YIELD LOSS ASSESSMENT OF RICE DUE TO BACTERIAL BLIGHT AT DIFFERENT RESISTANCE LEVEL

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ABSTRACT

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Susceptible Purbachi and Moderately resistant (tolerant) BR14 were evaluated for yield loss estimation in field condition under artificial inoculation with a virulent isolate (Bx09) of bacterial blight pathogen ((*Xanthomonas oryzae* pv. *oryzae)* at different rice crop growth stages during Boro (winter). The pathogen was inoculated at Active tillering (AT), Panicle initiation (PI), Booting (Bt) and Flowering (Fl) stages singly and combinedly like AT+PI, AT+PI+Bt and AT+PI+Bt+Fl. Disease severity index (DSI) was high in BB susceptible Purbachi (2.3-8.7) than BR14 (0.0-5.8). Disease severity index was low at flowering stage and the highest at booting stage inoculation in both the varieties. Significant variation was found in the number of unfilled spikelets per panicle. The number of unfilled spikelets per panicle was lower at flowering stage inoculation irrespective of varieties. Among single stage inoculations, Purbachi resulted similar number of spikelet sterility per panicle at panicle initiation (26.6) and Boot (23.4) whereas BR14 resulted maximum (27.0) at booting. However, BB inoculation combined at different stages in a treatment produced more number of spikelet sterility per panicle (26.3-40.4) than single stage inoculation 19.4-26.6) in Purbachi. It means early infection and the gradual development and spread of the disease to almost all the leaves significantly increased the spikelet sterility. Purbachi had significant yield reduction 14.9-28.5% in single and 21.1-47.4% in combined stage inoculations. BR14 had no significant yield reduction although there was 0.8-16.2% yield loss compared to the control. Both the susceptible (28.5%) and tolerant (16.2%) variety gave the highest reduction at booting stage and minimum at flowering stage (0.0-2.1%) inoculation. These results indicated that disease infection and development at booting stage in both susceptible and moderately resistant or tolerant variety is the most vulnerable stage for yield reduction. This information would be useful for the management strategies of early infection of bacterial blight in rice crop production.

Key words: Rice variety, bacterial blight, disease severity, yield loss

INTRODUCTION

Rice (*Oryzae sativa* L.) is one of the staple food crops in the world and feeds about half of the world population (Anon. 2016). Rice is synonym to food security in Bangladesh. It has been growing over two to three consecutive seasons in Boro (winter), Aus and Aman (summer) seasons in Bangladesh. Different rice diseases have put the rice production under threat. Among the diseases, Bacterial blight caused by *Xanthomonas oryzae* pv. o*ryzae* is one of the major diseases that generally occurred over the seasons in Bangladesh and also reported in different countries (Jeung *et al.* 2006, Ronald 1997, Mew 1987, Tagami and Mizukami 1962). This is a vascular disease and the bacteria cause systemic infection ((Mew 1987). Bacterial blight (BB) can cause 10-20% yield losses at medium level of disease incidence in moderate resistant cultivars. While the disease causes up to 50% yield loss in conducive condition in the susceptible cultivars (Ou 1985, Mew *et al*. 1993). Incidence of BB is reported every year in different parts of Bangladesh due to extensive use of nitrogen fertilizers as well as changing climate scenario (Anon. 2016a, Anon. 2017, Anon. 2018, Bashir *et al.* 2010, Ali *et al.* 2009, Akhter *et al.* 2003). Yield loss in BB resistant cultivars is insignificant (Ou 1985). But, virulent races of this disease often exist in tropical environment ((Buddenhagen and Reddy 1971). The virulent races of BB and favourable environment of the disease cause the rice crop vulnerable during the

growing period. Further, intensive rice culture and use of high dose of nitrogen enhance the disease severity. Therefore, irrespective of cultivar resistance, estimation of yield loss is very important for the development of disease resistant strategies.

High dose of nitrogen predisposes the plants to BB but BB resistant varieties may not be affected severely due to its defense response, characterized by an increase in peroxidase activities, the deposition of lignin into the plant cell wall, host cell death, and limitation of bacterial multiplication (Reimers *et al.* 1992). As a result, yield loss in resistant cultivars were reported insignificant under field conditions (Ou 1985). Estimation of yield loss varies depending on the location, season, weather conditions, rice cultivars, management factor like nitrogen and the crop stage at which the infection takes place. On the other hand, evaluation of disease severity and crop loss assessment help in reliable estimation of yield loss and thereby determine the economic impact (James 1974). Therefore, estimation of yield loss under local host-pathogen-environment interrelationship condition is necessary.Field experiments were conducted in Boro season to understand the yield losses to be occurred due to initiation of BB at different crop stages in different resistant levels of varieties.

MATERIALS AND METHODS

Location, season and plant materials

The experiment was conducted in the research field of Bangladesh Rice Research Institute (BRRI) during Boro season. A susceptible variety Purbachi and a moderately resistant BRRI variety BR14 were evaluated for yield loss estimation under artificial bacterial blight inoculation.

Field management

Land was prepared with four cultivations for seedling transplanting and growing. Basal fertilizers and Furadan5G (20 kg/ha) were applied during final land preparation following BRRI recommended dose. Urea was applied at 120 kg N/ha in three splits starting at 15 days after transplanting with 15 days interval. Seedlings were transplanted in the field at the age of 35 days. Rice seedlings were planted in rows spaced with 20 cm and 15 cm in between plants in a row. Individual plot size was 3m × 2m. Other management practices were as the BRRI recommended production practices (BRRI 2015).

Treatments and design

Plants were inoculated at different growth stages. Bacterial blight inoculation was done differently at Active tillering (AT), Panicle initiation (PI), Middle Booting (Bt) and Flowering (Fl). Bacterial blight inoculation in different crop stages in the same plants were also done in three different combinations like AT+PI, AT+PI+Bt andAT+PI+Bt+Fl. Therefore, there were eight treatments including a control (no inoculation). The experiment was laid out in RCB design with three replications.

Isolation and culture of Bxo9 isolates

A virulent isolate of bacterial blight Bxo9 was isolated from the bacterial blight infected leaf. Bacterial blight infected leaf samples were collected from the research field of Bangladesh Rice Research Institute (BRRI). Infected samples were sterilized first with 70% (v/v) ethanol for one minute and rinsed with sterile water. Then sterilized samples were cut into small pieces of 3-4 mm in size and rinsed twice in sterilized water for 2-3 minutes. After that the leaf pieces were soaked in 5 ml sterilized water for 30 min at room temperature to allow bacteria to disperse into the surrounding liquid in the Laminar flow. The water became cloudy which indicated the presence of a huge number of bacteria. A loop full of the washings (bacterial suspension) was streaked onto Peptone-sucrose-agar (PSA) medium and wrapped with cellophane tape to minimize the risk of contamination. Plates were incubated at 30 ^{0}C in an incubator. After 48 hours, several yellowish or light-yellow watery colonies appeared on the medium of the plate. Further streaking on PSA petri plates allowed single colonies and pure culture was obtained. Finally, single bacterial colony was cultured in a considerable number of slants and preserved at -20 ^{0}C for further use.

Inoculation

Fresh culture of Bxo9 isolate was done again using the slant prepared and preserved earlier before inoculation in any stage of the crop. Bxo9 was grown in PSA petri-plates or bottles under room temperature for 48 hours. Then distilled water was added in each petri plate/bottlefor making the bacterial suspension. The concentration of inoculum was adjusted approximately 10^8cfu/ml. Plants were inoculated with 48 hours old culture inoculum of Bxo9 at different growth stages singly and in combination as mentioned above. All the plants in each plot were inoculated following leaf clipping method (Kauffman *et al.* 1973). Almost all the leaves were cut 2-3 cm from the leaf tip with scissor dipping in bacterial suspension immediate before cutting the leaves.

Disease estimation and Data collection

In order to estimate the disease severity, 10 plants were selected from each replicated plot following diagonal method of sampling. Disease scoring was done at 21 days after inoculation (DAI). Disease severity index (DSI) was estimated based on leaf lesion spread following IRRI SES scale (IRRI 1988)

from all infected leaves in the selected 10 plants. Data on plant height (cm), panicle length (cm), number of unfilled spikelets/panicle, 1000 grain weight (g), and yield of the whole plot were recorded at the time of harvesting. Yield loss was calculated using the following formula:

$$\% \text{ Yield loss} = \frac{\text{Healthy plot yield} - \text{Diseased plot yield}}{\text{Healthy plot yield}} \times 100$$

RESULTS AND DISCUSSION

Disease severity

Disease severity in the inoculated leaves was high in BB susceptible Purbachi than moderately resistantBR14 (Table 1). Disease severity index ranged from 2.3-8.7 in Purbachi and 0.0-5.8 in BR14. Disease severity was significantly higher in all the treatments compared to the control irrespective of the varieties. The disease severity index was recorded 6.5 and 4.4 respectively in Purbachi and BR14 at flowering. While disease severity index was ranged from 7.8-8.7 in Purbachi and 5.7-5.8 in BR14 among AT to Booting stages. Disease severity index was low at flowering stage inoculation than the other three stages inoculation differently at AT, PI and Booting in both susceptible and tolerant varieties. Mondal and Latif (1996) also reported the similar disease severity index at maximum tillering and panicle initiation stages. Mew (1992) stated that disease incidence increases with plant growth and reached peak at the flowering stage. Mew (1993) also mentioned that disease progress of bacterial leaf blight is related to stages of plant growth. The reason behind the decrease in the mean lesion area at flowering stage of this study was due to change of resistance of the growing rice leaves or plants.

Table 1. Disease severity index (DSI) for bacterial blight (BB) inoculation at different growth stages

BB inoculation at crop stage	Disease Severity Index[a]	
	Purbachi	BR14
AT	8.7	5.7
PI	7.8	5.8
Booting	8.6	5.7
Flowering	6.5	4.4
AT+PI[b]	7.8	5.1
AT+PI+Bt[b]	7.6	5.4
AT+PI+Bt+Fl[b]	7.0	5.1
Control	2.3	0.0

[a]21 days after inoculation. [b]Disease index is the average of BB indices of all the stages. AT: Active tillering, MT: Maximum tillering, PI-Panicle initiation, Bt: Booting and Control (no inoculation)

Effect on growth characters

The plant height ranged from 90.33-93.27 cm in Purbachi (Table 2). Bacterial blight (BB) inoculation at different stages singly or in combination had no significant effect on plant growth. Similar results were also observed in BR14 where the plant height ranged from 108.67-115.73 cm in BR14. The panicle length showed no variation and inconsistent trend in both the varieties.

Table 2. Different crop growth characters as influenced by bacterial blight (BB) inoculation.

BB inoculation at crop stage	Plant height (cm)		Panicle length (cm)	
	Purbachi	BR14	Purbachi	BR14
AT	90.33 a	109.20 a	22.96 ab	28.00 a
PI	93.27 a	111.47 a	22.96 ab	26.81 a
Booting	92.33 a	110.13 a	23.37 ab	27.89 a
Flowering	91.50 a	111.07 a	21.71 a	27.20 a
AT+PI	87.33 a	108.67 a	22.79 ab	26.35 a
AT+PI+Bt	85.47 a	109.13 a	23.89 b	27.17 a
AT+PI+Bt+Fl	92.00 a	109.67 a	22.19 ab	26.69 a
Control	90.47 a	115.73 a	23.51 ab	26.88 a

In a column figures with common letters did not significantly differ at 5% level by DMRT. AT: Activetillering, MT: Maximum tillering, PI-Panicle initiation, Bt: Booting and Control (no inoculation)

Number of unfilled spikelets/panicle

Significant variation was found in the number of unfilled spikelets per panicle (Table 3 and Table 4). The number of unfilled spikelets per panicle ranged from 12.92-40.36 in Purbachi and 16.34-26.96 in BR14. In both the varieties, the lowest number of unfilled spikelets was observed in the control (no inoculation) treatment. On the other hand, the highest unfilled spikelets was recorded when plants were inoculated at all three stages AT+PI+Bt (40.36) followed by AT+PI+Bt+Fl (35.26) in Purbachi (Table 3). In BR14, the highest number of unfilled spikelets was recorded at booting stage inoculation (26.96)

followed by inoculation at AT+PI+Bt (24.3) and PI (24.09). Bacterial blight inoculation at flowering stage showed negligible effect on the number of unfilled spikelets per panicle in both the varieties. These results indicated that BB disease initiation from AT to booting stages caused the plant vulnerable to produce more unfilled spikelets per panicle. Irrespective of the variety, thousand grain weight showed no difference among treatments as compared with the control except for the lowest 20.52 g in AT+PI+Bt in Purbachi. However, the thousand grain weight was less in any treatments irrespective of the variety compared with the control. Intensification of the disease severity influenced the less weight of thousand grain weight (Shaheen *et al*. 2019).

Table 3. Effect of BB on yield and yield components of susceptible rice variety Purbachi during Boro.

BB inoculation at crop stage	No. of unfilled spikelets/panicle	1000 grain weight (g)	Yield (t/ha)	Yield loss (%)
AT	20.14 ab	22.07 ab	3.96 ab	26.1
PI	26.56 abc	21.92 ab	4.56 bcd	14.9
Booting	23.39 abc	21.44 ab	3.83 ab	28.5
Flowering	19.43 ab	21.43 ab	5.68 d	-6.0
AT+PI	26.32 abc	22.26 ab	4.23 bc	21.1
AT+PI+Bt	40.36 c	20.52 a	2.82 a	47.4
AT+PI+Bt+Fl	35.26 bc	21.39 ab	4.02 ab	25.0
Control	12.92 a	23.14 b	5.36 cd	0.0

In a column figures with common letters did not significantly differ at 5% level by DMRT. BB: Bacterial blight, AT: Active tillering, MT: Maximum tillering, PI-Panicle initiation, Bt: Booting and Control (no inoculation)

Table 4. Effect of BB on yield and yield components of a tolerant rice variety BR14 during Boro.

BB inoculation at crop stage	No. of unfilled spikelets/panicle	1000 grain weight (g)	Yield (t/ha)	Yield loss (%)
AT	21.81 bcd	25.68 a	6.12 a	0.8
PI	24.09 cd	25.66 a	5.86 a	5.0
Booting	26.96 d	23.81 a	5.17 a	16.2
Flowering	19.15 abc	24.81 a	6.04 a	2.1
AT+PI	23.95 cd	26.52 a	5.70 a	7.6
AT+PI+Bt	24.30 cd	25.86 a	5.49 a	11.0
AT+PI+Bt+Fl	18.10 ab	24.96 a	5.79 a	6.2
Control	16.34 ab	29.39 a	6.17 a	0.0

In a column figures with common letters did not significantly differ at 5% level by DMRT. BB: Bacterial blight, AT: Active tillering, MT: Maximum tillering, PI-Panicle initiation, Bt: Booting and Control (no inoculation)

Yield loss assessment

The yield varied much among the treatments in Purbachi but no differences were found in BR14. The yield ranged from 2.82-5.68 t/ha in Purbachi and 5.17-6.17 t/ha in BR14. The susceptible variety Purbachi produced significantly lower yield when BB inoculation was done at AT, Booting, AT+PI+Bt and AT+PI+Bt+Fl. Whereas, other treatments producedlow yield except at flowering. On the other hand, the tolerant variety BR14 produced similar yield in any treatments as compared with control. These results revealed that susceptible variety had the significant effect on yield reduction if the variety infected with BB disease at early stages from AT to Booting. The moderately tolerant variety like BR14 have the mechanism of yield recovery which could be a further interest of research.

The yield loss pattern in Purbachi indicated that BB inoculation at any stages have a considerable effect on yield reduction except at flowering (Table 3). Considering single stage inoculation, the yield loss was the highest at booting (28.5%) followed by AT (26.1%) and PI (14.9%) stages. On the other hand, the yield reduction was conspicuous at booting stage inoculation (16.2%) followed by PIand minimum at flowering stage inoculation (2.1%) in BR14 (Table 4). However, both the susceptible and tolerant variety gave the highest reduction at booting stage inoculation. Mondal and Latif (1996) reported 14.8% yield loss in Purbachi when inoculated at panicle initiation stage. But they did not investigate yield loss for inoculation at booting stage. Ou (1985) reported the yield was reduced by 10-30% based on disease severity and varieties used. However, the yield loss due to BB could be as high as 60-70% (1973). Results

indicated that the yield reduced by 47.4% in susceptible variety Purbachi if all the leaves inoculated successively at AT+PI+Bt stages. Bacterial blight inoculation at flowering stage did not affect the yield in both the varieties. These results indicated that disease infection and development at booting stage in both susceptible and moderately resistant ortolerant variety is the most vulnerable stage for yield reduction. This information would be useful for the management strategies of early infection of BB in rice crop production.

CONCLUSION

Bacterial blight disease development at early reproductive stages from PI to boot enhances the spikelet sterility of both susceptible and moderately resistant varieties. But significant yield loss was obtained only in susceptible variety. A considerable yield loss was recorded in moderately resistant variety. Therefore, disease management for early infection especially at booting stage or before should be concerned for saving and sustaining rice yield in the field.

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