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EFFECTS OF CONTINUOUS APPLICATION OF SALINE WATER ON GROWTH AND FODDER YIELD OF SORGHUM BICOLOR L. CV. SAROKARTUHO

M. Suleman Memon[1], I. Rajpar[1], N.B. Sial[1] and M.I. Keerio[2]

[1]*Department of Soil Science, Faculty of Crop Production, Sindh Agriculture University, Tandojam.*
[2]*Department of Plant Physiology & Biochemistry, Faculty of Crop Production, Sindh Agriculture University, Tandojam-70060 Pakistan*

ABSTRACT

Sorghum is well adapted to semiarid and arid tropics where salinity is the major problem due to limited water supply. Sarokartuho variety of Sorghum (*Sorghum bicolor* L) was continuously irrigated with fresh (control) and marginally to slightly saline EC_{iw} 2, 3, 4 and 5 dSm^{-1}) waters in a pot experiment conducted on silty clay loam soil at Sindh Agriculture University, Tando Jam, Pakistan. Increasing water salinity progressively decreased plant height and fodder yield (fresh and dry weight) per plant. AS compared to the control, the depression in dry fodder yield per plant was 78% at 5 $EC_{iw.}$ Reduction in dry fodder yield in EC_{iw}: 2, 3 and 4 (dSm^{-1}) was 26, 42 and 58% of the control, respectively. Saline water treated plants contained more Na^+, less K^+ and showed lower leaf K^+/ Na^+ ratio.

Key Words: Saline irrigation, Sorghum, Fodder yield

INTRODUCTION

Water is one of the three most essential elements of nature after sunlight and air to sustain life (Khan, 2006) and high agriculture production on our planet (Ghafoor *et al.* 2004). The total volume of water on the earth is finite at about 1400 million cubic kilometres of which only 2.5% is fresh. Most of the water in hydrosphere is salty, and much of the fresh water is frozen (Tanji 1995).Unfortunately most of the fresh water is locked up in the icecaps of the Antarctic and Arctic. Thus the useable portion of the fresh water resources is less than 1 % of all fresh water and only 0.01 % of all waters on the earth (Tanji, 1995). The shortage of this precious natural resource and the increasing demand for water as the world's population increases seriously limits development and threatens water security, at local, regional and global scale.

The Indus river along with about seven major big or small rivers is the lifeline of Pakistan, basically an agricultural country where eighty percent of population in the rural area depends on it (Khan, 2006). Annual floods, rains and underground water over the past many centuries had provided areas falling in Pakistan sufficient water. However, during the last 20 years the life giving commodity was declining due to shortage of rain water and natural droughts. Thus the present situation of water in Pakistan, Sindh in particular is the worst and water scarcity is expected to become even more severe in future (Siddiqui, 2004). Almost all the streams, lakes and most of the groundwater resources in Sindh are salty and or contaminated with different types of pollutants.

To meet the shortage of surface irrigation water, more than 0.53 million public or private tube wells are pumping about 49.91 MAF of the ground water in Pakistan. About 70% of that pumped water is of poor quality and is loaded with salts. These salts salinize soil profile on irrigation. The salinization has affected several hectares of irrigated land (FAO, 2000). In Pakistan, 13% of irrigated area is suffering from severe salinity problems in spite of the efforts made to provide drainage in irrigated areas (Martinez Beltran and Kielen, 2000).

Sorghum (*Sorghum bicolor L*) has been reported as the crop that can give satisfactory yield on poor soils (Khoso, 1992). Though, the sorghum plants can tolerate soil salinity up to 2.52 dSm^{-1} (Wahid *et. al.* , 1998). The effect of saline irrigation with different EC_{iw} levels on growth and fodder yield can still be useful to study. This study was, therefore, undertaken to evaluate the sarokartuho variety of fodder sorghum against saline irrigation.

MATERIALS AND METHODS

A pot experiment was conducted in the wire-house of the Department of Soil Science, Sindh Agriculture University, Tandojam. Fertile soil (plough layer) was collected from Latif Experimental Farm of the university. The soil was air dried and placed in earthen pots of 20 kg size with drainage holes at bottom. These pots were arranged on wooden benches of wire-house. Seeds obtained from Millet Research Station Dadu, Sindh were placed 1 cm deep and 4 cm apart in each soil filled pot. Seven days after sowing, five seedlings were allowed to grow in each pot. Five different water salinity treatments (T_1: control/tap water, T_2: EC_{iw} 2 dSm^{-1}, T_3: EC_{iw} 3 dSm^{-1}, T_4: EC_{iw} 4 dSm^{-1}, T_5: EC_{iw} 5 dSm^{-1}) were created by dissolving NaCl and $CaCl_2$ (20:1) in tap water. The experiment had 3 replicates and irrigation in each treatment was applied from beginning to harvest.

Urea fertilizer was used to apply recommended rate of N (120 kg N ha^{-1}) in two splits, first half at the time of sowing and remaining half at the time of first irrigation. Triple super phosphate (TSP) fertilizer at the time of sowing was used to apply recommended dose (60 kg ha^{-1}) of P_2O_5.

Twelve weeks after sowing, plants were harvested from each pot to record height (cm), fresh and dry fodder yield $plant^{-1}$. Top fully expanded leaf from each plant was detached and processed for the analysis of Na^+, K^+ and Cl^- following the single acid digestion method of Westerman, (1990). Contents of Na^+ and K^+ were determined by flame photometry, whereas Cl^- content was estimated by titration with standard $AgNO_3$, (USSL, 1954).

Soil before sowing was analyzed for texture, pH, EC_e (dS m^{-1}), Organic matter (%), Na^+, K^+, Ca^{2+} and Mg^{2+} , CO_3^{2-}, HCO_3^- and Cl^- following the appropriate methods of soil analysis. Sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) were calculated using the formula given by Rowell, (1994). Composite soil samples collected from each pot after harvest were also analyzed for same properties except texture and organic matter content.

RESULTS

Effect of saline irrigation on some soil properties

The soil filled in pots was non-saline (EC_e), non-sodic (ESP), calcareous ($CaCO_3$ %), and alkaline (pH) in reaction with silty clay loam texture. The organic matter (%), N (%) and P (ppm) contents of original soil were below the normal suggested ranges. Extractable K value fell within normal range.

As shown in Table-1 saline irrigation had significant ($P < 0.05$) effect on soil pH, EC_e and ESP. Increasing water salinity gradually increased EC_e and ESP and decreased pH. As compared to control, the concentrations of some ions such as Na^+ and Cl^- were higher in the soil samples collected from saline irrigation treatments (data not shown). Exchangeable sodium percentage (ESP) values which were calculated from soluble Na^+, Ca^{2+} and Mg^{2+} were also higher in those soil samples where plants were raised with saline irrigation.

Table 1. Effect of saline irrigation on some soil properties.

EC_{iw} (dS.m^{-1}) of irrigation water	pH (1: 2, H_2O)	EC_e (dS.m^{-1})	ESP
EC_{iw}: 0.6 dSm^{-1*}	7.64 ± 0.037 a	1.83e ± 0.026	3.26e ± 0.017
EC_{iw}: 2.0 dSm^{-1}	7.63 ± 0.072 a	4.13d ± 0.046	6.02d ± 0.023
EC_{iw}: 3.0 dSm^{-1}	7.54 ± 0.071 ab	6.12c ± 0.069	6.40c ± 0.011
EC_{iw}: 4.0 dSm^{-1}	7.41 ± 0.012 b	8.08b ± 0.077	6.74b ± 0.011
EC_{iw}: 5.0 dSm^{-1}	7.29 ± 0.020 c	9.42a ± 0.205	6.83a ± 0.014
MSD ($P < 0.05$) **	0.204	0.496	0.075

* Fresh water, ** Minimum significant difference (Tukey's test)

Effect on plant height:

The effects of saline irrigation treatments on plant height are presented in Table-2. It is evident from the data that although the difference between EC_{iw} 2 and 3 was not significant ($P > 0.05$), increasing water salinity significantly decreased plant height. Compared with the control, plants that received irrigation water of EC_{iw} 2, 3, 4 and 5 dS.m^{-1} were 25.79, 32.2, 48.05 and 58.4% smaller, respectively.

Effect on fresh fodder yield $plant^{-1}$:

Fresh fodder yield produced by each plant in saline irrigation treatments was significantly ($P < 0.05$) lower than in normal irrigation treatments (Table-2). Plants irrigated with water of EC_{iw} 2, 3, 4 and 5 dS.m^{-1} gave fresh fodder yield $plant^{-1}$ lower in magnitude i.e., 43.27, 57.05, 66.71 and 76.76 % of the control, respectively..

Effect on Dry fodder yield $plant^{-1}$:

Dry fodder yield $plant^{-1}$ was also significantly lower in saline irrigation treatments (Table 2). Compared to control, plants irrigated with water of EC_{iw} 2, 3, 4 and 5 dS.m^{-1} gave dry fodder yield $plant^{-1}$ lower in magnitude i.e., 26.3, 42.2, 57.5 and 77% of the control, respectively.

Table 2. Effect of saline irrigation on height and fodder yield (g $plant^{-1}$)

EC_{iw} ($dS.m^{-1}$) of water applied	Height (cm)	Fresh fodder yield (g $plant^{-1}$)	Dry fodder yield (g $plant^{-1}$)
EC_{iw}: 0.6 dSm^{-1*}	49.67a ± 1.20	21.33a ± 0.66	10.26a ± 1.09
EC_{iw}: 2.0 dSm^{-1}	36.86b ± 0.59	12.10b ± 0.30	07.56ab ± 0.68
EC_{iw}: 3.0 dSm^{-1}	33.66b ± 0.81	09.16c ± 0.33	05.93cb ± 0.32
EC_{iw}: 4.0 dSm^{-1}	25.80c ±1.67	07.10d ± 0.30	04.36cd ± 0.20
EC_{iw}: 5.0 dSm^{-1}	20.60d ± 0.67	05.00e ± 0.29	02.30d ± 0.26
MSD ($P < 0.05$) **	4.9801	1.891	2.857

* Fresh water, ** Minimum significant difference (Tukey's test)

Effect of saline irrigation on Na^+, K^+ and Cl^- contents and K^+/Na^+ ratio determined in dry matter of sorghum plants

With comparison to control, Na^+, and Cl^- contents were significantly (P <0.05) higher in dry matter of plants grown with 4 and 5 EC_{iw} (dSm^{-1}) water treatments than with 2 and 3 EC_{iw} (dSm^{-1}) water (Table 3). Plants grown with 2, 3, 4 and 5 EC_{iw} (dSm^{-1}) water showed 0.5, 5.1, 10.2 and 30.6% higher Na^+, 6.41, 11.82, 17.9 and 245 higher Cl^- and 11.4, 20, 37.1 and 65% lower K^+ in leaf tissue. The K^+/Na^+ ratios remained lower in plants grown with saline irrigation than with fresh water.

Table 3. Effect of saline irrigation on the contents of Na^+%, K^+% and Cl^-% and K^+/Na^+ ratio determined in dry matter (DM) of leaves.

EC_{iw} (dSm^{-1}) of irrigation water	Ion contents (%DM of leaves) Na^+	K^+	Cl^-	K^+/Na^+
EC_{iw}: 0.6 dSm^{-1*}	1.36 ± 0.006 a	0.34 ± 0.003 a	2.23 ± 0.002 e	0.260 ± 0.0028 e
EC_{iw}: 2.0 dSm^{-1}	1.76 ± 0.010 c	0.31 ± 0.003 b	2.43 ± 0.005 d	0.158 ± 0.0045 d
EC_{iw}: 3.0 dSm^{-1}	1.86 ± 0.008 a	0.29 ± 0.003 c	2.61 ± 0.008 c	0.146 ± 0.0026 c
EC_{iw}: 4.0 dSm^{-1}	1.95 ± 0.006 b	0.22 ± 0.003 d	2.77 ± .005 b	0.120 ± 0.0020 b
EC_{iw}: 5.0 dSm^{-1}	1.96 ± 0.006 a	0.12 ± 0.003 e	2.96 ± 0.003 a	0.062 ± 0.0014 a
MSD** ($P < 0.05$) **	0.0373	0.0171	0.0275	0.0335

* Fresh water, ** Minimum significant difference (Tukey's test)

DISCUSSION

Sorghum (*Sorghum bioclor L*) or Jowar is an important food and fodder crop of Kharif season. This crop has been very successfully grown in various types of soils and climates (Khoso, 1992). This experiment was conducted to grow fodder Sarokartuho variety of sorghum with saline water irrigation on the calcareous soil with high pH but no problem of salinity and /or sodicity. High $CaCO_3$ and low organic matter contents in alluvial soils of Sindh deposited by river Indus have extensively been observed by several workers including Rajpar and Sial, (1997); Sial, (1985). The study showed that saline irrigation altered soil properties i.e. it decreased pH, and increased EC_e and ESP. Lower values of soil pH in saline irrigation treatments suggest the exchange of Ca^{2+}, Mg^{2+} and Na^+ from soil solution with H^+ from soil colloids (Rowell, 1994). Higher soil EC_e in saline irrigation treatments recorded appears to be the result of artificially prepared salinity levels. This restricts the regular application of saline irrigation for raising sorghum crop. The rapid rise in soil EC_e was possibly the result of accumulation of salts in soil due to its fine-textured nature (silty clay loam). Several recent studies (Buckland, *et al.* 2002) have also noted similar effects of saline irrigation on soils.

Fifty percent reduction in growth was observed in saline irrigation treatments with EC_{iw} around 3.0 dSm^{-1}. Salinity induced physiological drought, toxicity of Na^+ and Cl^-, low K^+ and low K^+/Na^+ ratio observed in plant tissue were possibly the main factors responsible for poor performance of sorghum plants in saline irrigation treatments. Similar effects of saline irrigation on various crop species have extensively been observed by other workers (Gupta, 1990).

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