Research Article

Use of Hyacinth Compost in Salt-Affected Soils

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Abstract | Composting the unwanted aquatic weeds for supply of essential plant nutrients and improving the health of salt-affected soil is a simpler technique. Therefore, present research work was carried out to appraise the efficacy of water hyacinth compost as an ameliorant for improving the deteriorated properties of saline-sodic soil. Treatments included were; T_1, control, T_2, gypsum @ 100 % GR, T_3, gypsum @ 50 % of GR, T_4, hyacinth compost @ 15 t ha^{-1}, T_5, gypsum @ 50 % of GR + hyacinth compost @ 5 t ha^{-1}, T_6, gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1}, T_7, gypsum @ 50 % of GR + hyacinth compost @ 15 t ha^{-1}. At start of study, soil had pH_s (pH of soil saturated past) = 8.91, SAR (sodium adsorption ratio) = 44.24, EC_e (electrical conductivity of soil extract) = 5.02 (dS m^{-1}), GR (gypsum requirement) = 10.18 (t ha^{-1}), BD (bulk density) = 1.66 (Mg m^{-3}), HC (hydraulic conductivity) = 0.35 (cm hr^{-1}). Rice and wheat, crops were grown in the rotation. Data analysis showed that gypsum and hyacinth compost remarkably improved the soil SAR, pH_s, EC_e, BD, HC, growth and yield characteristics of rice and wheat crops, however at the same time use of gypsum and hyacinth compost in combination proved more superior to their sole application. Hyacinth compost @ 10 and 15 t ha^{-1} with gypsum @ 50 % of GR performed equally in all studied parameters of rice and wheat crops and soil properties. Therefore, integrated use of gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1}, seem as economical and a potential agro-ecological strategy for improving the deteriorated properties of saline-sodic soil and crop production.

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Introduction

Any material (organic or inorganic), applied to soil to provide one or more essential plant nutrients is called fertilizer (Vidya and Lakshmi, 2014). Weeds are one of the overlooked natural resources that can support and help to reduce the use of chemical fertilizers. The addition of compost to salt-affected soil improved the soil properties including soil porosity water holding capacity, improved nutritional status, bulk density, soil pH_s, EC_e and SAR (Zaka *et al*., 2018; Wright *et al*., 2007).

Aquatic weed, water hyacinth (*Eichhornia crassipes*) grows at an alarming rate and float freely on rivers, ponds, lakes etc. (Lata and Veenapani, 2011). Due to its harmful effects on people's livelihoods and water bodies, it is known as the most obnoxious weed in the world (Wilson *et al*., 2005; Singh and Bishnoi, 2013). Attempts made to control this weed through different means like biological, physical and chemicals have met with little success (Abdelsabour, 2010). Nonetheless, different researchers presented the idea to obtain the benefits from this aquatic weed rather than seeing it as a rogue plant (Anjanabha and

Kumar, 2010). Suitable and effective exploitation of the discarded hyacinth weed is indispensable as waste management (Ganguly *et al.*, 2012; Sotolu, 2013). The cost-effective and simplest technique that can be employed is composting of this aquatic weed (Gupta *et al.*, 2007). Water hyacinth, besides being a menace in water bodies, can be a cost-effective substitute for organic fertilizer in abundant quantity (Adesina *et al.*, 2011). In India, almost 200,000 ha of watercourses contain approximately 250 t ha^{-1} of water hyacinth and 100 tons of water hyacinth can produce 10 tons of compost so there is possibility of almost 5 million tons of hyacinth compost (Gratch, 1968).

Water hyacinth is a rich source of potassium that is present in sufficient amounts, particularly in its stalk (Gunnnarsson and Petersen, 2007). It is also documented as a rich source of phosphorus and nitrogen (Sahu *et al.*, 2002). Water hyacinth compost could then be added to soil as a source of organic NPK which are the most crop growth limiting plant nutrients (Wasonga *et al.*, 2008). Water hyacinth compost is increasingly being used as organic manure to supply nutrients for plant growth (Malik, 2007). According to Balasubramanian *et al.* (2013) hyacinth compost has a great potential to accelerate microbial activities that maintained the soil nutrient pool. Water hyacinth composted material is a rich source of N (3.2% in its dry mass) with a C: N ratio of 8 to 15 (Khan and Sarwar, 2002; Gunnarsson and Petersen, 2006). Osoro *et al.* (2014) stated that hyacinth compost can be efficiently used to enhanced maize production and restoration of soil health. They reported that compost from water hyacinth positively influenced the plant height, and root and shoot dry weight of maize crop. Hyacinth compost is the best alternative of organic manure as it significantly increases the protein, chlorophyll and reduces sugar contents, and improves the germination%, root and shoot length and biomass of wheat plants. Soil health was also improved by augmented organic matter contents (Vidya and Lakshmi, 2014).

Sanni and Adesina (2012) studied the response of *Celosia argentea* (Lagos spinach) to application of water hyacinth manure. They reported that growth and yield parameters of *C. argentea* were remarkably influenced by all applied treatment and hyacinth manure at the rate of 2.64 kg/plot (plot size of 2.7m × 1.5m) was the best among all the treatments. Similarly, Abdel-Fattah (2012) reported that the different combinations of gypsum with organic amendments (water hyacinth compost, and rice straw compost) were more useful in reducing the pH_s, SAR and EC_e of salt-affected soil than their sole application. Khan and Sarwar (2002) studied the effect of four levels of hyacinth compost (300, 500 and 1000 g per pot filled at the rate of six kg of soil) on physicochemical properties of soil and rice crop. They reported that increasing levels of compost increased the cation exchange capacity, reserved the moisture contents, and enhanced the formation of micro aggregate of soil. Rice grain yield increased by 8.13 % with the highest level of compost and they recommended the hyacinth compost as a very good natural source of organic fertilizer. Lekshmi and Viveka (2011) assessed the effect of fungal treated hyacinth compost on the performance of *Abelmoschus esculentus*. They stated that hyacinth compost remarkably increased the germination%, plant height, flowers and fruits of *Abelmoschus esculentus,* and enhanced the soil fertility status by improving the availability and content of the soil macro and micro-nutrients.

So, the current study was conducted to determine the effectiveness of hyacinth compost with gypsum and alone as an ameliorant for the reclamation of saline-sodic soil.

Materials and Methods

The present research work was carried out from 2015 to 2018 at Soil Salinity Research Institute, Pindi Bhattian, Pakistan. Before start of study, soil had SAR = 44.24, EC_e = 5.02 (dS m^{-1}), pH_s = 8.91, GR = 10.18 (t ha^{-1}), HC = 0.35 (cm hr^{-1}), BD = 1.66 (Mg m^{-3}). Treatments included were: T_1, control, T_2, gypsum @ 100 % GR, T_3, gypsum @ 50 % of GR, T_4, hyacinth compost @ 15 t ha^{-1}, T_5, gypsum @ 50 % of GR + hyacinth compost @ 5 t ha^{-1}, T_6, gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1}, T_7, gypsum @ 50 % of GR+ hyacinth compost @ 15 t ha^{-1}. The experiment was laid out in RCBD having three repeats. Hyacinth compost was prepared according to (How to build a compost www.exsands.com/ Gardening/ how to buildac). Fresh water hyacinth was collected from a nearby drain. It was chopped into small pieces. Cemented bins with size of 1.25 × 1.25×1.25 meters were used for compositing purpose. Bins were filled with alternate layers of water hyacinth (7 cm) and soil (3 cm). Compositing material was mixed after every fifteen days to ensure

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the proper decomposition. Well rotten decomposed compost was ready after 14 weeks (Table 1). Hyacinth compost and gypsum was applied thirty days before rice transplantation according to the treatment plan. During Kharif season 2015, rice (Shaheen Basmati) nursery was transplanted. Fertilizers @ 150-90-60 NPK kg ha^{-1} were applied to rice. Agronomic and plant protection measures were applied uniformly. Yield and yield characteristics of rice crop were recorded at the physical maturity of the crop. After the harvest of rice crop, wheat crop (Faislabad-2008) was sown in the same field. Fertilizers @ 160-114-60 NPK kg ha^{-1} were applied. All agronomic and plant protection measures were applied uniformly. Yield and yield determining parameters were recorded at maturity. Soil samples were collected at the end of the study and were analyzed for pH_s, EC_e, SAR, bulk density and hydraulic conductivity according to U.S. Salinity Laboratory Staff (1954). The collected crop data (rice and wheat) was statistically analyzed. The treatment mean comparison was made using the Least Significant Difference Test @ 5% probability (Steel *et al*., 1997) using STATISTIX 8.1 package software.

Table 1: *Chemical composition of hyacinth compost.*

Determinations	Units	
pH	-	5.85
EC	dS m^{-1}	0.56
Organic-C	%	32.00
Total-N	%	1.72
C/N ratio	-	18.60
P	%	0.096
K	%	0.72

Results and Discussion

Rice crop

Pooled data of rice crop showed that gypsum and hyacinth compost significantly influenced the growth characteristics of rice crop, however, at the same time integrated use of gypsum and hyacinth compost showed more positive effects than their sole application. Data in (Table 2) displayed that gypsum and hyacinth compost significantly ($P \leq 0.05$) increased the plant height and maximum value of 133.67 cm was observed in T_7 (gypsum @ 50 % of GR + hyacinth compost @ 15 t ha^{-1}) which was insignificant with gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1} (T_6). Whereas, the lowest plant height of 120.0 cm was documented in control (T_1). Data about spikelet $panicle^{-1}$ and tillers m^{-2} showed that maximum spikelet (215) and tillers (230) were observed with gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1} followed by gypsum @ 50 % of GR + hyacinth compost @ 15 t ha^{-1} and statistically both treatments were alike. On the other hand, minimum tillers (215) and spikelet (200) were observed where no amendments were used i.e. in control (Table 2). Data revealed that the highest 1000-grain weight (30 g) was divulged at gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1}, followed by gypsum @ 50 % of GR + hyacinth compost @ 15 t ha^{-1} and gypsum @ 50 % of GR + hyacinth compost @ 5 t ha^{-1} and all the treatments were statistically alike (Table 3). While, control produced the lowest 1000-grain weight of 25 g. Data about paddy and straw yield showed inclining pattern, amongst all the treatments, combination of gypsum and hyacinth compost performed better than their individual application. Compost @ 10 and 15 t ha^{-1} with gypsum performed equally well in paddy and straw yield, however, compost @ 10 t showed its superiority over other treatments and maximum paddy (3.71 t ha^{-1}) and straw yield (9.29 t ha^{-1}) was documented in gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1} (Table 3). On the contrary, minimum paddy (1.85 t ha^{-1}) and straw yield (4.94 t ha^{-1}) were documented in T_1 i.e. control.

Wheat crop

Data about wheat crop exhibited that increasing levels of hyacinth compost with gypsum significantly improved growth and yield attributes, however, hyacinth compost remained effective only up to 10 t ha^{-1} and further increase had no significant influence on these attributes. Data in (Table 4) showed that taller plants (70.66 cm) were observed in gypsum @ 50 % of GR + hyacinth compost @ 15 t ha^{-1} statistically insignificant with gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1}. Data also showed that maximum number of tillers (162.67), grain $spike^{-1}$ (30) and 1000-grain weight (33 g) were ensued with gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1} statistically alike with gypsum @ 50 % of GR + hyacinth compost @ 15 t ha^{-1}. Minimum number of tillers (133.33), 1000-grain weight (26 g) and grain $spike^{-1}$ (25) were divulged in control. Yield data revealed that maximum grain (3.58 t ha^{-1}) and straw yield (4.62 t ha^{-1}) were achieved with application of gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1} followed by gypsum @ 50 % of GR + hyacinth

Table 2: *Effect of hyacinth compost and gypsum on rice growth (average of three seasons).*

Treatments	Plant height (cm)	No. of spikelet panicle^{-1}	No. of tillers m^{-2}
T_1 - Control	120.00 d	200.00 e	215.00 d
T_2 - Gypsum @ 100% of GR	126.33 bc	208.33 bc	223.00 b
T_3 - Gypsum @ 50 % of GR	125.00 bc	204.67 cd	221.00 bc
T_4 -Hyacinth compost @ 15 t ha^{-1}	124.33 c	200.67 de	218.33 cd
T_5 - Gypsum @ 50 % of GR + Hyacinth compost @ 5 t ha^{-1}	127.33 b	214.00 a	223.67 b
T_6 - Gypsum @ 50 % of GR + Hyacinth compost @ 10 t ha^{-1}	131.33 a	215.00 a	230.00 a
T_7 - Gypsum @ 50 % of GR + Hyacinth compost @ 15 t ha^{-1}	133.67 a	212.67 ab	229.33 a
LSD	2.7128	4.5189	3.885

Table 3: *Effect of hyacinth compost and gypsum on rice growth (average of three seasons).*

Treatments	Paddy Yield (t ha^{-1})	Straw Yield (t ha^{-1})	1000 grain weight (g)
T_1 - Control	1.85 d	4.94 d	25.00 c
T_2 - Gypsum @ 100% of GR	3.64 a	9.35 a	27.33 b
T_3 - Gypsum @ 50 % of GR	2.58 c	6.86 c	26.66 bc
T_4 -Hyacinth compost @ 15 t ha^{-1}	2.44 c	6.43 c	25.66 bc
T_5 - Gypsum @ 50 % of GR + Hyacinth compost @ 5 t ha^{-1}	2.96 b	7.79 b	29.33 a
T_6 - Gypsum @ 50 % of GR + Hyacinth compost @ 10 t ha^{-1}	3.71 a	9.29 a	30.00 a
T_7 - Gypsum @ 50 % of GR + Hyacinth compost @ 15 t ha^{-1}	3.52 a	8.97 a	29.66 a
LSD	0.2261	0.5258	1.6996

Table 4: *Effect of hyacinth compost and gypsum on wheat growth (average of three seasons).*

Treatments	Plant height (cm)	No. of grain spike^{-1}	No. of tillers m^{-2}
T_1 - Control	60.00 e	25.00 d	133.33 c
T_2 - Gypsum @ 100% of GR	65.00 cd	27.33 bc	156.33 ab
T_3 - Gypsum @ 50 % of GR	63.33 d	26.00 cd	151.33 b
T_4 -Hyacinth compost @ 15 t ha^{-1}	60.66 e	25.66 cd	150.00 b
T_5 - Gypsum @ 50 % of GR + Hyacinth compost @ 5 t ha^{-1}	66.66 bc	28.66 ab	160.67 a
T_6 - Gypsum @ 50 % of GR + Hyacinth compost @ 10 t ha^{-1}	68.66 ab	30.00 ab	162.67 a
T_7 - Gypsum @ 50 % of GR + Hyacinth compost @ 15 t ha^{-1}	70.66 a	29.00 a	161.00 a
LSD	2.6425	2.0110	6.6185

Table 5: *Effect of hyacinth compost and gypsum on wheat growth (average of three seasons).*

Treatments	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	1000 grain weight (g)
T_1 - Control	1.52 d	2.02 d	26.00 c
T_2 - Gypsum @ 100% of GR	3.53 a	4.59 a	28.33 b
T_3 - Gypsum @ 50 % of GR	2.89 bc	3.82 bc	27.33 bc
T_4 -Hyacinth compost @ 15 t ha^{-1}	2.68 c	3.56 c	27.00 bc
T_5 - Gypsum @ 50 % of GR + Hyacinth compost @ 5 t ha^{-1}	3.10 b	4.03 b	29.00 b
T_6 - Gypsum @ 50 % of GR + Hyacinth compost @ 10 t ha^{-1}	3.58 a	4.62 a	33.00 a
T_7 - Gypsum @ 50 % of GR + Hyacinth compost @ 15 t ha^{-1}	3.49 a	4.51 a	32.00 a
LSD	0.3318	0.4380	2.0966

compost @ 15 t ha^{-1} and gypsum @ 100 % of GR and these treatments were statistically insignificant from each other (Table 5). Whereas minimum grain (1.52 t ha^{-1}) and straw (2.02 t ha^{-1}) yield were recorded in control.

Table 6: *Effect of hyacinth compost and gypsum on soil chemical properties at the end of study.*

Treatments	EC_e	% decrease over initial value	pH_s	% decrease over initial value
T_1 - Control	4.98	0.80	8.88	0.34
T_2 - Gypsum @ 100% of GR	2.78	44.62	8.26	7.30
T_3 - Gypsum @ 50 % of GR	3.29	34.46	8.44	5.27
T_4 -Hyacinth compost @ 15 t ha^{-1}	3.79	24.50	8.57	3.82
T_5 - Gypsum @ 50 % of GR + Hyacinth compost @ 5 t ha^{-1}	3.14	37.45	8.37	6.06
T_6 - Gypsum @ 50 % of GR + Hyacinth compost @ 10 t ha^{-1}	2.76	45.02	8.29	6.96
T_7 - Gypsum @ 50 % of GR + Hyacinth compost @ 15 t ha^{-1}	2.86	43.03	8.27	7.18

Table 7: *Effect of hyacinth compost and gypsum on soil chemical properties at the end of study.*

Treatments	SAR	% decrease over initial value
T_1 - Control	44.16	0.18
T_2 - Gypsum @ 100% of GR	12.26	72.29
T_3 - Gypsum @ 50 % of GR	20.52	53.62
T_4 -Hyacinth compost @ 15 t ha^{-1}	27.24	38.43
T_5 - Gypsum @ 50 % of GR + Hyacinth compost @ 5 t ha^{-1}	15.04	66.00
T_6 - Gypsum @ 50 % of GR + Hyacinth compost @ 10 t ha^{-1}	10.86	75.45
T_7 - Gypsum @ 50 % of GR + Hyacinth compost @ 15 t ha^{-1}	12.08	72.69

Soil properties

Soil analysis data displayed that soil physical and chemical properties were substantially improved at the end of study by gypsum and hyacinth compost applied either singly or in combination, however, at the same time their integrated use was more effective in reclaiming the salt-affected soil than their sole application. Data regarding the soil EC_e revealed that maximum reduction of 45.02% over its initial value was noted with gypsum @ 50% of GR + hyacinth compost @ 10 t ha^{-1} followed by gypsum @ 50 % of GR + hyacinth compost @ 15 t ha^{-1} with a reduction of 43.03% over its initial value (Table 6). Whereas, minimum reduction in EC_e (0.80%) was recorded in control. With respect to soil pH_s maximum reduction (7.18%) was observed with gypsum @ 50% of GR + hyacinth compost @ 15 t ha^{-1} and lowest reduction of 0.34% was noted where no amendments were used i.e. in control (Table 6). Similarly, soil sodicity indicator i.e. SAR was also significantly improved by the amendments. Maximum reduction (75.45%) in soil SAR was recorded with gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1} and lowest reduction (0.18%) was noted in control (Table 7). Data regarding soil bulk density showed that hyacinth compost @ 10 and 15 t ha^{-1} with gypsum @ 50 % of GR performed equally in improving the soil bulk density with a maximum reduction of 4.79 % over its initial value and on the other hand minimum reduction of 0.60 % was documented in control (Figure 1). Soil hydraulic conductivity was also remarkably ameliorated by gypsum and hyacinth compost. A maximum increase (31.43%) in hydraulic conductivity was documented with gypsum @ 100% of soil GR. On the contrary, a minimum increase of 2.86% was observed in control (Figure 2).

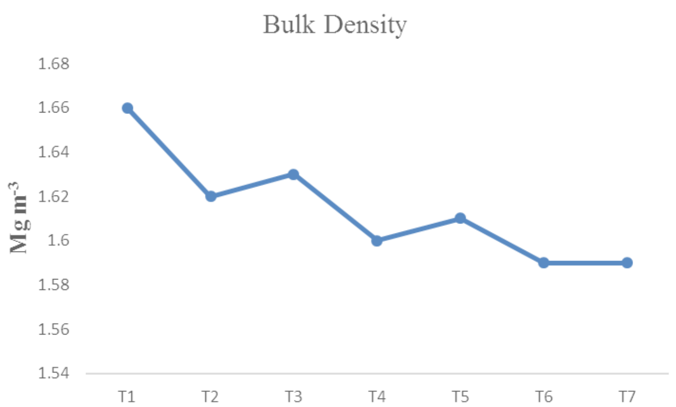

Figure 1: *Effect of hyacinth compost and gypsum on bulk density ($Mg\ m^{-3}$) of soil at the end of study.*

Water hyacinth with a terrific potential of high rate of vegetative growth (Wilson *et al*., 2005) causing a severe interruption to the nation's development activities (Maine *et al*., 1999). It degraded the water quality and reduces its movement, blockage of canals and rivers, clogging water supply ways, restricted the oxygen and light diffusion and causes the changes in the plant and animal community (Gopal, 1987). Despite of all these environmental hazardous created by water hyacinth, some advantageous aspects have also been reported. It is worthful in making of ropes, carbon black production, mushroom bedding material, biogas production, use in traditional medicine, production of fiber boards, green manure, ornamental plant, fish feed and as animal fodders (Jayaweera *et al*., 2007; Singh and Bishnoi, 2013; Vidya and Lakshmi, 2014). Owing to low lignin content of 9% and a narrow C: N ratio of 1:24.3 this obnoxious waterweed has high potential productivity for organic fertilizers (Jafri, 2010). Previously, hyacinth compost is reported as nutrient rich organic fertilizer which accelerated the microbial activities and enhanced the fertility status of the soil. So, it was decided to assess the ameliorative effect of hyacinth compost on the poor health of salt-affected soil and the productivity of rice-wheat crops. Hyacinth compost and gypsum were applied either singly or in different combinations. Results of three years study revealed that hyacinth compost with gypsum produced more pronounced effects on growth and yield characteristics of rice and wheat crops than their sole application. In most cases, yield and yield characteristics of both crops were remarkably increased with gypsum @ 50 % of GR and hyacinth compost application @ 10 t ha^{-1} while further increase in compost quantity i.e. 15 t ha^{-1} could not produce the significant effect and most of the yield determining factors of both crops remain stagnant. Improved crop growth and yield of rice or wheat crop with gypsum and hyacinth compost @ 10 and 15 t ha^{-1} may be attributed to improved fertility status of soil, as hyacinth compost is rich source of essential macro and micro-nutrients (Balasubramanian *et al*., 2013; Viveka and Grace, 2009) which release during mineralization process. The results are consistent with earlier findings that water hyacinth compost increased the yield of corn, onion, sesame, rice, gourd and brinjal (Majid *et al*., 1980; Majid, 1983, 1992). Comparable results were reported by (Gunnarsson and Petersen, 2007) that hyacinth compost improved the nutritional status of poor soil and consequently crop yield is increased. Similarly, composted water hyacinth material increased the yield of rice (Amitava *et al*., 2008), cowpea (Seoudi, 2013) and tomato (Kayum *et al*., 2008). Chukwuka and Omotayo (2009) suggested that hyacinth compost improved soil fertility on a sustainable basis by supplying the nitrogen during the mineralization process which results the increased production of *Zea mays* crop. Hyacinth compost remarkably improved the growth parameters in wheat crop (Widjajanto *et al*., 2001) and physicochemical properties and microbial activities in soil (Lata and Veenapani, 2011). Furthermore, being easily decomposable water hyacinth qualifies as a potential organic source for nutrient management which can also stimulate microbial activities (Balasubramanian *et al*., 2013). *Brassica Juncea* showed a positive response in growth and yield to water hyacinth manure application (Lata and Veenapani, 2011). In addition, plants were also benefited through improved soil properties by the ameliorative effects of gypsum (Ahmed *et al*., 2015).

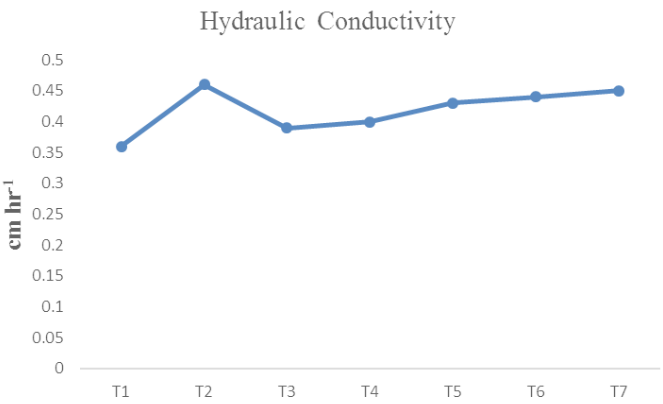

Figure 2: *Effect of hyacinth compost and gypsum on hydraulic conductivity (cm hr^{-1}) of soil at the end of study.*

Soil analysis data of the current study exhibited that soil properties were noticeably improved with integrated use of gypsum and compost. Gypsum is a rich source of Ca^{2+} which substitutes the Na^{+} from the exchange site and leaches it out of root zone and consequently, soil properties were improved (Abdel-Fattah, 2012). On the other hand, hyacinth compost releases the organic acids and CO_2 during mineralization (Tisdale *et al*., 1985) which solubilizes the native Ca^{2+} to replace Na^{+} from the exchange site (Qadir and Oster, 2002). Therefore, a sharp decline in soil salinity indices (pH_s, EC_e and SAR) was observed with hyacinth compost and gypsum.

The effects of soil EC_e, pH_s and SAR are directly translated into soil physical properties. The higher value of BD indicates harder and less porous soil. Soil BD was also substantially improved with the application of gypsum and hyacinth compost which correspond to more favorable soil conditions. Similarly, hydraulic conductivity also increased manifold with hyacinth compost and gypsum. Improved value of soil bulk density and hydraulic conductivity may be explained on the basis that gypsum improves the soil porosity and flocculation of clay particles (Shainberg *et al*., 1989). Several researchers also concluded that gypsum and compost improved the soil physical properties (Ahmed *et al*., 2015; Zaka *et al*., 2018)

Conclusions and Recommendations

Water hyacinth compost can be used to support with partial replacement of chemical fertilizers to improve crop production and to amend the deteriorated properties of saline-sodic soil. From the above results, it is established that the combined use of hyacinth compost and gypsum is more beneficial than their individual application. Hyacinth compost @ 10 and 15 t ha^{-1} with gypsum @ 50 % of GR performed equally in all studied parameters of rice and wheat crops and soil properties. Therefore, integrated use of gypsum @ 50 % of GR + hyacinth compost @ 10 t ha^{-1} in salt-affected soils may promote better utilization of this obnoxious waterweed.

Novelty Statement

Unwanted aquatic weed, water hyacinth (*Eichhornia crassipes*) is considered as a rogue plant, whereas composting of discarded hyacinth weed is a suitable waste management technique. In salt affected soils integrated use of gypsum @ 50 % of GR + hyacinth compost@ 10 t ha-1, seem as economical and a potential agro-ecological strategy for improving the deteriorated properties of saline-sodic soil and crop production.

Author's Contribution

Khalil Ahmed, conceived the idea, conducted the study for three years and wrote the article, Amar Iqbal Saqib and Ghulam Qadir, wrote abstract and materials and methods, Muhammad Qaisar Nawaz, Muhammad Khalid, and Muhammad Arif did data collection and statistical analysis, Abdul Rasul Naseem and Imtiaz Ahmad Warraich, provided technical input at every step.

Conflict of interest

The authors have declared no conflict of interest.

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