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Incidence of bacterial leaf blight of rice in Raigarh district of Chhattisgarh and its management

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ABSTRACT

Rice (*Oryza sativa* L.) is one of the most important cereal crops in the world. In India, rice is the second major cereal crop with a production of 103.00 million metric tons in an area of 42.75 million hectares. The crop is suffering from a number of biotic and abiotic diseases. Among them, bacterial leaf blight (BLB) caused by *Xanthomonas oryzae* pv. *oryzae* (ex. Ishiyama) Swings *et al.* is one of the most important biotic diseases causing moderate to severe crop loss in Chhattisgarh. It has a serious constraint on rice production, especially for HYV where the yield losses are high more than 50% during severe infection. A field study was carried out during 2021-2022 at 07 villages of Raigarh district in Chhattisgarh. The lowest incidence was recorded in Jorapali (1.17%), while it was highest in Tarapur (28.71%). The relationship between PDI and temperature was negatively correlated, while a significant positive correlation was recorded between PDI with RH and the total rainfall. Five varieties were evaluated against BLB for their resistant reaction. The variety, MTU 1156, MTU 1010, and Sadhana were recorded as resistant; Sampada was moderately resistant while the variety Swarna was found to be moderately susceptible. Among the treatments used against BLB of rice, a minimum BLB incidence of 15.55% was recorded in streptocycline, followed by Kasugamycin (17.03%) and Bacterinashak (18.05%). The maximum disease incidence of 41.26% was recorded in untreated control followed by cow dung (22.20%). This information can be helpful for further study, and to develop suitable management strategy against the disease.

Key words: *Bacterial leaf blight, Incidence, Resistant varieties, Management*

Introduction

Rice (*oryza sativa* L., family - Poacae) is a most important staple food in the world. India has a long history of rice production. India ranks 1st position in area and 2nd in production after China. It is a most nutritious cereal crops used mainly for human consumption containing a good amount of carbohydrate, protein, vitamin, minerals and lower amount of fat (Hossain and Fisher, 1995). In India, total rice production is 122.27 MT during 2021-22. The leading rice producing states in India are West Bengal, Uttar Pradesh, Panjab, Andhra Pradesh, Tamil Nadu, Orissa and Chhattisgarh (INDISTAT, 2020-21). Some of the popularly grown varieties of rice in Chhattisgarh are Swarna, MTU-1010, Turia Kabri, Chudi Paddy, MTU-1156, Sampada, Sadhana, Samba Mashuri, Samleshwari, Chandrahasini and Lal Dhan (Directorate of Economics and Statistics Ministry of Agriculture, 2021). Rice is a highly vulnerable crop at its all growth stages to different pathogens and abiotic stresses that affect both the quality and quantity in rice production (Kreye *et al*., 2009; Devine, 2009; Sarkar *et al.*, 2012). Among the

diseases BLB is most important and destructive disease in this area, which causes heavy losses in yield especially for high-yielding rice varieties where the yield losses are as high as 50% during severe infection (Rao and Kauffman, 1971). Moreover, the BLB is particularly severe in irrigated and rainfed low land ecosystems (Mew, 1987). The BLB is caused by *Xanthomonas oryzae* pv. *oryzae* (ex. Ishiyama) Swings *et al.* belongs to the Phylum - Proteobacteria, Class - Gammaproteobacteria, Order - Xanthomonadales, Family - Xanthomonadaceae, Genus – *Xanthomonas*, species – *oryzae*, subspecies - *oryzae*. It is a gram-negative, rod shaped, non - spore forming monotrichous (single polar flagellum) bacterium, size varies 1.0 – 2.0µm × 0.4 - 0.7 µm (Brar and Khush, 1996). There are two phases of the disease (kresek and leaf blight) in which kresek phase (wilt phase) is most destructive phase of the disease as this phase is vascular in nature (Ou, 1972). Symptoms are mainly observed at tillering and booting stage with a peak at flowering stage, infected panicles become sterile and unfilled (Srivastava, 1967). After the introduction of the high yielding rice varieties, the disease has become more severe. The climatic conditions of Chhattisgarh are ideal for growth and development of the pathogen too. Therefore, this disease is predominantly available in this area. The management strategies demonstrated by the researchers effective against the pathogen causing bacterial leaf blight both in *in-vitro* and *in-vivo* condition are antibiotics, antibacterial compounds, and botanicals including plant extracts or sea weed extracts. The effectiveness of the botanicals may be due to their high concentration of antimicrobial properties as they contain terpenoids, flavonoids, and phenolic compounds etc, and are ecologically safe and biodegradable (Hostetmann *et al.,* 1995; Jun-Dong *et al.,* 2006).

Materials and Methods

The field experiments were conducted at different locations of Raigarh district of Chhattisgarh during 2021-2022. The experimental site is situated under the sub-tropical climate having red yellow sandy-loam soil. The average maximum temperature varied from 29°C - 33.9°C and the average minimum temperature varied from 20.9°C to 27.6°C in this region.

Survey on the disease

A survey was conducted during Kharif season 2021 using stratified random sampling method. Samples were collected from 7 different villages of the district. For this purpose 5 plots were considered for each village. In each plot 25 plants were selected randomly to record the disease data using 0-9 disease rating scale (Anonymous, 1996). The per cent disease index (PDI) was calculated and correlated with weather parameters.

Confirmation of the disease and isolation of the pathogen

The infected surface sterilized (1 % NaOCl) leaves were cut into small pieces and put into sterile water in a sterile glass tube and watch glass separately for rapid confirmation of the bacterial pathogen through ooze test. Potato Dextrose Agar (PDA) medium was used to isolate the bacterium. The experiments were conducted in aseptic environmental conditions.

Pathogenicity test of the isolated bacterium was performed on rice variety "Swarna" using artificial clip inoculation technique (Kauffman *et al.,* 1973). For this purpose bacterial suspension of 10^5 cells ml^{-1} was used and clip inoculated to the growing rice plants. The inoculated plants were tagged to record the development of characteristic symptoms. The bacterium was re-isolated from the artificially inoculated plants to prove Koch's postulates and compared with the original culture.

Varietal susceptibility study

Five different varieties *viz.* Swarna, Sadhana, Samapda, MTU 1010 and MTU 1156 were evaluated at maximum tillering stage to know the variation of symptomatology and disease reaction using 0-9 disease rating scale.

Bio-efficacy study against the pathogen

The experiment was conducted to evaluate six different types of materials viz., streptocycline (antibiotic), bacterinashak (antibacterial chemical), neem oil (botanical), cow dung (organic matter), *Pseudomonas fluorescens* (antagonistic microorganism), and kasugamycine (antifungal antibiotic) against the disease in Tarapur village of Raigarh district during 2021-2022. The experimental design was Randomized Block Design (RBD) with three replications. The size of the individual unit plot was 5m × 5m. The test materials were applied two times at 10 days intervals starting from the first appearance of the disease in field condition.

Results and Discussion

Present status of BLB of rice in Raigarh

Survey conducted during *Kharif* 2021-2022 on bacterial leaf blight of rice in Raigarh district was revealed that the highest disease incidence was in Patelpali (12.22%) followed by Tarapur (11.51%), Kotra (11.11%) and Baghanpur (10.14%) (Table 1).

Table 1. BLB incidence on paddy in Raigarh during Kharif 2021-2022

Location	Observations of PDI at 20 days intervals			Average PDI
	1st	2nd	3rd	
Kotra	1.98	7.4	23.96	11.11
Baghanpur	1.77	5.92	22.73	10.14
Jorapali	1.17	2.22	16.87	6.75
Dhanagar	1.29	3.7	19.77	8.25
Tarpali	1.44	5.92	21.79	9.71
Tarapur	1.39	4.44	28.71	11.51
Patelpali	2.65	8.14	25.89	12.22
Average	1.67	5.39	22.82	-

The result indicated that the intensity of the disease gradually increased with time. Rate of increment of the disease was surprisingly higher may be due to the high amount of shower along with higher wind velocity during the study period.

On investigation, it was revealed that the indigenous practices of the local people are the reasons for this ambiguous situation. Most of the local farmers of these areas used to clip the upper portion of the seedling before transplanting with a view to reducing the lodging tendency of the plants. There is no separate or common irrigation channel for each plot to drain out the excess water. Here, each and every plot is used as irrigation channel for the next plot. Irrigation water flows from one field to another, which may disseminate the pathogen from infected field to non-infected one, and act as inoculum source for disease development. Shivalingaiah and Umesha (2011) observed the bacterial leaf blight incidence in the range of 12 - 37 % in Karnataka. Similar results were also obtained by Mew *et al.* (1993). Sere *et al.* (2005) reported a higher level of disease incidence (70 - 80 %) in several West African countries.

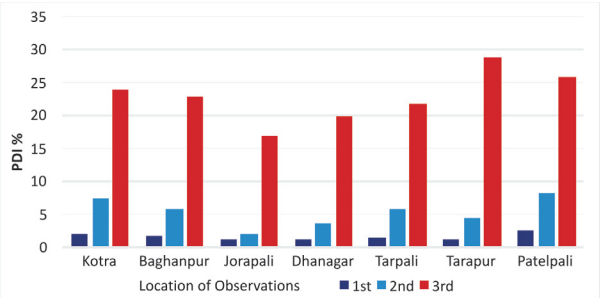

Fig. 1. Incidence of BLB recorded during survey at different locations of Raigarh

Symptomatological study

There was no symptomatological variation recorded among the field visited during survey. Tiny water-soaked lesion recorded on the leaf blade, mainly at the leaf margin at 1-2 cm away from the tip, which later turned into a yellowish stripe along with the leaf margins. The stripes enlarged both in length and width. The lesion rapidly covers large areas of the leaf blade which become pale straw to greyish in colour. The leaf blight lesion had a wavy outline which is a distinguishing feature of the BLB. Some tillers of the rice hills were found to be died in the field during the study. After a thorough study, it was revealed that this symptom is related to the systemic phase of the disease, i.e. kresek phase. In this case, the lesion usually started from the leaf margins, two or three weeks after transplanting. Infected leaves become greyish-green to yellow, folded up and rolled along with the midrib which exhibited Kresek symptoms. The two phases of the disease, i.e. the leaf blight phase and the kresek or seedling wilt phase at 3 weeks after transplanting along with tiller mortality was recorded by earlier workers (Srivastava 1972; Mew *et al.*, 1979; Ranga Reddy, 1987; and Raja rajeswari *et al.*, 2005, Thimmegowda, 2006).

Effect of weather variables on the development of BLB disease

A profound effect of different weather parameters

Table 2. Correlation coefficient between weather parameters with PDI

Weather variables	Correlation coefficient (r)
Temperature (max.) °C	-0.821
Temperature (min.) °C	-0.834
Relative humidity (mor.) %	0.981*
Relative humidity (eve.) %	0.840
Total Rainfall (mm)	1.000**

*t- test significant at 5% ** t -test significant at 1%

on BLB of rice was recorded during the study. The correlation coefficient analysis was made to establish the relationship between weather factors with per cent disease incidence (PDI) recorded for the month of July, August and September (Table 2, Fig. 1). During 2021, maximum (r = -0.821) and minimum (r = -0.834) daily temperature had a significant role and negative correlation with PDI indicating that with the increase of one parameter there is a proportionate decrease in the other. Significant and positive correlation had existed with relative humidity morning (r = 0.981*) and evening (r = 0.840). It was also revealed that the total rainfall had highly significant (r = 1.000**) with PDI. This indicated that with the increase in one parameter there is a parallel and proportionate increase in other parameters.

Confirmation of the pathogen

The pathogen was confirmed through isolation in PDA medium (Plate 1), symptomatology, morphological studies and pathogenicity test. Small pinhead size, yellow, mucoid, round and smooth bacterial colonies, which is typical of *Xanthomonas oryzae* pv. *oryzae* was appeared on PDA medium (Ghasemie *et al.*, 2008). Isaka (1970) stated that the bacterial exudate is superior for isolation than infected plant tissues because they are less liable to contamination, whereas Di Ming *et al.* (1991) opined that it was easier from the infected leaves than the infected seeds, because of the presence of other strains of microorganisms in high concentrations in seeds. On pathogenicity, typical symptoms of BLB were appeared on the inoculated leaves after 15 days. Re-isolation of the pathogen was performed from the artificially inoculated leaf and compared as similar with the cultured isolates. On microscopy, the bacterium was gram-negative and rod shaped. The isolates were relatively similar in respect to their cultural and morphological characters, which confirmed Koch's postulate (Brar and Khush, 1996, Shazia, 2007).

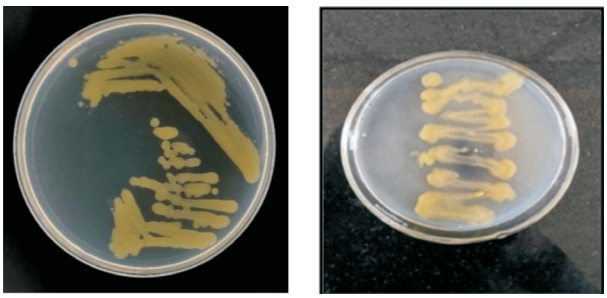

Plate 1. Growth of the bacterium in PDA medium

Varietal susceptibility study

Out of 5 varieties MTU 1156, MTU 1010 and Sadhana were found to be resistant with 4.50%, 4.74% and 5.33% disease incidence, respectively. The variety Sampada (9.10% disease incidence) was moderately resistant and Swarna (17.29% disease incidence) was moderately susceptible against bacterial leaf blight of rice (Table 3 & 4). This may be due to their different level of biochemical and physiological defence system. Besides, farmers of the area are usually applying high dose of nitrogenous fertilizer to gain a higher yield. The vulnerable cultivar, along with excessive nitrogenous fertilizers, might well have predisposed the plants to the infection of bacterial blight pathogen.

Table 3. Performance of rice varieties under field conditions against bacterial leaf blight

Sl. No.	Varieties	% Disease severity	Grade	Disease reaction
1	MTU 1156	4.50	1	R
2	Sadhana	4.74	1	R
3	MTU 1010	5.33	1	R
4	Sampada	9.10	3	MR
5	Swarna	17.29	7	MS

Where, R= Resistant, MR= Moderately Resistant, MS= Moderately Susceptible

The results of the present study were corroborated with the Singh *et al*. (2015). They evaluated rice cultivars against the disease and reported that the cultivars RP Bio 226 (Improved Samba Mashuri) and PB 1460 showed resistant reaction (less than 6% disease severity), while the moderately susceptible variety showed 27.9 to 34.20% disease severity against BLB under epiphytotic conditions. Similar results were also reported by the Thimmegowda *et al*. (2011). Seventy-one rice varieties were observed under natural epiphytotic conditions by them. They were not found any varieties showing immune to BLB. However, 3 varieties Ajaya, TKM-6 and IR-8 were resistant, 6 varieties were moderately resistant and 23 varieties were moderately susceptible, 24 varieties were susceptible and 15 varieties were highly susceptible.

Evaluation of different antibacterial agents against BLB of rice under field condition

The disease severity was significantly low in all the

Table 4. Varietal reaction against bacterial leaf blight in field condition

Grade	Reaction	Leaf infection range	Variety
0	Immune	0	-
1	Resistant	1-5	MTU 1156, Sadhana,MTU 1010
3	Moderately resistant	6-12	Sampada
5	Moderately susceptible	13-25	Swarna
7	Susceptible	26-50	-
9	Highly susceptible	51-100	-

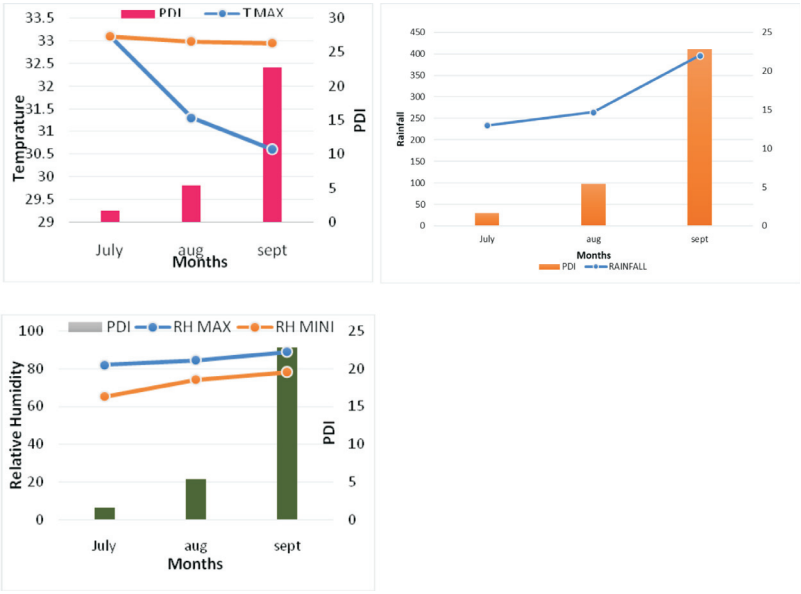

Fig. 1. Role of weather variables on the incidence of BLB of rice

treated plots as compared to untreated control. There was no significant variation among the treatments before spraying. However, significant difference was recorded after the first spray. Minimum disease incidence (17.76%) was recorded in streptocycline treated plots after 1st spraying which was found to be at par with Kasugamycin (18.51%) treated plots followed by bacterinashak (19.25%) and Pseudomonas (21.48%). Among all the treatments cow dung showed the lowest efficiency

Table 5. Option for management of BLB under field conditions

Treatment	PDI at 15th days after 1st spray	PDI at 15th days after 2nd spray	% reduction of disease incidence over control after 2nd spray	Yield (t/ha)	% increase of yield over control
Streptocycline @0.5g l^{-1}	17.76 (24.91)*	15.55(23.22)*	62.31	5.01	36.51
Neem oil @ 2ml l^{-1}	22.96(28.62)	22.12(28.04)	46.38	4.38	19.34
Pseudomonas @ 10g l^{-1}	21.48(27.60)	20.01(26.56)	51.50	4.49	22.34
Kasugamycine @ 2ml l^{-1}	18.51(25.47)	17.03(24.36)	58.72	4.96	35.14
Bacterinashak @ 0.5g l^{-1}	19.25(26.01)	18.05(25.13)	56.25	4.79	30.51
Cow dung @ 60 g l^{-1}	23.70(29.12)	22.20(28.10)	46.19	4.36	18.80
Control	34.07(35.70)	41.26(39.95)	0.0	3.67	0.0
Sem (±)	0.663	0.702	-	0.41	-
CD(p=0.05)	1.987	2.103	-	1.23	-

*Figures in parentheses indicates angular transform values

(23.70%) followed by neem oil (22.96%) but varied significantly from the untreated control plot (34.07%). At 15th days after 2nd spray the tested antibacterial agents was significantly reduced the disease, and almost similar results were observed in streptocycline (15.55%) followed by kasugamycin (17.03%) and bacterinashak (18.05%), however, the maximum incidence was recorded in the untreated control (41.26%). Effect of cow dung (22.20%), neem oil (22.12%) and Pseudomonas (20.01%) were found at par with each other (Table 5).

Results observed after the second spray revealed that all the treated plots gave better results compared to the untreated control. The streptocycline treated plot showed the best result, where 62.31% disease reduction was calculated over control followed by kasugamycine (58.72%) and bacterinashak (56.25%) (Fig. 5).

Biswas *et al*. (2009) found that the seed treatment with streptocycline (100 ppm) along with the foliar spray of streptocycline in a combination of copper oxychloride (100ppm+500ppm) gave a better result for controlling bacterial leaf blight of rice. A similar result was observed by Singh *et al.* (1980). They found that combining streptocycline and copper oxychloride resulted in a significant reduction in disease severity. Thimmegowda *et al.* (2007) reported that the efficacy of bacterinashak at 0.041% concentration to reduce the disease, while, Pseudomonas at 1% and neem oil 300 ppm at 0.75% was least effective against the disease. According to Mary *et al.* (1986) foliar spray of cow dung (20g l^{-1}) was efficacious against *Xanthomonas oryzae* pv. *oryzae* causing BLB. In our study, similar results were obtained even after increase the dose of cow dung.

Conclusion

Bacterial leaf blight of rice caused by *Xanthomonas oryzae* pv. *oryzae* is increasing gradually in the Raigarh district of Chhattisgarh. The variability in BLB severity among locations and seasons was related primarily to the seed source, environmental conditions, host genetics factors, cultivation practices, and farmers' practices etc. In this study, the varieties recorded as resistant or moderately resistant viz. MTU 1156, MTU 1010, Sadhana and Sampada can be recommended to the farming communities to avoid havoc damage due to the disease. These varieties may also be used as resistant source for the development of superior varieties. Further, foliar application of streptocycline can be suggested to reduce the disease incidence in Chhattisgarh under field condition. The findings of the study can be incorporated in the integrated disease management programme of sustainable rice production system.

Conflict of Interest

The article titled 'Incidence of bacterial leaf blight of rice in Raigarh district of Chhattisgarh and its management' is herewith submitted for publication in

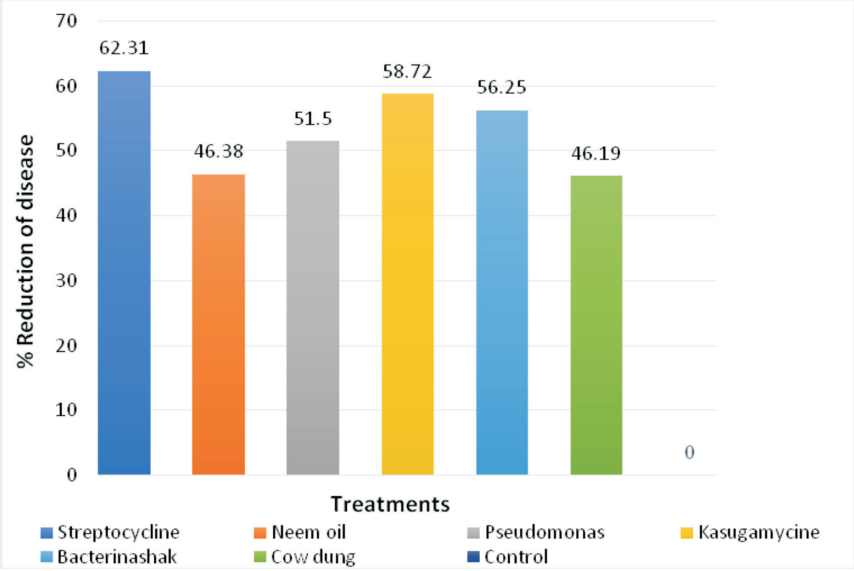

Fig. 5. Percent reduction of disease incidence over control after second spray

'Ecology, Environment and Conservation', has not been published before, and it is not under consideration for publication in any other journal (s). We declare that there is no conflict of interest for publication of the article.

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