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Research Article

Efficiency of Farmyard Manure to Reduce Injurious Impacts of Salt Enriched Irrigation on Chemical Properties of Soil

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Abstract | Irrigation with saline water is a key issue affecting crop growth. Saline irrigation has drastic effects, limiting normal physiological activity and productive capacity of crops. The saline water irrigation leads to salt accumulation in the vicinity of roots which results in reduced yield along with soil deterioration. Organic matter application can prove helpful in keeping the salt level low in root rhizosphere. To check the efficacy of organic matter in mitigating the harmful impacts of salty water irrigation on soil characteristics, this trail was conducted. The irrigation water of 3 different types (canal water and saline water of electrical conductivity values 2 and 3 dS m^{-1}) were used alone and with farmyard manure (FYM) at 5 and 10 Mg/ha. This trial comprised of 09 treatments which were; T_1 = irrigation of canal water, T_2 = irrigation of EC 2 dS m^{-1} water, T_3 = irrigation of EC 3 dS m^{-1} water, $T_4 = T_1$+ FYM at 5 Mg/ha, $T_5 = T_2$ + FYM at 5 Mg/ha, $T_6 = T_3$ + FYM at 5 Mg/ha, $T_7 = T_1$ + FYM at 10 Mg/ha, $T_8 = T_2$ + FYM at 10 Mg/ha and $T_9 = T_3$ + FYM at 10 Mg/ha. The design of research study was randomized complete block design (RCBD) with four replications. The test crop was sorghum cultivar "Hegari". Analysis of soil was carried out for various characteristics like pH, EC, SAR, organic matter, phosphorus, and potassium in soil before sowing and after harvesting sorghum. The best performance was observed in T_7 (canal water + FYM at 10 Mg/ha) which improved soil properties by lowering pH, EC, and SAR and enhancing concentration of organic matter, phosphorus and potassium. However, T_3 (water of EC 3 dS m^{-1}) increased soil electrical conductivity, pH, SAR, and lowered organic matter, phosphorus and potassium concentration. Data were statistically analyzed by statistix 8.1 ANOVA approach along with Tukey's test (HSD) at probability level of 5% for comparing treatments significance.

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Introduction

Pakistan is located in semi-arid region having 6.67 million hectares of area damaged by salinity which constitute about 1/3rd of cultivable area. Additionally, out of 6.67 million hectares, 3.7 and 2.90 million hectares is saline and sodic/saline-sodic in nature (Khan, 1998). Salinity presence in soil affects photosynthetic process, formation of proteins and the uptake of essential nutrients resulting in reduced production of crops (Farhoudi et al., 2012). Soil salinity is a global problem (Chen et al., 2019) and excessive soluble salts and exchangeable sodium are major salt related issue in soils (Paz et al., 2019). Hence, minimizing harmful salinity effects by adopting appropriate management practices is

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essential (Qadir and Schubert, 2002).

The dynamic reduction in resources of fresh water is driving toward unavoidable utilization of saline water for irrigating crops (Ali et al., 2019). There is a dire need to start appropriate management techniques for using saline water to irrigate crops and to avoid salt buildup for sustainable crop production (Chowdary et al., 2016). The increase in demand for resources of water is imposing farmers to utilize low quality waters for irrigation purpose. Irrigating crops with poor quality water for the whole growing season limit the productivity of crops, even the tolerant crops do not produce satisfactory yield. However, mixing good and poor-quality water is being practiced to keep the irrigation water salinity below threshold level. The high content of salts in irrigation water is a major issue that restricts crops yield because of high salt content (Fuller et al., 2012). Usage of saline water results in an increase in soil EC (Kim et al., 2016). The use of such deteriorated quality water limits the productivity of crops and sometimes leads to complete crop failure (Plaut et al., 2013). Under higher salinity levels, crop growth is severely affected (Narjary et al., 2019) due to imbalance of nutrients, oxidative stress, osmotic effect and water deficit (Kim et al., 2008). Irrigation with water of saline nature may result in salt accumulation in rhizosphere resulting in reduced yield and deteriorating the natural soil resources (Ahmed et al., 2007). It is also necessary to know the salinity distribution as well as its composition for better management of soil (Wang et al., 2019, 2020).

Salt affected soils are normally reclaimed by using various chemicals (Qadir et al., 2007). The most beneficial method for lowering salts is leaching of excessive sodium away from the roots (Ghafoor et al., 2008). Similarly, adding organic matter like FYM and solid municipal waste is also an effective approach for ameliorating soils affected by salts and excessive sodium on exchange complex (Pang et al., 2010). Organic matter like FYM not only enhances the nutrient availability but also the soil fertility status resulting in increased fodder productivity (Ahmed et al., 2007). Organic matter such as FYM, poultry manure, compost and residues of crops enhances the availability of nitrogen in soil leading to improved fertility of the soil as well as the production of fodder and grains. The low availability of phosphorus severely affects plants growth (Abbaszadeh-Dahaji et al., 2019). Higher salinity level is a major cause of reduction in yield for economically important crops (Ivushkin et al., 2019). The recycling of nutrients from organic matter like FYM and compost has been given more attention for assuring sustainable use of land. The role of organic matter in improving soil properties and fertility status has been well documented by many scientists. The use of organic matter like animal manure, crop residues, poultry manure and compost has gained much importance due to increase in cost of synthetic fertilizers. In Pakistan, farmyard manure is locally available source of organic matter (Iqbal et al., 2008). Higher yield of maize fodder can be obtained by modifying soil with chicken and cattle manure along with ash of wood (Materechera and Salagae, 2002).

Sorghum is a C_4 plant which have better ability to process photosynthesis and increased ability to tolerate abiotic and biotic stresses. It is moderately tolerant to salts where salinity is a key concern (Chowdary et al., 2016). Sorghum is not only a source of food and feed for livestock, but it also provides raw materials for making alcohol, fiber, starch and biofuels. Sorghum is grown as staple food in dry regions of Africa and India (Mehmood et al., 2008).

In the world, there annual sorghum production is about 60 million tons whereas in Pakistan is 0.21 million tons with an average yield of 620 kg/hectare. Sorghum is grown on 0.34 million hectares in Pakistan. Area under sorghum crop was 490 thousand hectares in 1990 which declined in 1991 and then grew rapidly at the end of 1992 while it was 457 thousand hectares in 2011. Similarly, the production of sorghum had an upward and downward trend from 1990-2011 which declined in 1991 and then grew swiftly in 1992. The production of sorghum was 195 thousand tons during the year 1990 while it was 303 thousand tons in the year 2011. Resultantly, area under sorghum crop has not increased as compared to the sorghum production. The reduction in area might be due to negative climatic conditions and economics (Habib et al., 2013).

There is a need to reduce the toxicity of salts and to bring an improvement in soil by using techniques requiring low cost like addition of manures (Shaaban et al., 2013). Organic matter is of great importance for soil carbon and nitrogen in varying ecosystems which can increase the nutrition of plants (Marzi et al., 2019). Benazzouk et al. (2019) observed a reduction in sodium accumulation by the use of vermicompost. The application of organic matter improves soil properties which are affected by salts, resulting in an improvement in growth through accelerating the leaching of toxic salts and cation exchange (Clark et al., 2007). The decay of manures results in increased level of CO_2 in the soil and release of H^+ ions which encourages the dissolution of $CaCO_3$ liberating calcium for the exchange of sodium (Ghafoor et al., 2008). Hence, addition of FYM is indispensable for sustainable use of land and productivity of the crops (Wong et al., 2009).

Hence, due to so much significance of FYM, current trial was conducted to judge the efficiency of FYM to mitigate drastic bad impact of irrigation with saline water on soil properties.

Materials and Methods

The research was carried out to evaluate FYM as tool to mitigate harmful impacts of salts on soil properties under field condition (Table 1) while irrigating it with saline water. The trial consisted of nine treatments with four replications in RCBD design. The plots having size 3.5m × 3.5m with 25 cm plant to plant distance and 75 cm row to row distance were used. Seed beds were prepared and sorghum cultivar "Hegari" was sown by using seed rate at 40 kg/acre. The treatments that included water of varying electrical conductivity and FYM were applied according to the plan. Fertilizers were applied at recommended rates. Crop was harvested at maturity stage. Soil samples were again examined chemically. Trial consisted of following 09 treatments.

T_1= irrigation of canal water; T_2= irrigation of EC 2 dS m^{-1} water; T_3= irrigation of EC 3 dS m^{-1} water; T_4= T_1 + FYM at 5 Mg/ha; T_5 = T_2 + FYM at 5 Mg/ha; T_6 = T_3 + FYM at 5 Mg/ha; T_7 = T_1 + FYM at 10 Mg/ha; T_8 = T_2 + FYM at 10 Mg/ha; T_9 = T_3 + FYM at 10 Mg/ha.

Table 1: *Analysis of experimental soil.*

Characteristic	Unit	Value
pH_s	-	7.8
EC_e	dSm^{-1}	1.33
SAR	-	5.44
Soil textural class	-	Clay loam

Statistical analysis

The data was analyzed by using statistix 8.1 ANOVA and Tukey's (HSD) test at a probability level of 5% (Steel et al., 1997). However, the laboratory analysis was performed by using procedures as mentioned in Hand book 60 of US Laboratory Staff (1969).

Results and Discussion

Effect of saline water on soil pH_s

Soil pH is of great importance as it affects the various soil dynamics like nutrient availability which leads to growth of plants. Figure 1 showed that maximum value of soil pH (8.4) was noted in the treatment T_3 (water of EC 3 dS m^{-1}) T_2 and T_6 that produced pH value of 8.2 and 8.1, respectively. The treatment T_2 and T_6 were statistically non-significant. The pH values of 7.8, 7.7 were recorded for T_1 (canal water) and T_5 (T_2 + FYM at 5 Mg/ha). The pH value of 7.5 was recorded for T_4, T_8 and T_9. The lowest soil pH (7.2) was noted in treatment T_7 where irrigation was done with canal water along with 10 Mg/ha FYM. These results are supported by Haq et al. (2007) that a declining in pH value from an original level of 10 to 9.21 occurred by applying organic matter under salinity environment. Likewise, Joachim et al. (2007) illustrated that applying organic matter reduced the value of pH in comparison to control.

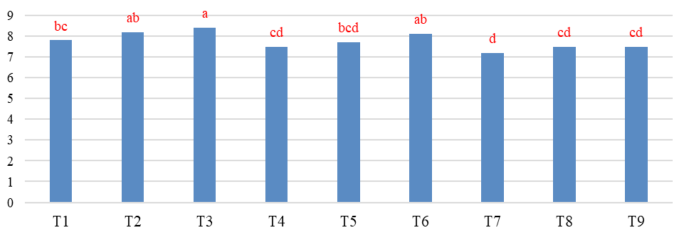

Figure 1: *Canal and saline water impact with and without FYM on soil pH having HSD value 0.5114 at probability level 0.05*

Effect of saline water on soil EC_e

Electrical conductivity is one of the most crucial parameters of soil. Successful crop production and nutrient management requires a clear understanding of this parameter. Figure 2 represented that the maximum value of EC (2.80 dS m^{-1}) was recorded in T_3 (water of EC 3 dS m^{-1}) followed T_6 and T_9 that indicated the EC values of 2.71 and 2.62 dS m^{-1}. An electrical conductivity values of 2.42, 2.30 and 2.12 dS m^{-1} were noted for T_2, T_5 and T_8 respectively. However, T_2 and T_5 were non-significant statistically. On the other hand, the lowest worth of EC (1.11 dS m^{-1}) was noted in the T_7 (T_1+ FYM at 10 Mg/ha) followed by T_4 and T_1 that produced an EC value of 1.22 and 1.32 dS m^{-1}. These outcomes are reinforced by Haq et al. (2007) that incorporating FYM reduced soil EC considerably. Similar outcomes were demonstrated by Khan et al. (2010) that applying FYM lessened the destructive effects of salinity and improved the characteristics of soil like EC, pH and SAR.

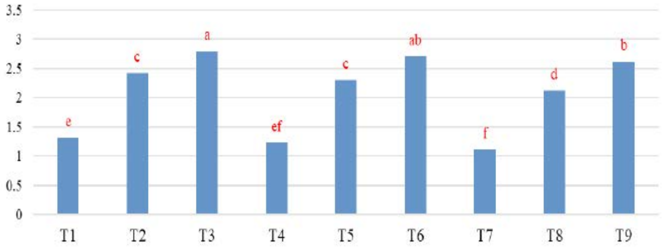

Figure 2: *Canal and saline water impact with and without FYM on soil EC (dS m^{-1}) having HSD value 0.1456 at probability level 0.05*

Effect of saline water on soil SAR

SAR is a degree of the sum of Na relative to Ca + Mg in the water extract from saturated soil paste. Figure 3 demonstrated that maximum SAR (17.20) was recorded in T_3 (water of EC 3 dS m^{-1}) followed by treatment T_6 and T_9 that were recorded 15.74 and 14.63 respectively. However, the treatment T_3 and T_9 were exposed statistically significant with each other. Treatments T_2, T_5 and T_8 were noted as 13.85, 12.55 and 11.60, respectively. The lowest SAR (3.21) was found in T_7 (T_1 + FYM at 10 Mg/ha) followed by T_4 and T_1 that were recorded 4.07 and 5.07 respectively. Similarly, Hussain et al. (2001) observed that adding FYM and gypsum lowers the SAR value thereby reducing the hazard of salinity for plants. These results are also favored by Saeed et al. (2007) who explained that using saline water enhanced the SAR but adding of organic matter lessened soil SAR.

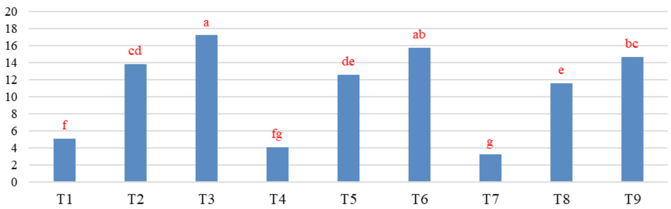

Figure 3: *Canal and saline water impact with and without FYM on soil SAR having HSD value 1.6679 at probability level 0.05*

Effect of saline water on soil organic matter content

Organic manure is the vital constituent of soil as it provides nutrients to plants and habitat to microbes. It binds soil particles resulting in improved structure and water holding capacity of the soil. Figure 4 exhibited that maximum organic matter content of 0.99% was recorded in T_7 (T_1 + FYM at 10 Mg/ha) followed by T_4 and T_1 that were noted 0.96 and 0.91% respectively. The organic matter content of values 0.83, 0.78 and 0.74% were recorded for the treatment T_8, T_5 and T_2, respectively. The minimum organic matter content (0.62%) was recorded in T_3 (water of EC 3 dS m^{-1}) followed by T_6 and T_9 that were noted 0.68 and 0.70%, respectively. The results are favored by Crecchio et al. (2004) that adding compost in soil improves the chemical and physical properties under salinity environment and applying solid municipal waste compost continuously for extended periods increases the content of organic matter in soil as well as C/N ratio when compared to soil with no organic matter additions. Similarly, Sarwar et al. (2008) found heightened organic matter in soil by adding of compost.

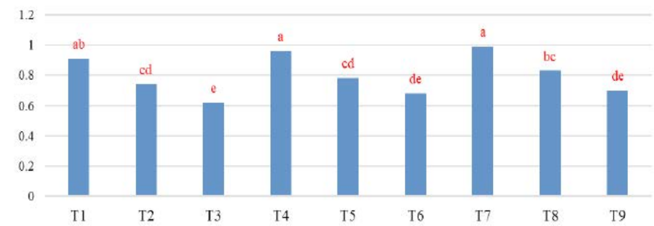

Figure 4: *Canal and saline water impact with and without FYM on soil organic matter (%) having HSD value 0.1022 at probability level 0.05*

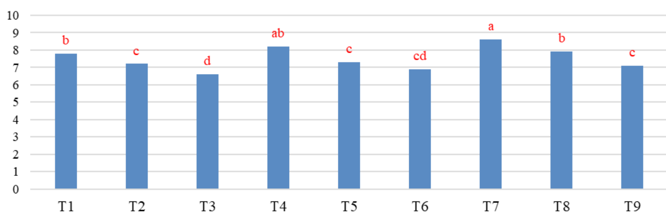

Figure 5: *Canal and saline water impact with and without FYM on soil phosphorous concentration (ppm) having HSD value 0.4762 at probability level 0.05*

Effect of saline water on soil phosphorus content

Phosphorus is a macronutrient required by crop plants to complete their growth stages as it is the integral component of ATP. However, the presence of salinity lowers its concentration in soil. Figure 5 revealed that maximum phosphorus concentration (8.60 ppm) was obtained in the treatment T_7 (T_1 + FYM at 10 Mg/ha) followed by T_4 and T_8 that were recorded 8.20 and 7.90 ppm respectively. The phosphorus concentration of 7.80, 7.30 and 7.20 ppm were recorded for T_1, T_5 and T_2. The lowest concentration of phosphorus (6.60 ppm) was recorded in the treatment (T_3) which was followed by T_6 and T_9 that were recorded 6.90 and 7.10 ppm in soil, respectively. Similarly, Sarwar et al.

(2008) examined that applying compost improved soil phosphorus and other nutrient needed by crops. These research results are also supported by Turner (2004) who stated that organic manure augmented the concentration of phosphorus in soil under the conditions of salinity.

Effect of saline water on soil potassium content

Potassium is required by plants in order to complete their lifecycle but its concentration in soil decreases by increasing the salinity level of soil. Figure 6 revealed that maximum potassium concentration (4.0 meq/L) was obtained in the treatment T_7 (T_1 + FYM at 10 Mg/ha) followed by T_4 and T_8 that produced 3.7 and 3.6 meq/L respectively. The potassium concentrations of 3.5, 3.2 and 3.1 meq/L were noted in treatment T_1, T_9 and T_5 respectively. The lowest value of potassium (2.7 meq/L) was noted in treatment T_3 followed by T_2 and T_6. Likewise, Lakhdar et al. (2008) depicted that using saline water for irrigating crop lowers the potassium level of soil which can be maintained by adding various organic materials are similar to our results. Similarly, the results of Hanay et al. (2004) depicted that concentration of potassium enhances by adding various organic materials.

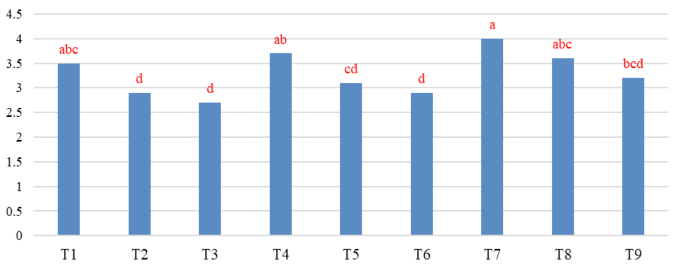

Figure 6: *Canal and saline water impact with and without FYM on soil potassium concentration (meq/L) having HSD value 0.5487 at probability level 0.05*

Conclusions and Recommendations

The results demonstrated that adding FYM is important for reducing detrimental saline irrigation impacts on soil health. The incorporation of FYM also lowered lethal saline water impacts on crop by bringing an improvement in soil properties. The treatment T_7 (T_1 + FYM at 10 Mg/ha) performed outstandingly by producing maximum values of nutrients both in soil and crop as well as improved the properties of soil like pH, EC, organic matter content and SAR. However, T_3 (water of EC 3 dS m^{-1}) increased soil electrical conductivity as well as pH and SAR values. It is recommended that FYM should be applied at varying rates under saline irrigation system in order to minimize destructive effects on soil properties.

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.
Muhammad Ashraf Malik: Performed different statistical analysis and assisted in excel work.
Muhammad Zeeshan Manzoor: Member of research group and helped in data collection.
Ayesha Zafar: Member of research group and helped in laboratory analysis.
Sher Muhammad: Technical assistance at every step.

Conflict of interest

The authors have declared no conflict of interest.

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