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# Response of Sorghum to potassium and Zinc application under saline condition

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**Abstract**

*A green house pot experiment was conducted on the fodder sorghum in saline soils at varying salinity levels with potassium and Zinc fertilization. The treatments comprising 2 salinity levels (control and 8 dS/m) and potassium levels 4 (control, 20, 40 and 60 Kg $K_2O$/ha) with 4 zinc levels (Control, 10, 20 and 30 Kg/ha) were arranged in Factorial rendomized block design with three replication. As compared to normal condition (Control) the magnitude of decreased in green foliage and dry matter yield in higher saline condition at soil salinity level 8 dS/m. Minimum green foliage and dry matter yield recorded at 8 dS/m due to soil salinity has a significant effect on decline the green foliage and dry matter yield of Sorghum. The increase in the green foliage and dry matter yield of sorghum at 60 Kg K/ha application. Zinc sulphate application to the soil also proved beneficial as at enhanced the greenfoliage and drymatter yield of Sorghum over control. All the levels of zinc sulphate tried in experiment proved significantly superior over control in respect of green foliage and drymatter yield of sorghum crop. The highest green foliage and drymatter yield of sorghum crop. The highest green foliage and drymatter yield was obtained with 30 Kg $ZnSO_4$/ha application followed by 20, 10 and 0 (Control) Kg Zn $SO_4$/ha. All the possible interactions were found to be non- significant on green foliage and drymatter production by sorghum. N and Na content increased in saline soil but P, Ca, Mg and Zn content decreased significantly over control, but K content reduced non-significantly in sorghum. N uptake by sorghum recorded maximum in saline condition at salinity level 8 dS/m non-significantly, but Na uptake increased significantly. P, K, Ca, Mg and Zn uptake by sorghum decreased significantly. N, Ca, Mg, Na and Zn content in sorghum crop with increasing levels of K. The minimum average value of all these content in sorghum plant were noted under 60 Kg K/ha. K application level 60 Kg K/ha show a synergistic effect on the absorption of R and K by sorghum plant. The uptake of N, P, K by the sorghum crop was increased gradually up to 60 Kg K/ha application, but the Na uptake gradually increased up to 40 Kg K/ha. The application of K reduced the uptake of Ca, Mg and Zn by sorghum significantly at higher level of K (60 Kg/ha).*

*Key worlds: Sorghum, drymatter, uptake, content, saline*

## Introduction

Sorghum is very popular as a fodder crop growing in all the zones of country. Sorghum is a nutritive green roughage for used as a cattle feed, its luxurious vegetative growth favors' to production as a fodder crop. Fodder sorghum is used in various from of cattle feed like soiling crop, silage crop hay making and surplus. Sorghum is grown on a variety of soil types; But a specific Character of sorghum, it may tolerate mild acidity to mild salinity of soil under pH 5.5 to 8 has grown successfully. So selection of sorghum crop, in recent studies to find out its tolerance of soil salinity with potassium and zinc application.

Saline soils contain sufficient concentration of soluble salts in the root zone soil to adversely affect plant growth and productivity. The soluble salts in these

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soil are predominantly the chlorides and sulphates of sodium, Calcium and magnesium, these soil have pH of Saturation paste less than 8.5, ESP less than 15 and EC more than 4 dS/m at 25$^0$C. It is commonly held conception that fertilizer application is likely to further aggravate the salinity problem. Maintained an optimum level of soil fertility is essential for successful crop production in saline soil as the problem is more of nutritional nature. This can be said more for nitrogen and for potassium to some extent. Potassium plays a regulatory role in plant metabolism and development but is not a structural component of the plant. It regulates the opening and closing of stomata, which essential for photosynthesis, water and nutrient transport and plant calling. It increases root growth and improves draught tolerance and neutrilizers orgenic anions in the plant and helps in maintaining cytoplasmic pH within range of 7-8 ideal for many enzyme reactions. It shows that there are differences of opinions regarding the amount of fertilizers to be applied and its effect on crop growth. For successful crop production from saline soils efficient and economic use of fertilizers is of vital importance. Zinc was recently assumed great importance in crop production as it plays a significant role in oxidation reduction process. Quantitative and qualitative importance of Zinc application of Several crops has been well established in literature (Sharma and Singh, 1990). Therefore, the present study will be under-taken to determine the effect of zinc on growth yield and quality of sorghum crop under saline conditions was conducted in the Deptt. of Agricultural Chemistry and Soil Science, R.B.S. College, Bichpuri, Agra.

## Materials and Method

A green house pot experiment was conducted to evaluate the effect of K and Zn application on sorghum under saline condition. The details were as follow, two levels of salinity with control (Control and 8 dS/m) were created artificially by adding the calculated amount of $CaCl_2$, $MgSO_4$, $MgCl_2$ and NaCl in to the soil. After mixing the soil lots of different EC thoroughly 10 Kg soil was filled in pots; four levels of potassium (Control, 20, 40 and 60 Kg $K_2O$/ha) with four levels of Zn $SO_4$ (Control, 10, 20 and 30 Kg/ha). Zinc was applied as Zinc sulphate and potassium were applied through muriate of potash. A recommended dose of Nitrogen and phosphorus were applied through Urea and single super phosphate. The required earthen pots of similar size and shape for experiment were selected, cleaned and lined with polythene sheet. The pots were arranged in a factorial randomized block design with three replication. At appropriate moisture level, the soil of each pot was pulverized and seeded with 10 seed of the sorghum. The plants were thinned to five when they attained 5-7 cm height. The crop was irrigated as per when needed. The crops were harvested after 60 days of sowing and after recording the green foliage and dry matter yield, the sample were retained for the Chemical analysis.

The plant samples were first oven dried the ground in a wiley mill. The finely ground materials was then subjected to Chemical analysis. These samples were wet digested with nitric and perchloric acid as outlined by Johanson and Ulrich (1959). Phosphorus was determined in the acid extract by ammonium molybadate vanadate yellow colour method as described by Chapman and Pratt (1961). The aliquots obtained after wet digestion were diluted to the desired level and analyzed for K and Na on a direct reading flame-photometer. For calcium and magnesium determination, the aliquots. Obtained after wet digestion were titrated against EDTA using EBT as indicator at pH 10 as outlined by Chapman and Pratt (1961). Calcium was determined using ammonium perputrate in the presence of Carbonate crystals and 16% NaOH solution (Chapman and Pratt,1961). Magnesium was obtained by difference. Zinc content in the acid extract was determined on atomic absorption spectrophotometer. The uptake of nitrogen and various nutrients by plants was worked out by multiplying their content values with corresponding yield data. The data regarding yield chemical composition and nutrients uptake were processed and analyzed statistically to test whether the effects of different treatments were significant. The interpretation of results is based on statistical significance of calculated 'F' values at 5% level. Critical difference (C.D.) has been worked out for comparing the difference between the levels of a significant treatment.

## Results and Discussion

Results reveals that the green foliage yield of Sorghum decreased significantly at 8 dS/m level of soil salinity due to osmotic effect which lowers the osmotic potential of the medium, a possibility under salt stress condition. (Kaskar, 1991). The green foliage yield of sorghum was increased significantly with potassium application for each level of K as compared

Table 1: Yield and content in sorghum crop as influenced by salinity, K and Zn levels

| Treatments | Yield (g/pot) Green foliage | Yield (g/pot) Dry matter | N(%) | P(%) | K(%) | Ca(%) | Mg(%) | Na(%) | Zn(ppm) |
|---|---|---|---|---|---|---|---|---|---|
| Salinity levels (dS/m): | | | | | | | | | |
| 0 | 491.5 | 98.3 | 1.73 | 0.56 | 2.17 | 0.29 | 0.19 | 0.64 | 36.2 |
| 8 | 456.8 | 91.3 | 1.87 | 0.51 | 2.12 | 0.24 | 0.14 | 0.92 | 29.9 |
| Cd at 5% | 10.63 | 1.08 | 0.014 | 0.010 | NS | 0.010 | 0.011 | 0.012 | 0.44 |
| K Levels (kg/ha): | | | | | | | | | |
| 0 | 421.9 | 85.0 | 1.84 | 0.49 | 1.97 | 0.31 | 0.19 | 0.83 | 37.6 |
| 20 | 473.1 | 94.4 | 1.81 | 0.52 | 2.09 | 0.27 | 0.17 | 0.79 | 34.7 |
| 40 | 496.5 | 98.9 | 1.78 | 0.55 | 2.23 | 0.26 | 0.15 | 0.76 | 31.5 |
| 60 | 505.0 | 101.0 | 1.76 | 0.57 | 2.30 | 0.23 | 0.14 | 0.74 | 28.4 |
| CD at 5% | 14.88 | 1.50 | 0.02 | 0.14 | 0.08 | 0.014 | 0.015 | 0.017 | 0.64 |
| Zn levels (kg/ha): | | | | | | | | | |
| 0 | 435.4 | 86.2 | 1.69 | 0.51 | 2.23 | 0.29 | 0.18 | 0.80 | 21.6 |
| 10 | 463.2 | 92.9 | 1.76 | 0.52 | 2.11 | 0.27 | 0.17 | 0.79 | 29.0 |
| 20 | 494.4 | 98.5 | 1.83 | 0.54 | 2.15 | 0.26 | 0.16 | 0.77 | 36.0 |
| 30 | 503.5 | 101.6 | 1.90 | 0.56 | 2.10 | 0.25 | 0.15 | 0.76 | 45.0 |
| CD at 5% | 14.88 | 1.50 | 0.02 | 0.14 | 0.08 | 0.014 | 0.015 | 0.017 | 0.64 |

to control. The increase in the green foliage yield with 20, 40 and 60 Kg $K_2O$/ha were 12.1, 17.7 and 19.7 per cent over control, respectively. A significant increased in green foliage yield of sorghum with application of $ZnSO_4$ levels (10,20 and 30 Kg/ha) produced 6.4, 13.6 and 15.6 percent respectively moreover control. The maximum yield was recorded at 30 Kg/ha, ZnSO4/ha level (Table 1). Similar results were also reported by Shrinivasan (1992). All the possible interactions were found to be non significant. Almost similar trend was observed with respect to dry matter yield of Sorghum. The average decrease in dry matter yield due to higher soil salinity level at 8 dS/m. Similar results were also reported by Kaskar (1991). Similarly, with respect to K, while the mean dry matter yield with all the levels of K improved significantly over control; an increase in dry matter yield with 20, 40 and 60 Kg K/ha over control were 11.0, 16.3 and 18.8%, respectively. Zinc sulphate application to the soil also enhanced the dry matter yield of Sorghum significantly, at all the levels of $ZnSO_4$ (10, 20 and 30 Kg/ha) were increased average yield of dry matter as 7.8, 14.3 and 17.9 percent respectively over control. and Sharma and Singh (1990) also reported a significant response to wheat and maize, respectively. Any interaction was not affected dry matter yield significantly.

*Nutrient contents*

***Nitrogen***

It is apparent from Table 1 that irrespective of treatment, it is noted that the soil salinity level (8 dS/m) enhanced the concentration of N in sorghum significantly over control. A study of data indicates that the N content in sorghum decreased significantly with increasing levels of K. The minimum value of N content was recorded at higher level of K 60 Kg/ha. The nitrogen content of Sorghum crop as increased significantly with Zn $SO_4$ application. The higher level of Zn $SO_4$ (30 Kg/ha) had a beneficial effect on N content over its lower levels and control. The maximum value of N content was recorded at 30 Kg $ZnSO_4$/ha addition. The interactions were non-significant.

***Phosphorus***

The concentration of P decreased significantly with increased soil salinity level at 8 dS/m (Table 1). This may be due to higher concentration of anions in soil solution which competited with P for absorption sites on root surface. The data show a Synergistic effect of K application on the absorption of P by sorghum. Potassium application was a significantly increased in P content from 0.49% in control treatment to 0.57% at higher dose at K at 60 Kg/ha treatment. Application of $ZnSO_4$ tended to increase the P content in sorghum plant. The magnitude of increase in P concentration was significant up to highest level of Zinc sulphate application at 30 Kg/ha treatment. The interactions did not affect the P content in sorghum significantly.

***Potassium***

The data reveal that, in general, there was a non-significant reduction in K content with salinity level (8 dS/m) over control (Table 1). This may due to the abundance of sodium in growth medium which reduced absorption of K by plants. The application of K tended to increase the content of K in plant significantly, a consistant and significant increase in K content was recorded up to highest level up to 60 Kg K/ha. The K content in sorghum crop was affected significantly with Zinc sulphate levels. A gradual decrease in K content in sorghum was recorded minimum at higher level of $ZnSO_4$ 30 Kg/ha application, that indicating an antagonistic effect of Zn on K. Interactions were non-significant in K content.

*Calcium*

The increasing soil salinity level at 8 dS/m, a significant decrease in concentration of Ca by sorghum as compared to control. Decrease in Ca content may be due to an increase in Na concentration in soil solution. It is seen from the table 1 the magnitude of decrease the content of Ca in sorghum crop significantly was higher level at 60 Kg $K_2O$/ha than its lower levels and control. The antagonistic of K application on Ca absorption was mainly due to ionic competition on the surface of plant root or in soil solution. It is observed from data, the concentration of Ca in sorghum plants was higher under no zinc sulphate treatment. With increasing zinc levels a significant maximum reduction in Ca content was recorded at highest level of Zinc application at 30 Kg $ZnSO_4$/ha. None of the interactions had significant effect on Ca content in Sorghum.

***Magnesium***

A significant reduction in Mg content in sorghum were recorded with a higher soil salinity level at 8 dS/m (Table 1). This decrease in Mg content due to ascribed to reduction in Mg absorption with increasing Na concentration in soil solution. K application decreased the Mg content in sorghum significantly over control. The minimum average value of Mg content in plants were noted under 60 Kg K/ha treatment. This decrease in Mg content may be ascribed to reduction in the absorption of divalent cation with increasing concentration of K. Zinc application to the soil tended to decrease the Mg content in sorghum significantly. The minimum values of Mg content were recorded at 30 Kg $ZnSO_4$/ha, treatment due to Zn showed antagonistic effect on Mg content in sorghum at higher level treatment. An interaction was not affected significantly.

*Sodium*

Soil salinity level 8 dS/m increased the Na content in sorghum compared to control (Table 1). Which may be ascribed to addition of sodium salt in soils. The data reveals that the, there was a significant reduction in Na content with increasing levels of K. The minimum value of Na content was noted with 60 Kg K/ha treatment which may ascribe to antagonistic relationship between Na and K. Zinc application in soil, a significant reduction in Na content was recorded at each higher level of Zinc. The lowest value of Na content was noted at 30 Kg $ZnSO_4$/ha treatment may be devoted to adverse effect of Zn on Na absorption by sorghum. Interactions were not significant.

***Zinc***

In general, enhancement in soil salinity significantly decreased Zn content in sorghum plants at salinity level 8 dS/m. Similar results were also reported by Singh et al. (1987). Zn content also decreased significantly with increasing levels of K in sorghum plants. Zn content in plants decreased from 37.6 ppm in control to 28.4 ppm with 60 Kg K/ha treatment. These results suggested a antagonistic effect of K on Zn content in plant. It is clear in study the table 1 that the Zinc content in sorghum plant increased significantly with increasing level of Zn. There was a consistant and significant increase in Zn content with each increasing level of Zn and maximum value of Zn content were recorded in Sorghum at 30 Kg $ZnSO_4$/ha treatment. Deb (1990) also supported these findings. Salinity x ZnSo4 interaction had a significant effect on the Zn content in sorghum crop. Zinc sulphate application improved its content in absence and presence of salt concentration. Salinity (8 dS/m) tended to reduced the Zn content at all levels of Zinc minimum value of Zn content was noted in Ec 8 dS/m + No $ZnSO_4$ treatment.

*Nutrient uptake studies*

***Nitrogen***

Nitrogen uptake by Sorghum crop was not affected significantly with soil salinity level (8 dS/m.). However, a non-significant increase was recorded in N uptake by crop; in the other hand utilization of N by crop significantly increased at highest K application upto 60 Kg/ha over control (Table 2). The application

Table 2: Effect of salinity, K and Zn application on the uptake of nutrients by sirghum crop

| Treatments | Uptake (mg/pot) | | | | | | |
|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | Na | Zn |
| Salinity levels (dS/m): | | | | | | | |
| 0 | 1699.6 | 550.5 | 3137.4 | 284.0 | 182.1 | 628.5 | 3.58 |
| 8 | 1709.5 | 465.6 | 1945.8 | 218.4 | 1248 | 836.6 | 2.77 |
| CD at 5% | NS | 10.76 | 66.26 | 9.32 | 6.78 | 5.94 | 0.09 |
| K levels (kg/ha): | | | | | | | |
| 0 | 1565.5 | 421.5 | 1672.1 | 259.4 | 164.1 | 697.4 | 3.27 |
| 20 | 1709.6 | 492.5 | 1967.5 | 257.2 | 156.6 | 744.6 | 3.34 |
| 40 | 1766.0 | 541.2 | 2205.1 | 251.7 | 152.0 | 750.1 | 3.18 |
| 60 | 1777.2 | 577.0 | 2321.7 | 236.4 | 241.0 | 738.0 | 2.92 |
| CD at 5% | 31.92 | 15.22 | 93.72 | 13.45 | 9.58 | 16.80 | 0.08 |
| Zn levels (kg/ha): | | | | | | | |
| 0 | 1456.2 | 438.4 | 1932.2 | 247.4 | 153.2 | 683.7 | 1.86 |
| 10 | 1632.9 | 489.3 | 1962.0 | 254.0 | 156.8 | 725.6 | 2.68 |
| 20 | 1801.7 | 535.5 | 2126.5 | 254.0 | 155.9 | 754.6 | 3.53 |
| 30 | 1927.5 | 569.1 | 2145.6 | 249.0 | 147.8 | 766.3 | 4.62 |
| CD at 5% | 31.92 | 15.22 | 93.72 | NS | NS | 16.80 | 0.08 |

of Zinc sulphate also improved the N uptake by sorghum significantly over control. Zn $SO_4$ levels (10, 20 and 30 Kg/ha) utilized, 12.1, 23.7 and 32.4 per cent greater N, respectively over control. Interaction did not affected significant N uptake by plant.

*Phosphorus*

Soil salinity level (8 dS/m) significantly reduction in P uptake by sorghum over control. This reduction in P uptake may be ascribed to lower by dry matter yield production. It is also clear from the data (Table 2) a consistent increased significantly in P uptake by crop with different K levels. Maximum value of P uptake by sorghum was recorded at higher level (60 Kg/ha) K treatment. A gradual significant increase in P uptake by sorghum was recorded upto 30 Kg ZnSo4/ha level. The interaction (Salinity x K) had significant effect on the uptake of P by sorghum crop. Salinity reduced P uptake by crop at all the levels of K significantly in other hand P uptake by crop increased significantly with uptake (60 Kg/ha) application at both the levels of soil salinity.

*Potassium*

Soil salinity level (8 dS/m) decreased significantly K uptake in crop (Table 2). This reduction in K uptake may be due to an increase in Na concentration in soil solution. The uptake of K by sorhgum crop gradually increased significantly upto 60 Kg K/ha application. All the levels of K proved significantly beneficial over control in respect of K utilization by sorghum. The addition of $ZnSO_4$ to the soil, there was a gradual significant increase in the uptake of K by sorghum crop upto 30 Kg $ZnSO_4$/ha over control or lower level of Zn (10 Kg/ha). The interactions effect to be non significant effect.

*Calcium*

A significant reduction in Ca uptake by sorghum was observed with increase in soil salinity level (Table 2). This reduction in Ca uptake may be ascribed to decrease in dry matter yield. The addition of K in to the soil Ca uptake by sorghum significantly decreased at higher levels (40 and 60 Kg/ha) K over control. Singh and Agarwal also reported similar results. The uptake of Ca by sorghum increased non-significantly with the application of $ZnSO_4$ over control. However, the value of Ca uptake was higher 10 and 20 Kg $ZnSO_4$/ha than 30 Kg $ZnSO_4$/ha treatment. Interactions are non-significant.

*Magnesium*

The uptake of Mg also decreased significantly with increasing salinity level which may be ascribed to reduction in dry matter yield (Table 2). A significant reduction of Mg content by sorghum was recorded at higher levels (40 and 60 Kg/ha) of K over control. The minimum value of Mg uptake was recorded at 60 Kg K/ha addition. Singh et al. (1986) also reported similar results. Application of $ZnSO_4$ did not affect the uptake of Mg by sorghum crop significantly. However, a slightly increased in Mg uptake by crop over control. Thereafter a slightly reduction in Mg uptake was recorded with 30 Kg $ZnSO_4$/ha over control, that indicating an antagonistic relationship between these two elements.

*Sodium*

Soil salinity level (8 dS/m) increased the uptake of Na by crop significantly over control (Table 2). The uptake of Na sorghum increased significantly with addition of K to the soil over control. A gradual increase in the Na uptake by sorghum upto 40 Kg K/ha, thereafter a reduction in Na uptake was recorded at 60 Kg $K_2O$/ha level. Application of $ZnSO_4$ also increased the uptake of Na significantly over control. A consistant uptake of Na by sorghum upto 30 Kg $ZnSO_4$/ha level. The increase in Na uptake may be due to increased production of dry matter with application of $ZnSO_4$ to the soil. Interaction were found non- significant.

*Zinc*

A significant reduction in Zn uptake by sorghum crop due to increased in soil salinity over control (Table 2). This reduction may be due to lower dry matter production at higher salinity levels. Singh et al. (1987) also reported a decreased in Zn uptake with increasing levels of Na. The increasing levels of K tended to decrease the Zn uptake by sorghum. The lowest value of Zn uptake was recorded at 60 Kg K/ha. The reduction in Zn uptake may be ascribed to antagonistic relationship between K and Zn. Increasing supply of $ZnSO_4$ resulted in a significant increase in the uptake of Zn by sorghum crop over control. The magnitude of increase in Zn uptake was significant up to highest level of Zn $SO_4$ application. Sharma and Singh (1990) also reported an increase in Zn uptake by crop with its addition. The interaction between soil salinity and $ZnSO_4$ had a significant effect on uptake of Zn by Sorghum. Zn $SO_4$ application tended to increase the uptake of Zn by crop on both levels of soil salinity. The maximum uptake of Zn was recorded at 30 Kg $ZnSO_4$/ha treatment and control treatment. Salinity of soil reduced the Zn uptake by sorghum due to an antagonistic effect on absorption of Zn by the crop.

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