The Agriculturists 10 (1):31-37 (2012) ISSN-1729-5211
A Scientific Journal of Krishi Foundation

Effect of Phosphate Rock on the Growth and Yield of Wheat (*Triticum aestivum* L.) under Old Brahmaputra Floodplain Soils

Md. Nurul Huda Al Mamun[1]*, Md. Safinur Rahman[1], N. M. Jahangir[1], M. Safiqul Moula[1] and Kazi Nazrul Islam[2]

[1]*Soil Resource Development Institute, Bangladesh*
[2]*SLOPB, Patuakhali, Bangladesh*

**Corresponding author and Email: nhalmamun@yahoo.com*

Received: 30 December 2011 Accepted: 26 May 2012

Abstract

A study was conducted to determine the direct and residual effects of phosphate rock (PR) on the growth and yield of wheat cv. Kanchan during Rabi season of 2004-2005 at the Bangladesh Agricultural University farm, Mymensingh. The experiment was designed with four treatments and was laid out in a Randomized Complete Block Design (RCBD) with four replications. The treatments were: $T_{1:}$ control (0 kg P ha^{-1}), T_2: PR (26 kg P ha^{-1}), T_3**:** TSP (26 kg P ha^{-1}), and T_4: PR (210 kg P ha^{-1} applied in previous crop to cover 6 succeeding crops). Dry matter yield at panicle initiation (PI) stage was significantly influenced by the treatments. Effective tillers $hill^{-1}$ and grains $panicles^{-1}$ varied significantly with P treatments. The highest grain yield (3.10 t ha^{-1}) and straw yield (5.54 t ha^{-1}) were found in T_3 treatment. Economic analysis demonstrated that the highest net benefit of Tk. 24,788 ha^{-1} was obtained in T_3 treatment which was followed by Tk. 22,964 ha^{-1} and Tk.12,292 ha^{-1} in T_4 and T_2, respectively. The highest net benefit was obtained from T_3 treatment due to higher grain and straw yields.

Keywords: **Residual effect, phosphate rock, growth and yield, wheat**

1. Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop and it ranks third both in acreage and production in the world (UNDP and FAO, 2008). It has been established as the second most important staple food crop after rice in Bangladesh. Bangladesh produces 8,44,000 tons of wheat per annum from 3,90,000 ha of land (BBS, 2008). Cereal crop production like wheat should be increased to meet the demand of the escalating population of Bangladesh, where an individual requires 454 g cereal food per day (BARI, 2004). The soil and climate of Bangladesh is favorable in winter for wheat production but the average yield of wheat (2.40 t ha^{-1}) in this country is quite low as compared to those in many wheat growing countries of the world.

Improper management of fertilizers is one of the major causes of low yield because fertilizer plays an important role in augmenting yield of wheat. Phosphorus is the second key plant nutrient that is needed in adequate quantity and in available form for the growth, reproduction, and yield of crop. The phosphorus content of Bangladesh soils is being depleted gradually due to crop removal particularly, in intensive culture. Application of phosphatic fertilizers is recommended for all soils and crops in Bangladesh to obtain better yield (BARC, 2005).

Triple super phosphate (TSP) is the main source of phosphorus. However, phosphate rock (PR) is another source of phosphorus which is the cheapest and economic source of phosphorus (Hoffland, 1991), but is not being used in the crop field due to its insolubility. The direct application of finely ground phosphate rock (PR) may be an alternative to the use of more expensive soluble P-fertilizer for certain crops and soils (Hammond *et al*., 1986). However, in Bangladesh, a little research work has been done in this aspect. Keeping this in this view, the present research was conducted to compare the effect of direct application of PR and TSP on the growth and yield of wheat; and to study the residual effects of high rate of PR applied in the preceding T. aman crop on wheat.

2. Materials and Methods

2.1. Site description

The field experiment was carried out with wheat (cv. Kanchan) grown in sequence after aman rice under some selected treatments. The experiment was set up at the Science field Laboratory of Bangladesh Agricultural University, Mymensingh under Old Brahmaputra Floodplain (AEZ 9) agro-ecological region of Bangladesh during the Rabi season of 2004-2005. The farm belongs to the general soil type Non-calcareous Dark Grey Floodplain soil under Sonatala series.

2.2. Treatments and design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 4 replications. Each block was sub-divided into 4 unit plots. The total number of plots was 16 (4X4) and the unit plot size was 8 X 5 m. The spacing between blocks was 1 m and between plots was 0.3 m. There were four treatments consisting of TSP and two rates of phosphate rock (PR) and a control. The treatment combinations were $T_{1:}$ control (0 kg P ha^{-1}), $T_{2:}$ PR (26 kg P ha^{-1}), T_3**:** TSP (26 kg P ha^{-1}) and T_4: PR (210 kg P ha^{-1} applied in previous crop to cover 6 succeeding crops).

2.3. Crop husbandry operations

The experimental field was first opened on 20 days before sowing with the help of power tiller and cross-ploughed 6 times. All kinds of weeds and residues of previous crop were removed from the field. The plant nutrients like nitrogen, phosphorus, potassium, sulphur and boron were used in the research field at 100 kg N ha^{-1}, 26 kg P ha^{-1}, 33 kg K ha^{-1}, 20 kg S ha^{-1}and 1kg B ha^{-1}, respectably. All fertilizers except N were applied into the soil during final land preparation. Nitrogen as urea was applied in two times: firstly, 2/3rd of urea was applied during final land preparation and the remaining 1/3rd urea was applied as top dressing at 21 days after emergence of seedlings. The Seeds were shown on November 20, 2004 and seed rate was 120 kg ha^{-1} as recommended by BARI (2004). Line to line distance was 20 cm with continuous distribution of seeds in the lines. Intercultural operations such as irrigation, weeding and pest control etc. were done as and when required.

2.4. Harvesting and data collection

At the spike emergence stage and at harvest, the plant samples were collected from each plot. Ten hills per plot were collected randomly for the determination of dry matter yield and nutrient analysis. The crop was harvested at full maturity on 14 March, 2005. Sun dry weight of both grain and straw was recorded plot-wise for each treatment.

2.5. Chemical analysis of soil and plant samples

The initial soil samples was collected before land preparation from 0-15 cm and was analyzed for both physical and chemical properties in the Laboratory of the Department of Soil Science, Bangladesh Agricultural University, Mymensingh. Particle size analysis of soil was done by Hydrometer method (Gee and Bauder, 1986). Soil pH was measured with the help of glass electrode pH meter using soil water suspension of 1:25 (Jackson, 1962). Organic carbon in soil was determined by wet oxidation method (Walkley and Black, 1934). Cation exchange capacity (CEC) of soil was determined by sodium saturation method as outlined by Chapman (1965). Total nitrogen of soil was estimated by micro Kjeldhal method (Bremner and Mulvaney, 1982). Available soil phosphorus was measured by Olsen method (Olsen and Sommers, 1982). Exchangeable potassium was determined using flame photometer (Black, 1965) and available sulphur was determined by turbidimetric method.

The grain and straw samples from each plot were dried in an oven at 65 ^{0}C for 48 hours, after which they were ground by a grinding mill. Later the ground samples were sieved through a 20 mm mesh sieve. The prepared samples were then chemically analyzed for N, P, K and S following diacid digestion procedure (Jones and Case, 1990; Watson and Issac, 1990). Analysis of variance for crop characters and nutrient elements of plant samples were done following the F-test. Mean comparisons of the treatments were done following Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

3.1. Growth of wheat plants at panicle initiation (PI) stage

All the treatments significantly influenced dry matter yield at PI stage of wheat plants. Maximum dry matter production (2.25 t ha^{-1}) was obtained in T_3 treatment, which was 48.0% higher over control (Table 1). The minimum dry matter production (1.52 t ha^{-1}), was observed in control.

3.2. Plant height

Plant height, was not insignificantly influenced by treatments. The maximum plant height (105.40 cm) was attained in the treatment T_4 and the minimum plant height (102.20 cm) was obtained in T_1 treatment (Table 2).

3.3. Effective tillers hill $^{-1}$

Maximum number of effective tillers (3.26 hill^{-1}) was found in T_3 treatment (Table 2). TSP treatment showed better result over PR treatment having the same P rate. The minimum number of effective tillers (2.12 hill^{-1}) was found in control. Zaman *et al*. (1997) found increasing number of effective tillers hill^{-1} over control due to P application on wheat crop.

3.4. Panicle length

Panicle length was the highest in T_3 treatment (9.52 cm) (Table 2). TSP treatment showed better result over PR having the same P rate (26 kg P ha^{-1}). The lowest panicle length (7.12 cm) was found in T_1 treatment. The second highest panicle length was found in T_4 (210 kg P ha^{-1} applied in previous crop treatment).

3.5. Sterile spikelets spike^{-1}

Maximum numbers of sterile spikelets (5.12) were found in control (T_1) treatment, which was statistically similar to that in the PR treatment. However, the percentage of sterile spikelets spike $^{-1}$ ranged from 5.8 to 19.5 (Table 2). The lowest number of sterile spikelets spike^{-1} was found in T_3.

3.6. Grains spike^{-1}

The highest number of grains spike^{-1} (35.45) was recorded in T_3 (26 kg P ha^{-1}) treatment, which was statistically similar to that in T_4 treatment (210 kg P ha^{-1} applied in previous crop). However, the percentage of grains spike $^{-1}$ varied from 80.4 to 94.1 (Table 2). The lowest number of grains spike^{-1} was obtained in control.

3.7. 1000-grain weight

The weighted of 1000-grains varied from 46.22 to 48.25 g. The highest value was found in T_3 treatment and the lowest value was in $T_{1.}$ TSP treatment had better effect compared to PR having same rate of P (26 kg P ha^{-1}). However, 1000-grain weight did not vary significantly among the treatments.

3.8. Grain yield

Grain yield varied with P treatments ranging from 2.05 to 3.10 t ha^{-1} (Table 3). The maximum grain yield (3.10 t ha^{-1}) was obtained by T_3 (26 kg P ha^{-1}) treatment, which was 51.2% higher than in control. The second highest grain yield was obtained in T_4 treatment (2.85 t ha^{-1}), which was the third highest grain yield recorded in PR (T_2) treatment (2.35 t ha^{-1}). However, the treatments $T_{2,}$ T_3 and T_4 were statistically similar. The minimum grain yield was noted in control

Table 1. Effects of different treatments on dry matter yield at booting stage of wheat

Treatments	Dry matter yield (t ha^{-1})	Increase over control (%)
$T_{1:}$ Control (0 kg P ha^{-1})	1.52d	-
$T_{2:}$ PR (26 kg P ha^{-1})	1.9c	28.4
$T_{3:}$ TSP (26 kg P ha^{-1})	2.25a	48.0
T_4: PR (210 kg P ha^{-1*})	2.07b	36.4
SE (±)	0.0356	-
CV (%)	3.85	-

*****210 kg P ha^{-1} was applied in previous crop to cover six succeeding crops.
SE (±) = Standard error of means
Figures in a column having common letters do not differ significantly at 5% level of significance by DMRT.

Table 2. Effects of different treatments on yield contributing characters of Wheat

Treatments	Plant Height (cm)	Effective tillers $hill^{-1}$ (No.)	Panicle length (cm)	Sterile spikelet $spike^{-1}$ (No.)	Sterile spikelet $spike^{-1}$ (%)	Grains $spike^{-1}$ (No.)	Grains $Spike^{-1}$ (%)	1000-grain-weight (g)
$T_{1:}$ Control (0 kg P ha^{-1})	102.20	2.12c	7.12c	5.12a	19.5	28.65b	80.4	46.22
$T_{2:}$ PR (26 kg P ha^{-1})	103.40	2.63b	8.12c	4.94a	14.5	29.04b	85.4	46.65
$T_{3:}$ TSP (26 kg P ha^{-1})	105.12	3.26a	9.52a	2.21c	5.8	35.45a	94.1	48.25
T_4 : PR (210 kg P ha^{-1*})	105.40	2.95ab	9.15ab	3.15b	8.3	34.5a	91.6	46.90
SE (±)	NS	0.0922	0.2801	0.1186	-	1.0158	-	NS
CV(%)	2.21	6.73	6.61	6.15	-	6.37	-	7.1

*****210 kg P ha^{-1} was applied in previous crop to cover six succeeding crops. SE (±) = Standard error of means
Figures in a column having common letters do not differ significantly at 5% level of significance by DMRT.

Table 3. Effects of different treatments on grain and straw yields of wheat

Treatments	Grain		Straw	
	Grain yield (t ha^{-1})	Increased over Control (%)	Straw yield (t ha^{-1})	Increase over Control (%)
$T_{1:}$ Control (0 kg P ha^{-1})	2.05b	-	2.92c	-
$T_{2:}$ PR (26 kg P ha^{-1})	2.35a	14.6	3.62b	23.9
$T_{3:}$ TSP (26 kg P ha^{-1})	3.10a	51.2	5.54a	89.7
T_4 : PR (210 kg P ha^{-1*})	2.85a	39.0	5.38a	84.2
SE (±)	0.1667	-	0.1777	-
CV (%)	13.96	-	8.14	-

*210 kg P ha^{-1} was applied in previous crop to cover six succeeding crops. SE (±) = Standard error of means
Figures in a column having common letters do not differ significantly at 5% level of significance by DMRT

Table 4. Cost-benefit analysis of wheat during rabi season 2004-05

Treatments	Total output (kg ha^{-1})		Gross field income (Tk ha^{-1})			Total production cost (Tk ha^{-1})	Net income (Tk ha^{-1})	Net benefit due to addition of PR (26 kg P ha^{-1}) over control (Tk ha^{-1})	Net benefit due to addition of TSP (26 kg P ha^{-1}) over T_2 (Tk ha^{-1})	Net benefit due to addition of PR (210 kg P ha^{-1}) over T_3 (Tk ha^{-1})
	Grain	Straw	Grain	Straw	Total					
$T_{1:}$ Control (0 kg P ha^{-1})	2050	2920	30750	2920	33670	25166	8504	-	-	-
$T_{2:}$ PR (26 kg P ha^{-1})	2350	3620	35250	3620	38870	26578	12292	3788	-	-
$T_{3:}$ TSP (26 kg P ha^{-1})	3100	5540	46500	5540	52040	27252	24788	-	12496	-
T_4 : PR (210 kg P ha^{-1*})	2850	5380	42750	5380	48130	25166	22964	-	-	1824

*210 kg P ha^{-1} was applied in previous crop to cover six succeeding crops.
Production cost other than fertilizer and PR remain same in all treatments.
Grain and straw as per current market price.

treatment. Chowdhury and Mian (1978) reported that the grain yield of wheat increased with increasing levels of P from either TSP or PR.

3.9. Straw yield

Straw yield of wheat was also significantly influenced by different treatments. The maximum straw yield (5.54 t ha^{-1}) was obtained in T_3 treatment, which showed an increase of 89.7% over control. The treatments T_3 and T_4 were statistically similar. The lowest straw yield was recorded in control. However, TSP treatment showed significant straw yield increase.

3.10. Economic analysis

An analysis was done in order to ascertain the most profitable treatment based on cost- benefit ratios of various treatments (Table 4). Net benefit was calculated by subtracting the total input cost from the gross field profit. Gross field profit was calculated as the total market value of grain and straw of wheat. The input cost was calculated as the total market value of fertilizer and others material and non- material cost. The results of economic analysis of wheat demonstrated that highest net benefit of Tk. 24,788 ha^{-1} was obtained in $T_{3,}$ followed by Tk. 22964, Tk.12292, and Tk. 8,504 ha^{-1} in T_4, T_2 and control treatments, respectively. The farmers would preferably choose any of these treatments which could give higher net benefit with a relatively lower variable cost.

4. Conclusions

It may be concluded that the use of rock phosphate may be a new source of P fertilizer to be used in the country. TSP had better performance over PR having same rate of P (26 kg P ha^{-1}) and (210 kg P ha^{-1}). Treatment T_4 showed comparatively better performance than $T_{2,}$ because of its (PR) low solubility. Although PR bears some toxic substances in soil, but its low price and high residual effect on cropping system could be an added factor for easy acceptance of P fertilizer compared to other phosphatic fertilizers. The effect of TSP on growth and yield of wheat was better than the direct application of PR. The residual effects of high rate of PR applied in preceding T. aman crop had shown better performance than the PR, which was used in present wheat crop. The highest economic benefit was found in TSP receiving crops compared to PR.

References

BARC. 2005. Fertilizer Recommendation Guide. Soils Pub. 43, Bangladesh Agricultural Research Council, Farmgate, Dhaka.40-41 pp.

BARI. 2004. Hand book on Agro-Technology, 3rd Edition, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh, 1-2 pp.

BBS. 2008. Monthly Statistical Bulletin Bangladesh (December 2008). Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, 58 p.

Black, C. A. 1965. Methods of Soil Analysis part 1 and 2. Amer. Soc. Agron. Inc. Pub. Madison, Winsconsin, USA, 313-315 pp.

Bremner, J. M. and Mulvaney, C. S. 1982. Total Nitrogen, In: *Methods of Soil Analysis*, (eds.) R. H. Miller and D. R. Xeeny, Amer. Soc. Agron. Inc. Madi. Wis. USA. 595-622 pp.

Chapman, H. D.1965. Cation Exchange capacity. In: *Methods of Soil Analysis*, (ed.) C.A. Black, Amer. Soc. Agron., Inc., Madison, Wisconsin, 891-901 pp.

Chowdhury, S. U. and Mian, M. H. 1978. Effect of superphosphate on the yield of wheat and rice on acid soil of Nagaland and nutrient content of grain. *Indian Society of Soil Science*, 32(2):299-302.

Gee, G. W. and Bauder, J. W. 1986. Particle-size Analysis. In: *Methods of Soil Analysis*, Part-1 (2nd edn.), (ed.) A. Klute, Amer. Soc. Agron., Inc. and Soil Science Soc. Amer., Inc. Madison, Wisconsin, 383-411 pp.

Hammond, L. L., Chien, S. H. and Mokwunye, A. U. 1986. Agronomic value of unacidulated and partially acidulated phosphate Rocks Indigenous to the tropics. *Advance Agronomy*, 40:89-140.

Hoffland, E. 1991. Mobilization of rock phosphate by rape (*Brassica napus* L.). *Ph.D. Thesis*, Wageningen Agricutural University, Wageningen, The Netherlands, 93 p.

Jackson, M. L. 1962. Soil Chemistry of Analysis. Prentice Hall Inc. Englewood Cliffe, N. J.78 p.

Jones, Jr. J. B. and Case, V. W. 1990. Sampling,handling and analyzing plant tissue samples. In: *Soil testing and plant analysis*, 3rd edition, SSSA Book series 3,(ed.) W. S. Westermaan, Soil Science Society of America, Madision, WI,USA, 389-427 pp.

Olsen, S. R., Cole, C.V., Watanabe, F.S. and Dean, L. A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. Agric. Cire. 929 p.

UNDP and FAO. 2008. Land Respond Appraisal of Bangladesh for Agricultural Development. Report 1 Agro-ecological Regions of Bangladesh. Food and Agricultural Organization and United Nations Development Programme, 212-221 pp.

Walkley and Black, C. A. 1934. An examination of Degtjareff method for determining soil organic matter and proposed modification for the chromic acid titration method. *Soil Science*, 37: 29-38.

Watson, M. E. and Isaac, R. A.1990. Analytical Instruments for Soil and Plant Analysis. In: *Soil testing and plant analysis*, 3rd edition. SSSA Book series 3, (ed.) W. L. Westermaan, Soil Science Society of America, Madision, WI, USA, 691-740 pp.

Zaman, S. K., Razzaque, M. A., Karim, S. M. R. and Bhuiyan, N. I. 1997. Rice response to phosphorus in wetland soil. *Pakistan Journal of Science and Industrial Research*. 38(11-12): 438-440.