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Araştırma Makalesi

NaCl Tuz Stresini Giderilmesinde Farklı Dozlarda Portakal Biochar Materyalinin Etkisi: Yerfıstığı (*Arachis hypogaea* L.) Uygulamaları

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ÖZ

Bu çalışma farklı oranlarda NaCl tuzu ve Portakal ağacına ait Biochar materyali kullanılarak, NC-7 yerfıstığının gelişimi üzerine olan etkisini araştırmak için Bingöl Üniversitesi Ziraat Fakültesi Tarla Bitkileri Bölümünde açık hava şartlarında saksı denemesi şeklinde yapılmıştır. 5 farklı biochar dozu (0 kg/da 250 kg/da 500 kg/da 750 kg/da ve 1000 kg/da) ve 4 farklı NaCl dozu (0 mM, 50 mM, 100 mM ve 150 mM) kullanılmıştır. Sonuçta; dal sayısı, fide kuru ağırlığı, kök uzunluğu, kök yaş ağırlığını önemli ölçüde etkilerken, bitki boyu, fide yaş ağırlığı, yaprak alanı, K (%) ve Na (mg/kg) üzerine etkisi ise önemsiz bulunmuştur. Farklı dozlarda portakal biochar kullanılması, fide yaş ağırlığı, yaprak alanı, kök uzunluğu, kök yaş ağırlığı, K (%), Na (mg/kg) etkisini önemli ölçüde etkilerken, bitki boyu, dal sayısı ve fide kuru ağırlığını ise önemli ölçüde etkilememiştir. Fide uzunluğu 10,91-12,13 cm, dal sayısı 2,22-3,81 adet/bitki, fide yaş ağırlığı 4,81- 9,05 g, yaprak alanı 36,11-46,72 fide kuru ağırlığı 5,15-6,64 g, kök uzunluğu 27,00-39,72 cm, kök yaş ağırlığı 0.97-2,81 g, K (%) oranı %0,777-1,256 ve Na (mg/kg) oranı 344,60-670,80 mg/kg arasında değişim göstermiştir.

Anahtar Kelimeler: Yerfıstığı (*Arachis hypogaea* L.), portakal kömürü, tuz stresi, NaCl.

Effect of Different Doses of Orange Biochar Material on Relieving NaCl Salt Stress: Peanut (*Arachis hypogaea* L.) Applications

ABSTRACT

This study was carried out as a pot experiment under open air conditions at Bingöl University, Faculty of Agriculture, Department of Field Crops to investigate the effect of different rates of NaCl and biochar material of orange tree on the growth of NC-7 groundnut. 5 different biochar doses (0 kg/da 250 kg/da 500 kg/da 750 kg/da and 1000 kg/da) and 4 different NaCl doses (0 mM, 50 mM, 100 mM and 150 mM) were used. As a result, number of branches, seedling dry weight, root length and root wet weight were significantly affected, while plant height, seedling wet weight, leaf area, K (%) and Na (mg/kg) effects were found insignificant. The use of orange biochar at different doses significantly affected seedling wet weight, leaf area, root length, root wet weight, K (%), Na (mg/kg), while plant height, number of branches and seedling dry weight were not significantly affected. Seedling length 10.91-12.13 cm, number of branches 2.22-3.81, seedling wet weight 4.81-9.05 g, leaf area 36.11-46.72, seedling dry weight 5.15-6.64 g, root length 27.00-39.72 cm, root wet weight 0.97-2.81 g, K (%) ratio 0.777-1.256 and Na (mg/kg) ratio 344.60-670.80 mg/kg.

Keywords: Peanut *(Arachis hypogaea* L.*)*, Biochar, salt stress, NaCl.

INTRODUCTION

Since the effect of temperature on the growth and development of the peanut plant is important, it is very sensitve to hot conditions. As the temperature increases, the vegetation period (growing period) gets shorter. The generative period of peanut is more sensitive to temperature than the vegetative period is, and when the air temperature is over more than 40 °C during the period the plant is fully flowered and fruit formation occurs, the number of flowers increases, while pod set, pod weight and seed yield decrease (Boydak, 2020). Groundnut grows well in calcareous, sandy and sandy-loamy soils (Sürücü et al., 2013). Groundnut oil is dull yellow in colour and has distinctive taste and aroma characteristics (Çelik et al., 2000). Due to the high oil concentration in its seeds, its use as a suitable raw material for biodiesel production is being investigated (Celik and Boydak, 2019). The oil in the seeds consists of oleic acid (40-65%), lineleic acid (20-40%), palmitic acid (5-10%) and stearic acid (3-7%). The proportion of fatty acid components is affected many factors such as irrigation, drought and fertilisation (Boydak et.al., 2010). Since peanut is a legume plant, its green parts, stem parts and the residues (meal) remaining after the oil is extracted are utilised as feed for animals. In groundnut, especially after fruit harvest, the upper body is a source of animal dutrition for especailly during dry seasons (Kökten et al., 2014). Salt stress causes significant disorders on the physiological structures of plants. It has been reported (to have negative effects on plant growth and development, leaf area, bud formation and stomata, impaired fertilisation and small fruits (Önder and Uçar, 2021). Like many plants, peanut plant is quite sensitive to water stress during flowering and pod filling period. In crop production, adequate irrigation and soil moisture are important factors for the formation of plant pods (Balcı and Boydak, 2021). It is known that salt stress causes negative effects on plant growth and development due to osmotic stress and toxic effects of sodium chloride (Na-Cl) ions. The increase in leaf chloride concentration changes the nutrient balance and water potential of the plant and reduces growth by affecting carbon dioxide assimilation. It was found that in legume plants under salt stress between 50 mM and 200 mM sodium chloride, plant growth was inhibited and significant yield decreases were observed (Turhan, 2020). Plants are more sensitive to salinity at the seedling stage than at the germination stage. It has been reported that if the salt exposure period of plants is in the vegetative development stage, the development of all plant organs is suppressed, but stem development is more affected than root development (Bulut, 2007). Biochar is the production of various organic waste materials by low temperature pyrolysis method. When the biochar formed by this method is added to the soil, it stays in the soil for a longer time while decomposing slowly. Thus, it provides an alternative way to utilise the wastes generated in urban areas and agricultural production (Elmasoğlu et al., 2022). Pyrolysis occurs when plants remain in anearob, hot environments. Energy sources such as oil, coal, natural gas, charcoal, etc. are examples of pyrolysis. The most well-known biochar production is the one produced from wood charcoal (Akgül, 2017). Biochar (bio-coal) can hold 6 times its own weight of water in the soil. This ensures that elements such as phosphorus and nitrogen from the soil are more easily taken up by plants and a good nutrient medium is obtained for the development of plants. Biochar generally shows basic characteristics. When they are added to the soil, they regulate the soil pH by increasing the pH values of especially acidic soils (Akgül, 2017). Thus, biochar improves soil biodiversity and soil performance, reduces its sensitivity to weather conditions and the need for fertiliser inputs, contributes to the improvement of soil quality and consequently increases crop productivity. The nutrient content (especially N content) of biochar derived from plant materials is generally low compared to other organic fertilisers (Da Silva et al., 2021). Some researches related to the study are given below: Germination and emergence time and sensitivity index increased significantly with increasing salt content. Germination index, emergence rate and index, seedling and root length, wet and dry seedling and root weight, and salt tolerance decreased significantly (Kurtuluş and Boydak, 2022). A greenhouse experiment was established with soils taken from saline and non-saline areas of Harran Plain. In saline soils, PS biochar was found to be more effective than the control. At the same time, it was determined that the use of low dose of PS biochar material in non-saline soil and high dose in saline soil was more effective (Özyavuz, 2017). It was determined that salt stress had no effect on stem length, wet and dry root weight in peanut (Yolcı et al., 2021). As a result of the study carried out in order to prevent the lignite coal ash from causing environmental pollution and to benefit from the properties of the ash in the waste state, it was determined that the application of coal ash mixed with soil at a rate of 5% or less enriches the soil with plant nutrients such as nitrogen, organic matter, plant-useful potassium, copper, manganese, iron, calcium, zinc, magnesium (Yılmaz, 2015). It was observed that the use of humic + fulvic acid + K and leonardite had a positive effect on the yield and yield components of summer rapeseed variety Heros. It was determined that 10.000 ml ha-1 dose of humic acid + fulvic acid + K dose gave the most appropriate results (Gürsoy and Kolsarıcı, 2017). Leonardite and inorganic fertilisation significantly affected stem length, root length, stem wet weight, wet root weight, plant dry weight, root dry weight and number of leaves of tomato plants. However, the effects of the treatments on the number of flowers and stem diameter were found to be insignificant (Demirkıran et al., 2012). It was determined that Si application reduced the stress effect of salt on bean seedlings. At 100 and 200 ppm Si doses, favourable results were obtained for root and stem length, root and stem wet and dry weights and leaf area index (Oral et al., 2020). It was reported that phosphorus, proline, sodium (Na+) and chloride (Cl^-) contents of chickpea (*Cicer arietinum* L.) plants increased but potasium (K^+) content and dry weight decreased in sodium-chloride (NaCl) stress (Özcan et al., 2000). A study was carried out to investigate the effect of NaCl salinity on plant height, number of leaves, number of internodes, internode lengths, wet and dry weights of leaves, stems, roots and some minerals uptake (Fe, Ca, Mg, Mn, Na, K, Zn) of Eresen 87, Filiz 97 broad bean varieties grown in perlite medium prepared by adding 50 and 100 mM NaCl to Hoagland solutions containing KNO_3 (Potassium Nitrate) and CH_3COOK (Acetic Acid). As a result of this study, it was determined that the pod varieties, which are moderately sensitive to salt, were affected by ambient salinity, although not very severely, and that the pods do not have an inhibitory and protective mechanism against salinity (Bulut, 2007). Starting from 25 mM salt dose, Na accumulated in the above-ground plant parts. However, it was determined that 25 mM NaCl dose had a positive effect on some traits examined in some varieties. However, it was reported that increasing salt doses negatively affected plant growth (Zambi, 2019). It was reported that increasing salt doses prolonged the germination rate and emergence rate and therefore negatively affected seedling development (Balcı and Boydak, 2021). When characteristics (plant height, first pod height, number of pods per plant, number of grains per plant, 100 grain weight and grain yield) were examined, 100 kg da^{-1} leonardite application gave the highest values in both years of the study (Uçar et al., 2020). It was concluded that as the dose of organic materials increased, the amount of organic matter (OM), total nitrogen, plant-useful phosphorus, potassium and pH (except FZ) of the soil increased while the amount of plant-useful copper decreased, and iron decreased at the application level of 6 tonnes da-1. Plant-useful manganese and zinc contents of soils decreased as the biochar application dose increased. As a result of the research, among all the properties examined, the highest effect of organic material applications, except for pH and nitrogen, was obtained from hazelnut husk and the lowest effect was obtained from biochar applications (Tarakçıoğlu et al., 2019). While the positive effect of irrigation water with salt content less than 4 dS m^{-1} was determined (on plant growth and development parameters), the negative effect was determined in plants irrigated with saline irrigation water higher than 4 dS m^{-1}. The increase in the salt content of irrigation water affected the increase of sodium content in the leaf and root parts of the plant (Aydinşakır et al., 2015). Leonardite and salt doses were statistically significant in terms of root length, shoot length, root wet weight and shoot wet weight. In the uptake of macro and micro elements, potassium and phosphorus decreased while sodium increased. In leonardite applications, there was an increase in the amount of potassium and sodium and no change in the amount of phosphorus. It was reported that leonardite application had a positive effect on plant growth and ion uptake in bean plants exposed to salt (Kiyas, 2020). It was determined that the biochar applied to the soil positively affected the total weight and green parts weight of tomato plants with increasing biochar application dose, while green parts length, flowering period, number of leaves and stem diameters varied statistically according to the biochar application dose. It was reported that Leonardite biochar positively affected the green parts of the plant, while oak charcoal positively affected the root part of the plant seedling (Öztürk, 2022). It was reported that 3000 kg/da applications caused an increase in the amounts of micro and macro elements in the plant, and 1000 kg/da application had the highest effect on grain yield and grain weight of the plant. When the effect of leonardite on the wet weight and biomass of the plant was examined, it was concluded that the highest value was obtained from 3000 kg/da dose (Gürocak, 2022).

The aim of the presnet study is to have an idea about whether groundnut grown in soils containing excessive amounts of NaCI can contribute to the reduction of the negative effect of salt in the soil by using orange biochars.

MATERIAL AND METHOD

The research was conducted as a pot experiment under open air conditions in 2021 at Bingöl University, Faculty of Agriculture, Department of Field Crops. In the experiment, NC-7 peanut variety NaCI salt (4 doses), Orange biochar (5 doses) were used as materials and established on 12 June 2021. The soil used was taken from a depth of 0-30 cm in the field in Güveçli village of Bingöl province and sieved through a 4 mm sieve, and 5 kg of soil was weighed and used for each pot. Characteristics of the pots used: Low specific gravity , floatable in water, good dimensional stability against high humidity and temperature. It is an insulating material. Surface roughness value is low. Expansion coefficient is high after exposure to temperature. It is not resistant to weather conditions. It may oxidise. It interacts with solvents containing chlorine, nitric acid and other strong oxidisers. Melting temperature is 130-170 degrees. It is non-toxic. Characteristics of irrigation water; salinity is low (470 mS/cm), Ph value is close to neutral (7,41), Ca (2,67 mEq/lt) and Mg (3,88 mEq/lt) contents are at medium level, carbonate is absent, bicarbonate is at low level (0,49 mEq/lt), Cl content is low (1,33 mEq/lt), Na content (25,29 ppm) is at medium level (Avcı, 2019).

Table 1. Soil analysis results

pH	Salinity	Organic matter	Lime (%)	P (kg/da)	K (kg/da)
8,09	0,011	0,36	6,91	2,86	18,18
Slightly alkaline	Unsalted	Low	Medium	Low	Medium

According to the results of soil analyses presented in Table 1, the soil structure of the research area was slightly alkaline and moderately calcareous, non-saline, with moderate potassium content, moderate phosphorus content and low organic matter content.

Table 2. Climate data of Bingöl province

Months	Monthly average temperature (°C)		Monthly total precipitation (mm)		Monthly relative humidity (%)	
	2021	Long years average	2021	Long years average	2021	Long years average
June	24,4	22,2	1,8	21,1	30,2	44,3
July	28,4	26,7	0,2	6,9	28,6	37,2
August	27,3	26,7	3,9	4,9	31,0	36,0

Thirty-one years of data, averaged over many years, between 1990 and 2020, were evaluated.

The average temperature recorded during the months of the experiment (June - July) was 24.4 - 28.4°C in 2021 and 22.2 - 26.7°C for over years. The amount of precipitation is 1.8 - 0.2 mm in 2021 and the long-term average is 21.1- 6.9 mm. Relative humidity is 30.2-28.6% in 2021 and 44.3 - 37.2% for over years. The experiment was carried out according to the factorial design in randomised plots with 4 replications, 5 different biochar doses (0 kg/da 250 kg/da 500 kg/da 750 kg/da and 1000 kg/da) and 4 different NaCl doses (0 Mm, 50 Mm, 100 Mm and 150 Mm) were used. Grouping was done according to TUKEYS. After soil analysis, N-P-K fertilisers were applied to each pot at the rate of 6 kg/ha per decare by mixing with soil. 5 kg of soil was added to the pots and 5 peanut seeds were sown in each pot. After emergence, 3 plants were left in each pot by thinning. After the pots were first irrigated with normal tap water until the field capacity was reached, the solutions prepared according to 4 different NaCl doses (0 Mm, 50 Mm, 100 Mm and 150 Mm) were added to the pots. Subsequent irrigations were carried out with drip irrigation method once a week until the soil reached the field capacity. Necessary measurements were made when the plants started to flower. Plant height (cm), number of branches (pcs/plant), root length (cm), leaf area (cm^2), seedling wet weight (g), seedling dry weight (g), root wet weight (g), plant K (potassium) determination, plant Na (sodium) determination, plant P (phosphorus) determination were analysed.

RESULTS AND DISCUSSION

Plant Height (cm)

The groups of Biochar and NaCl treatments on the mean values of plant height of groundnut are given in Table 4.2. The highest mean plant height value was obtained from B_{250} Biochar treatment with 11,78 cm and the lowest value was obtained from B_{500} and B_{1000} treatments with 11,20 cm. The highest average plant height was obtained from N_0 with 11,59 cm and the lowest average was obtained from N_3 with 11,07 cm. It was determined that salinity negatively affected plant growth and decreased plant height, and biochar did not significantly reduce this negative effect (Table 3).

Table 3. Average values of the plant height and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl				
	N0	N1	N2	N3	Average
B0	12,11	10,96	10,91	11,28	11,32
B250	11,48	11,99	12,13	11,51	11,78
B500	12,11	10,92	11,258	10,49	11,20
B750	11,07	11,49	12,02	11,09	11,42
B1000	11,19	11,27	11,36	11,00	11,20
Average	11,59	11,33	11,54	11,07	

Yolcı et al. (2021), the effect of different amounts of salt applied to peanut on plant growth was investigated. As a result of the study, the effect of salt stress on stem length was found to be statistically insignificant. In the study on groundnut, it was determined that increasing salt amounts did not significantly affect plant height. In the study conducted by Özbay (2012), the effect of humic acid application on plant height in pickled cucumber grown in still water culture was not statistically significant. Biochar applied to peanut did not significantly affect plant height, which is in parallel with the study in which humic acid was applied.

Number of Branches (pcs./Plant)

The mean values of the number of branches of peanut for biochar and NaCl treatments are given in Table 4. The highest average number of branches was obtained from B_{750} treatment with 3,28 and the lowest value was obtained from B_0 treatment with 2,83. The highest average number of branches of NaCl treatment was obtained from N_O treatment with 3,33 and the lowest average was obtained from N_3 treatment with 2,82. It is known that salinity has a negative effect on plant growth. In order to overcome or reduce this negativity, biochar material treatments used in this study increased the number of plant branches under non-saline conditions (N_0). It was determined that this positive effect continued to decrease with the increase in the amount of salt.

Table 4. Average values of the number of branches and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl				
	N0	N1	N2	N3	Average
B0	3,33	2,58	2,57	2,83	2,83
B250	2,91	3,22	3,56	2,22	2,98
B500	3,06	3,00	3,00	3,33	3,10
B750	3,55	3,22	3,44	2,91	3,28
B1000	3,81	3,07	2,78	2,78	3,11
Average	3,33	3,02	3,07	2,82	

Gürsoy and Kolsarıcı (2017) reported that the effect of different humic acid doses applied to summer rape (*Brassica napus ssp. oleifera* L.) in Leonardite-coated soil on the number of branches of the plant was significant at p<0.01 level in the first year, while a significant difference was found at p<0.05 level in the number of side branches in the second year. When the effect of biochar on the number of branches of peanut on the number of branches was examined, it was found to be significant at the level of 0.01, although the treatments were not the same, it is in parallel with the study. As a result of many previous studies on biochar, it was reported that the number of branches of the plant increased with the increase in the amount of biochar. Demirkıran et al. (2012) reported that leonardite application used as fertiliser had a significant effect on the number of leaves of tomato plant. Öztürk (2022) reported that the number of branches increased with the increase in the dose of Leonardite and oak charcoal applied to tomato plant. In parallel with the results of the research, it was reported that biochar applied to peanut also had a significant effect on the number of branches. The findings obtained from the researches and the results of this study show that orange charcoal, like leonardite, can be used as a fertiliser in organic and sustainable agriculture.

Seedling Fresh Weight (g)

The mean values of seedling wet weight (g) of peanut for biochar and NaCl treatments are given in Table 4.6. The highest average seedling wet weight (g) of biochar treatment was obtained from B_{1000} treatment with 7,56 g and the lowest value was obtained from B_0 treatment with 6,05 g. The highest average seedling wet weight of NaCl treatment was obtained from N_2 treatment with 7,06 g and the lowest average was obtained from N_1 treatment with 6,61 g. The biochar material used to reduce the negative effect of salinity on plant growth had a positive and significant effect on seedling wet weight measurements (Table 5).

Table 5. Average values of seedling fresh weight and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl				
	N0	N1	N2	N3	Average
B0	7,47 abc	5,38 bc	4,81 c	6,55 abc	6,05 B
B250	6,25 bc	6,56 abc	7,63 ab	7,06 abc	6,87 AB
B500	6,44 abc	6,78 abc	6,22 bc	6,80 abc	6,56 AB
B750	7,41 abc	7,11 abc	7,58 ab	6,97 abc	7,27 A
B1000	6,14bc	7,22 abc	9,05 a	7,82 ab	7,56 A
Average	6,74	6,61	7,06	7,04	

Previous studies have also reported that biochar used to reduce the negative effect of salt has a positive effect. In Kiyas 2020, it was determined that the effect of salt and leonardite doses applied on bean plants on seedling wet weight of the plant was significant. It was determined that an increase in seedling wet weight was observed in parallel with the increase in the amount of leonardite. Öztürk 2022 reported an increase in seedling wet weight with the increase of oak and leonardite charcoal doses applied to tomato plants. Gürocak 2022 determined that leonardite applied to chickpea (*Cicer arietinum* L.) plant significantly affected seedling wet weight. The increase in seedling wet weight with the increase of biochar applied to groundnut is similar to the studies on the positive effect of biochar application on seedling wet weight.

Leaf Area (cm^2)

The mean values of leaf area (cm^2) of peanut for biochar and NaCl treatments are given in Table 6. The highest average leaf area was obtained from B_0 treatment with 45,85 cm2 and the lowest value was obtained from B_{750} treatment with 38,72 cm^2. The highest average leaf area of NaCl treatment was obtained from N_0 treatment with 42,68 cm2 and the lowest average was obtained from N_1 treatment with 39,52 cm^2 (Table 6).

Table 6. Average values of the leaf area and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl N0	N1	N2	N3	Average
B0	45,96	45,96	46,72	44,73	45,85 A
B250	42,55	43,09	38,03	43,16	41,71
B500	40,17	36,25	39,10	40,82	39,09 B
B750	45,58	36,11	36,93	36,26	38,72 B
B1000	39,13	36,20	44,45	44,06	40,96
Average	42,68	39,52	41,05	41,81	

It is known that salinity has a negative effect on plant growth. In this study conducted under saline conditions, it was understood that the effect of biochar material on the average leaf area of peanut was different, while it gave the highest value in the B_0 application, this effect decreased in the following applications, but increased again in the B_{1000} application. Oral et al. 2020 determined that the amount of salt applied at different rates affected the leaf area index in their study on bean plant. The highest leaf area index value was obtained from the control (0 mM) application. In the study on peanut, N_0 (0 mM) is in parallel with the measurement of the highest leaf area index.

Seedling Dry Weight (g)

The mean values of seedling dry weight (g) of groundnut for biochar and NaCl treatments are given in Table 4. The highest average seedling dry weight of biochar treatment was obtained from B_{1000} treatment with 6,02 g and the lowest value was obtained from B_0 treatment with 5,60 g. The highest average seedling dry weight of NaCl treatment was obtained from N_2 treatment with 6,15 and the lowest average was obtained from N_1 treatment with 5,43 g. The effect of these levels of salinity on seedling dry weight was not negative.

Table 7. Average values of seedlig dry weight and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl N0	N1	N2	N3	Average
B0	6,15	5,17	5,23	5,84	5,60
B250	5,15	5,65	6,64	6,13	5,89
B500	6,03	5,19	5,33	6,00	5,64
B750	5,72	5,71	6,37	5,99	5,95
B1000	5,16	5,43	7,19	6,31	6,02
Average	5,64 b	5,43 b	6,15 a	6,05 a	

Kiyas 2020, it was reported that there was a decrease in seedling dry weight parallel to the increase in the amount of salt, and an increase in seedling dry weight parallel to the increase in the amount of leonardite in bean plants treated with different salt and leonardite levels. Özyavuz 2017, when the seedling dry weight of eggplant plant in saline and non-saline soils of biochar applications were examined, it was determined that the amount of biochar increased the seedling dry weight in parallel with the increase in the amount of biochar, while saline soils significantly decreased the seedling dry weight of the plant. Öztürk 2022 stated that the increase in the amount of leonardite applied to tomato plant increased the seedling dry weight of the plant. The relationship between the salt doses applied to groundnut and the effect on bean and aubergine plants were parallel to each other. In parallel with the increase in the amount of biochar applied to tomato, aubergine and bean plants, it was determined that the dry weight of seedlings increased in parallel with the biochar application applied to peanut.

Root Length (cm)

The mean values of root length of groundnut for biochar and NaCl treatments are given in Table 8. The highest average root length of biochar treatment was obtained from B_0 treatment with 35,03 cm and the lowest value was obtained from B_{1000} treatment with 29,55 cm. The highest average root length of NaCl treatment was obtained from N_2 treatment with 35,61 cm and the lowest average was obtained from N_3 treatment with 30,24 cm. It was observed that biochar used to manage salinity stress had a positive effect on root length up to B_{750} application dose. It was determined that salinity stress could be managed in terms of root length until N_3, the last dose of salt application.

Table 8. Average values of the root lenght and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl				
	N0	N1	N2	N3	Average
B0	34,17	38,67	35,22	32,06	35,03 a
B250	33,77	37,56	35,33	28,50	33,79 a
B500	34,78	33,83	35,50	35,00	34,78 a
B750	32,67	28,78	39,72	25,83	31,75 b
B1000	27,00	29,14	32,25	29,80	29,55 b
Average	32,48 AB	33,60 AB	35,61 A	30,24 B	

In Kiyas 2020, a decrease in root length was found parallel to the increase in salt ratios. In parallel with the increase in leonardite ratios, a positive relationship was found in root length. Öztürk 2022, in his study, stated that the use of leonardite and oak charcoal at different rates applied to tomato plants had a positive effect on root length. The results of salt and biochar application at different rates applied in peanut are in parallel with the studies. Balcı and Boydak (2021) examined the effect of NaCl salt applied at different rates on the development of plants in their study on rapeseed plant, Kurtuluş and Boydak (2022) on safflower plant. Considering the effect on root development, they determined that there was a decrease in root length parallel to the increase in salt content. In many salinity studies conducted on peanut and other plants, it has been reported that salinity restricts root development in plants and there is a decrease in root length in parallel with the increase in salt doses applied (Aydinşakır et al., 2015; Kiyas, 2020; Oral et al., 2020; Uçar et al. 2020).

Root Wet Weight (g)

The mean values of root wet weight (g) of peanut for biochar and NaCl treatments are given in Table 9. The highest root wet weight (g) was obtained from B_0 treatment with 2,16 g and the lowest value was obtained from B_{1000} treatment with 1,11 g. The highest root wet weight (g) of NaCl treatment was obtained from N_0 treatment with 1,84 g and the lowest value was obtained from N_3 treatment with 1,56 g. It is known that salinity has a negative effect on plant growth. In order to eliminate or reduce this negativity, a positive effect of biochar material applications used in this study in terms of root wet weight was observed at N_1 and N_2 salt levels of B_{750} dose, but this effect could not be observed in other applications.

Table 9. Average values of the root wet weight and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl				
	N0	N1	N2	N3	Average
B0	2,81 a	2,01 bcd	1,86 bcd	1,57 bcd	2,16 A
B250	1,95 bcd	1,57 d-g	1,94 bcd	1,62 c-g	1,77 B
B500	1,77 b-e	1,48 d-g	1,91 bcd	1,78 bcd	1,74 B
B750	1,72 b-f	2,38 ab	2,29 abc	1,06 fg	1,87 B
B1000	0,97 g	1,10 efg	1,01 g	1,36 d-g	1,11 C
Average	1,84 A	1,71 AB	1,80 A	1,56 B	

Balcı and Boydak (2021) reported a decrease in plant root wet weight in parallel with the increase in the amount of salt at different rates applied to different rapeseed varieties. Zambi (2019), it was reported that there was a decrease in the root wet weight of the plant in parallel with the increase in the amount of salt when looking at different rates of salt doses applied to some pea varieties. (2020), the effect of different rates of silicon and salt doses on bean (*Phaseolus vulgaris* L.) plant was investigated. It was reported that increasing salt doses stressed the plant and affected the water intake, which negatively affected the development of the plant and caused a decrease in wet root weight. Özyavuz (2017), the mean values on the root wet weight of aubergine plants grown in saline and saline soils showed a significant difference. It was determined that there was a significant decrease in the root wet weight of eggplant plants grown in saline soils. When the results of two different biochar applications were examined in the study, it was stated that there was not much difference between the biochars in the increase of plant root wet weight, but when the general averages of the doses were examined, it was stated that there was an increase between the doses compared to the control. When the effects of biochar and salt concentrations applied to peanut were analysed, it was found to be in parallel with previous studies. It was observed that parallel to the increase in the amount of salt applied to peanut, there was a decrease in the root wet weight of the plant, and parallel to the increase in the amount of biochar, there was an increase in the root wet weight.

Ratio of K (Potassium) in Plant (%)

The mean values of K (%) of peanut for biochar and NaCl treatments are given in Table 10. The highest average K (%) of biochar application was obtained from B_0 application with 1,177% and the lowest value was obtained from B_{500} application with 0,953%. The highest mean K (%) of NaCl application was obtained from N_0 application with 1,09% and the lowest mean was obtained from N_1 application with 1,05%. When the effect of salinity on the potassium uptake of the plant was analysed, it was observed that this effect was not significant, and B_0 and B_{250} applications of biochar treatments provided the most positive increase in K content averages. It was determined that B_{250} application decreased the salinity stress, which was also understood from the interaction values.

Table 10. Average values of the ratio of potassium and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl				
	N0	N1	N2	N3	Average
B0	1,197	1,256 a	1,197	1,057 b-	1,177 A
B250	1,210 ab	1,160 a-e	1,120 a-g	1,200	1,173 A
B500	1,017 e-	0,777 ı	0,970 fgh	1,047 b-	0,953 C
B750	1,130 a-	1,090 a-g	1,030 c-h	0,900 hı	1,038 B
B1000	0,900 hı	0,957 gh	1,027 d-	1,160 a-c	1,011 B
Average	1,09	1,05	1,07	1,07	

Kiyas (2020), in a study on bean plant, it was determined that leonardite application had a significant effect on K (potassium) value, leonardite applied at certain ratios increased K content, and the positive effect of leonardite decreased in parallel with the increase in salt content. Yilmaz (2015) reported that the use of coal ash in agricultural soils increased the potassium concentration in the soil with 5% or less ash. Tarakçıoğlu et al. (2019) reported that biochar produced from hazelnut shell increased the K (potassium) that the plant can use in the soil in a certain incubation period. When we look at the biochar application applied to peanut, it shows that the most positive result was obtained from the B_{250} application against salinity and thus there is a similarity between the studies and the results found.

Ratio of Na (sodium) in plant (mg/kg)

The mean values of Na (mg/kg) of peanut for biochar and NaCl treatments are given in Table 11. The highest mean value of Na (mg/kg) of biochar application was obtained from B_{1000} application with 521,00 mg/kg and the lowest value was obtained from B_{250} application with 417,86 mg/kg. The highest mean of NaCl application was obtained from N_2 application with 508,17 mg/kg and the lowest mean was obtained from N_0 application with 422,46 mg/kg. It is known that salinity has a negative effect on plant growth. In addition, it is also known that sodium is a plant nutrient element and the plant needs this element to some extent. When evaluated in this context, it was observed that sodium element increased with salt applications, but decreased again at N_3 dose. In addition, it was observed that biochar applications had a positive effect on Na uptake of the plant.

Table 11. Average values of the ratio of sodium and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl N0	N1	N2	N3	Average
B0	408,40	450,00	487,20	595,95	485,39
B250	360,45	490,65	426,95	393,40	417,86
B500	503,35	344,60	497,85	465,90	452,93
B750	412,70	550,45	458,05	487,65	477,21
B1000	427,40	501,10	670,80	484,70	521,00
Average	422,46	467,36	508,17	485,52	

Kiyas (2020) reported a positive correlation between the increase in the amount of Na with the increase in leonardite and salt doses applied to bean plants. Zambi (2019) reported that the amount of Na accumulated in the above-ground parts generally increased as the salt doses applied to pea plants at different rates increased. Bulut (2007), when the seedling development of broad bean plant was examined, it was determined that a high amount of Na accumulated in roots, stems and leaves with increasing salinity. Özcan et al. (2000) reported that salt stress applied to three different chickpea varieties increased Na accumulation in the plant. Aydinşakır et al. (2015), as a result of the research on how salt stress affects the development of peanut, stated that the increase in the salt content of irrigation water caused an increase in the amount of Na in the leaves and roots. The findings we obtained as a result of the applications applied to peanut are in parallel with the previous studies. Elmasoğlu et al. (2022) stated that biochar can be used to improve saline soils and increase soil fertility. They stated that carbonisation of the wastes generated as a result of agricultural practices and reapplication to the soil will contribute positively to our soils which are poor in organic matter.

Ratio of P (Phosphorus) in plant (%)

The effects of salt stress on phosphorus content in the plant and the effects of biochar applications in reducing it were examined and found to be statistically significant. The average phosphorus content decreased at N_1 dose and increased at N_2 and N_3 doses (Table 12).

Table 12. Average values of the ratio of Phosphorus and groups formed in Biochar and NaCl applications of peanut

Biochar	NaCl N_0	N_1	N_2	N_3	average
BP_0	0,368 a	0,300 bcd	0,307 bc	0,303 bc	0,320 A
BP_1	0,267 c-f	0,267 c-f	0,280 cde	0,270 cde	0,271 CD
BP_2	0,247 ef	0,227 f	0,283 cde	0,272 cde	0,257 D
BP_3	0,259 def	0,287 cde	0,299 bcd	0,300 bcd	0,286 BC
BP_4	0,267 c-f	0,291 cd	0,301 bcd	0,338 ab	0,299 B
Average	0,282 BC	0,275 C	0,294 AB	0,297 A	

The average phosphorus content of biochar treatments was highest in the control, decreased in BP_1 and BP_2 treatments, and increased slightly in BP_3 and BP_4 treatments. When the effects of interaction were analysed, the lowest phosphorus content was found in BP_2N_1 treatment and the highest phosphorus content was found in the control (BP_0N_0) treatment (Table 12). Salinity quitely impairs the growth and physiology of plants. The responses of plants to salinity stress may be different. Biochar applications have attracted increasing interest in recent years as a potential soil amendment agent under stress conditions. Our findings are in parallel with the following studies. Biochar (2, 4 and 6%) obtained from maize was used to increase this resistance of *Glycyrrhiza uralensis Fisch*. (*liquorice*), a *legume* and salt-tolerant plant, and it was found that biochar increased nodule, root length, N and K concentrations in the plant under saline conditions (Egamberdieva et al. 2021). The growth of Suaeda salsa treated with biochar derived from *wheat* straw and phosphorus fertilisation in saline-sodic soil was investigated and it was found that the treatments showed a significant ($P < 0.05$) negative (antagonistic) interaction on plant P concentration. This was explained by the fact that when biochar and P fertilisation were applied together, phosphate precipitation/sorption reaction occurred in saline-sodic soil and plant P availability decreased in saline-sodic soil (Xu et al. 2016). In a study, the use of biochar (control, 10% and 20% addition) to ameliorate saline soil (non-saline, 6, 12 dS m-1 NaCl) was considered and the development of bean (*Phaseolus vulgaris* L.) seedlings was examined for this purpose. The results showed that salt increased sodium (Na) concentration in leaves and roots. (Farhangi-Abriz, S., & Torabian, S. (2018).

In a study investigating the plant growth and nutrient content status of the application of biochar (0, 30 and 45 g) in saline conditions (0, 1 and 1.5%), as a result, B45S1.5 application had an effect on plant height, number of plant leaves, leaf area and above-ground fresh -It was determined that it increased dry biomass and root fresh-dry biomass. Similarly, the highest total phosphorus (TP) in maize shoot was observed in B30S1, B0S1.5, CK and B0S1.5. It has been reported that the highest TN, TP, TK and Na concentrations in the root were obtained in the B0S1 application, respectively (Soothar et al. 2021).

CONCLUSIONS AND RECOMMENDATIONS

According to the results of the present research, the application of a certain amount of orange charcoal to the soil had an important effect on some physiological properties of peanut plant. It was concluded that it reduces the negative effect of salt. It was concluded that the use of materials containing organic matter has a positive effect on soil fertility and plant growth in many ways. It can be said that the stress caused by increasing the salt concentration in the seedling stage of peanut plant can be reduced by the application of orange biochar.

Notice: In this research, the figures in the thesis of Sultan ASLAN, a graduate student, were used.

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