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RESEARCH PAPER

Comparative efficiency of compost, farmyard manure and sesbania green manure to produce rice-wheat crops under salt stressed environmental conditions

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Key Message: Organic amendments (compost, farmyard manure and sesbania green manure) were integrated with chemical fertilizers that not only increased production of rice-wheat crops, but also reclaimed sodic soil. However, role of compost remained superior to farmyard manure and sesbania green manure.

Abstract: This study was planned to thrash positive effects of different organic amendments not only on yield of rice and wheat plants, but also on its role as a recovery agent. To achieve this purpose, sodic soil having pH = 8.75, TSS (total soluble salts) = 25.3 me L^{-1}, SAR (sodium adsorption ratio) = 25.65 $(mmol.L^{-1})^{1/2}$ was selected and filled in pots. Experiment consisted of 9 treatments that were repeated 4 times using a completely randomized design. Treatments of experiment were; 1) control (no nutrition), 2) sesbania green manure @ 5 % soil volume, 3) FYM @ 5 % soil volume, 4) compost @ 5 % soil volume, 5) compost @ 10 % soil volume, 6) sesbania green manure @ 5% soil volume + chemical fertilizer, 7) FYM @ 5% soil volume + chemical fertilizer, 8) compost @ 5% soil volume + chemical fertilizer and 9) compost @ 10% soil volume + chemical fertilizer. All organic amendments like compost, farmyard manure and sesbania green manure were applied 30 days before sowing. At time of ripening, data on several crop parameters were recorded. Pots were prepared again and wheat was sown and harvested until ripe. Results indicated that use of compost (5% of soil volume) when coupled with chemical fertilizer (T8) proved superior to all other treatments. This treatment T8 produced plant height of 95.8 cm, number of fertile tillers 7.8, weight of 1000 grains = 19.1 g and total grain yield of rice = 20.86 g respectively indicating its supremacy over all other treatments. In the case of wheat crop, the best noted treatment was T9 (compost10% of soil volume + chemical fertilizer). This treatment produced 83.3 cm plant height, 5.0 tillers and 32.65 g yield of wheat grains.

Keywords: Chemical fertilizer, Compost, Farmyard manure, Rice and wheat, Sesbania green manure, Sodic soil

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Introduction

Compost is nutrient enriched tonic for crops and soils. Its use and application enhance the status of nutrients in the soil and also makes these nutrients more available to plants (Sarwar, 2005). Soil physical, chemical and biological properties are not only upgraded by addition of compost to the soil but crop yield is also enhanced (Sarwar et al., 2008). Hence, it can be said that usage of compost is an awful requirement of time in the current scenario of agriculture. Hussain et al. (2001) noted much more crop growth when FYM was used as a source of organic matter. In general, rice yield and inclusion of nitrogen, phosphorus and potash exhibited a fertilization plan having farm and green fertilizers or city manure coupled with the recommended doses. NPK would maximize yield and nutrient uptake as if only the recommended amounts of manure-free fertilizers were used (Jagadeeswari & Kumaraswamy, 2000).

Addition of various organic amendments improved the maximum height of rice-wheat. The use of compost proved to be superior to that of Sesbania and FYM green manure. This tendency to increase the height of the plant increased when the chemical fertilizer was combined with these organic materials. The combination of fertilizers and compost at the highest rate was the most successful treatment (Sarwar, 2005). Similarly, combining both amounts of compost + chemical fertilizers caused maximum agglomeration in rice-wheat plants compared to FYM and Sesbania. Using FYM proved to be superior to control and led to a substantial rise in the number of rice-wheat crop growers. A comparison of compost and fertilizer proved the superiority of compost over chemical fertilizer in this regard, but combination of these proved to be more successful than using compost alone (Sarwar et al., 2007).

Salinity leads to a decline of the natural resources of the soil, which affects agricultural production (Ren et al., 2019). Increased salinity is a major cause of reduced yield in economically important plants (Ivushkin et al., 2019). Hence, excessively soluble salts and replaceable sodium are a major problem associated with salt in soils (Paz et al., 2019). Soil salinity is a global problem (Chen et al., 2019). Therefore, preventing salinity is a key to improving plant productivity in regions having dry climate (Wang et al., 2019). Plant growth is strongly influenced by nutrient imbalance, oxidative stress, osmotic effects and lack of water (Kim et al., 2016). The growth of most plants is reduced by the presence of salts in the soil (Zorb et al., 2019).

Halima et al. (2019) used sugarcane compost and gypsum as an amendment on soils with different salinity levels and found that amendments are good pH buffer and nutrients sink even with soil salinization effect. The highest reduction in electrical conductivity was observed irrespective of amendment used. Fang et al. (2020) suggested that application of organic amendments combined with inorganic fertilizers or gypsum in poorly structured soil is the best management practice aiming to ameliorate physicochemical constraints and improving soil carbon storage. Likewise, Nguyen-sy et al. (2020) concluded that organic carbon and total nitrogen contents of the bulk soils were higher in the plots that were treated with inorganic fertilizers plus organic matter than in the PK and NPK plots. Yao et al. (2019) also found that growing leguminous green manure to replace summer fallow can increase the quantity and stability of soil organic carbon, suggesting that the proposed management practice could promote sustainable agriculture.

Smiciklas et al. (2002) conducted research on maintenance of soil health through the use of compost prepared from various sources. It emerged from these studies that plots treated with compost showed decline in soil reaction values compared to control. The percentage of organic matter increased in almost all treatments with mature/ raw compost compared to the control. They also observed a decrease in CEC after spreading various organic materials and nitrogenous fertilizers. From these studies, they came to the conclusion that use of mature compost did not change any measured soil parameters one to three years after annual application, regardless of the application rate. Revegetation studies of salt deposits in the potash industry in Germany, consisting of sodium chloride (> 90%), showed that the use of compost (1-5 liters plant^{-1}) in the plant (birch), Scotch, Aspen and Goat Willow). Compost and fertilizer also promoted the spread of grasses, without which they could no longer survive (Hofmann, 2004).

Similarly, Lim et al. (2020) also suggested that fertilization management as well as salinity management via drainage, gypsum application, tillage, and proper irrigation may be necessary to improve rice production. Likewise, Rani et al. (2020) concluded that NPK availability in soil also enhances significantly with integrated usage of FYM, compost and slurry biogas over control. This integrated approach can be used for the growth of wheat under semi-arid conditions of India. Cao et al. (2020) found beneficial results of hyper-thermophilic compost in soils and crop could reduce the use of mineral fertilizer for sustainable production of vegetables. In another study, Shi et al. (2019) evaluated the integrated effect between microbial communities and organic amendments in salt stress soil environment. Addition of various amendments having organic origin increased fertility as well as enzymatic activities in saline sodic soils.

Nguyen et al. (2020) found an increase in methane emissions by use of cow manure from paddy salt affected soils. However, addition of biochar mitigated the methane emissions, reduced activities of methanogens while increased those of methanotrophs. Zhou et al. (2019) suggested that combined application by aluminum sulfate with organic-inorganic compound fertilizer is an effective amendment of saline-sodic soils in Songnen Plain, Northeast China. These outcomes are likely due to sodium leaching and enhanced soil organic carbon leading to increased fertilizers retention. Application of vermicompost and humic acid fertilizer increased nitrogen, phosphorus and potassium content in maize. Therefore, application of humic acid fertilizer and vermicompost can be integrated as a practice for improving coastal saline soil (Liu et al., 2019). Current experiment was carried out with the objective to monitor efficiency of compost, farmyard and sesbania green manure to enhance not only rice-wheat yield but also its impact on soil health after reclaiming the saline sodic soil.

Materials and Methods

Sodic soil was selected after laboratory analysis and brought to the wire house for experimentation (Table 1). This soil was filled in pots @ 12 kg pot^{-1}. Soil was uniformly packed in all pots and pots were arranged according to completely randomized design (CRD). Experiment comprised of 9 treatments which were replicated four times. 1) control (no nutrition), 2) sesbania green manure @ 5% soil volume, 3) FYM @ 5% soil volume, 4) compost @ 5% soil volume, 5) compost @ 10% soil volume, 6) sesbania green manure @ 5% soil volume + chemical fertilizer, 7) FYM @ 5% soil volume + chemical fertilizer, 8) compost @ 5% soil volume + chemical fertilizer and 9) compost @ 10% soil volume + chemical fertilizer. Different organic materials like compost, FYM and sesbania green manure were added to respective pots as per treatment plan. These materials were analyzed before applying to pots (Table 2). All pots were irrigated for about 30 days to allow amendments to completely mixing with soil particles. Rice was the first crop following wheat. Five seedlings of rice were transplanted in each pot and 03 were maintained after establishment. Chemical fertilizer was applied to the plants @ 100-70-70 kg ha^{-1} for nitrogen, phosphorus and potash respectively. At maturity, plant height and number of fertile tillers were counted for each pot. Rice plants were harvested and total biomass and grain yield was recorded for each pot.

Weight of 1000 grains was also noted. After harvesting rice, wheat seeds were sown in all pots and after germination 03 wheat plants pot^{-1} were maintained. Chemical fertilizer was applied to the plants according to treatment plant @ of 140-110-70 kg ha^{-1} for N, P and K respectively. Sources of N, P and K were urea, single super phosphate (SSP) and sulfate of potash respectively for both crops. At maturity, plant height and tillers were counted and plants were harvested. Total biomass and grain yield were recorded. Weight of 1000 grains was also noted for each pot.

Analytical methods for soil and organic amendments determinations

All laboratory analysis of soil, compost, FYM and sesbania green manure samples were done according to the USDA Analysis Methods Manual 60 (U.S. Salinity Laboratory Staff, 1969).

Table 1 Laboratory determination of soil

S. No.	Parameters	Unit	Value
1	Soil saturation (SP)	%	28.0
2	Soil reaction (pH)	-	8.75
3	Total soluble salts (TSS)	me L^{-1}	25.3
4	Sodium adsorption ratio (SAR)	(mmol. L^{-1})$^{1/2}$	25.65
5	Organic carbon	%	0.10
6	Olsen's phosphorus	ppm	6.65
7	Water soluble potassium	me L^{-1}	0.50
8	Textural Class	-	Sandy Loam

Table 2 Laboratory determination of compost, FYM and sesbania green manure

S. No.	Parameters	Unit	Compost	FYM	Sesbania
1	Soil reaction	-	7.67	8.05	6.60
2	Total soluble salts	me L^{-1}	63.1	127.8	59.2
3	Organic matter %	-	48.15	40.36	46.86
4	Organic carbon %	-	28.00	23.47	27.24
5	C/N ratio	-	13.33	13.04	14.33

Results

Application of an amendment is one of the major pre-requisites for reclamation of sodic soils. The amendment may be chemical or organic in nature. Like chemical fertilizers, the cost of chemical amendments has become very high which are beyond the pocket of the poor farmers. The organic amendments have an edge over chemical amendments because these improve the soil physical conditions rapidly as well as enhance the fertility status simultaneously. Compost can be prepared from rice and wheat straw by the small farmers and can be used for reclamation purposes without incurring much amount. The prime objective of this study was to compare compost, farmyard manure and Sesbania green manure for their exclamative value and determine the rate of application.

Plant height (cm)

Height of any plant is always considered as a significant parameter that contributes to plant health and yield. Data indicated that maximum plant height of 103.3 cm was noted for T8 (compost @ 5% soil volume + chemical fertilizer) in case of rice and it was followed by T5 (compost @ 10% soil volume) and T4 (compost @ 5% soil volume) with values of 101.8 and 100.0 cm respectively (Fig. 1). The lowest height of 92.3 cm was observed for control treatment (T1). In case of wheat crop, this trend was little bit changed as T9 (compost @ 10% soil volume + chemical fertilizer) proved superior to all other treatments with height value of 83.3 cm while T8 (compost @ 5% soil volume + chemical fertilizer) was next best treatment having 76.5 cm plant height. The values of height for T2 (sesbania green manure @ 5% soil volume) and T3 (FYM @ 5% soil volume) were 67.8 and 63.8 cm respectively (Fig. 1). Both these treatments remained at par when observed in terms of statistics.

Number of fertile tillers

Tillers are a very important agronomic yield component as more tillers will produce more yield of any crop. Data indicated that maximum number of fertile tillers of 18.8 were noted for T8 (compost @ 5% soil volume + chemical fertilizer) in case of rice and it was followed by T6 (sesbania green manure @ 5% soil volume + chemical fertilizer) and T7 (FYM @ 5% soil volume + chemical fertilizer with values of 14.3 and 12.5 respectively (Fig. 2). The lowest count of 3.2 was observed for control treatment (T1). In case of wheat crop, this trend was little bit changed as T9 (compost @ 10% soil volume + chemical fertilizer) proved superior to all other treatments with number of fertile tillers value of 5.0 while T8 (compost @ 5% soil volume + chemical fertilizer) was next best treatment having 4.6 number of fertile tillers. The values of number of fertile tillers for T2 (sesbania green manure @ 5 % soil volume) and T3 (FYM @ 5 % soil volume) were 3.0 and 2.7 respectively (Fig. 2).

Weight of 1000 grains (g)

Weight of 1000 grains of any crop indicates the health condition of crop and seed. More the weight, much healthy crop will be and vice versa. It was found that 1000 grains weight of 20.9 g was noted for T4 (compost @ 5 % soil volume) in case of rice and it was followed by T5 (compost @ 10 % soil volume), T2 (sesbania green manure @ 5 % soil volume) and T8 (compost @ 5% soil volume + chemical fertilizer) indicating height values of 20.2, 20.1 and 20.1 g respectively (Fig. 3). The lowest 1000 grains weight of 17.2 g was observed for control treatment (T1). In case of wheat crop, this trend was little bit changed as T9 (compost @ 10% soil volume + chemical fertilizer) proved superior to all other treatments with 1000 grains weight value of 39.0 g while T8 (compost @ 5% soil volume + chemical fertilizer) was next best treatment having 35.8 g 1000 grains weight. The values of 1000 grains weight for T2 (sesbania green manure @ 5 % soil volume) and T3 (FYM @ 5 % soil volume) were 25.0 and 23.2 g respectively (Fig. 3). Both these treatments remained at par when observed in terms of statistics.

Total biomass (g)

Importance of the total biomass of any crop needs no discussion as it is directly related with grain yield; the most desired attribute of cultivation for stakeholders. Data reflected that total biomass of 91.4 g was noted for T8 (compost @ 5% soil volume + chemical fertilizer) in case of rice and it was followed by T5 (compost @ 10 % soil volume), T7 (FYM @ 5% soil volume + chemical fertilizer) and T6 (sesbania green manure @ 5% soil volume + chemical fertilizer) indicating total biomass values of 76.16, 67.03 and 54.98 g respectively (Fig. 4). The lowest total biomass of 17.87 g was observed for control treatment (T1). In case of wheat crop, this trend was little bit changed as T9 (compost @ 10% soil volume + chemical fertilizer) proved superior to all other treatments with total biomass value of 49.83 g while T8 (compost @ 5% soil volume + chemical fertilizer) was next best treatment having 40.74 g total biomass. The values of total biomass for T2 (sesbania green manure @ 5 % soil volume) and T3 (FYM @ 5 % soil volume) were 17.57 and 17.12 g respectively (Fig. 4). Both these treatments remained at par when observed in terms of statistics.

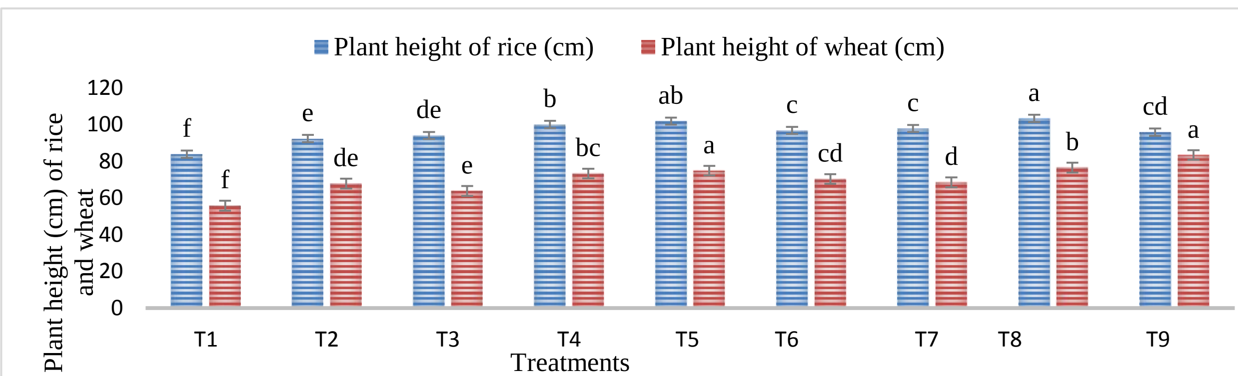

Fig. 1 Effect of compost, FYM and sesbania green manure on plant height (cm) of rice-wheat under sodic soil environment

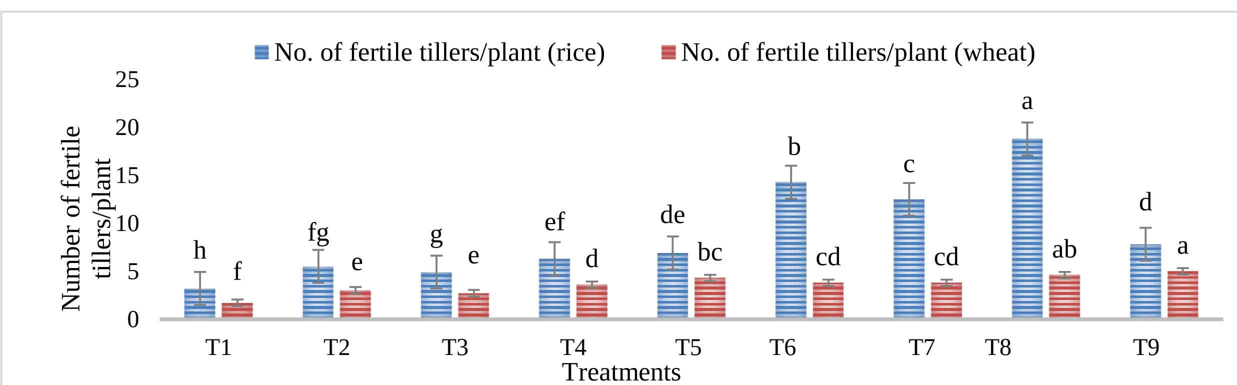

Fig. 2 Effect of compost, FYM and sesbania green manure on number of fertile tillers/plant of rice-wheat under sodic soil environment

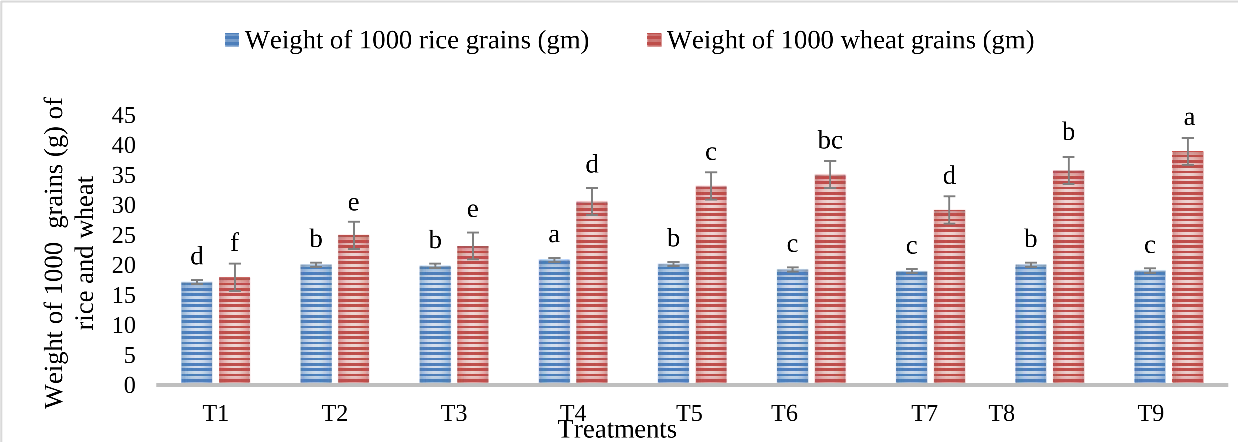

Fig. 3 Effect of compost, FYM and sesbania green manure on weight of 1000 grains (g) of rice-wheat under sodic soil environment

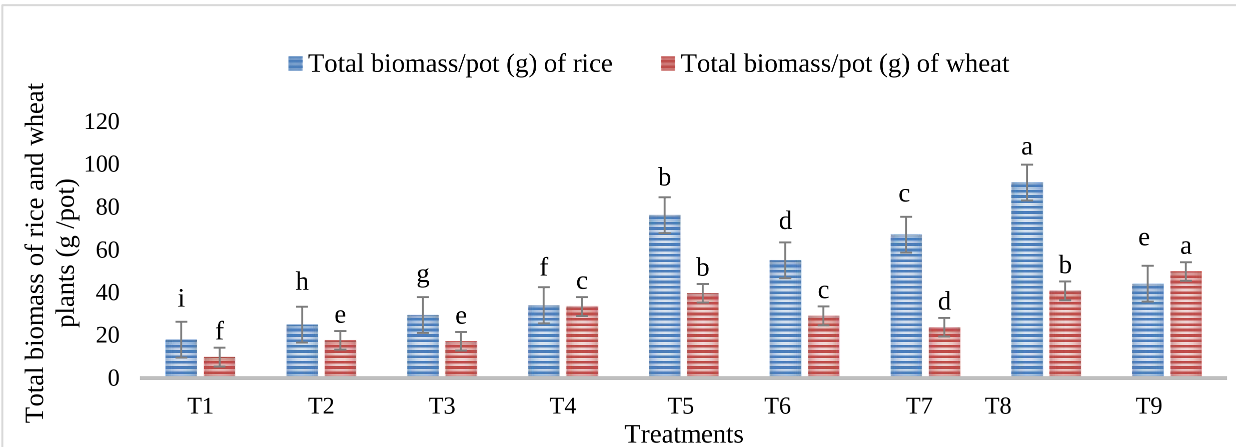

Fig. 4 Effect of compost, FYM and sesbania green manure on total biomass/pot (g/plant) of rice-wheat under sodic soil environment

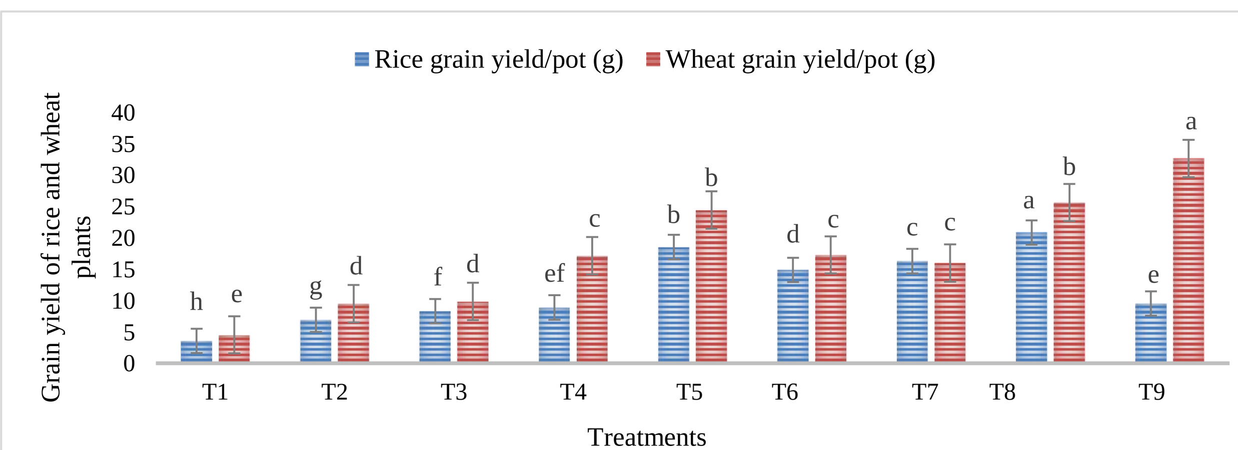

Fig. 5 Effect of compost, FYM and sesbania green manure on grain yield/pot (g) of rice-wheat under sodic soil environment

Grain yield (g)

Ultimate task and final objective of all farming operations is to get the maximum grain yield of any crop. Data indicated that grain yield of 20.86 g was noted for T8 (compost @ 5% soil volume + chemical fertilizer) in case of rice and it was followed by T5 (compost @ 10 % soil volume), T7 (FYM @ 5% soil volume + chemical fertilizer) and T6 (sesbania green manure @ 5% soil volume + chemical fertilizer) indicating grain yield values of 18.53, 16.28 and 14.88 g respectively (Fig. 5). The lowest grain yield of 3.59 g was observed for control treatment (T1). In case of wheat crop, this trend was little bit changed as T9 (compost @ 10% soil volume + chemical fertilizer) proved superior to all other treatments with grain yield value of 32.65 g followed by T8 (compost @ 5% soil volume + chemical fertilizer) having 25.64 g grain yield. The values of grain yield for T2 (sesbania green manure @ 5 % soil volume) and T3 (FYM @ 5 % soil volume) were 9.53 and 9.86 g respectively (Fig. 5).

Soil reaction (pH)

Data regarding soil reaction (pH) was depicted in Fig. 6. It was noticed that maximum soil pH was observed in treatment T1 (control) with numerical value of 8.75 for rice crop. This value was lowered up to the level of 8.39 by the application of compost @ 10% soil volume + chemical fertilizer (T9) followed by 8.42 in T5 receiving compost @ 10 % soil volume. In case of wheat crop, the trend was same where maximum soil pH was noticed in control (T1) and minimum soil pH was recorded in T9 (compost @ 10% soil volume + chemical fertilizer) followed by T5 (compost @ 10 % soil volume) with recorded values of 8.39 and 8.40 respectively (Fig. 6). Both these treatments remained at par when observed in terms of statistics.

Electrical conductivity (dS m^{-1})

Data about the effect of various organic and inorganic nutritional sources on soil electrical conductivity was portrayed in Fig. 7. It was found that in the case of rice crop, maximum soil EC was recorded in T9 receiving compost @ 10% soil volume + chemical fertilizer followed by T5 (compost @ 10 % soil volume) with values of 6.43 and 4.19 dS m^{-1} respectively. On the other hand, minimum soil electrical conductivity was noted in T1 (control) with value of 2.67 dS m^{-1}. However, data regarding wheat crop depicted that minimum soil electrical conductivity was found in T1 where no external source of nutrients was applied showing value of 2.62 dS m^{-1}. This was reached to the maximum value of 3.04 dS m^{-1} in T5 receiving compost @ 10 % soil volume. Treatment T9 was next in this regard showing a value of 2.83 dS m^{-1}.

Sodium adsorption ratio (SAR)

Data regarding sodium adsorption ratio was indicated in Fig. 8. In case of rice crop, maximum sodium adsorption ratio was reported in T1 (control) with value of 24.8 (mmol.L^{-1})$^{1/2}$ followed by T3 (FYM @ 5 % soil volume), T2 (sesbania green manure @ 5 % soil volume) and T6 (sesbania green manure @ 5% soil volume + chemical fertilizer) indicating values of 15.4, 14.5 and 12.2 (mmol.L^{-1})$^{1/2}$ respectively (Fig. 8). The lowest sodium adsorption ratio of 8.7 (mmol.L^{-1})$^{1/2}$ was noticed for treatment T8 (compost @ 5% soil volume + chemical fertilizer). In the case of wheat crop, this trend was similar as T9 (compost @ 10% soil volume + chemical fertilizer) resulted in a minimum sodium adsorption ratio having 7.1 (mmol.L^{-1})$^{1/2}$. On the other hand, maximum sodium adsorption ratio was found in T1 (control) with value of 23.7 (mmol.L^{-1})$^{1/2}$.

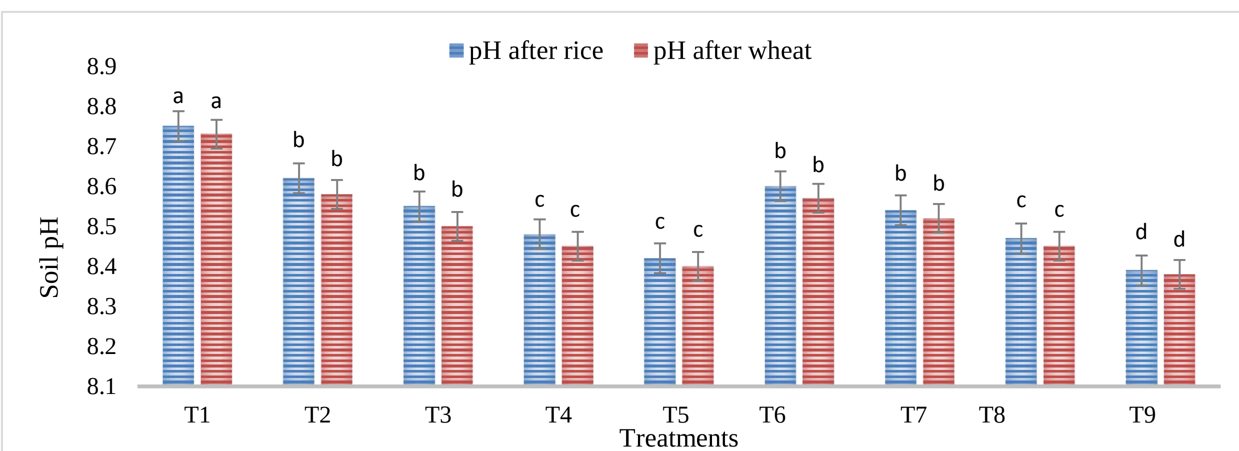

Fig. 6 Effect of compost, FYM and sesbania green manure on soil pH of rice-wheat under sodic soil environment

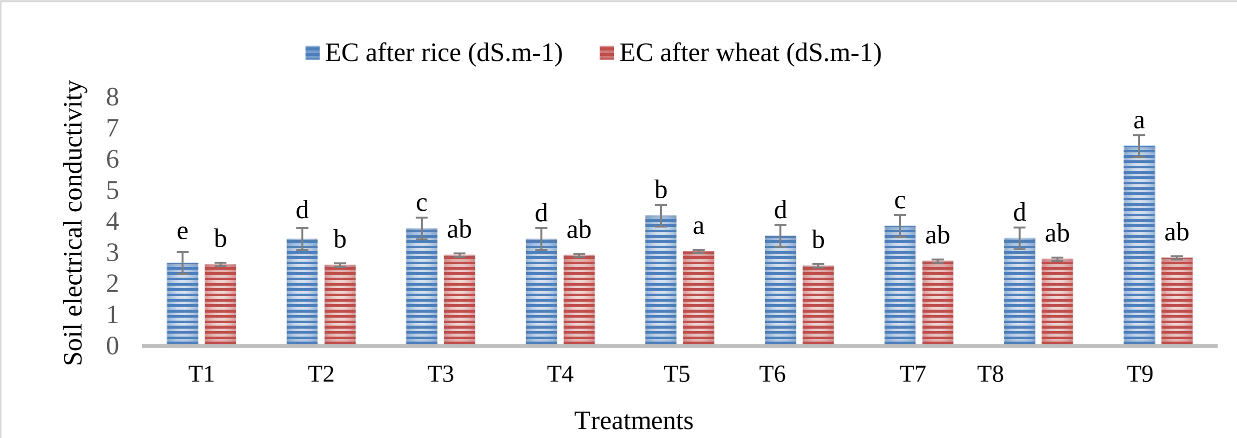

Fig. 7 Effect of compost, FYM and sesbania green manure on soil electrical conductivity after rice-wheat crops under sodic soil environment

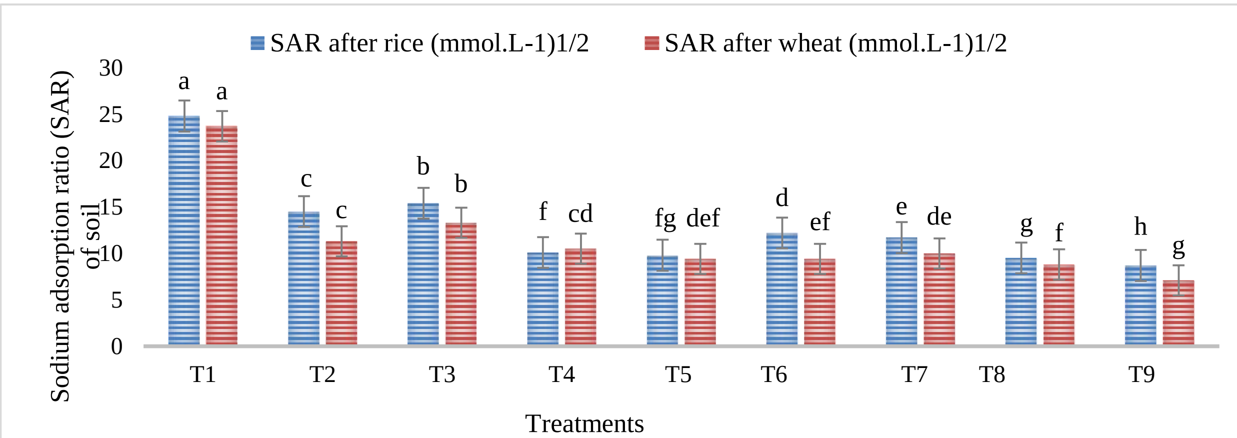

Fig. 8 Effect of compost, FYM and sesbania green manure on sodium adsorption ratio after rice-wheat crops under sodic soil environment

Discussion

Ultimate objective of crop production is to get maximum yield or profit from a given piece of land throughout the globe. In current study, compost performed its role efficiently in enhancing and improving the different yield components like tillers, height of plants, total biomass and weight of 1000 grains. All these components when improved indicate more yield resultantly. Integration of compost, FYM and sesbania green manure with mineral fertilizer proved superior to its sole application. No doubt, compost application at both levels was admirable but its application at higher rate resulted in more yield either alone or when integrated with chemical fertilizers. This trend was almost the same and uniform for rice and wheat crops. Phenomenon of growth increase of rice-wheat after compost is the result of a series of given chain processes. An increase in the fresh biomass along with improvement in all agronomic parameters of sorghum was observed when use of saline water as source of irrigation was coupled with farmyard manure (Murtaza et al., 2020a).

Soil reaction (pH) is the property of soil that determines its suitability for plant growth in connection with nutrition supply and salinity/sodicity status. Like other arid and semi-arid regions, pH of majority of soils ranges from 7.0-10.0. Therefore, any techniques that can lower soil pH are desirable. Incorporation of compost lowered soil pH of saline sodic soil due to its acidifying effect by producing and subsequently releasing different organic acids during the mineralization process of the nutrients. The pH of alkaline soil is controlled by Na. When compost is used as a source of nutrients, it makes free Ca that leads to reduction in soil pH. Resultantly, Na ions are released in soil solutions that are leached down the soil profile (Brady & Weil, 2005).

Soil salinity or high concentration of total soluble salts is major issue of agriculture around the globe. Due to this problem, plants face a problem of water uptake linked with osmotic effect. Plants also have limited uptake of nutrients that is caused by specific ion effects. When compost is added to the soil, it produces plenty of acid forming substances that show their reaction with partially soluble salts present natively in the soil and change these into highly soluble ones. These highly soluble salts are leached down and soil properties are improved. Still quantity of this improvement is linked with amount of compost applied (Sarwar, 2005). There was decrease in soil pH and SAR when irrigation of saline water was integrated with farmyard manure (Murtaza et al., 2020b).

Sodicity status of a soil is assessed by measuring its SAR value that indicates Na content in soil. High sodium content is harmful for plant growth. Addition of compost decreased values of soil SAR. Application of other amendments (rice straw, FYM and green manures) also lowered the numerical value of SAR in the soil. This reduction in SAR values is coupled with the release of various useful substances in soil. Hence, concentration of Ca is enhanced in the soil that leads to reclamation by lowering SAR (Zaka et al., 2003). Such reduction in SAR occurs either due to increase in Ca content or decrease in Na concentration (Sarwar, 2005).

As all types of microbial activity and nutrients are linked with concentration of organic matter in soil, so it is a single parameter that controls all other growth production parameters in soil. In salt affected soils, quantity of organic matter was raised with the usage of compost at either rate. Reason of this improvement is very obvious as organic matter was applied to the soil in the form of compost. Hence, organic matter status of soil has direct relationship with the applied quantity of its source (Sarwar et al., 2003). Availability of phosphorus to plants is directly linked with pH level of the soil. As explained earlier, use of compost lowered soil pH values, so resultantly phosphorus availability was enhanced and more P content was estimated in soil samples collected after both crops (Brady & Weil, 2005). Similarly, concentration of water-soluble potassium increased in the soil as a result of compost application. This positive change is also attributed as the result of organic acids production due to use of compost. The H ion are released from the exchange site of clay which lead to improved K content in the soil (Sarwar et al., 2009). Concentration of various nutrients like nitrogen, phosphorus, potassium, calcium and magnesium was improved when farmyard manure was applied with saline water irrigation (Murtaza et al., 2020c).

Similarly, results of early scientists also favoured these findings. Addition of farm yard manure in saline sodic soil yielded more rice production due to the above explained phenomenon. These positive effects of FYM were also carried over to the subsequent wheat crop (Tiwari et al., 2001). In the same way findings of Ahmad et al. (2002); Parmer & Sharma (2002); Sarwar (2005); Sarwar et al. (2009); Sarwar et al. (2020) were also in the same direction and favoured the above phenomenon and hypothesis.

Conclusion

It was concluded from this study that use of compost, FYM and sesbania is useful for enhancing yield of rice-wheat production grown from salt affected soil environment. However, utilization of compost when coupled with chemical fertilizer proved superior to others. Results indicated that use of compost (5% of soil volume) when coupled with chemical fertilizer (T8) proved superior to all other treatments. This treatment T8 produced the highest height of plants, greater tillers/plant 1000 grains weight and grain yield of rice crop indicating its supremacy over all other treatments. In the case of wheat crop, the best noted treatment was T9 (compost10% of soil volume + chemical fertilizer). This treatment produced maximum height of plants, tillers/plant and yield of wheat grains.

Author Contribution Statement: Ghulam Sarwar planned, designed, conducted and carried out this research study. Muhammad Ashraf Malik performed statistical analysis and assisted in excel work. Noor-Us-Sabah contributed in data analysis, description and edited the manuscript. Mukkram Ali Tahir contributed in wire house research by performing various activities as desired by the crops at different stages. Muhammad Aftab recorded plant data of various parameters and helped in laboratory analytical work. Muhammad Zeeshan Manzoor helped in conducting the research project and wrote the manuscript. Ayesha Zafar contributed in laboratory analysis of various parameters prescribed in the manuscript. All the authors read and approved the manuscript to be published in Journal of Pure and Applied Agriculture.

Conflict of Interest: The authors declare that they have no conflict of interest.

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