Volume 14, Issue 1, Page 1-8, 2025 https://doi.org/10.46810/tdfd.1517099 Research Article

Türk Doğa ve Fen Dergisi
Turkish Journal of Nature and Science
www.dergipark.gov.tr/tdfd

Effect of Leonardite Material Doses on The Elimination of Salt Stress in Groundnut (*Arachis Hypogaea* L.)

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(Received: 16.07.2024, Accepted: 11.10.2024, Online Publication: 26.03.2025)

Keywords
Peanut *(Arachis hypogaea* L.*)*,
Leonardit,
NaCI,
Salt stress

Abstract: This study was established as a pot experiment with 4 replicates according to the coincidence plots factorial experimental design to investigate the positive and negative effects of sodium clor (NaCI) salt and leonardite material doses prepared at different rates on the development of NC-7 groundnut variety in the summer season of 2021. 5 different leonardite doses (0 kg/da, 25 kg/da, 50 kg/da, 75 kg/da and 100 kg/da) and 4 different NaCI doses (0 mM, 50 mM, 100 mM and 150 mM) were applied. As a result of the study; plant height 10.06-12.36 (cm), number of branches 3.00-3.78 (pcs/plant), seedling wet weight 5.66-8.94 (g), seedling dry weight 4.42-7.27 (g), leaf area index 36.62-47, 53 (cm2), root length 26.31-45.93 (cm), root wet weight 0.44-2.52 (g), K content 0.957-1.337 (%), sodium (Na) content 386.25-699.05 (mg/kg). According to the data obtained in the experiment; NaCI salt application had a significant effect on seedling dry weight, seedling wet weight, Na and root wet weight. Leonardite application had significant effect on plant height, root length, potassium (K) and root wet weight. Leonardite x NaCI interaction had significant effect on root length, root wet weight, seedling dry weight, K (%) content and Na (mg/kg) content.

Yerfıstığı *(Arachis Hypogaea* L.*)*'nda Leonardit Materyali Dozlarının Tuz Stresini Gidermede Etkisi

Anahtar Kelimeler
Yerfıstığı (*Arachis hypogaea* L.),
Leonardit,
NaCI,
Tuz stresi

Öz: Bu çalışma 2021 yılı yaz sezonunda farklı oranlarda hazırlanmış NaCI tuzu ve leonardit materyali dozlarının NC-7 yerfıstığı çeşidinin gelişimi üzerine olumlu ve olumsuz etkilerini araştırmak için saksı denemesi şeklinde tesadüf parselleri faktöriyel deneme desenine göre 4 tekerrürlü olarak kurulmuştur. 5 farklı leonardit dozu (0 kg/da, 25 kg/da, 50 kg/da, 75 kg/da ve 100 kg/da hesabına göre) ve 4 farklı NaCI dozu (0 mM, 50mM, 100mM ve 150mM) uygulanmıştır. Çalışma sonucunda; bitki boyu 10.06-12.36 (cm), dal sayısı 3.00-3.78 (adet/bitki), fide yaş ağırlığı 5.66-8.94 (g), fide kuru ağırlığı 4.42-7.27 (g), yaprak alanı indeksi 36.62-47.53 (cm^2), kök uzunluğu 26.31-45.93 (cm), kök yaş ağırlığı 0.44-2.52 (g), K oranı 0.957-1.337 (%), Na oranı 386.25-699.05 (mg/kg), arasında değiştiği gözlenmiştir. Denemede elde edilen verilere göre; NaCI tuzu uygulaması fide kuru ağırlığı, fide yaş ağırlığı, Sodyum (Na) ve kök yaş ağırlığına önemli etkide bulunmuştur. Leonardit uygulaması bitki boyu, kök uzunluğu, K (potasyum) ve kök yaş ağırlığına önemli etkide bulunmuştur. Leonardit x NaCI interaksiyonuna bakıldığında ise kök uzunluğu, kök yaş ağırlığı, fide kuru ağırlığı, K (%) oranı ve Na(mg/kg) miktarı önemli bulunmuştur.

1. INTRODUCTION

The origin of the peanut is South America. It is the region extending from southern Bolivia to northern Argentina. It is thought that peanuts were taken from North America to Europe by Spanish sailors [1]. Peanut is a plant that grows in tropical and subtropical regions from its natural growing area and likes plenty of light and warmth and does not like cold. As temperatures increase, growing times shorten and photosynthesis decreases in extreme temperatures, resulting in a decrease in yield. Peanut plant needs a total temperature requirement of 3000°-4500°C during the growing period [2].

Biochar is a soil conditioner. Leonardite has been accepted as a soil conditioner as a result of recent studies [3]. Leonardite is very high in phosphorus (P2O5) and calcium carbonate contents in terms of plant nutrients but poor in potassium (K). Soil reactions (pH) are around neutral [4]. Leonardite plays an important role in correcting soil colour, aerating compacted soil and reducing soil salinity [3]. Humic substances generally contribute to plant development and ecosystem balance by improving the physical, chemical and biological properties of the soil [5]. With the ability of humic acid to bond with metals, nutrient losses occurring in the soil are prevented and the amount of fertiliser to be used is reduced [6]. Leonardite, due to its high water retention capacity, prevents the irrigation water away from the soil and provides low water consumption [7].

Salinity problem is more common in arid and semi-arid regions and 10 million hectares of land are lost every year in the world due to salinity [8]. Salinity is an important stress factor that has a negative effect on plant growth, development, bud formation, leaf area and stomata and causes significant decreases in yield [9]. Excessive and incorrect fertilisation used in agriculture also causes salinisation in the soil [10]. In order to eliminate the negative effects of salinity, it is necessary to apply improving substances to the plant growth environment. Recently, studies on organic matter applications have been intensified [11]. It is seen that different concentrations of humic acid are used in studies carried out to determine the effects of humic acid on salinity [12]. The nutritive functions of humic acids occur especially in the passage of macro and micronutrients to the plant [13]. When groundnut (Arachis hypogaea L.) is exposed to salt stress, which is common in soils, especially in arid climates, significant crop loss occurs. Salinity can disrupt the ionic and osmotic balance in the cell, causing damage to functional-structural proteins and cell membrane and alteration in cell membrane fluidity [14]. Salt stress can affect the peanut plant directly or indirectly. Leaves and stems of plants affected by salinity may appear stunted. [15]. Like many plants, groundnut plant is most sensitive to water stress during flowering and pod filling [16].

Some previous scientific researches on the subject of the study are presented below. NaCI salt application was found to be significant on root wet weight and number of branches at 0.01 level, while it was significant on root length and seedling dry weight at 0.05 level. Biochar treatment was significant on root wet weight, seedling wet weight, K (%) ratio at 0.01 level, while it was significant on root length and leaf area at 0.05 level. In Biochar x NaCI interaction, root fresh weight, number of branches, seedling fresh weight and K (%) ratio were found significant at 0.01 level, while Na (mg/kg) ratio was found significant at 0.05 level [17]. It was reported that 3000 kg leonardite application per decare before sowing caused an increase in the amounts of macro and micro elements in the plant, 1000 kg/da application had the highest effect on grain weight and grain yield of the plant, and the highest value was obtained at 3000 kg/da dose on biomass and wet weight [18].

It was determined that the germination rate and emergence rate prolonged with increasing salt doses and this negatively affected seedling development [16]. 100 mM, 200 mM, 300 mM 3 different NaCl doses were applied and values such as germination time (days), average emergence time (days) and sensitivity index increased significantly with increasing salt doses, while values such as emergence rate (%), seedling wet weight (g), root wet weight (g), seedling length (mm), root length (mm), seedling dry weight (g) and root dry weight (g) decreased [19]. Four doses of sodium chloride (NaCl) (0 mM, 50 mM, 100 mM and 150 mM) and four doses of leonardite (0 g/kg, 20 g/kg, 30 g/kg and 40 g/kg) were used in salt stress. Leonardite material and salt doses significantly affected shoot wet weight, root wet weight, root length and shoot length. It was determined that leonardite applications had a positive effect on plant growth and ion uptake in plants exposed to salt [20]. The effect of leonardite applications on root and stem wet weight, root and stem length, root and stem dry weight, leaf area index of plants exposed to salt stress was found to be statistically significant [21]. Leonardite applications significantly increased the phosphorus (P), nitrogen (N) and organic matter content of the soil, while it showed a certain increase in terms of potassium (K), but no statistically significant difference was found [22].

7 different salt doses (0 mM, 25 mM, 50 mM, 75 mM, 100 mM, 125 mM, 150 mM NaCl) were applied and it was determined that Na (Sodium) accumulated in the aboveground plant parts starting from 25 mM salt dose in all genotypes, and it was determined that 25 mM NaCl dose had a positive effect on some traits, but it was determined that plant development was negatively affected with the increase in salt doses in all genotypes [23]. Leonardite and nitrogen doses had no effect on the number of branches, plant height, branch height and 1000 grain weight [24]. It was found that as the dose of organic materials increased, the total nitrogen, plant-available phosphorus, organic matter, extractable potassium and pH of the soil increased, and the effect of organic material applications on all parameters examined, except nitrogen and pH, was obtained from the highest hazelnut husk, while the lowest was obtained from biochar applications [25].

It was determined that the stem weight decreased by 21.4%, plant height by 21.6% and root length by 30% above 4 dS m^{-1} and 8 dS m^{-1}, respectively. The increase in salt content in irrigation water caused an increase in Na content in the leaves and roots of plants [26]. Na was found in high amounts in roots, leaves and stems with increasing salt content. There was a significant decrease in Ca, K and Mg in leaves. It was shown that the studied varieties of faba bean, which are moderately sensitive to salt, were moderately affected by ambient salinity and did not have a protective mechanism against salinity [27]. The proline, Na, CI and P concentrations of the cultivars exposed to salt stress increased and K concentration decreased [28].

2. MATERIAL AND METHOD

This research was established in June-July 2021 in the campus area of Bingöl University Faculty of Agriculture in the form of a pot experiment under open air conditions and NC-7 peanut variety, leonardite biochar as Leonardite material and NaCI salt for salt application were used in the experiment. The soils used in the pots were first sieved through 4 mm sieves and transferred to 5 kg pots. The experiment was established on 12 June 2021. NC-7 peanut variety was registered by the Western Mediterranean Agricultural Research Institute Directorate in 1991 [29].

Table 1. Climate data for Bingöl province

Months	Monthly average Temperature (°C)		Monthly relative humidity (%)		Monthly total Precipitation (mm)	
	2021 year	Long years average	2021 year	Long years average	2021 year	Long years average
June	24.4	22.2	30.2	44.3	1.8	21.1
July	28.4	26.7	28.6	37.2	0.2	6.9
August	27.3	26.7	31.0	36.0	3.9	4.9

*:Long-term average for 1990-2020 (thirty-one years of data analysed)

The average temperature value recorded in June and July was 24.4-28.4°C in 2021 and the long-term average temperature was 22.2-26.7°C. The amount of precipitation was 1.8-0.2 mm in 2021 and the long-term average was 21.1- 6.9 mm. Relative humidity was 30.2-28.6% in 2021 and the long-term average was 44.3-37.2%.

Table 2. Soil analysis results

pH	Organic mat. (%)	Salinity (%)	Lime (%)	K (kg/da)	P (kg/da)
8.09	0.36	0.011	6.91	18.18	2.86
Slightly alkaline	Az	unsalted	medium	medium	low

According to Table 2, the soil structure was slightly alkaline, organic matter content was low, no salt, lime and potassium content was medium and phosphorus content was low.

The pot experiment was carried out in 4 replicates according to the random plots factorial experiment design with 5 different leonardite doses (0 kg/da (control), 25 kg/da, 50 kg/da, 75 kg/da, 100 kg/da) and 4 different NaCI doses (0 Mm, 50 Mm, 100 Mm, 150 Mm). The soils used in the pots were dried under natural conditions and analysed. Five peanut seeds were sown in each pot and diluted after germination and 3 plants were left in each pot. The pots were irrigated with tap water until they reached the field capacity and NaCI solution was added to the pots after irrigation. The pots were watered once a week and the plants were harvested during the flowering period.

Plant height (cm), number of branches (number), seedling wet weight (g), leaf area index (cm2), root length (cm), root wet weight (g), seedling dry weight (g), plant sodium (Na) content, plant potassium (K) content and plant phosphorus (P) content were determined. Data analyses were performed using JMP Statistical Package Programme.

3. RESULTS AND DISCUSSION

3.1. Plant Height (cm)

Table 3 shows the mean values of leonardite and NaCI treatments on plant height of groundnut. According to the table, the highest average plant height was obtained from L4 with 11.39 cm and the lowest average plant height was obtained from L1 with 10.40 cm. The highest mean plant height of NaCI treatment was obtained from NO with 11.33 cm and the lowest mean plant height was obtained from N1 with 10.68 cm.

Table 3. Mean Values of plant height of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	Average
L0	11.73	11.56	10.83	10.60	11.18 AB
L1	10.06	10.17	10.44	10.94	10.40 B
L2	11.06	10.70	10.61	10.83	10.80 AB
L3	11.46	10.47	11.89	11.31	11.28 A
L4	12.36	10.53	11.91	10.74	11.39 A
Average	11.33	10.68	11.14	10.89	

Our findings are in agreement with [26] who reported that salt doses up to 400 mM did not significantly affect stem length, but increasing salt doses after 400 mM decreased stem length, [20] who found the effect of salt and leonardite applications on plant height statistically significant, [30] who found the effect of leonardite and oak charcoal applications on plant height statistically significant.

[17] investigated the effect of biochar and NaCI applications on plant height of peanut under Bingöl conditions. As a result of the study, the effect of biochar x NaCI application on plant height was not found significant. The highest mean plant height value was obtained from B250 biochar application with 11.78 cm, while the lowest value was obtained from B500 and B1000 applications with 11.20 cm. The highest mean plant height value of NaCI treatment was obtained from N0 treatment with 11.59 cm, while the lowest value was obtained from N3 treatment with 11.07 cm. It was determined that increasing salt content did not have a significant effect on plant height of groundnut.

3.2. Number of Branches (Number/Plant)

Table 4 shows the mean values of the number of branches of peanut for leonardite and NaCI treatments. According to this table, the highest average number of branches of leonardite treatment was obtained from L0 treatment with 3.56 and the lowest average number of branches was obtained from L1 treatment with 3.35. The highest average number of branches of NaCI treatment was obtained from N2 and N3 treatments with 3.53 and the lowest average number of branches was obtained from N0 treatment with 3.38.

Table 4. Mean Values of Number of Branches of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	Average
L0	3.67	3.44	3.33	3.78	3.56
L1	3.00	3.33	3.56	3.50	3.35
L2	3.33	3.45	3.67	3.67	3.53
L3	3.11	3.39	3.56	3.44	3.38
L4	3.78	3.39	3.56	3.28	3.50
Average	3.38	3.40	3.53	3.53	

Our findings; Our results are similar to those of [17] who found the effect of different salt doses applied to peanut on branching to be statistically significant and the effect of different biochar doses on branching to be statistically significant, [22] who applied different doses of leonardite to Java variety of bean and found the effect of leonardite on branching to be statistically significant and did not find the branching data statistically significant in Volare variety, [24] who applied different leonardite doses to sesame plant and found the effect of leonardite on branching to be statistically significant.

3.3. Seedling Wet Weight (g)

Table 5 shows the mean values of seedling wet weight of peanut for leonardite and NaCI treatments. According to this table, the highest seedling wet weight average of leonardite treatment was obtained from L4 treatment with 7.30 g, while the lowest seedling wet weight average was obtained from L3 treatment with 6.81 g. The highest seedling wet weight of NaCI treatment was obtained from N2 treatment with 7.79 g, while the lowest seedling wet weight average was obtained from N1 treatment with 6.70 g.

Table 5. Mean Values of Seedling Wet Weight of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	Average
L0	7.57	7.52	6.51	7.48	7.27
L1	6.34	6.65	8.23	7.31	7.13
L2	6.77	7.36	7.31	6.27	6.93
L3	6.33	6.31	7.96	6.65	6.81
L4	7.46	5.66	8.94	7.13	7.30
Average	6.89 AB	6.70 B	7.79 A	6.97 AB	

Our findings are in harmony with the studies conducted by [17] who stated that there was an increase in seedling wet weight with the increase in biochar material applied to peanut, [30] who stated that there was an increase in seedling wet weight by applying leonardite and oak charcoal to tomato, [18] who stated that there was an increase in seedling wet weight by applying leonardite to chickpea, [20] who stated that there was an increase in seedling wet weight in parallel with the increase in the amount of leonardite applied to beans.

3.4. Leaf Area Index (cm^2)

According to Table 6, the mean leaf area values of leonardite and NaCI treatments of groundnut are shown in the table. Accordingly, the highest mean leaf area of leonardite treatment was obtained from L3 treatment with 43.60 cm^2 and the lowest mean leaf area was obtained from L1 treatment with 40.29 cm^2. The highest mean leaf area of NaCI treatment was obtained from N2 treatment with 43.73 cm2 and the lowest mean leaf area was obtained from N3 treatment with 40.05 cm^2.

Table 6. Mean Values of Leaf Area Index of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	Average
L0	41.50	41.22	42.85	42.74	42.08
L1	40.43	39.97	40.39	40.38	40.29
L2	42.96	41.76	42.25	40.96	41.98
L3	47.07	42.13	45.65	39.56	43.60
L4	42.69	40.62	47.53	36.62	41.87
Average	42.93	41.14	43.73	40.05	

Our findings are in agreement with [17] who reported that the effect of biochar material on leaf area in peanut, to which salt and biochar were applied at different rates, was different under saline conditions, and that while it gave the highest value in some applications (B0), this value decreased and increased again in the following applications, and [21] who reported that the leaf area index of the amount of salt applied at different rates in beans was obtained from 0 mM (control) application.

3.5. Root Length (cm)

According to Table 7, the mean root length values of leonardite and NaCI treatments of groundnut are shown in the table. According to the table, the highest root length average of leonardite treatment was obtained from L0 treatment with 39.20 cm, while the lowest root length average was obtained from L4 treatment with 28.93 cm. The highest root length average of NaCI treatment was obtained from N1 with 35.66 cm, while the lowest root length average was obtained from N0 with 32.01 cm.

Table 7. Mean Values of Root Lenght of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	Average
L0	36.94 abc	45.93 a	41.10 ab	32.82 abc	39.20 A
L1	35.90 abc	30.28 bc	30.45 bc	33.60 abc	32.56 B
L2	31.11 bc	33.49 abc	31.48 bc	34.89 abc	32.74 B
L3	29.78 bc	39.36 abc	31.94 bc	28.69 bc	32.44 B
L4	26.31 c	29.22 bc	29.28 bc	30.90 bc	28.93 B
Average	32.01	35.66	32.85	32.18	

Our findings; [16] who reported a decrease in root length depending on the amount of salt applied at different doses to different rapeseed varieties, [17] who stated that biochar used to manage salinity stress in root length with different doses of salt and biochar application in peanut has a positive effect up to B750 application dose and can manage the stress of salinity up to N3 dose, which is the last dose of salt applications, [21] who reported that root length decreased with the increase in the amount of salt in beans, [26], [21] who reported that root length decreased with the increase in the amount of salt applied at different doses in bean.

As a result of the interaction of leonardite and salt treatments, the highest root length was 45.93 cm in L0N1 treatment and the lowest root length was 26.31 cm in L4N0 treatment. This situation explains that the root length was the highest in the first dose of salt application without leonardite, and the root length decreased in the other cases where leonardite and salt increased.

3.6. Root Wet Weight (g)

According to Table 8, the average root wet weight values of leonardite and NaCI treatments of groundnut are shown in the table. According to this table, the highest root wet weight average of leonardite treatment was obtained from L0 treatment with 1.99 g, while the lowest root wet weight average was obtained from L4 treatment with 0.92 g. The highest root wet weight average of NaCI treatment was obtained from N0 treatment with 1.52 g, while the lowest root wet weight average was obtained from N1 treatment with 1.03 g.

Table 8. Mean Values of Root Wet Weight of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	Average
L0	2.52 a	1.92 b	1.68 b	1.85 b	1.99 A
L1	1.93 b	0.44 g	0.71 fg	0.72 efg	0.95 B
L2	1.16 c	0.94 c-f	0.83 def	0.86 c-f	0.95 B
L3	0.98 c-f	0.96 c-f	1.09 cd	0.95 c-f	0.99 B
L4	1.02 cde	0.86 c-f	0.98 c-f	0.84 def	0.92 B
Average	1.52 A	1.03 B	1.06 B	1.04 B	

Our findings are in accordance with [16] who reported a decrease in root wet weight parallel to the amount of salt applied to different rapeseed varieties at different doses, [17] who reported that root wet weight decreased with the increase in the amount of salt applied to peanut, [17] who reported that root wet weight increased with the increase in the amount of biochar, [31] who reported a decrease in root wet weight of eggplant grown in saline soils.

As a result of the interaction of leonardite with salt treatments, the highest root wet weight of 2.52 g was obtained from L0N0 application and the lowest root wet weight of 0.44 g was obtained from L1N1 application. This situation explains that the root wet weight was the highest in the absence of leonardite and salt applications, while the root wet weight decreased in the other cases where leonardite and salt increased.

3.7. Seedling Dry Weight (g)

Table 9 shows the mean values of seedling dry weight of peanut for leonardite and NaCI treatments. According to the table, the highest seedling dry weight average of leonardite application was obtained from L0 application with 6.22 g, while the lowest seedling dry weight average was obtained from L1 application with 5.67 g. The highest seedling dry weight average of NaCI treatment was obtained from N2 treatment with 6.62 g, while the lowest seedling dry weight average was obtained from N1 treatment with 5.28 g.

Table 9. Mean Values of Seedling Dry Weight of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	Average
L0	6.28 abc	6.35 abc	6.04 abc	6.21 abc	6.22
L1	5.26 abc	4.42 c	6.76 abc	6.23 abc	5.67
L2	5.98 abc	6.34 abc	5.96 abc	6.32 abc	6.15
L3	6.27 abc	4.59 c	7.06 ab	5.81 abc	5.93
L4	6.24 abc	4.71 bc	7.27 a	6.27 abc	6.12
Average	6.01 AB	5.28 B	6.62 A	6.17 A	

As a result of the interaction of leonardite with salt treatments, the highest seedling dry weight of 7.27 g and the lowest root wet weight of 4.42 g and 4.59 g were obtained from L4N2 and L1N1 and L3N1 treatments, respectively. This shows that the seedling wet weight of leonardite increased despite the salt treatments, and the lowest values were determined in the first (N1) dose of salt in different doses of leonardite.

Our findings are in agreement with [17] who stated that there was no negative effect of salinity on seedling dry weight in peanut with different doses of salt and biochar application, [30] who stated that seedling dry weight increased with the increase in the amount of leonardite applied to tomato, [20] who stated that seedling dry weight decreased with the increase in the amount of salt in beans with different doses of salt and leonardite and increased with the increase of leonardite.

3.8. Determination of Sodium (Na) in Plant (mg/kg)

As a result of the interaction of Leonardite with salt treatments, the highest Na contents in the above-ground part of the seedling were obtained from L0N2 and L3N3 treatments as 699.05 mg/kg and 692.10 mg/kg, respectively. The lowest sodium content was obtained from L2N1 treatment as 386.25 mg/kg. This situation explains that leonardite and salt applications increased sodium content at certain levels and decreased it at some doses (L2N1). According to these results, when the sodium content is taken into consideration, it shows that leonardite applications can be applied in saline environments and under saline conditions by paying attention to the application doses (Table 10).

Table 10. Mean Values of Determination of Sodium (Na) in Plant of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	Average
L0	424.75 ab	521.15 ab	699.05 a	525.35 ab	542.56
L1	625.10 ab	453.20 ab	432.45 ab	649.25 ab	540.00
L2	538.65 ab	386.25 b	582.45 ab	529.15 ab	509.13
L3	563.75 ab	525.30 ab	597.95 ab	692.10 a	594.78
L4	649.55 ab	598.35 ab	474.80 ab	620.70 ab	570.85
Average	560.36 AB	484.85 B	557.34 AB	603.31 A	

Our findings are similar to those of [26] who reported that the amount of Na in leaves and roots increased with increasing salt content in irrigation water in peanut, [20] who reported that the amount of Na increased with increasing salt doses in bean and there was a positive relationship between leonardite and salt, [27] who reported that sodium accumulated in roots, leaves and stems with increasing salt content in broad bean, [28], [23] who stated that the amount of Na increased in the above-ground evening with increasing salt doses in pea, [17] who stated that Na element increased with salt application to peanut and biochar applications had a positive effect on the sodium intake of the plant.

3.9. Determination of Potassium (K) in Plant (%)

Table 11 shows the mean values of K (%) of peanut for leonardite and NaCI treatments. According to this table, the highest K (%) average of leonardite application was obtained from L1 application with 1.248 and the lowest K (%) average was obtained from L4 application with 1.008. The highest K (%) average of NaCI application was obtained from N0 application with 1.169 and the lowest K (%) average was obtained from N3 application with 1.139.

Table 11. Mean Values of Determination of Potassium (K) in Plant of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	Average
L0	1.170 a-d	1.257 ab	1.140 a-d	1.247 ab	1.203 A
L1	1.237 ab	1.157 a-d	1.260 ab	1.337 a	1.248 A
L2	1.257 ab	1.260 ab	1.147 a-d	1.147 a-d	1.203 A
L3	1.200 abc	1.107 bcd	1.070 bcd	1.007 cd	1.096 B
L4	0.980 cd	0.977 d	1.117 a-d	0.957 d	1.008 C
Average	1.169	1.151	1.147	1.139	

As a result of the interaction of Leonardite with salt treatments, the highest potassium content in the above-ground part of the seedling was obtained as 1.337 % from L1N3 treatment. The lowest potassium contents were obtained from L4N1 and L4N3 treatments as 0.977 and 0.957 %, respectively. This situation explains that potassium was accumulated in the above-ground part of the plant at the L1 dose of leonardite and N3 application of salt, and this situation (potassium content) decreased with the increase of leonardite. According to these results, leonardite applications in terms of potassium content can be applied in saline environments or saline water conditions by paying attention to the application doses.

Our findings are similar to those of [20] who stated that leonardite material applied at certain doses increased the K content in beans and decreased the positive effect of leonardite in parallel with the increase in the amount of salt, [32] who stated that the ash remaining at 5% and below increases the potassium concentration in the soil with the use of coal ash in agricultural areas, [25], [17], who reported that salinity did not have a significant effect on the potassium intake of the plant, while biochar applications increased the potassium content at certain levels, the salinity stress was reduced in the B250 application.

3.10. Determination of Phosphorus (P) in Plants (%)

The effects of salt stress on phosphorus content in the plant and the effects of leonardite applications in reducing it were examined and found to be statistically significant. With salt applications, the average phosphorus content increased at N1 dose, decreased at N2 dose and increased again at N3 dose. With Leonardite applications, the average phosphorus contents increased in L1, L2 and L3 applications and decreased slightly in L4 application compared to the control. When the effects of interaction were analysed, the lowest phosphorus content was found in L0N0 application and the highest phosphorus content was found in L3N3 application.

Table 12. Mean Values of Determination of Phosphorus (P) in Plant of Peanut in Leonardite and NaCI Treatments and Resulting Groups

Leonardit	NaCI				
	N0	N1	N2	N3	average
L0	0.278 f	0.290 def	0.279 ef	0.297 c-f	0.286 C
L1	0.327 a-d	0.340 ab	0.311 a-f	0.339 abc	0.329 A
L2	0.310 a-f	0.320 a-f	0.322 a-d	0.322 a-d	0.319 AB
L3	0.290 def	0.332 a-d	0.321 a-e	0.352 a	0.324 AB
L4	0.313 a-f	0.318 a-f	0.307 b-f	0.303 b-f	0.310 B
Average	0.304 C	0.320 AB	0.308 BC	0.322 A	

It can be concluded that leonardite doses have positive effects on salt tolerance depending on plant growth parameters and nutrient contents such as phosphorus. Perennial ground cover plants Alchemilla mollis and Nepeta x faassenii (Catmint ‘Walker's Low’) were treated with salt (0, 50, 100, 200 and 400 mM NaCl) and it was determined that salt increased P content in A. mollis and decreased P content in N. x faassenii [33]. Sesleria caerulea (L., Ard.) and Koeleria glauca (Spreng, DC.) were treated with salt (0, 5, 10, 15, 30 g NaCl.dm^{-3}) and it was reported that leaf P content decreased [34]. The effects of proline (100 mM) and phosphorus (P; 10 and 100 mg kg^{-1} sand) application on growth, P content and ion balance of maize (30/87 hybrid) under salt stress were investigated. Salt stress caused a significant decrease in shoot and root P content. However, proline and P application significantly improved plant P content [35]. In a study, humic acid (0, 750 and 1500 mg.kg^{-1}) and phosphorus (0, 50, 100 and 150 mg.kg^{-1}) were applied to pepper seedlings (Demre variety) grown under salt stress (8 mM NaCl). Humic acid application significantly increased shoot P content of pepper seedlings. Humic acid is a product containing many elements that increase the fertility of the soil and increase the usefulness of nutrients, affect plant growth and yield and improve the harmful effects of salt stress [36].

4. CONCLUSION

In the study, it was determined that the leonardite material applied to the soil at certain doses improved the soil and contributed to the soil physically, chemically and biologically. It was also observed that it had a positive effect on the early developmental stages of the peanut plant used in the study. Considering the soil improving effect of Leonardite material, it will provide an important benefit by minimising the use of chemical inputs for sustainable agriculture. Leonardite applications can improve the detrimental effects of salt stress on groundnut seedlings and leonardite, which contains substances that have a positive effect on plant growth such as humic acid, can be an economical and simple application to reduce the problems of growing groundnut in moderately saline soils.

Acknowledgement

In this study, the figures in the thesis of master's student Bahar ENES were used.

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