*P*<0.01) correlation was found between relative humidity (%) versus minimum temperature during 2011. Moderately and highly significant (*P*<0.01) positive relationship was found between maximum versus minimum temperature. The precipitation showed non-significant (*P*>0.05) interaction with maximum temperature.

The disease incidence (%) in Basmati Super recorded strong highly significant (*P*<0.01) positive relationship with maximum temperature (0.768) which was found at par with PK-1121 (aromatic)/Pakistan Selection-2 (0.751) variety (Figure 2A). Similarly moderate and highly significant (*P*<0.01) negative relationship was recorded with humidity in Basmati Super (-0.621) and PK-1121 (aromatic)/PS-2 (-0.603) during 2010 (Figure 2C). The correlation regarding disease incidence with minimum temperature and rainfall (mm) found non-significant weak and negative relationship (Figure 2B and 2D).

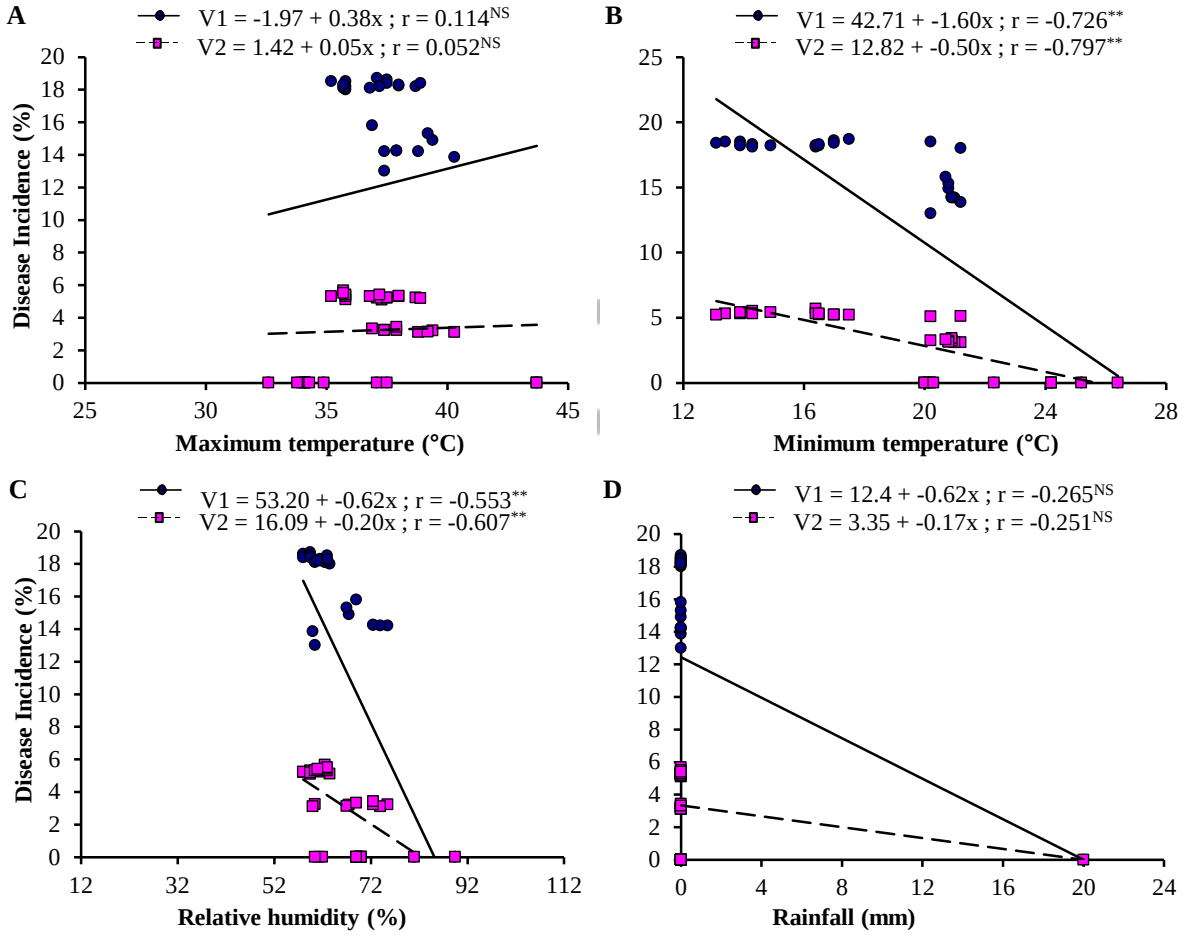
Figure 2 showing the impact of disease incidence (%) correlated with different climatic factors during Kharif 2010



Whereas the described Pearson's Correlation matrix between disease incidence (%) versus Maximum temperature (°C) indicated (A); disease incidence (%) versus Minimum temperature (°C) indicated (B); disease incidence (%) versus Relative Humidity (%) indicated (C); disease incidence (%) versus Rainfall (mm); V1 (Basmati Super); V2 (Pakistan Selection-2/PK-1121 (aromatic)) indicated (D). * = Significant (P<0.05); ** = Highly significant (P<0.01), NS = Non-Significant

The correlation showed strong negative highly significant (P<0.01) relationship (-0.726) with minimum temperature in disease incidence on Basmati Super which was at par with PK-1121 (aromatic) (-0.797) during 2011 (Figure 3B). Highly significant (P<0.01) moderate negative correlation regarding disease incidence (%) was found with relative humidity (Figure 3C). The correlation regarding disease incidence with maximum temperature (°C) and rainfall (mm) found non-significant and negative weak relationship (Figure 3A and 3D). These results are in line with the researchers who reported that high temperature showed a detrimental impact on the variety and incidence of disease in Chenab basmati. Pak basmati found significant impact on disease incidence with maximum temperature, followed by variety Basmati 385 and Kisan basmati, which also showed a significant effect [11]. These results are in accordance with the researchers who reported that increase in temperatures, disease outbreaks are hastened, while wind speed and raindrops encourage the spread of inoculums [12].

Figure 3 showing the impact of disease incidence (%) correlated with different climatic factors during Kharif 2011

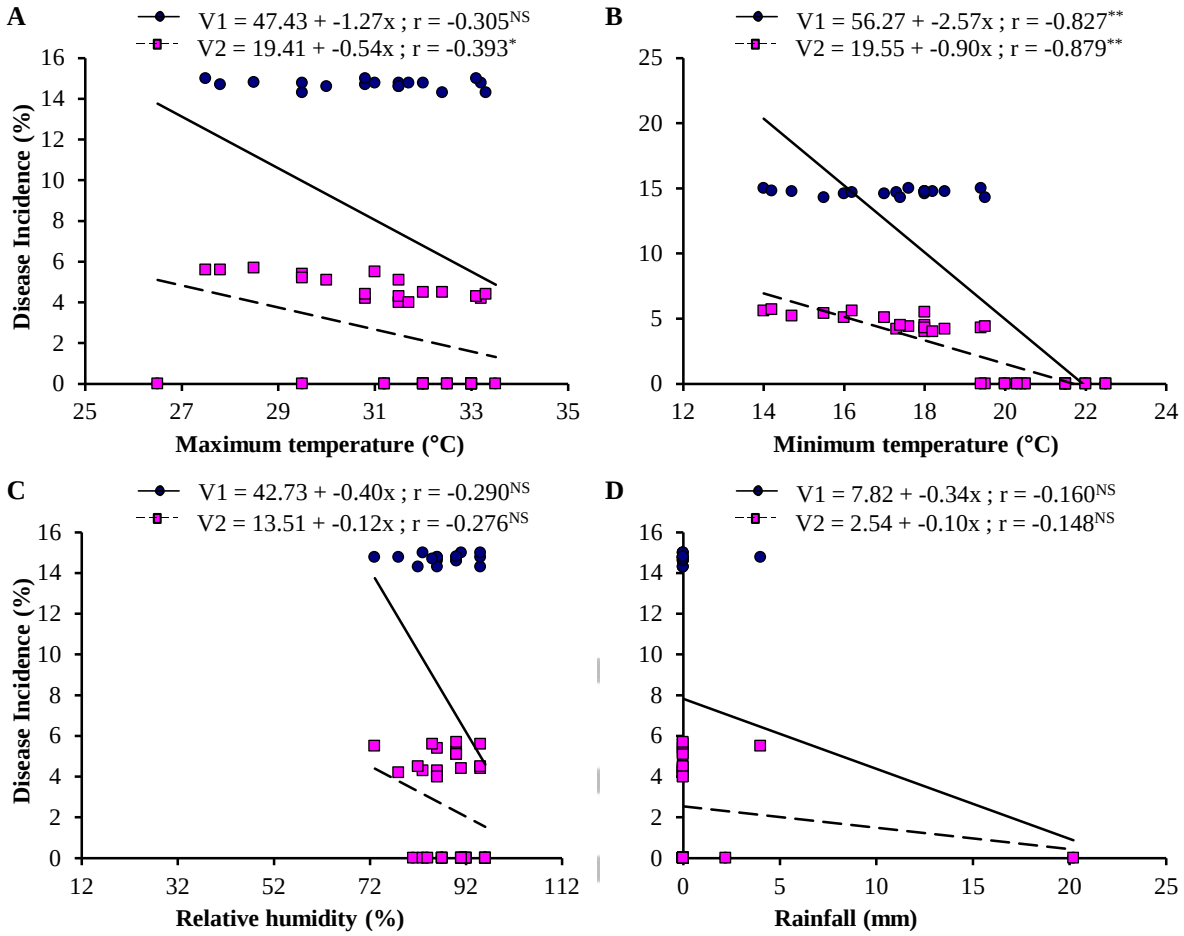


Whereas the described Pearson's Correlation matrix between disease incidence (%) versus Maximum temperature (°C) indicated (A); disease incidence (%) versus Minimum temperature (°C) indicated (B); disease incidence (%) versus Relative Humidity (%) indicated (C); disease incidence (%) versus Rainfall (mm); V1 (Basmati Super); V2 (PS-2/PK-1121 (aromatic)) indicated (D). * = Significant (P<0.05); ** = Highly significant (P<0.01), NS = Non-Significant

Strong negative highly significant (*P*<0.01) relationship of disease incidence (%) found with minimum temperature during 2012 (Figure 4B). Weak but significant (*P*<0.05) relationship was found in PK-1121 (aromatic)/PS-2 compared to Basmati Super (Figure 4A). Disease incidence with relative humidity (%) and rainfall (mm) differed non-significantly and found negative relationship (Figure 4C and 4D). These results are in accordance with the researchers who reported that minimum temperature gives negative impact on the disease incidence of Chenab basmati showed highly significant (*P*<0.05) effect on disease incidence. Pak basmati showed highly significant effect on disease incidence with Basmati 385 and Kisan Basmati. The incidence of BLB incidence recorded

36.8-7.46%, 11.67- 46.67% and 12-21.67% in rice crop at Sindh, Baluchistan and in Punjab provinces [11]. Our results are contradictory with the researchers who reported that, with an average yearly temperature of over 24°C and more than 200 mm of rainfall, the incidence of BLB is most frequently experienced on rice crop [13].

Figure 4 showing the impact of disease incidence (%) relationship with different climatic factors during Kharif 2012



Whereas the described Pearson's Correlation matrix between disease incidence (%) versus Maximum temperature (°C) indicated (A); disease incidence (%) versus Minimum temperature (°C) indicated (B); disease incidence (%) versus Relative Humidity (%) indicated (C); disease incidence (%) versus Rainfall (mm); V1 (Basmati Super); V2 (PS-2/PK-1121 (aromatic)) indicated (D). * = Significant (P<0.05); ** = Highly significant (P<0.01), NS = Non-Significant

Basmati Super rice recorded high disease incidence 10.10% to 10.90% compared to Pakistan Selection-2/PK-1121 (aromatic) (1.99% to 2.70%) during 2010 (Figure 5).

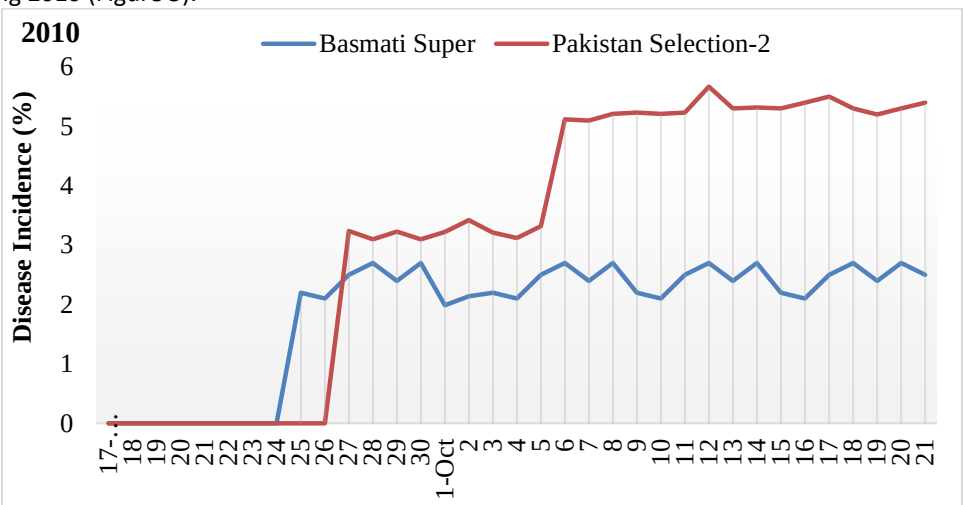


Figure 5 showing the relationship of bacterial leaf blight incidence (%) on Basmati Super and Pakistan Selection-2/PK-1121 (aromatic) during 2010

BLB incidence was found high in basmati super (13.00% to 18.70%) compared to Pakistan Selection-2/PK-1121 (aromatic) i.e. 3.10% to 5.67% during 2011 (Figure 6).

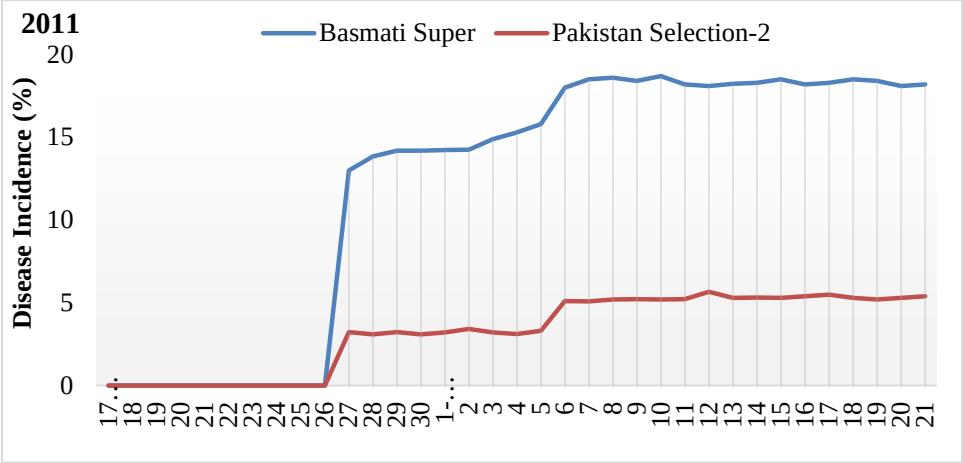


Figure 6 showing the reationship of bacterial leaf blight incidence (%) on Basmati Super and Pakistan Selection-2/PK-1121 (aromatic) during 2011

BLB was recorded high incidence in Basmati Super (14.30% to 15%) with maximum-minimum temperature ranged between 33.10°C-19.40 °C and 32.40°C-17.40°C with high humidity ranges between 73% to 90%. The fluctuation of climatic change the disease incidence also changed its regime accordingly during 2012 (Figure 6). These results are in accordance with the researchers who reported that the environment contributed to the spread of the pandemic [14]. The environment showed significant impact on disease development, data sets for environmental factors such as daily temperature changes, relative humidity in the morning or the evening, precipitation, wind speed, and daylight hours were collected and their correlations were examined. Environmental variables affected both the biological activities of the bacteria and the host plant, which was crucial in the progression of the illness. Even though the bacteria is virulent, under un favorable circumstances, it would not be able to cause infection in the host plant, allowing the plant to avoid the disease [11].

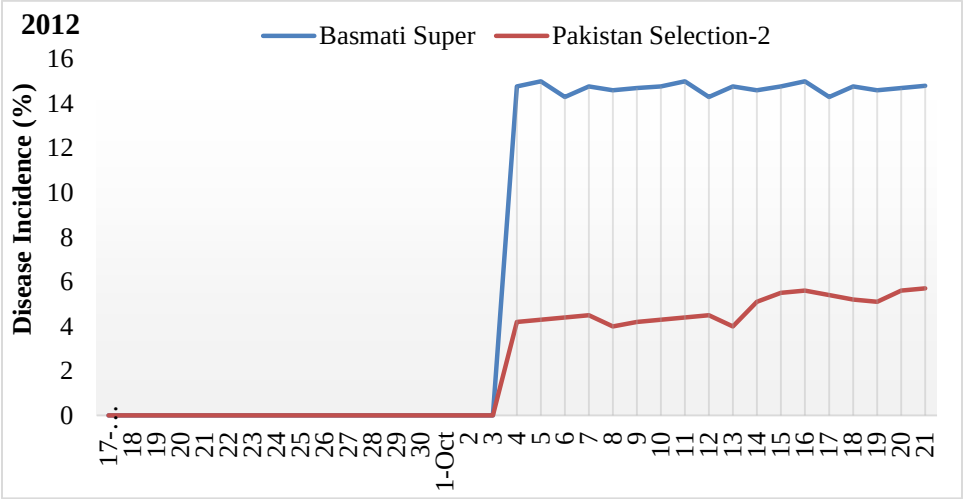


Figure 7 showing the impact of bacterial leaf blight incidence (%) on Basmati Super and Pakistan Selection-2/PK-1121 (aromatic) during 2012

The attack in plants prefers temperatures between 25°C and 34°C, with relative humidity of at least 70%. Strong winds and persistent downpours frequently cause it, which makes it easy for the disease-causing bacteria to disseminate through loose droplets on lesions of infected plants. The incidence and progression of plant diseases are greatly influenced by weather conditions. Our results are in line with the researchers who reported that environmental factors strongly correlated negatively with the onset of BLB disease [11]. These results are in accordance to the researchers who reported that rice plants are susceptible to a number of bacterial pathogens, one of which is *Xanthomonas oryzae pv oryzae*, which causes bacterial leaf blight (BLB). However BLB causes significant losses in rice cultivation regions [15]. In conclusion, dispersal of BLB incidence showed its high impact with maximum, minimum

temperature (°C) along with relative humidity (%) during the growing seasons. Basmati Super is susceptible against BLB that causes maximum disease which was in range (10.10% to 18.70%) compared to Pakistan Selection-2 later on known as PK-1121 (aromatic) (1.99% to 5.67).

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