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Contribution of zinc and phosphorus on yield phosphorus and zinc content in aman rice and distribution in post-harvest soil

Abstract

An experiment was carried out to study the effect of phosphorus and zinc on yield, phosphorus and zinc content in rice as well as P distribution in post harvest soil, on a silty loam soil of Sonatola series (Non-calcareous Dark Grey Floodplain Soil) at Bangladesh Agricultural University Farm. There were 3 levels of P (0, 25 and 50 kg ha^{-1} from TSP) and 4 levels of Zn (0,5,10 and 20kg Zn ha^{-1} from zinc sulphate) along with basal doses of 100 kg N ha^{-1} from urea, 40 kg K_20 ha^{-1} from mediate of potash and 12 kg S ha^{-1} from gypsum. The single and interaction effect of P and Zn had significant positive effect on the grain and straw yield. The highest grain yield (5.97 t ha^{-1}) and straw yield (11.50 t ha^{-1}) were obtained from Zn10 P50 treatment. Phosphorus application significantly increased the P content in grain and straw but zinc content significantly decreased while effect of zinc significantly decreased the P content in grain and straw but increased the Zn content. The highest amount of P content in grain and straw were 0.35% and 0.140% respectively obtained from Zn_0 P_{50} treatment whereas the zinc content in grain and straw were 32.8 ppm and 50.60 ppm respectively obtained from $_{Zn20}$ P0 treatment. The availability of phosphorus gradually increased with the increasing levels of P and decreased with the increasing levels of Zn. The maximum water-soluble P (4.5mgkg^{-1}) and labile P (1.8 mgkg^{-1}) were obtained from Zn_0 P_{50} treatment. The application of P and Zn gradually increased the Al-Fe-P, Mg/Ca-P and Total P with the increasing levels of P and Zn. The highest amount of Al/Fe-P, Mg/CaP and Total-P were obtained from $Zn2_0$ and P_{50} treatment. The combined application of P and Zn increased the grain and straw yield but decreased P and Zn content and availability of P to from Al/Fe-P and Mg/Ca-P as a result of Zn-P interaction in soil solution.

Keywords: soil, yield, rice, zinc, phosphorus

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Introduction

Rice *(Oryza sativa L.)* is one of the most staple food and feeds over half population of the world. The existing population of the world is 7.5 billion as of July 2017 and growth rate of around 1.11% per year. Food scarcity has been and will remain a major concern for Bangladesh, as currently (2017) population growth rate is 1.15% per year.[1] Rice contributes 91.12% of the total intake of this country's people (MOA, 1996).[2] Rice is grown in about 72.47% of the arable land of 10.12 million hectares. More than 2.0 million hectors of rice lands are unfavorably affected by excess water and reduces 5% average yield in Bangladesh.[3] Out of total rice production in this country, about 60% come from Aman and the rest 18% and 22% come from Aus and Boro crops respectively.[4] At present rice alone covers about 92% of the total food grains produced annually in the country and supplies 75% of the total calories and 55% of the protein over average daily diets.[5] Soil is the main source of plant nutrients. It supplies almost all of the essential nutrients to crop plants. The inherent nutrient supply capacity of Bangladesh soil has been found to declining due to continuous cultivation for growing more than one crop in the same piece of land in the same year. Until 1980, only the major three nutrients viz. NPK were usually supplied to our soils of which in majority case only N was supplied. The practice of intensive cropping with modern varieties cause a marked depletion of inherent nutrient reserve in soils of Bangladesh consequently in addition to N, P and K deficiencies some other nutrient such as B, Zn, and S deficiencies are being observed in may parts of the country.[6,7]Phosphorus plays a vital role in crop production since it is an integral part of metabolic processes. But the availability of this clement in soil is very critical owing to its rapid fixation into complex forms. Annual crops planted after the application of phosphorus fertilizers often recover only 1-20% of the applied-P. A large part of the applied-P is rapidly become insoluble & unavailable to plants as a result of chemical reactions involving the formation of iron, manganese aluminum & magnesium phosphate. Under reduced condition the oxide bound-P become available hence wetland crops do not respond to phosphate application. Information on the amount of various chemical forms of phosphorus & their effect on P fertility is necessary to know the supplying power of soil before going for phosphate fertilization. Zinc deficiency has been detected as the third major nutritional problem for Bangladesh soil next to N & P limiting the growth of wetland rice. In some places of Bangladesh, yield loss due to zinc deficiency ranged from 10-18%. A survey on zinc nutrition in rice in Bangladesh showed that soil with high pH & calcareous soils of north western districts & also the soils which have been integrity cultivated with transplant rice have Zn deficiency problem. Zn plays an important role in many physiological functions of plants. It serves as a constituent of plant metabolic enzymes system as alcohol dehydrogenase, carbonic anhydrous & various peptidases. In consideration of the importance of these two plant nutrient elements in wetland rice production in Bangladesh the objectives of the studies to evaluate the effect of P & Zn on yield and yield attributes of rice, to find out the optimum doses of P & Zn for rice cultivation, to investigate the interaction effects of P & Zn on the yield & yield attributes of rice, to find out information on the effect of zinc on distribution of added P in different fractions of post harvest soil.

Methods and materials

The experiment was conducted at Bangladesh Agricultural University with a view to finding out of the effect of phosphorus and zinc on yield, phosphorus and zinc content by rice (BR11) and phosphorus distribution in post harvest soil fractions.

The experimental field belongs to the agro ecological region of the Old Brahmaputra Flood plan. The region occupies a large area of Barahmaputra sediments, which are down before the river shifted into its present Jamuna channel about 200 years ago.

The experiment comprised of four levels of zinc (Zn), 0,5,10 and 20kg Zn ha^{-1} and three levels of phosphorus (P), 0, 25 and 50kg P_20_5 ha-' (Table 1).

Table 1 The total number of fertilizer treatment combinations was 12 and they were as follows

Zn_0P_0	Zn_5P0	$Zn_{10}P_0$	$Zn_{20}P0$
Zn_0P_{25}	Zn_5P_{25}	$Zn_{10}P_20_5$	$Zn_{20}P_{25}$
Zn_0P_{50}	Zn_5P_{50}	$Zn_{10}P_{50}$	$Zn_{20}P_{50}$

Under the trial, the total area was 400 square meters. The size of each plot was $10m^2$ (4mx2.5m). The experiment was laid out in Randomize Complete Block Design (RCBD) having 12 fertilizer combinations each of them replicated 3 times. Application of N, K and S were used at rate of 100kg N ha^{-1}, 40kg f_20 ha^{-1} and 12kg S ha^{-1} respectively among with the treatment combination. Sources used for the different elements were Urea (46% N), TSP (48% ^{P}205), MP (60% $_{K20)}$, Zinc sulphate (36% Zn) and Gypsum (18% S) which were collected from the local market, Mymensingh.

Total phosphorus was extracted from 2 g soil sample that has been (passed through 0.5 mm sieve, was weighed and transferred to a 300 ml conical flask. Thirty milliliter of 60% $HClO_4$ was added and the digestion was carried out at 130°C in a special apparatus designed to remove from $HClO_4$ fumes. Phosphorus was determined from the extract by adding ammonium molybdate and $SnCl_2$ solution and measuring the color with the help of Spectrophotometer at 660nm.[8] Zinc concentrations in the extract of grain and straw samples were determined directly by atomic absorption spectrophotometer in Central laboratory.[9]

The data of crop characters and nutrient content of plant and soil samples were analyzed statistically by means of computer package MSTAT. The difference among the treatments was adjusted by the Duncan's Multiple Range Test (DMRT) as outlined by Gomez and Gomez.[10]

Result and discussion

Grain yield

Effect of phosphorus

Phosphorus application was shown the significant variation on grain yield of rice. The highest grain yield (5.51 t ha^{-1}) was obtained from P50 treatment and that was significantly different from P_{25} (5.10 t ha^{-1}) treatment. Both the treatments (P_{25} and P_{50}) were significantly superior to P_0 (4.41 t ha^-) treatment. Higher yields in both P_{25} and P_{50} treatments were attributed to the production of higher number of tillers $hill^{-1}$, higher number of grains panicle-' and production of heavier grain than P_0 treatment. Heenan and Batten.[11] Saggar et al.[12] Bunta et al.[13] Fageria[14] Mahajan et al.[15] and Subba Rao et al.[16] were also found that phosphorus application increased the grain yield of rice.

Effect of Zinc

Zinc fertilizer significantly increased the grain yield of rice. The highest grain yield was obtained from Zn_{20} (5.47 t ha-1) treatment. The lowest grain yield was obtained from Zn_0 (4.58 t ha-1) treatment which was significantly inferior to Zn_5 and Zn_{10} treatments. The effect of zinc was an agreement with the findings of Ram et al.[17]

Effect of interaction

The combined effect of phosphorus and zinc on grain yield was found significant. The highest grain yield (5.97 t ha^{-1}) was obtained from Zn_{10} P_{50} treatment and was similar with Zn_{10} P25 (5.74 t ha- 1) but significantly higher than all other combined treatment of phosphorus and zinc. The lowest grain yield (4.24 t ha-1) was obtained from Zn_0 P_0 treatment, which was significantly lower than all other interactions of phosphorus and zinc. Zamal et al.[18] stated that application of P and Zn had a positive effect on grain yield of rice.

Straw yield

Effect of phosphorus

The highest straw yield (9.64 t ha^{-1}) was obtained from P50 treatment but it was significantly higher than all other treatments. Though apparently it was seen that P_{25} (9.10 t ha^{-1}) over control P0 (8.46 t ha^{-1}) but it was lower than P_{50} treatment. P_0 treatment produced the lowest straw yield (8.46 t ha^{-1}).

Effect of zinc

Application of zinc shows a significant effect on straw yield. The highest straw yield was observed at Zn_{20} (10.23 t ha^{-1}) treatment whereas control treatment Zn_0 produced the lowest straw yield (8.57 t ha^{-1}). Moreover, the treatments (Zn_0 and Zn_{10}) were produced statistically identical straw yield over control.

Effect of interaction

Interaction effect of phosphorus and zinc was significant in straw production. The highest straw yield (11.5 t ha^{-1}) was obtained from Zn_{10} P_{50} treatment and the lowest yield (8.20 t ha^{-1}) from control (Zn_0 P_0). Bunta et al.[13] reported that application of P at any rates, whether in combination with Zn or not increased grain and straw yield of rice.

Phosphorus and zinc content in grain

Effect of phosphorus

Phosphorus application increased P content in grain significantly. The highest P content (0.305%) in grain was obtained from the P_{50} t treatment and the lowest P content (0.274%) was obtained from the P_0 treatment (Table 2). The treatment P_{25} produced 0.290% P content in grain, which was significantly higher than P_0 treatment but it was lower than P_{50} treatment. Padihar and Dikshit [19] reported that P content in rice increased when P levels was increased.

Table 2 Single effect of P & Zn on P-Zn content by T-aman rice BR11

Treatments	P-content (%)		Zn-content (ppm)	
	Grain	Straw	Grain	Straw
Phosphorus				
P0	0.274c	0.090b	27.46a	39.15a
P25	0.290b	0.090b	24.20b	36.88b
P50	0.305a	0.108a	20.53c	34.95c
Zinc				
Zn0	0.322a	0.123a	16.87b	25.30d
Zn5	0.300b	0.121b	24.77c	32.80c
Zn10	0.270c	0.084c	27.07b	42.93b
Zn20	0.267c	0.077c	29.54a	46.93a

In a column figurers with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT).

Effect of zinc

P content in grain was decreased significantly by zinc application (Table 2). The maximum amount of P content in grain (0.322%) was obtained from the control (Zn_0) treatment and the minimum amount of P content in grain (0.267%) was obtained from the Zn_{20} treatment (Table 3). Zn_{10} treatment produced 0.270% P content in grain, which was identical with Zn_{20} treatments. 0.300% P content obtained from Zn_5 treatment which was significant with Zn_{20} and Zn_{10} treatment.

Table 3 Interrelation effect of P & Zn on P-Zn content by T-aman rice BR11

Treatments	**P-content** (%)		**Zn-content** (ppm)	
	Grain	Straw	Grain	Straw
Zn_0 P_0	0.28d	0.100c	20.80c	25.50g
Zn_0 P_{25}	0.33b	0.130ab	16.60b	25.90g
Zn_0P_{50}	0.35a	0.140a	15.21e	24.50g
Zn_5 P_0	0.24e	0.090cd	27.50b	34.90e
Zn_5 P_{25}	0.25e	0.120b	25.40b	32.70f
Zn_5 P_{50}	0.31c	0.130ab	21.40c	30.80f
Zn_{10} P_0	0.25e	0.080de	30.70a	45.60b
Zn_{10} P_{25}	0.31c	0.080de	25.70b	43.00c
Zn_{10} P_{50}	0.32bc	0.093cd	24.80b	40.20d
Zn_{20} P_0	0.23f	0.070e	32.83a	50.60a
Zn_{20} P_{25}	0.25e	0.080de	30.10a	45.90b
Zn_{20} P_{50}	0.24e	0.080de	25.70b	44.30bc

In a column figurers with same letter or Nithout letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DM).

Water soluble phosphorus in soil

Effect of phosphorus

Water-soluble phosphorus in soils showed a wide variation among the treatments. The maximum amount of water soluble-P (3.6 mg kg^{-1}) was observed from P_{50} treatments which are highly significant with all other treatments. The minimum amount of P (1.85 mg ka^{-1}) was observed from P_0 treatment which was lower than all other treatments. P_{25} treatment shows water soluble-P (2.9 mg ka^{-1}) which was significantly higher than control treatment. Therefore, it showed an increasing trend of water soluble-P in soil with the increasing levels of P treatments.

Effect of zinc

The application of zinc gradually decreased the water soluble-P in soil. The highest amount of water-soluble-P (3.33 mg kg^{-1}) was obtained from control treatment (Zn_0) which are high significant with any other treatments. The lowest amount of water soluble-P (2.33 mg kg^{-1}) was obtained from Zn_{20} treatment.

Effect of interaction

The interaction effect of phosphors and zinc on water-soluble phosphorus in soil was highly significant. The maximum amount of water-soluble P (4.5 mg kg^{-1}) was found in treatment Zn_0 P_{50}. The minimum amount of water-soluble P (1.5 mg kg-1) was found in Zn_{20} P_0 treatment. The Figure 1 showed the increasing trend of water-soluble-P with the increase of P levels and the decreasing trend of water-soluble-P with the increase of Zn level because antagonistic effect of P-Zn in soil.

Labile Phosphorus in soil

Effect of phosphorus

Labile phosphorus in soils showed a wide variation among the treatment. The highest amount of labile-P (1.475 mg kg^{-1}) was obtained from P_{50} treatments which are highly significant with any other treatments. The lowest amount of this P (0.55 mg ka^{-1}) was obtained from P_0 treatment which was lower than any other treatments. The Figure 1 showed the increasing trend of labile-P in soil with the increasing levels of P treatment.

Figure 1 Picture showing different plots at maturity stage of rice BR11.

Effect of zinc

The application of zinc gradually decreased the labile P in soil. The highest amount of labile-P (1.3 mg kg^{-1}) was obtained from control treatment (Zn_0) which was highly significant than other treatments. The lowest amount of labile-P (0.733 mg kg^{-1}) was obtained from Zn_{20} treatments. The Figure 1 shows a decreasing trend of labile-P in soil with the increase of Zn levels.

Effect of interaction

The interaction effect of phosphors and zinc on labile phosphorus in soil was highly significant. The highest amount of labile-P (1.8 mg kg^{-1}) was found in treatment Zn_0 and P_{50}. The

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lowest amount of labile-P (0.3 mg kg^{-1}) was obtained from Zn_{20} and P_0 treatment. The figure showed the increasing trend of labile-P in soil with the increase of P levels and the decreasing trend of labile-P with the increase of Zn levels because of antagonistic effect of P-Zn in soil solution.

Al/Fe banded P in soil

Effect of phosphorus

Al/Fe banded P in soil showed a wide variation among the treatments. The highest amount of Al/Fe-P (33.725 mg kg^{-1}) was obtained from P_{50} treatment which was highly significant than other treatments and the lowest amount (17.225 mg kg^{-1}) was obtained from P0 treatment.

Effect of zinc

Zinc application gradually increased the Al/Fe-P in soil. The maximum amount of Al/Fe-P (32.2 mg kg^{-1}) was obtained from Zn_{20} treatment which was highly significant with any other treatments. The lowest amount of Al/Fe-P (22.80 mg kg^{-1}) was obtained from Zn_0 treatment.

Summary and conclusion

The P content in grain and straw increased with increasing rate of P application but the content decreased with the increasing rate of Zn application. The highest P content in grain (0.305%) and straw (0.108%) was obtained from the highest rate of applied P that is P_{50} treatment while the lowest P content that is grain (0.267%) and straw (0.077%) was obtained from the highest rate of applied Zn in Zn_{20} treatment.

Phosphorus application significantly decreased the zinc content in grain and straw while zinc application increased the zinc content. The highest Zn content in grain (27.46 ppm) and straw (39.15 ppm) were observed in the P control (P_0) treatment while the highest Zn content in grain (29.54 ppm) and straw (46.93 ppm) was found in the highest rate of applied Zn that is in the Zn_{20} treatment.

The results reflected that the combined application of Zn_{10} and P_{50} treatment played a significant role on production of the highest yield. This has got positive effect also on yield contributing characters. However, application of zinc decreases phosphorus concentration in both grain and straw and water soluble-P and labile-P in soil but consequently increases Au-Fe-P, Mg/Ca-P and total-P in the soil resulting a Zn-P interaction in soil solution.

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Conflicts of interest

The authors declare that there is no conflict of interest.

References

1. Ray BP. Genetic analysis and development of submergence tolerance rice (Oryza sativa l.) lines through MAS. *Int J Complement Alt Med.* 2018;11(4):244–249.
2. MoA, (Ministry of Agriculture). Bangladesh food and agriculture. *World Food Summit*. Italy. 1996;13–17.
3. Ray BP, Uddin MI, Razia S, et al. Expression, isolation and identification of submergence induced genes from FR13A through RT-PCR. *MOJ Biology and Medicine*. 2017;1(6):00036:1–2.
4. BBS (Bangladesh Bureau of Statistics). Statistical yearbook of Bangladesh. Stat. Div., ministry of planning, *Government of the People's Republic of Bangladesh*, Dhaka: 1999;113–130.
5. Ray BP, Sarker SK, Sarker M. Genotype selection and selection criteria of submergence tolerant rice (Oryza sativa L.). *J Biol Chem Research*. 2013;30(2):409–420.
6. Jahiruddin M, Bhuiya ZH, Hague MS, et al. Effect of rates and methods of zinc application on rice. *Madras Agric J*. 1981;68(4): 211–218.
7. Haque MS, Jahiruddin M. Effect of single and multiple application of sulphur and zinc in a continuous rice cropping pattern Indian. *J Agric Res*. 1994;28(1):9–14.
8. Olsen SR, Cole CV, Watanable FS, et al. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *US Dept Agron Circa*. 1954;929.
9. McLaren RG, Swift RS, Quinon BF. EDTA extractable copper, zinc and manganese in soils of the Chaterburt plain NZ. *J Agric Res*. 1984;27:207–217.
10. Gomez KA, Gomez AA. Statistical procedures for agricultural research. *Johon Wiley and Sons*, New York. 1984;680.
11. Heenan DP, Batten GD. Response to superphosphate by rice in an annual rice cropping system to southern New South Wales. *Australian J Expt Agric*. 1986;26(9):691–695.
12. Saggar S, Dev G, Mulu OP. Available Soil Phosphorus in rice-wheat rotation after extended superphosphate application. *Int Rice Res NewsL*. 1986;11(3):26–27.
13. Bunta, A, Gunarto L, Rauf M, et al. Effect of phosphorus with or without zinc on wetland rice. *Rice Abst*. 1989;12(6):306.
14. Fageria NK. Response of rice cultivars to phosphorus fertilizer on dark red Latosols in central Brazil. *Revista Brasileria-de-Ciencia-do¬solo*. 1991;15(1):63–67.
15. Mahajan JP, Singh RP, Dwivedi AK. Utilization of fertilizer phosphorus by some rice varieties as influenced by phosphorus fertilization in black soil. *J Nucl Agric Biol*. 1994;23(4):242–245.
16. Subba Rao A, Ganeshamurthy AX, Sammi Reddy K. et al. Evaluation of some phosphate carriers for their efficiency in vertic Ustocherpt to sustain high productivity of wheat and rice. *J Indian Soc Soil Sci*. 1995;43(3):386–391.
17. Ram S, Chuhan RPSB. Response of rice to zinc application in sodic soil of Uttar Pradesh, *Indian J Agric Sci.* 1995;65:225–527.
18. Zaman MW, Rahman SH, Morita B, et al. Phosphorus and zinc interaction in rice grain. *Progress Agric*. 1994;5(2):273–278.
19. Padihar SK, Dikshit PR. Nutrient composition and yield of rice of different level of phosphorus and moisture. *Oryza (India)*. 1985;22(1):17–22.