J. Agrofor. Environ. 2(1): 1-6, 2008 ISSN 1995-6983

Phosphate solubilizing rhizoplane bacteria on growth and yield of transplant aman rice

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Abstract: The effect of Inoculation of phosphate solubilizing bacteria (PSB) isolated from rice rhizoplane on transplant aman rice (*Oryza sativa* L.) cv. BRRIdhan 39 with addition of four different levels of P (0, 15, 30 and 45 kg P ha^{-1}) as triple superphosphate was studied through a pot culture experiment. Inoculation of rice seedlings with PSB strains RB03 and RB10 increased plant height, number of tillers hill^{-1}, panicle length, number of filled grains panicle^{-1}, weight of 1000 grains and grain yield of rice. Inclusion of TSP accentuated the performance of PSB in increasing the growth and yield attributes of rice.
Keywords: Phosphate solubilizing rhizoplane bacteria, transplant aman rice, root inoculation, growth and yield.

Introduction

Phosphorus (P) is a most essential macronutrient required for maximizing the yield of crops. In some soils, it remains in insoluble form (Abd-Alla, 1994; Yadav and Dadarwal, 1997). A considerable part of it accumulates as a consequence of regular applications of P fertilizers (Richardson, 1994). On the other hand, a large portion of soluble inorganic phosphate applied to soil as chemical fertilizer is rapidly immobilized soon after application and becomes unavailable to plants (Yadav and Dadarwal, 1997). Phosphorus fixation and precipitation in soil is highly dependent on pH and soil type. In acid soils, free oxides and hydroxides of Al and Fe fix P, while in alkaline soils it is fixed by Ca, causing a low efficiency of soluble P fertilizers (Lindsay, 1979). A substantial number of bacterial species, mostly those associated with the plant rhizosphere, may exert a beneficial effect upon plant growth (Glick, 1995). This group of bacteria has been termed “plant growth promoting rhizobacteria” or PGPR (Kloepper and Schroth, 1978) and, among them, some phosphate- solubilizing bacteria (PSB) are already in use as commercial biofertilizers for agricultural improvement (Rodriguez and Fraga, 1999). For agronomic utility, inoculation of plants by target microorganisms at a much higher concentration than those normally found in soil is necessary to take advantage of their beneficial properties for plant yield enhancement. Seed or soil inoculation with phosphate-solubilizing bacteria is known to improve solubilization of fixed soil phosphorus and applied phosphates resulting in higher crop yields (Abd-Alla, 1994; Yadav and Dadarwal, 1997). PSB associated with plant roots have been considered as one of the possible alternatives for inorganic phosphatic fertilizer for promoting plant growth and yield (Rodríguez and Fraga, 1999). The present piece of work was, therefore, undertaken to study the performance of phosphate solubilizing bacterial strains as compared to chemical P fertilizers on growth and yield attributes of rice.

Materials and Methods

The study was conducted at bacteriology laboratory of Seed Pathology Centre and Net House and laboratory of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh during March, 2006 to November, 2006 using acidic red soil through pot culture. Following root inoculation with previously isolated PSB strains RB03 and RB10, four seedlings of BRRIdhan 39 (life span -110 days, T. aman rice variety released by BRRI) were transplanted per hill in each pot (30cm×15cm×30cm) containing 7.5 kg acidic red soil collected from Bhaluka (Clay textured soil having pH 4.47) in Aman season. The experiment was laid out in randomized complete block design with two factors viz. PSB inoculants {i.e. Inoculation without PSB strain (RB_0) and with PSB strains RB03 (RB_{03}) and RB10 (RB_{10})} and four different levels of P (0, 15, 30 and 45 kg P h^{-1}) as triple superphosphate fertilizer with 3 replications. N, P, K, S fertilizers were applied @ 120 kg N ha^{-1}, 30 kg P ha^{-1}, 60 kg K ha^{-1} and 9 kg S ha^{-1} as urea, TSP, MoP and gypsum respectively. To compare the efficiency of PSB, P was applied at the rate of 0, half, full and one and a half times of the recommended dose as TSP. One third of N and total of the other fertilizers were mixed with soil at the time of pot preparation. Rest two third of urea was top dressed 25 days of transplanting and before panicle initiation. Intercultural operations were done as and when needed for proper growth and development of the crop. Data on growth, yield and different yield components of rice were recorded during the growing period and after harvest.

Results and Discussion

Effects of Inoculation of PSB on growth and yield attributes of rice

Among the growth and yield attributes of T. aman rice cv. BRRIdhan 39 under study, panicle length, total number of grains panicle^{-1}, number of filled grains panicle^{-1}, weight of 1000 grains, grain yield pot^{-1} of rice were significantly influenced by the inoculation of phosphate solubilizing bacteria (Table 1). On the other hand plant height, number of tillers hill^{-1}, number of effective tillers hill^{-1} and straw yield pot^{-1} were not significantly influenced by the inoculation of phosphate solubilizing bacteria.

The plant height ranged from 83.08 cm in RB_{10} treatment to 86.00 cm in RB_{03} while the number of tillers hill^{-1} ranged from11.25 to 12.42 from RB_{10} and

Table 1. Effect of inoculation of phosphate solubilizing bacteria on different growth and yield attributes of T. aman rice cv. BRRIdhan 39

PSB inoculants	Plant height (cm)	No. of tillers $hill^{-1}$	No. of effective tillers $hill^{-1}$	Panicle Length (cm)	Total no. of grains $panicle^{-1}$	No. of filled grains $panicle^{-1}$	Weight of 1000 grains(g)	Grain yield pot^{-1} (g)	Straw yield pot^{-1} (g)
RB0	84.42	12.33	9.25	19.42b	117.58b	84.00b	19.66b	17.06b	23.65
RB03	86.00	12.42	9.17	21.75a	125.08a	93.54a	21.58a	20.89a	24.55
RB10	83.08	11.25	9.17	21.50a	124.92a	94.42a	21.32a	20.43a	25.30
Level of significance	NS	NS	NS	**	**	**	**	*	NS
LSD(0.05)	-	-	-	0.88	4.39	6.41	0.89	2.96	-
CV (%)	6.67	14.49	15.60	4.99	4.23	8.35	5.03	17.97	15.88

Figures in a column followed by same letter are not varied significantly at 5% level
** = Significant at 1% level of probability
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RB_{03} treatment respectively. The number of effective tillers $hill^{-1}$ at harvest was 9.25 obtained without the inoculation of PSB while inoculation of RB_{03} and RB_{10} produced 9.17 number of effective tillers $hill^{-1}$ which was less than that of RB_0. The highest panicle length (21.75 cm) of rice 39 was obtained from the inoculation of RB_{03} followed by RB_{10} (21.50 cm) and it was least (19.42 cm) in RB_0. The number of grains $panicle^{-1}$ was 125.08 in RB_{03}, 124.92 in RB_{10} and 117.58 in RB_0. The number of filled grains $panicle^{-1}$ ranged from 84.00 in treatment RB_0 to 94.42 in RB_{10} and RB_{03} produced 93.54 filled grains $panicle^{-1}$. The highest weight of 1000 grains (21.58 g) of rice was obtained in RB_{03} treatment followed by RB_{10} (21.32 g) and it was lowest (19.66 g) in RB_0. Sattar and Habibullah (1987) also obtained significant response of P dissolving microorganism inoculation in increasing thousand grains weight in a field experiment. The highest grain yield pot^{-1} (20.89 g) of rice was obtained in RB_{03} followed by that in RB_{10} (20.43 g) and highest straw yield pot^{-1} was in RB_{10} (25.30 g) followed by that in RB_{03} (24.55 g). The lowest grain and straw yields pot^{-1} of rice was (17.06 g and 23.65 g respectively) obtained in RB_0. The grain yield pot^{-1} of RB_{03} and RB_{10} treatments were statistically similar and superior to that of control. This finding is in agreement with Sattar and Habibullah (1987) and Thakuria *et al*. (2004) who obtained increased rice grain yield in PSB inoculation over the uninoculated control.

Effects of different levels of P on growth and yield attributes of rice

The application of different levels of P alone exerted significant variation in plant height, number of tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, panicle length, total number of grains $panicle^{-1}$ and number of filled grains $panicle^{-1}$, grain and straw yields pot^{-1} of rice (Table 2), but weight of 1000 grains was not significantly influenced by the application of different levels of P.

The plant height increased with the increase in P level up to P_{30} and at further higher level it decreased. The highest plant height (88.11 cm) was observed in the treatment P_{30}. The control treatment P_0 produced the lowest plant height (68.39 cm). Akinrinde and Gaizer (2006) obtained significant influence of P application rates on plant height after 4 week of planting. Their findings are in agreement with our results. The number of tillers $hill^{-1}$ and effective tillers $hill^{-1}$ of rice increased due to the application of different P levels. The number of tillers $hill^{-1}$ ranged from 8.78 in P_0 to 15.44 in P_{45} treatment while the number of effective tillers $hill^{-1}$ varied from 7.33 in P_0 to 10.33 P_{45}. The highest panicle length (21.67 cm) was obtained from the treatment P_{45} and treatment P_0 produced lowest panicle length of rice (20.00 cm). The effect of P_{15}, P_{30} and P_{45} treatments produced statistically similar effects in increasing panicle length. This finding is in agreement with Akinrinde and Gaizer (2006). The maximum number of grains $panicle^{-1}$ (129.00) and number of filled grains $panicle^{-1}$ (104.33) were obtained from the treatment P_{45} followed by that of P_{30} (127.22 and 103.56 respectively). The control treatment P_0 produced the minimum number of grains (110.56) and filled grains (66.22) $panicle^{-1}$ respectively. The weight of 1000 grains of rice increased due to the effect of different levels of P but it did not maintain any regular pattern with increase in the levels of P fertilizer. The treatment P_{15} induced the maximum weight of 1000 grains of rice (21.13 g) and it was minimum (20.31 g) with the treatment P_0. The yield of grain and straw of rice increased as the levels of P increased. The maximum grain yield (24.52 g pot^{-1}) and straw yield (29.65 g pot^{-1}) was obtained from the treatment P_{45} followed by P_{30} (21.68 g and 26.11 g pot^{-1} respectively) and that was minimum in control treatment (12.46 g and 17.18 g pot^{-1} respectively).

Interaction effects of PSB strains and different levels of P on growth and yield attributes of rice

The interaction effect of PSB strains and different levels of P significantly influenced the weight of 1000 grains and straw yield pot^{-1} of T. aman rice cv. BRRIdhan 39. The plant height, number of tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, panicle length, total

Table 2. Effect of different levels of P on different growth and yield attributes of T. aman rice cv. BRRIdhan39

Levels of P	Plant height (cm)	No. of tillers hill^{-1}	No. of effective tillers hill^{-1}	Panicle Length (cm)	Total no. of grains panicle^{-1}	No. of filled grains panicle^{-1}	Weight of 1000 grains (g)	Grain yield pot^{-1} (g)	Straw yield pot^{-1} (g)
P0	78.44b	8.78c	7.33b	20.00b	110.56c	66.22c	20.31	12.46c	17.18c
P15	84.22a	12.00b	9.78a	20.78ab	123.33b	88.56b	21.13	19.18b	25.06b
P30	88.11a	11.78b	9.33a	21.11a	127.22ab	103.56a	20.98	21.68ab	26.12ab
P45	87.22a	15.44a	10.33a	21.67a	129.00a	104.33a	20.99	24.52a	29.65a
Level of significance	**	**	**	*	**	**	NS	**	**
LSD(0.05)	5.51	1.70	1.40	1.02	5.07	7.40	-	3.42	3.80
CV (%)	6.67	14.49	15.60	4.99	4.23	8.35	5.03	17.97	15.88

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NS = Not significant

Table 3. Interaction effect of inoculation of phosphate solubilizing bacteria and different levels of P on different growth and yield attributes of T. aman rice cv. BRRIdhan 39

PSB inoculants × levels of P interaction	Plant height (cm)	No. of tillers hill^{-1}	Number of effective tillers hill^{-1}	Panicle Length (cm)	Total number of grains panicle^{-1}	Number of filled grains panicle^{-1}	Weight of 1000 grains (g)	Grain yield pot^{-1} (g)	Straw yield pot^{-1} (g)
$RB_0 P_0$	74.00	8.33	6.00	17.67	106.00	60.00	17.53c	7.93	13.63e
$RB_0 P_{15}$	85.67	13.67	11.33	20.00	119.00	85.67	21.27a	19.91	29.78ab
$RB_0 P_{30}$	91.00	11.67	9.67	20.00	123.67	91.00	19.27bc	18.21	23.01bcd
$RB_0 P_{45}$	87.00	15.67	10.00	20.00	121.67	99.33	20.57ab	22.18	28.16abc
$RB_{03}P_0$	81.00	9.33	8.00	21.00	116.33	72.00	21.40a	14.95	18.35de
$RB_{03} P_{15}$	87.70	12.33	9.67	21.33	125.00	89.00	21.07ab	20.62	24.07abcd
$RB_{03} P_{30}$	88.00	12.00	8.67	22.00	128.67	102.67	22.00a	21.54	24.84abcd
$RB_{03} P_{45}$	87.33	16.00	10.33	22.67	130.33	110.67	21.87a	26.45	30.95a
$RB_{10} P_0$	80.33	8.67	8.00	21.33	109.33	66.67	22.00a	14.50	19.55de
$RB_{10} P_{15}$	79.33	10.00	8.33	21.00	126.00	91.00	21.07ab	17.01	21.34cd
$RB_{10} P_{30}$	85.33	11.67	9.67	21.33	129.33	117.00	21.67a	25.29	30.47ab
$RB_{10} P_{45}$	87.33	14.67	10.67	22.33	135.00	103.00	20.53ab	24.92	29.84ab
Level of significance	NS	NS	NS	NS	NS	NS	**	NS	*
LSD (0.05)	-	-	-	-	-	-	1.776	-	6.586
CV (%)	6.67	14.49	15.60	4.99	4.23	8.35	5.03	17.97	15.88

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number of grains panicle^{-1}, number of filled grains panicle^{-1} and grain yield pot^{-1} although increased due to the interaction effect of PSB strains and different levels of P fertilizers but the increase was not significantly induced by their interaction effect (Table 3).

The treatment RB_0P_{30} produced the highest plant height (91.00 cm) and that was lowest (74.00 cm) in RB_0P_0 treatment. Swarnkar *et al.* (2005) obtained maximum plant height of rice with 30-30-30 kg NPK/ha + *Sesbania rostrata* + phosphorus solubilizing bacteria. $RB_{03}P_{45}$ produced the maximum number of tillers hill^{-1} (16.00) whereas control treatment produced the minimum number of tillers hill^{-1} (8.33). Sattar and Habibullah (1987) obtained significant responses using different P dissolving microbes in increasing tiller number at 60 days of plant growth. These findings are in agreement with this result. The panicle length was highest (22.67 cm) in $RB_{03}P_{45}$ and the control treatment RB_0P_0 produced the lowest panicle length (17.67 cm) of rice. Swarnkar *et al.* (2005) obtained maximum panicle length from the treatment consisting of 30-30-30 kg NPK/ha + *Sesbania rostrata* + phosphorus solubilizing bacteria. The maximum number of grains panicle^{-1} (135.00) was produced by the treatment $RB_{10}P_{45}$ and the control treatment RB_0P_0 produced the minimum number of that (106.00) while maximum grain yield (26.45 g pot^{-1}) was produced by $RB_{03}P_{45}$ and the control treatment produced the minimum grain yield (7.93 g pot^{-1}). Swarnkar *et al.* (2005) found elevated grain yield by the treatment consisting of 30-30-30 kg NPK/ha + *Sesbania rostrata* + phosphorus solubilizing bacteria. Sattar and Habibullah (1987) also obtained significant responses in grain yield by the application of different phosphate solubilizing microbes alone and in combination with TSP fertilizer. The maximum and statistically identical straw yield of rice (30.95 g pot^{-1}) was produced by the treatments RB_0P_{15}, RB_0P_{45}, $RB_{03}P_{15}$, $RB_{03}P_{30}$, $RB_{03}P_{45}$, $RB_{10}P_{30}$ and $RB_{10}P_{45}$ and the control treatment produced the minimum straw yield of rice (13.63 g pot^{-1}) which was statistically similar with that of treatments $RB_{03}P_0$ and $RB_{10}P_0$.

The maximum number of effective tillers hill^{-1} (11.33) was produced by RB_0P_{15} while the control treatment produced the minimum number of effective tillers hill^{-1} (6.00). The number of filled grains panicle^{-1} was highest (117.00) in $RB_{10}P_{30}$ treatment and it was lowest (60.00) in the treatment RB_0P_0. Both the strains of PSB increased the number of grains panicle^{-1} as the levels of P increased. Swarnkar *et al.* (2005) obtained increased number of grains panicle^{-1} when 30-30-30 kg NPK/ha + *Sesbania rostrata* + phosphorus solubilizing bacteria were used in a field experiment. This finding is in agreement with our results.

The treatments $RB_{03}P_{30}$ and $RB_{10}P_0$ produced the maximum weight of 1000 grains (22.00 g) followed by $RB_{30}P_{45}$ (21.87 g) $RB_{10}P_{30}$ (21.67 g), $RB_{03}P_0$ (21.40 g) and RB_0P_{15} (21.27 g) of rice while it was minimum (17.53 g) in RB_0P_0 treatment. Swarnkar *et al.* (2005) obtained higher 1000-grains weight (27.18 g) of rice with 30-30-30 kg NPK/ha + *Sesbania rostrata* + phosphorus solubilizing bacteria indicating that PSB had accelerated 1000 grain weight of rice, which is in agreement with our results.

It is therefore evident from the result that the isolated phosphate solubilizing bacteria used in this study acted favourably in increasing growth and yield attributes of rice in almost all aspects of observation made, and inclusion of P accentuated the performance of PSB in making phosphorus available to rice plant particularly in acid soil.

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