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Research
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Effects of salt stress on germination and seedling growth of different bread wheat (*Triticum aestivum* L.) cultivars

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Abstract

This study was conducted to determine the effects of different salt treatments on seed germination and seedling growth of some bread wheat cultivars. In present experiments, 7 different bread wheat cultivars (Es-26, Harmankaya-99, Müfitbey, Nacibey, Sönmez-2001, Soyer-02 and Yunus) were subjected to 5 different salt concentrations (0, 25, 50, 100 and 150mM). Experiments were conducted in randomized plots experimental design with 3 replications. It was observed that cultivars had different responses to salt doses in terms of germination time. Dry coleoptile and radicula weights and lengths decreased with increasing salt concentrations. It was concluded that salinity negatively influenced germination times and seedling growth of bread wheat cultivars.

Key words: Coleoptile weight, NaCl, Radicula length, *Triticum aestivum* L.

Farklı ekmeklik buğday (*Triticum aestivum* L.) çeşitlerinde tuz stresinin çimlenme ve fide gelişimine etkileri

Öz

Bu araştırmada bazı ekmeklik buğday çeşitlerinde tohum çimlenmesi ve fide büyümesi üzerine tuzluluğun etkileri belirlenmiştir. Araştırmada 7 farklı ekmeklik buğday çeşidi (Es-26, Harmankaya-99, Müfitbey, Nacibey, Sönmez-2001, Soyer-02 and Yunus ve 5 farklı tuz konsantrasyonu (0, 25, 50, 100 ve 150 mM) kullanılmıştır. Araştırma tesadüf parselleri deneme desenine göre üç tekrarlamalı olarak yürütülmüştür. Çalışma sonucunda kullanılan çeşitlerin çimlenme süresi bakımından tuz dozlarına karşı tepkilerinin farklı olduğu tespit edilmiştir. Ayrıca tuz konsantrasyonları arttıkça çeşitlerin koleoptil, radicula taze ve kuru ağırlıklarının radikula ve koleoptil uzunluklarının azaldığı görülmüştür. Tuzluluğun ekmeklik buğday çeşitlerinin çimlenme süreleri ve fide gelişimini olumsuz yönde etkilediği söylenebilir.

Anahtar kelimeler: Koleoptil ağırlığı, tuz, radikula uzunluğu, *Triticum aestivum* L.

Introduction

Salinity is a significant abiotic stress factor. It restricts plant production and food safety, thus influence socio-economic structure of several countries. Salinity is estimated to reduce genetic yield potential of the plants over almost 20% of the cultivated lands and almost half of the irrigated lands (Flowers, 2004; Jones, 2007; Munns et al., 2006). It is quite difficult for producers to improve genetic yield potential of the plants under stress conditions (Blum, 2005; Kalhora et al., 2016). High salt concentrations in soils or irrigation waters have devastating effects on plant metabolism, destruct cellular homeostasis and have various negative impacts on physiological and biochemical processes (Niu et al., 1995; AL-Razak and AL-Saady, 2015).

Salinity reduces osmotic potential of soil solution and hinders water uptake of the roots and ultimately ends up with water deficits (Kochak-Zadeh et. al,. 2013; Fernández-Torquemada and Sánchez-Lizaso, 2013). Such an effect of salt on osmotic potential negatively influence moisture uptake of the seed for germination (Abbasdokht, 2011; Aslan et al., 2016). In plants under salt stress, reactive oxygen species like hydrogen peroxide incorporated into different functions of salicylic acid, jasmonic acid and ethylene-like plant growth hormones are generated (Zhang et al., 2014; Wang et al., 2016).

Salinity problem is experienced over 1.5 million land area in Turkey (Ekmekçi et al., 2005). During the fallow practices of the soils for plants like winter wheat, salts move toward to soil surface through evaporation and result in excessive salinity in those soils (Maghsoudi Moudi and Maghsoudi, 2008).

Wheat is moderately tolerant to salinity (Shannon, 1997). Weak development is observed in saline soils and as compared to late periods, wheat is much more sensitive to salinity in germination and seedling periods (Akkaya, 1994).

Germination is the initial critical stage of the plants as compared to the later periods. Since the seeds are close to soil surfaces, they are more sensitive to stress conditions than the plants in later development stages (Dodd and Donovan, 1999). There are several studies reporting negative effects of salinity on germination of wheat seeds (Guo et al., 2010; Rawat et al., 2011). Salt resistant seeds can be identified through creating NaCl-induced ionic stress in germination studies. Ionic stress is generated through toxic salt accumulation in plant tissues. The reduction in germination rates can easily be determined with the increase in NaCl concentrations (Murillo-Amador et al., 2002; Akbarimoghaddam et al., 2011). Response of plants exposed to salt stress should be investigated to develop salt-resistant cultivars. Plants have different responses to different salt concentrations. Under saline conditions, germination and seedling development stages are the most critical periods throughput the life-cycle of the plants (Katerji et al. 2005).

Cultivar is an important factor influencing germination performance of the seeds. In previous studies, different germination rates, root and shoot lengths and weights were reported for different wheat cultivars (Rahman et al., 2008; Moud and Maghsoudi 2008; Fuller et al., 2012; Kochak-zadeh et al., 2013). This study was conducted to investigate the effects of different salt concentrations on germination parameters of bread wheat cultivars.

Materials and Methods

Experiments were conducted to determine the changes in plants throughout the germination period of some wheat (*Triticum aestivum* L.) cultivars under different salt concentrations. Experiments were implemented at laboratories of Field Crops Department of Ordu University Agricultural Faculty in 2014. Experiments were designed in randomized plots – factorial experimental design with 3 replications. In present experiments, 7 different wheat cultivars (Es-26, Harmankaya, Müfitbey, Nacibey, Sönmez, Soyer and Yunus) were subjected to 5 different NaCl doses (0, 25, 50, 100 and 150 mM).

Before germination experiments, seeds were sterilized in 5% sodium hypochlorite solution for 10 minutes. Sterilized seeds were placed in between drying papers and then into perti dishes as to have 25 seeds in each petri dish. Each petri dish were then supplemented with 10 ml of specified NaCl doses. Salt-supplemented petri dishes were placed into climate chambers and left for germination at full-dark environment at 24±1^{o}C for 10 days. Germinated seeds were counted everyday throughout the experiments and the ones with about 1 mm rootlets were accepted as germinated. At the end of 10th day, total number of germinated seeds were determined and germination rates (%) were calculated. Germination times were also calculated as follows: $GT = \Sigma(Dn)/\Sigma n$ (D = number of days counted from the beginning of the germination test and n = number of seeds which germinated on day (Demirkaya et al., 2018). Coleoptile and radicula measurements were performed on 10 seedlings at the end of 10th day. Experimental results were subjected to variance analysis (ANOVA) with SAS-JMP statistical software in accordance with randomized plots – factorial experimental design and means were separated with LSD test.

Results and Discussion

Significant differences were observed in germination rates of the cultivars (Table 1). The lowest germination rate (95.6%) was observed in müfitbey cultivar. Germination rates of the cultivars generally varied between 97-100%. Genetic differences between the cultivars may have significant effects on germination rates. Different germination rates were also reported for different cultivars studies in previous studies (Eskandari et al., 2011; Sourour et al., 2014). Salt doses had significant effects on germination times of the wheat cultivars. Cultivars generally germinated in shorter times at control treatments. Germination times prolonged with increasing salt doses. As compared to the control treatments, about 46% longer germination times were observed at 150 mM salt dose (Table 2). Increasing germination times with increasing salt doses may be attributed to salt-induced osmotic stress and ionic stress and resultant decrease in seed water uptakes (Tabassum et al., 2017).

Table 1. Effects of different NaCl concentrations (mM) on germination rates (%) of wheat cultivars

Wheat Cultivars	Salt Concentrations (mM)					Cultivar Means
	Control	25 mM	50 mM	100 mM	150 mM	
Es-26	100	100	100	100	100	100 A
Nacibey	98.3	100	100	100	100	99.6 A
Mufitbey	100	100	98.3	95.0	95.0	95.6 C
Harmankaya-99	100	96.6	100	100	98.3	100 A
Sonmez-2001	98.3	95.0	95.0	96.6	100	97.0 BC
Soyer-02	100	100	100	100	98.3	100 A
Yunus	100	100	100	100	98.3	99.6 A
Concentration Means	99.5	98.8	99.0	98.8	98.5	

LSD value at 0.01 alpha level for cultivars means =2.17

Table 2. Effects of different NaCl concentrations (mM) on germination times (day) of wheat cultivars

Wheat Cultivars	Salt Concentrations (mM)					Cultivar Means
	Control	25 mM	50 mM	100 mM	150 mM	
Es-26	1.17 q-r	1.10 r	1.10 r	1.48 h-o	1.43 j-o	1.25 D
Nacibey	1.36 k-p	1.56 f-m	1.52 g-n	1.55 f-m	1.58 f-k	1.51 BC
Mufitbey	1.18 p-r	1.32 n-r	1.40 j-p	1.63 f-j	2.11 bcd	1.53 BC
Harmankaya-99	1.29 n-r	1.27 o-r	1.57 f-l	1.73 fg	2.04 cd	1.58 B
Sonmez-2001	1.34 m-q	1.35 l-p	1.39 k-p	1.46 ı-o	1.68 f-ı	1.44 C
Soyer-02	1.18 p-r	1.37 k-p	1.47 ı-o	1.67 f-ı	1.77 ef	1.49 BC
Yunus	1.47 ı-o	1.75 f	1.98 de	2.15 bcd	2.49 a	1.97 A
Concentration Means	1.28 e	1.39 d	1.49 c	1.67 b	1.87 a	

LSD value at 0.01 alpha level for cultivars means =0.103 for salt concentration = 0.203 and interaction = 0.231

Table 3. Effects of different NaCl concentrations (mM) on coleoptile and radicula dry weights (g) of wheat cultivars

Coleoptile Dry Weights						
Wheat Cultivars	Salt Concentrations (mM)					Cultivar Means
	Control	25 mM	50 mM	100 mM	150 mM	
Es-26	0.14	0.16	0.13	0.10	0.11	0.13BC
Nacibey	0.15	0.15	0.10	0.013	0.06	0.10C
Mufitbey	0.15	0.18	0.16	0.12	0.12	0.15B
Harmankaya-99	0.12	0.13	0.12	0.09	0.10	0.11C
Sonmez-2001	0.11	0.16	0.13	0.11	0.09	0.12C
Soyer-02	0.14	0.19	0.20	0.19	0.19	0.18A
Yunus	0.18	0.22	0.19	0.14	0.13	0.17A
Concentration Means	0.14b	0.17a	0.15bc	0.12cd	0.11d	
Radicula Dry Weights						
Es-26	0.09	0.09	0.09	0.07	0.07	0.08C
Nacibey	0.12	0.13	0.10	0.08	0.05	0.09B
Mufitbey	0.12	0.11	0.09	0.11	0.09	0.10B
Harmankaya-99	0.09	0.10	0.08	0.08	0.07	0.08C
Sonmez-2001	0.07	0.09	0.07	0.05	0.04	0.06D
Soyer-02	0.13	0.13	0.11	0.11	0.09	0.12A
Yunus	0.11	0.11	0.09	0.08	0.07	0.09B
Concentration Means	0.10A	0.10A	0.09B	0.08B	0.07C	

LSD(Coleoptile Dry Weights) value at 0.01 alpha level for cultivars means = 0.017, for salt concentration = 0.14

LSD (Radicula Dry Weights) value at 0.01 alpha level for cultivars means = 0.009, for salt concentration = 0.007 and interaction = 0.30

With increasing salt concentrations, CAT (catalase) enzyme activity which is required for germination is reduced (Dash and Panda, 2001; Tabatabaei, 2014). Decreased enzyme activities with increasing salt concentrations also reduced coleoptile and radicula lengths of the seeds (Table 4). There were significant differences in radicula lengths of the cultivars . As compared to the control treatments, about 46 % decrease was observed in radicula lengths with increasing salt concentrations. Coleoptile fresh and dry weights decreased with increasing salt doses. While the greatest coleoptile dry weights were observed in 25 mM salt dose, the lowest values were observed in 150 mM salt dose (Table 3). Radicula dry weights also decreased with increasing salt doses. The greatest radicula dry weight was observed in control seeds and the lowest radicula dry weight was observed in 150 mM salt dose (Table 3). As compared to the control treatments, 21% reduction was observed in coleoptile dry weights at 150 mM salt treatment. As compared to the control treatments, increasing salt doses also reduced dry weights by 30%. Sourour et al. (2014) indicated that toxic impacts of salts might total dry matter quantities transported from the seeds through coleoptile and radicula. Excess salt is known to reduce seed external water uptake either totally or after a certain time (Ahmad, R. et al., 1992; Moud, A. M. and Maghsoudi, K., 2008; Jalali et al., 2017). Differences in cultivar responses to salt stress may be resulted from genetic differences in their cell membranes and cellular homeostasis capacities (Hussain et al., 2013).

Table 4. Effects of different NaCl concentrations (mM) of coleoptile lengths (mm) and radicula lengths (mm) of wheat cultivars

Coleoptile Lengths						
Wheat Cultivars	Salt Concentrations (mM)					Cultivar Means
	Control	25 mM	50 mM	100 mM	150 mM	
Es-26	178.40	133.82	78.10	48.01	47.03	97.07
Nacibey	117.00	109.97	76.98	69.84	47.14	84.19
Mufitbey	136.53	146.04	88.61	66.50	56.65	98.86
Harmankaya-99	125.89	121.66	138.90	75.84	67.78	106.0
Sonmez-2001	105.83	111.25	97.34	64.24	47.87	85.30
Soyer-02	128.71	137.96	122.63	87.03	58.16	106.90
Yunus	138.67	126.52	103.98	67.74	57.59	98.30
Concentration Means	133,01a	126,75ab	100,93abc	68,46c	54,60bc	
Radicula Lengths						
Es-26	156.61	125.07	89.83	57.51	61.10	98.02CD
Nacibey	119.73	121.54	75.89	81.58	43.49	88.45D
Mufitbey	117.16	144.12	135.38	87.23	82.14	113.20B
Harmankaya-99	102.09	113.88	114.82	70.90	75.31	95.40D
Sonmez-2001	119.82	122.51	122.41	107.19	63.50	107.08BC
Soyer-02	137.64	155.29	145.06	123.20	100.73	132.36A
Yunus	140.05	144.64	120.55	96.44	54.93	111.32B
Concentration Means	127.59a	132.43a	114.85b	89.15c	68.74d	

LSD (Coleoptile Lengths) value at 0.01 alpha level for salt concentration = 41.539

LSD (Radicula Lengths) value at 0.01 alpha level for cultivars means = 9.957, for salt concentration = 7.872

Conclusion

At this study, it can be finalized that under control condition all eight cultivars of bread wheat had well growth. It was concluded based on present findings that germination parameters of the cultivars negatively influenced by salt doses greater than 25 mM. Cultivars had different responses to salt doses and some of them exhibited better emergence and development performance than the others. These results show that there is genetic variation between bread wheat cultivars in terms of growth rate of early wheat under salt stress. Here, under severe salt stress, the 'Soyer' variety is the most tolerant variety that can be recommended for growing in salt stress. To determine the response characteristics and threshold level of different varieties, there is a need for further studies to be applied to the salt at various levels.

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