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Research Article

Management of Bacterial leaf blight of rice caused by *Xanthomonas oryzae pv. oryzae* through Integrated approach in western undulating zones of Odisha

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Abstract

Bacterial leaf blight (BLB) is considered as a major threat to rice production because of its wide spread, distribution and its destructiveness under favourable conditions. The disease is caused by *Xanthomonas oryzae pv. oryzae* is one of the most serious diseases in irrigated and rain fed environment in Asia and cause considerable loss. Thus, pooled data of experiments conducted at Regional Research and Technology Transfer Station, Bhawanipatna, OUAT for two years during 2021-22 and 2022-23 to know the efficacy of different commercially available fungicides, antibacterial chemicals and bio-agents against the bacterial leaf blight of rice. Results indicated that, seedling root dip treatment with *Pseudomonas fluorescens* @10gm/lt, 1st spray with *P. fluorescens*, 2ndspray with Streptocyclin+$CuOCl_2$ and 3rd spray with *P. fluorescens* at 15 days interval found to be best with lowest PDI (9.44%) and highest yield (42.0q/ha) with B:C ratio 1.89 followed by seedling root dip treatment with *Streptocyclin*@1gm/10lt and three times foliar spraying along with $CuOCl_2$ @ 3gm/lt at 15days interval with PDI (16.78%) and yield 40.53 q/ha with B:C ratio 1.83 when compared to untreated control which has recorded the maximum PDI of 78.39 % and minimum yield 23.07 q/ha with lowest B:C ratio 1.12.

Key words: Bacterial leaf blight, *Pseudomonas fluorescens*, PDI, Management.

1. Introduction

A major source of calories for about 60% of the world's population, rice (Oryza sativa L.) affects the livelihoods and economies of several billion people, many of whom are concentrated in Asia, Latin America, the Middle East, and the West Indies. It is grown in five main ecosystems: rice that is irrigated, deep water, upland, lowland, and rice that is supplied by rain. Numerous bacterial, viral, fungal, viral, phytoplasma, nematode, and other non-parasitic disorders affect it. Bacterial leaf blight (BLB), one of the bacterial diseases, is regarded as a significant danger to paddy output due to its widespread distribution and destructiveness under favorable conditions.

The disease is caused by the bacterium *Xanthomonas oryzae pv. oryzae*, which is one of the most devastating diseases in Asia's irrigated and rain-fed ecosystems and causes significant damage, particularly where high yielding types are planted (Mew, 1987). There are two stages to disease: the Kresek phase or the Wilt phase, which typically happens during the active tillering period and causes the death of the tillers. The most frequent phase is Leaf Blight Phase, which is another. In this stage, the disease first appears on one or both leaf margins, which water soaked and turn straw-coloured and wavy-yellow. The spread of disease and drying causes the leaf blade to dry out, killing the leaves.

In order to mitigate plant diseases, integrated disease management (IDM) uses chemicals as crucial components. Therefore, the effectiveness of commercially available fungicides, antibiotics, and other bioagents against the disease was assessed. Equally crucial IDM components are the biological control agents. The effectiveness of several biological control agents against the target disease has thus been tested in this regard under field conditions. To control the BLB, a variety of agents, antagonists, botanicals, and nutrient applications were suggested in different rice-growing regions. application of bio agents that not only function as pathogen antagonists but also encourage plant development and create systemic disease resistance. In western undulating zones of Odisha, the bacterial leaf blight disease is emerging as a serious problem since last few years. With this perspective in mind, the current experiment was conducted to manage the BLB of rice and prevent output losses.

2. Materials and Methods

At the Research Farm, Regional Research and Technology Transfer Station (RRTTS), Bhawanipatna, OUAT, Odisha, India, a group of commercially available fungicides, antibiotics, and bio-agents were assessed against bacterial blight of rice during *Kharif* 2021–22 and 2022–23. Three replications of the Randomized Block Design (RBD) were used to plan the field trial. For this investigation, seedlings of the cultivar Swarna were planted in the field at a spacing of 10 × 20 cm when they were 25 days old. The crop was transplanted during 3rd week of July.

It was preferable to first recognize and report the correct disease symptoms on the rice crop. For the purpose of observing disease symptoms, the leaves of the infected plants were collected. Infected plant samples were collected and treated with sterile water treatment. With a sterilized razor blade and a dewdrop of sterile water, infected tissues were sliced. They were then placed on a slide. The samples were examined for bacterial streaming using an Olympus microscope with a 10x and 100x ocular and objective lenses (Anon, 2007).

Treatment details:

T_1: Seed soaking with Streptocyclin @0.01% for 12 hours, seedling root dip with the same for 15 minutes before transplanting, followed by spraying with Streptocyclin @0.01% +$CuOCl_2$ @0.3% 3 times at 15 days interval after disease initiation.

T_2: Seed soaking with 2- Bromo- 2-Nitropropane @0.05% for 12 hours, seedling root dip with the same for 15 minutes before transplanting, followed by 3 times spraying with 2-Bromo- 2-Nitropropane @0.05% at 15 days interval after disease initiation.

T_3: Spraying with $CuOCl_2$ @0.3% 3 times at 15 days interval after disease initiation.

T_4: Seed soaking with *Pseudomonas fluorescens* @ 1.5 % for 12 hours, seedling root dip with same for 15 minutes before transplanting, followed by 3 times spraying with *Pseudomonas fluorescens* @ 1.5 % after disease initiation.

T_5: Seed soaking with *Pseudomonas fluorescens* + *Trichoderma viride* each @10g/lt of water for 12 hours, seedling root dip with same for 15 minutes before transplanting, followed by 3 times spraying with *P.fluorescens* + *T.viride* each @10g/lt of water after disease initiation.

T_6: Seed soaking with Streptocyclin @0.01% for 12 hours, seedling root dip with same for 15 minutes before transplanting followed by 1st spray with *Peudomonas fluorescens* @ 1.5 % ,2nd spray with Streptocyclin @0.01% + $CuOCl_2$ @0.3%,3rd spray with *P. fluorescens* @ 1.5 %.

T_7: Seed soaking with Streptocyclin @0.01% for 12 hours, seedling root dip with same for 15 minutes before transplanting followed by spraying with 20% cow dung solution 3 times at 10 days interval by dissolving fresh cow dung @2kg/10lt of water, strain it in fine cloth.

T8: Untreated Control

Disease Assessment:

The assessment of disease was recorded after the initiation of disease by using 01-09 Standard Evaluation System (SES) (IRRI, 2014) (Table 1).

Table 1: SES scale for scoring of bacterial leaf blight disease (IRRI, 2014)

Scale	Resistance reaction	% leaf area diseased
1	Resistant (R)	1-5
3	Medium Resistant (MR)	6-12
5	Medium susceptible (MS)	13-25
7	Susceptible (S)	26-50
9	Highly Susceptible (HS)	>50

Computation of disease severity:

The percent disease index (PDI), a measure of disease severity, was used in the calculation. The five plants in each replication of the 6 m x 4 m plots were chosen at random, and the PDI for each replication will be determined using the formula below (Wheeler, 1969). After that, the disease severity records from the three replications were averaged, and the data was statistically examined at the 5% level of critical difference.

$$\text{Percent Disease Index (PDI)} = \frac{\text{Sum of all numerical ratings}}{\text{Total number of leaves observed x maximum rating}} \times 100$$

Using the formula provided by Mathur et al. (1971), the percentage of diseases controlled and the percentage of yield deviation were computed.

$$\text{Disease control (\%)} = \frac{\text{PDI in control-PDI in treatment}}{\text{PDI in control}} \times 100$$

$$\text{Yield increase (\%)} = \frac{\text{Yield in treatment- Yield in control}}{\text{Yield in control}} \times 100$$

3. Results and Discussions

The experiment was carried out with eight treatments to know the efficacy of chemical fungicides (copper oxychloride, 2-bromo-2 nitropropane), antibacterial chemicals (Streptocycline), Indigenous Technical Knowledges i.e ITKs (cow dung) and bio agents (*Pseudomonas fluorescence* and *Trichoderma viridae*) for management of bacterial blight of rice under field condition for the two consecutive years 2021-22 and 2022-23. The different doses of chemicals were sprayed on the plots after disease appearance then continued of another two sprayings at fifteen days interval. The disease parameters like percent disease index, disease control percent and yield parameters like yield (q/ha) and yield increase percent were obtained from this experiment. The symptoms of *Xanthomonas oryzae pv. oryzae* were easily identified. Blighting, withering (kresek), and yellowing of the leaves are symptoms of the disease (Fig. 2). Curvy, elongated patches along the leaf margins were used to identify leaf symptoms. Additionally, bacterial ooze was seen coming from these kinds of contaminated leaves. Infected plants' leaves twisted, wilted, and eventually developed a greyish-green tint, killing the plant. The systemic infection that occurred during the tillering phase is what causes the yellow or pale-yellow leaves. Young leaves were found to have yellow stripes. Similar symptoms were noticed by an earlier researcher, Goto (1992).

The disease intensity showed differential reaction due to application of different fungicide in their respective doses in different alternate manner in both the two consecutive years. The result (Table 2) showed that the application of all chemicals in alternate manner reduced the disease intensity significantly in comparison to untreated control.

In the year 2021-22, the disease intensity was to some extent less in comparison to the year 2022-23. Among the treatments, minimum disease intensity (8.10%) was obtained in the T6= Seed soaking with Streptocyclin @0.01% for 12 hours, seedling root dip with same for 15 minutes before transplanting followed by 1st spray with *Pseudomonas fluorescens* @ 1.5 %, 2nd spray with Streptocyclin @0.01% + $CuOCl_2$ @0.3% and 3rd spray with *P. fluorescens* @ 1.5 % followed by the treatment T1= Seed soaking with Streptocyclin @0.01% for 12 hours, seedling root dip with the same for 15 minutes before transplanting, followed by spraying with Streptocyclin @0.01% +$CuoCl_2$ @0.3% 3 times at 15 days interval after disease initiation and their difference was statistically significant. In the year 2022-23, different treatments also reduced the disease intensity in comparison to untreated control. In this year, disease intensity was to more than the previous year 2021-22. Among the treatments, minimum disease intensity (10.77%) was obtained in the T6 followed by T1(16.54%). Similar types of observations were obtained at pooled mean of two-year disease data of 2021-22 and 2022-23 (Table.2 and Fig.1). The two years pooled mean showed that the different fungicide application in an alternate manner, the disease intensity at different treatments were statistically significant in respect to untreated control and the highest per cent disease reduction of 87.96 was recorded in treatment T6 followed by treatment T1 (78.59%).

Yield (q/ha) and Net returns

Applications of different fungicides in an alternate manner in different treatments were ultimately reflected on yield of rice. Due to difference in disease reactions in two different years the differences in yield also observed in two different years and also in pooled mean and their differences were statistically significant. In every year, the yield of rice was significantly increased in different fungicide application in comparison to untreated control. In the year 2021-22, the maximum yield was harvested in T6 treatment (43.00q/ha) followed by T1treatment (41.00q/ha) and they were statistically significant in increase the yield of rice. In the year 2022-23, similar type of results was obtained that T6 treatment gave maximum yield (41.00q/ha) followed by T1treatment (40.07q/ha) and they were statistically at par in increase the yield of rice. The pooled mean also showed similar type of results that maximum yield was harvested in T6 treatment (42.00q/ha) followed by T1treatment (40.53q/ha) and minimum inT8 treatment (23.07q/ha) and the highest per cent of yield increase of 82.05 was recorded in treatment T6 followed by treatment T1 (75.68%) (Table-2 and Fig.1).

Significantly the highest yield of 42.00q/ha was observed with treatment T6 with maximum net return Rs. 38862.00 and B:C ratio of 1.89 followed by treatment T1 (40.53q/ha) with net return of Rs. 36229.00 and B: C ratio of 1.83 compared to least yield of 23.07q/ha in untreated control with least B:C of 1.12 (Table. 3). However, treatment T6 recorded maximum yield, the net returns and B:C ratio were more with treatment T1. Thus, the treatment T6 was found for better management of the BLB disease in rice with maximum net returns and B: C ratio of Rs. 38862.00 and 1.89 respectively.

According to our research, Streptocycline and copper oxychloride were the best medications for preventing the growth of *Xanthomonas campestris oryza* (Xoo). The current results are also consistent with past studies that found Streptocycline to have good antibacterial properties against Xoo and inhibit the protein synthesis of bacteria (Durgaprasad et al. 2018, Mahto et al., 1988; Chauhan, 1980), as well as copper oxychloride 50% WP (Patel, 2008 and Khan et al., 2005). In comparison to other compounds, Copper oxychloride @ 0.25% + Streptomycin sulphate (200ppm) was determined to be the most effective chemical for inhibiting Xoo, according to Tandan and Chaliganjewar (2016). Fruit spotting caused by this pathogen has been observed to be greatly decreased by products containing copper (Gleason et al., 1993; Thirumalesh et al., 2016). When combination with other treatments, copper was

Fig 2. (A) Kresek phase

(B) Leaf blight phase

Table 2: Evaluation of different fungicides against BLB caused by *Xanthomonas oryzae pv. oryzae* on Rice

Treatments	Percent Disease Index (PDI)			Disease decreases over control (%)			Yield (q/ha)			Yield increase over control (%)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T1	17.03 (24.37)*	16.54 (23.98)*	16.78 (7.19)*	77.24	79.83	78.59	41.00	40.07	40.53	70.83	81.05	75.68
T2	43.33 (41.16)	44.88 (42.06)	44.11 (19.03)	42.08	45.25	43.73	27.00	26.27	26.63	12.50	18.69	15.43
T3	37.55 (37.79)	38.62 (38.42)	38.09 (16.42)	49.81	52.89	51.41	31.00	30.92	30.96	29.17	39.73	34.20
T4	34.92 (36.22)	31.85 (34.35)	33.39 (14.20)	53.32	61.15	57.41	34.00	33.85	33.93	41.67	52.97	47.07
T5	27.07 (31.35)	22.38 (28.21)	24.73 (10.39)	63.81	72.70	68.45	37.00	34.70	35.85	54.17	56.80	55.40
T6	8.10 (16.53)	10.77 (19.15)	9.44 (4.19)	89.16	86.87	87.96	43.00	41.00	42.00	79.17	85.27	82.05
T7	38.99 (38.63)	49.30 (44.60)	44.15 (19.48)	47.87	39.87	43.68	29.00	27.28	28.24	20.83	23.29	21.98
T8	74.81 (59.87)	81.98 (64.91)	78.39 (34.04)	0.00	0.00	0.00	24.00	22.13	23.07	0.00	0.00	0.00
CD (5%)	5.29	8.16	1.18	-	-	-	3.86	11.10	2.32	-	-	-
SEm	1.56	2.69	0.58	-	-	-	1.21	3.66	1.13	-	-	-

* Values in parenthesis are arcsine transformed values.

Table 2: Cost benefit ratio of fungicide management of BLB caused by *Xanthomonas oryzae pv. Oryzae* on Rice

Treatment	Yield q/ha Pooled	Gross return	Total Cost	Net Return	B:C Ratio
T1	40.53	79818	43589	36229	1.83
T2	26.63	52442	43540	8902	1.20
T3	30.96	60991.8	42325	18666.8	1.44
T4	33.93	66830.4	43917.5	22912.9	1.52
T5	35.85	70544	46200	24344	1.53
T6	42.00	82670	43808	38862	1.89
T7	28.14	55379	40500	14879	1.37
T8	23.07	45376	40500	4876	1.12
CD (5%)	2.32				
SEm	1.13				

more effective. This increased effectiveness has also been shown against *Pseudomonas syringae pv. mango* when copper is used in combination with carbamate fungicides. The synergistic effects of Streptocycline and copper sulphate against *Xanthomonas campestris oryza* were significant findings from this investigation. According to Pranamika et al. (2017), *P. fluorescens* has been utilized to biologically manage a number of plant diseases. The siderophores pyochelin and pyoverdin, as well as the antibiotics pyoluteorin (PLT), pyrrolnitrin (PRN), and 2,4-diacetylphloroglucinol, are all produced by pseudomonads (Stutz et al., 1986). Anuratha and Gnananmanickam (1990) have noted that *P. fluorescens* produces antibiotics.

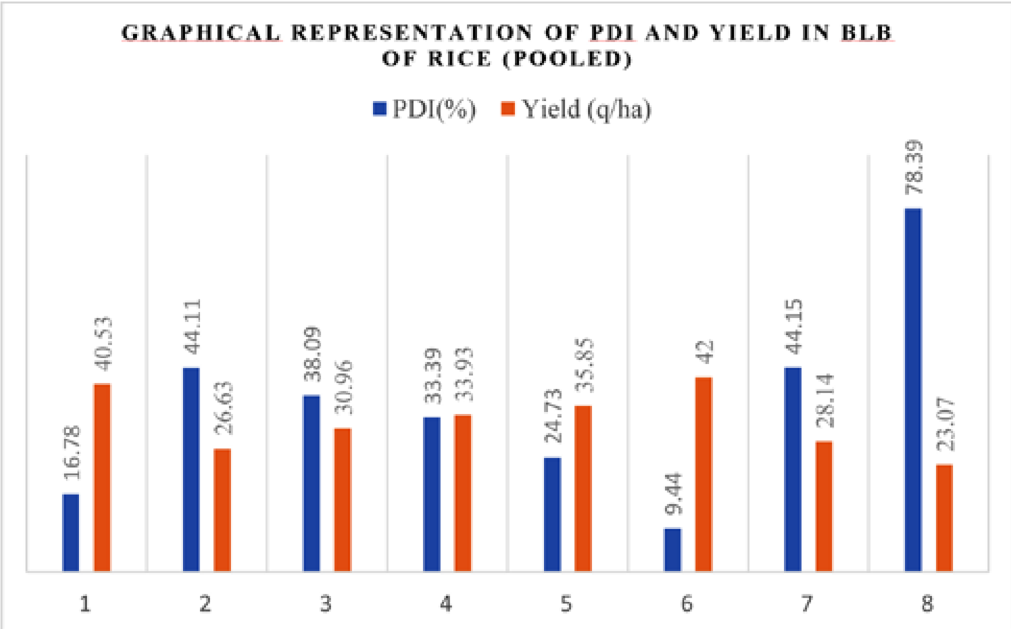

Fig 1: Per cent disease index (PDI) and Yield (q/ha) under field evaluation of fungicides for the management of BLB on Rice

Conclusion

The possibilities for integrated seed treatment, seedling root dipping, and foliar spraying may contribute to the development of an efficient and cost-effective method to control the *Xanthomonas* infections. In order to evaluate the effectiveness of seed treatment options that include seed dressing fungicide and bio agent combined with foliar spray of efficient fungicides and antibiotic for the management of BLB disease, a field experiment was carried out during *kharif*, 2021–22 and 2022–23. Combination fungicide treatments that included seed soaking in Streptocyclin at 0.01% for 12 hours, seedling root dipping in the same solution for 15 minutes prior to transplanting, and then first spraying with *Pseudomonas fluorescens* at 1.5%, second spraying with Streptocyclin at 0.01% + CuOCl2 @0.3%, and third spraying with *P. fluorescens* at 1.5% were found to be very effective in controlling rice's bacterial blight in western undulating zones of Odisha.

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Author Contributions

All authors contributed equally for preparing the final version of the manuscript.

Conflict of Interest

Authors declare no conflict of interest.

Ethical Approval

The article doesn't contain any study involving ethical approval.

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