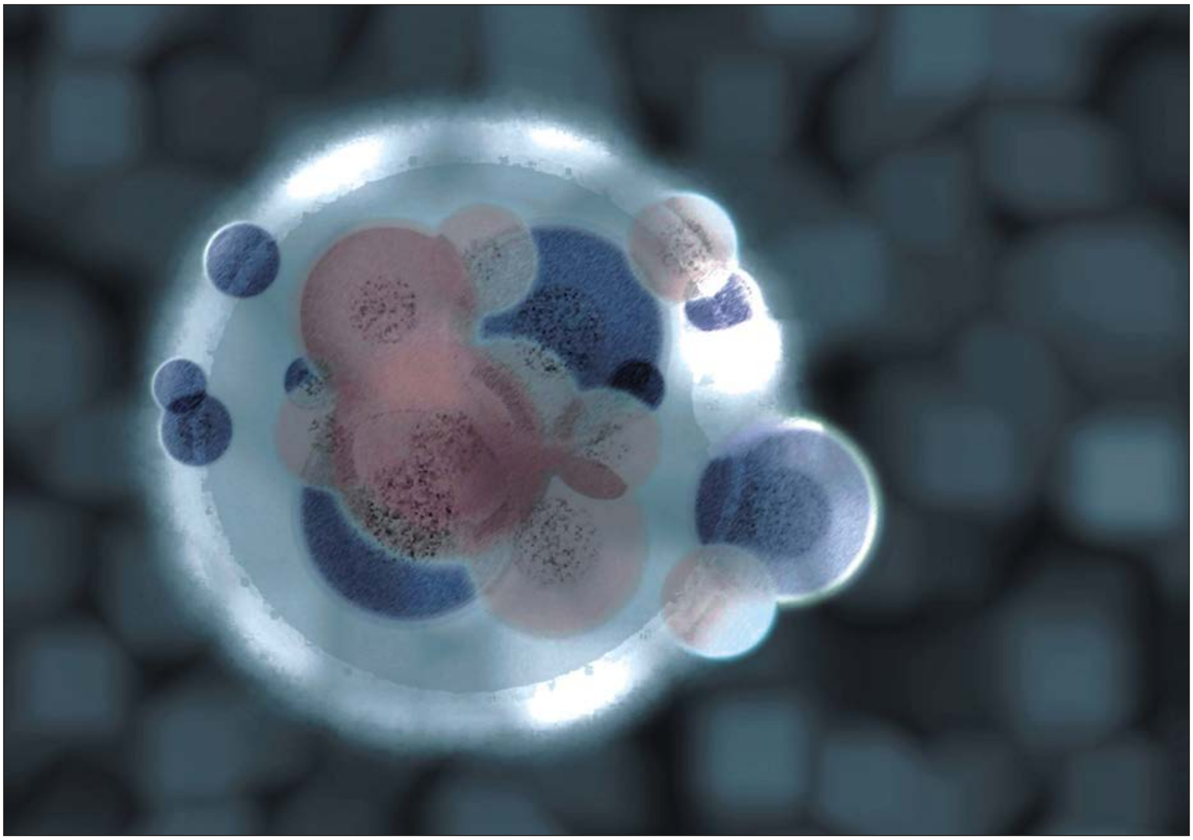

Journal of Biological Sciences

ISSN 1727-3048

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Journal of Biological Sciences 7 (5): 823-826, 2007
ISSN 1727-3048

Response of Wheat to Applied Supplemental Potassium in Saline Sodic Soil

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Abstract: A field experiment was conducted to determine the response of wheat to applied potassium in saline-sodic soils. Five rates of K_2O were applied i.e., 0, 30, 60, 90 and 120 kg ha^{-1} along with a basal dose of N and P_2O_5 i.e., 140 and 110 kg ha^{-1}, respectively. The whole of P, K and ½ of N was applied at the time of sowing and remaining ½ N was applied at the time of 1st irrigation. 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. Wheat variety inqulab-91 was sown as test crop. The yield and yield components data was recorded and grain and straw samples were analysed for K contents. Soil samples after harvesting the crop were also collected and analysed for the extractable soil K. The results indicated that increasing rates of potassium fertilizer increased the number of tillers m^{-2}, plant height (cm), 1000-grain weight, grain and straw yield significantly. Maximum grain (3.06 t ha^{-1}) and straw (3.57 t ha^{-1}) yield were found in T_4 (90 kg K_2O ha^{-1}). Increasing rates of potassium fertilizer increased concentration of potassium in grain and straw significantly. After harvesting the crop, the extractable potassium contents of soil increased from that of the original soil.

Key words: Growth parameters, grain and straw yield, potassium application, saline sodic soil

INTRODUCTION

Soil salinity is indeed a global problem posing a major threat to the 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. In Pakistan 6.67 million hectare is salt affected out of which 56 % is saline-sodic (Soil Survey of Pakistan, 1965).

Wheat yield on slightly and moderately salt affected soils is reduced by 36 and 68%, respectively, as compared to those obtained on non-saline-sodic soils (Qayyum and Malik, 1988). Because in saline sodic soils Na competes with K and reduces its uptake and causes potassium deficiency (Carden *et al*., 2003). Jami (1982) recorded the effect of soil salinity on number of tillers, leaves, fresh and dry weight of shoots and roots in case of wheat and pointed out that all these parameters were adversely affected due to high salinity. Niazi *et al.* (1992) conducted a pot experiment to evaluate the effect of potassium under different artificially developed sodicity levels for wheat and rice. K levels were 0, 15, 30, 45 and 60 mg kg^{-1} soil and developed sodicity levels (ESP) were 5.4 (initial), 18 and 34. They found that increasing sodicity levels decreased the grain yield, straw yield and productive tillers. K concentrations and its uptake in grain and straw were increased significantly with its increasing application. Hussain *et al.* (1992) conducted a pot experiment to note the potassium effect on wheat at different salinity levels i.e., 8, 12 and 16 dS m^{-1}. Potassium levels were 0, 15, 30, 45 and 60 mg kg^{-1} soil. The results showed that the grain and straw yields of rice and wheat decreased with increasing salinity levels. In wheat, K concentration and its uptake were significantly increased up to 30 mg kg^{-1} application rate and further increase in K proved ineffective. Saifullah (2002) studied the effect of potassium on growth and yield of wheat in saline sodic soil. Five rates of potassium (0, 75, 150, 225 and 300 kg ha^{-1}) were tested in the presence of basal doses of N and P_2O_5 i.e., 140 and 110 kg ha^{-1}, respectively. Yield, its components and K contents were increased while Na contents were decreased. Keeping all this in view present study was conducted to see the response of wheat to applied potassium in saline sodic soil.

MATERIALS AND METHODS

A field experiment was conducted at the research farm of Soil Salinity Research Institute, Pindi Bhattian, during the year 2005-2006. Before sowing of the wheat, a composite soil sample was collected from the experimental field. The soil sample was air-dried, ground, well mixed and passed through a 2 mm sieve and analyzed for the physical and chemical characteristics.

Four rates of potassium i.e., 30, 60, 90 and 120 K_2O kg ha^{-1} beside control were applied. A basal dose of 140 and 110 (kg ha^{-1}) of N and P_2O_5, respectively was

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also applied. The system of lay out was Randomized Complete Block Design with four replications. Net plot size was 6×4 m. The field was plowed thoroughly for seedbed preparation and divided into 15 plots. Wheat variety inqulab-91 was sown as test crop on 21 November, 2005. Nitrogen, phosphorus and potassium were applied as urea, tripple super phosphate and potassium sulphate, respectively. The whole of P, K and ½ of N was applied at the time of sowing and remaining ½ of N was applied at the time of 1st irrigation. The crop was harvested at maturity on 24 April 2006 and number of productive tillers, plant height and 1000-grain weight (g), grain and straw yield (t ha^{-1}) data was recorded. Plant samples (grain and straw) were collected at the harvest of the crop. The samples were oven dried, ground and analyzed for potassium. All the soil and plant analysis was done according to the methods given in Hand Book No. 60 (US Salinity Laboratory Staff, 1954) except texture by Moodie *et al.* (1959) and available soil phosphorus by Watanabe and Olsen (1965).

The statistical analyses of data were carried out by applying analysis of variance technique (Steel and Torrie, 1980) and treatment means were compared using the Least Significant Difference Test.

RESULTS AND DISCUSSION

The original soil analysis before the sowing of wheat is given in Table 1. The soil was sandy loam in texture, saline-sodic in nature, low in organic matter and P and medium in K.

Effect of potassium application on the growth parameters and yield of wheat

Yield parameters of wheat: The yield of crop is the estimation of all the yield components, of which the number of tillers per unit area, plant height and 1000-grain weight are the most important components. The data regarding the effect of potassium application on the number of productive tillers, plant height and 1000 grain weight is presented in Table 2. The results showed that all the three parameters increased significantly with the application of potassium fertilizer up to 90 kg K_2O ha^{-1} and higher application rates of K_2O remained ineffective in increasing these parameters.

It is clear from the data that when we increased the potassium fertilizer rate, these parameters increased significantly. This might be due to more uptake of potassium from salt affected soil where K was applied. The increased response of wheat to increasing levels of K application in this saline sodic soil was due to antagonistic interaction between Na and K. High salinity levels lead to Na toxicity accompanied by potassium deficiency (Muhammed, 1986) and thus higher rates of K_2O up to 90 kg ha^{-1} increased number of productive tillers. These results are similar to those reported by Macleod (1969), Gulshad (1985) and Azam (1993) in salt affected soil.

This increase in plant height was due to the greater availability of K, which regulated the stomatal opening and closing and maintained osmotic or solute potential in plants due to which growth of cells and tissues remained continuous (Sinha, 1978). The increase in 1000-grain weight was due to the positive effect of K on wheat yield under saline-sodic soil. 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 wheat grains. Similar results were found by Gulshad (1985), Hussain *et al.* (1992) and Niazi *et al.* (1992) in salt-affected soil.

Grain and straw yield of wheat (t ha^{-1}): The grain yield is a function of the combined contribution of various yield components that have direct relationship to the growing conditions and practices adopted to manage the crop. The data showing the grain and straw yields of wheat crop are given in Table 2. The results revealed that the potassium fertilizer treatments gave significantly higher yield than the control. The minimum yield of wheat grain (2.52 t ha^{-1}) and wheat straw (2.91 t ha^{-1}) was found in T_1 (control). Low yield in T_1 (control) was due to salinity sodicity in

Table 1: Physical and chemical characteristics of soil before sowing of wheat

Characteristic	Value
Textural class	Sandy loam
EC_e	5.31 (dS m^{-1})
pH_S	8.56
SAR	28.85 (mmol L^{-1})$^{1/2}$
OM	0.38 (%)
Available phosphorus (P)	5.68 (mg kg^{-1})
Extractable potassium (K)	118 (mg kg^{-1})

Table 2: Effect of potassium application on growth parameters and yield of wheat

Treatments	K_2O application rates tillers (m^{-2})	No. of productive	Plant height (cm)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	0	245d	79.5d	36.55e	2.52c	2.91c
T_2	30	253c	81.8c	37.08d	2.61c	3.12c
T_3	60	259b	82.8b	38.13c	2.82b	3.38b
T_4	90	264a	83.4a	41.62a	3.06a	3.57a
T_5	120	266a	83.2a	40.96b	2.99ab	3.54a
LSD		2.44	0.307	0.124	0.1786	0.2382

Table 3: Potassium concentrations in wheat grain and straw (%)

Treatments	Grain	Straw
T_1	0.36b	1.31c
T_2	0.38ab	1.33c
T_3	0.41a	1.38b
T_4	0.41a	1.40ab
T_5	0.42a	1.42a
LSD	0.0333	0.0308

Table 4: Effect of potassium application on extractable potassium content ($mg\ kg^{-1}$) in soil after harvesting of wheat

Treatments	Soil K after wheat harvest
T_1	112e
T_2	117d
T_3	121c
T_4	126b
T_5	130a
LSD	2.99

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 Muhammed (1986). According to them high salinity sodicity levels lead to potassium deficiency due to antagonistic effect of Na on potassium absorption or disturbance of the Na^+/K^+ ratio.

Maximum wheat grain (3.06 t ha^{-1}) and straw (3.57 t ha^{-1}) yield was found in T_4 (90 kg K_2O ha^{-1}) that was at par with T_5 (120 kg K_2O ha^{-1}) and followed by T_3 (60 kg K_2O ha^{-1}) and T_2 (30 kg K_2O ha^{-1}). These results are in accordance with the findings of MacLeod (1969), Chhabra (1983), Gulshad (1985), Farooq (1989), Niazi *et al.* (1992), Azam (1993) and Singh (2005). It is clear from Table 2 as potassium level was increased in saline-sodic soil, yield increased significantly. This might be due to more uptake of potassium from the salt affected soil where potassium fertilizer was applied.

Effect of potassium application on K concentrations in wheat grain: The data of potassium concentration in wheat grain is given in Table 3. The results indicated that minimum K conc. (0.36%) was observed in T_1 (control) while maximum (0.42%) was found in T_5 (120 kg K_2O ha^{-1}), T_4 (90 kg K_2O ha^{-1}) and T_3 (60 kg K_2O ha^{-1}) followed by T_2 (30 kg K_2O ha^{-1}). The treatments T_5, T_4 and T_3 were statistically non-significant but they were significant over control (T_1). These results are in line with those of reported by Anonymous (1982), Ohno and Grunes (1985), Muhammed (1986), Fageria *et al.* (1990), Niazi *et al.* (1992), Logbina and Bugaevskii (1992), Hussain *et al.* (1992), Azam (1993) and Singh (2005).

Effect of potassium application on concentrations of K in wheat straw: The data regarding the effect of potassium application on the concentrations of K, in wheat straw is presented in Table 3 which, showed that concentrations of K increased significantly with the use of potassium fertilizer. Minimum K concentration (1.31 %) was observed in T_1 (control) while maximum (1.42 %) was found in T_5 (120 kg K_2O ha^{-1}) followed by T_4 (90 kg K_2O ha^{-1}), T_3 (60 kg K_2O ha^{-1}) and T_2 (30 kg K_2O ha^{-1}). The treatments T_5 and T_4 in potassium concentration were statistically nonsignificant with each other and significant over T_2 and control (T_1). The increase in potassium concentration of wheat straw with potassium fertilizer treatments might be due to higher uptake of K by plants (Chhabra, 1983; Muhammad, 1986). These results are in line with findings of those reported of reported by Anonymous (1982), Ohno and Grunes (1985), Muhammed (1986), Fageria *et al.* (1990), Niazi *et al.* (1992), Logbina and Bugaevskii (1992), Hussain *et al.* (1992), Azam (1993) and Singh (2005).

Effect of potassium application on extractable soil K after wheat harvest: The effect of potassium fertilizer on the extractable potassium contents in saline-sodic soil after harvesting the wheat crop is given in Table 4.

The results revealed a significant difference among treatments. Maximum extractable soil potassium (130 mg kg^{-1}) was found in T_5 (120 kg ha^{-1}) followed by T_4 (90 kg ha^{-1}), T_3 (60 kg ha^{-1}) and T_2 (30 kg ha^{-1}). Minimum extractable potassium (112 mg kg^{-1}) was found in T_1 (control). Over all the treatments were statistically significant to each other and over control (T_1).

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 T_5 maximum extractable potassium was found because here maximum potassium fertilizer (120 kg ha^{-1}) was applied. The original level of extractable K in soil was 118 ppm and after wheat harvest, analysis showed 112 ppm extractable K in the control plots. Similar results were found by Chaudhary (1981), Azam (1993) and Singh (2005).

CONCLUSION

In saline sodic soils, maximum wheat yield and yield components i.e., No. of tillers m^{-2}, plant height (cm), 1000-grain weight, grain and straw yield can be obtained at 90 kg K_2O ha^{-1}.

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