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# RICE RESPONSE TO PHOSPHORUS IN WETLAND SOIL

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Field experiments were carried out in a severely P deficient farmer field to evaluate the P response of Boro (dry season irrigated) and T.Aman (wet season) rices. Five levels of phosphorus (0, 25, 50, 75, and 100 kg/ha) as TSP were used. Modern varieties of rices, BR3 for dry season (Boro) and BR11 for wet season were tested. The application of P led to increased plant height, tiller and panicle production. Application of P at the rate of 25 kg/ha increased grain yield by 1.0 t/ha in dry season; increasing the P rate to 50, 75 or 100 kg/ha brought about additional yield benefits. The yield response was, however, much less sharp in the wet season.

***Key words:*** Rice, Phosphorus, Wetland soil.

## Introduction

Phosphorus is one of the macronutrients essential for plant growth. Phosphorus is needed for energy production and transfer in plants, especially in young rapidly growing plants [1]. Phosphorus is required in large amounts for the normal growth and yield of rice [1]. However, the effect of P fertilizer on rice has not been found to be as dramatic as that of N fertilizer in Bangladesh [3,4]. Some researchers also found that a single application of P fertilizer at a moderate rate of 50-60 kg $P_2O_5$ per ha could support 2-4 consecutive rice crops [5].

Most tropical rice soils, particularly in upland areas, are low in P [6]. Phosphorus is commonly less deficient in flooded than in upland rice soils because P becomes more available under anaerobic conditions. Nevertheless, P deficiency still occurs in wetland rice soil and response to P is observed in millions of hectares of the world's rice [7].

Phosphorus deficiency occurs primarily on ultisols, oxisols, vertisols and certain inceptisols, particularly andepts and acid sulphate soils. Not only are these soils low in available P, they also fix P fertilizer into highly insoluble compounds. Besides, the increased P availability brought about by soil submergence is low in these soils [8].

Modern varieties of rice remove about three times more nutrients from soil than do traditional varieties. Recent results show that P deficiency is wide-spread, particularly in modern rice varieties where yield levels are upto 6 t/ha [9].

Nearly five thousand hectares of agricultural land are severely deficient in P at Muhuri Irrigation Project area. The farmers in these areas seldom use P fertilizer. No research work in this regard was done in the past. This study was undertaken to evaluate the P response of rice on such a P deficient soil.

## Materials and Methods

Two field experiments were conducted in a farmer field in Sonapur, Feni inside the Muhuri Irrigation Project area, one each in the dry and wet seasons of 1990. The soil of the experimental field (Grey Flood Plain Soil, Kumaria Series) was a silt loam having pH 7.6, 1.48% organic matter, 0.09% total N, 3.0 mg/kg Olsen P, 0.23 meq/100 exchangeable K, 14 mg/kg available S, 2.3 mg/kg available Zn and 23 meq/ 100 g cation exchange capacity (CEC). Thus, the soil was severely P deficient.

Five levels of P (0, 25, 50, 75 and 100 kg/ha) as TSP were used as the treatments. Blanket doses of N, K, S and Zn at the rates of 120, 35, 20 and 5 kg/ha in the dry season (Boro) and in the wet season (T.Aman) as urea, gypsum and zinc sulphate were applied.

The full doses of P, K, S and Zn were applied before transplanting at final land preparation. Nitrogen was applied in 3 equal splits: 1/3 N basally, 1/3 N at active tillering stage and 1/3 N 5-7 days before panicle initiation stage.

The experiment was laid out in a randomized complete block design with 3 replications. The individual plot size was 5 x 4m. In the succeeding T.Aman season, the experiment was conducted on the same lay out.

The test varieties were BR3 for dry season (Boro) and BR11 for wet season. In the dry season, 45 days old seedlings and in the wet season 30 days old seedlings were transplanted at a spacing of 20 x 20cm. Necessary intercultural operations and plant protection measures were taken as and when required.

At the active tillering stage (35 days after transplanting) growth parameters like plant height, tiller number and shoot dry matter were recorded. For shoot dry matter and straw yield, 16 hills were collected from four random spots outside the 5m² area of each plot, excluding two border rows all around. The hills were cut at the ground level and then oven dried at 70°C for 72 hrs and weights were recorded and calculated in ton per hectare. The crop was harvested at maturity. One hundred and twenty five (10 x 12 + 5) rice hills equivalent to 5 m² were harvested from the middle of each plot. Grain yields were determined based on the weight of threshed grains. The dry grains were blown, weighed and moisture content was determined and finally calculated in t/ha adjusted to 14% moisture. Shoot, straw and grain samples were analyzed for total P concentration using a standard analytical procedure [10].

## Results and Discussion

*Growth and yield of rice.* Plant height, tiller number and shoot dry matter yield at 35 DAT were significantly increased with the application of P. The shoot dry matter yield ranged from 0.48-1.5 t/ha in the dry season and 1.2 -1.8 t/ha in the wet season (Table 1). In dry season, the crop showed distinct P deficiency symptoms and the P response was more pronounced than that in the wet season. The probable reason might be the low temperature (9-12°C) at the early growth stages and slow release of available P to the growing plant in the dry season. Other researchers reported that crop variety, soil properties, initial available P and seasonal conditions influenced the response to P of flooded rice [4]. Modern rice varieties responded more to P than did the tall traditional varieties, particularly in a cool and clear dry season.

Plant height, tiller and panicle number at maturity were

TABLE 1. AGRONOMIC CHARACTERS OF RICE PLANT AT 35 DAYS AFTER TRANSPLANTING AND AT MATURITY UNDER DIFFERENT P LEVELS.

| P-Levels (Kg/ha) | 35 DAYS | | | Maturity | | |
|---|---|---|---|---|---|---|
| | Plant height (cm) | Tiller No./m² | Shoot drymatter weight(t/ha) | Plant height (cm) | Tiller No./m² | Panicle No./m² |
| **Dry season** | | | | | | |
| $P_0$ | 35a | 70a | 0.48a | 70a | 138a | 129a |
| $P_{25}$ | 48b | 171b | 0.89b | 82b | 232b | 212b |
| $P_{50}$ | 54c | 178b | 1.2c | 87c | 237bc | 219b |
| $P_{75}$ | 60d | 194c | 1.4c | 87c | 246c | 232c |
| $P_{100}$ | 60d | 198c | 1.5c | 86c | 241bc | 222b |
| **Wet season** | | | | | | |
| $P_0$ | 66a | 84a | 1.2a | 95a | 140a | 132a |
| $P_{25}$ | 74b | 183b | 1.7b | 104b | 228b | 215b |
| $P_{50}$ | 77b | 183b | 1.7b | 104b | 228b | 215b |
| $P_{75}$ | 75b | 206c | 1.6b | 108c | 236bc | 222bc |
| $P_{100}$ | 76b | 207c | 1.8b | 108c | 240c | 232c |

In a column, means followed by a common letter (s) are not significantly different at 5% level by DMRT.

also significantly greater in the P treated plots than those in the untreated plots (Table 2). In the dry season, a 1.0 t/ha grain yield advantage was obtained with the application of P at the rate of 25 kg/ha ($P_{25}$). Increasing the P rate to $P_{50}$ and $P_{75}$ gave an additional yield increase of 0.2 to 0.5 t/ha. However, there was no further response at a P dose higher than $P_{75}$ (Table 2). The soil had a very low available P content, only 3.0 mg/kg, whereas, the critical lower limit is 10 mg/kg [11].

TABLE 2. GRAIN AND STRAW YIELD OF RICE AS AFFECTED BY DIFFERENT LEVELS OF PHOSPHORUS.

| P-levels (kg/ha) | Grain yield (t/ha) | Straw yield (t/ha) | Agronomic efficiency (kg grain/kg added P) |
|---|---|---|---|
| **Dry season** | | | |
| $P_0$ | 1.6a | 1.6a | - |
| $P_{25}$ | 2.6b | 2.1b | 40 |
| $P_{50}$ | 2.8bc | 2.4bc | 24 |
| $P_{75}$ | 3.1bc | 2.6c | 20 |
| $P_{100}$ | 3.2c | 2.4bc | 16 |
| **Wet season** | | | |
| $P_0$ | 2.1a | 2.6a | - |
| $P_{25}$ | 2.6b | 3.1b | 20 |
| $P_{50}$ | 2.5ab | 3.0ab | 8 |
| $P_{75}$ | 2.8b | 3.4b | 9 |
| $P_{100}$ | 2.8b | 3.3b | 7 |

In a column, means followed by a common letter (s) are not significantly different at 5% level by DMRT.

In the wet season, however, yield response of BR11 was not as marked (Table 2). A yield advantage of only 0.5 to 0.7 t/ha was obtained with P application. Greater responses of rice to P generally in the dry/summer season than in the wet season have been attributed to higher yield potentials due to more sun shine, better water control, lower disease incidence and lower soil P availability during the dry season [13]. However, other researchers reported no or negligible seasonal differences in response of rice [14].

The agronomic efficiency of the P fertilizer (kg grain/kg P) decreased gradually with increasing levels of P in both the seasons. The agronomic efficiency values ranged from 16-40% for the dry season and 7-20% for the wet season (Table 2).

*Phosphorus content and uptake.* The experimental result in Table 3 showed that the concentration of P significantly increased with the application of P fertilizer for both the seasons. In dry season, the concentration of shoot P ranged from 0.08 to 0.14%, the maximum shoot P (0.14%) was obtained with the application of P at the rate of 75 kg/ha (Table 3). The earlier experimental result observed that the critical concentration of shoot P at active tillering stage was 0.1% whereas the concentration of untreated plots only 0.08%.

TABLE 3. PHOSPHORUS CONTENT AND UPTAKE OF RICE AS AFFECTED BY DIFFERENT LEVELS OF P.

| P-levels (kg/ha) | P-content (%) | | | P-uptake (kg/ha) | Apparent P recovery (%) |
|---|---|---|---|---|---|
| | Shoot | Straw | Grain | | |
| Dry season | | | | | |
| $P_0$ | 0.08a | 0.05a | 0.22a | 4.3 | - |
| $P_{25}$ | 0.12b | 0.06a | 0.25b | 7.8 | 14.0 |
| $P_{50}$ | 0.13bc | 0.08b | 0.26bc | 9.2 | 9.8 |
| $P_{75}$ | 0.14c | 0.08b | 0.28c | 10.8 | 8.7 |
| $P_{100}$ | 0.12bc | 0.06a | 0.26bc | 9.7 | 5.4 |
| Wet season | | | | | |
| $P_0$ | 0.09a | 0.06ab | 0.25a | 6.9 | - |
| $P_{25}$ | 0.11b | 0.07b | 0.26ab | 9.0 | 8.4 |
| $P_{50}$ | 0.12bc | 0.08b | 0.27ab | 9.2 | 4.6 |
| $P_{75}$ | 0.15d | 0.08b | 0.28b | 10.5 | 4.8 |
| $P_{100}$ | 0.13cd | 0.07b | 0.28b | 10.1 | 3.2 |

In a column, means followed by a common letter (s) are not significantly different at 5% level by DMRT.

Thus, the result indicated that the shoot P content of $P_0$ (P control) plots were also severely deficient in P.

Although there were no significant differences in the total P content of grain and straw of rice due to different treatments, the total P uptake was the lowest (4.3 kg/ha) in untreated ($P_0$) plots. The highest P uptake, 10.8 kg/ha was obtained in the plots where P was applied at the rate of 75 kg/ha. Almost similar uptake patterns were also observed in the wet season (Table 3).

Apparent recovery percent decreased with increasing P rates (Table 3). The recovery of added P was the highest, when P was applied at the rate of 25 kg/ha and the least at 100 kg/ha. The percent recovery of added P ranged from 5.4 to 14 for dry season and 3.2 to 8.4 for wet season, respectively. The recovery percent was considerably higher in dry season than that of wet season.

The present experimental results suggest that the application of P at the rate of 25 kg/ha increased acceptable optimum grain yield in a severe P deficient soil.

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