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Germination and Growth Parameters in Sorghum Cultivars (*Sorghum bicolor* L.) Effected by Boron Application Under Salinity Stress

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ABSTRACT

The aim of this research is investigating the effects of boron on the germination and growth of three sorghum cultivars at different salinity stress levels. The experiment was arranged as four replications according to the factorial experimental design in completely random blocks The three sorghum (*Sorghum bicolor* L.) cultivars (Erdurmuş, Uzun and Gözde 80) selected for the genetic material. NaCl compound was utilized as salt source and solutions were prepared at concentrations of 0-75-150 mM. Boron was applied as H_3BO_3 at 0-5-10-15 mM. In general regarding growth parameters, the values obtained in Gözde 80 cultivar were determined as the highest averages. Whereas the salinity levels effect was examined in this study, a decrease was determined in the parameters measured as the level of the stress factor increased. Salinity had a high adverse effect at the 150 mM level, and as expected the highest averages were obtained in the control treatments. Low-dose boron applications have possitive effects on germination and growth parameters in this experiment. Therewithal under salinity stress conditions, low-dose boron applications showed affirmative efficacy compared to the control of each condition. In this experiment, determined that boron applications reduce this effect under salinity stress conditions that sorghum seeds may encounter during the germination period, but the boron dose level to be applied should be properly controlled.

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Tuzluluk Stresi Altında Bor Uygulamasından Etkilenen Sorgum Çeşitlerinde (Sorghum bicolor L.) Çimlenme ve Büyüme Parametreleri

ÖZET

Bu araştırmanın amacı, farklı tuz stresi seviyelerinde üç sorgum çeşidinin çimlenmesi ve büyümesi üzerine borun etkilerini araştırmaktır. Deneme, tesadüf blokları faktöriyel deneme deseni kullanılarak dört tekerrürlü olarak düzenlenmiştir. Genetik materyal için seçilen üç sorgum çeşidi (*Sorghum bicolor* L.) Erdurmuş, Uzun ve Gözde 80'dir. Tuz kaynağı olan NaCl bileşiğinden 0-75-150 mM konsantrasyonlarda çözeltiler hazırlanarak stes koşulları oluşturulmuştur. Bor dozları ise 0-5-10-15 mM olarak H_3BO_3 kimyasalından hazırlanarak uygulanmıştır. Genel olarak Gözde 80 çeşidinde elde edilen değerler en yüksek ortalamalar olarak belirlenmiştir. Bu çalışmada tuzluluk düzeylerinin etkisi incelendiğinde, stres faktörünün düzeyi arttıkça ölçülen parametrelerde azalmalar tespit edilmiştir. En düşük ortalamalar 150 mM seviyesinde tuz uygulamalarında elde edilirken, en yüksek ortalamalar kontrol uygulamasında belirlenmiştir. Düşük dozlarda bor uygulamaları bu çalışmada tüm parametreler üzerinde artışlar meydana getirmiştir. Tuzluluk stresi koşullarında düşük dozda bor uygulamaları her koşulun kontrolüne göre pozitif etki göstermiştir. Bu denemede, sorgum tohumlarının çimlenme döneminde karşılaşabilecekleri tuzluluk stresi koşullarında bor uygulamalarının bu etkiyi azalttığı ancak uygulanacak bor doz seviyesinin uygun şekilde kontrol edilmesi gerektiği belirlenmiştir.

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INTRODUCTION

The request for food is spawning day by day with the rapid increase in the world population. However, human activities and geological processes cause adverse biotic or abiotic agents, especially salinity problems (Kumar et al., 2017; Guo et al., 2022). Salinity is a major hazard in arid and semi-arid climatic areas and is a significant stinting factor in universal food manufacture (Ahmed et al., 2020; Tolay, 2021). Salinity occurs when soluble salts that accumulate in groundwater by washing in arid and semi-arid climatic regions rise to the soil surface with capillarity due to high groundwater and accumulate on the surface as a result of water evaporation. Salinity stress primarily occurs in degradations in metabolic and functional mechanisms. Than, it causes injury to plant organs, reduce in product quality and even death (Shabala, 2009; Arslan et al., 2013).

Salinity is one of main abiotic stress limiting plant growth, development and productivity. The significant inhibitory effect of salinity on plant growth and crop is due to (1) osmotic effect, (2) ion toxicity, and (3) nutritional deficiency leading to reduced photosynthetic effect and other physiological disorder (Almodares et al, 2008).

Nowadays, it is stated that there is a substantial decrease in crop yield due to global soil salinization and salt effect is approximately millions hectares (Pirasteh-Anosheh et al., 2017; Asgari & Diyanat, 2021; Karle et al., 2021). Therefore, it has turned into immediate needs to increase plants grown in salty areas and utilized for food and treatment and to discover a solution to salinity stress (Shahid et al., 2021).

Sorghum (*Sorghum bicolor* L.) is member of a cereal crop family with various utilizes food, forage crop (Baran & Kocabağlı, 2000; Arslan et al., 2017) and energy (Rooney & Waniska, 2000; Ribas, 2014). Whereat it is from the cereal family, it can be easily made into silage (Vadakkekara Joseph, 2016; Arslan et al., 2017) and as a result, it can be fed to animals (Karadağ & Özkurt 2014). Sorghum, studied annually (Pontieri et al., 2012) by breeders, has wide genetic changeabilty (Tigabu et al., 2012; Shakeri et al., 2017) and germplasm origins to adopt new varieties into multiple ecoregions (Bibi et al., 2016). Sorghum is one of the C4 plants that is moderately saline tolerant (Maas & Hoffman, 1986) and highly adaptable to semi-arid and arid regions where salinity creates problems for vegetative production (Kebede et al., 2001; Ejeta & Knoll, 2007; Ali et al., 2011).

Boron has a significant role in physiological courses within plants and is therefore one of the most major micronutrients for their growth (Warrington, 1923). This is one of the most limiting nutrient for grains especially for lucubratory varieties growing in sandy soils where it can vanish by filtering due to its high mobility in the soil (Uraguchi & Fujiwara, 2011). There are differences in boron access in plant species and varieties (Hu & Brown, 1997). Within its roles, the element boron is associated with increasing seed yield and quality (Batista et al., 2021). Excessive boron intake limits plant growth and damages the photosynthetic system. Thereby causing ciritical physiological reactions such as degradation of auxin biosynthesis leading to decreased fruit or crop yields. Since boron is an element involved in cell growth, nucleic acid formation, nitrogen fixation, cell wall biosynthesis, sugar translocation, as well as flowering and pollen tube growth, its importance is further increased under stress conditions (Marschner, 2012).

It is obtained that germination and emergence processes in sorghum breeding are the most enlightening phases of the plant life cycle to determine the effect of salinity (Krishnamurthy et al., 2017). It is necessary to develop new strategies and appropriate methods in order to reduce the negative effects of low salt stress that plants are exposed to during the germination and seedling stages of sorghum cultivation. In these cases, it has been found that the seed can stimulate some metabolic processes in germination by pretreatment with some plant growth regulators and increase seed emergence under varied environmental conditions (Ren et al., 2020). Therefore, we hypothesized that the adverse effects at different salt stress levels could be mitigated by boron application. The aim of the experiment was to examine the probability of differential salt stress reduction at the seedling stage of three sorghum varieties by applying boron levels.

MATERIAL ve METHOD

As investigating the effects of boron on the germination and seedling growth of three sorghum cultivars at different salt stress levels, this experiment was carried out in the Forage Crops Laboratory of the Field Crops Department of Akdeniz University. The trial was arranged in four replications using factorial arrangement according to the completely randomized blocks experimental design. The three sorghum cultivars (*Sorghum bicolor* L.) selected for the genetic material are Erdurmuş, Uzun and Gözde 80 and were obtained from the Western Mediterranean Agricultural Research Institute.

Petri dishes were rinsed with deionized water, sterilized and incubated as a general protocol procedure. Twenty sorghum seeds in same size of each cultivar were placed evenly in a petri dish (9 cm diameter) using forceps after two sterilized Whatman Filter papers. NaCl (Sigma®) compound was utilized as salt source and solutions were prepared at concentrations of 0-75 mM-150 mM. Boron was applied as H_3BO_3 at 0-5-10-15 mM. To prevent evaporation, all the petri dishes were wrapped with parafilm. The petri dishes were settled in a growth chamber at 20ºC under photoperiodic condition 16 hours light 8 hours dark. Observations were recorded daily. The study ended on the eleventh day.

Germination tests were carried out according to ISTA rules (2017). Radicle and plumula lengths of seedling were measured using a scale. The seed of germination (MGT) was calculated using formulas described by Majda et al. (2019). Germination rate (GR) was calculated according to Xia et al. (2019). Germination index (GI) and seedling vigor index (SVI) were counted by the method of Xia et al. (2019). The radicle/plumula ratio (R/S ratio) was calculated as the following equation (Shtaya et al., 2021). The calculation of stress tolerance indices formulas as described by Naraw et al. (2014).

MGT (day): $\sum \frac{\text{number of seeds germinated on the } i^{th} \text{ day}}{\text{number of days to count the } n^{th}}$

GR(%):number of germinated seed/total number of seed tested*100

GI: $\sum \frac{\text{the number of germinated seeds in day}}{\text{day of counting seed germination}}$

SVI: germination percentage*average seedling length/100

R/P ratio: Radicle length/ plumule length

SLSI (%): (Plumula length of stressed plant/ Plumula length of control)*100

RLSI (%): (Radicle length of stressed plant/ Radicle length of control)*100

SFSI (%): (Plumula fresh weight of stressed plant/ Plumula fresh weight of control)*100

RFSI (%): (Radicle fresh weight stress of stressed plant/ Radicle fresh weight of control)*100

Statistic Analysis

Datas determined for the study subjected to analysis variance using R (ANOVA) and compared with Duncan's multiple range, which differed significantly at 0.05 levels. (4.3.19)

RESULTS and DISCUSSION

The variance analysis of the different boron applications on germination and seedling parameters of sorghum cultivars affected by salinity conditions are given in Table 1 and Table 2.

Table 1. Results of variance analysis on growth parameters of boron doses and salinity in sorghum cultivars
Çizelge 1. Tuz stresi seviyelerinde üç sorgum çeşidinin büyüme parametreleri üzerine borun etkileri

Source of variance	df	PFW	RFW	TB	PLSI	RLSI	PFSI	RFSI
C	2	21.90**	20.26**	0.20	615.00**	75.00**	227.00**	1655.00**
S	2	3529.70**	319.92**	5661.70**	83691.00**	74442.00**	84182.00**	77026.00**
B	3	4646.30**	235.67**	7337.50**	948.00**	779.00**	701.00**	510.00**
C*S	4	29.80**	26.68**	62.50**	184.00**	255.00**	78.00*	905.00**
C*B	6	23.50**	12.83**	49.60**	187.00**	124.00**	41.00	338.00**
S*B	6	213.50**	10.59**	349.00**	253.00**	211.00**	192.00**	180.00**
C*S*B	12	6.90**	7.46**	11.70**	104.00**	82.00**	14.00	146.00**

*Significant at the 0.05 probability level. **Significant at the 0.01 probability level.
(Cultivar (Çeşit): C, Salinity (Tuzluluk): S, Boron (Bor): B, Mean germination time (Ortalama Çimlenme Zamanı): MGT, Germination Rate (Çimlenme oranı): GR, Germination index (Çimlenme indeksi): GI, Seedling Vigor index (Fide canlılık indeksi): SVI, Plumula length (Plumula uzunluğu): PL, Radicle length (Radicle uzunluğu: RL, Radicle/Plumula rate (Radicle/ plumula oranı): R/S)

According to analysis of variance, all parameters except total biomass were statistically significant at the level of 1% in all cultivars. Similarly, increasing salinity levels, boron doses and their interactions had a significant effect (p<0.01) on the germination and seedling parameters of sorghum cultivars. Closely, the interaction of cultivars-boron doses and full interaction factor showed meanful effects (p<0.01) on all parameters except plumula fresh weight stress tolerance index. The plumula fresh weight stress tolerance index was effected at 5% levels, as the other germination and seedling parameters were significantly (p<0.01) influenced by the interaction between cultivars and salinity levels (Table 1 and 2).

In general, the values obtained in Gözde 80 cultivar were determined as the maximum averages. The specified parameters are MGT, PL, RL, R/P rate and RFW. However, the highest germination rate and seedling weight were found in Erdumuş cultivar (Table 3a-3b).

Table 2. Results of variance analysis on growth parameters and stress tolerances of boron doses and salinity in sorghum cultivars

Çizelge 2. Tuz stresi seviyelerinde üç sorgum çeşidinin büyüme parametreleri ve stres toleransları üzerine borun etkileri

Source of variance	df	PFW	RFW	TB	PLSI	RLSI	PFSI	RFSI
C	2	21.90**	20.26**	0.20	615.00**	75.00**	227.00**	1655.00**
S	2	3529.70**	319.92**	5661.70**	83691.00**	74442.00**	84182.00**	77026.00**
B	3	4646.30**	235.67**	7337.50**	948.00**	779.00**	701.00**	510.00**
C*S	4	29.80**	26.68**	62.50**	184.00**	255.00**	78.00*	905.00**
C*B	6	23.50**	12.83**	49.60**	187.00**	124.00**	41.00	338.00**
S*B	6	213.50**	10.59**	349.00**	253.00**	211.00**	192.00**	180.00**
C*S*B	12	6.90**	7.46**	11.70**	104.00**	82.00**	14.00	146.00**

*Significant at the 0.05 probability level.**Significant at the 0.01 probability level.

Table 3a. The effects of boron doses on growth parameters of sorghum cultivars exposed to salinity

Çizelge 3a. Farklı tuz stresi seviyelerine maruz kalmış üç sorgum çeşidinin büyüme parametreleri üzerine borun etkileri

C	MGT (day)	GR (%)	GI (%)	SVI (%)	PL (cm)	RL (cm)
E	3.91±0.34^{b}	89.58±8.86^{a}	91.88±9.09^{b}	48.55±4.80^{c}	5.42±1.91^{b}	4.75±1.99^{c}
U	4.04±0.24^{a}	79.17±14.06^{b}	99.58±14.81^{a}	52.88±9.03^{a}	5.31±1.94^{c}	5.09±2.92^{b}
G	3.76±0.37^{c}	79.80±13.81^{b}	83.99±17.20^{c}	51.21±9.13^{b}	6.10±2.30^{a}	6.16±2.34^{a}

Different letters next to values indicate statistically different means at p<0.05 level, and p<0.01 levels.

Ortalamaları temsil eden farklı harfler, p<0.05 düzeyinde ve p<0.01 düzeyinde istatistiksel olarak farklı ortalamaları gösterir.

Table 3b. The effects of boron doses on growth parameters of sorghum cultivars exposed to salinity

Çizelge 3b. *Farklı tuz stresi seviyelerine maruz kalmış üç sorgum çeşidinin büyüme parametreleri üzerine borun etkileri*

C	R/P rate	PFW (mg)	RFW (mg)	TB (mg)
E	0.85±0.09^{b}	35.99±11.80^{a}	6.63±2.16^{c}	42.62±13.91
U	0.95±0.19^{a}	35.00±11.82^{b}	7.51±4.12^{b}	42.51±15.86
G	0.96±0.09^{a}	34.70±14.58^{b}	7.90±389^{a}	42.57±18.52

Different letters next to values indicate statistically different means at p<0.05 level, and p<0.01 levels.

Ortalamaları temsil eden farklı harfler, p<0.05 düzeyinde ve p<0.01 düzeyinde istatistiksel olarak farklı ortalamaları gösterir.

As there was no statistical difference between the total biomass, the averages were determined as nearly 43.00 mg in cultivars (Table 3b). Significant differences in biomass were not only due to genetic makeup but also to the growth medium (Amano et al., 1996). The reason why a difference was not obtained in this study is thought to be due to the fact that it was made in a petri dish. Mean germination time, is one of the most distinctive features of the cultivars, was obtained in Erdurmuş, Uzun and Gözde-80 cultivars as 3.91 days, 4.04 days and 3.76 days, respectively (Table 3a).

In this experiment, it was concluded that different morphological features showed different responses to applications. In addition, it was observed that the applications helped the tolerance under stress conditions on the cultivars. In most cases, germination traits were useful in predicting the suitability of seeds for commercial usage due to their quality at the seedling stage, whereas germination rate affects seed emergence uniformity (Ching, 1959; Thomson & El-Kassaby, 1993; El-Kassaby, 2000, El-Kassaby et al., 2008).

As the effect of salinity levels was examined in this study, a decrease was determined in the parameters measured as the level of the stress factor increased. The lowest averages were obtained in salt applications at the level of 150 mM, and the highest values were determined in the control (Table 4a,4b). A high salt concentration was a limiting agent for initiating and maintaining germination, decreasing the amount of water available in the presence of salt and this affects both germination percentage and germination speed (dos Santos et al., 2019; Moghaddam et al., 2020).

In this study and many experiment, as the NaCl concentration increased, the seeds generally had lower germination than the control (Table 4a, Atta et al., 2021); however, it was observed that the mean germination day increased (Table 4a, Kara et al., 2011; Li et al., 2016; Önal Aşcı & Üney, 2016) and germination index (Table 4a, Carpıcı et al., 2009; Aishah et al., 2010; Atış, 2011).

As the salt stress level increased, 23.44% and 37.50% decrease in plumula length and 25.86% and 45.57% reduction in radicle length were determined, respectively (Table 4a). The obtained decreases were found to be compatible with other studies. (Rajakumar, 2013). In terms of salt stress tolerance, root and stem lengths are significant parameters (Arslan & Aydinoğlu, 2018), whereat nutrients and water are get into the plant through direct contact with the roots and subscrible to shoot development (Haileselasie & Gselasie, 2012). Similar to these results, reductions of 26.68% and 38.54% in plumula fresh weight and 32.54% and 50.19% in radicle fresh weight, respectively, were observed. In other words, as can be seen from these results, 150 mM salt application caused a half reduction in radicle fresh weight (Table 4b, Datta et al., 2009; Yildirim et al., 2011; Ödemiş et al., 2019; Bhati et al., 2021; Tenikecier & Ates, 2022; Quamruzzaman et al., 2022). Thus, it was determined that the radicle was more precision to salinity than the plumula (Kaya et al., 2003).

Table 4a. The growth parameters of sorghum cultivars exposed to salinity
Çizelge 4a. Sorgum çeşitlerinde tuzluluğun büyüme parametreli üzerine etkisi

SL (mM)	MGT (day)	GR (%)	GI (%)	SVI (%)	PL (cm)	RL (cm)
0 mM	3.68±0.37^{c}	90.94±10.55^{a}	100.67±13.57^{a}	55.80±6.97^{a}	7.04±2.26^{a}	7.00±2.81^{a}
75 mM	3.90±0.28^{b}	83.13±11.04^{b}	92.26±12.87^{b}	51.13±6.60^{b}	5.39±1.60^{b}	5.19±2.07^{b}
150 mM	4.13±0.22^{a}	74.48±12.85^{c}	82.52±14.26^{c}	45.71±7.31^{c}	4.40±1.34^{c}	3.81±1.27^{c}

Different letters next to values indicate statistically different means at p<0.05 level, and p<0.01 levels.
Ortalamaları temsil eden farklı harfler, p<0.05 düzeyinde ve p<0.01 düzeyinde istatistiksel olarak farklı ortalamaları gösterir.

Table 4b. The growth parameters of sorghum cultivars exposed to salinity
Çizelge 4b. Sorgum çeşitlerinde tuzluluğun büyüme parametreli üzerine etkisi

SL (mM)	R/P rate	PFW (mg)	RFW (mg)	TB (mg)
0 mM	0.97±0.13^{a}	44.27±14.30^{a}	10.14±3.61^{a}	53.91±18.03^{a}
75 mM	0.94±0.16^{b}	34.23±7.19^{b}	6.84±2.90^{b}	41.56±11.63^{b}
150 mM	0.86±0.11^{c}	27.21±9.29^{c}	5.05±1.62^{c}	32.26±8.73^{c}

Different letters next to values indicate statistically different means at p<0.05 level, and p<0.01 levels.
Ortalamaları temsil eden farklı harfler, p<0.05 düzeyinde ve p<0.01 düzeyinde istatistiksel olarak farklı ortalamaları gösterir.

The salinity condition reduces the total photosynthetic capacity of the cultivars and the amount of chlorophyll level, thus reducing the synthesis of assimilate required for plant growth, and as a result, it is now clear that it causes a shrinkage in plant biomass (Taiz et al., 2015; Pirasteh-Anosheh & Hedayati-Firoozabadi, 2022). Another reason for the loss of biomass may be the decrease in the metabolic energy of the plant due to adaptation, the photosynthesis rate of the leaf, the decrease in carbon uptake, and tissue damage if the plant reaches the maximum salt concentration that the plant can tolerate (Pirasteh-Anosheh et al., 2016).

Table 5a. The effects of boron doses on growth parameters of sorghum cultivars
Çizelge 5a. Bor uygulamalarının sorgum çeşitlerin büyüme parametreleri üzerine etkileri

Boron (mM)	MGT (day)	GR (%)	GI (%)	SVI (%)	PL (cm)	RL (cm)
0 Mm	3.91±0.28^{c}	92.78±8.14^{a}	97.11±10.35^{b}	53.84±5.07^{b}	6.54±1.11^{b}	6.39±1.81^{b}
5 Mm	3.51±0.28^{d}	87.92±6.37^{b}	103.15±10.39^{a}	57.24±5.53^{a}	7.28±1.77^{a}	7.31±2.24^{a}
10 Mm	4.03±0.24^{b}	83.61±8.83^{c}	92.78±10.55^{c}	51.42±5.00^{c}	5.58±1.51^{c}	5.28±1.66^{c}
15 Mm	4.17±0.13^{a}	67.08±12.33^{d}	74.23± 12.74^{d}	41.01±5.74^{d}	3.04±0.62^{d}	2.35±0.44^{d}

Different letters next to values indicate statistically different means at p<0.05 level, and p<0.01 levels.
Ortalamaları temsil eden farklı harfler, p<0.05 düzeyinde ve p<0.01 düzeyinde istatistiksel olarak farklı ortalamaları gösterir.

Table 5b. The effects of boron doses on growth parameters of sorghum cultivars
Çizelge 5b. Bor uygulamalarının sorgum çeşitlerin büyüme parametreleri üzerine etkileri

Boron (mM)	R/P rate	PFW (mg)	RFW (mg)	TB (mg)
0 Mm	0.96±0.13^{b}	39.30±8.68^{b}	8.00±2.84^{b}	47.98±10.97^{b}
5 Mm	1.00±0.12^{a}	47.30±11.31^{a}	10.34±3.48^{a}	57.64±14.44^{a}
10 Mm	0.94±0.11^{b}	34.01±6.83^{c}	6.86±2.24^{c}	40.87±8.74^{c}
15 Mm	0.78±0.08^{c}	20.29±3.65^{d}	4.18±2.29^{d}	23.80±4.40^{d}

Different letters next to values indicate statistically different means at p<0.05 level, and p<0.01 levels.
Ortalamaları temsil eden farklı harfler, p<0.05 düzeyinde ve p<0.01 düzeyinde istatistiksel olarak farklı ortalamaları gösterir.

Low-dose boron applications increased all parameters in this study and Alamri et al. (2018) showed an increase only on the germination day, as there was an inverse relationship in this parameter only on the germination day. High boron doses had a negative effect on both plant shoot and root length (Table 5a-5b). Among the functions of boron element due to its functions in plant metabolism, it is related to increasing seed yield and quality (Silva-Matos et al., 2017; Batista et al., 2021). The fact that high boron levels induce harmful effects on plant growth (Bhamburdekar, 2002) and development (Tariq & Mott, 2006) is remarkable (Jadhav & Bhamburdekar, 2014). In addition, excess boron primarily inhibits plant germination and cell division and damages the thylakoid assembly by affecting photosynthesis, thereby reducing CO_2 absorption, resulting in reduced root and shoot growth (Reguera et al., 2009; Uluisik et al., 2018).

In general, it was determined that the effect of salinity on the growth of different cultivars decreased linearly. Considering the cultivars, the plumule length decreased by 19.00% and 35.44% in Erdurmuş, by 32.68% and 42.82% in Uzun, and by 18.40% and 33.96% in Gözde-80 (Figure1).

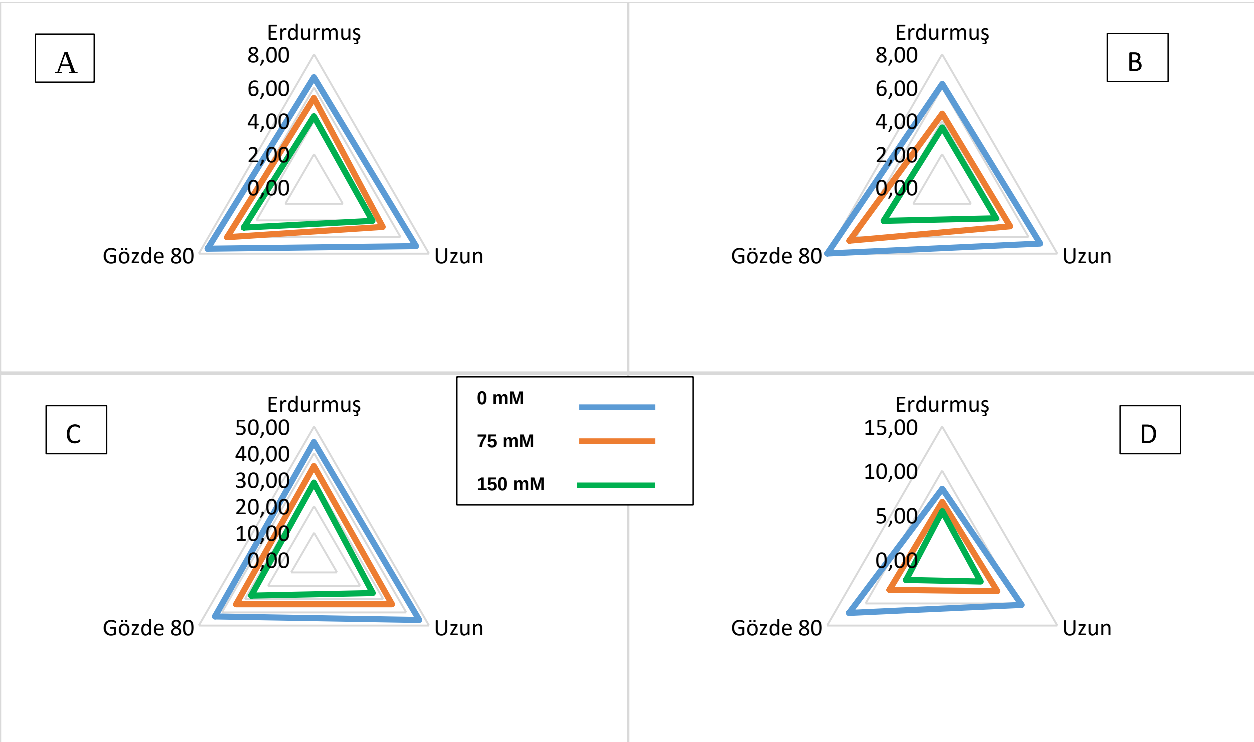

Figure 1. The effects of salinity on a. plumula length (cm), b. radicle length (cm), c. plumula fresh weight (mg) and d. radicle fresh weight (mg) in sorghum cultivars

Şekil 1. Sorgum çeşitlerinde tuzluluğun a. plumula uzunluğunda (cm), b. kök uzunluğunda (cm), c. plumula taze ağırlığında (mg) ve d. kök taze ağırlığında (mg) etkileri

On the other hand, in the same cultivars salinity stress decreased the radicle length by 28.94%, 42.12%, 30.84%, 44.94%, 19.20% and 48.94%, respectively. The highest plumule fresh weight was found in the control application and the lowest was in the application of 150 mM salt at Uzun cultivar. At the same time, when the radicle was examined in terms of fresh weight, the highest average was determined in the control application (12.12 mg) in Gözde80 cultivar and the lowest average was determined in the 150 mM application (4.70 mg) in the same variety. As a result of the reductions, it was found that Uzun is the most sensitive variety to salinity in general (Figure 1).

Whenever the effects of increasing boron doses on the cultivars were examined, the highest averages in length parameters were obtained at a dose of 5 mM in Gözde 80 cultivars, and the lowest averages were determined at a dose of 15 mM in Erdurmuş cultivars. However, when looking at the fresh weights, the highest and lowest means were obtained in Uzun cultivar at 5 mM and 15 mM doses, respectively (Figure 2). Low boron dose has a positive effect on plant growth up to 5 mM dose, which can be explained by the effectiveness of boron element in plants such as cell division, elongation in meristimatic tissues, membrane integrity, cell wall formation, leaf expansion (Marschner, 2012; Gupta & Solanki, 2013; Da Rocha Pinho et al., 2015).

CONCLUSION

As a result of this study, different salinity levels created with NaCl decreased germination and growth parameters. Differences and responses between cultivars were also observed. In addition, determined that low-level boron applications caused an increase in the parameters examined under increasing NaCl conditions, yet observed that high-level applications caused a decrease in the parameters. It is thought that the effects of different salinity levels and boron applications determined in this study on germination and growth will be beneficial for further studies.

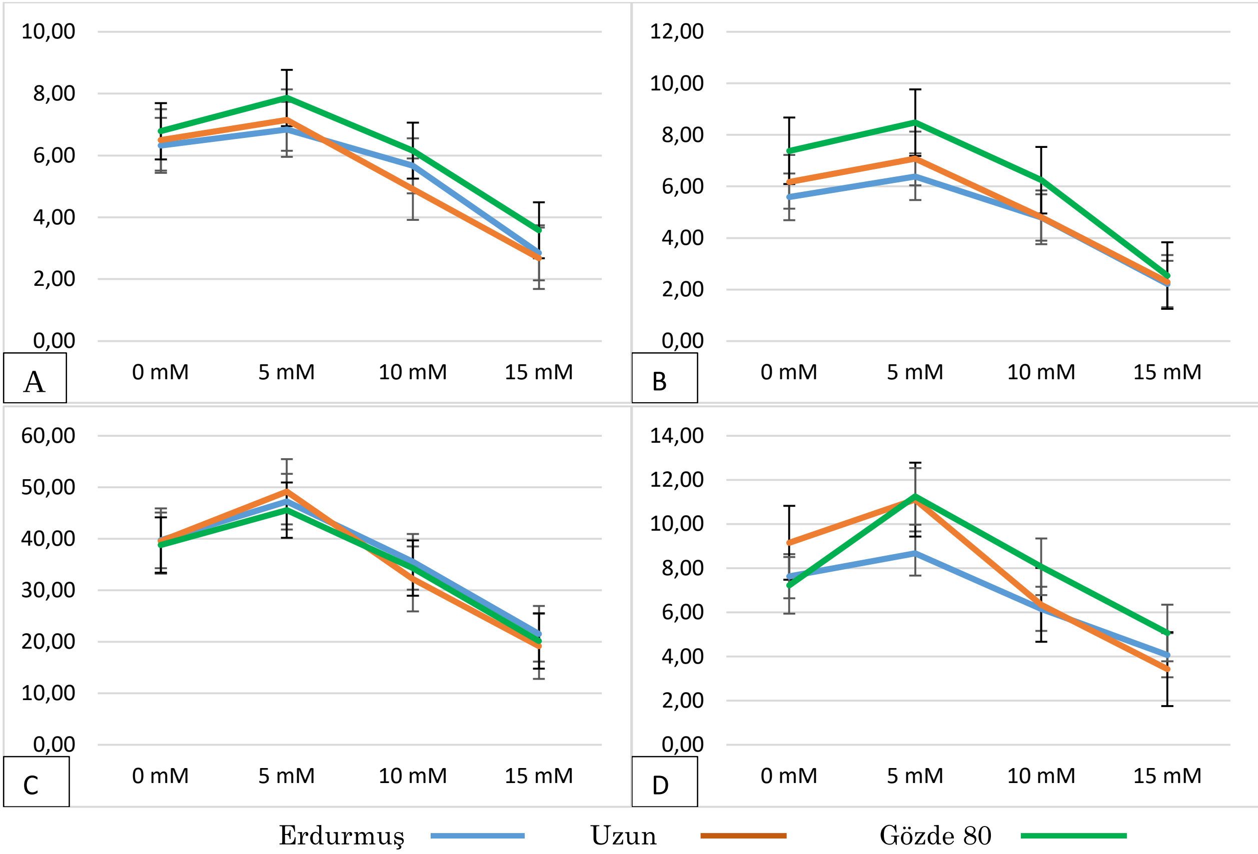

Figure 2. The effects of boron doses on a. plumula length (cm), b. radicle length (cm), c. plumula fresh weight (mg) and d. radicle fresh weight (mg) in sorghum cultivars

Şekil 2. Sorgum çeşitlerinde bor uygulamalarının a. plumula uzunluğunda (cm), b. kök uzunluğunda (cm), c. plumula taze ağırlığında (mg) ve d. kök taze ağırlığında (mg) etkileri

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Researchers Contribution Rate Declaration Summary

The authors declared that they have contributed to the article equally. All authors discussed the results and contributed to the final manuscript.

Statement of Conflict of Interest

Author has declared no conflict of interest.

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