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Impact of salinity stress on growing, seedling development and water consumption of peanut (*Arachis hypogaea* cv. NC-7)

Tuzluluk stresinin yerfıstığı (*Arachis hypogaea* cv. NC-7)'nda büyüme, fide gelişimi ve su tüketimi üzerine etkileri

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ABSTRACT

This research was carried out in order to determine the effects of different salinity levels (control, 1, 2, 4, 8 and 16 dS m^{-1}) on the growth, seedling development, and water use of peanut (*Arachis hypogaea* cv. NC-7). The study was conducted in 36 pots according to randomized block design in 6 replications. Saline water was prepared by adding NaCl, $MgCl_2$ and $CaCl_2$ into tap water. The tap water (ECi= 0.50 dS m^{-1}) was also used as control treatment. Peanut was harvested at flowering stage. Saline water less than 4 dS m^{-1} had positive effects on plant growth and development parameter while saline water more than 4 dS m^{-1} negatively affected the same crop parameters. Plant height and fresh weight decreased as much as 21.6% and 21.4%, respectively, after 4 dS m^{-1}; while root length decreased 30% after 8 dS m^{-1}, compared to control treatment. Increasing salinity caused an increase in Na concentration in leaves and roots.

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Yerfıstığı
Tuzluluk
Su kullanımı
Fide gelişimi

ÖZ

Bu araştırma, farklı tuzluluk seviyelerinin (0.5, 1, 2, 4, 8 ve 16 dS m^{-1}) NC-7 yerfıstığı çeşidinin büyüme, fide gelişimi ve su tüketimi üzerine etkilerini belirlemek amacıyla yürütülmüştür. Araştırma, tesadüf parsellerinde 6 tekerrürlü olarak toplam 36 saksıda yürütülmüştür. Tuzlu sulama suları NaCl, $MgCl_2$ ve $CaCl_2$ tuzlarının şebeke suyuna karıştırılmasıyla elde edilmiştir. Şebeke suyu (ECi= 0.50 dS m^{-1}) aynı zamanda kontrol konusu olarak kullanılmıştır. Yerfıstığı bitkileri çiçeklenme döneminde hasat edilmiştir. Tuzluluğu 4 dS m^{-1}'den daha düşük sular, bitki büyüme ve gelişme parametreleri üzerine olumlu etkide bulunurken, 4 dS m^{-1}'den daha yüksek tuzluluğa sahip sulama suyu ile sulanan bitkilerin büyüme ve gelişim parametrelerinin olumsuz etkilendiği belirlenmiştir. Bitki boyu ve gövde ağırlığının 4 dS m^{-1}'den sonra sırasıyla %21.6 ve %21.4; kök uzunluğunun ise 8 dS m^{-1}'den sonra %30 oranında azaldığı saptanmıştır. Sulama sularının tuz içeriğinin artması yaprakta ve kökte Na miktarının artmasına yol açmıştır.

1. Introduction

Salinity stress is one of the most important abiotic stress factors that limit crop production in arid and semi-arid regions. Over 6 % of the world's total land area and 20% of the irrigated land area are salt-affected. Most importantly, between 35% and 50% of the world's population in about 80 countries live in semi-arid areas where salinization is a major problem. Salinity has reached a level of 19.5% of all irrigated-land (230 million ha of irrigated land, 45 million ha are salt-affected soils) and 2.1% of dry-land (1500 million ha of dryland agriculture, 32 million are salt-affected soils) agriculture worldwide. According to the FAO, around 1.5 million ha of land in Turkey have both salinity and sodicity problems (FAO 2009; Sönmez 2004).

Decreasing and pollution of natural water resources gradually as a result of global warming and allocation to other sectors (urban and industry) results in the intensive use of marginal quality waters in irrigated agriculture, especially in arid and semi-arid regions. Therefore, researches about the use of saline or marginal quality water in irrigated agriculture are currently being conducted. When the fresh water resources are deficient, saline water is used for irrigation with the precautions taken to prevent any adverse effect on soil and plant. Irrigation water salinity and soil salinity adversely affect crop development and growth, and decrease yield quality considerably. Therefore, salt tolerant plants need to be grown in areas where both soil and water salinity is a problem. The salt threshold values of the crops that will be grown under saline conditions should be known for a successful cultivation and agricultural economy.

Salinity negatively affects plant growth when salts accumulate in the root zone. High levels of salinity affect seed germination and plant growth by water deficit (osmotic stress), ion toxity and ion imbalance (ionic stress) or a combination of these factors (Läuchli and Grattan 2007; McNeil et al. 1999; Reinhardt and Rost 1995). The osmotic effect initially reduces the ability of the plant to absorb water. Several minutes after the initial decrease in leaf growth, a gradual growth recovery takes place until a new steady state is reached, depending on the salt concentration outside the root (Munns et al. 2002). It has been reported that the differences in plant response to the amount of salt available in soil and irrigation water depends not only on plant species but also crop development stages (Maas and Hoffman 1977). Seedling growth stages are the most vulnerable stages in the life cycle of plants. Therefore, in salinity studies, these stages are focused and taken into the consideration when the salt tolerance of a plant is determined (van Hoorn 1991; Ghoulam and Fares 2001). Generally, the growth failure in saline environments stems from the fact that water intake into the seed is hindered (Coons et al. 1990; Mansour 1994). In addition, yield reduction in saline conditions are due to the toxic effect caused by excessive concentration of Na and Cl ions, breakdown of crop ion balance, problems in nutrient uptake and transport, and decrease in physiological processes such as respiration and photosynthesis (Levitt 1980; Yeo and Flowers 1983; Leopold and Willing 1984; Marschner 1995).

Ion balance of plant under salt stress is broken down since uptake of K and NO_3 is hindered by Na and Cl, respectively. It is reported that salinity stunts root and stem elongation (Dash and Panda 2001; Ashraf et al. 2002), and decreases fresh weight and water content (El-Mashad and Kamel 2001).

Most of the literature indicates that crops are particularly susceptible to salinity during the seedling and early vegetative growth stages as compared to germination. Examples are reported in melon (Botia et al. 1998; Nerson and Paris 1984), cowpea (Maas and Poss 1989), lettuce (Coons et al. 1990), beans (Goertz and Coons 1991), zucchini squash (Graifenberg et al. 1996), pepper (Chartzoulakis and Klapaki 2000), spinach (Wilson et al. 2000), tomato (Del Amor et al. 2001), cabbage (Jamil and Rha 2004), and watermelon (Yetisir and Uygur 2009).

Peanut (*Arachis hypogaea* L.) is the second most important cultivated grain legume and the fourth largest edible oilseed crop grown in the world (Shilman et al. 2011). Peanut is grown on 35.5 million ha across 82 countries in the world (Kambiranda et al. 2011).

Among the various abiotic stresses, salinity stress is the most important factor limiting crop productivity throughout the world and has been focus of much research. Little is known about the salinity tolerance of peanut and no attempt has been made to breed salinity tolerant peanut varieties (Vadez et al. 2005). Salinity is one of the important abiotic stresses affecting peanut productivity by hampering germination, arresting vegetative and reproductive growth and affecting seed quality. Efforts to enhance crop yields under salinity stress have also had a limited success because available knowledge of the mechanisms of salt tolerance has not been turned into useful selection criteria to evaluate a wide range of genotypes within and across species. According to the classification of crop tolerance to salinity, peanut is relatively sensitive to salinity (Maas et al. 1986). The problem of salinity continues to grow further because of increasing area under irrigated crops, use of poor quality water for irrigation, poor drainage facility and ingression of sea water. Peanut could be grown with water having EC up to 3.0 dS m^{-1}, but studies have shown that peanut plant starts facing salinity stress above 2.0 dS m^{-1} and EC above 4.5 dS m^{-1} kills the plant.

Salinity is a serious threat to agriculture in arid and semiarid regions (Rao and Sharma 1995). Nearly 40% of the world's land surface can be categorized as having potential salinity problems; most of these areas are confined to the tropics and Mediterranean regions. Increases in the salinity of soils or water supplies used for irrigation result in decreased productivity of most plants and lead to marked changes in the growth pattern of plants (Cordovilla et al. 1994).

The susceptibility of peanut to salinity stress varies with growth stages. Peanuts have a low tolerance to certain salts. The foliar symptoms that develop after irrigation with saline irrigation water vary from a brown marginal leaflet burn to death of the leaf. Pod rot often increases when the sodium and potassium cations accumulate in the fruiting zone. Peanut (*Arachis hypogaea* L.) is an important oilseed, food and feed crop of Turkey. Salinity is one of the important abiotic stress which affect al stages of peanut growth and finally the yield. Among several strategies advised to overcome the problem of salinity stress, the selection of crop species or cultivars with salt tolerance traits has been considered an economical and efficient strategy. It is necessary to identify the sensitivity and tolerance level of a variety at early seedling stages for successful crop production in a saline environment. Therefore, this study was aimed to influence of salinity stress on peanut at early seedling period.

2. Material and Method

This study was carried out in a glasshouse at Bati Akdeniz Agricultural Research Institute (BATEM), in Antalya, Turkey, between 01.06.2013-08.07.2013 to determine the effects of different salinity levels in irrigation water on growth characteristics of peanut (*Arachis hypogaea* cv. NC-7). The geographic coordinates of the experimental area was located at a latitude of 36 56' N and a longitude of 30 53' E, and an altitude of 28 m. The glasshouse was a ventilated naturally with side and ridge openings. Its length, width and floor area were 12.0 m, 30.0 m and 360 m^2, respectively.

Seeds were sown in a mixture of peat and perlite in a 1:1 ratio and were allowed to germinate in greenhouse condition. Seedlings at the 2-true-leaf stage were transplanted to 3 liters pots filled with a mixture of peat and perlite in a 1:1 ratio, and were amended with 0.4 g N l^{-1}, 0.175 g P l^{-1}, 0.332 g K l^{-1}, and 0.4 g Ca l^{-1}. Pots' height, length and width were 15, 40 and 20 cm, respectively. Six kg of peat and perlite mixture was placed in each pot. Thus total volume and surface area of each pot were 12 liters and 800 cm^2, respectively. Pots were saturated with tap water to determine the field capacity. The water contents of the pots after the drainage stopped were assumed as field capacity (W_{FC}), so that we determined each pot separately. Water content of each pots was monitored by weighing the pots as weighing lysimeter method, thus each pot was weighed before each irrigation practices (W). Amount of irrigation water to be applied to each pots (I) was calculated by Ünlükara et al. (2008).

$$I = [(W_{FC}-W)/\rho w]/(1-LF)$$

where, I is amount of irrigation water (Liter), LF is leaching fraction, W is the pot weight just before irrigation starts and ρw is density for water (1.0 kg L^{-1}). The pot surface area is 0.080 m^2, so the depth of irrigation amount can be calculated by dividing 'I' to pot surface area. LF was taken 0.25. Amount of drainage water was measured after irrigation. Drainage leachate was collected by a syringe from each pot. Collected drainage water volume was measured after irrigation. Seasonal water use was determined by means of modified equation of Jensen et al. (1989);

$$WU = d_b + d - d_d - d_s$$

Where, WU is seasonal water use (L), d_b is soil moisture at the beginning of the experiment (L), d is total irrigation water (L), d_d is drainage volume (L), and d_s is soil moisture at the end of the experiment (L).

Seedlings were irrigated with tap water (EC: 0.50 dS m^{-1} and pH: 6.5) for 1 week and then salt application began. Plants were irrigated every 2 days with 5 different saline treatments. The saline waters were prepared by adding $MgCl_2$, $CaCl_2$ and NaCl salts into tap water. In order to eliminate the adverse effect of sodium adsorption ratio (SAR), irrigation water SAR values were maintained less than 5. Salinity levels having different concentrations of 1, 2, 4, 8, and 16 dS m^{-1}, as measured by electrical conductivity, were prepared using salt source of NaCl, $MgCl_2$ and $CaCl_2$. Tap water is used for control treatment. Quality parameters of irrigation water used in the experiment were shown in Table 1.

Table 1. Quality parameters of irrigation water.

EC dS m^{-1}	pH	Anions (me l^{-1})				Cations (me l^{-1})				SAR
		Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4	
0.5	7.7	0.60	0.05	3.25	1.44	-	3.93	1.30	0.11	0.36
1.0	7.9	2.09	0.06	5.28	4.65	-	4.07	6.91	1.10	1.11
2.0	7.7	8.26	0.07	8.78	7.62	-	3.86	14.56	6.31	1.87
4.0	7.7	17.85	0.08	13.65	14.02	-	4.01	25.65	15.94	3.18
8.0	7.6	30.32	0.09	31.34	26.50	-	4.02	52.45	31.78	4.12
16.0	7.6	42.45	0.11	39.68	44.12	-	3.75	87.65	34.96	4.85

The experiment was conducted as a randomized block design with 6 replications, with a total of 36 pots. At the end of 5 weeks (beginning of the flowering stage in the control treatment) plants were harvested and evaluated for their response to salinity. Plant height was measured. Roots and shoots of the plants were separated from the growth medium surface. Plant roots were cleaned off growth medium under running water. Na^+, K^+, and Ca^{2+} concentrations in the leaves and roots were determined by ICP (Varian 720 ES) after nitric acid digestion (Zarcinas et al. 1987). Variance analysis is applied for the obtained data using MSTAT-C program and the differences between the means were compared using Duncan's multiple range test (P≤0.05) (Gomez and Gomez 1984).

3. Results and Discussion

Plant height: The effects of different salinity levels on plant height of peanut are presented in Figure 1. It was determined that salinity level is significant at 0.1 % confidence level. In the study, plant heights are ranged from 13.3 to 24.7 cm. The highest plant height was obtained from 1 dS m^{-1} (24.7 cm), and this was followed by 2, 4, control, 8, and 16 dS m^{-1}.

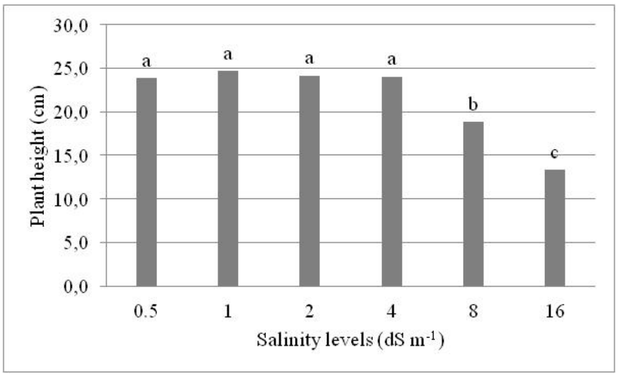

Figure 1. The effects of different salinity levels on plant height (cm).

Root length: The effect of different salinity levels on root length of peanut are presented in Figure 2. It was determined that salinity level is significant at 0.1 % confidence level. Root length decreased with increasing salinity levels and ranged between 14.4 cm in 16 dS m^{-1} and 27.6 cm in control treatment.

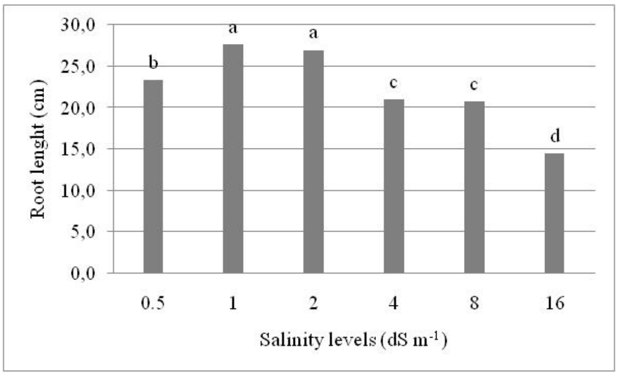

Figure 2. The effects of different salinity levels on root lenght (cm).

Plant fresh weight: The fresh weight is an important parameter determining the growth of a plant. The effects of different salinity levels on plant fresh weight are presented in Figure 3. It was determined that salinity levels are significant at 0.1 %. The highest plant fresh weight was obtained from 2 dS m^{-1} (13.3 g), and this was followed by 4, 1, control, 8, and 16 dS m^{-1}. The lowest plant fresh weight was obtained from 16 dS m^{-1} (3.4 g). It was observed that fresh weights decreased drastically at 8 dS m^{-1} and 16 dS m^{-1} of salinity levels.

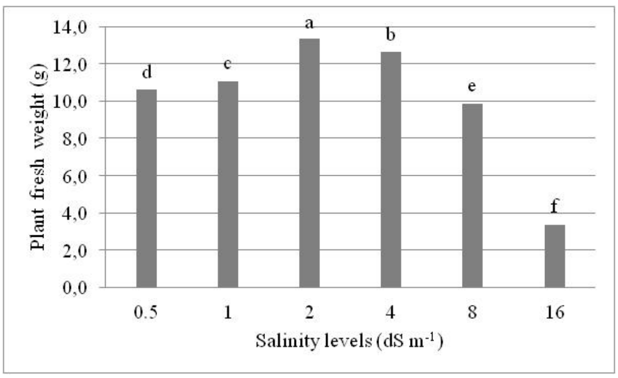

Figure 3. The effects of different salinity levels on plant fresh weight (g).

Root fresh weight: The effects of different salinity levels on root fresh weight are presented in Figure 4. It was determined that salinity levels are significant at 0.1 %. In the study, root fresh weights are ranged from 1.9 to 5.3 g. The highest root fresh weight was obtained from 2 dS m^{-1} (5.3 g), and the lowest root fresh weight was obtained from 16 dS m^{-1} (1.9 g). Similar trend was found in case of root fresh weights like plant fresh weight. Root fresh weight showed a sharp decline after 4 dS m^{-1}.

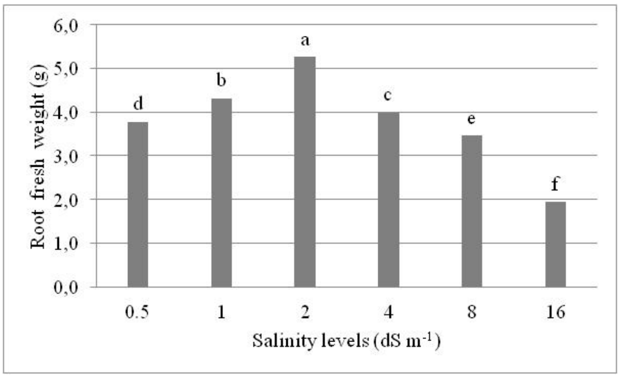

Figure 4. The effects of different salinity levels on root fresh weight (g).

As seen in above given figures, different growing characteristics were significantly affected by salinity stress. The first organ that interacts with salt is roots, as is the case for most of the crops. Therefore, it is inevitable that the crops are affected by salt concentration. From this point of view, the results are in accord with the already published results which reported that increasing salt concentration negatively affects root and shoot development (Dash and Panda 2001; Ashraf and Tufail 1995; Delgado and Sanchez-Raya 2007; Munns et al. 2002; Reinhardt and Rost 1995). The reason that the root and shoot length are affected negatively by salt stress stems from the fact that cytokinesis and cell expansion are inhibited and toxic effect of salts. Additionally, the decrease in hormones that stimulate the growth and increase in hormones that hinder growth can cause shorter root and shoot lengths (Ashraf and O'leary 1997; Foolad 1996; Prakash and Prathapasenan 1990; Taiz and Zaiger 1998). The increase in osmotic pressure around the roots as a result of saline environment can also prevent water uptake by roots, resulting shorter root length and plant height (Al-Karaki 2001; Bohnert et al. 1995; Werner and Finkelstein 1995; Mensah et al. 2006; Sadat-Noori et al. 2008).

Salinity stress had remarkable effects on other plant growth parameters such as plant and root fresh weight. High foliar concentration of Na^{+} is capable of reducing CO_2 assimilation because of ionic toxicity (Cachorro et al. 1993). Reduction in plant and root fresh weight in response to salt stress has been reported for other crops, such as soybean (Zaidi and Sing 1993), chickpea (Khalid et al. 2001), cowpea (Düzdemir et al. 2009), broadbean (De Pascale and Barbieri 1997), black cumin (Hajar et al. 1996), melon (Sivritepe et al. 2005), tomato (Yurtseven et al. 2005), watermelon (Yu-feng 2006), and okra (Ünlükara et al. 2008).

The plant height and root length are the most important parameters for salinity because roots are in direct contact with soil and absorb water from soil and shoot supply it to the rest of the plant. For this reason, root length and plant height provide an important clue to the response of plants to salt stress (Jamil and Rha 2004). Root length and plant height decreased with increasing salinity levels; at 4 dS m^{-1} they decreased drastically. The reason for reduced plant and root development may be due to toxic effects of the salt sources used as well as unbalanced nutrient uptake by the seedlings. High salinity may inhibit root and plant elongation due to slowing down the water uptake by the plant may be another reason for this decrease (Werner and Finkelstein 1995). Neumann (1995) indicated that salinity can rapidly inhibit root growth and hence capacity of water uptake and essential mineral nutrition from soil. These results are similar to those reported by Gupta and Srivastava (1989), Francois et al. (1991), Huang and Redmann (1995), Foolad (1996), Jamil and Rha (2007), and Aydinsakir et al. (2013a).

Ion uptake: The results of the present study showed that salinity levels caused an increase in Na^{+} concentration in the root and leaves. Increased Na^{+} concentration is one of the primary plant responses to salinity (Shachtman and Munns 1992). Sodium accumulation in the root and leaves were affected by the salinity level (Figure 5). The lowest Na^{+} concentration in the leaves were observed from control (0.04 %), while the highest Na^{+} concentration in the leaves were observed from 16 dS m^{-1} (4.15 %). The lowest Na^{+} concentration in the root was obtained from control (0.28 %), while the highest Na^{+} concentration in the root was obtained from 16 dS m^{-1} (6.29 %). Sodium concentration increased in response to salt treatment. The salinity levels increased leaf and root Na^{+} concentration. Previous studies showed similar effects of salinity in sorghum (Beck et al. 2004; Krishnamurthy et al. 2007), maize (Karmoker et al. 2008) wheat (Hu and Schmidhalter 1997), rye-grass (Sagi et al. 1997), eggplant (Chartzoulakis and Loupassaki 1997), pepper (Chartzoulakis and Klapaki 2000), and watermelon (Yetisir and Uygur 2009).

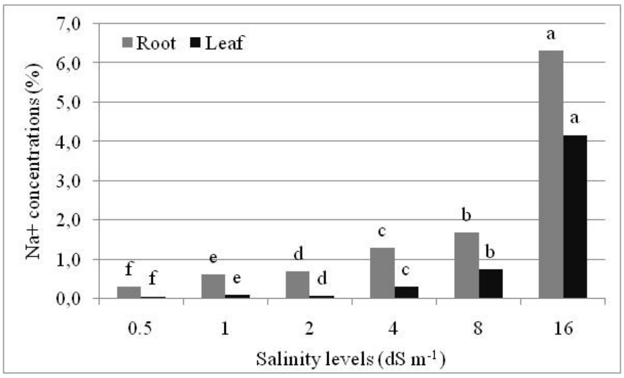

Figure 5. The effect of salinity levels on Na+ concentration in the root and leaves (significant at 0.01 level).

Ca^{++} is important during salt stress, for example, inpreserving membrane integrity (Rengel 1992; Ashraf and Orooj 2006), signalling in osmoregulation (Mansfield et al. 1990). It was reported that the decrease of calcium attraction under saline conditions is because of the increase in Na^{+}/Ca^{++} ratio, this also limits the root's growth (Orcutt and Nilsen 2000; Garcia-Sanchez et al. 2002). In the study, Ca^{++} concentration in the root and leaves significantly decreased in salinity levels. The lowest Ca^{++} concentration in the leaves was observed from 16 dS m^{-1} (1.59 %), while the highest Ca^{++} concentration in the leaves was observed from control (2.61 %). The lowest Ca^{++} concentration in the root was obtained from 16 dS m^{-1} (0.88 %), while the highest Ca^{++} concentration in the root was obtained from control (1.94 %) (Figure 6). The observations in present study are in good agreement with similar studies in peanut and different plants (Singh and Prasad 2009; Cachorro et al. 1993; Cramer et al. 1986; Francois et al. 1991; Loupassaki et al. 2002)

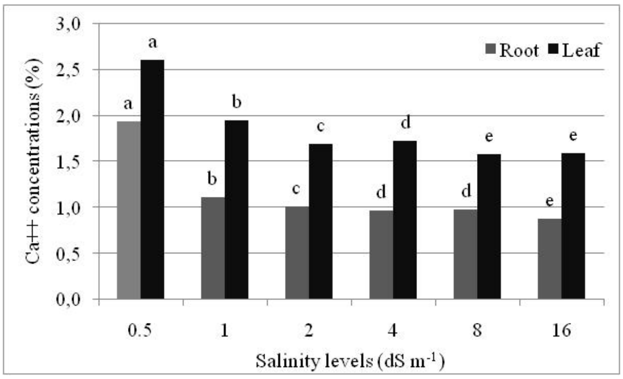

Figure 6. The effect of salinity levels on Ca^{++} concentration in the root and leaves (significant at 0.01 level).

Excessive sodium ions at the root surface disrupt plant potassium nutrition. Because of the similar chemical nature of sodium and potassium ions, sodium has a strong inhibitory effect on potassium uptake by the root (Weimberg 1987; Zhu 2002). Several studies with a wide variety of horticultural crops have shown that K^+ concentration in plant tissue, declines as the salinity in the root media is increased (Francois 1984; Izzo et al. 1991; Graifenberg et al. 1995; Perez-Alfocea et al. 1996). In the study, K^+ concentration decreased with increasing salinity levels (Figure 7). The effect of salinity levels on K^+ accumulation in the study was significant. Control application had the highest K^+ concentration in root and leaves, while 16 dS m^{-1} application had the lowest K^+ concentration in root and leaves. Previous studies showed similar effects of salinity in rice (Lutts et al. 1996), maize (Karmoker et al. 2008), Melilotus segetalis (Romereo and Maranon 1996), spinach (Chow et al. 1990), wheat (Begum et al. 1992), eggplant (Chartzoulakis and Loupassaki 1997), pepper (Chartzoulakis and Klapaki 2000), and watermelon (Yetisir and Uygur 2009).

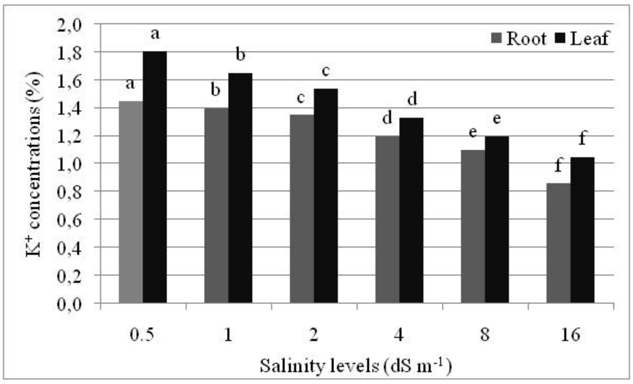

Figure 7. The effect of salinity levels on K^+ concentration in the root and leaves (significant at 0.01 level).

Increasing salinity levels antagonistically affected plant and root fresh weight. Some researchers argue that the plants had the reduction in their fresh weights because of the proportional increase in Na^+ concentration, which could imply that an ionic effect was being manifested. Similar kind of result was observed by Jeannette et al. (2002), and Aydinsakir et al. (2013b).

The level of the salinity in the growth medium directly effects the accumulation of cations (Na^+, Ca^{++}, Mg^+) in leaves as well as roots of seedling. Increasing the salinity levels resulted in significant increase in concentrations of Na in leaves and roots. Leaf parts accumulated less Na^+ than did the root parts. This shows that Na^+ transport from root to leaves accelerated when salinity levels increased as reported by Begum et al. (1992).

According to Weimberg (1987), high levels of Na^+ inhibit the K^+ uptake. As expected, increasing salinity levels resulted in significant decreases in leaves and root concentrations of K^+. Maintenance of adequate levels of K^+ is essential for plant survival in saline habitats. Potassium is the most prominent inorganic plant solute, and as such makes a major contribution to the low osmotic potential in the stele of the roots that is a prerequisite for turgor-pressure-driven solute transport in the xylem and the water balance of plants (Marschner 1995). Under saline conditions, high levels of external Na^+ not only interfere with K^+ acquisition by the roots, but also may disrupt the integrity of root membranes and alter their selectivity. The selectivity of the root system for K^+ over Na^+ must be sufficient to meet the levels of K^+ required for metabolic processes, for the regulation of ion transport, and for osmotic adjustment (Grattan and Grieve 1999). As found with K^+, the concentration of Ca^{++} in leaves and roots was also decreased by the saline treatment.

Water use and water use efficiency: The plant height, applied water, drainage water, pot water depletion, evapotranspiration and water use efficiency from seedling to flowering period in all treatments are presented in Table 2. The amount of water applied 0.5, 1.0, 2.0, 4.0, 8.0, and 16.0 dS m^{-1} treatments were 23.0, 21.6, 25.1, 24.5, 22.4, and 18.4 L pot^{-1} respectively. Drainage water from the pot was also one of the important components in soil water balance, especially in salinity studies. The difference of drainage amount between treatments depended on the amount of applied water and leaching fractions. When the salinity levels increased, a decrease in pot water depletion was observed because of the increased deficiency in pot water storage as a result of transpiration by peanut leaves. Water use of peanut decreased with increasing salinity (Table 2).

The greatest water use value was observed at 2.0 dS m^{-1} irrigation water salinity with 20.2 L. The rest of the treatments had reduced water use. Water use efficiency decreased with increasing salinity levels. The highest water use efficiency was obtained in 1.0 dS m^{-1} treatments (1.4 cm L^{-1}) and the rest of treatments caused to decrease in water use efficiency. Reduction of water use and water use efficiency is a common phenomenon of many crop plants grown under saline conditions The current results are similar to results from tomato (Yurtseven et al. 2005), okra (Ünlükara et al. 2008), eggplant (Ünlükara et al. 2010), carrot (Ünlükara et al. 2011) and fennel (Semiz et al. 2012).

The results of the present study showed that salinity levels caused a decrease in plant height (Table 2). However, compared to control treatment, small increase in plant height in the treatments of 1.0, 2.0 and 4.0 dS m^{-1} was observed. Salinity levels more than 4 dS m^{-1} decreased plant height sharply, comparing to the treatment of 1.0 dS m^{-1}. Plant height in the treatments of 2.0, 4.0, 8.0, and 16.0 dS m^{-1} was lower than that of the treatment of 1.0 dS m^{-1} as much as 2.0 %, 2.8 %, 23.9 %, and 46.2 %, respectively.

Table 2. The component of evapotranspiration and water use efficiency of the experiment.

Treatment ($dS\ m^{-1}$)	Plant height (cm)	Applied water (L)	Drainage water (L)	Pot water depletion (L)	Water use (L)	Water use efficiency ($cm\ L^{-1}$)
0.5	23.8	23.0	5.7	1.3	18.5	1.3
1.0	24.7	21.6	5.4	1.3	17.5	1.4
2.0	24.2	25.1	6.2	1.3	20.2	1.2
4.0	24.0	24.5	6.1	1.2	19.6	1.2
8.0	18.8	22.4	5.6	0.9	17.7	1.1
16.0	13.3	18.4	4.6	0.9	14.7	0.9

4. Conclusion

This study examined the effects of different salinity levels on the early seedling growth stage of peanut. It was concluded that increasing levels of salinity affected negatively the early seedling growth stage and ion uptake. When compared to control treatment, plant height and fresh weight decreased about 21.6% and 21.4%, respectively, after 4 $dS\ m^{-1}$; while root length decreased 30% after 8 $dS\ m^{-1}$. Increasing salinity caused an increase in Na concentration in leaves and roots, while it decreased K and Ca concentration gradually.

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