Irrigation Water Salinity Influences at Various Growth Stages of *Capsicum annuum*

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Abstract:

Availability of fresh surface water for irrigation is declining in southern New Mexico, and saline groundwater is increasingly used for irrigation. This study evaluates the effects of irrigation using saline water on the chile pepper plants. The chile pepper (*Capsicum annuum L.*) cultivars selected include, AZ 1904, NuMex Joe E. Parker, NuMex Sandia Select, LB 25, and 3441. Salt tolerance of these five cultivars was studied at various growth stages including germination, emergence, vegetative growth, flowering and fruiting stages in a greenhouse set up. The five saline treatments included for germination were tap water of EC 0.6 (control), well water of EC 3 and 6, and RO concentrate of EC 8 and 10 dS/m. During plant emergence and growth, natural water ECs for irrigation were 0.6 (control), 3, 5 and 8 dS/m. Increasing irrigation water salinity increased mean germination time but did not affect the final germination percentage. Increasing irrigation water salinity increased mean emergence time but the final percentage emergence was affected significantly only after $EC \geq 3$ dS/m. Plant growth was significantly affected after several weeks of continuous exposure to saline water application ($EC \geq 3$ dS/m). Increasing salinity decreased days to flowering, photosynthesis, stomatal conductance, relative fresh shoot and fruit weights, and water use efficiency. Results show that the selected chile pepper cultivars can be irrigated up to an irrigation water salinity level of ≤ 3 ds/m. Among all the cultivars, 3441 was found to be the most tolerant to salinity. Environmentally sound reuse of RO concentrate will encourage desalination in water scarce areas and greenhouse chile cultivation.

Key-words: chile peppers, flowering, concentrate, salt tolerance, yield, greenhouse

1.0 Introduction:

Salinity and drought are two of the major abiotic stresses for crop production in many parts of the world including the southwestern United States. These regions are predominantly arid to semiarid and are affected by salinity due to low rainfall, high evapotranspiration and saline groundwater (Niu *et al.*, 2010). With the persistent drought in these regions, the surface water availability for irrigation has declined and groundwater is increasingly used by farmers for irrigation. About 75% of the available groundwater is saline, with an electrical conductivity > 3 dS/m (Lansford *et al.*, 1990; WRRI, 1997). Continuous application of saline water can lead to the buildup of salts near the soil surface. Consequently, osmotic potential and nutritional imbalance induce stress in plants and consequently adversely impact growth and yield (Asiraf, 1994; Singh *et al.*, 2014); however, effects of salinity could be a function of the growth stages, species and variety of the plant (Botia *et al.*, 1998).

The responses of crops to salinity often change from one development stage of growth to the next. Most crops show tolerance to salinity during germination with a delay in days to germination (Mass and Poss, 1989a). Unlike germination however, most crops are susceptible during emergence and vegetative development as seedlings are subjected to water stress, varying salinities due to capillary rise and evaporation near the soil surface (Katerji *et al.*, 1994; Pasternak *et al.*, 1979). Plants become progressively more tolerant to salinity with maturity, especially at later stages of development (Lauchli and Epstein, 1990; Foolad, 2007). However, the growth responses to salinity can differ within species. Like sugarbeet (*Beta vulgaris* L.), a crop known to be salt tolerant during later growth stages is fairly sensitive at germination stage (Jamil and Rha, 2004); and turnip (*Brassica campestris* L.) has salt tolerance at germination, but is more susceptible to salts at seedling growth (Francois, 1984). In addition, salinity induces

early flowering in onion (*Allium cepa* L.), but it delays flowering of tomato (*Lycopersicon esculentum* L.) (Shannon and Grieve, 1998). Thus, there is variability of growth responses to salt stress within species and quantitative information available on salt tolerance at different growth stages for many of the species is meager.

Chile pepper is an important cash crop of Southwestern United States, with nearly 8,000 to 10,000 acres harvested annually in New Mexico with a processed value estimated to be \$500 million (Bosland and Walker, 2014). It has been classified as moderately sensitive to salinity with a threshold level of 1.5 dS/m, above which yield begins to decline (Maas and Hoffman, 1977). Some studies have reported that the seedling stage of chile pepper is more sensitive to salinity than germination (Chartzoulakis and Klapaki, 2000; Niu *et al.*, 2010). Introduction of salt tolerant genotypes could be an effective way to eliminate salinity effects for all crops including chile pepper. Limited studies have reported that some chile pepper genotypes are more salt tolerant than others (Atkas, 2006; Chartzoulakis and Klapaki, 2000; Niu *et al.*, 2010). Thus, it is necessary to examine the stress response of different varieties of chile pepper at various growth stages for sustaining crop production.

Salt components in the irrigation water can have a large variability across the globe. However, Na^+ , Ca^{2+} and Mg^{2+} are dominant cations, and Cl^- , SO_4^{2-} and HCO_3^- are the dominant anions in most of the groundwater (Grattan and Grieve, 1998). To our knowledge, most of the saline studies conducted so far on peppers used NaCl either as sole or as dominant salinizing agent (Aktas *et al.*, 2006; Chartzoulakis and Klapaki, 2000; Demir and Mavi, 2008; Niu *et al.*, 2010; Yildirim and Güvenç, 2006). Therefore, research on the use of natural brackish groundwater for irrigation is needed for sustaining chile pepper production in arid areas including the southwestern USA. Objectives of the study were to assess 1) the effect of saline

groundwater irrigation at various growth stages of chile peppers; and 2) the relative salt tolerance of five chile peppers cultivars. This study was conducted in a greenhouse environment because there is a potential of greenhouse chile pepper production in New Mexico and New Mexico Department of Agriculture does not allow land application of water with $EC > 4$ dS/m.

2.0 Materials and Methods

This study was carried out in a greenhouse located at the Fabian Garcia Science Center of New Mexico State University (NMSU), Las Cruces, New Mexico (32.2805° N latitude and 106.770° W longitude at an elevation of 1186 m above sea level). The average air temperature in the greenhouse recorded during the entire experiment was $32.44 \pm 0.16^{\circ}\text{C}$ during day and $24.22 \pm 0.12^{\circ}\text{C}$ during night. Five chile pepper cultivars were selected for this study. NuMex Joe E. Parker and NuMex Sandia Select are NMSU cultivars. Seeds of the remaining three cultivars were obtained from various seed suppliers (AZ 1904 from Curry Chile and Seed, Pearce, AZ; LB25 from Biad Chile, Leasburg, NM; and 3441 from Olam, Las Cruces, NM). Natural saline well water and concentrate coming out of the reverse osmosis (RO) system were used for irrigation. Both well water and RO concentrate were provided by the Brackish Groundwater National Desalination Research Facility (BGRNDRF), Alamogordo, NM.

2.1 Germination experiment

A replicated germination experiment was conducted in petri dishes (100 mm diameter, 16 mm height). The salinity treatments consisted of five levels including tap water of EC 0.6 (control), well water of EC 3 and 6 and RO concentrate of EC 8 and 10 dS/m. In each petri dish four filter papers were placed and moistened with different levels of saline water, and excess water was drained. For each chile pepper cultivar, 25 seeds were placed on the moistened filter paper. Petri dishes were tightly sealed using parafilm to avoid evaporation. The experiment was

conducted on a greenhouse bench and petri dishes were protected from direct sunlight by black shade cloth placed above the dishes so that air movement was not restricted. Based on the reduction in weight of petri dish, about 1 ml of tap water was added to each petri dish once every week to replenish the lost moisture. Seeds were considered germinated and removed once the length of the radicle surpassed the length of the seed. Ungerminated seeds remained in the dish until the conclusion of the study and their viability was determined using the imbibed crush test. The number of seeds germinated was counted daily and final germination was determined after 28 days. The experiment was a completely randomized design with four replications of each combination of treatments.

2.2 Emergence Experiments

Replicated emergence experiments were conducted in the soil collected from the Fabian Garcia Science Center of NMSU (Table 1). Irrigation waters including, brackish well waters and RO concentrate, were collected once a month from BGNDRF and chemical analysis was performed (Table 2). Additionally greenhouse environmental parameters varied, therefore, two experiments for emergence were conducted simultaneously side by side in the greenhouse.

Soil was air dried, gently crushed, and sieved through a 4 mm sieve. Soil, sand, and organic peat were mixed thoroughly in the ratio 8:1:1 on a volume basis. Soil mix was sterilized in an oven at a temperature of 180⁰ F for 30 minutes. Cylindrical pots of 6.5 cm diameter and 25 cm length were used in the experiment. The perforated bottom of each pot was covered with cheese cloth to prevent soil loss and gravel were placed on the bottom to allow free drainage. Packing of the soil was done in 5 cm depth increments to obtain a homogenous profile. Soil was washed three times with tap water to leach any pre-existing salts. Four natural water treatments selected for irrigation were: tap water of EC 0.6, well water of EC 3 and 5 and RO concentrate of

EC 8 dS/m. Before sowing seeds, soil was irrigated twice with each of the water treatment to raise the soil salinity to the water treatment level. Sowing was done by placing four seeds of each chile pepper within a soil depth of 1-2 cm. Emergence was recorded at a two day intervals and final emergence was determined 35 days after sowing. Irrigation water treatments were continuously applied at an interval of 3 to 4 days, based on the change in weights of reference pots.

2.3 Growth Stages

The most vigorous seedling from the emergence experiment was saved 35 days after sowing and only one seedling was retained in each pot. Irrigation treatments used in the emergence experiment were continued. In one liter of each of the irrigation water treatments 2 g of Miracle-gro fertilizer was added and applied at the flowering stage and later at the fruiting stage. Height of each plant from the soil surface to the top of the main stem was measured once a month. Days to flower initiation from sowing date were recorded for each plant. At fruiting, physiological measurements including photosynthesis (P_n) and stomatal conductance (g_s) were recorded during midday using a portable photosynthesis system (Model LI-COR 6400, Lincoln, NE, USA). From each plant the two topmost, fully expanded, illuminated and healthy leaves were selected for measurement. Pods were harvested when they reached horticultural green mature stage and fresh pod weights were measured. Plants were hand harvested at the end of the growing season and fresh weights of shoots were recorded. Cultivars selected in this study have natural variations in height and yield under normal conditions. Thus, relative plant height was obtained as the ratio of actual height and the maximum height by variety, relative fresh shoot weight as the ratio of actual and maximum weight by variety, and relative fruit yield as the ratio of actual yield and the maximum yield by variety. Irrigation water use efficiency (IWUE) was

calculated as the ratio of total yield of each plant and the total irrigation water applied to that pot (Sharma *et al.*, 2015).

2.4 Statistical Analysis

The petri dishes for germination experiment and cylindrical pots for emergence experiments were arranged in a completely randomized design with four replicates by generating random numbers using data analysis in Microsoft Excel (2013). The data for whole experiment were analyzed using two-way analysis of variance (ANOVA) and proc GLM (SAS) for identifying significant differences at alpha 5% (SAS institute, 2013). The means were separated using Least Significance Difference (LSD) at 5% significance level ($p \leq 0.05$). Prior to ANOVA, the data were confirmed for normality distribution based on Shapiro-Wilk statistic (Shapiro and Wilk, 1965) using the univariate procedure for SAS. The residuals for all except one of the data were normally distributed with W-statistic ranging from 0.970 to 0.993 ($p > 0.05$). Stomatal conductance in experiment 2 was the only slightly non normal data with W-statistic of 0.969 ($p = 0.048$). The reason could be due to the high power of Shapiro-Wilk test for large sample sizes (Razali and Wah, 2011). The non normal data was log transformed but results for ANOVA and LSD comparison remained unchanged. Since ANOVA is reported to be not very sensitive to moderate deviation from normality (Glass *et al.*, 1972; Norman, 2010; Schmider *et al.*, 2010), the actual non-transformed data were used in this study.

3.0 Results

3.1 Irrigation Water Salinity and Germination

The germination percentage of five cultivars differed significantly ($p \leq 0.05$) when averaged across the water salinity treatments (Table 3). The maximum germination was at 93% for AZ 1904, while the minimum germination of 80.6% was obtained for LB 25. However,

average germination percentage of all five cultivars did not show any statistically significant difference with increasing irrigation water salinity. The mean germination time significantly increased above 3 dS/m treatment. Among the five cultivars, LB 25 took the longest time to germinate, whereas 3441 and AZ 1904 seeds took the least. There was no significant interaction between cultivars and water salinity levels for percent germination and germination time.

3.2 Irrigation Water Salinity and Emergence

Significant differences were observed among the cultivars and water salinity levels for percent emergence and mean emergence time, while there was no significant interaction (Table 4). Among cultivars, 3441 had the highest percent emergence and the least mean time for emergence, which were statistically similar to AZ 1904. LB 25 had the least percent emergence and the longest mean emergence time, which were statistically similar to NuMex Sandia Select and NuMex Joe E. Parker. Among water salinity levels, the average percentage emergence of five cultivars was statistically similar in 0.6 (control) and 3 dS/m, while it was significantly less in 5 and 8 dS/m treatments. Mean emergence time increased significantly with increasing irrigation water salinity ($P < 0.05$).

3.3 Irrigation Water Salinity and Plant Height

Uniform seedlings were retained after the emergence, and there was no significant difference in the relative plant heights of cultivars 10 days after emergence except NuMex Sandia Select in experiment 1 (Fig. 1A) and AZ 1904 in experiment 2 (Fig. 1C). In experiment 1, 100 days after emergence, no significant differences in relative plant height were observed for 3441, NuMex Joe E. Parker and NuMex Sandia Select followed by LB 25 and AZ 1904. In experiment 2, no significant differences in relative plant height were observed for 3441 and NuMex Joe E. Parker, but they were significantly higher than AZ 1904, NuMex Sandia Select

and LB 25. Significant salinity effect on the relative height of plants irrigated with 5 and 8 dS/m saline levels appeared 40 days after emergence (Fig. 1B and Fig. 1D). However, by 70 days after emergence, relative plant heights significantly decreased with increasing irrigation water salinity from 0.6 to 8 dS/m ($P<0.05$).

3.4 Irrigation Water Salinity and Flowering

Days to flowering decreased significantly with increasing water salinity ($P<0.05$; Table 5). Plants irrigated with 0.6 (control) and 3 dS/m saline water treatments needed more days to flower than plants irrigated with 5 and 8 dS/m waters. Among the cultivars, LB 25 and 3441 plants flowered more rapidly than NuMex Sandia Select, NuMex Joe E. Parker and AZ 1904, the last three cultivars were in the same statistical group.

3.5 Irrigation Water Salinity and Plant Physiology

Photosynthesis rate differed slightly among cultivars with irrigation water salinity levels (Table 6). P_n for 3441 was least affected across salinity levels followed by LB 25, while NuMex Joe E. Parker was most affected and was similar to AZ 1904 and NuMex Sandia Select. The average P_n of five cultivars generally decreased with increasing water salinity and the lowest P_n was observed at 8 dS/m level. The highest P_n was recorded in 0.6 dS/m (control) treatment in both of the experiments. Stomatal conductance variations among the cultivars were also small. NuMex Joe E. Parker and NuMex Sandia Select showed minimum conductance. However, like P_n , average g_s of five cultivars also decreased significantly with the increasing irrigation water salinity ($P<0.05$).

3.6 Irrigation Water Salinity and Plant Biomass

No significant differences were noted for relative biomass yields among cultivars (Table 7). Although, the average relative biomass yield of the five cultivars decreased significantly with

increasing salinity levels it was not statistically different at 5 and 8 dS/m levels. 3441 produced maximum relative fruit yield in both experiments but was only statistically different from NuMex Sandia Select in experiment 1. The average relative fruit yield of the five cultivars was found to decrease with increasing water salinity. Maximum relative fruit yield was observed in 0.6 (control), while the minimum was in 8 dS/m although no statistically significant differences were noted between 5 and 8 dS/m treatments in experiment 2.

Irrigation water use efficiency (IWUE) showed a significant decrease with increasing irrigation water salinity (Fig. 2B and Fig. 2D). The decrease in IWUE was about 13% in 3 dS/m from control; while in the 5 and 8 dS/m treatments, the decrease was 48% and 51%, respectively. However, only a slight difference in IWUE was observed among the cultivars (Fig. 2A and Fig. 2C). LB 25 was found to be most water efficient in both the experiments.

4.0 Discussion

No significant differences in germination percentage were noted and mean germination time increased by more than one day between control and concentrate (10 dS/m) treatments. Results of germination study were similar to those reported by Chartzoulakis and Klapaki (2000) and Yildirim and Güvenç (2006). Flores *et al.*, (2015) also observed similar results for six halophyte species using similar saline water treatments. Emergence of chile peppers was found to be similar up to 3 dS/m, suggesting that seedlings can be grown by using slightly saline water. However, emergence decreased with further increase in irrigation water salinity. Similar results were reported in other salinity studies conducted in pepper (Chartzoulakis and Klapaki, 2000; Miyamoto *et al.*, 1985; Yildirim and Güvenç, 2006). The emergence of chile peppers appeared to be affected due to post germination mortality of hypocotyl linked with salts accumulated at the soil surface, also reported in alfalfa (*Medicago*

sativa L.) (Assadian and Miyamoto, 1987) and chickpea (*Cicer arietinum* L.) (Esechie *et al.*, 2002). In our study, emergence of chile pepper was delayed with increasing salinity. To our knowledge, it has not been reported in chile peppers so far, while Al-Harbi *et al.* (2008) and Kaveh *et al.* (2011) also observed delay in emergence with increasing salinity in tomato (*Lycopersicon esculentum* L.). The delay in emergence was assumed to be associated with delayed germination and retardation in the radical growth under the influence of salinity.

During the experimental period, plant heights were recorded at monthly interval. It was demonstrated that relative plant heights were similar in 0.6 (control) and 3 dS/m 40 days after emergence, indicating that chile peppers can tolerate irrigation with low saline water for a short periods of time. However, after 70 days of continuous exposure, gradual stunting in growth was observed with increasing salinity. Chartzoulakis and Klapaki (2000) and Yildirim and Güvenç (2006) also found decreases in height of peppers with increasing salinity. The inhibition of plant growth begins by cellular response to decreased water availability caused by osmotic stress of external salts and furthered later on by toxic effects of excessive salt accumulation within the plant (Munns *et al.*, 1995). Among cultivars, growth was similar in the beginning and differences appeared after several weeks of continued exposure to salinity. Neumann (1997) also suggested that appearance of varietal differences in plant growth is only expected after a long-term exposure to salinity.

With increasing salinity levels, phonological traits like days to flowering decreased. To the best of our knowledge, no such results have been reported for chile peppers. While, Mass and Grieve (1990) and Grieve *et al.* (1994) observed a shorter time to flowering in wheat (*Triticum aestivum* L.) and concluded that salinity fastens shoot apex development and initiates

reproductive structures more rapidly. Among the cultivars, there was also a slight difference in terms of flower initiation due to genetic variation.

Pn and g_s of chile pepper cultivars significantly lower with increasing salinity levels. Pn was about 11%, 23%, and 30% lower in 3, 5, and 8 dS/m saline water treatment than control, respectively. However, g_s was about 26%, 50%, and 63% lower in 3, 5, and 8 dS/m than control, respectively. The lower Pn in saline treatments could be due to restriction of CO₂ entry through stomata. This decline in Pn under stress conditions has been attributed to decreased g_s in some other studies (Delfine *et al.*, 1999; Rasmuson and Anderson, 2002; Singh *et al.*, 2014). While in the cultivars tested here, Pn and g_s were not very different, LB 25 and 3441 had higher Pn and g_s among the cultivars across saline treatments.

Relative shoot weights and relative fruit yields also showed an inverse relationship with increasing water salinity. Decrease in plant height, photosynthesis, and stomatal conductance with increasing salinity contributed to lower fruit yield and shoot weight. The reduction in fruit yield and shoot weight with salinity was in agreement with other salinity studies conducted on peppers (Chartzoulakis and Klapaki, 2000; Yildirim and Güvenç, 2006; Pascale *et al.*, 2003; Navarro *et al.*, 2002). There were no significant differences among the cultivars for relative shoot weights. At the time of harvesting, some of the cultivars were matured and already starting to shed leaves while others had more leaves, which could be the reason for the similar shoot weights. In this study, decrease in IWUE (irrigation water use efficiency) was only 13% when chile pepper plants were irrigated with 3 dS/m of saline water, which can be considered acceptable if saline water is the only water available for irrigation. No interactions between cultivars and water salinity levels for any of the discussed parameters suggested that all cultivars responded to salinity in the same manner. This study showed that continuous application of

saline water and RO concentrate will result in yield decreases. Therefore, future research should focus on the early flowering due to the application of brackish groundwater and RO concentrate, and a new irrigation scheduling protocol using saline waters should be developed to sustain yields while simultaneously reusing RO concentrate.

5.0 Conclusion

This study was conducted to test the emergence, growth, and survival of chile peppers irrigated with natural brackish well water and RO concentrate. Irrigation with increasing water salinity resulted in less and delayed emergence, stunted plant growth, low photosynthesis and stomatal conductance, accompanied by considerable decrease in fresh weights of shoots and fruits. It was also observed that plants grown in saline water treatments 0.6 (control) and 3 dS/m were not much different in response to salinity. Thus, irrigation with saline water up to 3 dS/m is possible, at least for one growing season, for sustaining chile pepper production. However, more experiments should be done to determine how long irrigation with 3 dS/m could be sustained without significant yield reductions, and appropriate leaching fractions. Among cultivars, 3441 showed more tolerance due to higher fruit yield and less fluctuation in shoot weight and height across different salinity levels as compared to other cultivars. Its salt tolerance was also associated with the ability to maintain high photosynthesis and stomatal conductance. Although, LB 25 and 3441 showed similar results for most of the parameters, LB 25 was the most sensitive cultivar of the five cultivars tested at emergence stage. Overall cultivar 3441 was the most tolerant among five cultivars tested and would be a good candidate cultivar for irrigation with saline water.

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Figure 1: (A) and (C) Relative plant height of five chile pepper cultivars across irrigation water salinity levels in experiment 1 and 2 respectively. (B) and (D) Relative plant height of chile pepper cultivars as affected by four irrigation water salinity levels in experiment 1 and 2 respectively.

Bars with the same letter are not significantly different according to least significance difference test at $p \leq 0.05$. Error bars are standard errors.

NJEP: NuMex Joe E. Parker; NSS: NuMex Sandia Select

Figure 2: (A) and (C) Effect of saline waters irrigation on IWUE (Irrigation water use efficiency) of five different chile pepper cultivars in experiment 1 and 2 respectively. (B) and (D) IWUE of chile-pepper cultivars as effected by four saline waters irrigation in experiment 1 and 2 respectively.

Bars with the same letter are not significantly different according to least significance difference test at $p \leq 0.05$. Error bars are standard errors.

NJEP: NuMex Joe E. Parker; NSS: NuMex Sandia Select

Table 1: Mean $\pm$ SE (standard error) for some of the physiochemical properties of soil used for experiments.

Sand (%)	Silt (%)	Clay (%)	BD (g/cm ³)	Cations (meq/L)			SAR	pH	EC (dS/m)
				Mg	Ca	Na			
78.70 ± 0.09	11.00 ± 0.12	10.30 ± 0.03	1.36 ± 0.01	1.38 ± 0.22	2.75 ± 0.09	4.88 ± 0.19	3.41 ± 0.01	7.80 ± 0.03	0.87 ± 0.02

BD: Bulk Density, SAR: sodium adsorption ratio, EC: electrical conductivity

Table 2: Mean $\pm$ SE (standard error) for chemical properties of four saline waters over the growing season.

Saline water (dS/m)	Ion Concentration (meq/L)						SAR
	Mg	Ca	Na	K	Cl	SO ₄	
0.6	0.73 $\pm$ 0.01	2.16 $\pm$ 0.01	2.61 $\pm$ 0.04	0.17 $\pm$ 0.00	1.70 $\pm$ 0.06	1.68 $\pm$ 0.01	2.17 $\pm$ 0.03
3	8.55 $\pm$ 0.50	12.60 $\pm$ 0.43	9.09 $\pm$ 0.15	0.14 $\pm$ 0.00	12.10 $\pm$ 0.03	19.30 $\pm$ 0.99	2.79 $\pm$ 0.01
5	15.30 $\pm$ 0.32	17.60 $\pm$ 2.08	18.30 $\pm$ 1.76	0.20 $\pm$ 0.03	16.20 $\pm$ 1.91	39.40 $\pm$ 4.01	4.57 $\pm$ 0.60
8	26.40 $\pm$ 0.11	28.60 $\pm$ 3.26	34.90 $\pm$ 2.71	0.39 $\pm$ 0.05	30.70 $\pm$ 5.05	65.50 $\pm$ 8.34	6.70 $\pm$ 0.71

0.6 is control; SAR: sodium adsorption ratio

Table 3: Effect of water salinity levels on germination (%) and mean germination time of seeds of five chile pepper cultivars.

Cultivars (C)	Germination (%)	Mean Germination Time (days)
AZ 1904	93.00 a	7.53 c
NuMex Joe E. Parker	92.40 a	8.58 b
3441	87.40 b	7.74 c
NuMex Sandia Select	82.80 c	8.42 b
LB 25	80.60 c	9.40 a
LSD (0.05)	4.31	0.67

Salinity (S; dS/m)	87.00 a	7.57 c
0.6 (control)		
3	87.60 a	7.62 c
6	88.00 a	8.36 b
8	87.60 a	8.92 ab
10	86.00 a	9.19 a
LSD (0.05)	4.31	0.67
C x S	NS	NS

† Values within each column followed by same letter(s) are not significantly different according to least significance difference test ($p \leq 0.05$).

NS= Non-significant at $p \leq 0.05$.

Table 4: Effect of water salinity levels on emergence (%) and emergence time of five chile pepper cultivars.

	Experiment 1		Experiment 2	
	Emergence (%)	Mean Emergence Time (days)	Emergence (%)	Mean Emergence Time (days)
Cultivars (C)				
AZ 1904	68.75 ab	12.51 b	70.31 ab	12.38 b
NuMex Joe E. Parker	56.25 bc	13.56 a	57.81 bc	13.13 a
3441	73.44 a	12.37 b	71.87 a	12.27 b
NuMex Sandia Select	60.94 abc	13.33 a	59.37 abc	13.48 a
LB 25	51.56 c	13.72 a	53.12 c	13.51 a
LSD (0.05)	12.55	0.77	12.61	0.58
Salinity (S, dS/m)				
0.6 (control)	77.50 a	11.19 d	75.00 a	11.02 d
3	71.25 a	12.15 c	73.75 a	11.95 c

5	55.00 b	14.10 b	53.75 b	13.99 b
8	45.00 b	14.95 a	47.50 b	14.88 a
LSD (0.05)	11.23	0.69	11.27	0.52
C x S	NS	NS	NS	NS

† Values within each column followed by same letter(s) are not significantly different according to least significance difference test ($p \leq 0.05$).

NS= Non-significant at $p \leq 0.05$.

Table 5: Days to flowering of five chile pepper cultivars under the effect of different salinity levels.

	Experiment 1	Experiment 2
	Days to flowering	Days to flowering
Cultivars (C)		
AZ 1904	111.00 a	111.06 a
NuMex Joe Parker	110.81 a	110.25 ab
3441	106.62 b	107.37 bc
NuMex Sandia Select	110.31 a	110.00 ab
LB 25	105.19 b	105.44 c
LSD (0.05)	3.04	3.27
Salinity (S; dS/m)		
0.6 (control)	113.35 a	112.70 a
3	111.65 a	111.45 a
5	106.25 b	105.80 b
8	103.90 b	105.35 b
LSD (0.05)	2.72	2.93
C x S	NS	NS

† Values within each column followed by same letter(s) are not significantly different according to least significance difference test ($p \leq 0.05$).

NS= Non-significant at $p \leq 0.05$.

Table 6: Effect of water salinity levels on photosynthesis (Pn) and stomatal conductance (g_s) of five chile-pepper cultivars.

	Experiment 1		Experiment 2	
	Pn	g_s	Pn	g_s
	($\mu\text{mol m}^{-2} \text{s}^{-1}$)	($\text{mmol m}^{-2} \text{s}^{-1}$)	($\mu\text{mol m}^{-2} \text{s}^{-1}$)	($\text{mmol m}^{-2} \text{s}^{-1}$)
Cultivars (C)				
AZ 1904	7.34 b	0.096 a	7.97 ab	0.098 a
NuMex Joe Parker	6.92 b	0.078 b	7.11 b	0.082 b
3441	8.54 a	0.099 a	8.73 a	0.101 a
NuMex Sandia Select	7.18 b	0.083 b	7.12 b	0.081 b
LB 25	7.65 ab	0.103 a	8.44 a	0.098 a
LSD (0.05)	0.97	0.012	0.87	0.011
Salinity (S; dS/m)				
0.6 (control)	8.88 a	0.144 a	9.44 a	0.137 a
3	7.92 b	0.101 b	8.46 b	0.107 b
5	6.98 c	0.070 c	7.06 c	0.069 c
8	6.33 d	0.051 d	6.54 c	0.054 d
LSD (0.05)	0.86	0.011	0.78	0.010
C x S	NS	NS	NS	NS

† Values within each column followed by same letter(s) are not significantly different according to least significance difference test ($p \leq 0.05$).

NS= Non-significant at $p \leq 0.05$.

Table 7: Effect of water salinity levels on relative fresh biomass and relative fruit yield of five chile pepper cultivars.

	Experiment 1		Experiment 2	
	Relative fresh shoot weight (g)	Relative fruit yield (g)	Relative fresh shoot weight (g)	Relative fruit yield (g)
Cultivars (C)				
AZ 1904	0.750 a	0.587 ab	0.750 a	0.573 a
NuMex Joe Parker	0.802 a	0.609 ab	0.775 a	0.596 a
3441	0.751 a	0.632 a	0.757 a	0.615 a
NuMex Sandia Select	0.752 a	0.577 b	0.743 a	0.563 a
LB 25	0.810 a	0.604 ab	0.784 a	0.608 a
LSD (0.05)	0.063	0.047	0.046	0.054
Salinity (S; dS/m)				
0.6 (control)	0.929 a	0.891 a	0.926 a	0.915 a
3	0.828 b	0.762 b	0.811 b	0.783 b
5	0.681 c	0.406 c	0.669 c	0.355 c
8	0.654 c	0.347 d	0.641 c	0.311 c
LSD (0.05)	0.056	0.042	0.041	0.048
C x S	NS	NS	NS	NS

† Values within each column followed by same letter(s) are not significantly different according to least significance difference test ($p \leq 0.05$).

NS= Non-significant at $p \leq 0.05$.