ISSN: 2476-6909; ECOPERSIA. 2020;8(3):147-154

The Effect of Humic Acid on Soil Physicochemical and Biological Properties under Salinity Stress Conditions in Pot Culture of *Satureja khuzistanica* Jamzad

ARTICLE INFO

Article Type
Original Research

Authors
Zaremanesh H.[1] *MSc,*
Akbari N.[1] *PhD,*
Eisvand H.R.*[1] *PhD,*
Ismaili A.[1] *PhD,*
Feizian M.[2] *PhD*

How to cite this article
Zaremanesh H, Akbari N, Eisvand H.R, Ismaili A, Feizian M. The Effect of Humic Acid on Soil Physicochemical and Biological Properties under Salinity Stress Conditions in Pot Culture of *Satureja khuzistanica* Jamzad. ECOPERSIA. 2020;8(3):147-154.

[1]Agronomy & Plant Breeding Department, Agriculture Faculty, Lorestan University, Khorramabad, Iran
[2]Soil Science Department, Agriculture Faculty, Lorestan University, Khorramabad, Iran

***Correspondence**
Address: Lorestan University, 5th Kilometer of Khorramabad-Boroujerd Highway, Khorramabad, Lorestan, Iran. Postal code: 6815144316
Phone: +98 (66) 33120097
Fax: +98 (66) 33400289
eisvand.hr@lu.ac.ir

Article History
Received: September 1, 2019
Accepted: February 9, 2020
ePublished: September 20, 2020

ABSTRACT

Aims High salt accumulation has severe adverse effects on soil characteristics. Humic acid can improve the soil structure, soil microbial communities, and absorption and maintenance of mineral nutrients. The aim of the present study was to determine the effects of humic acid on some physicochemical and biological soil properties in soils under salt stress.

Materials & Methods The experiment was conducted as a factorial based on RCBD design with four replications. The first factor included humic acid in five levels (zero, 10, 20, 30, and 40mg kg^{-1} soil). The second factor was salinity stress in five levels (0, 25, 50, 75, and 100mM NaCl). The sampling was carried out in two stages, before and after harvest.

Findings The results showed that S1H5 treatment had the lowest soil electrical conductivity (EC), soil reaction (pH), bulk density, and population of actinomycetes with average values of 0.26dS m^{-1}, 6.21, 1.12g cm^{-3}, and 516cell g^{-1} of soil and had the highest fungal and bacterial population with an average of 1525000 and 137500000cell g^{-1} of soil, respectively.

Conclusion Salt stress has a significant effect on physicochemical and biological soil properties except for the population of actinomyces that their activity was better, at a high level of salinity stress, it had adverse effects on other properties. Although using humic acid improved soil properties. According to the results, using humic acid can be a good solution to reduce the adverse effects of salt stress.

Keywords Satureja; Soil Salinity; Humic; Cation; Actinomycetes

CITATION LINKS

[1] Use of organic amendment as a strategy for saline soil remediation: Influence on the physical, chemical and biological properties ... [2] The nature of phosphorus in calcareous ... [3] Beet vinasse applied to wheat under dryland conditions affects soil properties and ... [4] Assessment of the stability of a dispersive ... [5] Microbial performance in soils along a salinity ... [6] Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of ... [7] Influence of humic acid applications ... [8] Influence of humic acid on increase yield of ... [9] Effect of high humic substance levels on ... [10] Foliar and soil fertilization of humic acid ... [11] Humic substances-compounds of still ... [12] Lignite-derived humic acid effect ... [13] Influences of ascorbic acid and ... [14] Allelopathic potential of rice hulls on ... [15] Particle ... [16] The nature and properties ... [17] Kinetics and mechanisms of potassium ... [18] A comparison of methods ... [19] Total carbon, organic carbon, and ... [20] Cultural methods for soil ... [21] Phosphate-solubilizing bacteria ... [22] Methods in applied soil microbiology ... [23] Soil salinity decreases global soil ... [24] Arbuscular mycorrhizal fungi and glomalin-related ... [25] Effect of humic acid on soil chemical ... [26] Three approaches to define ... [27] Beneficial effects of compost application ... [28] Influence of integrated soil fertility ... [29] Impact of compost on soil properties ... [30] Use of composted organic wastes ... [31] Effect of integrated use of fertilizer ... [32] Effect of using some soil ... [33] Building and testing conceptual and ... [34] Effect of organic fertilizers ... [35] Effectiveness of humic acid applicationin ... [36] Soil properties and maize growth ... [37] Changes in soil properties and ... [38] Water pulses and biogeochemical ... [39] Impact of salinity on soil ... [40] Microbial activity and biomass ... [41] Response of microbial activity ... [42] Response of microbial activity ... [43] Field book for describing and sampling ... [44] Salt effects on the soil microbial ... [45] Bacterial salt tolerance is unrelated ... [46] Identification and optimal growth ... [47] Stress tolerance and characterization ... [48] Microbiology: Principles ...

Introduction

Ionic toxicity (soil salinity) is a major environmental factor limiting agricultural and environmental production worldwide. High salt accumulation has severe adverse effects on physical and chemical properties of soil, microbiological processes, plant growth, and in general, on soil fertility [1]. In fact, salinity and sodium content are key factors in limiting access to nutrients and crop production. Physical and chemical properties of the soil, such as soil structure, water content, pH, microorganismś activity, nutrient concentration, soil organic matter, etc., which support plant growth, are significantly affected by the presence of soil ionic salts [2]. In this regard, Tejada and Gonzalez [3] showed that increased electrical conductivity has adverse effects on the stability and stability of soil, density and soil permeability. Increasing salt destroys soil aggregate and microspores and modifies soil porosity. Moreover, the soil bulk density is increased due to increasing microspores, thereby all of these changes instable the soil structure and destroy it [4]. Usually, in soil with a high level of salinity, the amount of soil organic matter is reduced, and thereby microbial activity will be limited [5].

One of the management methods for improving soil properties under adverse conditions, such as salinity and sodium content, is to increase soil organic matter [6]. Organic matter can affect the physical, chemical, and biological properties of soil positively. Humus, a common organic matter in soil, provides a better nutrient (N, P, S, and K) cycling in soil, resulting in soil conservation, environmental aspects, and soil fertility [7].

Various organic compounds such as manure, green manure, compost, etc. have been widely used in various studies to meet the organic material requirements of the soil. Humic acid (HA) is an active ingredient in humus and can play an important role in soil conditioning and plant growth. This combination physically improves the soil structure and increases the water holding capacity. Biologically, the development of soil microbial communities is improved and is chemically enriched as an absorption and maintenance complex for mineral nutrients [8]. Humic material (HS) is a major component of soil organic matter. It is used in various agricultural fields such as soil chemistry, fertility, plant physiology, and biotechnology. Humic acid also affects the solubility of many nutrient elements by making complex forms or chemical agents of homocysteine with metal cathode [9].

Humic materials can absorb most of the metals in the soil and thus, make them more accessible to plants. Several studies have shown that plant growth, nutrient concentrations and nutrient uptake by soil have increased significantly by using humic materials [10]. Adding homochemicals to the soil leads to the exchange of cations with H^+ with soil colloids, which reduces soil pH. Increasing cationic and anionic interactions reduces aggregation and adhesion of soil particles and increases soil porosity, thereby affecting the flow of water and nutrients[11].

Assumption: Humic acid has not any effect on physicochemical and biological properties in salt stress conditions.

The purpose of the current study was to investigate the effect of humic acid on physicochemical properties and soil biology of pot culture of *Satureja khuzestanica* under salinity stress conditions.

Materials and Methods

The present study was conducted in 2017 at greenhouse of Lorestan University, Iran. The experiment was done as a factorial based on randomized complete block design (RCBD) with four replications. The first factor included humic acid in five levels (0, 10, 20, 30, and 40mg/kg soil) that was applied to the soil before plantation [12]. The second factor was salinity stress in five levels (0, 25, 50, 75, and 100mM NaCl) which was used after sprouting [13] and establishment of the plants during the fourth leaf stage. The levels of the factors are shown in Table 1. The required amounts of humic acid for pots were counted and mixed with the soil before sowing.

Table 1) Different levels of humic acid and salinity used in the present study

Levels	Abbreviation
Humic acid treatments (mg/kg soil)	
0	H1
10	H2
20	H3
30	H4
40	H5
Salinity treatments (mM NaCl)	
0	S1
25	S2
50	S3
75	S4
100	S5

The used plastic pots were 4kg in volume. The seeds of *Satureja khuzistanica* Jamzad were sterilized with sodium hypochlorite 10% for three minutes and then, washed by distilled water [14].

To determine the physical, chemical, and biological characteristics of the soil, before planting, soil sampling was carried out and the specimen was transferred to the lab for determination of soil properties (Table 2). This sampling was done in two stages before and after harvest to study the changes and effects of humic acid and salinity stress on the physicochemical and biological properties of soil. The core sampling by auger was used to measure the soil bulk density [15]. The soil specific gravity was determined 2.65g cm^{-3}. The soil porosity was calculated by the following equation [16]:

$$\text{Soil porosity percentage} = 1 - \frac{\text{bulk density}}{\text{Particle density}} \times 100$$

Soil acidity was measured in saturated flower conditions using a pH meter and electrical conductivity using an electrical conductivity meter in an impregnated extract [17]. The cation exchange capacity (CEC), by sodium acetate [18], soil organic matter by the Wakefield method [19], and the measurement of soil microbial biomass such as bacteria, fungi by the method of Wollum and Kucey [20, 21] and actinomycetes by the method of Alef and Nanipuri [22] were studied.

Finally, analysis of variance of data was done using SAS 9.4 software. Also, post hoc analysis was carried out using Duncan's multiple range test at 5% probability level.

Table 2) Soil characteristics before applying the treatments (humic acid and salinity)

Soil characteristics	
Population of actinomycetes (cell g^{-1} of soil)	500
Bacteria population (cell g^{-1} of soil)	950000000
Fungi population (cell g^{-1} of soil)	1000000
Cationic exchange capacity (CEC)	11.30
Porosity (%)	49
Bulk density (g cm^{-3})	1.28
Organic matter (%)	1.78
Electrical conductivity (ds m^{-1})	0.38
pH	7.02
Soil texture	Sandy clay loam

Findings and Discussion

Chemical properties

Percentage of soil organic matter

ANOVA results on the percentage of soil organic matter (Table 3) and results obtained from comparing the means of interactive effects (Diagram 1) indicated that the highest percentage of soil organic matter was observed in S1H5 treatment with an average of 2.98% and its lowest soil organic matter was seen in S5H1 with an average of 1.58%.

Research has shown that the organic carbon of saline soil is reduced by two ways including reduction of plant growth and, consequently, decreasing the entry of plant residues into the soil and reduced organic matter degradation in the soil [23]. It has been shown that the organic carbon content of the soil is one of the most important chemical indicators of soil quality for soil retrieval and fertility. So, it can make important changes in the biological, chemical, and physical properties of the soil [24]. Humic acid (HA) is a major component of the soil organic matter, which, through its various functions in the soil, affects many soil parameters including the solubility of many nutrients by making complex forms with chemical agents of humic materials [9]. To reduce the salinity stress, new methods such as the use of soil microorganisms, humic acid and fulvic acid, algae and plant extracts can be used. Owing to its specific structure, humic acid has the potential to reduce and neutralize soil salinity [6].

Electrical conductivity (EC) and soil reaction (pH)

There is a significant interaction between the factors in terms of two traits of electrical conductivity and soil reaction at a 1% level (Table 3). The results showed that the highest electrical conductivity (EC) and soil reaction (pH) were with a mean of 2.6ds m^{-1} and 7.37 at S5H1 and the lowest of these traits at S1H5 level, 0.26ds m^{-1} and 6.21 was observed (Table 4). EC values are closely related to soil pH. High amounts of EC soil are affected by the high contents of Na, K, Ca, and Mg of soil. The addition of humic acid to soil leads to the exchange of cationic H^+ with soil colloids, where its position is replaced by cationic salts and then decreases the salt concentration in the soil solution to reduce the amount of EC. Humic acid, in addition to EC change caused by cation exchange H^+ and replacement with single and double-cationic cations, leads to a decrease in soil pH. The cation exchange capacity of the soil is highly dependent on the organic matter content. A higher organic matter will result in a decrease in pH [11, 25]. It has reported that the humic acid (400mg kg^{-1} soil) reduced soil pH and cathodic change significantly [25].

Table 3) Analysis of variance (mean squares) of physical, chemical, and biological traits of soil under the salinity and humic acid factors

Traits	Rep	Salinity (S)	Humic acid (H)	S×H	CV (%)
Electrical conductivity	0.023	8.59**	1.19**	0.09**	6.69
Organic matter (%)	0.06	0.48*	1.68**	0.06^{ns}	17.75
pH	0.32	0.32**	0.83**	0.17**	3.35
Porosity (%)	413.6	646.19**	65.94**	19.39**	6.5
Bulk density	0.28	0.43**	0.045**	0.013**	5.54
CEC	0.032	3.43**	3.16**	0.12**	1.22
Population of soil fungi	4955666666.7	3.4277465e12**	162151000000**	32575250000**	3.53
Population of soil bacteria	2.5476667e13	4.32039e15**	1.00554e15**	1.151275e14**	3.92
Population of actinomycetes	22.6	125163**	37083**	12350**	1.78

ns, * and ** represent non-significant, significant at 5%, and 1% respectively.

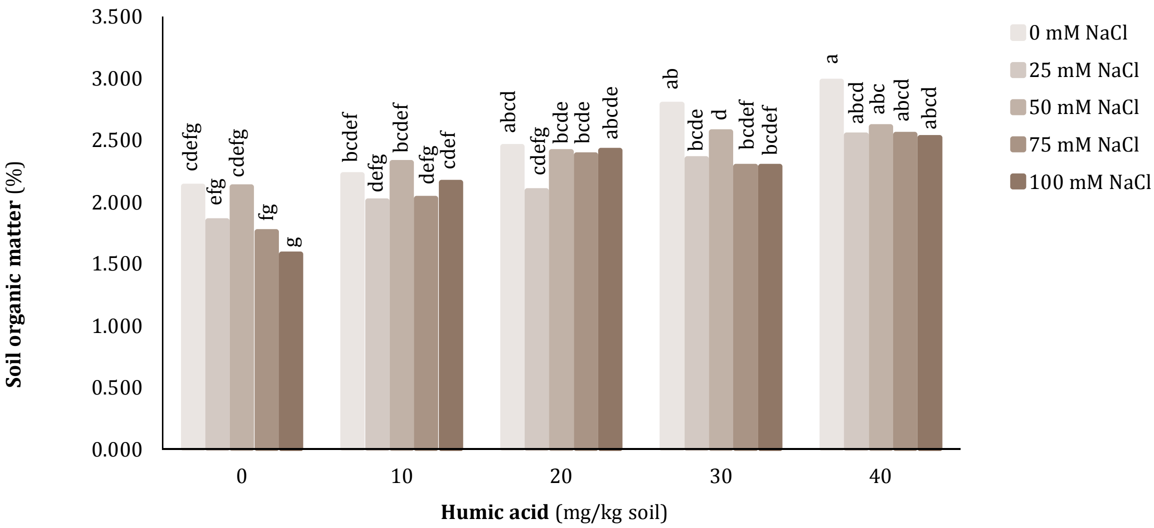

Diagram 1) Percentage of soil organic matter under different combination levels of the salinity and humic acid; Means with at least one common letter have not significant differences based on Duncan's multiple range test (p≤0.05)

Table 4) Mean comparison of soil traits under the combination of salinity and humic acid

Salinity×humic (S×H)	Soil actinomycetes population (cell g^{-1} of soil)	Soil bacteria population (cell g^{-1} of soil)	Soil fungi population (cell g^{-1} of soil)	CEC (meq/100g soil)	Bulk density (g cm^{-3})	Porosity (%)	pH	Electrical conductivity (ds m^{-1})
S1H1	518^{n}	102500000^{ef}	1025000^{e}	11.32^{gf}	1.31^{ijkl}	49.65^{cdef}	7.01^{abc}	0.41^{n}
S1H2	585^{jk}	107500000^{cde}	1150000^{d}	12.03^{c}	1.27^{jklm}	50.89^{bcde}	6.98^{bcde}	0.33^{no}
S1H3	567^{l}	112500000^{c}	1425000^{b}	12.14^{bc}	1.24^{lm}	52.47^{bc}	6.88^{bcdefg}	0.32^{no}
S1H4	545^{m}	125000000^{b}	1450000^{b}	12.32^{b}	1.18^{nm}	54.61^{ab}	6.68^{efghij}	0.31^{no}
S1H5	516^{n}	137500000^{a}	1525000^{a}	12.67^{a}	1.12^{n}	56.76^{a}	6.21^{k}	0.26^{o}
S2H1	655^{f}	95750000^{hij}	905000^{f}	10.88^{ijk}	1.37^{ghij}	47.15^{efgh}	6.94^{bcdef}	1.64^{e}
S2H2	610^{hi}	97750000^{fgh}	922500^{f}	10.95^{ij}	1.34^{hijkl}	48.45^{cdefg}	6.88^{cdefg}	1.24^{i}
S2H3	662^{f}	102500000^{ef}	1025000^{e}	11.04^{hi}	1.28^{jklm}	50.55^{bcde}	6.84^{defgh}	1.09^{kl}
S2H4	695^{e}	110000000^{cd}	1125000^{d}	11.29^{gf}	1.26^{klm}	51.61^{bcd}	6.62^{ghij}	1.07^{kl}
S2H5	525^{n}	112500000^{c}	1275000^{c}	11.60^{de}	1.25^{klm}	51.99^{bcd}	6.53^{hij}	0.93^{m}
S3H1	762^{c}	85750000^{jkl}	610000^{h}	10.75^{klm}	1.48^{cdef}	42.81^{ijkl}	7.05^{abcd}	1.47^{gh}
S3H2	705^{e}	90750000^{ij}	622500^{h}	11.61^{de}	1.46^{defg}	43.85^{hijk}	6.68^{efghij}	1.21^{ij}
S3H3	737^{d}	94750000^{gh}i	672500^{g}	11.63^{de}	1.42^{efgh}	45.33^{ghij}	6.44^{ijk}	1.13^{ijk}
S3H4	702^{e}	105000000de	687500^{g}	11.75^{d}	1.35^{hijk}	48.03^{defgh}	6.37^{jk}	1.01^{klm}
S3H5	652^{f}	98750000^{fg}	707500^{g}	12.02^{c}	1.34^{hijkl}	48.23^{defg}	6.59^{ghij}	0.99^{lm}
S4H1	782^{b}	81000000^{lmno}	425000^{k}	10.59^{lm}	1.54^{bcd}	40.55^{klm}	7.1^{ab}	1.99^{d}
S4H2	635^{g}	84750000^{klm}	442500^{k}	10.76^{jkl}	1.52^{bcde}	41.34^{jklm}	6.98^{bcde}	1.59^{ef}
S4H3	617^{h}	93250000^{hi}	455000^{jk}	11.53^{e}	1.49^{cdef}	42.53^{ijkl}	6.69^{efghij}	1.38^{h}
S4H4	595^{ij}	87000000^{jk}	482500^{ij}	11.59^{de}	1.43^{efgh}	44.95^{ghij}	6.65^{fghij}	1.38^{h}
S4H5	570^{kl}	98250000^{fgh}	502500^{i}	11.61^{de}	1.40^{fghi}	46.14^{fghi}	6.6^{ghij}	1.10^{jkl}
S5H1	837^{a}	78750000^{nop}	300000^{m}	10.57^{m}	1.75^{a}	32.74^{n}	7.37^{a}	2.6^{a}
S5H2	822^{a}	74500000^{p}	302500^{m}	11.04^{hi}	1.57^{bc}	39.48^{lm}	7.19^{ab}	2.35^{b}
S5H3	767^{bc}	76250000^{op}	322500^{lm}	11.16^{gh}	1.54^{bcd}	40.54^{klm}	6.85^{cdefg}	2.22^{c}
S5H4	652^{f}	79750000^{mnop}	322500^{lm}	11.25^{g}	1.52^{bcde}	41.41^{jklm}	6.81^{defgh}	2.04^{d}
S5H5	620^{gh}	82250000^{klmn}	350000^{l}	11.48^{ef}	1.65^{b}	37.80^{m}	6.78^{defgh}	1.51^{fg}

Means with at least one common letter have not significant differences based on Duncan's multiple range test (p≤0.05).

Soil cation exchange capacity (CEC)

The cation exchange capacity of the soil also accepted a significant interaction effect of salinity and humic acid at a 1% level (Table 3). The results showed that the highest amount of exchangeable soil capacity was observed at S1H5 level with 12.67meq/100g and the lowest value of this trait was 10.57% in the S5H1 treatment (Table 4). Narimani and Manafi [26] indicated that the cation exchange capacity of the soils has a very clear relationship with the amount of clay and organic substances. Soils with the highest organic carbon had the highest CEC value and the soils with the least organic carbon had the lowest CEC value.

The higher the dose of humic acid, the higher the CEC value. This was because of the addition of cations will increase them in the mineral surface and between minerals. Colloids do not only adsorbed ions but also absorbed water, so that increased water reserves. HA absorbs more than absorbents used to date [11].

According to Amlinger *et al.* [27], soil organic matter contributes about 20-70% of the CEC for many soils. In absolute terms, CEC of organic matter varies from 300 to 1,400cmol kg^{-1} soil being much higher than CEC of any inorganic material. These results are in agreement with studies of Agegnehu *et al.* [28], Abdel-Rahman [29] and Mohammad *et al.* [30], who said that compost amendment resulted in an increase of CEC due to input of stabilized OM being rich in functional groups into soil. Similar results were obtained from Dadhich *et al.* [31], who stated that the application of farmyard manure significantly increased the organic carbon and CEC of the soil.

Physical properties

Bulk density and soil porosity

Significant interactions between acidity and salinity levels were observed for bulk density and soil porosity ($p \leq 0.01$). Among the combination treatments, S1H5 treatment had a higher mean porosity of 56.76%, which was associated with a low soil bulk density with a mean of 1.12g cm^{-3} (Table 4). The lowest soil porosity and hence the highest bulk density were seen under conditions of high salinity and low levels of soil humic acid, S5H1, with a mean of 32.74% and 1.75g cm^{-3} (Table 4). Adding homochemicals to the soil leads to the exchange of cations with H^+ with soil colloids, which reduces soil pH. The high cationic and anionic interactions cause the accumulation and condensation of soil particles to decrease and the porosity of the soil increases significantly. Soil porosity changes affect the flow of water and soil nutrients. Humic acid can increase the stability of aggregates [11].

Mousa [32] showed that concerning the effect of the applied treatments on soil bulk density and hydraulic conductivity values, their values decreased by increasing the application rates of all the applied conditioners. The highest decreases of such values were associated with the treatment (20kg humic acids/fed) as the rate of decreases below the control under recent application reached 24.83 and 42.42%, respectively, while the respective values under residual application reached 12.08 and 50.00%. Such decreases in soil bulk density can be attributed to the low specific gravity of organic materials and the role of organic products in enhancing soil aggregation which increases the apparent soil volume and consequently decrease bulk density.

Tranter *et al.* [33] reported that soil organic carbon affects multiple soil physical properties and increase in soil organic carbon concentration decreases bulk density.

These results are in agreement with those of Vengadaramana *et al.* [34]. Researchers showed that the values of total soil porosity were increased in soil treated with humic acid at any rate compared to control where the highest value was found in the treatment of humic acid high rate of 2400ml/400L water (T4) with El-Salam canal compared to Baher Hados drain [35]. Similar results have been obtained by Oo *et al.* [36] who reported that the use of organic amendments resulted in substantial flocculation and the formation of a large number of soil aggregates.

Also, about bulk density, some researchers showed that the values of soil bulk density of soil profiles treated by humic acid at any rates were relatively lower than those of control, and the maximum decrease exists in case of humic acid high rate of 2400ml/400L water (T4) with El-Salam canal or Baher Hados drain compared to other treatments and control [35]. These results are confirmed with the results of Amlinger *et al.* [27], who observed that compost application influences soil structure in a beneficial way by lowering soil density as a result for the admixture of low density organic matter into the mineral soil fraction. This positive effect has been detected in most cases and it is typically associated with an increase in porosity because of the interactions between organic and inorganic fractions. Besides, the organic fraction is much lighter in weight than the mineral fraction in soils. Accordingly, the increase in the organic fraction decreases the total weight and bulk density of the soil [37].

Biological properties

The microbial biomass is the agent for decomposing plant residues and the release of nutrients in the soil, available to uptake by growing plants. Microbial biomass is one of the most important features and indices in the protection of the soil and important ecosystem processes such as carbon cycle, nutrient cycle and bioengineering [38].

The results of the current study showed that microbial communities of the soil were also affected by the interaction of salinity and humic acid at 1% level (Table 3). Soil fungal population in S1H5 treatment with the highest activity was 1525000cells g^{-1} of soil. This activity was the lowest in S5H1 treatment with an average of 300000cells g^{-1} of soil, although there was no significant difference with S1H2, S5H3, and S5H4 treatments (Table 4).

The highest soil bacterial population was observed in S1H5 treatment with an average of 137500000cells g^{-1} of soil and its lowest population was S5H2 with an average of 74500000cells g^{-1} of soil, although there was no significant difference with S1H1, S5H3, and S5H4 treatments (Table 4). Soil microorganisms play an important role in nutrient cycling and soil fertility by mineralizing, solubilizing, and stabilizing substances. Salinity can cause stress for soil microorganisms or even killing them [39]. Many researchers report the suppression of soil bacterial activity under salinity [40, 41]. Some studies have shown that, under salinity stress, the ratio of bacteria to fungi has increased significantly because of the higher sensitivity of fungi compared to bacteria to the salinity of water and soil [42].

The soil actinomycetes were also affected by acidic and salinity effects (Table 4). The highest number of actinomycetes (837cells g^{-1} of soil) was observed in S5H1 treatment, although there was no significant difference with S5H2 treatment. The lowest population of these microorganisms was seen in S1H5 treatment with a mean of 516cells g^{-1} of soil, which was not significantly different with S1H1 treatment.

A study on the flora of soil fungi showed that one of the reasons for the fungal growth restriction in the samples was high electrical conductivity. The electrical conductivity of the solution is an indicator of the total dissolved solids. As the concentration of anions and cations of a solution increases, its electrical conductivity increases, too [43], and this can be a factor creating the fungal growth restriction. Increased salt concentrations increase the osmolarity outside the microbial cell, lowering the microbial activity. As Na^+ accumulates in soils, soil structure would be destabilized and osmotic and specific ion effects would be induced. Thus, the microbial diversity and abundance are negatively affected in soils with a pH>7 and high Na^+ levels[44].

Rousk *et al.* [45] found that the short term growth rate of bacteria decreased with increasing EC irrespective of the EC of the soil they were extracted from.

Comparison of four actinomycetes strains under different soil pH and salinity by Ameerah *et al.* [46] has shown that all of the strains had optimum growth at pH= 7 and salinity of 3%. Moreover, in another study on five actinomycetes strains, the highest growth rate was related to pH higher than 7 and salinity of 0.5, 3, and 5% [47]. In the present study, although actinomycetes were able to grow without salt, they generally showed the lowest growth in non-salt conditions, and the reason for this may be the importance of Na^+ in the membrane transport system to maintain intracellular cell potassium at optimum concentration [48].

The results are in line with those of the researchers, and it was found that fungi and bacteria are increased with increasing organic matter content and are decreased with high salinity without humic acid. Also, humic acid was able to control the effects of high salinity and prevents a large decline in the population of fungi and bacteria in high salinity conditions. But for actinomycetes, the population of this group of microorganisms was much higher in saline conditions, and this is due to the greater need for these microorganisms to salinity, which is consistent with the research reported. When more humic acid is used, it reduces the population of actinomycetes due to improved soil structure and reduced soil salinity.

Conclusion

Salinity, one of the main environmental stress in many parts of the world, has a negative effect on the physical, chemical, and biological properties of the soil. Salinity stress has a negative effect on microbial activity by increasing the electrical conductivity of the soil, so, the microbial activity will have a negative trend. Based on the results of the current study, it can be said that the use of organic matter such as humic acid, can reduce salinity stress due to its properties and its effects on the soil. Also, a higher amount of humic acid will reduce the adverse effects of salinity efficiently.

Acknowledgments: The authors give their sincere thanks to the Central Laboratory of Lorestan University, for their supports in completing this study.

Ethical permissions: The case was not found by the authors.

Conflict of interests: The authors declare that there is no conflict of interests regarding the publication of this study.

Authors' Contribution: Hadis Zaremanesh (First author), Introduction author/Methodologist/Original researcher/Discussion author (35%); Naser Akbari (Second author), Introduction author/Discussion author (15%); Hamid Reza Eisvand (Third author), Introduction author/Methodologist/Discussion author (30%); Ahmad Ismaili (Fourth author), Methodologist/Statistical analyst (10%); Mohamad Feizian (fifth author), Introduction author/Discussion author (10%)

Funding/Support: The present study was supported by Lorestan University.

References

1- Tejada M, Garcia C, Gonzalez JL, Hernandez MT. Use of organic amendment as a strategy for saline soil remediation: Influence on the physical, chemical and biological properties of soil. Soil Biol Biochem. 2006;38(6):1413-21.

2- Leytem AB, Mikkelsen RL. The nature of phosphorus in calcareous soils. Better Crop. 2005;89(2):11-3.

3- Tejada M, Gonzalez JL. Beet vinasse applied to wheat under dryland conditions affects soil properties and yield. Eur J Agron. 2005;23(4):336-47.

4- Ouhadi V, Goodarzi A. Assessment of the stability of a dispersive soil treated by alum. Eng Geol. 2006;85(1-2):91-101.

5- Sardinha M, Müller T, Schmeisky H, Joergensen RG. Microbial performance in soils along a salinity gradient under acidic conditions. Appl Soil Ecol. 2003;23(3):237-44.

6- Khaled H, Fawy HA. Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. Soil Water Res. 2011;6(1):21-9.

7- Gümüş İ, Şeker C. Influence of humic acid applications on soil physicochemical properties. Solid Earth. 2015;7:2481-500.

8- Fahramand M, Moradi H, Noori M, Sobhkhizi A, Adibian M, Abdollahi S, et al. Influence of humic acid on increase yield of plants and soil properties. Int J Farming Allied Sci. 2014;3(3):339-41.

9- Leventoglu H, Erdal İ. Effect of high humic substance levels on growth and nutrient concentration of corn under calcareous conditions. J Plant Nutr. 2014;37(12):2074-84.

10- Yildirim E. Foliar and soil fertilization of humic acid affect productivity and quality of tomato. Acta Agric Scand Sect B Soil Plant Sci. 2007;57(2):182-6.

11- Peña-Méndez EM, Havel J, Patočka J. Humic substances-compounds of still unknown structure: applications in agriculture, industry, environment, and biomedicine. J Appl Biomed. 2005;3(1):13-24.

12- Tahir MM, Khurshid M, Khan MZ, Abbasi MK, Kazmi MH. Lignite-derived humic acid effect on growth of wheat plants in different soils. Pedosphere. 2011;21(1): 124-31.

13- Nikee E, Pazoki A, Zahedi H. Influences of ascorbic acid and gibberellin on alleviation of salt stress in summer savory (Satureja hortensis L.). Int J Biosci. 2014;5(4):245-55.

14- Ahn JK, Chung IM. Allelopathic potential of rice hulls on germination and seedling growth of barnyardgrass. Agron J. 2000;92(6):1162-7.

15- Blake GR, Hartage KH. Particle density. In: Klute A, Campbell GS, Jackson RD, Mortland MM, Nielsen DR, editors. Methods of soil analysis, part 1. 2nd Edition. Madison: Soil Science Society of America; 1986. pp. 377-81.

16- Brady NC, Weil RR. The nature and properties of soils. 11th Edition. Upper Saddle River: Prentice Hall; 1996.

17- Sadusky MC, Sparks DL, Noll MR, Hendricks GJ. Kinetics and mechanisms of potassium release from sandy Middle Atlantic Coastal Plain soils. Soil Sci Soc Am J. 1987;51(6):1460-5.

18- Jaremko D, Kalembasa D. A comparison of methods for the determination of cation exchange capacity of soils/Porównanie metod. Ecol Chem Eng S. 2014;21(3):487-98.

19- Nelson BW, Sammers LE. Total carbon, organic carbon, and organic matter. In: Page AL, editor. Methods of soil analysis part 2. Chemical and microbiological properties. Madison: American Society of Agronomy; 1982. pp. 539-77.

20- Wollum AG. Cultural methods for soil microorganisms. In: Page AL, editor. Methods of soil analysis, part 2. Madison: American Society of Agronomy; 1982. pp. 781-801.

21- Kucey RM. Phosphate-solubilizing bacteria and fungi in various cultivated and virgin Alberta soils. Can J Soil Sci. 1983;63(4):671-8.

22- Alef K, Nannipieri P. Methods in applied soil microbiology and biochemistry. Cambridge: Academic Press; 1995.

23- Setia R, Gottschalk P, Smith P, Marschner P, Baldock J, Setia D, et al. Soil salinity decreases global soil organic carbon stocks. Sci Total Environ. 2013;465:267-72.

24- Vasconcellos RL, Bonfim JA, Baretta D, Cardoso EJ. Arbuscular mycorrhizal fungi and glomalin-related soil protein as potential indicators of soil quality in a recuperation gradient of the Atlantic forest in Brazil. Land Degrad Dev. 2016;27(2):325-34.

25- Ali M, Mindari W. Effect of humic acid on soil chemical and physical characteristics of embankment. MATEC Web Conf. 2016;58:01028.

26- Sparling G, Parfitt RL, Hewitt AE, Schipper LA. Three approaches to define desired soil organic matter contents. J Environ Qual. 2003;32(3):760-6.

27- Amlinger F, Peyr S, Geszti J, Dreher P, Weinfurtner K, Nortcliff S. Beneficial effects of compost application on

fertility and productivity of soils: Literature Study. Unknown Publisher city: Federal Ministry for Agriculture and Forestry, Environment and Water Management; 2007.
28- Agegnehu G, Vanbeek C, Bird MI. Influence of integrated soil fertility management in wheat and tef productivity and soil chemical properties in the highland tropical environment. J Soil Sci Plant Nutr. 2014;14(3):532-45.
29- Abdel-Rahman G. Impact of compost on soil properties and crop productivity in the Sahel North Burkina Faso. Am Eurasian J Agric Environ Sci. 2009;6(2):220-6.
30- Golabi MH, Denney MJ, Iyekar C. Use of composted organic wastes as alternative to synthetic fertilizers for enhancing crop productivity and agricultural sustainability on the tropical island of Guam. 13th International Soil Conservation Organisation Conference, 2004 July 4-8, Brisbane, Australia. Unknown Publisher city: Unknown Publisher; 2004.
31- Dadhich SK, Somani LL, Shilpkar D. Effect of integrated use of fertilizer P, FYM and biofertilizers on soil properties and productivity of soybean-wheat crop sequence. J Adv Dev Res. 2011;2(1):42-6.
32- Mousa AA. Effect of using some soil conditioners on salt affected soil properties and its productivity at El-Tina plain area, north Sinai, Egypt. Egypt J Soil Sci. 2017;57(1):101-11.
33- Tranter G, Minasny B, McBratney AB, Murphy B, McKenzie NJ, Grundy M, et al. Building and testing conceptual and empirical models for predicting soil bulk density. Soil Use Manag. 2007;23(4):437-43.
34- Vengadaramana A, Jashothan PT. Effect of organic fertilizers on the water holding capacity of soil in different terrains of Jaffna peninsula in Sri Lanka. J Nat Prod Plant Resour. 2012;2(4):500-3.
35- Ahmed H, Ismail F. Effectiveness of humic acid applicationin improving saline soil properties and fodder beet production. J Soil Sci Agric Eng. 2016;7(9):623-34.
36- Oo AN, Iwai CB, Saenjan P. Soil properties and maize growth in saline and nonsaline soils using cassava-industrial waste compost and vermicompost with or without earthworms. Land Degrad Dev. 2015;26(3):300-10.
37- Brown S, Cotton M. Changes in soil properties and carbon content following compost application: Results of on-farm sampling. Compos Sci Util. 2011;19(2):87-96.
38- Austin AT, Yahdjian L, Stark JM, Belnap J, Porporato A, Norton U, et al. Water pulses and biogeochemical cycles in arid and semiarid ecosystems. Oecologia. 2004;141(2):221-35.
39- Wichern J, Wichern F, Joergensen RG. Impact of salinity on soil microbial communities and the decomposition of maize in acidic soils. Geoderma. 2006;137(1-2):100-8.
40- Elgharably A, Marschner P. Microbial activity and biomass and N and P availability in a saline sandy loam amended with inorganic N and lupin residues. Eur J Soil Biol. 2011;47(5):310-5.
41- Yan N, Marschner P. Response of microbial activity and biomass to increasing salinity depends on the final salinity, not the original salinity. Soil Biol Biochem. 2012;53:50-5.
42- Chowdhury N, Marschner P, Burns R. Response of microbial activity and community structure to decreasing soil osmotic and matric potential. Plant Soil. 2011;344(1-2):241-54.
43- Schoeneberger PJ, Wysoki DA, Boenhm EC, Broderson WD. Field book for describing and sampling soils. Lincoln: Natural Resource Conservation Service, National Soil Survey Center; 2002.
44- Rath KM, Rousk J. Salt effects on the soil microbial decomposer community and their role in organic carbon cycling: A review. Soil Biol Biochem. 2015;81:108-23.
45- Rousk J, Elyaagubi FK, Jones DL, Godbold DL. Bacterial salt tolerance is unrelated to soil salinity across an arid agroecosystem salinity gradient. Soil Biol Biochem. 2011;43(9):1881-7.
46- Abdul Hamid A, Ariffin S, Syed Mohamad SA. Identification and optimal growth conditions of actinomycetes isolated from mangrove environment. Malays J Anal Sci. 2015;19(4):904-10.
47- Kumari GS, Gundala PB, Kumar JK, Teja CP, Veena D, Chinthala P. Stress tolerance and characterization of actinomycetes from salt pan soils of Nellore district, Andhra Pradesh. Res J Pharm Biol Chem Sci. 2016;7(5):1426-35.
48- Black JG, Lewis LM. Microbiology: Principles and explorations. 7th Edition. Hoboken: John Wiley & Sons; 2005.