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Effect of Potassium Fertilizer on Development of Bacterial Blight of Rice

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Abstract

Effect of five potassium doses viz, recommended dose (RD) (40 kg Murate of Potash(MP)/hector), RD + 10 kg MP/ha, RD + 20 kg MP/ha, RD + 30 kg MP/ha, RD + 40 kg MP /ha to manage bacterial blight of rice were studied during Boro season in 2005. The experiment was laid in Randomized Completely Block Design (RCBD) having three replications. Highest disease severity (55.92%) was observed due to bacterial leaf blight at maximum tillering stage when applied 30 kg MP/ha additional potash. Lowest disease severity (0.45%) of bacterial leaf blight were recorded from the plot where no additional MP was applied but highest yield (4.35 tones/ha) was observed in the plot where additional 20 kg MP/ha was applied. The amount of potassium in the leaves did not vary significantly even after additional application of potassium either 30 or 20 kg MP/ha though it was more (1.31%) when applied 40 kg MP/ha. In another experiment in the present study the lowest disease severity 15.22% and 10.53% were recorded when additional 5kg MP /ha was applied seven days before inoculation at active tillering and panicle initiation stages, respectively. Disease severity was lower in single inoculation compare to multiple inoculations except the plot where 5kg/ha additional potash applied three days before bacterial inoculation. Maximum yield (3.86, 4.38, 4.64 t/ha) was recorded when inoculated at active tillering, panicle initiation and flowering stages separately if potassium was applied seven days before inoculation than those of multiple inoculations. The results suggested that potassium top dressing just before disease initiation was good for higher yield and less disease development. However inoculation in all the growth stages of the crop gave lower yields even potassium application was done at seven or three days before or after inoculation.

Key words: Bacterial leaf blight, *Oryza sativa* L., Potassium fertilizer

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops of the world and more than 60% of the world population depends on rice for their carbohydrate in diet (FAO 2000). In respect of total cropped area and production, rice ranks the top position by covering about 10.80 million hectares of land from which 26.53 million tons of rice is produced per annum in Bangladesh (BBS, 2006). Rice constitutes about 92% of the total food grains produced and about 80% of the total cropped area of the country. It provides about 75% calorie and 55% protein intake in daily diet of the people (Siddique, 2002). Among the many causes of low yield of rice in Bangladesh, diseases and pests play a major role, sometimes leading to disastrous consequences (Fakir, 1982). Ironically, the tropical and subtropical climates that favour the production of rice is also favourable for its disease development. Out of 32 diseases of rice 10 are considered as major diseases among which bacterial leaf blight (BLB) caused by *Xanthomonas oryzae* pv. *oryzae* (*Xoo*) may cause substantial loss to rice both in quality and quantity in Bangladesh. BLB of rice is also a destructive disease in South and Southeast Asia. It is a systemic disease and may cause an average of 20-30% yield loss (Ou, 1985). In the tropics, depending on the severity of infection, the loss may be as high as 60-70% (Ou, 1973). Srivasta and Kapoor (1989) obtained 6-37% yield loss against 1-9 infection grade in India. The yield loss caused by BLB in Bangladesh has been estimated as 10-30% (Ashrafuzzaman, 1992). Use of fertilizer use, and its judicious and timely application are important factor for yield maximization of modern rice (Ali, 1985). This dangerous and common disease of rice is being

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controlled specially by spraying bactericides in the field as well as by treating seeds with the seed treating chemicals and developing disease resistant cultivars. Use of chemicals for spraying in the field or treating seeds are creating environmental pollution. Nutritional management of the diseases could be considered as an alternate to chemicals and less hazardous to nature. Application of fertilizers and manures in the soil are aimed to supply nutrient elements to the plant that creates positive reaction, means of inducing disease resistance to plants and as a result the plants may recover the disease or may overcome the disease epidemic (*Hossain et al.*, 1995 and Kundu *et al.,* 1996). In general, plants receiving a balanced nutrition, in which all required elements are supplied in appropriate amounts, are more capable of protecting themselves from new infections and limiting existing infections than when one or more nutrients are supplied in excessive or deficient amounts. However, even a balanced nutrition may affect the development of a disease when the concentration of all the nutrients is increased or decreased beyond a certain range (Agrios, 1997).

Soil is a harbour of plants having complex system of nutrient elements. It is considered as principal supplier of plant nutrients. In Bangladesh, nutrient content in soil are becoming more and more unbalanced due to variation in their inherent capacities to supply them which gradually decline over time due to intensive cropping with high yielding varieties, application of limited number of nutrients, very little or no use of organic materials and improper soil and crop management practices (BARC, 1997). As a result, the cultivated crop plants are subjected to inadequate supply of nutrients of which is reflected to make them vulnerable to a particular pathogen and to develop acute or chronic symptoms resulted in poor yield and quality of harvest. In order to obtain the maximum yield by minimizing diseases, there is a need to add nutrients to the soil in a judicious way. Therefore, the present study was undertaken to determine the effect of potassium on the incidence and percent leaf area infection of BLB of rice caused by *Xoo.*

Materials and Methods

The experiment was carried out in the field of Plant Pathology Division, Bangladesh Rice Research Institute (BRRI), Gazipur during the transplanted Boro season *i,e* from December 2004 to May 2005.A modern transplanted Boro rice variety BRRIdhan 29 was used in this experiment. The experimental period was December 2004 to May 2005. Seedlings were raised in the seed-bed during the month of December, 2004 and transplanted in the month of January, 2005. Experimental data were collected during the crop growing period, (March-May, 2005). The crops were harvested in May 2005.

Seed bed preparation and raising of seedlings

A small piece (2 m x 3 m) of medium low field of BRRI farm was puddled with the power tiller. The land was marshy and rich in organic matter and no fertilizers were applied to the seedbed. Seeds were collected from the Plant Pathology Division, BRRI, Gazipur. Clean mature and healthy seeds were soaked in tap water for 24 hours. Sprouted seeds were sown uniformly in seedbed on December 2004. The seedbed was protected from birds and animals. Adequate water was applied to the growing seedlings in seedbed as and when required till before transplanting. The seed were then incubated in wet sack for 3 days for germination in room temperature.

Experimental design and field layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) having three replications for each treatment. Distance between the blocks and between the plots was 50 cm and 25 cm, respectively. There were altogether 15 (Expt.1) and 96 (Expt.2, 3, 4 and 5) plots for the study. Different treatments were assigned randomly to the unit plot (2 m x 1.5 m). Details of the field layout are presented in the following/Next page.

Land preparation

The main land was opened by power tiller. Later the soils was paddled thoroughly by 3 successive laddering and harrowing. The field layout was made immediately after final land preparation in accordance with the experimental design. The individual plots of each unit plot was then raised so that the fertilizer could not move from one plot to other.

Fertilizer application

The following chemical fertilizers as per recommendation dose (RD) were applied in the field as a general dose: (1) Nitrogen (N) as urea 80 kg/ha, (2) Phosphorus (P_2O_5) as TSP 60 kg/ha, (3) Potassium (K_2O) as MP 40 kg/ha. One third of nitrogen (N) and all other fertilizers were incorporated with soil during final land preparation. Rest 2/3rd of nitrogen were top dressed at 2 equal splits, 1/3rd at 25 days after transplanting and rest 1/3rd at maximum tillering stage. Additional potash (MP) was applied at 7 days before inoculation at the rate of 0 (T_1/control), 10 (T_2), 20 (T_3), 30 (T_4) and 40 (T_5) kg/ha (Expt.1). Additional potash (MP) (5 kg/ha) was applied at different growth stages (Active tillering, panicle initiation and flowering stage) at 7 days and 3 days before inoculation of Xoo (Expt. 2 and 3) and 3 and 7 days after inoculation (Expt. 4 and 5).

Transplantation of seedlings

Forty one day old seedlings were transplant the main field. Three seedlings per hill were planted with a spacing of 20 cm x 20 cm. Some of the seedlings were planted around the experimental plot as border crop at the same time. Transplantation was done on the 18th January, 2005.

Isolation and purification of *Xoo*

Bacterial blight infected leaves of rice were collected from the field of BRRI, Gazipur and brought to the laboratory of Plant Pathology Department of Botany, Dhaka University, Dhaka. The leaf tissue from the advancing lesion was used for isolation. The leaf tissue from advancing lesion were cut into pieces (ca 1.0 mm^2). Surface sterilization was done by soaking the leaf pieces in 70% ethyl alcohol followed by dipping in 5% chlorox for one minute (Vera cruz 1984). The surface sterilized pieces were kept for 30 minutes in sterile water to release the bacterium. Finally a full loop of the suspension was streaked on a plate of PSA medium and incubated at 28±2^{o}C temperature. Observation was made after 72 hours of streaking for the appearances of *Xoo* colonies. After 5 days the bright yellow bigger and slimy colonies were selected. The selected colonies were-re-streaked on the PSA medium. Finally pure single colonies were selected. The pure culture was used for further application. All these operation were done aseptically in the laminar flow chamber. The pure culture was preserved at refrigerator for further study.

Preparation of culture and inoculation

A bacterial leaf blight isolate (Bx0^9) was tested for its pathogenicity. The isolates revived in PSA medium after short-term preservation in a refrigerator just after isolation. The bacterium was grown on PSA slant for 48 hours. Then 10 ml of sterile water was poured in the tubes. After 5 minutes, the cultures were scarped and transferred to sterile empty test tubes. Finally a bacterial suspension having approx 10^{8-10} cfu/ml of water was made. The sterilized scissors were soaked in the suspension after cutting of each 3 leaves.

Selection of pathogenic strains

Fifteen days after inoculation, the isolates that developed blighted symptom were selected for resolution and further studies.

Methods of inoculation

The sterilized pair of scissors was soaked frequently in the suspension after cutting every 3-4 leaves. The plants were inoculated in the following manner:

a) Experiment-1

T_1 = Recommendation dose (RD) 40 kg/ha potash and no inoculation, T_2 = RD + additional 10 kg potash/hectare and 100% inoculation, T_3 = RD + additional 20 kg potash/hectare and 100% inoculation, T_4 = RD+ additional 30 kg potash/hectare and 100% inoculation, T_5 = RD + additional 40 kg potash/hectare and 100% inoculation.

b) Experiment-2, 3, 4, 5

T_1= Recommendation dose (RD) and no inoculation, T_2 = RD + additional 5 kg/ha at ATS stage, T_3 = RD + additional 5 kg/ha at PI stage, T_4 = RD + additional 5 kg/ha at FG stage, T_5 = RD + additional 5 kg/ha at ATS + PI stage, T_6 = RD + additional 5 kg/ha at ATS + FG stage, T_7 = RD + additional 5 kg/ha at PI+ FG stage, T_8 = RD + additional 5 kg/ha at ATS + PI+ FG stage.

Assessment of severity of bacterial leaf blight

Each plot was visited for recording the incidence and % leaf area infection owing to bacterial leaf blight after 14 days of inoculation. Data were recorded visually by observing the symptoms. Ten hills were selected randomly from each plot. The parameters considered for this study were: (i) Total number of tillers per hill, (ii) Diseased tillers per hill, (iii) Total number of leaves per hill, (iv) Diseased leaves per hill, and (v) Percentage of diseased leaf area.

Disease incidence and percentage of diseased leaf area were calculated by the following formula:

$$\text{Disease incidence,(DI)} = \frac{\text{Number of infected plants}}{\text{Total Number of plants}} \times 100$$

% Leaf area diseased was assessed by the following formula.

$$\% \text{ Leaf area diseased} = \frac{\text{Leaf area diseased}}{\text{Total leaf area}} \times 100$$

The collected data were analyzed statistically and the mean, standard deviation and other calculations are evaluated considering 5% level of significance by a computer package programme called SPSS (Statistical Package for Social Science) of version 14, now frequently being used to analyze all sort of data and this version was developed by SPSS Inc.

Results and Discussion

Effect of different doses of potassium at *Xoo* inoculation on disease severity (DS), grain weight and yield of rice

Effect of different doses of potassium at 7 days before *Xoo* inoculation on the disease severity , grain weight and yield of rice is presented in Table I. There were no significant differences in 1000 grain weight and yield among the treatments. However, significant difference were recorded in percent diseased leaf area/disease severity. The highest disease severity (55.92) was observed in T_4 and lowest (0.45) in T_1. However, additional 20 kg/ha potassium (K) application was found more effective and economic.

severity was lower in single inoculations (T_2, T_3, and T_4) compare to multiple inoculations (T_5, T_6, T_7 and T_8) except when K applied 3 days before bacterial inoculation. Disease severity was statistically similar T_2 (15.22%) with T_3 (10.53%) and 14 treatments when potassium applied at 7 days before inoculation. However, 1000 grain weight were not significantly different among the treatments. Yield was higher in single inoculated plots at different growth stages eg. T_2, T_3, and T_4 (3.86, 4.38, 4.64 t/ha respectively) when K applied at 7 days before inoculation compare to those of other applications. Yield of T_5, T_6, T_7 and T_8 (3.92, 3.7, 4.03 and 3.48 t/ha respectively) was higher when potassium applied at 3 days before inoculation compare to those of other applications. From the experiment, it might be concluded that k top dressing just before disease initiation was good for higher yield and less disease development. However, inoculation at all the growth stages of the crop gave lower yield even potassium application was done at 7 or 3 days before or after.

Effect of different doses of potassium on rice grain

Effect of different doses of potassium on rice grain are presented in Table III. The number of grains per panicle obtained in plants infected with bacterial leaf blight pathogens ranged from 73 to 80. The highest number (80) of

Table I: Effect of different doses of potassium on the disease severity (DS), grain weight and yield of rice

Treatments	Disease severity	Grain weight (g)	Yield(t/ha)	% of potassium at harvesting
T_1	0.45 a	23.05	4.30	1.10 ab
T_2	29.49 ab	22.55	4.22	1.03 a
T_3	25.07 ab	21.77	4.35	1.14ab
T_4	55.92 c	22.71	4.07	1.16 ab
T_5	21.13 ab	22.41	4.26	1.31 abc
LSD (5%)	53.37	0.45	1.87	0.26

T_1 = 0 (control), T_2 = 10 kg/ha, T_3 = 20 kg/ha, T_4 = 30 kg/ha and T_5 = 40 kg/ha, In column, values having common letter(s) do not differ significantly at P = 0.05 level by Duncan Multiple Rank Test (DMRT). Least Significant Difference (LSD) at 5% level of significance were calculated here.

Effect of additional potassium (5 kg/ha) application at different growth stage on the disease severity, grain weight and yield.

Effect of additional potassium (5 kg/ha) application at different growth stage on the disease severity (DS), grain weight and yield of rice presented in Table II, III, IV and V. Disease

grains per panicle was observed in T_2 (80) followed by T_5 (76.02) with significant difference with each other. In contrast, the lowest number of grains per panicle was observed in T_1 (73), followed by T_3 (74.36).

The highest number of healthy grains/panicle (72.0) was observed in T_2 followed by T_5 (71.18). These two treatments

Table II: Effect of additional potassium application at 7 days before *Xoo* inoculation on disease severity, grain weight and yield of rice

Treatments	Disease severity	Grain weight(g)	Yield (t/ha)
T_1	1.5 a	21.87	4.48 ab
T_2	15.22 b	22.82	3.86 bcde
T_3	10.53 b	21.79	4.38 abc
T_4	11.2 b	22.39	4.64 a
T_5	30.3 c	23.71	3.76 cde
T_6	38.91 d	21.98	3.31 dc
T_7	31.55 c	21.83	3.97 abcd
T_8	32.19 cd	21.37	3.26 e
LSD (p=0.05)	6.99	2.68	0.68

In column, values having common letter(s) do not differ significantly at P = 0.05 level by DMRT.

T_1 = No inoculation, T_2 = ATS, T_3 = PI, T_4 = FG, T_5 = ATS + PI, T_6 = ATS + FG, T_7 = PI + FG, T_8 = ATS + PI + FG.

had however, significant difference with each other. On the other hand, the lowest number of healthy grains per panicle was observed in T_1 (66.0).

Unfilled grains per panicle (%) ranged from 6.37% to 10.3 % . The highest number of unfilled grains per panicle was recorded on T_2 treated plots (10.3 %) followed by T_1 (9.6 %). The lowest number of unfilled grains per panicle was observed in T_5 (6.37 %) followed by T_3 (7.76 %) and T_4 (7.82 %).

Effect of additional potassium (K) application at 7 and 3 days after and before Xoo inoculation at different growth stages on rice grain.

The height number (127.70) of grains/panicle was observed in T_4 at 7 days before Xoo inoculated plot. The lowest number (68.5) of grain/panicle was observed in T_7 at 3 days after inoculation. Considering healthy grains/panicle the highest number (102.8) of healthy grains/panicle was observed in T_4 at 7 days before inoculation. On the other hand the lowest

Table III: Effect of different doses of potassium on the grain quality of rice

Treatments	Total No. of grains/panicle	No. of healthy grains/panicle	Unfilled grains/panicle (%)	Reduction of unfilled grains/panicle (%)
T_1	73.00 a	66.00 a	9.60 b	-
T_2	80.00 a	72.00 c	10.00 bc	0.4
T_3	74.36 a	68.59 ab	7.76 ab	-1.84
T_4	74.91 a	69.05 ab	7.82 ab	-1.76
T_5	76.02 a	71.18 bc	6.37 a	-3.23
LSD (0.05)	7.171	3.156	1.407	

In column, values having common letter(s) do not differ significantly at P = 0.05 level by DMRT.

T_1 = Recommended dose (40 kg/ha potassium) and 100 % inoculation

T_2 = RD + additional 10 kg potassium /hectare and 100 % inoculation .

T_3 = RD + additional 20 kg potassium /hectare and 100 % inoculation

T_4 = RD + additional 30 kg potassium /hectare and 100 % inoculation

T_5 = RD + additional 40 kg potassium /hectare and 100 % inoculation number (59.1) grains/panicle observed in T_7 at 3 days after inoculation.

Unfilled grains/panicle observed in T_8 at 7 days before inoculation the lowest number (8.30%) on unfilled grains/panicle observed in T_1. Control plot at 7 days after inoculation unfilled grains/panicle was higher in single inoculated plots at different growth stages eg. T_2, T_3 and T_4 (28.63, 26.00 and 27.56% respectively) when K applied at 7 days before inoculation compare to those of other application.

Average percentage disease severity of bacterial leaf blight on both inoculated and uninoculated plants answered at maximum tillering stage ranged from 0.45 to 55.92%. It was observed the % disease severity was increasing trend with increased amount of K. It indicated that potassium had no great preventive influence on disease severity of BLB in rice. This result contradicts with many workers (Reddy *et al*., 1979; Shahjahan, 1993; Haque, 1999). They reported that the percentage leaf area infection of BLB decreased with increased K fertilizers combination. Similar results was also reported by Naidu e*t al.* (1978) and Sudhakar *et al*. (1989). Anonymous, 1984 reported that balance fertilizer including potassium reduced percentage incidence of bacterial BLB in Nizersail.

Table IV: Effect of additional potassium application at 7 days before *Xoo* inoculation at different growth stages on rice grain

Treatments	Total No. of grains/panicle	No. of healthy grains/panicle	Unfilled grains/panicle (%)	Reduction of unfilled grains/panicle
T_1	107.62 a	88.1 cd	18.14 a	
T_2	108.97 a	81.04 b	25.63 cd	7.49
T_3	118.84 b	87.94 c	26.00 cd	7.86
T_4	127.70 c	92.5 d	27.56 d	9.42
T_5	115.98 b	87.93 c	24.15 bcd	6.01
T_6	117.47 b	91.67 cd	21.96 b	3.82
T_7	113.93 b	102.8 e	23.8 bc	5.1
T_8	115.13 b	67.86 a	41.05 e	22.91
LSD (0.05)	4.918	4.314	2.196	

In column, values having common letter(s) do not differ significantly at P = 0.05 level by DMRT.

T_1 = No inoculation, T_2 = ATS, T_3 = PI, T_4 = FG, T_5 = ATS + PI, T_6 = ATS + FG, T_7 = PI + FG, T_8 = ATS + PI + FG

Different doses of additional potassium fertilizers were applied to know the effect of potassium on incidence and percentage of disease severity of BLB. In the present study, results revealed that the disease severity was increased with increasing amount of potassium applied. That means potassium had no strong preventive influence on bacterial leaf blight infection.

This result partially agree with many workers (Reddy *et al.,* 1979; Naidu *et al*., 1978; Sudhakar *et al*., 1989). They reported that bacterial leaf blight of rice decreased with application of k fertilizers. Similar results were also reported by Shahjahan (1993) and Haque *et al.* (1999). It has been reported that phosphorous and potassium deficiencies incidence of BLB (Ou, 1985). In contrast, Rahman (2002) observed that increasing the doses of NPK fertilizers also increased the bacterial leaf blight.

Number of grains/panicle and unfilled grains/panicle differed significantly among the treatments. The lowest grains/panicle was observed in control and the lowest was observed in BLB inoculated plants. The nutrient uptake and translation inhibition in the infected plants resulted in the production of less number of filled grains/panicle with increased number of unfilled grains/panicle and finally the yield was drastically reduced (Rush and Lee, 1992).

Grain yield of rice profoundly varied from one treatment to another. Mean yield of different doses of BLB inoculated plots ranged from 4.07 to 4.35 tone/hector. The highest yield (t/ha) was obtained in T_3 treated plot 10 hectors 20 kg/ha K application. The BLB inoculation affected plants by inhibiting nutrients and translocation of the nutrients in the severely infected plants of plant growth which resulted in the production of yield was reduced. Result also revealed that k had paritial inhibitory effect on BLB in rice. Because, in T_4 disease severity (DS) was only 55.92 %. It was effect of additional K fertilization. Similar result was also observed in other additional k treated plots (T_2, T_3 and T_5). These results were in agreement with the finding of Kozaka (1975) who reported that yield of rice was highest from NPK + cow dung application. Further Khairul Bashar (2000) reported that combined fertilizer including K and had inhibitory effect on BLB infection. Therefore, additional K application may be advisable to the farmers for managing BLB of rice which is ecologically friendly and economically viable. But further research work need to be carried out to confirm the results.

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