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IMPACTS OF DIFFERENT SALT SOURCE AND CONCENTRATIONS ON GERMINATION AND SEEDLING GROWTH OF MANY PUMPKIN SEEDS USED AS ROOTSTOCH IN IRAN

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The effects of different salt sources (C Cl_2, NaCl, and KCl) and concentrations, as measured by electrical conductivity, (0, "control", 1, 3, 5, 7 and 9 dS m^{-1}) on seed germination and seedling growth of “Ferro”, “Obez”, “RS 841” and “Strong Tosa F1” pumpkin varieties used as rootstock were investigated in this study. The results showed that germination rate, root length, shoot length, fresh root weight, dry root weight, fresh shoot weight and dry shoot weights tend to decrease when the electrical conductivity of the solution is higher than 5 dS m^{-1}, independent of salt sources and in all of the varieties. Three days after seeding, a germination ratio of 5 % was obtained from RS 841 variety in all salt source and concentrations, while a germination ratio over 50 % was obtained in “Strong Tosa” variety for the same conditions except $CaCl_2$ salt source.

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Nevertheless, seeds germinated in medium having high concentrations of $CaCl_2$ had lower germination rate and poor seedling growth, compared to media having the same concentrations of NaCl and KCl. It was concluded that all of the varieties studied were more sensitive to the concentrations prepared using $CaCl_2$ than that of the KCl, and NaCl.

Key words: germination, rootstock, salinity, seedling

INTRODUCTION

The amount of irrigation water and salinity is one of the factors limiting crop growth in agriculture. Because the water resources over the world are not evenly distributed and cannot be easily accessible during growing period, irrigation is necessary to get the best quality and quantity in agricultural production. However, the irrigation water that contains salts, in a sense, becomes a threat for agricultural production carried out both in open field and protected conditions. In protected cultivation, intensive fertilizers and chemicals used for nutritional purposes and irrigations practiced unconsciously causes salt accumulation in the root zone decreasing the quality and quantity of production. Salinity is one of the major abiotic stresses affecting agricultural productivity. 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 water 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. It has been reported that the differences in plant's response to the amount of salt available in soil and irrigation water depends not only on plant species but also crop development stages (MAAS & HOFFMAN, 1977). Germination and 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 considerations when the salt tolerance of a plant is determined (VAN HOM, 1991; GHOULAM & FARES, 2001). Generally, the germination failure on 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 photosynthesize (LEVITT, 1980; YEO & FLOWERS, 1983; LEOPOLD & 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 slows down germination (KABAR & BALTEPE, 1987; GULZAR &

KHAN, 2002), stunts root and stem elongation (DASH & PANDA, 2001; ASHRAF *et al.*, 2002), and decreases fresh weight and water content (EL-MASHAD & KAMEL, 2001). In recent years, grafted seedlings are often used in vegetative cultivation instead of conventional seedling because grafted seedling are more tolerant to biotic an abiotic stresses. It is reported that grafted seedlings are also, to some extent, tolerant to soil borne pathogens as well as biotic stresses such as salinity and temperature (YETISIR & UYGUR, 2009). However, studies regarding the effect of different salt source and concentrations on the germination and seedling growth of rootstock seeds are lacking. Because reclamation of salt affected soils is difficult, expensive and time consuming, one of the most effective ways to overcome salinity problems is the introduction of salt tolerant crops. For an effective and economical production in saline environments, growers need to know in advance the tolerance level of a specific crop. Although salt tolerance of a crop is changing with developmental stage, the most sensitive stage to salinity is germination stage.

Therefore, the aim of this study is to determine the effects of different salt source (NaCl, $CaCl_2$ and KCl) and concentrations (0 “control”, 1, 3, 5, 7 and 9 dS m^{-1}), as measured by electrical conductivity, on germination and characteristics in the early seedling growth stage of seeds of pumpkin varieties included “Ferro”, “Obez”, “RS 841” and “Strong Tosa F1”, which were used very often as rootstock for commercial watermelon cultivation.

MATERIALS AND METHODS

The study is conducted in the laboratory and Greenhouse of the Department of Horticulture, Univerisity of Tehran, Karaj, Iran, in 2010. Seeds of pumpkin varieties, “Ferro”, “Obez”, “RS 841” and “Strong Tosa F1’, are chosen as crop material. Solutions having different concentrations of 1, 3, 5, 7 and 9 dS m^{-1}, as measured by electrical conductivity, were prepared using salt source of NaCl, $CaCl_2$ and KCl. Distilled water is used for control treatment. In agricultural salinity studies, electrical conductivity of irrigation water or soil saturation paste extracts are preferred to express the salinity levels for classification of irrigation water or the tolerance of a specific crop as it is easy to determine and a lumped parameter representing the total amount of ions in the solutions (AYERS & WETSCOT, 1985). As many as 15 seeds are placed in petri dishes having diameter of 15 cm after Whatman # 41 filter paper is spread out on the dishes. In the first October of 2010, as much as 20 ml of solution prepared using different salt sources is put in the petri dishes whose edges were covered with parafilm to avoid of evaporation. The petri dishes containing seeds and solutions are kept for 9 days in an incubator located in a dark room whose temperature is maintained constant at 24°C. The observations were carried out daily at the same time and the seeds having root length of 1 mm was assumed to be germinated. The germinated seeds in each petri dish were expressed as a percentage by dividing the germinated seeds to the total number of seeds. At the end of the 9th day of the experiment, petri dishes were kept for 5 days in the laboratory having the maximum light of 108 μmol s^{-1} m^{-2} at 400-700 nm wave length and temperature of 24.4±1.8ºC. The experiment was formed according to randomized block design with three factors (four different rootstock seeds, three different salt sources, six different concentration levels) and three replications. As many as 216 petri dishes were used and each petri dish containing 15 seeds was considered to be one replication. The parameters such as germination ratio root and shoot length, fresh and dry root weight and fresh and dry shoot weight are determined in the experiment. The change of germination ratio with time as well as salt source and concentrations are depicted in figures whereas variance analysis is applied for the other data using MSTAT-C program and the differences between the means were compared using Duncan's multiple range test ($P<0.05$) (GOMEZ & GOMEZ, 1984).

RESULTS AND DISCUSSION

Germination ratio

The effect of different salt source and concentrations on germination ratio (%) is explained in Figure 1. Generally, in all varieties studied, the results revealed that germination ratio decreased as salt concentration increased. The decrease in germination ratio is more pronounced especially in $CaCl_2$ salt source for all varieties (Fig.1). Seeds in control treatment reached a germination ratio over 80 % in three days in 'Strong Tosa' variety while a germination ratio less than 50 % was obtained from 'Ferro', 'Obez' and 'RS841' varieties. However, after sixth days, more than 90 % of the seeds in all of the control treatments were germinated, indicating that there was no difference among varieties in terms of germination ratio under non-saline conditions. The germination ratio in the first three days decreased depending on the salt source and concentrations for all varieties. Although the germination ratio increased as time progress, germination ratio depending on concentrations is differentiated in the sixth and ninth days of the experiment, especially in concentrations prepared using $CaCl_2$ salt source, showing that the concentration intervals were chosen properly. The highest germination ratio, starting 3rd days up to 9th days, was obtained from control treatments while the lowest one was obtained from the treatments of 9 dS m^{-1}, independent of salt sources (Fig.1). The effect of different concentrations, as expressed electrical conductivity, depending on salt source, on germination ratio (%) is plotted in Figure. 2. More than 80 % germination ratio was attained in NaCl and KCl salt sources. In other words, the effect of salinity is not pronounced well for all varieties. However, when $CaCl_2$ is used for salt sources, overall, a lower germination ratio and also a sharp decrease in germination ratio after 5 dS m^{-1} was observed. Also, higher variations in germination ratio for all varieties were observed in concentrations prepared using $CaCl_2$ whereas it was lower for concentrations prepared using NaCl and KCl (Fig 2). The decrease arises from addition of Ca ions. In a study in *Hordeum vulgare* and *Hordeum bulbosum* using $CaCl_2$ as a salt source was reported also that the germination ratio is decreasing in both of the varieties and attributed the decrease to affect of Ca^{+2} ions (TAVILI & BINIAZ, 2009). The decrease in germination ratio in higher concentrations may be caused by hindrance of water uptake, toxic effect of a special ion or inactivation of some of the enzymes necessary for germination, as pointed out by a number of researchers (DAN & BRIX, 2007; GREENWAY & MUNNS, 1980; KHLAJEH-HOSSEINI *et al.*, 2003; SHALHEVET *et al.*, 1995; SHONJANI, 2002; WANG & SHANNON, 1999).

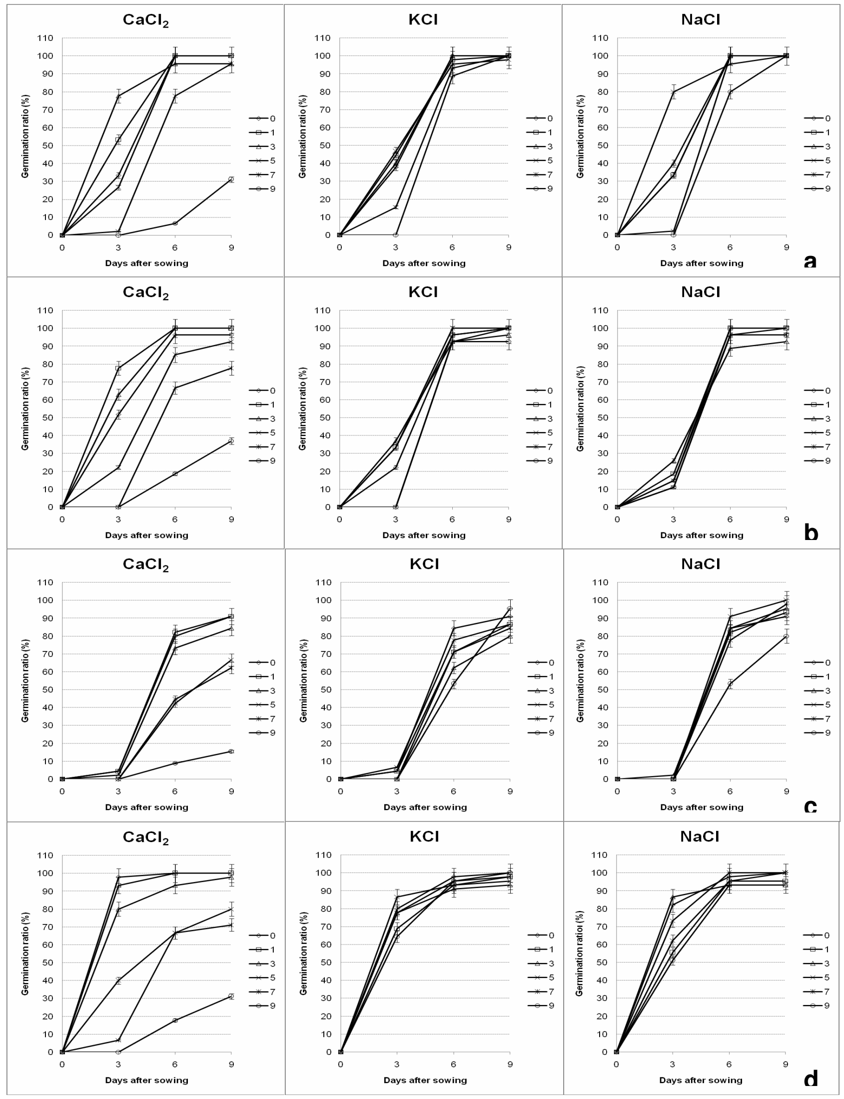

Figure 1. The effects of different salt source and concentration on germination ratio of a) Ferro, b) Obez, c) RS 841 and d) Strong Tosa.

The results obtained in this study are consistent with results obtained in lettuce (COONS *et al*., 1990), bean (GOERTZ & COONS, 1991; BAYUELO-JIMENEZ *et al*., 2002), sorghum and alfalfa (MALIBARI *et al*., 1993), corn (KATERJI *et al*., 1994), sunflower (ASHRAF & TUFAIL, 1995; KAYA & DAY, 2008), eggplant (DEMIR *et al*., 2003), barley (AKINCI *et al*., 2004; MADIDI *et al*., 2004), sorghum (SHARMA *et al*., 2004), watermelon (YU-FENG, 2006), and wheat (KARA & UYSAL, 2010).

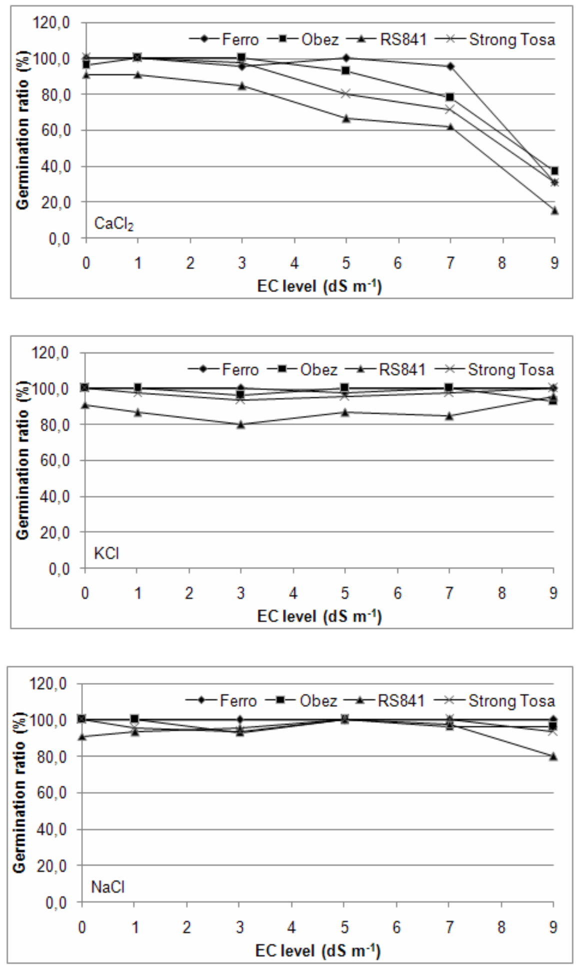

Figure 2. The effect of different salt source and concentration on final germination ratio.

Fresh root weight

The effects of different salt source and concentrations on fresh root weight of pumpkin seeds are presented in Table 1. It was determined that variety, salt source, concentration, and interactions of variety-salt source, salt source-concentration, variety-concentration and variety-salt source-concentration is significant at 0.1 % confidence level.

Table 1. The effects of different salt source and concentration on fresh root weight of varieties (mg).

Varieties	Salt Sources	Salt Concentrations (dS m^{-1}) 0	1	3	5	7	9	Mean of Varieties
Ferro	$CaCl_2$	128.9 df	210.2 ab	98.3 eg	64.2 gh	64.7 gh	28.3 h	131.6 B[z]
	KCl	87.9 fg	129.5 df	126.0 df	127.4 df	158.7 bd	144.1 ce	
	NaCl	127.4 df	151.9 ce	231.2 a	186.4 ac	177.8 bd	126.2 df	
Obez	$CaCl_2$	180.5 cd	345.4 a	168.3 de	71.4 gh	42.0 h	27.6 h	171.1 A
	KCl	93.7 fg	177.4 cd	120.3 ef	179.3 cd	179.3 cd	167.7 de	
	NaCl	196.1 cd	259.3 b	267.6 b	250.1 b	225.5 bc	129.0 ef	
RS 841	$CaCl_2$	111.8 bd	176.8 a	72.1 df	35.7 gh	36.1 fh	26.1 h	90.2 C
	KCl	66.4 eg	75.3 df	69.6 eg	108.0 be	88.4 ce	84.4 de	
	NaCl	100.7 be	105.0 be	130.2 b	133.8 b	128.7 b	73.4 df	
Strong Tosa	$CaCl_2$	162.5 bc	199.2 a	46.9 fg	56.2 f	17.1 gh	11.3 h	118.0 BC
	KCl	93.4 e	120.7 de	93.6 e	155.7 bc	116.4 de	99.9 e	
	NaCl	137.0 cd	143.1 cd	162.9 bc	181.2 ab	184.4 ab	142.9 cd	
Mean of Concentrations:		123.9 bc	174.5 a	132.3 b	129.1 bc	118.3 bc	88.4 c	

Mean of Salt Sources:	
$CaCl_2$	:99.2 B
KCl	:119.3 B
NaCl	:164.7 A

Significance:

Variety (V): ***[y] Salt Source (S): *** VxS:*** Concentrations (C):*** VxC:*** SxC:*** VxSxC:***

[z]:Means different according to Duncan test at 5% confidence level are shown using different letters. [y]: ***, significant at 0.1% confidence level.

In the study, fresh root weights are ranged from 11.3 to 345.4 mg. The highest fresh root weights, as expressed the mean of varieties, are obtained from 'Obez' variety (171.1 mg) and this was followed by 'Ferro' (131.6 mg), 'Strong Tosa' (118.0 mg) and 'RS 841' (90.2 mg) varieties. When mean of salt sources are taken into consideration, the highest fresh root weight was obtained from NaCl (164.7 mg), and this was followed by KCl (119.3 mg) and $CaCl_2$ (99.2 mg). The highest fresh root weight, as a mean of concentrations, was acquired from 1 dS m^{-1}, it decreased as salt concentration increased and reached the lowest fresh root weight (88.4 mg) in the treatment of 9 dS m^{-1}. 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 development (DASH & PANDA, 2001; ASHRAF & TUFAIL, 1995; DELGADO & SANCHEZ-RAYA, 2007; MUNNS, 2002; REINHARDT & ROST, 1995).

Dry root weight

The effects of different salt source and concentrations on dry root weight of pumpkin seeds are given in Table 2. As concentration increased, it was observed that dry root weights are differed depending on varieties. In general, the highest dry root weights values are attained when the concentration is 1 dS m^{-1} for all of the varieties studied and thereafter a decreasing trend was observed. Among the varieties, the highest mean dry root weights are obtained from 'Obez' variety (15.0 mg) and followed by 'Ferro' (12.0 mg), 'Strong Tosa' (12.0 mg) and 'RS 841' (8.8 mg) varieties. As salt sources are taken into account, the highest mean dry root weight was obtained from NaCl (13.6 mg), and this was followed by KCl (11.4 mg) and $CaCl_2$ (10.8 mg).

Table 2. The effects of different salt source and concentration on dry root weight of varieties

Varieties	Salt Sources	Salt Concentrations (dS m^{-1}) 0	1	3	5	7	9	Mean of Varieties
Ferro	$CaCl_2$	8.7 ef	22.2 a	11.5 de	10.7 de	7.6 f	4.1 g	12.0 AB[z]
	KCl	11.7 de	13.7 cd	13.5 cd	13.0 cd	11.9 cd	8.6 ef	
	NaCl	10.7 de	10.9 de	18.4 b	14.9 c	12.7 cd	12.1 cd	
Obez	$CaCl_2$	11.5 eg	29.4 a	21.7 b	8.5 gh	7.0 hý	3.8 ý	15.0 A
	KCl	14.4 de	10.1 fh	15.4 de	16.3 cd	15.0 de	12.9 df	
	NaCl	12.8 df	16.1 cd	21.9 b	19.9 bc	21.4 b	12.1 dg	
RS 841	$CaCl_2$	8.8 bf	17.0 a	10.7 bd	6.5 ef	5.0 fg	2.1 g	8.8 B
	KCl	9.9 be	7.0 df	7.8 cf	10.3 be	7.8 cf	7.7 cf	
	NaCl	7.7 cf	7.1 df	12.1 b	11.4 bc	10.9 bd	8.5 bf	
Strong Tosa	$CaCl_2$	12.7 bd	19.5 a	6.1 f	14.2 bc	9.25 ef	2.2 g	12.0 AB
	KCl	12.5 bd	9.2 ef	12.1 ce	13.8 bc	10.2 de	9.0 ef	
	NaCl	13.4 bd	13.4 bd	13.4 bd	15.6 b	14.7 bc	14.1 bc	
Mean of Concentrations:		11.2 ac	14.6 a	13.7 ab	12.9 ab	11.1 bc	8.1 c	

Mean of Salt Sources:	
$CaCl_2$	:10.8 B
KCl	:11.4 B
NaCl	:13.6 A

Significance:

Variety (V): ***[y] Salt Source (S): *** VxS:*** Concentrations (C):*** VxC:*** SxC:*** VxSxC:***

[z]:Means different according to Duncan test at 5% confidence level are shown using different letters. [y]: ***, significant at 0.1% confidence level.

Fresh shoot weight

The effects of different salt source and concentrations on fresh shoot weight of seeds are presented in Table 3. It was determined that variety, salt source, concentration, and interactions of variety-salt source, salt source-concentration, variety-concentration is significant at 0.1 % confidence level whereas interaction of variety-salt source-concentration is significant at 0.5 % confidence level. Among the varieties, the highest fresh root weight was obtained from ‘Obez’ (534.9 mg) variety followed by ‘Strong Tosa’ (399.0 mg), ‘Ferro’ (396.1 mg) ‘RS 841’ (270.0 mg). The lowest fresh root weight (291.4 mg) was obtained from treatments where $CaCl_2$ was used as salt source whereas the highest one (456.1 mg) was obtained by KCl, and the medium fresh shoot weight (452.5 mg) was attained from NaCl salt source. Fresh shoot weight obtained from control treatment, 0 dS m^{-1}, was found to be 488.6 mg, and thereafter it decreased as salt concentration increased, reaching the lowest value (260.8 mg) in the treatment where the concentration is 9 dS m^{-1}.

Table 3. The effects of different salt source and concentration on fresh shoot weight of varieties (mg).

Varieties	Salt Sources	Salt Concentrations (dS m^{-1}) 0	1	3	5	7	9	Mean of Varieties
Ferro	$CaCl_2$	552.7 ab	308.8 de	399.3 cd	248.3 ef	151.9 fg	117.7 g	396.1 B[z]
	KCl	444.5 bc	562.0 a	462.2 ac	456.0 ac	457.9 ac	447.1 ac	
	NaCl	473.3 ac	512.8 ac	480.9 ac	466.7 ac	408.0 cd	179.7 fg	
Obez	$CaCl_2$	658.0 ad	545.5 ce	513.5 de	316.7 f	152.4 g	91.2 g	534.9 A
	KCl	560.3 cd	737.1 ab	695.2 ac	642.4 ad	580.9 bd	512.0 de	
	NaCl	643.0 ad	799.4 a	599.7 bd	548.8 ce	638.9 ad	394.0 ef	
RS 841	$CaCl_2$	368.4 a	291.2 ab	302.0 ab	116.5 c	99.4 c	66.7 c	270.0 C
	KCl	313.0 ab	286.4 ab	313.9 ab	298.1 ab	283.6 ab	220.0 b	
	NaCl	361.6 a	376.5 a	325.0 ab	309.0 ab	289.3 ab	238.4 b	
Strong Tosa	$CaCl_2$	559.0 a	392.0 de	377.9 e	162.8 f	135.4 f	66.4 g	399.0 B
	KCl	430.6 be	492.6 ab	481.2 b	434.4 be	440.7 be	395.0 de	
	NaCl	498.5 ab	500.3 ab	455.8 bd	473.5 bc	484.2 b	401.6 ce	
Mean of Concentrations:		488.6 a	483.7 a	450.5 ab	372.8 b	343.6 b	260.8 c	

Mean of Salt Sources:	
$CaCl_2$	:291.4 B[y]
KCl	:456.1 A
NaCl	:452.5 A

Significance:

Variety (V): ***[y] Salt Source (S): *** VxS:*** Concentrations (C):*** VxC:*** SxC:*** VxSxC:***

[z]:Means different according to Duncan

Dry shoot weight

The effects of different salt source and concentrations on dry shoot weight are tabulated in Table 4. As seen in Table 4, the dry shoot weight values changed depending on increasing concentration. Generally speaking, the highest dry shoot weight was obtained from control treatment, 0 dS m^{-1}, and thereafter a decreasing trend was observed. Taking the salt sources into consideration, treatments prepared using $CaCl_2$ salt source gave the lowest dry shoot weight, comparing the dry shoot weight obtained from treatment prepared using KCl and NaCl salt sources. When the varieties are evaluated, it was observed that the dry shoot weight obtained from 'Ferro', 'Obez' and 'Strong Tosa' varieties were higher than that of the dry shoot weight obtained from RS841.

Table 4. The effects of different salt source and concentration on dry shoot weight of varieties (mg).

Varieties	Salt Sources	Salt Concentrations (dS m^{-1})						Mean of Varieties
		0	1	3	5	7	9	
Ferro	$CaCl_2$	98.9 ab	91.7 ab	92.1 ab	95.1 ab	64.8 d	56.1 d	87.5 A^z
	KCl	95.7 ab	94.2 ab	90.6 ac	89.6 ac	88.5 ac	82.4 bc	
	NaCl	103.9 a	88.9 ac	90.7 ac	89.1 ac	89.0 ac	72.8 cd	
Obez	$CaCl_2$	91.3 ac	88.8 ac	95.8 ac	85.8 ac	54.0 d	17.8 e	83.1 A
	KCl	92.6 ac	90.4 ac	101.0 a	95.8 ac	89.9 ac	75.0 c	
	NaCl	97.7 ab	86.3 ac	86.0 ac	86.1 ac	83.1 ac	77.8 bc	
RS 841	$CaCl_2$	79.5 ab	68.8 ab	59.6 ab	29.2 c	31.8 c	25.0 c	65.1 B
	KCl	79.6 ab	58.1 b	76.2 ab	63.0 ab	72.0 ab	68.4 ab	
	NaCl	75.4 ab	74.7 ab	76.7 ab	82.1 a	79.2 ab	72.4 ab	
Strong Tosa	$CaCl_2$	98.2 a	84.4 ab	90.1 ab	45.0 c	45.5 c	17.5 d	81.8 A
	KCl	93.4 a	91.3 a	91.9 a	97.8 a	88.3 ab	76.6 b	
	NaCl	94.5 a	88.3 ab	95.2 a	96.4 a	94.4 a	83.7 ab	
Mean of Concentrations:		91.7 a	83.8 ab	87.2 ab	79.6 ab	73.4 bc	60.5 c	

Mean of Salt Sources:	
$CaCl_2$	:67.0 B
KCl	:85.1 A
NaCl	:86.0 A

Significance:

Variety (V): ***^{y} Salt Source (S): *** VxS:*** Concentrations (C):*** VxC:*** SxC:*** VxSxC:***

^{z}:Means different according to Duncan test at 5% confidence level are shown using different letters. ^{y}: ***, significant at 0.1% confidence level.

Root length

The impact of different salt source and concentrations on root length of pumpkin seeds are presented in Table 5. While the effect of salt source, and interaction of variety-salt source and variety-salt source-concentrations on root length are found to be statistically not significant; variety, concentration and interactions of salt source-concentration, and variety concentration are found to be statistically significant at 0.1 % confidence level, as seen in Table 5. The highest root length among the varieties was obtained from 'Obez' variety (10.2 cm) and this was followed by 'Ferro' (8.1 cm), 'RS 841' (7.7 cm) and 'Strong Tosa' (6.4 cm) variety. Considering the salt sources, the shortest root length was attained in KCl (7.4 cm) while the longest root length was obtained from NaCl (8.9 cm). The longest root length (10.1 cm) was attained in the treatments where the concentration, as expressed electrical conductivity, was kept 1 dS m^{-1} while the shortest root length (5.2 cm) was attained in the treatments where the concentrations was 9 dS m^{-1}. In other words, the root length decreased as concentration increased.

Table 5. The effects of different salt source and concentration on root lenght of varieties (mg).

Varieties	Salt Sources	Salt Concentrations (dS m^{-1}) 0	1	3	5	7	9	Mean of Varieties
Ferro	$CaCl_2$	7.4 dg	14.5 a	8.5 df	8.0 dg	7.7 dg	2.7 h	8.1 AB[z]
	KCl	6.0 g	7.1 eg	7.3 eg	8.9 ce	8.0 dg	6.2 fg	
	NaCl	5.9 g	7.3 eg	11.7 b	9.7 bd	10.7 bc	7.8 dg	
Obez	$CaCl_2$	10.8 be	16.4 a	11.7 be	6.2 g	6.9 fg	2.8 h	10.2 A
	KCl	10.5 cf	10.7 be	9.4 eg	9.1 eg	9.4eg	8.8 eg	
	NaCl	10.3 df	11.6 be	13.0 ad	14.0 ac	14.2 ab	8.3 eg	
RS 841	$CaCl_2$	9.2 b	14.2 a	7.7 bd	5.6 de	7.4 bd	1.1 f	7.7 B
	KCl	9.0 b	6.5 ce	8.7 bc	7.5 bd	6.6 ce	5.0 e	
	NaCl	8.3 bc	7.4 bd	9.1 b	9.1 b	8.4 bc	7.0 be	
Strong Tosa	$CaCl_2$	8.4 b	12.4 a	7.0 bd	5.8 cd	5.6 cd	1.0 e	6.4 B
	KCl	5.8 cd	5.3 cd	6.4 bd	5.6 cd	5.5 cd	4.8 d	
	NaCl	5.6 cd	7.3 bc	7.2 bc	7.5 bc	7.4 bc	6.3 bd	
Mean of Concentrations:		8.1 a	10.1 a	9.0 a	8.1 a	8.1 a	5.2 b	

Mean of Salt Sources:	
$CaCl_2$	:7.9
KCl	:7.4
NaCl	:8.9

Significance:

Variety (V): ***[y] Salt Source (S): N.S. VxS: N.S. Concentrations (C): *** VxC: *** SxC: *** VxSxC:N.S.

[z]:Means different according to Duncan test at 5% confidence level are shown using different letters. [y]: *** and N.S., significant at 0.1% confidence level and not significant, respectively.

Shoot length

The impact of different salt source and concentrations on shoot length of pumpkin seeds are given in Table 6. The effects of variety, salt source, concentration and the interactions of variety-salt source, salt source-concentrations and variety concentration on shoot length are found to be statistically significant. The longest shoot length (6.8 cm) was obtained from 'Obez' variety and that was followed by 'Ferro' (5.2 cm), 'Strong Tosa' (4.9 cm), and 'RS 841' (4.5 cm) varieties. When the salt sources are considered, treatments where KCl was used for saline environments gave the longest shoot length (6.3 cm) and this was followed by the treatments of NaCl (5.5 cm) and $CaCl_2$ (4.5 cm) environments.

Table 6. The effects of different salt source and concentration on shoot lenght of varieties (mg).

Varieties	Salt Sources	Salt Concentrations (dS m^{-1}) 0	1	3	5	7	9	Mean of Varieties
Ferro	$CaCl_2$	6.4 ac	6.2 ac	5.5 c	4.0 d	2.4 e	1.2 f	5.2 B[z]
	KCl	6.2 ac	7.3 a	6.7 ab	6.0 bc	5.9 bc	5.5 c	
	NaCl	5.8 bc	7.2 a	6.2 ac	5.9 bc	4.4 d	0.9 f	
Obez	$CaCl_2$	8.8 ab	6.1 d	6.9 cd	4.1 e	3.2 e	0.9 f	6.8 A
	KCl	8.3 ab	9.5 a	9.3 a	8.3 ab	7.8 bc	6.7 cd	
	NaCl	8.5 ab	8.8 ab	7.8 bc	6.7 cd	6.5 cd	4.3 e	
RS 841	$CaCl_2$	5.8 a	4.2 bd	5.2 ab	4.1 bd	2.7 e	0.8 f	4.5 B
	KCl	5.5 a	5.4 a	5.9 a	6.0 a	4.9 ac	2.9 e	
	NaCl	5.9 a	5.3 a	4.8 ac	4.1 bd	4.0 cd	3.6 de	
Strong Tosa	$CaCl_2$	6.7 a	4.9 eg	5.3 cf	3.9 g	2.7 h	0.9 ý	4.9 B
	KCl	6.2 ac	5.6 bf	6.5 ab	4.9 eg	5.0 dg	4.7 fg	
	NaCl	6.1 ad	6.0 ae	5.5 bf	4.7 fg	4.6 fg	4.0 g	
Mean of Concentrations:		6.7 a	6.4 a	6.3 a	5.2 b	4.5 b	3.1 c	

Mean of Salt Sources:	
$CaCl_2$	:4.3 B
KCl	:6.3 A
NaCl	:5.5 A

Significance:

Variety (V): ***[y] Salt Source (S): *** VxS: *** Concentrations (C): *** VxC: *** SxC: *** VxSxC: ***

[z]:Means different according to Duncan test at 5% confidence level are shown using different letters.

[y]: ***, significant at 0.1% confidence level.

Among concentration, the longest shoot length (6.7 cm) was attained in control treatment and thereafter the shoot length decreased depending on increasing concentration. The shortest shoot length (3.1 cm) was obtained from treatment where concentration was 9 dS m^{-1}. The variety of 'Obez' gave the longest shoot length

(9.5 cm), comparing to the other varieties studied, in the treatment where the salt source was KCl and the concentration was 1 dS m^{-1}. The shoot and root length are important in salinity studies as these organs are in direct contact with soil particles and solution. In the study, comparing to $CaCl_2$ and NaCl solutions, the longer shoot length of seedlings was obtained in KCl concentration, whereas the longer root length was obtained in NaCl concentration. The shoot length was the organ that was affected by salinity at most. Similarly, in a study conducted in wheat, was reported that shoot length, rather than root length, was affected excessively by increasing salinity levels (GUPTA & SRIVASTAVA, 1989). 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 & O'LEARY, 1997; ATAK *et al*., 2006; BEGUM *et al*., 1992; FOOLAD, 1996; PRAKASH & PRATHAPASENAN, 1990; TAIZ & 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 and shoot length (AL-KARAKI, 2001; BOHNERT *et al*., 1995; WERNER & FINKELSTEIN, 1995).

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UTICAJ RAZLIČITIH IZVORA I KONCENTRACIJE SOLI NA KLIJANJE I RAST KLIJANACA VELIKOG BROJA SEMENA BUNDEVE KOJI SE KORISTE KAO PODLOGA U IRANU

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U radu su prikazani rezultati istraživanja efekta različitih izvora i koncentracija soli (C, Cl $_2$, NaCl I KCl) , merenih električnom provodljivošću (0, "kontrola", 1, 3, 5, 7 i 9 dS m^{-1}) na klijanje semena i rast klijanaca sorata bundeve “Ferro”, “Obez”, “RS 841” i “Strong Tosa F1” koje se koriste kao podloga. Dobijeni rezultati su pokazali da brzina klijanja, dužina korena, visina klijanca, težina sveže mase korena, težina suve mase korena, težina sveže mase klijanca i težina sveže mase klijanca imaju tendenciju smanjenja kod svih ispitivanih sorata kada je električna provodljivost rastvora veća od 5 dS m^{-1}, nezavisno od izvora soli. Tri dana posle setve klijavosti od 5% je dobijena kod sorte RS 841 na svakom izvoru soli i svim koncentracijama, dok je klijavost iznad 50% dobijena kod sorte “Strong Tosa” pod istim uslovima izuzev kod CaCl kao izvora soli. Nezavisno od toga, seme koje je naklijavano na podlozi koja je imala visoku koncentraciju CaCl je imalo manju brzinu klijanja i slab porast klijanaca kada se uporedi sa podlogom koja je imala iste koncentracije NaCl I KCl. Zaključeno je da su sve ispitivane sorte bile osetljivije na koncentracije CaCl nego na podlogama sa KCl i NaCl.

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