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Salt Tolerance of Pepper Cultivars during Germination and Seedling Growth

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Abstract: This study was conducted to evaluate the effect of salinity on the germination and emergence of pepper cultivars, and to investigate the potential for genetic salt tolerance during germination and seedling growth. Thus, seeds of 11 pepper cultivars were germinated using 0, 85, 170, and 215 mM NaCl solutions for 14 days. Germination percentage decreased with increased NaCl concentration. All cultivars germinated in all salinities, with the exception of Kandil Dolma in 215 mM NaCl. The greatest germination percentage at 215 mM of NaCl was 71% for 11-B-14. NaCl salinity at different concentrations adversely affected germination rates of the 11 pepper cultivars. The highest and the lowest germination rates at 215 mM NaCl were obtained for 11-B-14 cultivar (2.42) and Kandil Dolma (0.00), respectively. Greenhouse studies determined that no emergence of pepper cultivars was observed under the high-level salt-stress conditions (170 and 215 mM). At 85 mM NaCl, Çorbacı Acı Sivri had the highest emergence percentage (90%), while Kapia had the lowest (9%). Salt stress significantly decreased shoot height, root length, and fresh and dry weight of pepper cultivars. In the presence of salt stress, the greatest shoot height (3.40 cm) and root length (11.81 cm) was obtained with 11-B-14, while the greatest fresh weight (72.30 mg) and dry weight (6.75 mg) was obtained from Demre. Based on the results of the experiment, Demre, Ilıca 250, 11-B-14, Bağcı Çarliston, Mini Acı Sivri, Yalova Çarliston, and Yağlık 28 can be useful as genetic resources for the development of pepper cultivars with improved germination under salt stress.

Key Words: Pepper, seed germination, *Capsicum annuum* L., seedling, salt stress

Çimlenme ve Fide Döneminde Biber Çeşitlerinin Tuza Toleransı

Özet: Bu araştırma, biber çeşitlerinin çimlenme ve çıkışı üzerine tuzluluğun etkisini belirlemek ve çimlenme ve fide döneminde, biber çeşitlerinin tuza tolerans bakımından genetik potansiyellerini ortaya koymak için yürütülmüştür. Bu amaçla 11 biber çeşidi 14 gün süreyle 0, 85, 170 ve 215 mM NaCl içeren çözeltilerde çimlendirilmişlerdir. Denemede, çimlenme yüzdesinin artan tuz konsantrasyonuna bağlı olarak azaldığı tespit edilmiştir. Kandil Dolma hariç diğer çeşitler tüm tuz konsantrasyonlarında çimlenme göstermiştir. 11-B-14'ün, % 71 ile 215 mM tuzlulukta en yüksek çimlenme gösteren çeşit olduğu tespit edilmiştir. Tuzluluğun incelenen çeşitlerde çimlenme hızını da olumsuz etkilediği belirlenmiştir. 215 mM tuzlulukta en yüksek çimlenme hızı 2.42 ile 11-B-14 çeşidinden elde edilirken, en düşük 0.00 ile Kandil Dolma çeşidinden elde edilmiştir. Sera koşullarında yürütülen çalışmalarda, 170 ve 215 mM tuzlulukta çeşitlerin tümünde çıkışın olmadığı saptanmıştır. 85 mM tuz seviyesinde en fazla çıkış % 90 ile Çorbacı Acı Sivri, en az ise % 9 ile Kapia çeşidinden elde edilmiştir. Yine 85 mM tuzlulukta en fazla sürgün yüksekliği (3.40 cm) ve kök uzunluğunun (11.81 cm) 11-B-14, en fazla taze (72.30 mg) ve kuru (6.75 mg) ağırlığın Demre çeşidinde gerçekleştiği tespit edilmiştir. Denemeden elde edilen sonuçlara göre, Demre, Ilıca 250, 11-B-14, Bağcı Çarliston, Mini Acı Sivri, Yalova Çarliston ve Yağlık 28 çeşitlerinin tuz stresine diğer çeşitlerden daha fazla toleranslı oldukları ve bu çeşitlerin tuza dayanıklı yeni çeşitler geliştirmede genetik kaynak olarak kullanılabilecekleri belirlenmiştir.

Anahtar Sözcükler: Biber, tohum çimlenmesi, *Capsicum annuum* L., fide, tuz stresi

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Introduction

Salinity is a major environmental constraint to crop productivity throughout the arid and semi-arid regions of the world (Foolad and Lin, 1997). Salinity has reached a level of 19.5% of all irrigated land and 2.1% of dry-land agriculture worldwide (FAO, 2005). Excess salt in soil solution may adversely affect plant growth, either through osmotic inhibition of root water uptake or by specific ion effect. In many crop plants, seed germination and early seedling growth are the most sensitive stages to environmental stresses such as salinity (Sivritepe et al., 2003).

Salinity may cause significant reductions in the rate and final percentage of germination, which in turn may lead to uneven stand establishment and reduced crop yields (Foolad et al., 1999). Rapid, uniform, and complete germination is a prerequisite for successful transplant production and stand establishment in vegetable crops (Demir and Ermis, 2003). Several authors have shown that pepper is sensitive or moderately sensitive to salinity during different growth stages (Fernandez et al., 1977; Bethke and Drew, 1992; Gunes et al., 1996; Pascale et al., 2003). It has also been shown that salinity caused a decrease in both the germination rate and germination percentage of pepper seeds (Chartzoulakis and Klapaki, 2000).

One of the most effective ways to overcome salinity problems is the introduction of salt-tolerant crops. It has been reported that differences in salt tolerance exist, not only among different species, but also within certain species (Foolad and Lin, 1997; Chartzoulakis and Klapaki, 2000; Murillo-Amador et al., 2001). The success of selection depends on the amount of genetic variation distinguishable from environmental variation during the screening process. Evidence collected from many crop genera suggests that salt tolerance is a developmentally regulated, stage-specific phenomenon, such that tolerance at one stage of plant development may not be correlated with tolerance at other developmental stages. Therefore, specific stages throughout the ontogeny of the plant, such as germination and emergence, seedling survival and growth, and vegetative and reproductive growth, should be evaluated separately during the assessment of germplasm for salt tolerance. Such assessments may facilitate the development of cultivars with salt-tolerant characteristics throughout the ontogeny of the plant (Foolad and Lin, 1997). Screening and selection for any characters are desired at the earliest developmental stage possible (Murillo-Amador et al., 2001).

Many pepper cultivars belonging to the Longum and Grossum groups are cultivated in Turkey. It has been reported that total germination and germination rate of Demre, Çetinel 150, and Ilıca 256 pepper cultivars decreased with increasing NaCl concentrations ranging from 0 mM to 150 mM. Ilıca 256 showed the best NaCl tolerance at the germination stage and Demre was the most tolerant at the seedling stage (Yilmaz et al., 2004). However, reports concerning the effect of salinity on the germination of many pepper cultivars grown in Turkey are lacking and these cultivars have not been evaluated to establish their potential for genetic salt tolerance.

The objectives of this study were to evaluate the effect of NaCl salinity on the germination and emergence of pepper cultivars widely grown in Turkey, to determine the germination and emergence ability of these cultivars under a saline irrigation regime, and to determine their potential for salt tolerance during germination and seedling growth.

Materials and Methods

This study was carried out at Atatürk University, Hamza Polat Vocational Training School in Turkey, between March and July in both 2004 and 2005. Eleven pepper (*Capsicum annuum* L.) cultivars, namely Çetinel 150, Ilıca 250, Demre, Bağcı Çarliston, Mini Acı Sivri, Çorbacı Acı Sivri, and Yalova Çarliston (Longum group), and Kapia, 11-B-14, Yağlık 28, and Kandil Dolma (Grossum group), were used as plant material. They were obtained from the May and Agromar Seed Companies.

Germination Assays

Seeds were disinfected with 0.5% sodium hypochloride solution for 10 min, were rinsed with sterile distilled water several times, and then briefly blotted with sterile paper towels. Twenty-five disinfected seeds of 11 pepper cultivars were germinated in 2 folds of Whatman No. 1 filter paper (sterilised) placed in petri dishes (9 cm diameter). Each dish was moistened with 5 ml of distilled water or one of the saline solutions: 0 (control), 85, 170, and 215 mM NaCl. NaCl was used since it is a common salt that adversely affects plant growth under natural conditions (Levitt, 1980). The electrical conductivities of these solutions were determined with a Jenway Model 470 conductivity meter (Jenway Limited) as 0.002, 8.78, 17.05, and 21.04 dS m^{-1}, respectively. Petri dishes were tightly sealed using Parafilm to prevent evaporation. No additional solutions were added. Petri dishes were arranged in a completely randomised design in an incubator maintained in the dark at 25 ± 0.5 °C.

A seed was considered to have germinated at the emergence of the radicle (Chartzoulakis and Klapaki, 2000). The number of germinated seeds was recorded daily (germination rate), and the final germination percentage was determined after 14 days (ISTA, 1996). The germination rate was calculated according to Murillo-Amador et al. (2002): $M = n_1/t_1 + n_2/t_2 + \ldots n_{14}/t_{14}$, where n_1, n_2, ... are the number of germinated seeds at times t_1, t_2, ... t_{14} (days). Mean germination time (MGT) and sensitivity index (SI) were determined according to Demir et al. (2003) and Foolad and Lin (1997). SI is a measure of relative sensitivity of a genotype to salt-stress (larger indices indicate more salt sensitivity).

Seedling Growth

For seedling growth, 40 seeds of each cultivar were sown at 10 mm depth in 40-cell plastic trays filled with peat (pH: 5.5; EC: 250 mmhos/cm; N: 300 mg l^{-1}; P_2O_5: 300 mg l^{-1}; K_2O: 400 mg l^{-1}; organic matter: 2%). The trays were randomised on benches in a greenhouse and watered with appropriate solutions of NaCl (mentioned above) with 4 replicates (40 seeds per replication). Trays were covered with plastic to reduce evaporation until emergence began. After emergence, plants were irrigated manually to saturation every day with 0, 85, 170, or 215 mM saline solutions to maintain the level of salinity. Plants were harvested 30 days after sowing and their fresh weights determined. Normal seedlings were counted and cleaned, and abnormal seedlings (AOSA, 2004) were not evaluated. Plant height and root length of all normal seedlings were also determined in centimetres. Dry weights of seedlings were determined 24 h after plants were maintained in an oven at 80 °C. Temperature ranged between 15 and 33 °C for the first experiment, 16 and 35 °C for the second, and 15 and 36 °C for the third (minimum and maximum) for a period of 4 weeks.

Statistical Analysis

The experimental design was hierarchical with respect to 2 factors arranged in a completely randomised design with 4 replications. The first factor had 4 levels (0, 85, 170, and 215 mM NaCl) and the second one had 11 levels (cultivars). Data were analysed with two-way analysis of variance (ANOVA) using the GLIM procedure of SAS (SAS, 1985) for germination percentage, germination rate, emergence percentage, plant height, root length, and plant fresh and dry matter. Inverse regression analysis was used to predict a 10%, 25%, and 50% reduction in the germination percentage, which was calculated as a decrease in the percentage of germination compared to the control (0 mM NaCl). Percentage data were transformed using arcsine prior to statistical analysis (Montgomery, 2001). The differences between the means were compared using Duncan's multiple range test ($P < 0.05$). Simple correlation analyses were performed to indicate possible relationships between the parameters analysed. All experiments were conducted 3 times (i.e. 3 replications over time) for a total of 12 replications.

Results

Germination

The germination percentages of the 11 pepper cultivars decreased with increasing salt stress. All cultivars germinated in all the salinity levels, with the exception of Kandil Dolma in 215 mM of NaCl. At 215 mM of NaCl, the greatest germination percentages were as follows: 11-B-14 (71%), Ilıca 250 (70%), Demre (69%), and Yağlık 28 (69%) (Table 1). NaCl at different concentrations adversely affected the germination rates of the 11 pepper cultivars. Germination rates of all the cultivars decreased with increasing salt concentration. The greatest germination rate at 215 mM NaCl was obtained with 11-B-14 cultivar (2.42) (Table 1).

MGT and SI of the 11 cultivars increased with increasing salt stress. Çorbacı Acı Sivri germinated rapidly compared to other cultivars at 0 and 85 mM NaCl, while at 170 and 215 mM, 11-B-14 had the lowest MGT value (Table 2).

Table 1. Effect of salinity on germination percentage and germination rate of 11 pepper cultivars.

Cultivars	Germination Percentage (%)				Germination Rate			
	NaCl Concentrations (mM)							
	0	85	170	215	0	85	170	215
Çetinel 150	97 [n.s]	79 e[z]	50 d[z]	18 c[z]	4.77 cd[z]	3.82 de[z]	1.75 g[z]	0.78 d[z]
Ilıca 250	97	90 bc	71 c	70 a	4.94 bc	4.14 d	2.72 def	2.27 a
Demre	98	91 abc	83 a	69 a	5.26 bc	4.70 c	3.31 ab	1.53 bc
Bağcı Çarliston	97	87 cd	74 bc	67 a	5.20 bc	4.88 bc	3.02 bcd	1.63 bc
Mini Acı Sivri	98	84 de	76 bc	68 a	3.77 e	3.54 e	2.67 ef	1.64 bc
Çorbacı Acı Sivri	99	95	77 b	59 b	6.43 a	5.29 ab	3.10 bc	1.77 b
Yalova Çarliston	100	92 ab	84 a	67 a	6.39 a	5.01 bc	2.96 cde	1.78 b
Kapia	95	48 f	24 e	13 d	4.30 de	2.64 f	0.70 h	0.20 e
11-B-14	99	85 de	74 bc	71 a	5.53 b	5.55 a	3.62 a	2.42 a
Yağlık 28	100	84 de	75 bc	69 a	4.87 cd	3.99 d	2.58 f	1.38 c
Kandil Dolma	94	49 f	6 f	0 e	2.55 f	0.42 g	0.17 i	0.00 e

[z]: Numbers with the same letters are not statistically different ($P < 0.05$)
[n.s.]: non-significant

Table 2. Effect of salinity on mean germination time (MGT) and sensitivity index (SI) of 11 pepper cultivars.

Cultivars	NaCl Concentrations (mM)						
	0	85		170		215	
	MGT[z]	MGT	SI	MGT	SI	MGT	SI
Çetinel 150	5.15 ± 0.07	5.46 ± 0.03	1.06	6.58 ± 0.06	1.28	11.94 ± 0.15	2.32
Ilıca 250	4.72 ± 0.07	5.30 ± 0.07	1.12	6.65 ± 0.05	1.41	7.62 ± 0.10	1.61
Demre	4.01 ± 0.04	4.73 ± 0.03	1.18	5.82 ± 0.08	1.45	6.82 ± 0.07	1.17
Bağcı Çarliston	4.11 ± 0.08	4.21 ± 0.06	1.02	5.40 ± 0.04	1.31	7.45 ± 0.10	1.81
Mini Acı Sivri	6.08 ± 0.04	6.23 ± 0.05	1.02	6.62 ± 0.05	1.09	7.41 ± 0.12	1.22
Çorbacı Acı Sivri	3.44 ± 0.04	4.04 ± 0.02	1.17	6.39 ± 0.09	1.86	7.42 ± 0.13	2.16
Yalova Çarliston	3.48 ± 0.07	4.39 ± 0.08	1.26	6.87 ± 0.06	1.97	8.95 ± 0.02	2.57
Kapia	5.38 ± 0.10	6.46 ± 0.09	1.20	8.47 ± 0.09	1.57	12.46 ± 0.15	2.32
11-B-14	4.02 ± 0.04	4.07 ± 0.04	1.01	4.82 ± 0.05	1.20	5.60 ± 0.05	1.39
Yağlık 28	4.39 ± 0.08	5.18 ± 0.05	1.18	6.66 ± 0.10	1.52	7.23 ± 0.05	1.65
Kandil Dolma	8.21 ± 0.12	9.08 ± 0.10	1.11	11.10 ± 0.13	1.35	> 14[x]	

[x] Did not germinate in 14 days
[z] Each value is an estimate averaged over 12 replications ± SE of the differences among replications

Table 3. Predicted salinity levels (mM NaCl) that would affect 90%, 75%, and 50% germination as calculated from inverse regression analysis.

Cultivars	10%	25%	50%
Çetinel 150	43	84	153
Ilıca 250	79	184	359
Demre	94	212	408
Bağcı Çarliston	74	178	351
Mini Acı Sivri	67	177	361
Çorbacı Acı Sivri	81	163	299
Yalova Çarliston	87	194	373
Kapia	10	48	111
11-B-14	66	178	365
Yağlık 28	61	167	345
Kandil Dolma	14	45	97

Table 3 shows the predicted salinity levels (mM NaCl) that would affect 90%, 75%, and 50% germination as calculated by inverse regression analysis. Demre required the highest average NaCl concentration (94, 212, and 408 mM) to reduce germination to 10%, 25%, and 50% respectively, followed by Yalova Çarliston.

Seedling Emergence and Growth

The effect of salinity on emergence percentage, shoot height, root length, and fresh weight and dry weight of the 11 pepper cultivars is presented in Table 4. In the 3 successive experiments, pepper cultivars did not show emergence at 170 and 215 mM NaCl levels. In the absence of salt stress, Yalova Çarliston had the highest emergence percentage (96%), followed by Demre and 11-B-14 (95%), and Çorbacı Acı Sivri and Yağlık 28 (94%), In the presence of salt stress, Çorbacı Acı Sivri, Demre, Yalova Çarliston, and 11-B-14 had the highest emergence percentages (90%, 89%, and 88%, respectively), while Kapia, Çetinel 150, and Kandil Dolma had the lowest (9% and 14%, respectively). Salt stress significantly affected shoot height, root length, and fresh weight and dry weight of the 11 pepper cultivar seedlings ($P < 0.05$); all these parameters decreased with increased salt stress. The greatest shoot height and root length was obtained with 11-B-14 in the presence of salt stress, while the greatest fresh and dry weight was obtained from Demre.

Discussion

Saline soil and saline irrigation constitute a serious production problem in vegetable crops as saline conditions are known to suppress plant growth. Salt stress can affect seed germination by decreasing the ease with which the seeds take up water, because the activity and events normally associated with germination are delayed and/or proceed at a reduced rate. Salinity can also affect germination by facilitating the uptake of toxic ions, which can cause changes to certain enzymatic or hormonal activities of the seed. These physico-chemical effects upon the seed seem to result in a slower and/or lower rate of germination (Shannon and Grieve, 1999). The present study demonstrated that salinity adversely affected the germination and emergence of pepper cultivars. Salt stress decreased the germination percentage and germination rate of the 11 pepper cultivars (Table 1). The results of our study are in good agreement with those reported by Chartzoulakis and Klapaki (2000), and Yilmaz et al. (2004). Demre, Ilıca 250, 11-B-14, Bağcı Çarliston, Mini Acı Sivri, Yalova Çarliston, and Yağlık 28 had the greatest germination percentages under high salt stress. Similarly, the same cultivars had the greatest germination rates. There was a high level of variation in both germination percentage and rate under salinity. The differences in germination among the cultivars were greater in the presence of salinity in comparison to the absence of salinity. These differences can be attributed to genotypic variation in germination response being expressed to a greater degree under stress than under non-stress conditions. Certain genes may be stress-inducible and expressed only under salt-stress conditions (Foolad, 1996; Foolad and Lin, 1997).

There was a positive correlation ($r = 0.867$, $P < 0.05$) between the germination rate in the presence and absence of salinity. This correlation may indicate the presence of some common factors that contribute to rapid seed germination under salinity and non-salinity conditions (Foolad and Lin, 1997). As seen in Table 2, increasing the salt concentration from 0 to 215 mM increased SI and MGT values. A higher cultivar SI value is indicative of a greater sensitivity to salt stress. Demre, Mini Acı Sivri, and 11-B-14 had the lowest SI values. Based on the individual inverse regression analysis conducted for each cultivar to determine the response model of germination percentage to salinity, Demre, Yalova Çarliston, 11-B-14, Mini Acı Sivri, Ilıca 250, Bağcı Çarliston, and Yağlık 28 were classified as salt-tolerant.

Table 4. Effect of salinity on emergence percentage, shoot height, root length, and fresh weight and dry weight of 11 pepper cultivars, 30 days after sowing.

Cultivars	Emergence Percentage (%)		Shoot Height (cm)		Root Length (cm)		Fresh Weight (mg)		Dry Weight (mg)	
	0 mM	85 mM	0 mM	85 mM	0 mM	85 mM	0 mM	85 mM	0 mM	85 mM
Çetinel 150	86 d [z]	14 f [z]	2.13 e [z]	1.86 e [z]	11.19 f [z]	6.34 f [z]	118.73 f [z]	33.51 de [z]	8.40 g [z]	2.45 e [z]
Ilıca 250	93 abcd	84 bc	3.11 c	2.23 cd	11.69 f	7.21 e	151.68 d	64.56 b	13.95 d	5.83 b
Demre	95 ab	89 ab	3.23 bc	3.07 b	13.86 cd	10.97 b	154.1 d	72.30 a	14.76 c	6.75 a
Bağcı Çarliston	91 abcd	74 de	2.47 d	2.32 c	11.80 f	7.69 d	122.05 f	42.39 c	11.63 f	3.37 d
Mini Acı Sivri	92 abcd	83 bc	2.63 d	2.23 cd	14.12 c	8.02 cd	74.23 g	26.28 f	6.26 h	2.50 f
Çorbacı Acı Sivri	94 abc	90 a	3.39 b	2.42 bc	14.26 c	8.22 c	199.63 a	43.46 c	16.28 b	4.08 c
Yalova Çarliston	96 a	89 ab	3.71 a	2.51 bc	15.13 b	9.19 b	205.28 a	71.27 a	16.92 ab	6.66 a
Kapia	86 cd	9 f	3.28 bc	1.97 de	12.51 e	5.83 g	179.73 c	37.13 d	12.98 e	3.20 d
11-B-14	95ab	88 ab	3.71 a	3.40 a	16.62 a	11.81 a	188.18 b	64.70 b	17.14 a	5.94 b
Yağlık 28	94 abcd	68 e	3.12 c	2.26 cd	15.3 b	8.06 c	138.75 e	45.91 c	13.01 e	4.10 c
Kandil Dolma	88 bcd	14 f	2.45 d	1.97 de	13.22 d	7.03 e	125.78 f	30.80 e	11.06 f	2.40 e

z: Numbers with the same letters are not statistically different ($P < 0.05$)

Salinity affected seed emergence and seedling growth more than seed germination. Seed emergence was not observed for any of the pepper cultivars at the highest levels of salt stress (170 and 215 mM). Moreover, salt stress significantly decreased shoot height, root length, and fresh and dry weight of the pepper cultivars ($P < 0.05$). The reduction in root length was more than that in shoot height under saline conditions. In salt-stress conditions, root lengths of the pepper cultivars were reduced between 21% and 53% as compared to the absence of salt stress, whereas shoot height was reduced 6%-40%. It is generally accepted that roots are the first plant organ to suffer from exposure to environmental stress. Similarly, Chartzoulakis and Klapaki (2000) reported that seedling emergence and growth are more sensitive to salt stress than seed germination. Gunes et al. (1996) reported that the biomass production of pepper plants was inhibited by salinity. They suggested that this inhibition might result from either osmotic reduction in water availability or accumulation of some toxic ions, such as Na and Cl. Salt tolerance is a developmentally regulated, stage-specific phenomenon, such that tolerance at one stage of plant development may not be related to tolerance at other developmental stages (Foolad and Lin, 1997). The greatest shoot height and root length were obtained with 11-B-14 in the presence of salt stress, while the greatest fresh and dry weight were obtained with Demre (Table 4). Similar to the germination percentage and germination rate of the pepper cultivars, there was a high level of variation in the emergence percentage and the other measured growth parameters in the pepper cultivars, during the seedling stage, under salinity (Table 4). It has been reported that pepper is relatively tolerant during germination, but becomes more sensitive during the emergence and early seedling stages. This reduces the plant stand. Our findings support previous reports (Chartzoulakis and Klapaki, 2000).

Conclusion

The results of this study indicated the presence of genetic variation within pepper cultivars for germination, emergence, and seedling growth parameters under salt-stress conditions. Generally, seeds that germinate rapidly under non-stress conditions also germinate rapidly under salt-stress conditions. Ideally, the best genotypes for use as germplasm resources would be those exhibiting rapid germination over a wide range of environmental conditions (Foolad et al., 1999). In this study, several cultivars with considerable tolerance to salt stress and the ability to germinate rapidly under non-saline conditions were identified. This phenomenon may be attributed to common genes (or physiological mechanisms) that contribute to rapid germination under both stress and non-stress conditions. There also might be stress-specific genes, which contribute to rapid germination only under specific stress conditions (Foolad et al., 1999).

Based on the above results, Demre, Ilıca 250, 11-B-14, Bağcı Çarliston, Mini Acı Sivri, Yalova Çarliston, and Yağlık 28 should be very useful as genetic resources for the development of pepper cultivars with improved germination under salt-stress and non-stress conditions. Similar to the germination percentage and germination rate of the pepper cultivars, the most salt-tolerant cultivars were also the most tolerant ones during seedling stages. Since higher salt stress (170 and 215 mM) did not allow the normal emergence of all the pepper cultivars used in the study, the medium or irrigation water should not exceed 170 mM NaCl.

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