COMPARISON OF DIFFERENT PHOSPHORUS SOURCES FOR RICE AND WHEAT PRODUCTION IN SODIC SOIL

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A pot study was conducted during the year 1987-88 on rice and wheat to evaluate the effect of different sources of P (nitrophos, single super phosphate, diammonium phosphate and triple super phosphate) in soils having ESP of 10, 14, 27 and 41. Phosphorus for rice and wheat was applied @ 30 and 50 mg kg^{-1} soil along with a basal dose of N, K @ 45, 23 and 75, 25 mg kg^{-1} soil, respectively.

The P sources improved the productive tillers, grain and straw yields of rice and wheat, single super phosphate remained superior. The increasing sodicity levels decreased the number of tillers, grain and straw yields and P uptake. Phosphorus uptake was increased by applying P fertilizer in sodic soil, being maximum for SSP followed by TSP, DAP, NP and the control.

INTRODUCTION

According to estimates about 5.53 mha of arable land in Pakistan are affected by salinity and sodicity (Muhammad, 1983). In saline/sodic environments, the availability and uptake of P becomes a problem (Chhabra *et al.*, 1981). It has been noted that grain yield of rice was increased by application of P in saline-sodic soils (Jalil *et al.*, 1979). The yields of rice and wheat were not affected by P application in individual year in uncultivated sodic soil, but over a period of 6 years the yield of fertilized plots was more than the corresponding controls (Chhabra, 1985). Smith and Spenche (1974) in pot trials noticed that single super phosphate increased the grain yield of wheat in 2/3 among the 71 trials. Ahmad (1988), compared different P sources in a pot study, observed better P uptake, grain and straw yield of wheat with application of single super phosphate. In the present study, growth response of wheat and rice to P carriers was investigated under sodic soil conditions.

MATERIALS AND METHODS

A pot experiment was conducted on rice and wheat during the year 1987-88 at the Soil Salinity Research Institute Camp at Faisalabad to evaluate the effect of different sources of phosphorus (nitrophos, single super phosphate, diammonium phosphate and triple super phosphate) under four ESP levels (10, 14, 27 and 41). A normal loam textured (EC_e 1.9 dS m^{-1}, pHs 7.9, Oslon P 7 ppm, ESP 10) was collected from the field. The sodicity levels were developed by the addition of $NaHCO_3$. Ten kg of this soil were added in each pot. The treatments were: Control, nitrophos (N/P), single super phosphate (SSP), diammonium phosphate (DAP) and triple super phosphate (TSP).

Phosphorus for rice and wheat was applied @ 30 and 50 mg kg^{-1} soil along with a basal dose of N, K @ 45, 23 and 75, 25 mg kg^{-1} soil, respectively as ammonium

sulphate and potassium sulphate. Nitrogen was applied in two splits, i.e. Ist at transplanting/sowing and 2nd one month later.

samples were collected for P determination. All the chemical determinations were made according to the methods of U.S. Salinity Lab. Staff (1954). Available P in soil was

Table 1. Grain and straw yield (g pot^{-1}) and productive tillers of rice as affected by P sources and ESP

Treatment	ESP level				
	10	14	27	41	Average
		Grain			
Control	12.8 jkl	14.7 ijk	9.2 klm	-	9.2 D
N/P	19.4 ghi	20.0 fghi	22.4 efgh	2.6 no	16.1 C
SSP	37.9 a	30.6 bcd	26.2 cde	7.1 lmn	25.4 A
DAP	32.8 ab	28.3 bcde	25.8 defg	4.5 mno	22.2 B
TSP	31.7 abcd	32.3 abc	17.8 hij	7.9 lmn	22.5 AB
Average	26.9 A	25.2 A	19.7 B	4.4 C	
		Straw			
Control	83.0	77.5	32.1	-	48.2 D
N/P	133.3	91.1	51.9	14.3	72.7 C
SSP	159.0	105.3	76.4	36.0	94.2 A
DAP	146.3	107.1	75.6	28.6	89.4 B
TSP	139.0	117.6	76.7	46.3	94.9 A
Average	132.1 A	99.7 B	62.5 C	25.0 D	
		Productive tillers pot^{-1}			
control	26.7	21.0	10.0	-	14.4 C
N/P	32.0	26.7	13.0	4.7	19.1 B
SSP	32.3	33.0	20.7	16.3	25.9 A
DAP	45.0	28.0	23.3	12.0	24.6 A
TSP	38.3	33.0	19.3	14.0	26.2 A
Average	33.3 A	28.1 B	17.3 C	9.4 D	

Five plants of rice Bas. 385 and wheat Pb. 85 were maintained in each pot. At harvest, productive tillers, grain and straw yields were recorded. Grain and straw

determined according to Watanabe and Olsen (1965). Phosphorus uptake was calculated by the following formula:

$$\text{P uptake by grain (mg pot}^{-1}) = \frac{\%\ \text{P in grain} \times \text{grain (g pot}^{-1}) \times 1000}{100}$$

$$\text{P uptake by straw (mg pot-1)} = \frac{\%\ \text{P in straw} \times \text{straw (g pot-1)} \times 1000}{100}$$

P uptake by wheat and rice (mg pot^{-1}) = P uptake by grain and P uptake by straw, both as mg pot^{-1}

Table 2. Grain and straw yield (g pot^{-1}) and productive tillers of wheat as affected by P sources and ESP

Treatment	ESP level				
	10	14	27	41	Average
		Grain			
Control	5.9 efg	6.5 efg	0.4 g	-	3.2 C
N/P	17.4 a	15.1 abc	4.4 g	0.4 g	9.3 AB
SSP	17.1 a	16.7 ab	9.1 def	1.5 g	11.1 A
DAP	10.1 cde	14.5 abc	12.1 bcd	0.7 g	9.4 AB
TSP	12.0 cd	13.3 abcd	5.0 fg	1.1 g	7.9 B
Average	12.5 A	13.2 A	6.2 B	0.8 C	
		Straw			
Control	5.8	8.1	1.2	0	3.8 C
N/P	18.9	16.6	9.0	1.3	11.5 B
SSP	17.5	19.6	12.7	3.1	13.2 A
DAP	12.9	16.5	14.3	1.4	11.7 B
TSP	15.5	17.4	10.1	2.6	11.4 B
Average	14.1 B	15.7 A	9.5 C	1.7 D	
		Productive tillers pot^{-1}			
Control	6.3	8.7	5.0	-	5.0 D
N/P	16.0	12.7	9.7	5.0	9.5 C
SSP	16.0	15.7	13.0	5.7	12.6 A
DAP	14.3	16.0	14.3	5.0	12.4 A
TSP	11.3	14.0	11.0	5.3	10.4 B
Average	12.8 B	13.4 A	10.6 C	4.2 D	

All the data were statistically analysed following completely randomized design with factorial combination of treatments (Steel and Torrie, 1980).

Table 3. Phosphorus concentration in grain and straw of rice and uptake as affected by P sources and ESP

Treatment	ESP level				
	10	14	27	41	Average
			Phosphorus (%)		
Control	0.272	0.240	0.213	-	0.181 C
N/P	0.324	0.314	0.272	0.218	0.272 B
DAP	0.329	0.311	0.290	0.250	0.295 B
SSP	0.390	0.362	0.330	0.290	0.343 A
TSP	0.370	0.354	0.340	0.310	0.344 A
Average	0.338 A	0.310 AB	0.289 B	0.214 C	
			Straw		
Control	0.060	0.055	0.046	-	0.040
N/P	0.070	0.070	0.061	0.045	0.061
SSP	0.090	0.080	0.076	0.055	0.075
DAP	0.065	0.065	0.055	0.045	0.058
TSP	0.095	0.090	0.080	0.075	0.085
Average	0.076	0.072	0.063	0.044	
			ESP level (P uptake (mg kg^{-1})		
Control	85 l	78 m	34 p	0 s	49 E
N/P	155 f	131 h	92 a	12 r	98 D
SSP	291 a	194 e	144 g	40 o	167 A
DAP	203 d	157 f	116 j	24 q	125 C
TSP	249 b	219 c	122 i	59 n	162 B
Average	197 A	156 B	102 C	27 D	

RESULTS AND DISCUSSION

Rice growth characteristics: Maximum rice straw and grain yield was obtained for single super phosphate followed by TSP, DAP and N/P (Table 1). It remained minimum at ESP of 41. These results are in agreement with those of Jalil *et al.* (1979). Maximum grain yield was recorded in the treatment where SSP was applied in a soil of ESP 10 followed by DAP in the same soil and TSP in the soil having ESP of 14. However, there was no grain yield in the soil having ESP of 41 without fertilizer. It might be due to the toxic effect of exchangeable sodium on plants which could not survive in this treatment.

The productive tillers of rice (Table 1) was found maximum with SSP. On productive tillers, DAP and TSP have effect,

similar to SSP. With an increase of ESP, productive tillers decreased significantly. There was no survival of plants in the soil having ESP of 41 where no fertilizer was applied.

grain yield was recorded in a soil having ESP 10 with N/P and was similar with SSP at the same ESP level, followed by SSP, DAP and TSP at ESP of 14. Due to higher sodicity, there was no survival of plants in

Table 4. Phosphorus concentration in grain and straw of wheat and uptake as affected by P sources and ESP

Treatment	Phosphorus concentration (%)				
	10	14	27	41	Average
		Grain			
Control	0.31	0.30	0.26		0.22 B
N/P	0.33	0.31	0.29	0.21	0.29 A
SSP	0.37	0.37	0.31	0.19	0.31 A
DAP	0.34	0.34	0.27	0.23	0.30 A
TSP	0.36	0.35	0.31	0.19	0.30 A
Average	0.34 A	0.34 AB	0.29 B	0.16 C	
		Straw			
Control	0.10	0.06	0.07	0.00	0.06
N/P	0.13	0.09	0.09	0.07	0.10
SSP	0.18	0.13	0.14	0.12	0.14
DAP	0.14	0.10	0.09	0.07	0.10
TSP	0.17	0.16	0.14	0.11	0.15
Average	0.14	0.11	0.11	0.07	0.15
		P uptake (mg pot^{-1})			
control	24 k	24 k	2 o	0 p	13 D
N/P	82 c	62 g	21 l	2 o	42 C
SSP	95 a	87 b	46 i	7 m	59 A
DAP	52 h	66 f	46 i	3 n	42 C
TSP	70 e	75 d	30 j	5 mn	45 B
Average	65 A	63 B	29 C	3 D	

Wheat growth characteristics: The grain and straw yields of wheat (Table 2) was significantly affected, being maximum in the treatment receiving SSP followed by DAP, N/P and TSP. With an increase in ESP, being maximum in soil having ESP 14, followed by ESP 10, 27 and 41. The maximum

the soil having ESP of 41 without fertilizer. These results are in agreement with Smith and Spenche (1974).

The productive tillers (Table 2) were maximum with SSP followed by DAP, N/P and TSP. The ESP effects were similar to those on grain and straw yields of wheat.

The maximum productive tillers were recorded for soil ESP of 14, followed by 10, 27 and 41.

Per cent P in grain and straw of wheat and rice: Phosphorus concentration in rice grain (Table 3) was maximum with SSP and TSP, followed by DAP and N/P. Phosphorus concentration decreased with increasing ESP. However, there was no effect of P sources on concentration in rice straw (Table 3). The interaction effect of ESP levels and P sources was non-significant. The P concentration in wheat grain (Table 4) remained non-significantly different. The effect of P sources on P concentration in wheat straw and interaction between P sources and ESP in wheat grain and straw were non-significant (Table 4).

P uptake by rice and wheat: Phosphorus uptake by rice (Table 3) was maximum in the treatment receiving SSP followed by TSP, DAP, N/P and the control. Phosphorus uptake was maximum at ESP of 10, followed by 14, 27 and 41. The interaction between different P sources and ESP significantly affected the P uptake, being maximum for SSP applied in a soil having ESP of 10, followed by TSP in the same soil.

Phosphorus uptake by wheat (Table 4) was maximum in SSP treatment, followed by TSP, DAP, N/P and control. With an increase in ESP, P uptake was significantly decreased. Phosphorus uptake by wheat was maximum in the SSP treatment at soil ESP of 10, followed 14. The P uptake by rice and wheat was minimum at soil ESP of 41 in which N/P was applied. The P uptake was zero at soil ESP 41 without fertilizer and was due to the mortality of plants.

The SSP contains gypsum that ranges from 40% to 45%, which may help in increasing the availability of phosphorus to the plants. The DAP increases pHs particularly in calcareous sodic soils. So the uptake of P may further decrease which is already low due to the presence of higher amount of sodium. The TSP contains higher (46%) P and may help the supply of P to plants. The N/P is proved a poor source of P in sodic soils due to its low P contents and physiological activity. Basing upon the data of the present study and the quotient reasons brought above, it may be concluded that SSP is the best source of P in saline/sodic soils.

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