EFFICACY OF BIO-CHEMICAL AMENDMENTS ON PHOSPHATE AVAILABILITY AND WHEAT YIELD IN SALT AFFECTED SOILS

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ABSTRACT

In a field experiment conducted at Agricultural Research Institute, Dera Ismail Khan, Pakistan during 2004-06 effect of bio-chemical amendments {FYM, gypsum, press mud and dhaincha (green manure)} on phosphate availability and wheat yield was studied under rice-wheat cropping pattern in salt affected soil. The result showed that all treatments significantly ($P < 0.05$) influenced the wheat yield. The highest yield (4525 kg/ha) was observed in green manure with dhaincha (*Sesbania aculeata*), which was at par with pressumd. The phosphate content in soil increased each year and was significantly affected by various treatments. At the end of study, the highest P content (8.09 µg P/g soil) was recorded in green manure treatment. There was a positive correlation between P-uptake and extractable phosphate ($r = 0.99$). A close relationship ($r = 0.99$) between P-uptake and wheat yield was also observed. Moreover, the treatments were found effective in reducing pH, ECe and SAR of soil.

KEYWORDS: ***Triticum aestivum; Oryza sativa;*** **saline sodic soils; farm yard manure; gypsum; press mud;** ***Sesbania bispinosa;*** **Pakistan.**

INTRODUCTION

Phosphorus is an essential element classified as a macronutrient because of its relatively large amount required by plants. One of main roles of P in living organisms is in energy transfer. Organic compounds that contain P are used to transfer energy from one reaction to drive another reaction within cells. Adequate P availability for plants stimulates early plant growth and hastens maturity. The growing plant derives this vital nutrient from the soil, mainly from fertilizers in case of the most commercially grown crops. The dominant characteristics of soil phosphate include very low solubility and its strong binding on the particle surfaces. As a result phosphorus deficiency in crop is common.

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Saline soils contain large amount of soluble salts. These salts can be of any cation or combination of cations, i.e. Ca^{++}, Mg^{++}, Na^{+}, etc. The accumulated salts present either in dissolved form in a moist soil or as crystal in dry soil. Sodic soils differ from saline soil, which are occupied by large amount of sodium ions. Soil salinization and sodication affect large areas of agricultural land in the world. Amelioration of these soils to make them suitable for agricultural production depends on understanding sodium dynamics and chemical interactions governing nutrient availability (14). In salt affected soil as the concentration of salts increase, P availability to plants declines (3). The different organic and inorganic methods are used to reclaim the soil and increase P availability of soil. Chun *et al.* (5) reported that organic matter decreased the concentrations of CO_3^{--}, HCO_3^{-}, and Na^{+} in soil solution and increased the total volume of leachate. Organic matter also reduced the amount of available Fe and increased P availability. According to a survey conducted in NWFP, 44 percent soils are low in available P (< 5 mg/kg). As regards of various districts in NWFP a great P deficiency was observed in Dera Ismail Khan and Bannu districts (2).

The present research was carried out to investigate the effect of different biological and chemical methods on status of phosphorus and wheat yield in salt affected soils under rice-wheat cropping pattern.

MATERIALS AND METHODS

This study was carried out on saline sodic soil at Agricultural Research Institute, Ratta Kulachi, D.I. Khan, Pakistan during 2004-06. The experiment was started during rabi 2004-05 with wheat crop (cv. Raj-2000) followed by rice (cv. IRRI-6) and wheat during 2005-06. Bio-chemical amendments i.e. FYM, gypsum and press mud were applied @10, 5 and 10 tons per hectare, respectively. The recommended doses of NPK were applied @ 120-90-60 kg per hectare before each crop in all plots. The experiment comprised four replications with five treatments i.e. FYM + wheat – rice – wheat (T_1), gypsum + wheat – rice – wheat (T_2), press mud + rice – wheat (T_3) fallow – dhaincha – wheat (green manure) (T_4) and wheat – rice – wheat (control) (T_5). Layout system was RCBD.

After premixing of amendments in specified plots wheat was grown in all plots except fallow plots (T_4). In following kharif season 2005 rice was grown in all treatments except T_4 in which dhaincha (*Sesbania aculeata*) was grown. After rice harvesting and green manuring of dhaincha wheat was grown in all plots for yield comparison.

Samples from each treatment were collected and analysed for P content (15), soil properties like ECe, pH, sodium adsorption ratio (SAR) (11) and Organic matter (10). Plant samples of wheat were collected and analysed for P-uptake in wheat leaves (7, 12). Data on wheat and rice yields were recorded in each treatment and subjected to statistical analysis including F-test and LSD.

RESULTS AND DISCUSSION

Wheat and rice yields in three seasons

The results regarding wheat and rice yields showed a significant difference ($P < 0.05$) among the treatments during whole study period. In the year 2004-05, maximum wheat yield (3772 kg/ha) was obtained from press mud treatments (Table 1) followed by gypsum and FYM treatments. Similar trend was observed in rice yield for the year 2005 with higher yield (3293 kg/ha) from press mud and was at par with FYM. In final year, the results significantly differed ($P < 0.05$) for wheat yield. The green manuring treatment (dhaincha) yielded higher (4525 kg/ha) and was statistically at par with press mud amended treatment. The lowest wheat yield (3005 kg/ha) was recorded in control. These results are in line with Bhatti *et al.* (1) who reported that dhaincha (green manure) proved effective in increasing the yield due to its effect on organic matter and soil physical properties.

Table 1. Effect of different treatments on wheat and rice yields (kg/ha).

Treatments	Wheat 2004-05	Rice 2005	Wheat 2005-06	Increase in wheat yield
FYM + wheat – rice – wheat	2920 b	3118 ab	3735 b	815
Gypsum + wheat – rice – wheat	3100 b	2816 b	3770 b	670
Press mud + wheat – rice – wheat	3772 a	3293 a	4178 ab	406
Fallow – dhaincha – wheat	-	-	4525 a	-
Wheat – rice – wheat (control)	2612 c	1977 c	3005 c	393

Wheat yield comparison (2005-06)

The data showed that all treatments improved the soil properties and increased wheat yield during both seasons. However, maximum increase was observed in FYM treated plot (815 kg/ha) followed by gypsum (670 kg) and press mud (406 kg). An increase in yield was also observed in control (393 kg). It indicated that all treatments affected the crop yield.

Status of phosphate influenced by different amendments

The results showed that all treatments significantly differed from each other (Table 2) for soil phosphate at various crop harvests. However, after harvesting of wheat, 2004-05 higher P concentration (7.46 µg/g) was recorded in press mud treated plots, which was at par with FYM and gypsum. Singh *et al.* (13) also reported that press mud cakes used in soil may increase the P content of soil upto 60 percent over unamended control. Higher P recovery was also observed by Delgado *et al.* (6) in gypsum amended reclaimed soils. Memon (8) reported that addition of organic matter in various forms, including farmyard manure to mineral soil, increased phosphorous availability.

After harvesting of rice and dhaincha, higher P concentration (8.53 µg/g) was observed in green manure with dhaincha and was at par with press mud treated plots. The lowest P content was observed in control plot.

Table 2. Soil phosphate influenced by different treatments.

Treatments	Phosphate in soil (µg/g)		
	Wheat 2004-05	Rice 2005	Wheat 2005-06
Farmyard manure + wheat – rice – wheat	7.20a	7.25bc	7.17ab
Gypsum + wheat – rice – wheat	6.83ab	6.23d	7.03bc
Press mud + wheat – rice – wheat	7.46a	8.01ab	7.61ab
Fallow – dhaincha – wheat	5.00c	8.53a	8.09a
Wheat – rice – wheat (control)	6.08b	6.70cd	6.12c

Similarly in third season, higher P content after harvesting of wheat crop 2006 was observed in green manure plot (8.09 µg/g), which was at par with press mud and FYM treatments. However, the lowest P concentration was observed in control (6.12 µg/g). The highest amount of extracted P in green manured plot may be due to improved physical condition of soil, by providing aeration and enhancing the microbial activity.

Phosphorus uptake by wheat

P-uptake was significantly influenced by different treatments. The results showed that the highest P-uptake (13.66 kg/ha) by wheat leaves was observed in green manured crop followed by press mud treated soil (11.36 kg/ha) (Table 3). The lowest P-uptake was measured in control (4.35 kg/ha).

Table 3. Effect of various treatments by P-uptake of wheat leaves.

Treatments	P-uptake by wheat leaves (kg/ha)
FYM + wheat – rice – wheat	9.22 c
Gypsum + wheat – rice – wheat	9.04 c
Press mud + wheat – rice – wheat	11.36 b
Fallow – dhaincha – wheat	13.66 a
Wheat – rice – wheat (control)	4.35 d

Increase in P-uptake might be due to increase of soil P by bio-chemical amendments and use of commercial fertilizers. Positive correlation was noted between extractable P and P-uptake (r = 0.99) (Fig. 1). Mattingly *et al.* (9) recorded the correlation (r = 0.92) between soil P and P-uptake by rye grass in a group of soil. Correlation of P-uptake with wheat yield showed that increase in P-content of plant resulted in yield increase (Fig. 2).

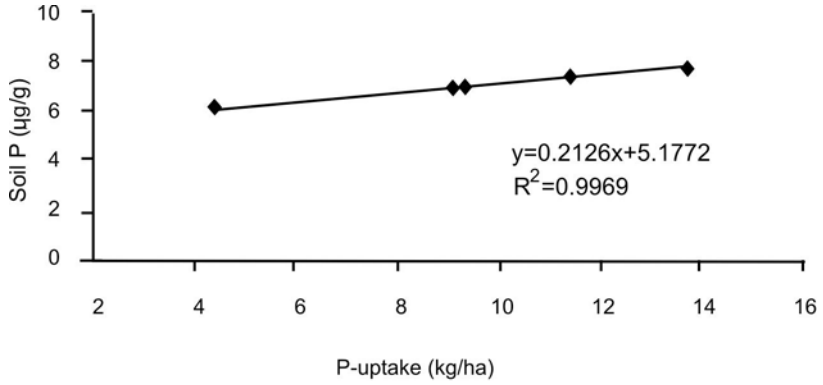

Fig. 1 Correlation of $NaHCO_3$ extractable P with P-uptake by leaves(r=0.9984).

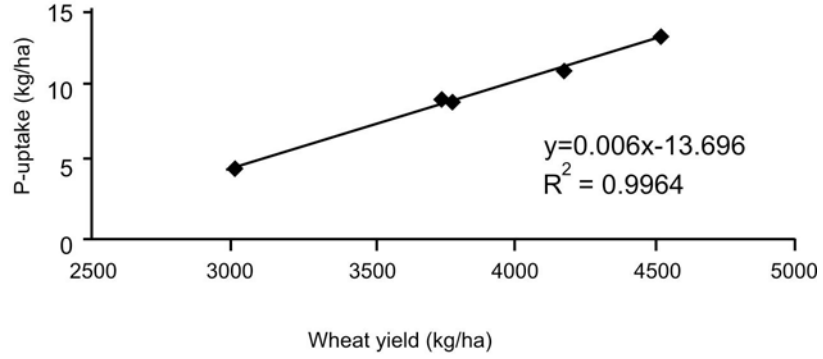

Fig. 2 Correlation between P-uptake and wheat grain yield(r=0.9982).

Effect of treatments on soil properties and salinity level

The results indicate that various treatments improved the soil properties. The pH of soil was reduced due to application of the treatments. In first season the pH was reduced after wheat in all treatments but maximum reduction was observed in gypsum treated soil (8.01) followed by press mud (8.05) and FYM (8.10). The comparison of results with untreated soil showed that pH was reduced in each treatment and after each season (Table 4).

The electrical conductivity (EC) of untreated soil was 15.22 before experiment and after treating with different amendments, it was reduced in all treatments (Table 4). In first year, the highest reduction (4.61) was observed in the treatment of press mud (T_3) and gypsum (T_2) (4.71), while in second year, the lowest EC (2.21) was observed in the treatment of FYM (T_1) followed by gypsum (T_2) (2.88). In final year, after harvesting of wheat the EC was lower than 4 in all treatments (Table 4).

Table 4. Effect of different treatments on soil properties.

Soil properties	Treatments	Before experiment	After experiment		
			Wheat, 2004-05	Rice, 2005	Wheat, 2005-06
PH	T_1	8.41	8.10	7.88	8.13
	T_2	8.41	8.01	7.71	8.07
	T_3	8.41	8.05	7.97	8.13
	T_4	8.41	8.36	7.91*	8.02
	T_5	8.41	8.30	8.01	8.21
EC	T_1	15.22	6.53	2.21	2.30
	T_2	15.22	4.71	2.88	3.09
	T_3	15.22	4.61	3.31	3.11
	T_4	15.22	13.11	4.10*	3.21
	T_5	15.22	14.52	4.47	3.91
SAR	T_1	17.77	6.35	5.52	5.72
	T_2	17.77	7.91	4.23	3.81
	T_3	17.77	8.85	6.11	6.23
	T_4	17.77	14.56	9.11*	4.88
	T_5	17.77	14.35	6.54	3.69

*After growing dhaincha (*Sesbania aculeata*)

The results further showed that SAR in untreated sample (17.77) reduced significantly after treating with bio-chemical amendments. The results of first year showed that observed SAR was reduced in all treatments, but the highest reduction (6.35) was observed in soil treated with FYM (T_1) followed by gypsum (T_2) (7.91) and press mud (T_3) (8.85). In second year after harvesting of rice the SAR was also reduced in all treatments. The lowest value of SAR (4.23) was observed in gypsum treated soil (Table 4). The final

year results showed a great reduction of SAR in all treatments. Similar results were observed by Bhatti *et al.* (1).

CONCLUSION

The study concludes that soil properties are influenced by the various treatments. Due to improvement of physical and chemical properties of soil, phosphate content, yields of rice and wheat and P-uptake were enhanced. Green manuring with *Sesbania aculeata* was found to be the most effective amongst the treatments in terms of reducing salinity problem, phosphate availability in soil and increasing wheat yield.

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