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Research Article

Judicious use of Saline Water for Growing Sorghum Fodder through the Application of Organic Matter

Ghulam Murtaza[1*], Ghulam Sarwar[1], Noor-Us-Sabah[1], Mukkram Ali Tahir[1], Fakhar Mujeeb[2], Sher Muhammad[3], Muhammad Zeeshan Manzoor[1] and Ayesha Zafar[1]

[1]Department of Soil and Environmental Sciences, College of Agriculture, University of Sargodha, Pakistan; [2]Soil Bacteriology Section, Ayub Agriculture Research Institute, Faisalabad, Pakistan; [3]Allama Iqbal Open University, Islamabad, Pakistan.

Abstract | The use of saline irrigation water leads to the buildup of salts in root zone, resulting in decreased yield and deterioration in soil resource. Continues use of organic manures, help in the reduction of salt concentration in the root zone. Organic matter was used to mitigate the negative effects of saline water irrigation using sorghum as test crop during summer, 2018. In this experiment water of 3 different types was applied coupled with addition of organic matter at 2 different rates. The experiment comprised of 9 treatments having 4 replications; T_1 = canal water, T_2 = saline water having EC value 2 dS m^{-1}, T_3 = saline water having EC value 3 dS m^{-1}, T_4 = T_1 + organic matter @ 5 Mg ha^{-1}, T_5 = T_2 + organic matter @ 5 Mg ha^{-1}, T_6 = T_3 + organic matter @ 5 Mg ha^{-1}, T_7 = T_1 + organic matter @ 10 Mg ha^{-1}, T_8 = T_2 + organic matter @ 10 Mg ha^{-1} and T_9 = T_3 + organic matter @ 10 Mg ha^{-1}. The experiment was laid according to randomized complete block design (RCBD). Sorghum cultivar "Hegari" was grown as a test crop. Data regarding plant parameters such as height of sorghum plants, diameter of stem, number of plants/ m^2, total biomass of fresh plants were noted. Among all the treatments, T_7 (T_1 + organic matter @ 10 Mg ha^{-1}) performed the best which produced the highest values of growth parameters. However, the treatment T_3 (water of EC 3.0 dS m^{-1}) proved inferior to all others with respect to height of sorghum plants, diameter of stem, number of plants m^{-2}, total biomass of fresh plants. All the collected data were analyzed by using statistix 8.1, ANOVA technique and significance of treatment were compared by using Tukey's (HSD) test at 5% probability level.

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***Correspondence** | Ghulam Murtaza, Department of Soil and Environmental Sciences, College of Agriculture, University of Sargodha, Pakistan; **Email:** ghulammurtazauos@gmail.com
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Introduction

Sorghum (*Sorghum bicolor* L.) is ranked at fifth number among cereal crops (Iqbal et al., 2010). It belongs to the Graminae family and is well adapted to semi-arid regions (Sharif et al., 2014). Sorghum is the cheapest source of micronutrients and energy after pearl millet (*Pennisetum glaucum*). Majority of people in Africa and central India are dependent on sorghum to fulfill their energy demand and micronutrients need (Rao et al., 2006). Sorghum being used as forage crop is grown normally in summer season that is used as feed in the livestock production (Saini, 2012). Sorghum is C_4 plant having greater ability to tolerate biotic and abiotic stresses as well as greater ability to process photosynthesis (Reddy et al., 2009). Sorghum is an important source of protein and energy in Africa and China (Elkhier and Hamid, 2008). The nutritional value of sorghum is similar to that of corn and because of its modern

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and wonderful nature animals enjoy it; therefore, the preferred species are those that produce both grain and stover (Habib et al., 2013). Sorghum provides not only food and forage but it also plays an important role in supplying raw materials like biofuel, starch, fiber, grapefruit syrup, alcohol and other byproducts (Mehmood et al., 2008).

Irrigation with saline water is one of the key factors that limits crop yield because most of the water available for irrigation is unfit for irrigating crops due to the presence of excessive concentration of salts (Fuller et al., 2012). Continuous irrigation of crops with saline water results in the rise in the EC of the soil (Kim et al., 2016). Saline water irrigation has negative impacts on soil water plant relationship, sometimes limiting the physiological activities of the plants and eventually the production of crops (Plaut et al., 2013). There is a need to minimize the toxicity of salts and to improve soil properties by the use of cost-effective approaches such as application of organic manure in the soil (Shaaban et al., 2013). Almost every plant growth and development stages are affected by salinity but the growth of seedling and germination percentage differs depending upon the plant species (Gul and Weber, 1999). The presence of high concentration of salt affects the germination of seedlings, restrict the uptake of water causing ions to be disrupted resulting to osmotic stress and specific ion toxicity. Salinity decreases soil water potential leading to osmotic stress (Khan and Panda, 2008). It has been found that a reduction in biomass, changes in the capacity of photosynthesis in the water of foliated leaf potential leaves is caused by salinity (Gama et al., 2007). Intensive salt concentration amplified the concentration of Na^+ and Cl^- while reduces the level of K^+ and Ca^{2+} which results in a decreased pigment content of leaves (Mansour et al., 2005). The canal water is not enough to meet crop requirements. Consequently, the installation of private wells is growing, unfortunately, about 70-75% of the pumped groundwater is not fit for irrigation because of EC, SAR and RSC values are more than the normal which affects crops growth negatively (Ghafoor et al., 2001). In rhizosphere salts are accumulated due to application of saline water (Patel et al., 2000).

The management of salt affected soils involves use of combined agricultural practices based on the quality of water, existing agricultural system, chemical modification and local conditions, including climate, economics and environment of the crops (Amezketa et al., 2005). In order to overcome the saltiness not even a single procedure have been invented but many other practices that perform adequately were used by scientists (Mashali, 1995). Effective tools to alter and uses of several modifications to improve the saline soil properties which may be either chemical or physical were compiled by scientists after a lot of research (Hanay et al., 2004). The benefits of adding organic materials in this regard are due to their role in upgrading, modifying and altering the soil characteristics as well as their role as a fertilizer. Organic manure and compost have been tested for their efficacy as some organic amendments in the recovery of saline soils (Wahid et al., 2015). For the reclamation of sandy soil, use of organic matter alone is little but its effectiveness to perk up physical property of soil is well documented in the literature (Mamo et al., 2000).

Organic matter is material that has come from a recently living organism. It is capable of decay, or is the product of decay; or is composed of organic compounds. The organic matter in soil comes from plants and animals. The addition of organic materials like poultry manure, farmyard manure (FYM), compost and crop residues are being recommended and utilized for a long time due to its importance as a source of nutrients required by crop plants and its role in altering and modifying the physio-chemical properties of the soil (Ahmad et al., 2007). The most commonly available source of organic matter is FYM whose efficiency depends upon its composition which varies depending upon the age and type of animal, nature of the feed consumed by animal and waste management methods (Iqbal et al., 2008). The purpose of this research was to examine the role of water salinity management technique (use of organic matter) for the growth of sorghum when continuously irrigated with saline water under local conditions.

Materials and Methods

This experimental trail was conducted at research area of College of Agriculture, University of Sargodha sited 32.08° North range and 72.67° East longitude. Its elevation is above the sea degree is 193 meters.

This study was performed in randomized complete block design (RCBD) design with 9 treatments that were replicated four times. The plot size was 3.5m

× 3.5m having row to row spacing of 75 cm and plant to plant distance 25 cm. The treatments of the experiments were as under:

T_1 = *Canal water*
T_2 = *Water of EC 2.0 dS* m^{-1}
T_3 = *Water of EC 3.0 dS* m^{-1}
$T_4 = T_1$ + *organic matter @ 5 Mg* ha^{-1}
$T_5 = T_2$ + *organic matter @ 5 Mg* ha^{-1}
$T_6 = T_3$ + *organic matter @ 5 Mg* ha^{-1}
$T_7 = T_1$ + *organic matter @ 10 Mg* ha^{-1}
$T_8 = T_2$ + *organic matter @ 10 Mg* ha^{-1}
$T_9 = T_3$ + *organic matter @ 10 Mg* ha^{-1}

Before sowing the sorghum seeds, the seed beds were prepared by ploughing the soil with tractor-installed cultivar. Organic matter in the form of FYM was added to the respective treatment plots. Sorghum cultivar "Hegari" was sown @ 40 kg $acre^{-1}$. To keep 25 cm plant to plant distance extra plants were uprooted. The hoeing was done two times in the whole growing season to reduce weed-crop competition. The crop was firstly irrigated after 10 days of germination while other irrigations were applied to the crop according to water requirements of the crops. Fertilizers like Urea, Single super phosphate (SOP) and Sulphate of potash (SOP) were the N, P, K sources used in the experiment. These fertilizers were applied @ 80, 60, 60 kg ha^{-1} for N, P and K respectively. At maturity crop was harvested, parameters like biomass, plant height, plant diameter and number of plants m^{-2} were noted. The analysis was made following the procedure written in Hand Book 60 of U.S Laboratory Staff (1969).

Statistical analysis

All data was statistically analyzed by statistix 8.1 ANOVA technique by comparing the significance of treatments through Tukey's (HSD) test at 5% probability level (Steel et al., 1997).

Results and Discussion

Plant height (cm)

Sorghum is grown for both grain and fodder purposes, so increase in height of plants resulted in increased forage production. Data indicated that the height of plants was affected significantly by the use of canal and saline water with and without organic matter. Data displayed in the Figure 1 showed that maximum height of plants (199 cm) was obtained in the treatment T_7 (canal water + organic matter @ 10 Mg ha^{-1}) followed by T_4 (canal water + organic matter @ 5 Mg ha^{-1}) and T_8 (water of EC 2.0 dS m^{-1} + organic matter @ 10 Mg ha^{-1}) that produced 191.75 and 188 cm respectively. However, T_8 and T_4 were significant with each other in terms of statistics. Plant heights of 183.25, 176 and 174.5 cm were noted in treatment T_1 (canal water), T_9 (water of EC 3.0 dS m^{-1} + organic matter @ 10 Mg ha^{-1}) and T_5 (water of EC 2.0 dS m^{-1} + organic matter @ 5 Mg ha^{-1}) respectively. Treatments T_5 and T_9 were found non-significant when statistically compared. The lowest value of plant height (163.75 cm) was observed in treatment T_3 where water of EC 3.0 dS m^{-1} was used for irrigation followed by T_2 (water of EC 2.0 dS m^{-1}) and T_6 (water of EC 3.0 dS m^{-1} + organic matter @ 5 Mg ha^{-1}) that produced 169.5 and 170 cm respectively (Figure 1). These research outcomes are favored by the findings of Abou El-Magd et al. (2008) who asked that the use of organic matter increased the sweet fennel height by alleviating the destructive of saline water. Similar results were given by Das et al. (2013) who described that application of organic matter reduced the stress of salts and improved the plant height of corn as well as forage production.

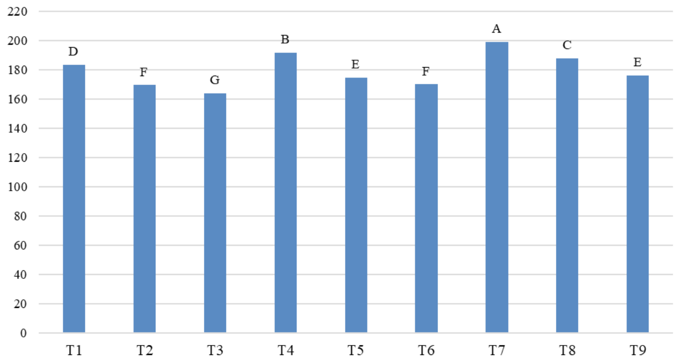

Figure 1: *Effect of canal and saline water with and without organic matter on plant height (cm) of sorghum (Sorghum bicolor L.).*

Stem diameter (cm)

Stem diameter of sorghum is of great importance for better yield of forage. As increase in diameter of stem will result in increased forage yield. Data demonstrated that stem diameter of sorghum was significantly affected by applying canal and saline water with and without organic matter. The use of canal water along with 10 Mg ha^{-1} organic matter (T_7) produced maximum stem diameter (2.6 cm) followed by treatment T_4 (canal water + organic matter @ 5 Mg ha^{-1}) and T_1 (canal water) that both produced stem diameter of 2.52 cm (Figure 2). However, treatments T_7, T_4 and T_1 were non-significant when compared statistically. Treatment T_5 (water of EC 2.0 dS m^{-1} + organic matter @ 5 Mg ha^{-1}) and T_8 (water of EC 2.0

dS m^{-1} + organic matter @ 10 Mg ha^{-1}) both produced stem diameter of 2.2 cm. The treatment T_9 (water of EC 3.0 dS m^{-1} + organic matter @ 10 Mg ha^{-1}) and T_2 (water of EC 2.0 dS m^{-1}) both produced stem diameter of 2.1 cm. The minimum diameter of stem (1.9 cm) was recorded in the treatment T_3 where water having EC 3 dS m^{-1} was applied which was followed by treatment T_6 (water of EC 3.0 dS m^{-1} + organic matter @ 5 Mg ha^{-1}) that produced stem diameter of 2.0 cm (Figure 2). Same were the outcomes of Idrees et al. (2004) that FYM when applied significantly increased the stem diameter of sugarcane under the conditions of saline irrigation. These research findings are favored by the outcomes of Almodares et al. (2008) that increasing the level of salinity caused a reduction in diameter of stem as well as stem yield.

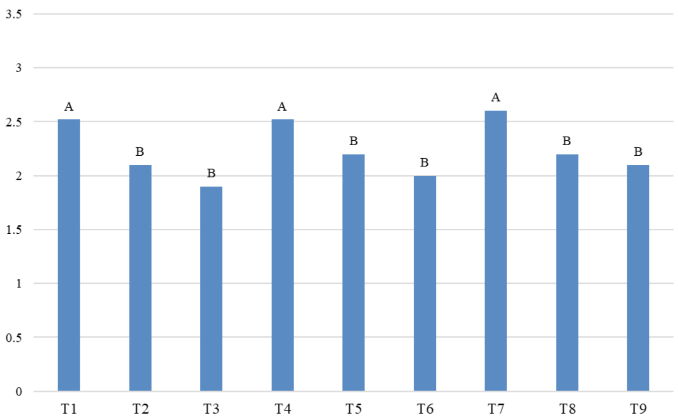

Figure 2: *Effect of canal and saline water with and without organic matter on stem diameter (cm) of sorghum (Sorghum bicolor L).*

Number of plants/m²

In sorghum, plants/m^2 is key selection criteria for better productivity. As increase in number of plants/ m^2 will result in increased plant population as well as photosynthesis leading to enhanced accumulation of photosynthates resulting in more grain yield. Data demonstrated that plants/m^2 of sorghum were drastically affected by applying canal and saline water with and without organic matter. Treatment T_7 where canal water was used along with 10 Mg ha^{-1} organic matter was achieved as the best amendment which produced maximum number of plants/ m^2 (32) followed by T_4 (canal water + organic matter @ 5 Mg ha^{-1}) and T_8 (water of EC 2.0 dS m^{-1} + organic matter @ 10 Mg ha^{-1}) that both produced 30 plants/ m^2 (Figure 3). The treatment T_1 where canal water was applied and treatment T_5 where water of EC 2.0 dS m^{-1} was applied along with 5 Mg ha^{-1}organic matter both produced 29 plants/ m^2. However, these treatments T_1 and T_5 were non-significant with each other in terms of statistics. The minimum number of plants/m^2 (23) were gained in the T_3 where water of EC 3 dS m^{-1} was used followed by T_6 (water of EC 3.0 dS m^{-1} + organic matter @ 5 Mg ha^{-1}) and T_2 (water of EC 2.0 dS m^{-1}) that both produced 25 plants/m^2 (Figure 3). These research findings are favored by outcomes of Mirza et al. (2005) who said that applying saline water decreased the germination percentage of cauliflower and rice. Same work was also reported by Zeng and Shannon (2000) that increased level of salinity lowered the seedling survival resulting in reduced number of plants as well as decreased tillering in rice.

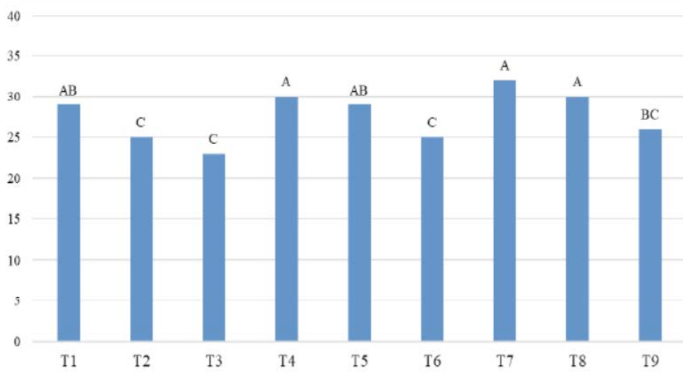

Figure 3: *Effect of canal and saline water with and without organic matter on number of plants/m² of sorghum (Sorghum bicolor L.).*

Fresh biomass weight (Mg ha⁻¹)

In sorghum, fresh weight is also a vital selection criterion which determines forage yield. As increase in fresh weight will results in increased productivity of green fodder. Data indicated that fresh weight of sorghum was significantly affected by applying canal and saline water with and without organic matter. The highest fresh weight of 61.03 Mg ha^{-1}was observed in treatment T_7 where canal water was used along with 10 Mg ha^{-1}following T_4 where canal water was used along with 5 Mg ha^{-1}organic matter and T_1 (canal water) that produced fresh weight of 59.08 and 57.33 Mg ha^{-1} respectively (Figure 4). However, T_1 and T_4 were non-significant with each other statistically. Fresh biomass of 54.49, 52.37 and 47.13 Mg ha^{-1} was taken from treatment T_8 (water of EC 2.0 dS m^{-1} + organic matter @ 10 Mg ha^{-1}), T_5 (water of EC 2.0 dS m^{-1} + organic matter @ 5 Mg ha^{-1}) and T_2 (water of EC 2.0 dS m^{-1}) respectively. The minimum fresh weight of 41.19 Mg ha^{-1} was observed in T_3 where water having EC 3 dS m^{-1} was used and it was followed by T_6 (water of EC 3.0 dS m^{-1} + organic matter @ 5 Mg ha^{-1}) and T_9 (water of EC 3.0 dS m^{-1} + organic matter @ 10 Mg ha^{-1}) that produced 43.31 and 45.78 Mg ha^{-1} respectively (Figure 4). These research outcomes are similar as given by Abou El-Magd et al. (2008) who found enhanced fresh weight of sweet fennel by applying organic matter which reduced the detrimental effects of saline water. Similarly, Alam et al. (2016) asked that addition of organic matter like FYM and poultry manure enhanced the growth and productivity of rice. These results are similar to the outcomes of Sarwar et al. (2008) who depicted that the addition of compost at different rates enhanced the content of phosphorus in soil along with other macro nutrients essential by plants.

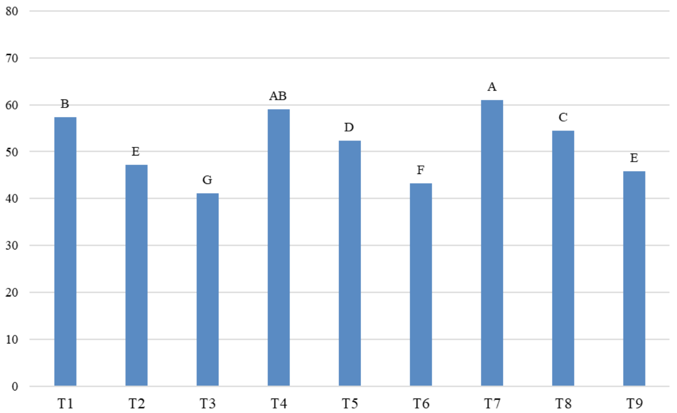

Figure 4: *Effect of canal and saline water with and without organic matter on fresh biomass weight (Mg ha^{-1}) of sorghum (Sorghum bicolor L.).*

Conclusions and Recommendations

It was concluded after analyzing results that addition of organic matter proved effective in minimizing the damaging property of saline water. The results demonstrated that application of organic matter decreased lethal impacts of saline water on growth of sorghum by improving the properties of soil. Among all the treatments, T_7 (canal water + organic matter @ 10 Mg ha^{-1}) performed the best which produced highest values of sorghum biomass, plant height, plant diameter and number of plants/m^2. However, treatment T_3 (water of EC 3.0 dS m^{-1}) remained inferior to all others by affecting all growth parameters negatively.

Author's Contribution

Ghulam Murtaza: Conception and design of the work, Conduction of experiment and write up.
Ghulam Sarwar: Academic Supervisor and guided throughout the research tenure.
Noor-Us-Sabah: Co-supervision, Interpretation of data and proof reading.
Mukkarram Ali Tahir: Supervision, Drafting and technical assistance at every step.
Fakhar Mujeeb: Technical assistance at every step.
Sher Muhammad: Contributed in statistical analysis.
Muhammad Zeeshan Manzoor: Member of research group and helped in data collection.
Ayesha Zafar: Member of research group and helped in laboratory analysis.

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