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Chloride salts inhibit emergence and seedling growth of chickpea rather than germination

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ABSTRACT

The effects of chloride salts (NaCl, $MgCl_2$ and $CaCl_2$) with the same electrical conductivity (EC) values on germination, emergence, seedling growth and Cl content of seedling in chickpea cultivars (Akçin 91, Aziziye, Gökçe, Inci, Işık-05 and Yaşa-05) were investigated. The EC values of the chloride salts were adjusted to 4, 8 and 16 dS m^{-1} and the distilled water was served as control. Germination percentage, mean germination time, radicula and plumula lengths, fresh and dry radicula and plumula weight, chloride (Cl^-) content of seedling in germination test, and seedling length, fresh and dry seedling weight in emergence test were measured. The results revealed that increasing salt doses caused a significant reduction in parameters of all cultivars. The dose of 16 dS m^{-1} from each salt was found to be lethal. Cl^- content of seedling was increased from 0.05 ppm in control to 4.10 ppm in 16 dS m^{-1}; resulting in decreasing germination, emergence and seedling growth. The cultivar Aziziye presented better performance and gave higher emergence rates in NaCl, while Işık-05 in $CaCl_2$ and Gökçe in $MgCl_2$; indicating that there was a genotypic variation towards different salt sources. It was concluded that emergence and seedling growth were severely influenced by increasing salinity without changing germination and emergence was not possible at 16 dS m^{-1}.

Key words: *Cicer arietinum* L., $CaCl_2$, $MgCl_2$, NaCl, Salinity, Seed viability.

INTRODUCTION

Among the food legumes cultivated in Turkey, chickpea (*Cicer arietinum* L.) is the most important plant because of its high adaptation ability to arid and semi-arid regions without irrigation requirement. It is commonly used for a rich source of protein (20-30 %), carbohydrates (40 %) and minerals for human diet (Flowers *et al.,* 2010; Gaur *et al.,* 2012). In the country, it has 359.000 hectares of cultivation areas with an annual seed production of 460.000 tons, giving an average seed yield of 1290 kg ha^{-1} (Anonymous, 2016). It is usually grown in crop rotation with wheat/barley-fallow system to increase farm productivity because limited crop plants can be grown due to inadequate rainfall (Kagan and Kayan, 2014); consequently, seed yield and quality are considerably reduced. Under these conditions, its productivity is severely affected by various biotic (*Ascochyta blight*) and abiotic stresses such as drought, heat and salinity.

Soil salinity naturally occurs on soils with low moisture because evaporation exceeds precipitation, leading the accumulation of salts on the soil surface. Saline soils contain various types of soluble salts, particularly, chlorides (NaCl, $CaCl_2$ and $MgCl_2$), sulfates (Na_2SO_4), nitrates ($NaNO_3$ and KNO_3), carbonates and bicarbonates (Na_2CO_3 and $NaHCO_3$). But, the major salt in saline soils is sodium chloride (NaCl) with 50-80 % of total soluble salts (Rengasamy, 2010). In general, NaCl has been studied for salinity tolerance but, little information exists the other salts on germination and emergence. They have different effects on plant life while one of the major impacts on initial plant growth is toxicity (Munns and Tester, 2008; Tobe *et al.,* 2004). Furthermore, salt stress causes a reduction in yield due to high accumulation of ions in different tissues of plant parts which results in cellular disfunction by ionic imbalance in the cells and limits plant growth (Munns, 2002). Tavakkoli *et al.* (2010) found both Na^+ and Cl^- were toxic to plant growth of faba bean, but Cl^- was more toxic than Na^+ while barley growth was inhibited by the additive effects of both Na^+ and Cl^- (Tavakkoli *et al.,* 2011).

The chickpea is classified as a salt sensitive plant by Mass and Hoffman (1977), Ashraf and Waheed (1993), while a significant genetic variation against salinity was observed (Valdez *et al.,* 2012; Turner *et al.,* 2013). Salinity usually causes less inhibition on germination than the

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subsequent early seedling growth of chickpea (Yadav *et al.,* 1989; Kaya *et al.,* 2008), but Kumar (1985) found that earlier growth stages of chickpea are more tolerant to salt stress rather than reproductive stages. Nevertheless, the response of chickpea to salt types existed in soil has not been reported. Because dominant salts in soils show a considerable variation, genotypic responses to each salt should be determined. The study was aimed to determine the influence of increasing levels of electrical conductivities on germination, emergence, seedling growth and the genotypic responses of chickpea to chloride salts.

MATERIALS AND METHODS

This research was conducted at the Department of Field Crops, Faculty of Agriculture, Erciyes University, Kayseri, Turkey under the laboratory conditions. The seeds of chickpea cultivars Akçin-91, Aziziye, Gökçe, Inci, Işik-05 and Yaşa-05 were used as the experimental material. NaCl, $MgCl_2$ and $CaCl_2$ levels with the electrical conductivities of 4, 8 and 16 dS m^{-1} were prepared using the conductivity meter WTW 3.15i before the beginning of the experiment. Distilled water was used as a control (0 dS m^{-1}).

For germination test, four replicates of 50 seeds from each cultivar (totally 200 seeds) were placed among three layers of filter papers with 30 ml of each salt concentration. The papers were replaced every 2 days to inhibit salt accumulation (Kaya *et al.,* 2008). After the papers were rolled, they were put into a sealed polyethylene bag to prevent moisture evaporation. The seeds were germinated at 20±1 °C in the dark condition in incubator for 10 d. The seeds were considered as germinated when the visible radicle elongated to 2 mm. Germination speed (GS) was calculated for the mean germination time as described by ISTA (2003) rules with the formula below:

$$MGT = \sum(Dn) / \sum n,$$

Where D is the number of newly germinated seeds on each day and n is days of counting.

Emergence percentage was determined at laboratory conditions using 4×50 seeds from each cultivar. The seeds were sown in a seedling tray (30 cm × 20 cm × 7 cm) filled with sterilized sand at 2 cm depths and the trays were transferred into a growth chamber at 20±1 °C and 70 % relative humidity. The seedlings emerged at the surface were daily counted up to 15 days after sowing.

After the seedlings sampled from each chloride salt and dose at germination test were washed with distilled water, they were separately dried at 70 °C for 48 h in an oven for chloride analysis. Chloride contents were detected by a titrimetric method as described by Johnson and Ulrich (1959).

The experiment was established as completely randomized blocks (CRD) with 3 factors. The first factor was cultivars (Akçin91, Aziziye, Gökçe, Inci, Işık-05 and Yaşa-05), the second was chloride salts (NaCl, $CaCl_2$ and $MgCl_2$), and the third was different salinity levels (0, 4, 8 and 16 dS m^{-1}). Data given in percentages were statistically analyzed after arcsine transformation. Analysis of variance (ANOVA) was performed for all investigated parameters by using the MSTAT-C computer software, version 2.10 (Michigan State University, USA). Significant differences among the means were compared by LSD test ($p<0.05$).

RESULTS AND DISCUSSION

A three-way interaction (cultivar, chloride salt and dose) was significant ($p<0.05$) for all investigated characters. Germination percentage was statistically influenced by cultivar, chloride salt and doses. The main effect of the investigated factors showed that cultivars, chloride salts and doses significantly affected mean germination time, plumula and radicula length (Table 1). The minimum germination

Table 1: Main effects of chloride salts and doses on germination and early seedling growth of chickpea cultivars in germination test

	Germination (%)	MGT (day)	Radicula length (cm)	Plumula length (cm)
Cultivars				
Akçin 91	99.5^{a}	3.29^{c}	2.32^{c}	1.35^{a}*
Aziziye	99.5^{a}	3.35^{bc}	2.07^{e}	1.16^{e}
Gökçe	99.5^{a}	3.41^{b}	2.38^{b}	1.23^{b}
Inci	91.2^{b}	3.06^{d}	2.19^{d}	1.32^{b}
Işık-05	99.5^{a}	3.61^{a}	2.39^{b}	1.05^{f}
Yaşa-05	99.9^{a}	3.14^{d}	2.71^{a}	1.27^{c}
Salts				
NaCl	98.1^{a}	3.50^{a}	2.72^{a}	1.60^{a}
$CaCl_2$	97.7^{b}	3.07^{c}	2.14^{c}	1.07^{b}
$MgCl_2$	98.7^{a}	3.36^{b}	2.17^{b}	1.02^{c}
Doses				
Control	97.8^{b}	3.14^{b}	2.80^{a}	1.50^{a}
4 dS m^{-1}	98.3^{a}	3.18^{b}	2.65^{b}	1.38^{b}
8 dS m^{-1}	98.7^{a}	3.22^{b}	2.28^{c}	1.22^{c}
16 dS m^{-1}	97.7^{b}	3.71^{a}	1.65^{d}	0.81^{d}

*: Means followed by the same letter(s) in each column are not significantly different at $p < 0.05$.

among the cultivars was determined in Inci with 91.2 %. Increasing electrical conductivity by chloride salts caused a considerable retardation in mean germination time. The highest the time to germination and the lowest seedling growth were detected in 16 dS m^{-1}; however, chickpea cultivars gave different responses to chloride salts. These results are in agreement with the observations of Okcu *et al.* (2005) in pea and Kaya *et al.* (2008) in chickpea, who found that increasing NaCl did not lead to a reduction in germination percentage but delayed MGT. This finding shows that germination failure due to salinity resulted from an osmotic barrier constituted by NaCl, $CaCl_2$ and $MgCl_2$ and supported by Murillo-Amador *et al.* (2002), Khajeh-Hosseini *et al.* (2003) and Okcu *et al.* (2005), However, seedling growth was more sensitive to salt stress than was germination.

For the emergence and seedling characteristics, the main effects of the cultivar, chloride salt and doses were displayed in Table 2. Among the cultivars, Inci had the minimum emergence percentage and the least emergence percentage was obtained from $MgCl_2$ with 75.4 %. A dose of 16 dS m^{-1} of the chloride salts showed the detrimental effects on emergence and seedling growth. The shortest seedling and the lowest seedling weights were observed in $CaCl_2$. Increasing dose of each salt resulted in a significant decrease in seedling growth.

Germination percentage was influenced by the three-way interaction of cultivar × chloride salt × dose, but inhibition did not clear to evaluate for practical purposes (Table 3). Generally, higher than 95% of germination was observed at all doses of the chloride salts except for cv. Inci, whose initial mean germination percentage was 89 %. Considering chickpea cultivars, Inci gave lower germination percentage in the all doses of salts. Similar results were determined by Dua (1992), Soltani *et al.* (2002) and Kaya *et al.* (2008) in chickpea, who found no difference in the effect of salinity on germination. However, emergence percentage was severely affected by increasing salinity doses and no emerged seedling was observed at 16 dS m^{-1} of all chloride salts (Table 3). Considering 8 dS m^{-1} of three salts, chickpea cultivars gave different responses to chloride salts. Emergence percentage of Yaşıa-05 was drastically decreased in $MgCl_2$, while Akçin 91 in $CaCl_2$ and Işık-05 in NaCl exhibited the worst emergence performance. Although the radicle length was adversely affected due to salt type and doses, significant and higher inhibition was very obvious at 16 dS m^{-1} ($p < 0.05$). Similarly, Esechie *et al.* (2002) observed a slower and lower emergence percentage than germination in solutions at same salinities.

Slower growth and greater reduction in plumula length due to salinity was very evident ($p< 0.05$) (Table 3). Salt types influenced the plumula length of the cultivars while the least inhibitory effect was determined in NaCl. Plumula growth was prevented when an increase in salt types existed. Radicle length was also shortened when the salt concentration increased. The longest root was obtained at control while the shortest was at 16 dS m^{-1} (Table 6). Similar findings, indicating that early seedling growth was more sensitive to salt stress than germination, were observed by Soltani *et al.* (2002) and Kaya *et al.* (2008) in chickpea.

Depending on decrease in plumula and radicle length in germination test, seedling length sharply declined with the increasing electrical conductivity of the chloride salts (Table 4). The longest seedlings were obtained from Işık-05 under all NaCl concentrations. Seedling length was adversely inhibited by increasing salt doses with complete

Table 2: Main effects of chloride salts and doses on emergence and early seedling growth of chickpea cultivars in emergence test

	Emergence (%)	Seedling length (cm)	Seedling fresh weight (mg $plant^{-1}$)	Seedling dry weight (mg $plant^{-1}$)
Cultivars				
Akçin 91	77.0^{b}	13.6^{c}	410^{e}	51.9^{b}*
Aziziye	78.6^{b}	12.9^{d}	460^{cd}	53.7^{b}
Gökçe	79.0^{b}	13.4^{cd}	436^{de}	50.3^{b}
Inci	69.4^{c}	16.3^{a}	490^{b}	62.3^{a}
Işık-05	82.9^{a}	16.1^{a}	550^{a}	66.0^{a}
Yaşa-05	77.9^{b}	15.3^{b}	472^{bc}	55.3^{b}
Salts				
NaCl	80.3^{a}	14.9^{a}	478^{a}	63.3^{a}
$CaCl_2$	76.6^{b}	13.9^{b}	450^{b}	52.0^{b}
$MgCl_2$	75.4^{b}	15.0^{a}	481^{a}	54.4^{b}
Doses				
Control	87.9^{a}	18.3^{a}	614^{a}	73.0^{a}
4 dS m^{-1}	86.1^{a}	15.7^{b}	503^{b}	60.4^{b}
8 dS m^{-1}	58.4^{b}	9.9^{c}	292^{c}	36.4^{c}
16 dS m^{-1}	-	-	-	-

*: Means followed by the same letter(s) in each column are not significantly different at $p < 0.05$. -: Data could not be taken due to any emergence and seedling growth

Table 3: Effects of chloride salts and doses on percentage of germination and emergence, and plumula length of chickpea cultivars

Salt	Dose dS m^{-1}	Cultivar					
		Akçin 91	**Aziziye**	**Gökçe**	**Inci**	**Işık 05**	**Yaşa 05**
		Germination percentage (%)					
NaCl	Control	100.0^{a}	99.5^{a}	100.0^{a}	89.5^{def}	100.0^{a}	100.0^{a*}
	4	100.0^{a}	99.5^{a}	100.0^{a}	91.0^{c-f}	100.0^{a}	100.0^{a}
	8	100.0^{a}	99.5^{a}	100.0^{a}	91.5^{cde}	100.0^{a}	100.0^{a}
	16	100.0^{a}	99.5^{a}	100.0^{a}	85.0^{f}	99.5^{a}	100.0^{a}
$CaCl_2$	Control	98.0^{ab}	100.0^{a}	98.0^{ab}	88.0^{ef}	99.5^{a}	100.0^{a}
	4	99.5^{a}	99.0^{a}	100.0	90.0^{def}	98.5^{a}	100.0^{a}
	8	99.5^{a}	100.0^{a}	99.5^{a}	92.0^{b-e}	99.0^{a}	100.0^{a}
	16	96.5^{abc}	98.5^{a}	98.5^{a}	90.5^{c-f}	100.0^{a}	100.0^{a}
$MgCl_2$	Control	100.0^{a}	99.5^{a}	100.0^{a}	88.5^{def}	100.0^{a}	100.0^{a}
	4	100.0^{a}	99.5^{a}	100.0^{a}	94.0^{a-e}	100.0^{a}	99.5^{a}
	8	100.0^{a}	99.5^{a}	99.5^{a}	99.5^{a}	99.5^{a}	99.5^{a}
	16	100.0^{a}	99.5^{a}	99.5^{a}	94.5^{a-d}	98.5^{a}	100.0^{a}
		Emergence percentage (%)					
NaCl	Control	$82.0^{a-ý}$	88.5^{a-g}	90.5^{a-e}	74.5^{a-l}	95.5^{abc}	93.0^{a-e}
	4	85.5^{a-h}	95.0^{abc}	90.0^{a-e}	76.5^{a-k}	89.0^{a-f}	90.0^{a-e}
	8	68.5^{e-n}	89.5^{a-f}	64.0^{g-n}	50.0^{l-q}	$60.0^{ý-o}$	63.5^{h-n}
	16	-	-	-	-	-	-
$CaCl_2$	Control	90.0^{a-e}	89.0^{a-f}	88.5^{a-g}	72.0^{c-l}	94.0^{a-d}	88.0^{a-h}
	4	$83.0^{a-ý}$	78.5^{a-k}	81.0^{a-j}	$82.0^{a-ý}$	90.0^{a-e}	94.5^{abc}
	8	45.0^{n-q}	47.0^{m-q}	36.0^{opq}	75.0^{a-k}	74.0^{a-l}	71.5^{c-m}
	16	-	-	-	-	-	-
$MgCl_2$	Control	$84.5^{a-ý}$	97.0^{ab}	98.0^{a}	69.5^{d-n}	92.5^{a-e}	94.5^{abc}
	4	89.5^{a-f}	92.0^{a-e}	94.5^{abc}	71.0^{c-m}	94.5^{abc}	73.0^{b-l}
	8	65.0^{f-n}	30.5^{q}	69.0^{e-n}	54.0^{k-q}	56.5^{j-p}	33.0^{pq}
	16	-	-	-	-	-	-
		Plumula length (cm)					
NaCl	Control	2.24^{cd}	1.92^{ef}	2.57^{ab}	2.08^{c-g}	1.51^{de}	1.76^{fg}
	4	2.40^{bc}	1.35^{j-p}	$1.57^{hý}$	$2.26^{ý-m}$	1.27^{e}	$1.60^{ghý}$
	8	1.73^{gh}	2.62^{a}	1.74^{gh}	1.46^{m-s}	$1.46^{ý-1}$	1.24^{n-v}
	16	1.07^{v-z}	0.86^{2-5}	1.01^{x-2}	1.10^{w-1}	0.78^{t-y}	0.83^{3-6}
$CaCl_2$	Control	1.37^{j-o}	1.13^{s-y}	1.29^{1-s}	1.15^{z-2}	1.18^{p-x}	1.35^{j-o}
	4	1.25^{n-o}	1.08^{u-z}	1.16^{q-x}	1.15^{s-w}	1.05^{w-1}	$1.45^{ý-1}$
	8	1.02^{x-7}	0.81^{3-6}	0.86^{2-5}	1.22^{r-w}	0.82^{3-6}	1.10^{t-y}
	16	0.76^{4-7}	0.74^{567}	0.61^{789}	0.89^{234}	0.67^{6-9}	$1.49^{ýjk}$

*: Means followed by the same letter(s) are not significantly different at $p < 0.05$. -: Data could not be taken due to any emergence

inhibition and no shoots growth at 16 dS m^{-1} in all cultivars. As no shoot growth was recorded at 16 dS m^{-1}, their seedling fresh and dry weights could not be measured. The minimum seedling length was determined in Aziziye exposed to 8 dS m^{-1} of $MgCl_2$. Compared to control, each increase in salt concentration caused a considerable decline in seedling fresh weight of all the cultivars. These results were similar to those observed by Soltani *et al.* (2002) and Kaya *et al.* (2008). Generally, the inhibitory dose of salinity was 8 dS m^{-1} while the detrimental level was 16 dS m^{-1}. Seedling fresh weight of cv. Aziziye was more susceptible to NaCl and $MgCl_2$ than $CaCl_2$, because the decrease in seedling fresh weight was more dramatic. Increasing EC levels from three salts induced a considerable reduction on seedling dry weight, but chickpea genotypes gave different responses (Table 4). This reported by several researchers (Ashraf and Waheed, 1993; Khalid *et al.,* 2001; Al-Mutawa, 2003) who found genotypic variation in seedling growth among chickpea varieties for tolerance to NaCl levels, but Kaya *et al.* (2008) seed size plays a key role for germination under salt stress.

Chloride contents of chickpea seedlings enhanced linearly with increasing electrical conductivity of the solution (Fig. 1). At the highest EC, 16 dS m^{-1}, the lower chloride content was obtained from $CaCl_2$ than the other salts. Chickpea cultivars had different responses to chloride salts in terms of Cl^- uptake and Inci had the maximum Cl^- content (Fig. 2). The lowest Cl^- content was observed from Gökçe in NaCl, Yasa-05 in $CaCl_2$ and Inci in $MgCl_2$. Higher Cl^- content relatively interested in lower emergence percentage and seedling growth. Tavakkoli *et al.,* (2010) revealed that accumulation of Na^+ and Cl^- leads to ion toxicity in plant tissues and faba bean growth was adversely affected by both Na and Cl^- toxicity while Cl^- was found more toxic than Na^+. Our findings confirmed these results because increasing Cl^-

Table 4: Effects of chloride salts and doses on radicle length, seedling length, seedling fresh and dry weight of chickpea cultivars

Salt	Dose dS m^{-1}	Cultivar					
		Akçin 91	**Aziziye**	**Gökçe**	**Inci**	**Işık 05**	**Yaşa 05**
		Radicle length (cm)					
NaCl	Control	2.82^{f-j}	3.26^{c}	4.18^{a}	3.04^{c-g}	3.17^{cde}	3.54^{b}*
	4	3.08^{c-f}	2.84^{f-j}	3.22^{cd}	2.66$^{ý-m}$	3.04^{c-g}	3.56^{b}
	8	2.76^{h-k}	1.18^{67}	2.65^{j-n}	2.40^{m-s}	3.16^{cde}	2.97^{d-h}
	16	2.01^{u-z}	2.08^{t-w}	1.94^{v-z}	1.91^{w-1}	2.04^{uvw}	1.75^{z12}
$CaCl_2$	Control	2.37^{o-s}	2.44^{m-q}	2.53^{k-o}	1.75^{z-2}	2.53^{k-o}	2.93^{e-h}
	4	2.36^{o-s}	2.32^{o-t}	2.35^{o-s}	2.14^{s-w}	2.39^{n-s}	2.92$^{e-ý}$
	8	2.16^{r-w}	2.02^{u-y}	1.95^{v-z}	2.15^{r-w}	1.96^{v-z}	2.48^{l-p}
	16	1.58^{234}	1.66^{123}	1.41$^{3-6}$	1.54^{234}	1.37^{456}	2.04^{u-x}
$MgCl_2$	Control	2.92$^{e-ý}$	2.18^{q-v}	2.80^{g-j}	2.40^{m-r}	2.74^{h-l}	2.77^{h-k}
	4	2.48^{l-p}	2.06^{t-w}	2.26^{p-u}	2.51^{k-p}	2.45^{m-p}	3.05^{c-g}
	8	2.01^{u-z}	1.78^{x-2}	2.00^{v-z}	2.38^{o-s}	2.26^{p-u}	2.73^{h-l}
	16	1.25^{567}	1.07^{7}	1.24^{567}	1.44^{345}	1.62^{234}	1.76^{y-2}
		Seedling length (cm)					
NaCl	Control	13.83^{l-q}	22.35^{ab}	19.90^{b-e}	21.41^{bc}	24.76^{a}	18.84^{e-j}
	4	14.55^{k-o}	17.02^{e-l}	12.98^{m-s}	17.38^{d-k}	19.47^{b-h}	13.07^{m-r}
	8	9.03^{t-x}	8.83^{u-x}	7.90^{wx}	8.14^{vwx}	10.03^{r-w}	9.17^{t-x}
	16	-	-	-	-	-	-
$CaCl_2$	Control	18.50^{c-j}	10.39^{r-w}	12.13^{n-t}	17.34^{d-k}	19.73^{b-f}	19.28^{b-h}
	4	15.45^{j-m}	8.09^{wx}	12.86^{m-s}	18.71$^{c-ý}$	15.38^{j-m}	18.22^{e-j}
	8	10.06^{r-w}	8.36^{u-x}	10.37^{r-w}	14.55^{k-o}	9.83^{s-w}	11.39^{o-u}
	16	-	-	-	-	-	-
$MgCl_2$	Control	14.45^{k-p}	19.61^{b-g}	16.33^{h-l}	20.40^{bcd}	18.84$^{e-ý}$	21.17^{bc}
	4	15.68$^{ý-m}$	14.83^{k-n}	16.67^{f-l}	18.56^{c-j}	16.39^{h-l}	16.48^{g-l}
	8	10.64^{q-w}	6.58^{x}	11.32^{p-v}	10.43^{r-w}	10.87^{q-w}	10.49^{r-w}
	16	-	-	-	-	-	-
		Seedling fresh weight (mg $plant^{-1}$)					
NaCl	Control	431^{h-o}	877^{a}	639^{e-f}	666^{b-e}	845^{ab}	563$^{e-ý}$
	4	454^{g-m}	553$^{e-ý}$	425^{h-o}	542$^{d-ý}$	635^{e-f}	359^{j-p}
	8	258^{op}	296^{m-p}	234^{p}	265^{nop}	347^{k-p}	222^{p}
	16	-	-	-	-	-	-
$CaCl_2$	Control	588^{e-h}	399$^{ý-p}$	430^{h-o}	535^{d-j}	705^{a-d}	641^{e-f}
	4	479^{f-l}	295^{m-p}	426^{h-o}	556$^{e-ý}$	534^{d-j}	632^{e-g}
	8	238^{p}	273^{nop}	307^{l-p}	440^{h-n}	294^{m-p}	326^{k-p}
	16	-	-	-	-	-	-
$MgCl_2$	Control	454^{g-m}	723^{abc}	626^{e-g}	599^{e-h}	623^{e-g}	706^{a-d}
	4	496^{e-k}	491^{e-k}	529^{d-j}	541$^{d-ý}$	621^{e-g}	484^{f-l}
	8	296^{m-p}	233^{p}	309^{l-p}	263^{nop}	347^{k-p}	319^{k-p}
	16	-	-	-	-	-	-
		Seedling dry weight (mg $plant^{-1}$)					
NaCl	Control	57.5^{d-q}	91.6^{abc}	85.3^{a-d}	100.9^{a}	97.4^{ab}	81.9^{a-f}
	4	61.9^{c-o}	66.6^{c-l}	58.2^{d-q}	74.7^{a-g}	82.6^{a-e}	53.4^{e-q}
	8	40.9$^{ý-r}$	43.4^{h-r}	17.9^{r}	41.3$^{ý-r}$	51.9^{f-q}	32.2^{o-r}
	16	-	-	-	-	-	-
$CaCl_2$	Control	67.9^{b-j}	41.9$^{ý-r}$	49.2^{g-q}	63.4^{c-n}	78.6^{a-g}	66.8^{c-k}
	4	58.6^{d-q}	37.0^{k-r}	51.7^{f-q}	70.7$^{a-ý}$	60.9^{d-p}	67.1^{b-k}
	8	32.8^{o-r}	32.5^{o-r}	35.9^{m-r}	43.1$^{ý-r}$	40.9$^{ý-r}$	37.4^{k-r}
	16	-	-	-	-	-	-
$MgCl_2$	Control	56.8^{d-q}	82.2^{a-f}	62.5^{c-o}	73.8^{a-h}	78.5^{a-g}	77.7^{a-g}
	4	55.4^{d-q}	57.9^{d-q}	55.6^{d-q}	59.9^{d-q}	64.9^{c-m}	49.9^{g-q}
	8	35.7^{m-r}	29.8^{qr}	36.3^{l-r}	33.4^{n-r}	38.1^{j-r}	31.2^{pqr}
	16	-	-	-	-	-	-

*: Means followed by the same superscript letter(s) and figure(s) are not significantly different at $p < 0.05$. -: Data could not be taken due to any shoot growth

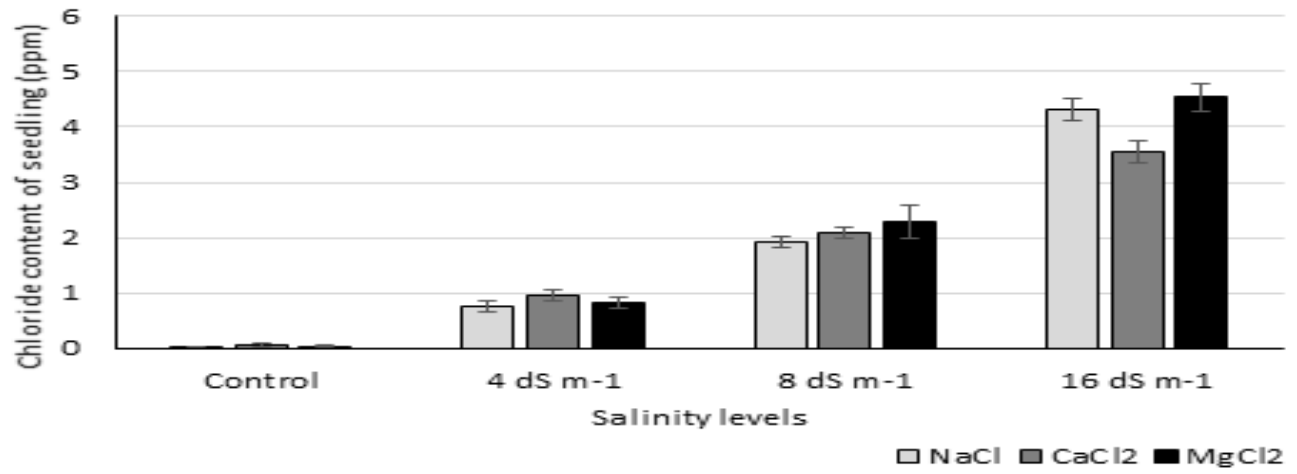


Fig 1: Chloride (Cl^-) contents of chickpea seedlings exposed to various levels of NaCl, $CaCl_2$ and $MgCl_2$. Bars on each column show standard error.

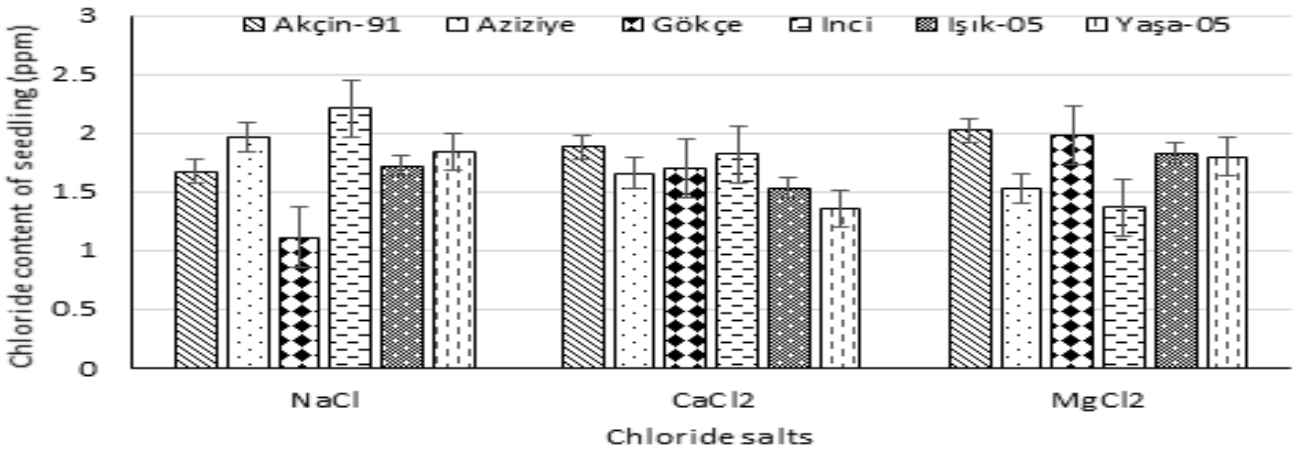


Fig. 2: Chloride (Cl^-) contents of seedlings of chickpea cultivars under NaCl, $CaCl_2$ and $MgCl_2$. Bars on each column show standard error.

content in chickpea seedling resulted in decreasing growth. Flowers *et al.* (2010) and Samineni *et al.* (2011) found that the Cl^- content of shoots is usually higher than that of Na^+. Moreover, Mamo *et al.* (1996) suggested that increased shoot Cl^- content reduced the seedling growth of chickpea, Grewal (2010) found a significant correlation between shoot growth and shoot Cl^- concentration.

In conclusion, laboratory experiments conducted to detect the responses of the chickpea cultivars to different chloride salts showed that there was a significant variation among chickpea cultivars under different chloride salts. The cultivars Aziziye, Işık-05 and Gökçe should be preferred in soils contaminated by NaCl, $CaCl_2$ and $MgCl_2$, respectively. Germination was not reduced by both chloride salts and increasing doses while emergence percentage decreased considerably. No emergence and seedling growth were determined at 16 dS m^{-1} of all salts, while the inhibition started at 8 dS m^{-1}. Among the chloride salts, there was no apparent difference for germination, but emergence and seedling growth were less influenced by NaCl compared to $CaCl_2$ and $MgCl_2$, indicating that their effects on plant growth was more deleterious than NaCl.

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