Effect of Compost on the Nitrate Phytoremediation by the Mung Bean Plant

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ABSTRACT

The present study aims to investigate the effect of compost on the nitrate absorption capability of the mung bean plant by employing the phytoremediation method. The examined factors at 7 levels include nitrate alone at concentration levels of 10 mg/L, 30 mg/L and 50 mg/L, nitrate at concentration levels of 10 mg/l, 30 mg/l and 50 mg/l together with compost and control treatment (compost- and nitrate-free soil) along with soil depth at three levels of 0-10 cm, 10 cm -20 cm and 20 cm -30 cm. The highest wet weights of the plant during the pod setting and maturity stages corresponding to the roots, were estimated as 36.97 g and 17.69 g in the compost+nitrate treatment at concentration level of 50 mg/L (SCn3), respectively. However, the lowest wet weight during the pod setting stage was recorded in the plant shoot as 4.87 g (control treatment) while it was measured as 6.41 g for the leaf during the maturity stage in the compost+irrigation treatment with a nitrate concentration of 30 mg/l (Scn_2). Furthermore, the highest plant's dry weight (103.3 g) was related to the plant root and irrigation treatment with 50 mg/l nitrate (Sn3) while the lowest one (26.7 g) was associated with the leaf and control treatment. According to the results obtained, during the pod setting stage, the nitrate uptake rate by mung bean root and shoot increased with the increasing compost. Moreover, at high nitrate concentration levels, the effect of compost on the nitrate uptake rate by the mung bean plant was greater and this matter was eventually transferred to the plant shoot.

Key words: Compost; Mung bean; Nitrate; Wet weight; Salinity; Phytoremediation

INTRODUCTION

Nitrate is one of the most important sources of water contamination and imposes a serious threat to the aquatic ecosystems. One of the nitrogen sources used in Iran is the urea chemical fertilizer. Studies show that the continued use of chemical fertilizers reduces the crop yield due to the soil acidi fication, degradation of the soil's physical and chemical properties and lack of micronutrients in them [1].

Phytoremediation is an effective, inexpensive, environmentally friendly and widely applicable method. It means using the capacity of plants to revitalize the environment using the low-cost technologies with the aim of eliminating various water and soil contaminations [2].

The phytoremediation costs are about 10 to 100 times lower than that of physico-chemical methods [3]. One of the effective processes in increasing the phytoremediation efficiency is the use of biological and organic fertilizers. As an organic fertilizer, compost has recently attracted much attention.

Organic matter increases the cation exchange capacity of the soil [4]. Which varies depending on the type of the material. It improves the soil structure and improves the conditions for biomass production and phytoremediation [5].

Among the studies conducted on the phytoremediation, one can refer to the researches performed and titled evaluation of the rangeland plants potential for the phytoremediation of soils contaminated with lead and zinc (rangelands around Zanjan Lead and Zinc Company) [6]. The ability of native plants around Zanjan province's industrial centers to accumulate the heavy metals [7].

Results showed that heavy metals in stations close to the lead and zinc smelting industrial complexes are much higher than average showing a high correlation with their respective metal concentrations in soils. This clearly indicates that heavy metal contents in tree leaves in the studied area are solely related to industrial activities notably National Iranian Lead and Zinc (NILZ) as well as Zinc Specialized Industrial Complex (ZSIC) companies.

Based on the results, the studied native plants accumulate different metals selectively and *Populus nigra* was found to be the best accumulator plant for Mn, Zn and Cd, *Thuja orientalis*, as the best phytoextractor for Fe, and *Cupressus sempervirens* var arizonica is the best species among the studied native plants for accumulation of pb.

Amirnejad, et al. investigated the interactions of alkalinity, salicylic acid and soil type on the growth parameters of the mung bean plant [8]. Their results indicated that a salicylic acid concentration of 500 µM as the optimal amount is able to neutralize the negative effect of the severe alkalinity stress.

Rouhi, et al. employed the neural network models in order to investigate the effect of biochar and compost on the contaminated soils. They found that the zinc and chromium contents of the soil increase by adding 0.8% compost and 0.52% biochar [9].

Mung bean with the scientific name *Vigna radiata* L. is a plant from the Fabaceae family. This plant plays an important role in the fertility and improving the physical properties of soil due to its ability to coexist with nitrogen-fixing bacteria in the air and produce organic matter [10].

According to the above and due to the importance of paying attention to the soil contamination caused by the industrial and agricultural activities, the aim of the present study is to use the phytoremediation and study the effect of compost on the nitrate phytoremediation ability by the mung bean plant that did not performed in researches of last.

MATERIALS AND METHODS

Soil and plant samples decomposition

The soil used in this research was prepared from the research farm of Gonbad Kavous University, which was prepared from a depth of 0 cm-30 cm, mixed and then poured into the pots. The soil properties before testing are presented in Table 1. Prior to the experiment, the soil and plant samples were first air-dried and then nitrate and salinity traits were measured as well.

Table 1. Properties of the soil under investigation.

Depth (cm)	EC (ds/m)	Ɵfc	Ɵm	clay	silt	sand	n	ρ^b	θ_s	NO_3^{-1}	pH	Ɵpwp
				(%)								
0-30	0.175	0.22	4.08	5.8	72	22.2	0.44	1.15	2.27	8.52	6.11	0.08

Note: EC=Electrical Conductivity, Ɵfc=Field Capacity (soil is wet), Ɵm=Surface Temperature, n=Nitrogen, ρ^b=Lead, θ_s=Osmium, NO_3^{-1}=Nitrate ion, pH=Potential of Hydrogen, θpwp=Permanent Wilting Point (soil is dry).

Experiment performance

The factorial experiment was conducted in a randomized complete block design with two replications in the greenhouse of Gonbad-e Kavous University. The examined factors included nitrate + compost composition at 7 levels, including nitrate concentration levels of 10 mg/l (Sn1), 30 mg/l (Sn2), 50 mg/l (Sn3), 10 mg/l nitrate +compost (Scn1), 30 mg/l nitrate + compost (Scn2), 50 mg/l nitrate + compost (Scn3) and soil treatment without compost and nitrate (control) along with soil depths at three levels of 0-10 cm, 10 cm-20 cm and 20 cm-30 cm. 3 kg pots were used for conducting the experiments and soil samples were poured into them after being air-dried and mixed. A total number of 28 pots were used for the experiments. In the soil and compost treatments, the amount of compost was considered to be 8% of the soil weight inside each pot. Five mung bean seeds of VC1973A cultivar were planted inside each pot in a circular pattern. Irrigation was performed once every five days by weighing each pot. For the uniform germination under the salinity stress and stress-free conditions, the first few irrigations were accomplished with the urban water. In the four-leaf stage, two plants were left in each pot and the rest were thinned. The application of nitrate treatments was initiated at the beginning of the flowering stage. Also, the potassium nitrate salt was used to impose the nitrate stress. During the pod setting and maturity stages, the roots, shoots and leaves of mung bean plant were sampled and several parameters such as Electrical Conductivity (EC), pH, soil and mung bean plant nitrate contents, wet and dry weights of the shoot and root (dried in an oven at 70°C for 72 h) were measured as well. The relative percentage of soil particles, pH of saturated flowers, electrical conductivity of the saturated flower and nitrate concentration were determined by hydrometer method (2013), pH meter, EC meter and spectrophotometer, respectively. In order to compare the mean values, the Least Significance Difference (LSD) test was used at 5% level.

RESULTS AND DISCUSSION

Nitrate and salinity within two stages of pod setting and maturity under the influences of soil depth and nitrate + compost composition

According to Table 2, the effects of soil depth and nitrate + compost composition on the nitrate and salinity traits were significant during the pod setting and maturity stages at 1% level. It is observed that the interaction effect of soil depth × nitrate + compost composition on the salinity during the pod setting stage is significant at 5%

level. However, it is significant at 1% level on the nitrate content during the pod setting and salinity during the pod setting and maturity stages.

Table 2. Results of Analysis of Variance (ANOVA) associated with the nitrate and salinity under the effects of soil depth and nitrate + compost composition.

Source	Freedom degree	Nitrate(maturity)	Salinity(maturity)	Nitrate(pod setting)	Salinity(pod setting)
block	1	1.157 ns	46.16**	2.419**	20.86*
depth	2	8.04**	8634**	27.2**	909.2**
treatment	6	36.78**	615.1**	21.77**	85.11**
a × b	12	3.62**	34.25**	0.35**	7.94*
error	20	0.64	5.59	0.09	2.93
CV (%)	–	8.38	3.77	5.62	11.07

Note: ns, * and ** stand for the non-significant and significant at 5 and 1% levels, respectively, a=depth, b=treatment.

Table 3. Comparison of the nitrate and salinity mean values during the pod setting and harvesting stages under the effect of nitrate + compost composition in the soil depths.

NO^{3-}	Depth	Y1	Y2	Y5	Y9	Y10
1	1	10.88^{cde}	68.35^{d}	8.38^{kj}	10.88^{cde}	68.35^{d}
2	1	7.76^{jkhi}	83.84	8.28^{kj}	7.76^{jkhi}	83.84^{c}
3	1	7.82^{jkhi}	93.12	19.07^{g}	7.82^{jkhi}	93.12^{b}
4	1	8.49^{jghi}	102.60^{a}	28.95^{c}	8.49^{jghi}	102.6^{a}
5	1	7.19^{jk}	81.1	8.89^{j}	7.20^{jk}	81.1^{c}
6	1	12.44^{cb}	103.2^{a}	23.64^{e}	12.44^{cb}	103.2^{a}
7	1	17.69^{a}	106.1^{a}	36.97^{a}	17.69^{a}	106.1^{a}
1	2	9.3^{fghe}	39.5^{j}	4.87^{m}	9.3^{fghe}	39.5^{j}
2	2	7.3^{jki}	44.9^{ihj}	6.24^{ml}	7.3^{jki}	44.9^{ihj}
3	2	8.29^{jghi}	54.1^{feg}	12.78^{i}	8.29^{jghi}	54.1^{feg}
4	2	10.49^{fde}	55.8^{fe}	19.34^{g}	10.49^{fde}	55.8^{fe}
5	2	7.70^{jkhi}	49^{hg}	6.98^{kl}	7.70^{jkhi}	49^{hg}
6	2	10.22^{fde}	57.9^{fe}	16.21^{h}	10.22^{fde}	57.9^{fe}
7	2	13.74^{b}	58.7^{e}	25.62^{d}	13.74^{b}	58.7^{e}
1	3	8.9^{fghi}	26.7^{k}	5.92^{ml}	8.9^{fghe}	26.7^{k}
2	3	7.21^{jki}	40.5^{ij}	7.17^{kl}	7.21^{jki}	40.5^{ij}
3	3	7.96^{jkhi}	45.5^{ih}	14.31^{i}	7.96^{jkhi}	45.5^{ih}
4	3	9.94^{fgde}	52.8^{fg}	21.95^{f}	9.94^{fgde}	52.8^{fg}
5	3	6.41^{k}	46.25^{h}	8.08^{kj}	6.41^{k}	46.25^{h}
6	3	9.88^{fgde}	52.9^{fg}	21.15^{f}	9.88^{fgde}	52.9^{fg}
7	3	11.36^{cd}	54.1	33.44^{b}	11.36^{cd}	54.1^{feg}

Note: y=yield, a, b, c, d, e, f, g, h, I, j, k indicate significant letters, similar letters indicate no significant difference.

Here, control, Sn1, Sn2, Sn3, Scn1, Scn2 and Scn3 stand for the control, 10 mg/l, 30 mg/l and 50 mg/l nitrate, 10mg/l, 30 mg/l and 50 mg/l nitrate + compost treatments, respectively.

Comparison of the nitrate mean values during the pod setting stage

As can be seen from Table 3, the highest nitrate concentration was observed during the pod setting stage in compost+ nitrate treatment with a concentration of 50 mg/L and soil depth of 0-10 cm (Scn3). The excess nitrate in this treatment can be attributed to its high consumption as well as short time interval between the consumption and measurement. Also, the lowest value was obtained from the control treatment and the depth of 10 cm-20 cm, which did not show a significant difference with the other three ones. Nitrate was not used in this treatment and the consumed nitrate also penetrated less deeply.

Comparison of the nitrate mean values during the maturity stage

The highest nitrate amount was achieved as 17.69 mg/L in the maturity stage in the Scn3 treatment and soil depth of 0-10 cm. However, the lowest value was estimated as 6.41 mg/L in the soil depth of 20 cm-30 cm while using compost + irrigation together with nitrate at a concentration of 10 mg/L which did not show a significant difference with the seven above-mentioned treatments.

Comparison of the wet and dry weights of the mung bean plant during the pod setting and maturity stages

According to Table 5, mung bean leaves have the highest wet weight during the pod setting stage and the highest dry weight in the pod setting and harvesting stages as well. In addition, the highest plant's wet weights associated with the roots were obtained as 36.97 g and 17.69 g during the pod setting and maturity stages.

Comparison of the salinity mean values during the maturity stage

The highest (102.60 μmhos/cm) and lowest (39.5 μmhos/cm) EC values during the harvesting stage were related to the Sn3 treatment in a soil depth of 0-10 cm and control one in a depth of 10 cm-20 cm, respectively (Table 3). Thomas indicated that the increasing salinity and biochar treatments significantly affect the soil salinity. Also, the highest soil salinity values during the pod setting and harvesting stages were observed to be 126.6 μ Siemens/cm and 106.1 μ Siemens/cm in the compost + salinity treatment, respectively, which was consistent with the result reported by Thomas, et al. [11].

Nitrate, salinity, wet and dry weights of the mung bean plant within the two stages of pod setting and maturity under the influence of plant organ and nitrate + compost composition

According to the results of ANOVA listed in Table 4, the nitrate, salinity and wet weight traits within the pod setting and harvesting stages and dry weight within pod setting and maturity ones, were affected by the plant organ at 1% and 5% levels, respectively. The effect of nitrate + compost composition on the nitrate and salinity traits during the pod setting and harvesting stages was observed to be significant at 1% level while it was significant at 5% level on the wet weight within the pod setting one. Other traits were not affected by nitrate + compost composition. The interaction effect of treatment × organ on the nitrate and salinity was significant at 1% level during the pod setting and harvesting stages, but the other traits were not affected.

Table 4. Nitrate, salinity, wet and dry weights of mung bean under the effects of plant organ and Nitrate + compost composition during the pod setting and maturity stages the pod setting and harvesting stages, respectively (using Scn3).

Source	Freedom degree	Nitrate (maturity)	Salinity (maturity)	Nitrate (pod setting)	Salinity(pod setting)	Dry weight (maturity)	Wet weight (maturity)	Dry weight (pod setting)	Wet weight (pod setting)
block	1	2.25ns	48.85**	0.154ns	168.56**	0.22*	0.38ns	0.26*	0.0076ns
plant	2	127.04**	551.53**	293.13**	5434.22**	0.31*	11.67**	0.33*	14.96**
Treat -ment	6	562.23**	2212.06**	172.63**	2481.09**	0.02ns	0.11ns	0.03ns	0.29*
a × b	12	8.58**	40.63**	30.65**	80.21**	0.08ns	0.06ns	0.04ns	0.18ns
error	20	1	1	1.1	11	0	0	0.04	0.1
CV (%)	-	5	1	10	4	63	34	71.1	31

Note: ns, * and ** stand for the non-significant and significant at 5 and 1% levels, a=depth, b=treatment.

However, the lowest wet weights were related to the shoot during the pod setting stage (4.87 g) in the control and leaf during the harvesting stage (6.41) when using the Scn2 treatment. Moreover, the highest and lowest dry weights of the plant were measured as 103.3 g and 26.7 g for the roots (Sn3 treatment) and leaves (control), respectively.

Table 5. Simple effects of the plant organ on the wet and dry weights during the pod setting and harvesting stages.

Plant organ	Wet weight (pod setting)	Dry weight (pod setting)	Wet weight (maturity)	Dry weight (maturity)
1	0.3869	0.20650	2.11	0.5011
2	0.5633	0.17293	0.55	0.5539
3	2.2590	0.45400	0.50	2.1086

Note: 1.root, 2. Stem, 3. Leaf.

Table 6. Simple effects of various treatments on the wet weight during the pod setting stage.

Treatment	Wet weight(pod setting)
1	1.1225
2	0.9062
3	0.7135
4	1.2407
5	1.3778
6	0.9812
7	1.1463

Comparison of the means associated with the simple effects of treatments on the mung bean plant's wet weight during the pod setting stage

Table 6 presents the simple effects of control, Sn1, Sn2, Sn3, Scn1, Sc and Scn3 treatments on the wet weight of the mung bean plant during the pod setting stage. According to this table, the highest and lowest wet weights were observed in Scn1, Scn1 and Scn2 to the amounts of 1.38, 0.91 and 0.71, respectively.

Nitrate content in the plant during the pod setting and maturity stages

Figures 1 and 2 exhibit the interaction effect of the treatment × organ on the nitrate concentration in the plant during the pod setting and maturity stages. As would be observed, the highest nitrate uptakes during the pod setting and maturity stages were dedicated to the plant roots and measured as 30.32 mg/L and 10.33 mg/L, respectively. However, the lowest nitrate amounts were related to the plant shoot in the pod setting (3.14 mg/L) and mung bean leaves in the maturity (1.5 mg/L) stages.

According to Figures 1 and 2, the highest nitrate concentration and salinity in the pod setting stage are related to plant roots and compost fertilizer application. However, the highest salinity in the plant during the maturity stage is associated with the plant roots in the absence of compost. Also, the highest wet weight of the plant was measured for the root in the absence of compost. Furthermore, the highest weight of the plant is at the root of the plant and without compost. The highest salinity amounts during the pod setting and maturity stages were measured as 126.55 μmhos/cm and 28.5 μmhos/cm for the roots using Scn2 and Sn3 treatments, respectively. Also, the lowest salinity was evaluated as 38.9 μmhos/cm by the plant shoot in the pod setting stage (Sn1 treatment) and 3.3 μmhos/cm by the leaf in the maturity one (using Scn2). According to the results obtained, compost has a great effect on the nitrate and salinity uptake by the roots.

Figure 1. The interaction effect of the treatment × organ on the nitrate concentration in the plant during the pod setting stage (LSD5%=0.28)

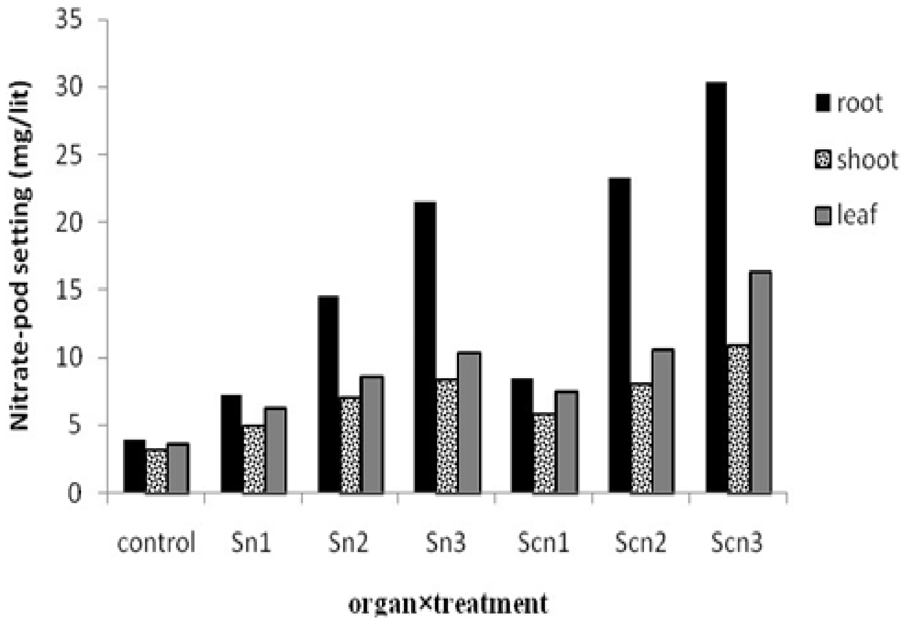
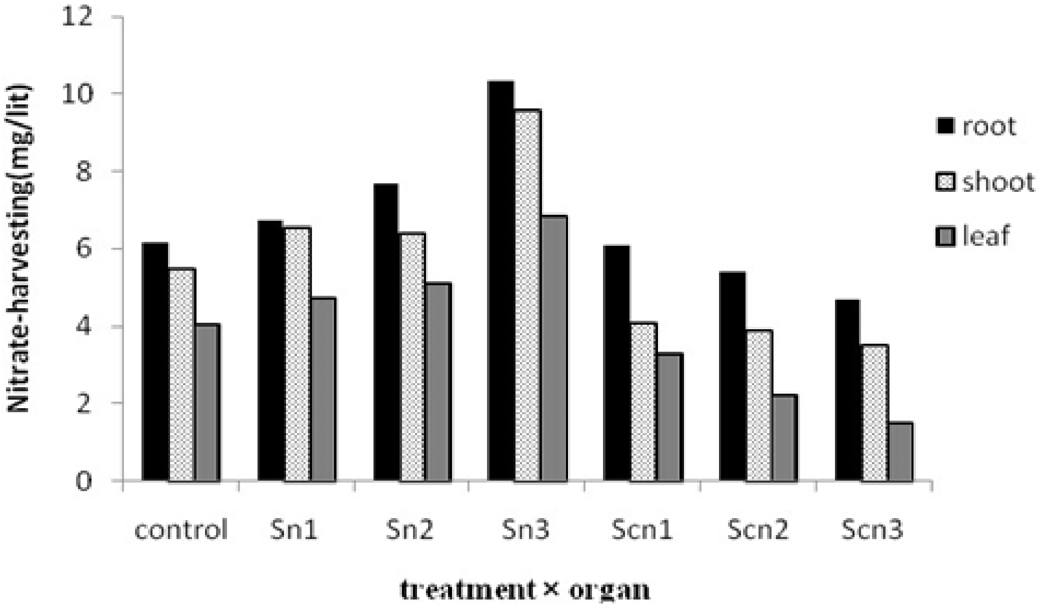


Figure 2. The interaction effect of the treatment × organ on the nitrate concentration in the plant during the maturity stage (LSD5%=0.0778)



As can be seen from Figures 1 and 2, the nitrate uptake in the control treatment is measured as 3.95 mg/l and the absorbed amount by plant organs increases with increasing compost. At high nitrate concentrations, the effect of compost on the amount of nitrate uptake by the mung bean plant has increased. During the pod setting stage, the absorbed nitrate amounts at concentration levels of 10 mg/L, 30 mg/L and 50 mg/L were estimated as 8.5 mg/L, 23.32 mg/L and 30.33 mg/L by the root, 5.79 mg/L, 8.02 mg/L and 10.83 mg/L by the shoot, 7.43 mg/L, 10.52 mg/L and 16.27 mg/L by the leaf, respectively. However, during the maturity stage of the mung bean plant, the absorbed nitrate amounts at concentration levels of 10 mg/L, 30 mg/L and 50 mg/L were found to be 8.89 mg/L, 23.64 mg/L and 36.97 mg/L by the root, 6.98 mg/L, 16.21 mg/L and 25.62 mg/L by the shoot, 8.08 mg/L, 21.15 mg/L and 33.44 mg/L by the leaf, respectively.

According to Figure 1, the highest and lowest concentrations of nitrate has accumulated in the mung bean plant roots and shoot, respectively.

As shown by these figures, the highest amounts of nitrate uptake during the pod setting and harvesting stages by plant roots were measured as 30.33 mg/L and 36.97 mg/L, respectively. However, the lowest absorbed concentrations by the shoot were evaluated as 5.79 and 6.98 mg/l within the two mentioned stages, respectively. According to the Statistical Analysis Results (SAS), the amount of nitrate uptake by the plant organs under the conditions of control and compost addition to the soil, has been significantly different.

Figures 3 and 4 show the interaction effect of the treatment × plant on the salinity concentration during the pod setting and maturity stages, respectively. Figure 5 also shows the concentration of nitrate absorbed in various treatments to remove the saline ions from water.

Figure 3. The interaction effect of the treatment × plant on the salinity concentration during the pod setting stage (LSD5%=0.0067).

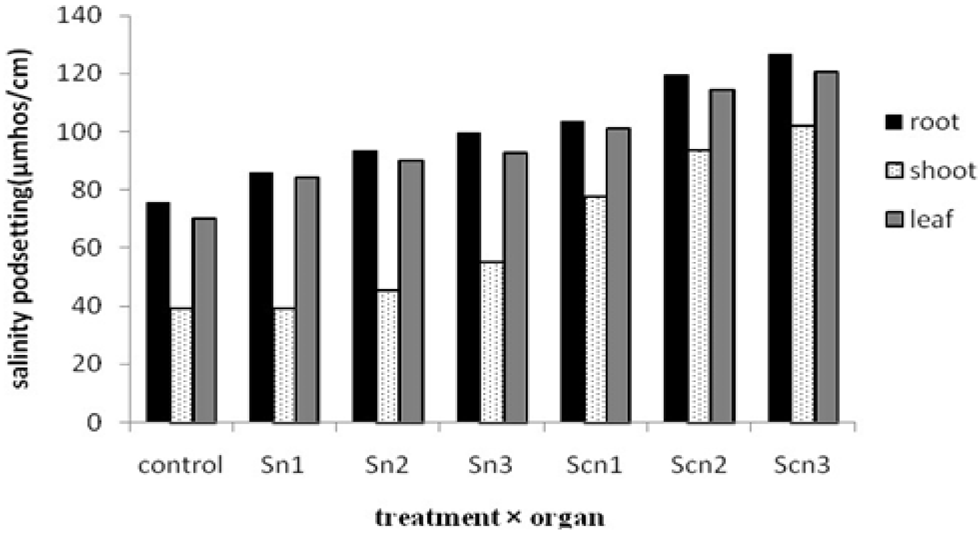
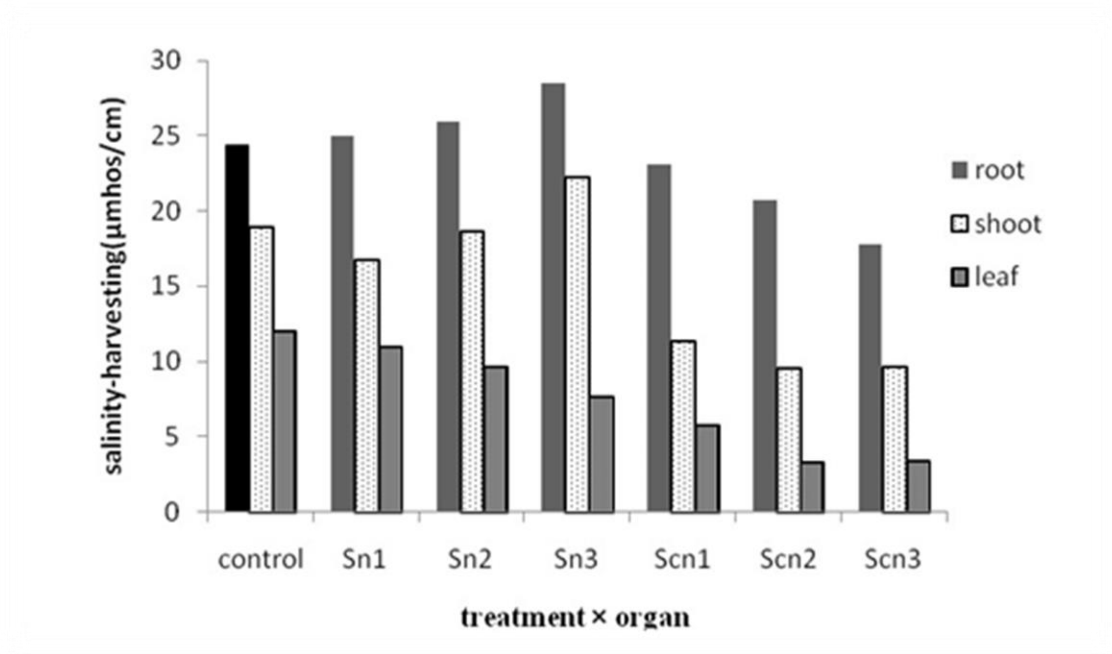


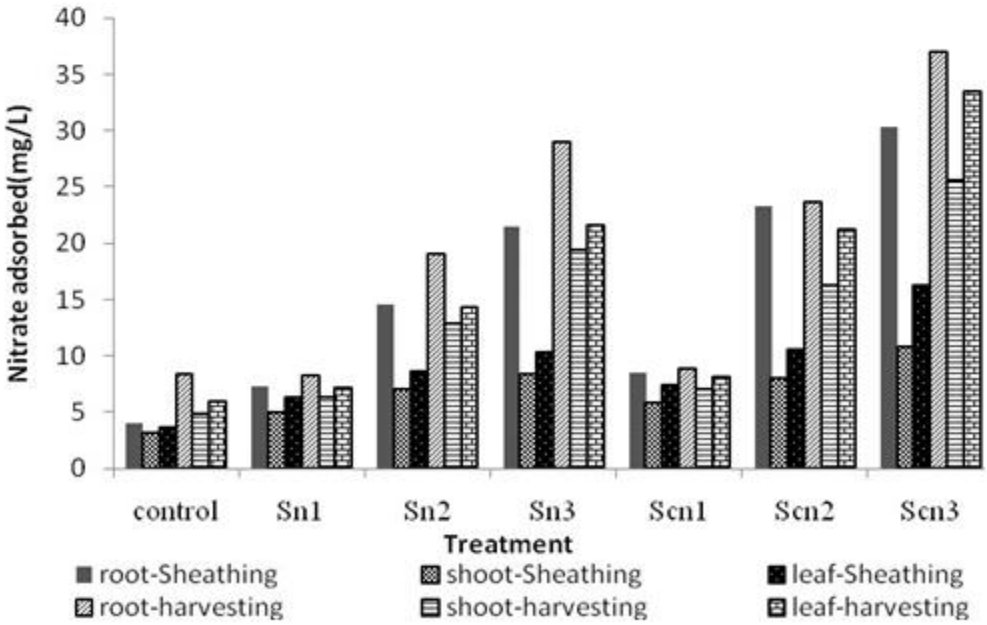
Figure 4. The interaction effect of the treatment × plant on the salinity concentration during the maturity stage (LSD5%=0.0361).



According to Figures 3 and 4, the highest absorbed salinity in the control treatment was observed for the mung bean leaves to the amount of 70.25 µmhos/cm and salinity uptake by plant organs increased with increasing compost. At high nitrate concentrations, the effect of compost on the absorbed amount of salinity by the mung bean plant has increased. During the pod setting stage, the amounts of salinity absorbed at concentration levels of 10 mg/L, 30 mg/L and 50 mg/L by the root were measured as 85.95 µmhos/cm, 93.4 µmhos/cm and 99.75 µmhos/cm, respectively. However, these values for the plant shoot were achieved as 38.95 µmhos/cm, 45.1 µmhos/cm and 55.25 µmhos/cm, respectively.

During the maturity stage, the absorbed nitrate amounts at concentration levels of 10, 30 and 50 mg/L were estimated as 24.95 µmhos/cm, 25.95 µmhos/cm and 28.5 µmhos/cm by the root, 16.7 µmhos/cm, 18.6 µmhos/cm and 22.2 µmhos/cm by the shoot, 10.95 µmhos/cm, 9.6 µmhos/cm and 7.6 µmhos/cm by the leaf, respectively. According to Figure 1, the highest salinity amount has accumulated in the plant root and the lowest one has piled up within the mung bean plant's shoot and leaf during the pod setting and maturity stages, respectively.

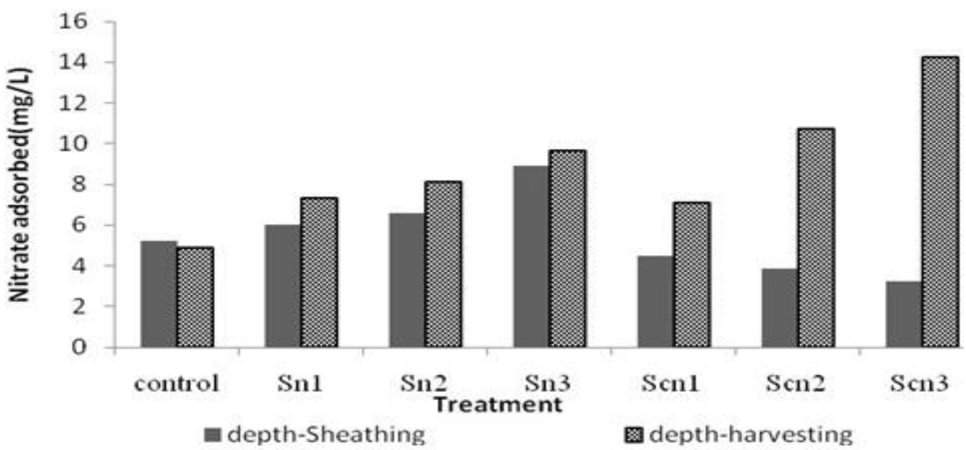
Figure 5. The nitrate concentration absorbed in various treatments in order to remove the saline ions from water.



As can be seen from Figure 5, the concentration of nitrate absorbed when using Scn3 treatment is higher for all three plant organs (roots, shoot and leaves).

The Figure 6 shows the influence of the absorbed nitrate concentration by the soil during the pod setting and maturity stages.

Figure 6. The effect of the absorbed nitrate concentration by the soil during the pod setting and maturity stages.



According to Figure 6, when using irrigation together with various nitrate concentrations of 10 mg/L, 30 mg/L and 50 mg/L, upon adding compost, the concentrations of nitrate accumulated in the soil were calculated to be 4.48 mg/L, 3.85 mg/L and 3.22 mg/L during the pod setting stage, respectively. However, the accumulated nitrate concentration in the control treatment was obtained as 5.22 mg/L. These values point out to the nitrate accumulation increasing in the soil at a concentration level of 10 mg/l compared to the control treatment.

In the maturity stage of the mung bean plant, the nitrate concentrations were reached 7.10 mg/L, 10.73 mg/L and 14.16 mg/L, in the above-mentioned three treatments, respectively and 4.86 mg/L in the control. These values indicate an increasing accumulation of nitrate in the soil during the irrigation with high concentration of nitrate (50 mg/L). Also, the highest nitrate amount absorbed by the soil was observed in the irrigation mode with 50 mg/L nitrate.

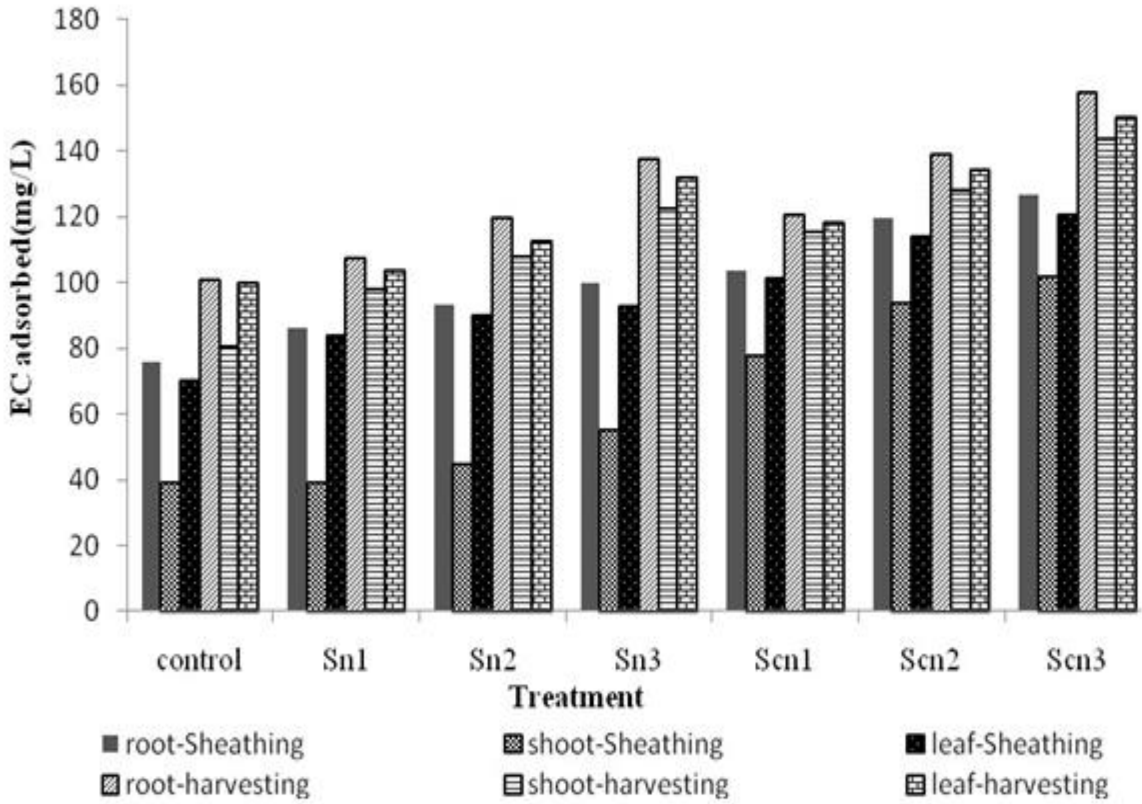
Comparison of the mean values associated with the treatments (Figures 1-6), indicated that the nitrate content of the plant increases with increasing compost. Statistically, the nitrate extent in the nitrate and compost + nitrate treatments significantly differs from the control with remarkably increased nitrate level in the plant. The results obtained from the research also show that the plant has a higher nitrate level upon using the Scn3 treatment. Nitrate is often the main source of available nitrogen in most plants, especially vegetables [12]. The nitrate amount in the soil, which may be related to the application of commercial fertilizers, is a major factor in determining the amount of nitrate accumulation in vegetables [13]. The results of this study have been in close agreement with those reported by Peyvast, et al. illustrated that increasing the amount of municipal waste compost to 100 tons per hectare, has led to the lowest amount of nitrate in the leaves and petioles of Chinese cabbage [14]. However, according to the results of the current study, the highest and lowest nitrate accumulations were observed in the root and shoot, respectively.

Peyvast, et al. indicated that the use of cow manure, municipal waste compost and vermicompost, have reduced the nitrate accumulation in Chinese cabbage, spinach, garlic, broccoli and parsley [15]. Moreover, the reduced nitrate accumulation was reported by the use of garden compost in lettuce during one crop season.

Utilizing 20 tons, 40 tons and 60 tons per hectare of poultry manure and three levels of inorganic fertilizer alone with the same concentrations, Vimala, et al. indicated that increasing fertilizer concentration does not significantly increase the nitrate amount in the plant [16] and did not increase the plant. The highest nitrate content has been reported for the fertilized products with inorganic fertilizers [17]. Our results are in agreement with the results of Sami, et al. in spinach [18]. Table 5 shows the results of the simple effects of plant organs on the studied traits. The present results were in compliance with those reported by Samih, et al. for spinach [18]. Table 5 lists the results associated with the simple effects of the plant organ on the studied traits.

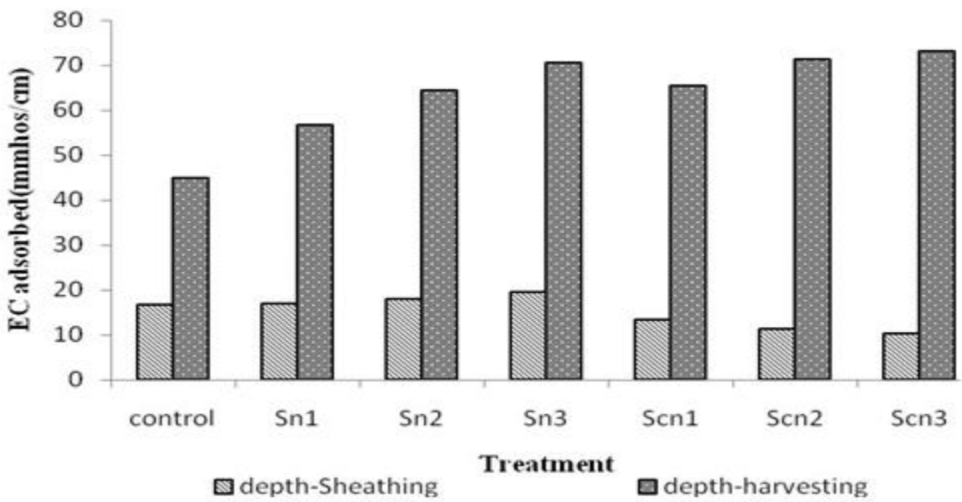
As illustrated by Figure 7, with increasing compost, the salinity amounts during the pod setting stage have been estimated as 103.55 µmhos/cm, 119.55 µmhos/cm and 126.55 µmhos/cm in the root, 77.7 µmhos/cm, 93.6 µmhos/cm and 101.85 µmhos/cm in the shoot, 101.25 µmhos/cm, 114.15 µmhos/cm and 120.75 µmhos/cm in the leaf, while using Sn1, Sn2 and Sn3 treatments, respectively. As would be observed, the salinity accumulation in the roots is higher than that of the leaves to the amount of 2%. Furthermore, with increasing compost, the salinity contents during the harvesting stage have been measured as 120.75 µmhos/cm, 139.1 µmhos/cm and 157.8 µmhos/cm in the root, 115.5 µmhos/cm, 128.3 µmhos/cm and 143.5 µmhos/cm in the shoot, 118.45 µmhos/cm,134.1 µmhos/cm and 150.2 µmhos/cm in the leaf, while using irrigation with the three nitrate concentration levels, respectively. Similar to the case observed in the pod setting stage, the salinity accumulation in the roots is higher than that of the leaves to the amount of 2%.

Figure 7. The effect of different treatments on the salinity absorbed by the plant.



According to Figure 7, with increasing compost and irrigation with nitrate-containing water, the salinity content has increased in plant organs, especially in the mung bean root. Figure 8 shows the effect of different treatments on the salinity absorbed by the soil.

Figure 8. The effect of different treatments on the salinity absorbed by the soil.



According to Figure 8, with increasing compost, the soil EC levels during the pod setting stage were achieved as 13.37 mmhos/cm, 11.20 mmhos/cm and 10.25 mmhos/cm, at the nitrate concentration levels of 10, 30 and 50 mg/l, respectively. However, these values were obtained as 65.45 mmhos/cm, 71.33 mmhos/cm and 72.97 mmhos/cm during the harvesting stage, respectively.

The present results showed that all studied treatments reduce the nitrate concentration in the soil, being consistent with the findings of research by Beesley and Marmiroli, et al [19]. The adsorption index increase of the compost treatment is due to its positive role in improving the physical and chemical properties of the soils and their fertility. Compost has the potential to improve the soil properties, crop yields and increase carbon separation from the soil. Increasing biochar causes root growth, reduces the soil toxic elements and increases its nutrients. Increasing the root surface caused by biochar, causes the transfer of metals to the plant. However, biochar reduces the soil nutrient access, calcium, nitrogen and phosphorus contents in the plant and even reduces the cations competition in metal uptake [20,21].

In addition to improving the plant growth and yield, compost reduces the agricultural impact on the water quality reported that the use of compost with supplementary fertilizers can significantly improve the soil nutrients (nitrogen, phosphorus and potassium), carbon and water holding capacity in the soil and crop yield. It also increases the soil microbial activity [22,23]. Shuman, et al. expressed that plants grow first under these conditions and store contaminants in their organs [24]. Second, plants need relatively high biomass in order to absorb contaminants from the soil. Phytoremediation may be used as a short-term option to absorb contaminants. The present achievements indicate that mung bean plant is a good choice for nitrate-contaminated soils and compost helps the plant absorb nitrate [25].

CONCLUSION

Using compost increase the photosynthetic pigments and light absorption capacity, production of photosynthetic materials and plant growth and increasing yield as a consequence. According to the obtained results, the highest nitrate uptakes during the pod setting and maturity stages were dedicated to the plant roots and measured as 30.32 mg/L and 10.33 mg/L, respectively. However, the lowest nitrate amounts were absorbed by the plant shoot in the pod setting (3.14 mg/L) and mung bean leaves in the maturity (1.5 mg/L) stages. The highest wet weights of the plant during the pod setting and maturity stages were evaluated for the plant roots as 36.97 g and 17.67 g, respectively (using Scn3 treatment). However, the lowest wet weights were recorded as 4.87 g in the plant shoot during the pod setting (control treatment) and 6.41 g in the leaves during the maturity stage (using Scn3). In addition, the highest dry weight (103.3 g) was related to the plant root when using Sn3 treatment, while the lowest one (26.7 g) was observed in the leaves under control treatment.

The results of the current research indicated that the use of compost can be an alternative to the chemical fertilizers for the mung bean plant. Due to the importance of nitrate accumulation in mung bean and based on the present results, it is recommended to use compost fertilizer in order to achieve proper yield with very low amount of nitrate in the plant and less use of chemical fertilizers.

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COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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Masumeh Farasati: Methodology, Writing – original draft.

Tanveer Saeed Ferdous: review & editing.

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Ali Nakhzari moghaddam: Data analysis.

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