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# Growth and yield components of wheat genotypes as influenced by potassium and farm yard manure on a saline sodic soil

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## Abstract

*The adequate supply of mineral nutrients through chemical fertilizers and manure may help to sustain the crop productivity and ensure plant survival under salinity stress. A field study was conducted on saline sodic soil ($EC_e$ = 13 dS $m^{-1}$, SAR 23.3 (mmol $L^{-1})^{1/2}$, pH = 8.6 of surface 15 cm layer) to quantify the effects of potassium (K) and farm yard manure (FYM) on two wheat genotypes differing in salinity tolerance. Three K levels (0, 80, 120 kg $ha^{-1}$) and two FYM levels (0, 10 t $ha^{-1}$) were tested using randomized compete block design (RCBD) with three replications. The application of K along with FYM reduced $Na^+$ uptake and accumulation in plant tissue. The K concentration and $K^+/Na^+$ ratio were significantly improved in both wheat genotypes with the supplementation of K and FYM. The grain yield was improved by 40-156% in salt tolerant genotype and 46-206% in salt sensitive genotype with added K and FYM. Similar trend was observed in yield components. Ameliorative effects of added K and FYM were more marked in salt sensitive genotype (Auqab-2000) than in salt tolerant (Inqlab-91). Grain yield of salt sensitive and salt tolerant wheat genotypes was positively correlated with leaf $K^+$ concentration determined at various treatments. Addition of K along with FYM decreased sodium adsorption ratio (SAR) and electrical conductivity (EC) of soil particularly in upper layers. Therefore, it is concluded that K along with FYM could help to alleviate deleterious effects of salts and thus improve the productivity of salt affected soils.*

**Key words**: Ionic relations, plant growth, sodium, yield and yield attributes

## Introduction

Soil salinity/sodicity restricts the growth of crops and holds back the development of agriculture in many arid and semi-arid regions of the world (Sharma *et al*., 2005). The global estimates show that more than $900 \times 10^6$ hectares of cultivated land is threatened by or already lost by salinity (Flowers and Yeo, 1995). Soil salinity reduces plant growth by perturbing different biochemical and physiological processes (Zeng and Shannon, 2000; Hussain *et al.,* 2008). The build up of toxic ions in the rhizosphere initially causes injury to plant roots and their gradual accumulation in aerial parts causes heavy damage to plant metabolism, synthesis of carbohydrates, proteins, nucleic acid and ultimately growth and yield of crop is reduced (Wahid, 2004; Wahid and Ghazanfar, 2006).

Plants have adopted a wide range of mechanisms to survive the salt stressed environment (Ashraf *et al*., 2007). Proper management of mineral nutrients plays a crucial role in increasing plant resistance to salinity (Marschner, 1995). Among the mineral nutrients, K plays a particular role to increase the yields and improve quality of crops under salinity stress (Mengel and Kirkby, 2001). Potassium is essential for many physiological processes such as photosynthesis, translocation of photosynthates into sink organs, maintenance of turgescence, activation of enzymes and reducing the excess uptake of ions such as $Na^+$ and $Cl^-$ under salinity stress (Cakmak, 2005; Ibrahim *et al.,* 2007). Addition of organic matter can accelerate leaching of $Na^+$, decrease the exchangeable $Na^+$ percentage and EC and hence facilitate the management and reclamation of salt affected soils (Lax *et al*., 1994; Qadir *et al*., 2001).

Past studies mostly addressed role of K to alleviate the detrimental effects of salinity on the growth and development of different crops (Botella *et al*., 1997; Subasinghe, 2006) but little work has been reported about the combined effects of K and FYM on yield and yield components of wheat under salinity stress. The objective of this study was to quantify the effects of K and FYM on soil properties, plant growth and yield components of salt

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sensitive and salt tolerant wheat genotypes grown on a saline sodic soil.

## Materials and Methods

### Treatments and soil analysis

The experiment was conducted on a saline sodic soil (31.65° N latitude and 72.36° E longitude and 157.65 m altitude) under natural field conditions at Reclamation Farm, Mianchannu, Punjab, Pakistan. Soil samples were collected at depth of 0-15, 15-30, 30-60 and 60-90 cm from each plot before and after the harvest of wheat crop. These soil samples were dried, ground, passed through 2 mm sieve and analyzed for texture (Gee and Bauder, 1986), $EC_e$, SAR, pH and extractable ions (Bigham, 1996); organic matter (Nelson and Sommers, 1996), and K (Soltanpour and Worker, 1979) (Table 1). Two wheat genotypes, Inqlab-91 (salt tolerant) and Auqab-2000 (salt sensitive) were grown on November 15, 2008. Five treatments (i) control; (ii) 80 kg $K_2O$ $ha^{-1}$; (iii) 80 kg $K_2O$ $ha^{-1}$ + 10 tons FYM $ha^{-1}$; (iv) 120 kg $K_2O$ $ha^{-1}$; (v) 120 kg $K_2O$ $ha^{-1}$ + 10 tons FYM $ha^{-1}$ were applied with three replications using RCBD. Nitrogen at 90 kg $ha^{-1}$ and phosphorus at 120 kg $ha^{-1}$ were used as basal dose while remaining N (90 kg $ha^{-1}$) was applied in two splits. The N as urea, P as single super phosphate and K as sulphates of potash were used. The maximum temperature ranged from 7-40 ºC and minimum from 5-29 ºC while relative humidity dropped from 95 to 58% during experimental period.

### *Plant tissue analysis*

When plants were 70 days old, leaf samples were collected and digested with di-acid mixture of $HNO_3$ and $HClO_4$ (3:1) for $K^+$ and $Na^+$ analysis (Yoshida *et al*., 1976). The concentrations of $K^+$ and $Na^+$ in the digested samples were estimated by flame-photometery.

### *Yield and yield attributes*

At maturity grain yield and yield contributing parameters like number of tillers $plant^{-1}$, spike length and number of grains $spike^{-1}$ were recorded by selecting ten plants at random from each replication plot.

### *Statistical analysis*

The data were subjected to statistical analysis using computer software MSTAT-C (Russell and Eisenmith, 1983) and following methods described by Gomez and Gomez (1999).

## Results

### *Ionic relations*

Leaf $K^+$ concentration showed significant ($p \leq 0.05$) differences between the treatments in both wheat genotypes grown on a saline sodic soil (Table 2). Addition of different levels of K alone and in combination with FYM increased leaf $K^+$ concentration by 55–240% in salt tolerant genotype (Inqlab 91) and 70–276% in salt sensitive genotype (Auqab 2000) as compared to control. Leaf $Na^+$ concentration was significantly ($p \leq 0.05$) higher in salt sensitive genotype than salt tolerant genotype when grown on a saline sodic soil without any amendment (Table 3). In salt tolerant genotype, leaf $Na^+$ concentration was reduced by 16% with the application of $K_1$ (80 kg $K_2O$ $ha^{-1}$), 39% with $K_1$ + FYM, 61% with $K_2$ (120 kg $K_2O$ $ha^{-1}$) and 69% with $K_2$ + FYM as compared to control. Similarly, 18–63% decrease in leaf $Na^+$ concentration of salt sensitive genotype was observed with different levels of K and FYM. Both wheat genotypes indicated significant ($p \leq 0.05$) differences in maintaining leaf $K^+$/ $Na^+$ ratio under salinity stress (Table 4). The salt tolerant genotype accumulated more $K^+$, less $Na^+$ and consequently maintained higher $K^+$/ $Na^+$ ratio than

**Table 1: Selected physical and chemical properties of experimental field before cropping of wheat**

| | Soil depth (cm) | | | |
|---|---|---|---|---|
| **Soil property** | **0–15** | **15–30** | **30–60** | **60–90** |
| pH | 8.6 | 8.5 | 8.5 | 8.3 |
| EC (dS $m^{-1}$) | 13.0 | 13.7 | 14.4 | 13.8 |
| SAR (mmol $L^{-1})^{1/2}$ | 23.3 | 19.7 | 21.6 | 26.4 |
| $Na^+$ (meq $L^{-1}$) | 83.4 | 63.0 | 43.4 | 41.6 |
| $Ca^{2+}$ (meq $L^{-1}$) | 5.0 | 2.5 | 4.0 | 3.5 |
| $Mg^{2+}$ (meq $L^{-1}$) | 20.5 | 18.0 | 1.0 | 1.5 |
| Available K (mg $kg^{-1}$) | 115 | 103 | 123 | 121 |
| Organic matter (%) | 0.88 | 0.74 | 0.79 | 0.73 |
| Saturation percentage | 45 | 50 | 47 | 44 |
| Textural class | Loam | Loam clay | Silt loam clay | Silt loam clay |

salt sensitive genotype grown on a saline sodic soil. Addition of K alone and in combination with FYM reduced the uptake of $Na^+$ and improved $K^+/Na^+$ ratio in both wheat genotypes. However, K when applied in combination with FYM was more effective to alleviate the deleterious effects of salinity than K alone.

206% in salt sensitive genotype by the addition of different levels of K alone and in combination with FYM (Figure 1). Number of tillers $plant^{-1}$ were improved by 57–125% in salt tolerant genotype and 73–168% in salt sensitive genotype by added K and FYM as compared to control (Figure 2). Almost similar trends were found in spike length (Figure 3)

**Table 2: Potassium concentration (mg $g^{-1}$) in wheat genotypes grown on a saline sodic soil as affected by K and farm yard manure (FYM)** (Means of three replications)

| Treatment | Salt tolerant genotype (Inqlab-91) | Salt sensitive genotype (Auqab-2000) |
|---|---|---|
| Saline sodic soil only | 21.9 ± 2.21 | 15.8 ± 1.67 |
| 80 kg $K_2O$ $ha^{-1}$ | 34.0 ± 2.15 | 26.9 ± 2.41 |
| 80 kg $K_2O$ + 10 t FYM $ha^{-1}$ | 49.3 ± 2.26 | 37.2 ± 2.74 |
| 120 kg $K_2O$ $ha^{-1}$ | 57.0 ± 3.16 | 46.5 ± 2.57 |
| 120 kg $K_2O$ + 10 tons FYM $ha^{-1}$ | 74.4 ± 2.87 | 59.5 ± 3.45 |
| LSD $_{(0.05)}$ | 10.02 | |

**Table 3: Sodium concentration (mg $g^{-1}$) in wheat genotypes grown on a saline sodic soil as affected by K and farm yard manure (FYM)** (Means of three replications)

| Treatment | Salt tolerant genotype (Inqlab-91) | Salt sensitive genotype (Auqab-2000) |
|---|---|---|
| Saline sodic soil only | 40.7 ± 2.32 | 66.0 ± 2.32 |
| 80 kg $K_2O$ $ha^{-1}$ | 34.0 ± 2.15 | 54.1 ± 2.71 |
| 80 kg $K_2O$ + 10 t FYM $ha^{-1}$ | 24.6 ± 3.61 | 44.4 ± 2.08 |
| 120 kg $K_2O$ $ha^{-1}$ | 16.0 ± 1.97 | 34.8 ± 4.34 |
| 120 kg $K_2O$ + 10 tons FYM $ha^{-1}$ | 12.6 ± 0.71 | 24.4 ± 2.20 |
| LSD $_{(0.05)}$ | 13.34 | |

**Table 4: $K^+/Na^+$ ratio in wheat genotypes grown on a saline sodic soil as affected by K and farm yard manure (FYM)** (Means of three replications)

| Treatment | Salt tolerant genotype (Inqlab-91) | Salt sensitive genotype (Auqab-2000) |
|---|---|---|
| Saline sodic soil only | 0.54 ± 0.02 | 0.24 ± 0.03 |
| 80 kg $K_2O$ $ha^{-1}$ | 1.00 ± 0.05 | 0.50 ± 0.06 |
| 80 kg $K_2O$ + 10 t FYM $ha^{-1}$ | 2.02 ± 0.24 | 0.89 ± 0.10 |
| 120 kg $K_2O$ $ha^{-1}$ | 3.60 ± 0.55 | 1.34 ± 0.09 |
| 120 kg $K_2O$ + 10 tons FYM $ha^{-1}$ | 5.93 ± 0.43 | 2.44 ± 0.20 |
| LSD $_{(0.05)}$ | 3.69 | |

### *Yield and yield components*

Significant ($p \leq 0.05$) differences between treatments were found in grain yield, number of tillers per plant, spike length and number of grains $spike^{-1}$ of wheat genotypes grown on a saline sodic soil (Figure 1 to 4). Addition of K alone and in combination with FYM to soil improved yield and yield components of both genotypes. However, the improvement was significantly ($p \leq 0.05$) higher in salt sensitive genotype than salt tolerant. The grain yield was improved by 40–156% in salt tolerant genotype and 46– and number of grains $spike^{-1}$ (Figure 4) of both wheat genotypes. Grain yield of wheat was positively correlated ($R^2 = 0.96$ for salt sensitive genotype and $R^2 = 0.98$ for salt tolerant genotype) with leaf $K^+$ concentrations determined for various treatments (Figure 5).

### *Soil properties*

At harvest, the SAR and EC were reduced in upper soil layers (0–15 and 15–30 cm) while slightly increased in lower soil layers (30–60 and 60–90 cm) by the addition of K alone and in combination with FYM as compared to control. The SAR was reduced by 19–33% at 0–15 cm depth and 8–16% at 15–30 cm by the addition of different levels of K and FYM as compared to control. In contrast, the SAR was increased by 13–25% at 30–60 cm soil depth and 4–8% at 60–90 cm in treated plots compared to control (Figure 6). The EC was reduced up to 31% at 0–15 cm soil depth and 3–22% at 15–30 cm with K and FYM as compared to untreated plots (Figure 7).

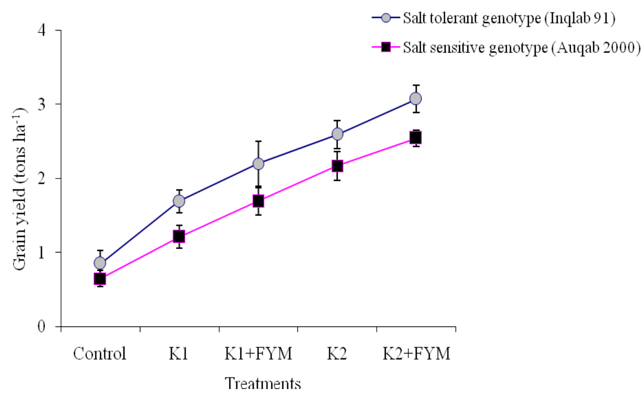


**Figure 1: Grain yield of wheat genotypes grown on a saline sodic soil as affected by K and FYM.** (Means of three replications ± SE, LSD $_{(0.05)}$ = 0.49). Control: Saline sodic soil only; $K_1$: 80 kg $K_2O$ $ha^{-1}$, $K_1$ + FYM: 80 kg $K_2O$ + 10 tons FYM $ha^{-1}$; $K_2$: 120 kg $K_2O$ $ha^{-1}$; $K_2$ + FYM: 120 kg $K_2O$ + 10 tons FYM $ha^{-1}$

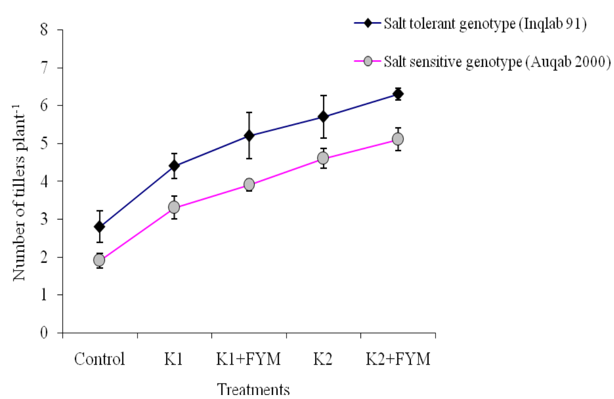


**Figure 2: Number of tillers per plant of wheat genotypes grown on a saline sodic soil as affected by K and FYM.** (Means of three replications ± SE, LSD $_{(0.05)}$ = 0.68). Control: Saline sodic soil only; $K_1$: 80 kg $K_2O$ $ha^{-1}$; $K_1$ + FYM: 80 kg $K_2O$ + 10 tons FYM $ha^{-1}$; $K_2$: 120 kg $K_2O$ $ha^{-1}$; $K_2$ + FYM: 120 kg $K_2O$ + 10 tons FYM $ha^{-1}$

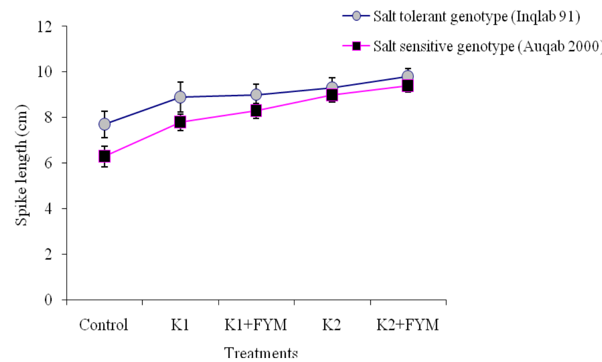


**Figure 3: Spike length of wheat genotypes grown on a saline sodic soil as affected by K and FYM.** (Means of three replications ± SE, LSD $_{(0.05)}$ = 1.34). Control: Saline sodic soil only; $K_1$: 80 kg $K_2O$ $ha^{-1}$; $K_1$ + FYM: 80 kg $K_2O$ + 10 tons FYM $ha^{-1}$; $K_2$: 120 kg $K_2O$ $ha^{-1}$; $K_2$ + FYM: 120 kg $K_2O$ + 10 tons FYM $ha^{-1}$

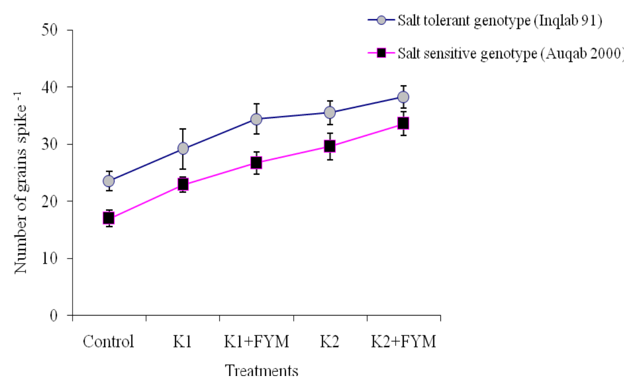


**Figure 4: Number of grains per spike of wheat genotypes grown on a saline sodic soil as affected by K and FYM.** (Means of three replications ± SE, LSD $_{(0.05)}$ = 2.94). Control: Saline sodic soil only; $K_1$: 80 kg $K_2O$ $ha^{-1}$; $K_1$ + FYM: 80 kg $K_2O$ + 10 tons FYM $ha^{-1}$; $K_2$: 120 kg $K_2O$ $ha^{-1}$; $K_2$ + FYM: 120 kg $K_2O$ + 10 tons FYM $ha^{-1}$

## Discussion

Soil salinity is an increasing constraint threatening the crop production globally (Lopez *et al*., 2002). Screening of germplasm of various crops for salinity tolerance, transfer of genes for salt tolerance into adopted cultivars and adequate regulation of mineral nutrients are seemed to supplement the engineering and reclamation approaches to sustain the productivity of salt affected soils (Mahar *et al*., 2003; Ashraf *et al*., 2007). In present study, the significant

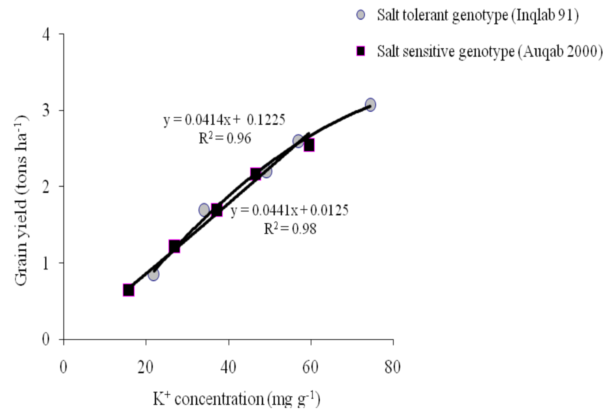


**Figure 5: Relationship between grain yield and leaf $K^+$ concentration of salt tolerant and salt sensitive wheat genotypes grown on a saline sodic soil by supplying K and FYM**

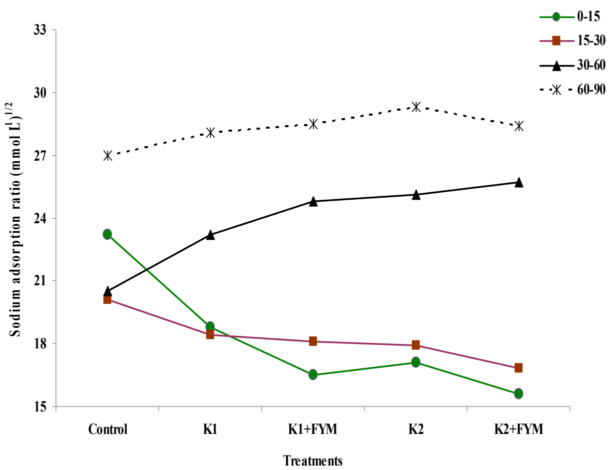


**Figure 6: Sodium adsorption ratio (SAR) of soil after the harvest of wheat grown with different levels of K and FYM.** Control: Saline sodic soil only; $K_1$: 80 kg $K_2O$ $ha^{-1}$; $K_1$ + FYM: 80 kg $K_2O$ + 10 tons FYM $ha^{-1}$; $K_2$: 120 kg $K_2O$ $ha^{-1}$; $K_2$ + FYM: 120 kg $K_2O$ + 10 tons FYM $ha^{-1}$

($p \leq 0.05$) differences in yield and yield components of both wheat genotypes under salinity stress were related to their abilities to selectively absorb $K^+$ over $Na^+$. Qadir and Schubert (2002) reported that crop genotypes varied not only in the rate at which they absorb the available nutrients but also in the manners by which they translocate and distribute the elements within their bodies. The higher yield and yield attributes in salt tolerant genotype were associated with its genetic ability to accumulate the lowest $Na^+$, the highest $K^+$ and higher $K^+$/ $Na^+$ ratio compared to salt sensitive genotype. Munns and James (2003) demonstrated that genotypes with lowest $Na^+$ concentration, accumulated greatest biomass and vice versa. Improvement in yield and yield components of both wheat genotypes by the addition of K and FYM was attributed to antagonistic effect of $K^+$ with $Na^+$ and improved soil properties (Sanjakkara *et al.*, 2001; Cakmak, 2005). Added K either alone or in combination with FYM reduced $Na^+$ uptake and its toxicity in plant tissue, increased leaf $K^+$ concentration and $K^+$/ $Na^+$ ratio resulting in improvement in yield and yield components of both wheat genotypes. Past studies also demonstrated that deleterious effects of high $Na^+$ in different crop species could be alleviated by the addition of K to substrate (Subasinghe, 2006). The higher beneficial effects of K in combination with FYM as compared to K alone could be due to the ameliorative effects of FYM on soil properties. Robbins (1986) reported that use of waste matter and manures improved water infiltration, water holding capacity and aggregate stability of soil. Walker and Bernal (2004) also reported that promotion in plant growth by manure in two Brassica species under salinity stress was related to decline in shoot $Na^+$ or increase in shoot $K^+$ concentration. The decrease in SAR of soil by K and FYM was due to the reason that a part of added K either from $K_2SO_4$ or FYM displaced $Na^+$ from exchange complex and retained there. The decrease in EC of soil by the addition of K and FYM could be attributed to improved infiltration and leaching of salts by irrigation water. Lax *et al.* (1994) reported that addition of organic matter to salt affected soils improved infiltration and accelerated leaching of salts and hence decreased EC of soil.

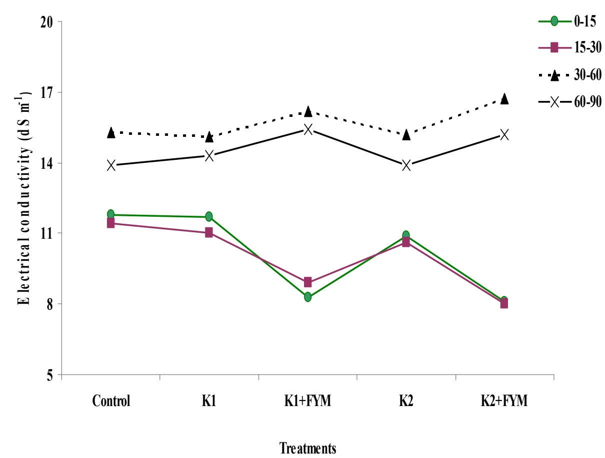


**Figure 7: Electrical conductivity (EC) of soil after the harvest of wheat grown with different levels of K and FYM.** Control: Saline sodic soil only; $K_1$: 80 kg $K_2O$ $ha^{-1}$; $K_1$ + FYM: 80 kg $K_2O$ + 10 tons FYM $ha^{-1}$; $K_2$: 120 kg $K_2O$ $ha^{-1}$; $K_2$ + FYM: 120 kg $K_2O$ + 10 tons FYM $ha^{-1}$

## Conclusions

The application of K along with FYM reduced SAR and EC of soil and increased the yield components in both wheat genotypes grown on saline sodic soil. However, the beneficial effects of K with FYM were more pronounced in salt sensitive genotype (Auqab-2000) than salt tolerant (Inqlab-91). Furthermore, the K in combination with FYM was more effective to alleviate deleterious effects of injurious salts than K alone.

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