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Response of Rice Advance Line PB-95 to Potassium Application in Saline-sodic Soil

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Abstract: A field experiment was conducted to evaluate the response of rice crop to potassium fertilization in saline-sodic soil during 2005. Soil samples were collected before transplanting of rice crop and analysed for physical and chemical properties of the soil. In this experiment five rates of K_2O (0, 25, 50, 75 and 100 kg ha^{-1}) were applied in the presence of basal doses of N and P_2O_5 i.e., 110 and 90 kg ha^{-1}, respectively. Whole of P, K and ½ of N were applied at the time of rice transplanting. Twelve and half kg ha^{-1} $ZnSO_4$ was also applied 15 days after rice transplanting. The remaining half of N was applied 30 days after rice transplanting. The system of layout was Randomized Complete Block Design with four replications. The net plot size was 6×4 m. Fertilizer sources of NPK were urea, TSP and SOP, respectively. Rice salt tolerant line PB-95 was used as test crops. The data of growth parameters and yield was recorded and samples of paddy and straw were collected treatment-wise and analysed for N, P and K contents. Soil samples after harvesting the crop were also collected, processed and analysed for the changes in the extractable soil K. The results showed that increasing rates of potassium fertilizer increased the number of tillers m^{-2}, plant height (cm), 1000-paddy weight and paddy as well as straw yield significantly. Maximum paddy (3.24 t ha^{-1}) and straw (3.92 t ha^{-1}) yields were obtained in T_5 (100 kg K_2O ha^{-1}) which was at par with T_4 (75 kg K_2O ha^{-1}). With increasing rates of potassium fertilizer, concentration of potassium in paddy and straw increased significantly. After harvesting the crop, the extractable potassium contents of soil increased from that of the original soil. It was concluded from the results that there was an increase of 30.65% in paddy over control by applying potassium (100 kg K_2O ha^{-1}) in saline-sodic soil.

Key words: Potassium fertilization, saline sodic soil, paddy and straw yield

INTRODUCTION

Soil salinity is indeed a global problem posing a major threat towards the sustainability of agriculture in the world. According to an estimate (El-Ashry *et al*., 1985) salinity is seriously limiting crop production on 20 million hectare in the world. Out of 79.61 million hectare of geographic area of Pakistan, 6.67 million hectare, including about 18.4% of canal commanded area, is salt affected and is confined almost exclusively to the Indus plain. About 56% of the salt affected soils of Pakistan are saline-sodic (Soil Survey of Pakistan, 1989).

Pakistan falls under arid and semi-arid climate. High evapotranspiration and low rainfall are responsible for inadequate leaching of salts and consequently the accumulation of salts in the root zones. Sodium becomes a dominant cation in soil solution and on the exchange complex due to the precipitation of calcium and magnesium. High salinity levels lead to Na and Cl toxicity accompanied by the potassium deficiency in soil (Muhammad, 1983). Chhabra (1983) reported that barren sodic soils in the Indo-Gangetic region, contained high amounts of available K (upto 400 kg K_2O ha^{-1}) due to the dominance of illite in their clay fraction. Due to this no response to applied K was observed. He also reported that plant grown under high salinity might show potassium deficiency due to anagonistic effect of Na^+ and Ca^+ on K^+ absorption and /or disturbed Na^+/K^+ or Ca^{++}/K^+ ratio. Under such conditions application of potassium fertilizer may give increased plant yield. Din *et al.* (2001) conducted a pot experiment at salinity levels of 1.6, 6.0 and 12 dS m^{-1} with 50 mg kg^{-1} K_2SO_4 as soil application and 0.5% K_2SO_4 soultion as foliar spray on rice. He concluded that foliar and soil application of K increased significantly the number of tillers $plant^{-1}$, plant height, number of grains $plant^{-1}$, paddy and straw yield and grain to straw ratio in saline conditions. He also found that with foliar and soil application of potassium, the concentration of N and P increased in rice shoot and straw in saline conditions. He also found that foliar application of K increased the K^+

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concentration in rice shoot and straw compared to soil application. As a major part of Pakistani soils is saline-sodic. So particularly in such soils Na competes with K and reduces its uptake and causes potassium deficiency (Carden *et al*., 2003). In plant cells maintaining cytosolic K in an environment with a high Na concentration is a key factor in determining the ability to tolerate salinity (Maathuis and Amtmann, 1999). As the function of potassium in plants as an osmotically active cation and its involvement in controlling the water household gives balanced fertilization with potash the unique opportunity to improve the tolerance of plants to salinity, drought and frost. So potassium is one of the most important nutrients for rice production in many areas of Asia and in southeast

Chaudhary (1989), Farooq (1989) and Hassan *et al.* (2001) reported that salinity adversely affected the tillering capacity, plant height, paddy and straw yield and paddy to straw ratio. A significant increase in the sterility percentage with progressive increase in salinity was also observed. Aslam (1987) reported that Na, Ca, Cl and osmotic pressure of shoot sap increased while K and Mg concentration in the sap decreased with increasing concentration of NaCl salt in the root medium. Similar trend in the concentration of Na, Ca, Mg and Cl was observed for the root sap. He further reported that tolerant cultivar maintained lower concentration of Na and Cl in younger leaves than fully expanded older leaves.

Bansal *et al.* (1993) found a significant and positive interaction of N and K on grain and straw yield of rice. Application of 100 mg and 60 mg K kg^{-1} proved to be the optimum dose. N and K application influenced nutrient composition of both grain and straw at harvest.

A lot of work has been done on potassium effects on different crops in normal soils, but a little information is available regarding K fertilization effects on K/Na ratio and paddy yield increase in salt affected soils. Keeping in view the above facts, the present study was planned to evaluate the role of potassium fertilization in paddy and straw yield improvement in saline-sodic soil.

MATERIALS AND METHODS

The research reported in this study was carried out at the experimental area of Soil Salinity Research Institute, Pindi-Bhattian during the year 2005.

A field experiment was conducted to study the response of rice crop to potassium fertilization in saline-sodic soil. A composite soil sample was collected before the transplanting of rice from the experimental field. The soil was air-dried, ground, mixed and passed through a 2 mm sieve and analyzed for physical and chemical characteristics (Table 1). In this experiment there were five treatments i.e., 0, 25, 50, 75 and 100 kg K_2O ha^{-1}. The system of lay out was Randomized Complete Block Design with four replications. The net plot size was 6×4 m. The fields were plowed thoroughly for seedbed preparation and divided into 15 plots. New advance rice salt tolerant line PB-95 was transplanted as test crop. Canal water was used for irrigation. A basal dose of nitrogen and phosphorus at the rate of 110 and 90 kg ha^{-1} was applied, respectively. The sources of nitrogen, phosphorus and potassium were urea, TSP and SOP, respectively. The whole of P, K and ½ of N were applied at the time of rice transplanting. Twelve and half kg ha^{-1} $ZnSO_4$ was applied 15 days after transplanting. Five kilogram Furadon (granular) ha^{-1} was applied 25 days after transplanting to control insect attack. The remaining ½ of N was applied 30 days after rice transplanting. The crop was harvested at maturity and growth parameters i.e., Plant height (cm), Productive/fertile number of tillers per m^2, 1000 grain weight (g) and paddy and straw yield (t ha^{-1}) data were recorded. Paddy and straw samples were collected. The samples were oven dried ground and analyzed for potassium concentration. After harvesting of crops, composite soil samples were taken from each plot and analyzed for extractable potassium.

All the soil and plant analysis was done according to the methods given in Hand book No. 60 (US Salinity Lab. Staff, 1954) except texture by Moodie *et al.* (1959), total nitrogen by Jackson (1962), available phosphorus by Watanabe and Olsen (1965).

All the data was statistically analysed by using RCBD and treatment means were compared by least significant difference test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The soil was sandy loam in texture, saline-sodic, very low in organic matter and P and adequate in K (Table 1). The yield of crop is the estimation of all the yield components, of which the number of tillers per unit area is one of the most important components as high number of tillers per unit area reflects a good crop stand. The data in Table 2 indicated that the average number of

Table 1: Physical and chemical characteristics of soil before transplanting of rice

Characteristic	Value
Sand	65 (%)
Silt	16 (%)
Clay	19 (%)
Textural class	Sandy loam
EC_e	4.52-5.10 (dS m^{-1})
pH_S	8.55-8.61
SAR	23.66-28.95 ((mmol $L^{-1})^{½}$
OM	0.31 (%)
Available phosphorus (P)	4.32 (mg kg^{-1})
Extractable potassium (K)	110 (mg kg^{-1})

Table 2: Effect of potassium application on growth and yield of rice crop

Treatments	No. of productive tillers m^{-2}	Plant height (cm)	1000-grain weight (g)	Paddy yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	156d	69.66e	21.40e	2.48c	2.98d
T_2	195c	77.66d	21.49d	2.64bc	3.18cd
T_3	220b	78.77c	21.71c	2.88b	3.52bc
T_4	246a	86.7b	22.02b	3.17a	3.80ab
T_5	248a	96.7a	22.33a	3.24a	3.92a
LSD	2.160	0.1674	0.0404	0.2766	0.3797

Figures having the same letter are nonsignificant at 5% level of probability, LSD = Least Significant Difference

productive tillers increased significantly with the application of potassium fertilizer. The minimum number of tillers (156) was found in T1 (control) where no potassium fertilizer was applied. Maximum numbers of productive tillers (248) were found in T5 (100 kg K_2O ha^{-1}) and it was followed by T4, T3 and T2 where 75, 50 and 25 kg K_2O ha^{-1} was applied respectively. Treatment T5 (100 kg K_2O ha^{-1}) and T4 (75 kg K_2O ha^{-1}) were statistically at par. The increased response of rice to increasing levels of K application in this sodic soil was due to antagonistic interaction between Na and K. High salinity levels lead to Na toxicity accompanied by potassium deficiency (Mehdi *et al*., 2001) and thus higher rates of K_2O up to 75 kg ha^{-1} increased number of productive tillers. Plant height is an other important growth parameter. The results showed that plant height increased significantly with the application of potassium fertilizer (Table 2). The plant height was increased upto 50 kg K_2O ha^{-1}. The treatments T5 (100 kg K_2O ha^{-1}), T4 (75 kg K_2O ha^{-1}) and T3 (50 kg K_2O ha^{-1}) were statistical significantly different from each other. Further increase in K rates could not increase the plant height. Many research workers reported that plants remain stunted in salt-affected soils because of low fertility status of such soils. These results are in agreement with the findings of Anonymous (1982), Farooq (1989), Din *et al.* (2001), Mehdi *et al.* (2001) and Hassan *et al.* (2001) in salt-affected soil. These are in line in normal soil by Janardan and Singh (2000). The 1000 paddy weight is one of the most important components of the yield. Heavier the paddy, the greater will be the yield. The data indicated that 1000 paddy weight was increased significantly by the application of potassium in saline sodic soil (Table 2). Maximum paddy weight was recorded in T_5 (100 kg K_2O ha^{-1}), which was significantly higher than all other treatments. The increase in 1000-grain weight was due to the positive effect of K on paddy yield under saline-sodic soil conditions. Actually K has significant role in starch synthesis and in grain development (Mengal, 1982) thus its adequate supply showed a profound effect in producing heavier paddy (Gulshad, 1985, Niazi *et al*., 1992; Singh, 2005). These results are similar to those reported by Farooq (1989), Niazi *et al.* (1992), Mehdi *et al.* (2001), Hassan *et al.* (2001) and Din *et al.* (2001).

The paddy and straw yield was increased significantly by the application of potassium in saline sodic soil. Maximum paddy and straw yield was recorded in T_5 (100 kg K_2O ha^{-1}) and minimum in control where no potassium was applied. All the treatments differed significantly from each other. Maximum paddy (3.24 t ha^{-1}) and rice straw yield (3.92 t ha^{-1}) was observed in T5 (100 kg K_2O ha^{-1}) which was at par with T4 (75 kg K_2O ha^{-1}) and followed by T3 (50 kg K_2O ha^{-1}) and T2 (50 kg K_2O ha^{-1}). All the treatments were statistically different from each other except T4. Lowest yield in T1 (control) was due to salinity sodicity in the rooting zone and low fertility status with respect to NPK. There are many causes of low yield under saline-sodic conditions and were discussed earlier by various workers including Chhabra (1983) and Muhammad (1986). According to them high salinity sodicity levels lead to potassium deficiency due to antagonistic effect of Na on potassium absorption or disturbance of Na/K ratio. Actually K has significant role in starch synthesis and in grain development (Mengal, 1982) thus its adequate supply showed a profound effect in producing more paddy and straw yield (Gulshad, 1985, Niazi *et al.* 1992; Singh, 2005). These results are in accordance with the findings of Anonymous (1982), Chhabra (1985), Gulshad (1985), Farooq (1989), Fageria *et al.* (1990), Niazi *et al.* (1992), Mehdi *et al.* (2001), Hassan *et al.* (2001) and Din *et al.* (2001).

The data regarding the effect of potassium application on the concentrations of K in paddy is given in Table 3. Minimum K conc. (0.31 %) in paddy was observed in T1 (control) while maximum K conc. (0.36 %) was found in T5 (100 kg K_2O ha^{-1}) followed by T4 (75 kg K_2O ha^{-1}), T3 (50 kg K_2O ha^{-1}) and T2 (25 kg K_2O ha^{-1}) nonsignificant and significantly over control. The increase in potassium concentration of paddy with potassium fertilizer treatments might be due to higher uptake of K by plants (Chhabra, 1983; Muhammed, 1986). These results are in line with those reported by Anonymous (1982), Muhammed (1986), Fageria *et al.* (1990), Niazi *et al.* (1992), Hussain *et al.* (1992) Mehdi *et al.* (2001) and Din *et al.* (2001). Similar results were reported in normal soils by Bansal *et al.* (1993), Janardan and Singh (2000), Jeegadeeswari *et al.* (2001) and Hong and GuangHuo (2004) in normal soils.

Analysis of variance showed that concentrations of K in straw (Table 3) increased significantly. Minimum K conc. (1.12%) in rice straw was observed in T1 (control) while maximum K conc. (1.22%) was found in T5 (100 kg K_2O ha^{-1}) followed by T4 (75 kg K_2O ha^{-1}), T3 (50 kg K_2O ha^{-1}) and T2 (25 kg K_2O ha^{-1}). Treatments T5 (100 kg K_2O ha^{-1}) and T4 (75 kg K_2O ha^{-1}) were statistically non-significant to each other and significant over control (T1). The increase in potassium

Table 3: Effect of potassium application on K concentrations (%) in rice paddy and straw

Treatments	Paddy (%)	Straw (%)
T_1	0.31b	1.12c
T_2	0.33ab	1.14c
T_3	0.35a	1.18b
T_4	0.35a	1.20ab
T_5	0.36a	1.22a
LSD	0.0288	0.0264

Figures having the same letter are nonsignificant at 5% level of probability, LSD = Least Significant Difference

Table 4: Extractable potassium in soil after harvest

Treatments	Soil K (mg kg^{-1}) after rice harvest
T_1	107d
T_2	116c
T_3	127b
T_4	131a
T_5	133a
LSD	1.95

Figures having the same letter are nonsignificant at 5% level of probability, LSD = Least Significant Difference

concentration of rice straw with potassium fertilizer treatments might be due to higher uptake of K by plants (Chhabra, 1983; Muhammed, 1986). These results are in line with those reported by Anonymous (1982), Muhammed (1986), Fageria *et al.* (1990), Niazi *et al.* (1992), Hussain *et al.* (1992), Mehdi *et al.* (2001), Hassan *et al.* (2001) and Din *et al.* (2001) in salt affected soil.

The results showed that maximum extractable soil potassium (133 mg kg^{-1}) was found in T5 (100 kg ha^{-1}) followed by T4 (75 kg ha^{-1}), T3 (50 kg ha^{-1}) and T2 (25 kg ha^{-1}) (Table 4). Minimum extractable potassium (107 mg kg^{-1}) was found in T1 (control). All the treatments were statistically significant to each other and over control.

Saline soils are generally medium to high in available potassium (Sharma *et al.* 1968) but plants grown under high salinity may show K deficiency due to antagonistic effect of Na: K or disturbed Na: K ratio (Chhabra, 1983). In T5 (100 kg K_2O ha^{-1}) maximum extractable potassium was found because here maximum potassium fertilizer was applied. The original level of extractable K in soil was 110 ppm and after rice harvest, analysis showed 107 ppm extractable K in the control plots. Similar results were found by Azam (1993) and Mehdi *et al.* (2001).

From the present study it is concluded that rice yield can be increased by applying potassium at the rate of 75 kg K_2O ha^{-1} in saline sodic soils.

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