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Chlorophyll content, water relation traits and mineral ions accumulation in soybean as influenced by organic amendments under salinity stress

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Abstract

The pot experiment was conducted to assess the effect of organic amendments to improve leaf chlorophyll and water content as well as mineral ions accumulation in BARI soybean 5 under saline condition. Two types of organic amendments i. water hyacinth compost ii. rice husk biochar were mixed in soil at 5 tha^{-1} and 10 tha^{-1} of both. Irrigation was done with 50 and 100 mM saline solution from 14^{th} days after sowing (DAS) to maturity, where control plants were irrigated with tap water. Data on chlorophyll content, exudation rate, relative water content (RWC), water retention capacity (WRC) in leaf were measured at flowering stage as well as Na, K, Ca, Mg and Na: K ratio in leaf and stem were also recorded at harvest. Results revealed that salinity decreased chlorophyll content, exudation rate, relative water content, water retention capacity and K, Ca, Mg content in leaf and stem of soybean plant. Water hyacinth compost and rice husk biochar had positive effects to mitigate negative effects of salinity on soybean plant. However, rice husk biochar at 5 tha^{-1} showed best result to mitigate salinity stress on soybean at low salinity (50 mM) condition.

Keywords: Chlorophyll, mineral ions, organic amendments, salinity, water relations.
Abbreviations: DAS_ days after sowing; RWC_ relative water content; WRC_ water retention capacity.

Introduction

Agricultural productivity is severely affected by soil salinity and the damaging effect of salt accumulation in agricultural soils has become an important environmental concern all over the world (Jaleel et al., 2007). Salinity drastically affects different physiological processes in plant like water relation traits, chlorophyll degradation; accumulation of organic solutes and other activities includes photosynthesis (Soussi et al., 1998), nitrogen (Cordovilla et al., 1995; Mansour, 2000) and carbon metabolism (Delgado et al., 1994; Soussi et al., 1999). Such physiological changes will result in a decrease in plant growth (Mensah et al., 2006) and consequently in crop yield. Accumulation of excess Na and Cl in plant body causes ionic imbalances that may impair the selectivity of root membranes and induce potassium deficiency (Gadallah, 1999). There are evidences that soil amendments with various organic substances such as farmyard manure, poultry manure and mulch can be used for the reduction of toxic effects of salinity in various plant species (Idrees et al., 2004; Abou El-Magd et al., 2008; Leithy et al., 2010; Raafat and Thawrat, 2011). The beneficial influence of compost on soil physical and chemical properties has been well documented (Debosz et al., 2002; Lynch et al., 2005; Tejada et al., 2006; Wanas and Omran, 2006). Biochar is pyrolysed organic material intended for use as a soil amendment to sustainably sequester C and concurrently improve soil function, while avoiding any adverse effects, on both the short and long terms (Lehmann and Joseph, 2009; Verheijen et al., 2009). Biochar enhanced soil water-holding capacity (Asai et al., 2009; Laird et al., 2010); improved soil water permeability (Asaie t al., 2009); improved saturated hydraulic conductivity (SHC) (Asai et al., 2009); reduced soil strength (Chan et al., 2007, 2008) and modification in soil bulk density (ρb) (Laird et al., 2010). Dramatic improvement of soil chemical properties has been reported with biochar applications to agronomic soils (Chan et al., 2007; Laird et al., 2010). However, role of organic amendments to mitigate salinity effect on plant physiology is not clearly understood. The aim of this research work was to find out the effect of water hyacinth compost and rice husk biochar on some physiological parameters related to salinity tolerance in soybean plants under salt stress.

Results and Discussion

Leaf Chlorophyll Content

Organic amendment significantly increased chlorophylla in soybean leaf under control and saline conditions (Table 1). Highest chlorophyll a (3.21 mg g^{-1}) was found in plant where biochar was added at 5 t ha^{-1} and it was 2.72 mg g^{-1} when compost was added at 5 t ha^{-1} under control condition. At 50 mM saline condition highest chlorophyll a (2.43 mg g^{-1}) was obtained from biochar at 5 t ha^{-1}and it was lowest (2.15 mg g^{-1}) when biochar was applied at 10 t ha^{-1}. At 100 mM saline condition highest total chlorophyll (1.86 mg g^{-1}) was obtained when soil was treated with compost at 5 t ha^{-1} and it was lowest (1.48 mg g^{-1}) when biochar was added in the soil at 10 t ha^{-1}. Increasing salinity concentration in the rooting medium significantly reduced the chlorophyll a, chlorophyll b, and total chlorophyll reported by Ashraf et al. (1989). Chlorophyll b content of soybean plant also was reduced significantly at saline conditions (Table 1). It was significantly lowest at 100 mM salt level than control. Organic amendment significantly increased chlorophyll b of soybean plant under control and saline conditions. Highest chlorophyll b (1.91 mg g^{-1}) was observed when compost was added at 5 t ha^{-1} and it was 1.57 mg g^{-1} when biochar was added at 5 t ha^{-1} under control condition. At 50 mM salinity condition, highest chlorophyll b (1.59 mg g^{-1}) was obtained from biochar at 10 t ha^{-1} and lowest chlorophyll b (1.23 mg g^{-1}) was observed when biochar was applied at 5 t ha^{-1}. Under 100 mM saline condition highest chlorophyll b content (1.04 mg g^{-1}) was obtained when soil was treated with compost at 10 t ha^{-1} and it was lowest (0.63 mg g^{-1}) when compost was added in the soil at 5 t ha^{-1}. Both chlorophyll a and chlorophyll b decreased with increasing salinity. Our findings are in line with the findings of Hajer et al. (2006). Total chlorophyll of leaf in soybean plant also was reduced significantly at salinity conditions. Organic amendment significantly increased total chlorophyll of soybean under control and saline conditions. Highest total chlorophyll (4.79 mg g^{-1}) was observed when biochar was added at 5 t ha^{-1} and the lowest was 4.53 mg g^{-1} when compost was added at 10 t ha^{-1} under control condition. At 50 mM salinity condition, highest total chlorophyll (3.81 mg g^{-1}) was obtained from compost at 5 t ha^{-1} and lowest total chlorophyll (3.67 mg g^{-1}) was observed when biochar was applied at 5 t ha^{-1}. At 100 mM saline condition, highest total chlorophyll (2.65 mg g^{-1}) was obtained when soil was treated with compost at 10 t ha^{-1} and it was lowest (2.38 mg g^{-1}) when biochar was added in the soil at 10 t ha^{-1}. When plants are grown under saline conditions, photosynthetic activity was decreases leading to reduced chlorophyll content and chlorophyll fluorescence reported by Muhammad et al. (2007). Ali et al. (2004) also showed that the chlorophyll concentrations were reduced by salinity. Plants grown under salinity without biochar amendment showed 9.7%, 17% and 30% reduction in total chlorophyll content compared to respective control. Results indicate that chlorophyll content was improved by biochar application under salinity stress. Under the normal condition, 4% increase in total chlorophyll content was observed by 2% biochar, while 7% increase at 1% biochar. Under stress of 150 mM solution of NaCl, the application of 2% biochar showed an increase of 20%, while 1% biochar showed an increase of 13%. (Kanwal et al., 2017). Considerable increase in chlorophyll content was observed due to biochar amendment across all treatments. According to Akhtar, Andersen, and Liu (2015b), the application of biochar elevates photosynthesis rate, which is an indication of increased chlorophyll content.

Exudation rate

Salinity decreased the exudation rate drastically in soybean plant and decreasing rate was higher with increasing salinity levels (Fig. 1). The lowest exudation rate (178 mg h^{-1}) was found at 100 mM salt stress level when no organic amendment was applied in the soil. Compost and biochar amendments increased the exudation rate of soybean plant both in control and saline conditions. At control condition highest exudation rate (903 mg h^{-1}) was observed when biochar was added in the soil at 5 t ha^{-1} and it was lowest (659 mg h^{-1}) when soil was treated with compost at 5 t ha^{-1}. At 50 mM salinity stress highest exudation was 458 mg h^{-1} when compost was added at 5 t ha^{-1}. On the other hand lowest exudation was 417 mg h^{-1} when soil was treated with biochar at 5 t ha^{-1}. At 100 mM salinity maximum exudation (332 mg h^{-1}mg/h) was observed in the treatment when biochar was added at 5 t ha^{-1} and it was minimum (284 mg h^{-1}) when soil water hyacinth compost was added at 5 t ha^{-1} in the soil. In a study, there was clear evidence of amendment soil interaction processes affecting both soil properties and exudation rate particularly for biochar that might lead to greater changes with additional field emplacement time reported by Akhter et al. (2015). Salinity induced reduction of xylem exudation rate was also observed by Pessarakli and Kabir et al. (2005).

Relative water content

RWC was decreasing with increasing salinity levels (Fig. 2).The control treatment showed 89% RWC and it reduced to 73% at 100 mM salinity level. Organic amendment significantly increased RWC of soybean under control and saline conditions. Highest RWC (93.67%) was observed when biochar was added at 5 t ha^{-1}and lowest RWC (88.67%) was when biochar was added at 10 t ha^{-1} under control condition. At 50 mM salinity condition, highest RWC (88%) was obtained from compost at 5 t ha^{-1}and lowest RWC (84%) was observed, when biochar was applied at 5 t ha^{-1}. Under 100 mM saline condition highest RWC (78.33%) was obtained when soil was treated with compost at 5 t ha^{-1}and it was lowest (76.33%) when biochar was added in the soil at 5 t ha^{-1}. Salinity induced decrease of RWC was also reported by, Nandwal et al. (2000) and Stoyanov (2005) in young bean, Kabir et al. (2005) in mungbean. These findings also correlate with the study of Akhtar et al. (2015), where adverse effects of salinity on the midday water potential of plants were determined, but biochar amendment played its role in overcoming the negative effect of stress on leaf water potential.

Water retention capacity

Salinity decreased the water retention capacity **(**WRC) significantly in soybean plant and the decreasing rate was higher with increasing salinity levels (Fig. 3). Organic amendments significantly increase WRC of soybean among at 5 t ha^{-1} and at 10 t ha^{-1} compost and biochar treatment at 0 mM, 50 mM and 100 mM salinity levels. In case of biochar, WRC were significantly increased by biochar treatment at every salinity level. Highest WRC (8.2) was observed when biochar was added at 5 tha^{-1} and it was 7.6 when biochar was added at 10 t ha^{-1} under control condition. At 50 mM salinity condition highest WRC (6.5) was obtained from biochar at 5 t/ha and lowest WRC (5.4) was observed when compost was applied at 5 t ha^{-1}. Under 100 mM saline condition highest WRC (4.4) was obtained when soil was treated with compost at 5 t ha^{-1}and it was lowest (3.8) when biochar was added in the soil at 10 t ha^{-1}. Organic amendments like compost has beneficial effects on reclamation of saline soils through improvement of soil

Table 1. Effect of organic amendments on chlorophyll a, chlorophyll b and total chlorophyll of soybean leaf under saline conditions.

Treatments	Chlorophyll a (mg g^{-1}fresh wt.)	Chlorophyll b (mg g^{-1} fresh wt.)	Total chlorophyll (mg g^{-1} fresh wt.)
Control	2.54 cd	1.85 ab	4.39 c
50 mM sea water	1.81 gh	1.80 abc	3.61 dfg
100 mM sea water	1.27 k	1.01 fg	2.28 h
Control x 5 tha^{-1} compost	2.72 c	1.91 a	4.63 ab
Control x 10 tha^{-1} compost	2.94 b	1.59 abc	4.53 bc
50 mM sea water x 5 tha^{-1} compost	2.33 ef	1.48 cd	3.81 d
50 mM sea water x 10 tha^{-1} compost	2.26 ef	1.53 bcd	3.79 d
100 mM sea water x 5 tha^{-1} compost	1.86 g	0.63 h	2.49 fgh
100 mM sea water x 10 tha^{-1} compost	1.61 hi	1.04 fg	2.65 dfg
Control x 5 tha^{-1} rice biochar	3.21 a	1.57 bc	4.79 a
Control x 10 tha^{-1} rice biochar	2.99 b	1.73 abc	4.72 ab
50 mM sea water x 5 tha^{-1} rice biochar	2.43 de	1.23 df	3.67 df
50 mM sea water x 10 tha^{-1} rice biochar	2.15 f	1.59 abc	3.74 d
100 mM sea water x 5 tha^{-1} rice biochar	1.58 ij	1.00 fg	2.59 dfg
100 mM sea water x 10 tha^{-1} rice biochar	1.48 ij	0.90 gh	2.38 gh
CV (%)	5.5	14.1	3.8

(Figures having similar letters did not vary significantly)

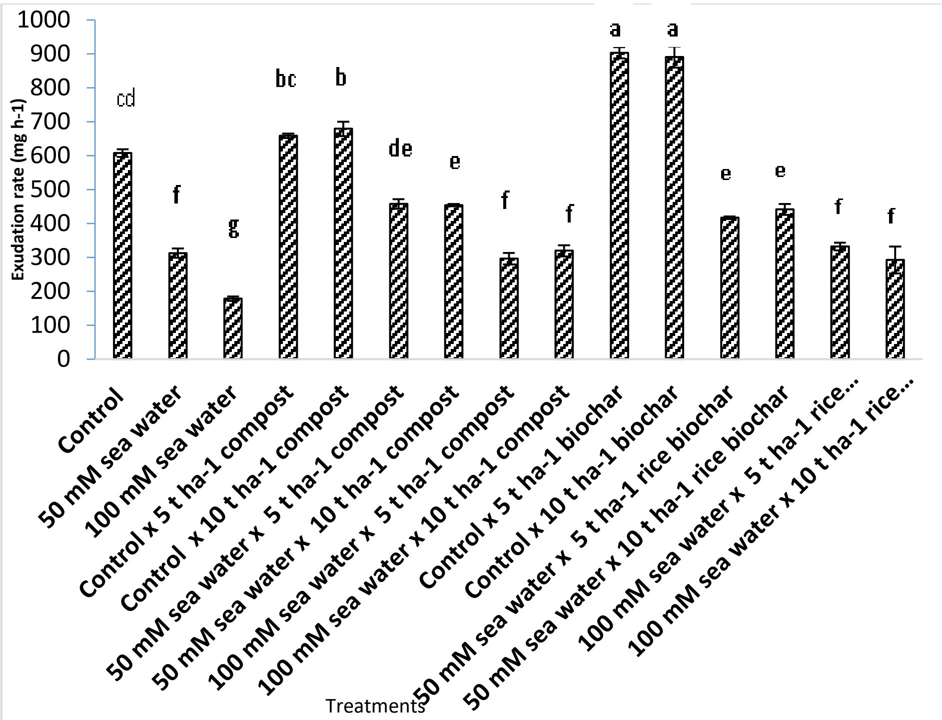

Fig 1. Effect of organic amendments on exudation rate under saline conditions. Bars indicate SE (±). (Figures having similar letters did not vary significantly).

Table 2. Effect of organic amendments on concentration of Na, K, Ca, Mg and Na: K ratio in leaf of soybean under saline conditions.

Treatments	Na (%)	K (%)	Ca (%)	Mg (%)	Na:K ratio
Control	0.71	1.03 ab	1.15 fg	0.54	0.68 bc
50 mM sea water	0.83	0.73 ab	1.07 gh	0.50	1.14 ab
100 mM sea water	0.90	0.62 a	0.86 i	0.40	1.44 a
Control × 5 tha^{-1} compost	0.69	1.09 ab	2.07 c	0.58	0.63 bc
Control × 10 tha^{-1} compost	0.67	1.08 ab	2.27 b	0.58	0.62 bc
50 mM sea water × 5 tha^{-1} compost	0.78	0.83 ab	1.43 e	0.54	0.94 abc
50 mM sea water × 10 tha^{-1} compost	0.75	0.82 ab	1.27 f	0.52	0.91 abc
100 mM sea water × 5 tha^{-1} compost	0.82	0.76 ab	1.06 gh	0.44	1.07 abc
100 mM sea water × 10 tha^{-1} compost	0.81	0.78 ab	0.95 hi	0.47	1.04 abc
Control × 5 tha^{-1} rice biochar	0.63	1.29 a	2.43 a	0.67	0.48 c
Control × 10 tha^{-1} rice biochar	0.66	1.16 ab	2.23 b	0.63	0.57 bc
50 mM sea water × 5 tha^{-1} rice biochar	0.75	1.11 ab	1.63 d	0.59	0.68 bc
50 mM sea water × 10 tha^{-1} rice biochar	0.79	1.09 ab	1.70 d	0.57	0.73 bc
100 mM sea water × 5 tha^{-1} rice biochar	0.83	0.91 ab	1.07 gh	0.44	0.91 abc
100 mM sea water × 10 tha^{-1} rice biochar	0.84	0.85 ab	1.06 gh	0.48	0.99 abc

CV (%)	2.3	3.7	6.1	4.0	4.2

(Figures having similar letters did not vary significantly).

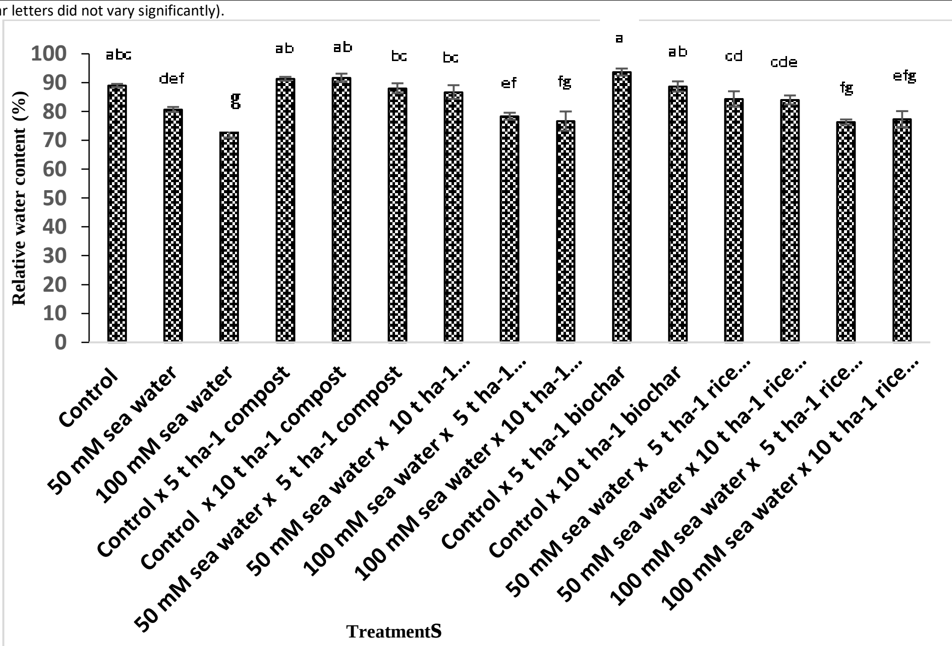

Fig 2. Effect of organic amendments on relative water content under saline conditions. Bars indicate SE (±). (Figures having similar letters did not vary significantly).

Table 3. Effect of organic amendments on concentration of Na, K, Ca, Mg and Na: K ratio in stem of soybean under saline conditions.

Treatments	Na (%)	K (%)	Ca (%)	Mg (%)	Na:K ratio
Control	0.67 b	1.11	0.69 bcde	0.43 c	0.60
50 mM sea water	0.89 ab	0.99	0.63 cde	0.41 c	0.91
100 mM sea water	1.06 a	0.84	0.38 e	0.37 c	1.28
Control × 5 tha^{-1} compost	0.64 b	1.14	0.90 abc	0.46 c	0.57
Control × 10 tha^{-1} compost	0.67 b	1.05	0.86 abcd	0.57 abc	0.64
50 mM sea water × 5 tha^{-1} compost	0.76 ab	0.98	0.82 abcd	0.56 abc	0.79
50 mM sea water × 10 tha^{-1} compost	0.75 ab	1.06	0.71 bcde	0.55 abc	0.71
100 mM sea water × 5 tha^{-1} compost	0.95 ab	0.92	0.45 e	0.53 bc	1.03
100 mM sea water × 10 tha^{-1} compost	0.97 ab	0.91	0.44 e	0.48 bc	1.07
Control × 5 tha^{-1} rice biochar	0.60 b	1.24	1.07 a	0.86 a	0.48
Control × 10 tha^{-1} rice biochar	0.62 b	1.19	0.99 ab	0.79 ab	0.52
50 mM sea water × 5 tha^{-1} rice biochar	0.82 ab	1.15	0.87 abcd	0.62 abc	0.71
50 mM sea water × 10 tha^{-1} rice biochar	0.87 ab	1.06	0.92 abc	0.59 abc	0.82
100 mM sea water × 5 tha^{-1} rice biochar	0.93 ab	1.0	0.46 e	0.42 c	0.93
100 mM sea water × 10 tha^{-1} rice biochar	0.86 ab	0.96	0.55 de	0.45 c	0.90
CV (%)	2.9	4.1	2.9	3.6	5.6

(Figures having similar letters did not vary significantly)

structure and permeability thus enhancing salt leaching, reducing surface evaporation, and inhibiting salt accumulation in surface soils (Raychev et al., 2001). The impact of biochar on soil WRC was most likely related to an effect in overall porosity of the sandy loam soil, which was evident from an increase in saturated soil moisture and macro porosity with 0.5 and 1.6% for each Mgha^{-1} of biochar applied, respectively observed by Carvalho et al. *(*2014). Biochar can improve plant productivity directly as a result of its nutrient content and release characteristics, as well as indirectly, via: improved soil physical properties (Chan et al., 2008), including an increase in soil water retention (Laird et al., 2010). Increasing the water-holding capacity of sandy soils will help improve efficiency of water use in agricultural production, and may be critical for providing enough energy and food for an increasing global population. Biochar added to sandy loam soil increases water-holding capacity and might increase water available for crop use. (Basso et al., 2012).The application of biochar in soil enhances plant growth by improving water retention, soil organic carbon, and nutrient availability via increasing root density (Kappler et al., 2014; Ramzani et al., 2016a).

Concentration of Na, K, Ca, Mg and Na: K ratio in leaf

Salinity significantly increases the concentration of Na and Na: K ratio in leaf of the soybean, while that of K and Ca decreased with increasing salinity levels.Organic amendments with both compost and biochar significantly decreased Na and Na: K ratio of soybean as well as increased the K, Ca, and Mg in leaf of soybean plant at 0mM, 50 mM and 100 mM salinity stress conditions. At control condition, the lowest Na (0.63%) was found when soil was treated with biochar at 5 tha^{-1} and the highest rate (0.69%) was obtained when compost was added in the soil at 5 tha^{-1} and the lowest Na: K (0.48) ratio was found when soil was treated with biochar at 5 tha^{-1} and the highest rate was (0.63) observed when compost was added in the soil at 5 tha^{-1}. At 50 mM salt condition, lowest Na (0.75%) was found when soil was treated with biochar at 5 tha^{-1} as well as compost at 10 t/ha and the highest rate was (0.79%) obtained when biochar was added in the soil at 10 t/ha and lowest Na: K (0.68) ratio was found when soil was treated with biochar at 5 tha^{-1} and it was highest (0.94) when compost was added in

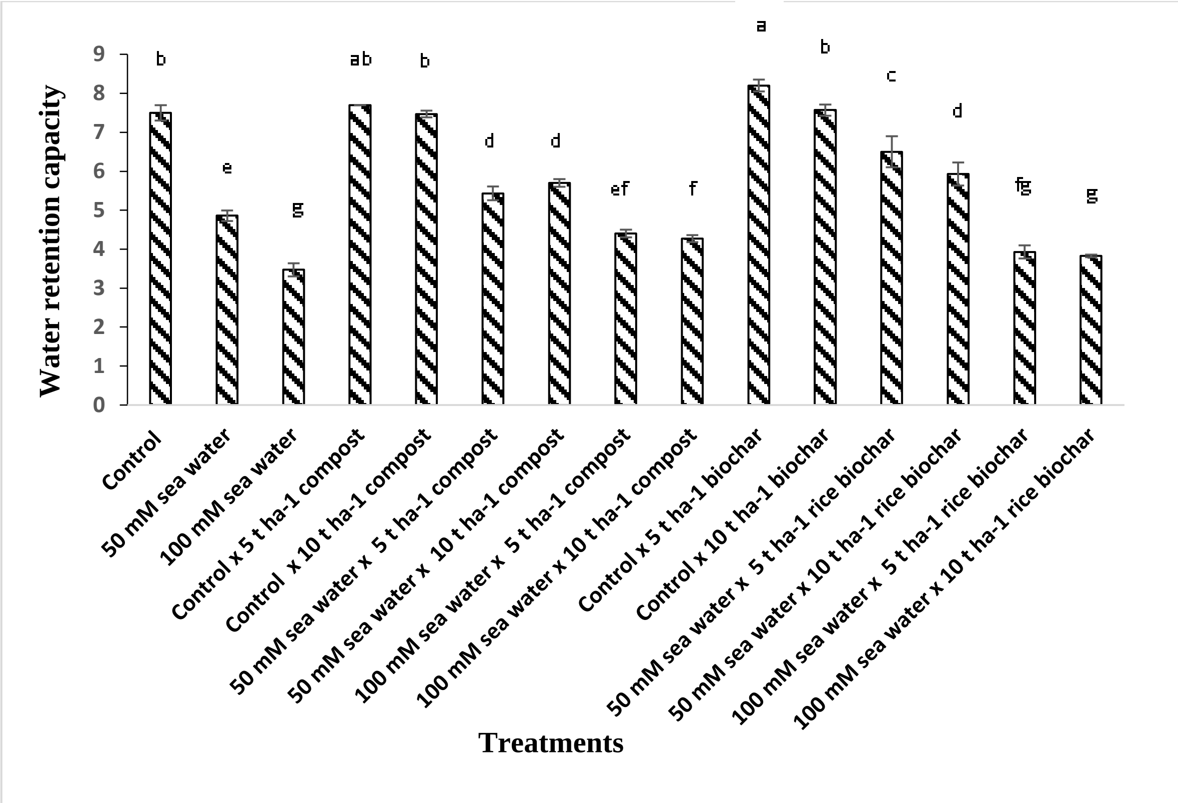

Fig 3. Effect of organic amendments on water retention capacity under saline conditions. Bars indicate SE (±). (Figures having similar letters did not vary significantly).

The soil at 5 tha^{-1}. On the other hand under 100 mM salinity condition the lowest Na (0.81%) was found when soil was treated with compost at 10 t/ha and it was highest (0.84%) when biochar was added in the soil at 10 t/ha and lowest Na: K (0.91) ratio was found when soil was treated with biochar at 5 t/ha^{-1} and it was highest (1.07) when compost was added in the soil at 5 tha^{-1}. Application of 5 t/ha^{-1} biochar performed the best among the organic amendments. At control condition, highest K (1.29%), Ca(2.43%), Mg (0.67%) was found when soil was treated with biochar at 5 t/ha^{-1} and the lowest K(1.08%), Ca(2.07%), Mg (0.58%) when compost was added in the soil at 10 t/ha, 5 t/haand both at 5 tha^{-1} as well as 10 t/ha respectively. At 50 mM salt condition highest K (1.11%), Ca (1.7%), Mg (0.59%) was found when soil was treated with biochar at 5 tha^{-1}, at 10 t/ha 5 t/ha, respectively, and the lowest K (0.82%), Ca (1.27%), Mg (0.52%) when compost was added in the soil at 10 t/ha. At 100 mM salt stress condition highest K (0.91%), Ca (1.07%), Mg (0.48%) was found when soil was treated with biochar at 5 tha^{-1}, 5 t/ha and 10 t/ha, respectively and the lowest K (0.76%), Ca (0.95%), Mg (0.44%) when compost was added in the soil at 5 tha^{-1}, at 10 t/ha and 5 t/ha, respectively. The compost and manure increased markedly the shoot growth; this seemed to be related to decreases in the shoot concentrations of Na and Cl and increases in K (Ashraf et al., 2004). Conversely, Leithy et al. (2010) found that organic amendments did not show any changes of nutrient content except Na. Organic manures have been shown to increase K/Na ratio in sweet fennel (Abou El-Magdet al., 2008). Biochar can increase nutrient content and improved retention of nutrients (Lehmann et al., 2003; Wardle et al., 1998); Amanullah (2008) showed in rice crop.

Concentration of Na, K, Ca, Mg and Na: K ratio in stem

There was variation in accumulation of these elements in stem of soybean plant due to different salinity levels (Table 3). The concentration of Na in stem of the soybean increased, while that of K, Ca and Mg were decreased with increasing salinity levels. Organic amendments with both compost and biochar significantly decrease Na and Na: K ratio of soybean as well as increase the K, Ca, Mg in stem of soybean plant at 0 mM, 50 mM and 100 mM salinity stress conditions. At control condition lowest Na (0.60%) was found when soil was treated with biochar at 5 tha^{-1} and it was highest (0.67%) when compost was added in the soil at 10 t ha^{-1} and lowest Na: K (0.48) ratio was found when soil was treated with biochar at 5 tha^{-1} and it was highest (0.64) when compost was added in the soil at 10 t ha^{-1}. At 50 mM salt condition lowest Na (0.75%) was found when soil was treated with compost at 10 t ha^{-1}and it was highest (0.87%) when biochar was added in the soil at 10 t ha^{-1} and lowest Na: K (0.71) ratio was found when soil was treated with biochar at 5 tha^{-1} and it was highest (0.82) when biochar was added in the soil at 10 t ha^{-1}.On the other hand under 100 mM salinity stress condition, lowest Na (0.86%) was found when soil was treated with biochar at 10 t ha^{-1} and it was highest (0.97%) when compost was added in the soil at 10 t ha^{-1} and lowest Na: K (0.90) ratio was found when soil was treated with both biochar at 10 t ha^{-1} and at 10 t ha^{-1} compost, whereas, the highest ratio (1.07) was found when compost was added in the soil at 10 t ha^{-1}. At control condition, highest K (1.24%), Ca (1.07%), Mg (0.86%) were found when soil was treated with biochar at 5 t/ha^{-1} and the lowest K(1.05%), Ca (0.86%), Mg (0.46%) were obtained, when compost was added in the soil ha at 10 t ha^{-1}@ 10 t/ha and at 5 tha^{-1}, respectively. At 50 mM salt condition, highest K (1.15%), Ca (0.92%),Mg (0.62%) were found when soil was treated with biochar @ 5 t/ha, at 10 t ha^{-1}@ 10 t/ha and 5 t/ha, respectively and the lowest K (0.98%), Ca (0.71%), Mg (0.55%) when compost was added in the soil at 5 tha^{-1}, at 10 t ha^{-1} and 10 t/ha, respectively. At 100 mM salt stress condition, highest K(1.0%), Ca (0.55%), Mg (0.53%) was found when soil was treated with biochar at 5 t/ha^{-1}, at 10 t ha^{-1} and compost at 5 tha^{-1}, respectively, and the lowest K (0.91%) , Ca (0.44%)@ 10 t/ha compost and Mg (0.42%) when biochar was added in the soil at 5 tha^{-1}, respectively. Incorporation of organic materials for reducing deleterious effects of saline water was reported by many scientists (Minhas et al., 1995; Choudhary et al., 2002). In relation to the application of compost and its benefits, researchers (Graber et al., 2010, Zhang et al., 2012) confirmed that biochar can be also an important tool to increase Ca, K and Mg in soybean plants. The high Na+ adsorption capacity of biochar has also been recently reported by Thomas et al. (2013). Biochar maintains the nutrient balance in soil solution by releasing mineral nutrients, particularly K^+, Ca^{2+} and Mg^{2+}, thereby reducing Na^+ uptake, which ultimately increased the ratio of K^+ or other cations to Na^+ (Aktar et al., 2015).

Materials and Methods

The experiment was carried out at the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladeshfrom November 2015 to March 2016.

Planting material

BARI cultivar of soybean was tested.

Soil analysis

The soil was a sandy loam with pH (6.93), total N (0.07%), available P (0.08 mg 100 g^{-1}), exchangeable K (0.79 $cmol_c$ kg^{-1} dry soil), available S (10ppm), organic carbon (0.61%), CEC (13.05 $cmol_c$ kg^{-1} dry soil) and EC0.4 dSm^{-1}.

Treatments: Two organic amendments i. water hyacinth compost ii. rice husk biochar were mixed in soil of pot at 5 t ha^{-1} and 10 t ha^{-1} of both. Chemical composition of water hyacinth compost and rice husk biochar are presented in the following table (Shaon, 2016)

Organic amendments	pH	N %	P %	K %	Ca %	Mg %	S %	EC ms/cm
compost	5.9	1.10	0.096	0.16	1.08	0.12	0.63	0.35
Biochar	7.15	2.57	0.21	0.231	1.024	0.458	0.339	1.325

Saline solution was prepared by adding tap water in sea water to make 50 and 100 mM salinity level equivalent to 5 and 10 dSm^{-1}, respectively. Sea water was collected from the Bay of Bengal and the concentration was 400 mM equivalent to 40 dS m^{-1}. Salt solutions were applied in pots from 14^{th} days after sowing (DAS) to maturity and in control pots tap water was used. The treatment combinations were: i. Control (no amendments and no saline water) ii. 50 mM sea water iii. 100 mM sea water iv. Control ×5 tha^{-1} compost v. Control ×10 tha^{-1} compost vi. 50 mM sea water ×5 tha^{-1} compost vii. 50mM sea water ×10 tha^{-1} compost viii. 100mM sea water ×5 tha^{-1} compost ix.100mM sea water ×10 tha^{-1} compost x. Control ×5 tha^{-1}rice biochar xi. Control ×10 tha^{-1}rice biochar xii. 50mM sea water ×5 tha^{-1}rice biochar xiii.50mM sea water ×10 tha^{-1}rice biochar xiv.100mM sea water ×5 tha^{-1}rice biochar xv.100mM sea water ×10 tha^{-1} rice biochar. The experiment was laid out in CRD with three replications. Data on different physiological parameters like chlorophyll content, exudation rate, relative water content (RWC), water retention capacity (WRC) in leaf were measured at flowering stage as well as Na, K, Ca, Mg and Na: K ratio in leaf and stem were also recorded at harvest.

Statistical analysis

The recorded data were statistically analyzed by "CROPSTAT 7.2" software to examine the significant variation of the results due to different treatments. The treatment means were compared by Duncan's Multiple Range test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

Conclusion

Salinity decreased chlorophyll content, exudation rate, relative water content, water retention capacity and K, Ca, Mg content in leaf and stem of soybean plant. Application of water hyacinth compost and rice husk biochar had positive effects to mitigate negative effects of salinity on physiological parameters studied. However, rice husk biochar at the rate of 5 t ha^{-1} showed best result to mitigate salinity effects at low salinity (50 mM) condition.

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