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EVALUATION OF MORPHO-PHYSIOLOGICAL TRAITS OF TURKISH RICE GENOTYPES IN RESPONSE TO SALT STRESS UNDER *IN VITRO* CONDITIONS

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ABSTRACT

Salinity limits the rice germination and seedling growth at early growth stages. This study aimed to determine the morpho-physiological response of seventeen Turkish rice genotypes to four NaCl salinity stress (0, 40, 80 and 120 mM) under *in vitro* conditions during seed germination and early seedling stages. The effects of NaCl stress on water uptake, germination ratio, root length, shoot length, root fresh weight, root dry weight, shoot fresh weight, shoot dry weight, ion contens (Na, K, Ca and K/Na) for both root and shoot, and photosynthetic pigments (Chl *a*, Chl *b*, Chl *a*+*b* and carotenoid) in 17 rice genotypes were investigated in the experiment. The values of all traits were decreased by increasing the NaCl levels ($p \leq 0.05$), and genotype specific variations were identified under salt stress ($p \leq 0.05$). The investigated traits were decreased by salt stress including germination rate (43.1%), root and shoot lengths (80.3 and 78.4%), root fresh and dry weights (85.9 and 83.1%), shoot fresh and dry weights (70.4 and 64.9%), root and shoot K/Na (97.8 and 98.6%), and chl *a* (44.3%). According to genotype, genotype × environment (GGE) biplot analysis, principal components (PC1 and PC2) represented (38.02 and 18.39%, respectively) 56.41% of the total variation among the genotypes under salt stress. Gönen cultivar showed greater performance for the investigated traits, and had the highest salt tolerance among the cultivars. It is concluded that Gönen cultivar could be recommended for the region.

Key words: GGE biplot, ion contents, photosynthetic pigments, rice, salinity stress.

INTRODUCTION

A major portion of global population consumes rice (*Oryza sativa* L.) at least once a day (Chauhan *et al.,* 2017). Rice was grown on an area of 116.056 ha in Turkey and yielded 920.000 tons of paddy during the year 2016 (TÜİK, 2017). Weeds, rice blast disease (*Pyricularia oryzae*) and salinity are the major factors that limit the rice growth and yield. It is predicted that salinity will cause far more losses to rice yield in the future more than the other factors. Salinity, which restricts crop production, can occur as a result of natural factors as well as improper agricultural practices. Furthermore, most of the soils in rice areas are naturally saline (Hussain *et al.,* 2018).

The rice plant is described as moderately salt tolerant (Xiong *et al.,* 2014; Rahman *et al.,* 2016). Therefore, it is an appropriate crop for saline soils (Hussain *et al.,* 2018), but the level of salinity tolerance varies in rice genotypes (Khan *et al.,* 1997). The salinity affects seed germination by creating osmotic stress due to reduced water uptake or through ionic imbalance due to toxic effects of sodium (Na^+) and chloride (Cl^-) ions (Hosseini *et al*., 2003; Hussain *et al*., 2018). The increased salt level of the conditions lowered the water uptake of the seeds and germination rate (Akbarimoghaddam *et al*., 2011; Shereen *et al*., 2011; Balkan *et al*., 2015; Doğan and Çarpıcı, 2016). Many studies have reported that high level of salinity in rice reduces shoot and root length and shoot and root fresh-dry weight (Haq *et al*., 2009; Kazemi and Eskandari, 2011; Hussain *et al*., 2013; Balkan *et al*., 2015; Solangi *et al*., 2015; Zafar *et al*., 2015; Dolo *et al*., 2016). It is also reported that lower Na, higher K and K/Na ratio provides salt tolerance in rice (Tatar and Gevrek, 2007; Tatar *et al*., 2010; Hussain *et al*., 2013; Zafar *et al*., 2015). The salt stress limits the plant growth besides other abiotic stresses. The closed stomata, limited CO_2 uptake and insufficient photosynthesis are the reasons for the reduction in plant growth as a result of salinity. Singh *et al*. (2009) reported that salt stress shortened the plant height of rice, reduced the leaf area, lowered the dry weight and limited the photosynthesis and chlorophyll content.

In recent years, GGE (genotype, genotype × environmet) biplot analyses were used to evaluate many crop plants in different experiments. One of the main reasons for researchers to use this analysis that it enables to build graphics indicating more than one traits of the genotypes and provides a comparasion between genotypes and traits, since the salt tolerance is highly related with germination and seedling stage traits (Yan *et* *al*., 2000; Yan, 2001; Sayar and Han, 2015 and 2016; Kendal *et al*., 2016; Erdemci, 2018).

The aims of the study were i- to determine and compare salt tolerance of the genotypes at germination and early seedling stages, ii- to determine the varieties that could be grown in the rice cultivation areas with the salinity problem and to recommend the varieties with the highest tolerance to salinity, iii- and to find out rice genotypes which could be used in future rice breeding programs to improve salt stress tolerance in 17 Turkish rice genotypes widely grown in Turkey.

MATERIALS AND METHODS

The 17 Turkish rice cultivars that were provided by Thrace Agricultural Research Institute of Turkey were used as plant materials. The genotypes used in the study were; Osmancık-97, Gönen, Halilbey, Edirne, Gala, Çakmak, Hamzadere, Efe, Paşalı, Kale, Yatkın, Biga İncisi, Tosya Güneşi, Sürek M711, Balaban, Sarhan and Ülfet.

The seeds of the rice genotypes used in the experiment were surface sterilized with 10% sodium hypochlorite solution for five minutes and then rinsed with distilled water. The seeds were placed into 11 cm diameter petri dishes each having 25 seeds on a double-layer filter paper. Afterwards, 15 ml of relevant salt solution, including 0, 40, 80 and 120 mM NaCl were added to petri dishes for each salt concentration and put into the incubator at 25±1 °C for eight days.

The investigated traits such as water uptake (WU-%), germination ratio (GR-%), root length (RL-cm), shoot length (SL-cm), root and shoot fresh weight (RFW and SFW-mg) and root and shoot dry weights (RDW and SDW-mg) were measured as described in the literature (Akbarimoghaddam *et al.,* 2011). The plant samples were prepared to determine ion contents by burning at 500 °C for 6 h and the ashes were dissolved with 2 ml of 10 N Nitric Acid (HNO_3). The readings were performed using Flame photometer (BWB Technologies) (Müftüoğlu *et al.,* 2014). The photosynthetic pigments were determined in fresh leaf samples before harvest. The fresh leaf samples (500 mg) were homogenized with acetone (90% v v^{-1}), the homogenate was filtered and made up to a final volume of 10 ml. The absorbance of homogenate was measured at 663, 645, and 470 nm using a spectrometer (Shimadzu UV-1201; Tokyo). Finally, the concentrations of chlorophyll *a* (Chl *a*), chlorophyll *b* (Chl *b*), chlorophyll *a*+*b* (Chl *a*+*b*), and carotenoids (Car) were calculated according to the formulas showed below by Lichtenthaler (1987).

$$\text{Chl } a \text{ (mg/g FW)} = (11.75 \times A_{663}) - (2.35 \times A_{645}) \times V / FW$$

$$\text{Chl } b \text{ (mg/g FW)} = (18.61 \times A_{645}) - (3.96 \times A_{663}) \times V / FW$$

$$\text{Car (mg/g FW)} = (1000 \times A_{470}) - (2.27 \times \text{Chl } a) - (81.4 \times \text{Chl } b) / 227 \times V / FW$$

Where; *A*: absorbance at wavelength, V: the final volume of acetone solution, and FW: the fresh weight of leaf samples in mg.

Statistical analyses: The experiment was arranged in a completely randomized factorial design with three replications. The experimental data was analyzed using ANOVA procedure with the JMP software (JMP, 2007). Duncan's Multiple Range Test was used to compare mean data. GGE biplot analysis was carried out using GenStat 14th edition as described by Yan (2001).

RESULTS AND DISCUSSION

Germination and Seedling Traits: The water uptake of seeds was significantly affected by salinity levels and their interactions (Table 1). At the end of 24 h for mean values, the highest water uptake rate was 29.60% by Halilbey genotype, while the lowest water uptake rate was 25% by Sürek M711 genotype. The average water uptake rate was 26.93% among the rice genotypes. Salt concentrations had a negative effect on water uptake rate at 24 h, and there was a decrease water uptake with an increase in salt concentrations. According to mean salinity levels; the highest water uptake rate (28.89%) was found in control treatment while the lowest water uptake (25.19%) was found for 120 mM salt concentration (Table 1).

For germination rate, NaCl concentrations and genotype × salt concentration interactions varied between 9.3 and 100%. The highest germination rate was obtained from Çakmak and Gönen varieties with 100% germination rate at control level. In contrast, the lowest germination rate (9.3%) was noted for Halilbey variety at 120 mM NaCl dose. Among the varieties, Biga İncisi (90.6%) was the variety that had lowest effect by salt stress, and Halilbey (44%) was the most sensitive variety. The decrease in germination rates of some varieties were declined gradually with increase in NaCl doses, the reduction rates in some varieties were more severe and irregular (Table 1). The rice cultivars were found variable for root length. The longest root lengths were obtained from Biga İncisi, Tosya Güneşi, Yatkın, Gönen and Gala cultivars as 4.84, 4.81, 4.80, 4.75 and 4.69 cm, respectively while the shortest root length was obtained from Halilbey cultivar as 3.35 cm. The root length was gradually decreased by increased salt concentration and the reduction was recorded as 80.27% at 120 mM salt concentration compared to control group. Genotype × salt concentration interaction was identified as significant for root length. Therefore, Edirne cultivar had the highest root length at 0 mM salt concentration with 8.83 cm, while Çakmak cultivar had the lowest root length at 120 mM salt concentration with 0.70 cm (Table 1). According to shoot lenght analyses, the highest shoot length was obtained from Gönen cultivar as 3.91 cm while the shortest shoot length was obtained from Halilbey cultivar as 2.16 cm. The shoot length was decreased significantly as a result of increasing salt concentration doses, and the shoot length was decreased by 78.42% at 120 mM salt concentration compared to control dose. Genotype × salt concentration dose interaction was significant on shoot length, while Gönen and Hamzadere varieties had the highest shoot length with 5.96 cm at 0 mM salt concentration, Gala and Kale varieties had the lowest shoot length values of 0.76 cm at 120 mM salt concentration (Table 1).

The root fresh weight was found significant among the rice cultivars and the highest value was obtained from Yatkın cultivar (20.34 mg), while Halilbey had the lowest value with 7.12 mg. In addition, the root fresh weight was decreased with the increased salt concentrations and 120 mM dose had 85.89% decrease compared to control. The genotype × salt concentration interaction was found important for root fresh weight and Gönen cultivar had 36.18 mg root fresh weight at control dose, while Sürek M711 cultivar had the lowest root fresh weight with 1.01 mg at 120 mM dose (Table 2). There were significant differences among the rice cultivars and genotype × salt concentration interaction for shoot fresh weight. The highest shoot fresh weight values were obtained from Gönen and Biga İncisi cultivars as 12.97 and 13.31 mg, respectively and the lowest value was found as 6.55 mg from Halilbey cultivar. The shoot fresh weight value of the cultivars decreased by increased salt concentrations and according to salt concentrations, a decrease of 70.36% was measured between 120 mM to control dose. The Biga İncisi cultivar had the highest shoot fresh weight with 20.43 mg at control dose, while Halilbey cultivar had the lowest shoor fresht weight with 2.39 mg at 120 mM dose (Table.2).

The rice cultivars and genotype × salt concentration interaction were differed for root dry weight (RDW) ($p < 0.01$). The highest RDW was obtained from Yatkın cultivar with 2.3 mg, while Halilbey cultivar had the lowest RDW with 1.07 mg. There was an 83.06% decrease between 120 mM and control doses. The Gönen cultivar had the 3.94 mg RDW at 0 mM dose, while Sürek M711 had the 0.03 mg at 120 mM dose (Table 2). The significant differences were identified between rice genotypes and genotype × salt concentration interactions for shoot dry weight (SDW). While the Gönen cultivar had the highest SDW with 2.35 mg, and the Halilbey cultivar had the lowest SDW with 1.22 mg. The decrease between 120 mM to 0 mM salt concentrations was measured as 65%. The Biga İncisi cultivar had the highest SDW with 3.27 mg at 0 mM concentration, while Sürek M711 cultivar had the lowest SDW with 0.34 mg at 120 mM dose (Table 2).

The Na and Ca rates were increased with high salt concentration in both root and shoot, while K and K/Na concentrations decreased which was observed in all genotypes and lower Na and Ca levels were accumulated in the shoots rather than roots. This result might be related with the direct relationship between root and NaCl. The lowest and highest Na concentrations were measured in Gönen (34.02 mg/g) and Ülfet (91.51 mg/g) cultivars in the roots, respectively. While the highest Na was observed in Balaban, Ülfet and Osmancık-97 (53.04, 54.47 and 54.52 mg/g, respectively) cultivars, the lowest Na was measured at Gönen (31.41 mg/g) in shoots. On the other hand, the highest K value was observed in Ülfet cultivar with 12.83 mg/g and the lowest K concentration was obtained from Gönen with 8.56 mg/g in roots, while the highest K value was measured in Osmancık-97 cultivar with 18.24 mg/g. In addition, Balaban cultivar has the lowest K with 12.19 mg/g in shoots. In terms of Ca concentration in roots, Ülfet cultivar had the highest value with 6.18 mg/g and Gönen had the lowest value with 2.38 mg/g. While Balaban had the highest values as 2.93 mg/g, Osmancık-97 had the lowest Ca concentration as 1.39 mg/g in shoots. In addition, the highest K/Na value was obtained from Biga İncisi cultivar with 1.04 and the lowest one was obtained from Balaban cultivar with 0.54 in roots. Biga İncisi cultivar had the highest K/Na concentration with 4.22, while Ülfet cultivar had the lowest one with 1.85 in shoots (Table 3 and 4).

According to these results, osmotic pressure was increased with an increasing in salt concentrations, which decreased the water uptake of the seeds. Salinity inhibits water uptake of the seeds and this has been reported by Akbarimoghaddam *et al.* (2011) for wheat, Shereen *et al.* (2011) and Balkan *et al.* (2015) for rice and, Doğan and Çarpıcı (2015; 2016) for wheat and triticale. Ekmekçi *et al*. (2005) reported that reduction in germination rates because of increased salt levels was due to toxicity of Na^+ and Cl^- ions. Furthermore, water imbibition required for the seed germination was blocked due to increased osmotic potential. Our results were in agreement with the findings of other researchers who have reported that the germination rates of genotypes were decreased with increasing salt concentrations in major crops (Dumlupınar *et al*., 2007; Datta *et al*., 2009; Akbarimoghaddam *et al*., 2011; Hussain *et al*., 2013; Mahmoodzadeh *et al*., 2013; Balkan *et al*., 2015; Solangi *et al*., 2015 and Zafar *et al*., 2015).

For the root length, similar results were reported by Atış (2011) for sorghum, Uyanık *et al*. (2014) for canola, Balkan *et al*. (2015) for rice, Solangi *et al*. (2015) for rice and Zafar *et al*. (2015) for rice, Dolo *et al*. (2016) for rice. However, Hussain *et al*. (2013) indicated that root length in rice was increased by higher salt concentration which was inconsistent to our findings. As the salt concentrations were increased, the length of the shoots was decreased. This situation was a result of negative effects on water uptake caused by the toxic effects of the salt ions and the osmotic pressure. Similar results were reported for sorghum (Atış, 2011), canola (Uyanık *et al*., 2014), and rice (Hussain *et al.,* 2013; Balkan *et al.,* 2015; Solangi *et al.,* 2015).

The root fresh weight values were lowered by higher salt concentrations. Similar findings were reported by Balkan *et al*. (2015) and Solangi *et al*. (2015) in rice. We found that shoot fresh weight values were decreased with increased salt concentrations. Our findings were in agreement with Haq *et al*. (2009) for rice, Atış (2011) for sorghum, Hussain *et al*. (2013) for rice, Uyanık *et al*. (2014) for canola, Balkan *et al*. (2015) for rice, Solangi *et al*. (2015) for rice and Zafar *et al*. (2015) for rice. The results indicated that root growth was significantly decreased under severe salinity stress. Our results were also in agreement with the findings of Kazemi and Eskandari (2011), Balkan *et al*. (2015), Solangi *et al*. (2015), Zafar *et al*. (2015) and Dolo *et al*. (2016) who found that RDW was inhibited by high salinity levels in rice. It is also determined that high salt concentrations lowered the shoot dry weight which was supported by the results of the previous works in rice (Haq *et al.,* 2009; Balkan *et al.,* 2015; Solangi *et al.,* 2015; Zafar *et al.,* 2015).

In previous works; Tatar and Gevrek (2007) reported that increased salt concentrations caused an increase in leaf K/Na rates. Haq *et al*. (2009) also indicated that increased salt concentrations raised the Na ion accumulation in the shoots, while decreased the K ion accumulation. It is concluded that, one of the key features of plant salt tolerance is the ability of plant cells to maintain optimal K/Na ratio in the cytosol, when exposed to salt stress (Maathuis and Amtmann, 1999; Carden *et al.,* 2003; Tester and Davenport, 2003; Ashraf, 2004; Kaya *et al.,* 2012).

Photosynthetic Pigment Contents**:** Genotype, salt concentrations and genotype × salt concentration interactions were found significant for photosynthetic pigments. The Chl *a* pigment value was increased at 0 and 40 mM doses, while decreased at 80 and 120 mM salt concentration doses. The highest value obtained from Halilbey with 0.199 mg/g, while the lowest one obtained from Paşalı cultivar with 0.344 mg/g. On the other hand, the Chl *b* pigment content was increased at control and 40 mM doses, while decreased at 80 mM doses, but had the highest content 120 mM dose. The highest Chl *b* pigment content at 120 mM was due to closed leaves of the shoots. Sürek M711 had the highest content with 0.195 mg/g, and the lowest ones were obtained from Çakmak and Gönen cultivars with 0.080 mg/g. In addition, caratenoid pigment contents increased at control and 40 mM doses and decreased at 80 and 120 mM salt concentration doses. The highest carotenoid value was obtained from Paşalı cultivar with 0.205 mg/g, while Halilbey cultivar had 0.124 mg/g as the lowest. The Chl *a+b* content was higher at control and 40 mM doses, in contrast, it was decreased by 80 and 120 mM doses. The Sürek M711 and Haliley cultivars indicated the highest (0.506 mg/g), and the lowest (0.310 mg/g) values, respectively (Table 5).

It was determined that Chl *a* was much more affected than Chl *b* under salt stress which was also indicated by Lutts *et al*. (1996) and Tatar *et al*. (2010). It was also reported that chlorophyll pigment concentration was significantly changed under different salinity concentrations (Tatar and Gevrek, 2007; Aliu *et al*., 2015).

Evaluation of Genotype and Traits using GGE Biplot Analysis under Salt Stress: The GGE biplot analysis was performed to present a visual demonstration of the study. In recent years, the GGE biplot analysis was preferred by plant breeders and it provides interpretation of releationships between genotypes and environments, investigated traits and environments and correlations of investigated traits (Kendal *et al.,* 2016; Aktaş *et al.,* 2017; Erdemci, 2018). The biplot can be used reliably and provided the explaining an adequate amount (≥50%) of total variation (Yan *et al.,* 2000). Accordingly, the results of the present study revealed that principal component analysis explained 56.41% of the total variation where 38.02% was represented by PC1 and 18.39% by PC2, respectively (Figure 1, 2 and 3). The biplot analysis showed the most promising characters as a selection criteria for the cultivars used in this study. As shown in Figure 1, the genotypes and investigated traits were separeted by 5 mega-environments and differed in the distribution of genotypes. The Gönen variety found on the corner of the polygon in Figure 1 (which-won-where) shows the relationship between the genotypes and the features examined, the genotype has the highest values for SFW, RFW, SL, SDW, RDW, GR, RL, Chl a, Chl a + b, Car and shoot K. Halilbey was located on the corner of the polygon, but has no ideal properties for any characters. The genotypes at the corner of the polygon were found to have the most ideal or undesirable properties in terms of their characters. The ranking model of GGE biplot showed genotypes based on mean and stability of traits in Figure 2. The comparison model of GGE biplot also showed ideal genotypes based on traits in Figure 3. According to ranking and comparison of genotypes based on their traits (Figure 2 and 3), Gönen was an ideal genotype. Furthermore, these genotypes can also be considered as ideal since its values for almost investigated traits. Other researchers have reported similar results for wheat, triticale and chickpea (Kendal *et al.,* 2016; Aktaş *et al.,* 2017; Aslan *et al.,* 2017, Erdemci, 2018).

Table 1. Water uptake, germination rate, root lenght and shoot lenght of rice cultivars under different salinity levels.

	Water uptake (%)					Germination rate (%)					Root length (cm)					Shoot length (cm)				
	Salinity levels (mM)																			
Cultivars	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean
Halilbey	31.93^{ab}	28.96^{c-h}	28.83^{c-j}	28.70^{c-j}	29.60^{a}	76.0^{h-m}	66.6^{l-p}	24.0^{u}	9.3^{v}	44.0^{f}	6.43^{g-l}	3.50^{q}	2.33^{r-t}	1.16^{u-x}	3.35^{f}	4.16^{i-k}	2.20^{p-s}	1.30^{u-y}	1.00^{w-y}	2.16^{k}
Osmancık-97	30.30^{abc}	29.63^{a-f}	28.03^{c-n}	27.70^{c-o}	28.91^{ab}	94.6^{a-d}	96.0^{a-c}	88.0^{a-h}	18.6^{uv}	74.3^{d}	6.30^{g-m}	4.83^{p}	2.56^{q-s}	0.90^{x}	3.65^{ef}	4.53^{e-j}	4.43^{g-j}	2.63^{o-q}	1.03^{w-y}	3.15^{d-g}
Çakmak	29.66^{a-e}	27.10^{e-r}	26.20^{h-u}	25.80^{k-v}	27.19^{cd}	100.0^{a}	93.3^{a-e}	74.6^{i-m}	25.3^{u}	73.3^{d}	6.50^{f-l}	6.60^{f-k}	2.00^{s-w}	0.70^{x}	3.95^{cde}	4.56^{e-j}	4.36^{g-j}	2.30^{p-s}	0.96^{xy}	3.05^{e-h}
Gönen	26.50^{g-s}	26.03^{i-v}	25.10^{o-v}	24.66^{p-v}	25.57^{e}	100.0^{a}	93.3^{a-e}	86.6^{b-i}	53.3^{q-s}	83.3^{bc}	6.86^{d-i}	8.36^{a-c}	2.86^{q-s}	0.93^{wx}	4.75^{a}	5.96^{a}	5.40^{a-d}	3.26^{m-o}	1.03^{w-y}	3.91^{a}
Hamzadere	30.20^{a-d}	29.63^{a-f}	26.73^{g-s}	23.60^{t-w}	27.54^{bc}	96.0^{a-c}	96.0^{a-c}	90.6^{a-f}	48.0^{r-t}	82.6^{c}	6.13^{g-n}	6.43^{g-l}	2.13^{s-u}	0.93^{wx}	3.90^{de}	5.96^{a}	5.16^{b-e}	2.53^{p-r}	0.86^{xy}	3.63^{ab}
Efe	27.03^{e-s}	25.96^{j-v}	25.33^{m-v}	25.10^{o-v}	25.85^{de}	97.3^{a-c}	92.0^{a-f}	90.6^{a-f}	72.0^{k-o}	88.0^{abc}	5.06^{n-p}	7.20^{d-g}	3.26^{q-r}	0.90^{x}	4.10^{b-e}	4.23^{i-k}	5.03^{b-g}	2.86^{n-p}	0.86^{xy}	3.25^{c-f}
Gala	28.86^{c-i}	28.36^{c-l}	27.43^{c-p}	26.43^{h-t}	27.77^{bc}	92.0^{a-f}	81.3^{e-k}	86.6^{b-i}	41.3st	75.3^{d}	9.2^{a}	6.06^{h-n}	2.56^{q-s}	0.93^{wx}	4.69^{a}	5.46^{a-c}	5.33^{a-d}	2.60^{o-r}	0.76^{y}	3.54^{bc}
Paşalı	30.10^{a-d}	27.46^{c-p}	27.00^{e-s}	26.06^{i-v}	27.65^{bc}	96.0^{a-c}	94.6^{a-d}	85.3^{e-j}	58.6^{p-r}	83.6^{bc}	4.93^{op}	5.83^{i-p}	3.30^{q-r}	0.93^{wx}	3.75^{ef}	4.43^{g-j}	4.30^{h-k}	1.66^{s-w}	0.80^{xy}	2.80^{hi}
Edirne	28.96^{c-h}	28.90^{c-i}	27.33^{d-q}	26.36^{h-u}	27.89^{bc}	81.3^{e-k}	61.3^{n-q}	60.0^{o-r}	26.6^{u}	57.3^{e}	8.83^{ab}	5.50^{l-p}	2.66^{q-s}	1.03^{v-x}	4.50^{ab}	5.50^{ab}	3.66^{k-m}	1.93^{r-v}	1.00^{w-y}	3.02^{e-h}
Balaban	26.90^{e-s}	26.40^{h-t}	24.90^{o-v}	24.20^{s-v}	25.60^{e}	90.6^{a-f}	89.3^{a-g}	76.0^{h-m}	74.6^{i-m}	82.6^{c}	6.86^{d-i}	6.40^{g-l}	2.56^{q-s}	2.06^{s-v}	4.47^{abc}	3.40^{l-n}	3.43^{l-n}	1.36^{t-y}	1.13^{w-y}	2.33^{jk}
Ülfet	30.10^{a-d}	28.20^{c-m}	27.36^{d-p}	25.70^{k-v}	27.84^{bc}	82.6^{d-k}	77.3^{g-l}	64.0^{m-q}	58.6^{p-r}	70.6^{d}	5.23^{m-p}	5.70^{j-p}	2.53^{q-s}	2.16^{s-u}	3.90^{de}	4.23^{i-k}	3.46^{l-n}	1.46^{t-x}	1.26^{v-y}	2.60^{ij}
Sarhan	26.16^{h-v}	25.30^{n-v}	24.86^{o-v}	24.46^{q-v}	25.20^{e}	96.0^{a-c}	92.0^{a-f}	82.6^{d-k}	82.6^{d-k}	88.3^{abc}	7.03^{d-h}	6.73^{e-j}	2.10^{s-v}	2.36^{r-t}	4.55^{ab}	4.63^{e-j}	4.06^{j-l}	1.43^{t-y}	1.40^{t-y}	2.88^{ghi}
Yatkın	28.53^{c-k}	27.60^{c-o}	27.13^{e-r}	26.30^{h-u}	27.39^{c}	98.6^{ab}	92.0^{a-f}	88.0^{a-h}	77.3^{g-l}	89.0^{ab}	5.63^{k-p}	7.70^{c-e}	2.86^{q-s}	3.03^{q-s}	4.80^{a}	5.13^{b-f}	4.93^{b-h}	2.33^{p-s}	2.00^{q-t}	3.60^{ab}
Biga İncisi	27.36^{d-p}	26.76^{f-s}	24.33^{r-v}	23.30^{vw}	25.44^{e}	97.3^{a-c}	96.0^{a-c}	92.0^{a-f}	77.3^{g-l}	90.6^{a}	6.76^{e-j}	7.93^{b-d}	3.30^{q-r}	1.36^{t-x}	4.84^{a}	5.43^{a-d}	5.46^{a-c}	1.96^{q-u}	1.10^{w-y}	3.49^{bcd}
Tosya Güneşi	32.26^{a}	27.70^{c-o}	21.23^{w}	20.93^{w}	25.53^{e}	81.3^{e-k}	76.0^{h-m}	73.3^{j-n}	57.3^{p-r}	72.0^{d}	7.80^{b-e}	7.53^{c-f}	2.90^{q-s}	1.03^{v-x}	4.81^{a}	5.03^{b-g}	4.56^{e-j}	2.70^{op}	1.03^{w-y}	3.33^{b-e}
Sürek M711	26.26^{h-u}	25.33^{m-v}	24.90^{o-v}	23.50^{uvw}	25.00^{e}	89.3^{a-g}	88.0^{a-h}	73.3^{j-n}	40.0^{t}	72.6^{d}	6.56^{f-e}	7.53^{c-f}	2.16^{s-u}	1.10^{u-x}	4.34^{a-d}	4.76^{d-i}	4.80^{c-i}	1.30^{u-y}	0.80^{xy}	2.91^{f-i}
Kale	30.03^{a-d}	29.36^{b-g}	26.83^{e-s}	25.53^{l-v}	27.94^{bc}	98.6^{ab}	88.0^{a-h}	80.0^{f-k}	72.0^{k-o}	84.6^{abc}	6.73^{e-j}	5.96^{h-o}	2.10^{s-v}	0.83^{x}	3.90^{de}	4.56^{e-j}	4.46^{f-j}	1.83^{s-v}	0.76^{y}	2.90^{f-i}
Mean	28.89 ^{a}	27.57 ^{b}	26.09 ^{c}	25.19 ^{d}	26.93	92.2 ^{a}	86.6 ^{b}	77.4 ^{c}	52.5 ^{d}	77.1	6.64 ^{a}	6.46 ^{a}	2.60 ^{b}	1.31 ^{c}	4.25	4.82 ^{a}	4.41 ^{b}	2.08 ^{c}	1.04 ^{d}	3.08
LSD ($P<0.05$)	C:1.42	SL: 0.69		CxSL:2.84		C:6.08		SL: 2.95		CxSL: 12.16	C:0.53		SL: 0.26		CxSL: 1.06	C: 0.34		SL: 0.16		CxSL: 0.68
F values	C: **		SL: **	CxSL: *		C:**		SL: **		CxSL: **	C: **		SL: **		CxSL: **	C:**		SL:**		CxSL:**

Table 2. Root and shoot fresh – dry weights of rice cultivars under different salinity levels.

	Root (fresh weight)					Root (dry weight)					Shoot (fresh weight)					Shoot (dry weight)				
	Salinity levels (mM)																			
Cultivars	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean
Halilbey	16.14^{i-m}	5.84^{r-y}	3.81^{t-y}	2.72^{v-y}	7.13^{l}	2.47^{h-n}	1.42^{r-v}	0.26^{zh}	0.14^{zi}	1.07^{g}	11.42^{k-q}	7.97^{t-w}	4.43^{zd}	2.39^{zg}	6.55^{j}	1.81^{l-r}	1.67^{n-s}	0.94^{xyz}	0.44^{ze}	1.22^{h}
Osmancık-97	17.49^{g-k}	21.44^{e-h}	8.14^{q-u}	3.79^{t-y}	12.71^{d-g}	2.92^{d-j}	2.45^{i-n}	1.82^{o-s}	0.62^{x-zc}	1.95^{bcd}	11.03^{n-r}	13.22^{g-l}	7.37^{v-x}	3.80^{ze}	8.85^{efg}	2.10^{h-l}	2.08^{h-m}	1.57^{p-t}	0.48^{zd}	1.56^{g}
Çakmak	17.84^{g-k}	14.66^{j-o}	5.69^{r-y}	3.29^{u-y}	10.37^{g-j}	2.26^{l-p}	1.81^{o-s}	1.14^{t-x}	0.64^{x-zc}	1.46^{ef}	13.60^{f-j}	12.59^{h-n}	8.53^{s-v}	4.20^{zd}	9.73^{de}	2.17^{f-l}	1.87^{k-q}	1.50^{q-t}	0.60^{zc}	1.54^{g}
Gönen	36.18^{a}	24.11^{c-f}	9.82^{o-s}	1.78^{xy}	17.97^{ab}	3.94^{a}	3.00^{d-i}	1.65^{q-t}	0.26^{zh}	2.21^{ab}	18.40^{ab}	17.70^{b-d}	11.07^{m-q}	4.73^{zc}	12.97^{a}	3.24^{a}	3.13^{a}	2.02^{h-o}	1.00^{v-y}	2.35^{a}
Hamzadere	18.68^{g-k}	17.63^{g-k}	5.18^{s-y}	2.23^{w-y}	10.93^{f-j}	3.77^{ab}	2.94^{d-i}	1.29^{r-w}	0.39^{zf}	2.10^{abc}	16.21^{c-e}	14.07^{f-h}	7.51^{u-x}	4.10^{zd}	10.47^{cd}	2.91^{a-d}	2.55^{c-f}	1.79^{l-r}	0.90^{xyz}	2.04^{bc}
Efe	15.27^{j-n}	18.06^{g-k}	11.90^{l-q}	1.61^{xy}	11.71^{e-i}	2.87^{d-k}	2.57^{g-n}	2.05^{n-q}	0.35^{zg}	1.96^{bcd}	12.16^{h-o}	13.25^{g-l}	9.49^{q-u}	4.49^{zd}	9.85^{de}	2.24^{e-k}	2.16^{f-l}	1.90^{j-p}	0.98^{w-z}	1.82^{def}

Gala	15.86^{i-m}	22.65^{c-g}	9.30^{p-s}	1.55^{xy}	12.34^{d-h}	3.34^{b-e}	3.00^{d-i}	1.84^{o-r}	0.26^{zh}	2.11^{abc}	11.92^{i-p}	15.65^{d-f}	8.64^{s-v}	3.47^{ze}	9.92^{cd}	2.33^{e-i}	2.24^{e-k}	1.80^{l-r}	0.93^{xyz}	1.83^{de}
Paşalı	19.89^{f-j}	22.71^{c-g}	10.49^{n-r}	3.51^{u-y}	14.15^{cde}	3.09^{d-g}	2.68^{f-m}	1.60^{q-t}	0.66^{x-zc}	2.01^{bc}	13.18^{g-m}	13.72^{f-j}	7.05^{v-y}	4.48^{zd}	9.61^{de}	2.14^{g-l}	2.11^{h-l}	1.39^{s-v}	0.93^{xyz}	1.64^{efg}
Edirne	15.07^{j-o}	8.96^{p-t}	2.82^{v-y}	2.81^{v-y}	7.42^{kl}	2.52^{h-n}	1.47^{r-u}	0.46^{yze}	0.39^{zf}	1.21^{fg}	13.99^{f-i}	9.86^{p-t}	5.53^{x-za}	3.51^{ze}	8.22^{gh}	2.52^{d-g}	2.11^{h-l}	1.23^{t-x}	0.36^{zf}	1.55^{g}
Balaban	11.39^{m-q}	11.36^{m-q}	5.88^{r-y}	5.66^{r-y}	8.57^{jkl}	2.84^{d-k}	2.11^{m-q}	0.96^{u-z}	0.99^{u-y}	1.72^{de}	8.93^{r-v}	8.58^{s-v}	5.02^{yzb}	4.79^{zc}	6.83^{ij}	2.21^{f-k}	1.97^{i-p}	1.09^{u-y}	0.87^{x-za}	1.54^{g}
Ülfet	17.04^{h-l}	14.10^{k-p}	5.54^{r-y}	2.55^{w-y}	9.81^{h-k}	2.49^{h-n}	2.36^{j-o}	0.95^{u-z}	0.59^{x-zd}	1.60^{e}	11.83^{j-p}	9.52^{q-u}	5.94^{w-z}	3.45^{ze}	7.69^{hi}	2.04^{h-n}	1.97^{i-o}	1.37^{s-w}	1.19^{t-x}	1.65^{efg}
Sarhan	19.38^{f-j}	13.95^{k-p}	2.45^{w-y}	2.31^{w-y}	9.52^{i-l}	3.03^{d-h}	2.23^{m-p}	0.29^{zh}	0.80^{w-zb}	1.59^{e}	13.86^{f-j}	11.16^{l-q}	4.76^{zc}	4.32^{zd}	8.53^{fgh}	2.19^{f-l}	2.27^{e-j}	1.02^{v-y}	1.01^{v-y}	1.63^{fg}
Yatkın	33.45^{a}	34.86^{a}	5.89^{r-y}	7.18^{q-w}	20.34^{a}	3.78^{ab}	2.96^{d-i}	0.89^{v-za}	1.59^{q-t}	2.30^{a}	15.28^{e-g}	17.18^{b-e}	7.76^{u-w}	6.06^{w-z}	11.57^{b}	2.39^{e-h}	2.33^{e-i}	1.45^{r-u}	1.70^{m-s}	1.96^{cd}
Biga İncisi	31.53^{ab}	27.21^{bc}	5.00^{s-y}	2.17^{w-y}	16.48^{bg}	3.69^{abc}	2.86^{d-k}	0.74^{w-zb}	0.26^{zh}	1.88^{cd}	20.43^{a}	18.26^{bc}	9.58^{q-w}	4.99^{yzb}	13.31^{a}	3.27^{a}	2.98^{ab}	1.64^{o-s}	0.94^{xyz}	2.21^{ab}
Tosya Güneşi	26.70^{b-d}	21.89^{d-h}	6.72^{q-x}	3.22^{u-y}	14.63^{cd}	3.16^{c-f}	2.82^{e-l}	1.27^{s-w}	0.49^{yze}	1.93^{bcd}	18.00^{bc}	14.03^{f-i}	7.48^{u-w}	4.07^{zd}	10.89^{bc}	2.92^{abc}	2.62^{b-e}	1.43^{r-u}	0.76^{yzb}	1.93^{cd}
Sürek M711	26.29^{b-e}	15.07^{j-o}	5.02^{s-y}	1.01^{y}	11.85^{e-i}	3.40^{a-d}	1.74^{p-s}	0.81^{w-zb}	0.03^{zj}	1.49^{e}	13.90^{f-j}	10.26^{o-s}	4.98^{yzb}	2.83^{zf}	7.99^{gh}	2.05^{h-n}	1.86^{k-q}	0.76^{yzb}	0.34^{zf}	1.25^{h}
Kale	20.81^{f-i}	21.84^{d-h}	7.91^{q-v}	3.34^{u-y}	13.47^{def}	2.54^{g-n}	2.33^{k-o}	1.15^{t-x}	0.37^{zg}	1.60^{e}	13.43^{g-k}	11.17^{l-q}	8.78^{s-v}	4.73^{zc}	9.53^{def}	2.04^{h-n}	2.11^{h-l}	1.45^{r-u}	0.87^{x-za}	1.61^{g}
Mean	21.12 ^{a}	18.61 ^{b}	6.56 ^{c}	2.98 ^{d}	12.31	3.07 ^{a}	2.40 ^{b}	1.13 ^{c}	0.52 ^{d}	1.78	13.97 ^{a}	12.83 ^{b}	7.29 ^{c}	4.14 ^{d}	9.55	2.39 ^{a}	2.24 ^{b}	1.43 ^{c}	0.84 ^{d}	1.72
LSD (P<0.05)	C:2.57	SL: 1.24		CxSL:5.15		C:0.27		SL: 0.13		CxSL: 0.55	C:1.00		SL: 0.48		CxSL: 2.02	C: 1.98		SL: 0.10		CxSL: 0.39
F values	C: **		SL: **	CxSL: **		C:**		SL: **		CxSL: **	C: **		SL: **		CxSL: **	C:**		SL:**		CxSL:**

Table 3. Shoot Na, K, Ca and K/Na of rice cultivars under different salinity levels.

	Na					K					Ca					K/Na				
	Salinity levels (mM)																			
Cultivars	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean
Halilbey	1.39^{y}	46.90^{mno}	58.36^{gh}	78.29^{d}	46.24^{b}	19.19^{j-n}	17.27^{n-r}	11.39^{zg}	6.68^{zp}	13.63^{h}	1.43^{s}	2.39^{k-o}	3.62^{c-f}	0.83^{t}	2.07^{cd}	13.77^{b}	0.37^{l-r}	0.19^{n-r}	0.08^{qr}	3.60^{b}
Osmancık-97	2.69^{y}	32.62^{vwx}	46.46^{m-p}	136.32^{a}	54.52^{a}	23.73^{abc}	25.55^{a}	16.83^{o-s}	6.87^{zo}	18.24^{a}	0.31^{u}	2.07^{n-q}	2.89^{hij}	0.31^{u}	1.39^{f}	8.78^{i}	0.78^{l}	0.36^{l-r}	0.05^{r}	2.49^{hi}
Çakmak	2.03^{y}	35.39^{t-w}	50.63^{j-m}	69.76^{ef}	39.45^{e}	18.22^{m-p}	22.59^{c-f}	14.28^{t-x}	6.53^{zr}	15.40^{fg}	0.23^{u}	1.81^{qrs}	2.13^{l-q}	4.61^{b}	2.20^{c}	8.95^{i}	0.64^{l-p}	0.28^{l-r}	0.09^{qr}	2.49^{hi}
Gönen	1.48^{y}	33.57^{u-x}	41.72^{pqr}	48.88^{k-n}	31.41^{i}	15.75^{q-u}	19.14^{j-n}	17.12^{o-r}	14.36^{t-x}	16.59^{de}	0.18^{u}	1.79^{qrs}	2.11^{m-q}	2.91^{hij}	1.75^{e}	10.60^{ef}	0.57^{l-q}	0.41^{l-r}	0.29^{l-r}	2.97^{def}
Hamzadere	1.66^{y}	33.11^{vwx}	48.70^{k-n}	52.18^{i-l}	33.91^{gh}	19.71^{i-m}	23.34^{bcd}	16.69^{o-s}	9.48^{zj}	17.31^{a-d}	0.18^{u}	1.78^{qrs}	2.55^{j-m}	3.12^{ghi}	1.91^{de}	11.89^{cd}	0.70^{lmn}	0.34^{l-r}	0.18^{o-r}	3.28^{c}
Efe	2.03^{y}	30.83^{vwx}	40.73^{qrs}	74.35^{de}	36.99^{f}	20.61^{f-k}	22.71^{cde}	18.06^{m-p}	11.50^{zf}	18.22^{a}	0.22^{u}	1.94^{o-r}	2.36^{k-p}	3.74^{cde}	2.07^{cd}	10.14^{fg}	0.73^{lm}	0.44^{l-r}	0.15^{pqr}	2.87^{efg}
Gala	1.82^{y}	30.54^{wx}	44.87^{n-q}	84.07^{c}	40.32^{de}	17.45^{n-q}	22.21^{c-h}	15.98^{q-t}	13.10^{w-zb}	17.19^{bcd}	0.03^{u}	1.79^{qrs}	2.59^{jkl}	4.76^{ab}	2.29^{bc}	9.58^{h}	0.73^{lm}	0.35^{l-r}	0.15^{pqr}	2.70^{gh}
Paşalı	1.83^{y}	38.49^{r-u}	61.81^{g}	72.81^{ef}	43.74^{c}	19.60^{i-m}	22.34^{c-g}	13.37^{w-za}	10.57^{zh}	16.47^{de}	0.05^{u}	2.09^{m-q}	3.09^{ghi}	3.83^{cd}	2.27^{bc}	10.67^{e}	0.58^{l-q}	0.22^{n-r}	0.14^{pqr}	2.90^{efg}
Edirne	2.16^{y}	47.66^{l-o}	63.00^{g}	73.66^{def}	46.62^{b}	24.84^{ab}	19.88^{i-m}	15.41^{yzd}	12.25	18.10^{ab}	0.21^{u}	2.52^{j-n}	3.34^{e-h}	3.89^{c}	2.49^{b}	11.56^{d}	0.42^{l-r}	0.24^{m-r}	0.16^{pqr}	3.10^{cde}
Balaban	1.84^{y}	38.42^{r-u}	87.61^{c}	84.29^{c}	53.04^{a}	14.44^{t-w}	16.91^{o-s}	8.81^{zk}	8.63^{zl}	12.19^{i}	0.03^{u}	2.17^{k-q}	4.37^{b}	5.15^{a}	2.93^{a}	7.82^{j}	0.44^{l-r}	0.10^{qr}	0.10^{qr}	2.11^{j}
Ülfet	3.17^{y}	39.85^{rst}	69.08^{f}	105.79^{b}	54.47^{a}	20.74^{e-j}	21.56^{d-i}	13.59^{v-z}	12.44^{x-zc}	17.08^{cd}	0.27^{u}	2.48^{j-n}	3.54^{c-g}	5.18^{a}	2.87^{a}	6.55^{k}	0.54^{l-r}	0.19^{n-r}	0.12^{qr}	1.85^{k}
Sarhan	1.92^{y}	31.70^{vwx}	62.13^{g}	73.06^{ef}	42.20^{cd}	18.52^{l-o}	21.41^{d-i}	16.03^{q-t}	15.54^{q-v}	17.88^{abc}	0.15^{u}	1.92^{pqr}	3.20^{f-i}	3.62^{c-f}	2.22^{c}	9.65^{gh}	0.68^{l-o}	0.26^{m-r}	0.21^{n-r}	2.70^{gh}
Yatkın	1.97^{y}	32.71^{vwx}	59.05^{gh}	71.00^{ef}	41.18^{de}	15.96^{q-t}	18.64^{k-o}	13.95^{u-y}	13.30^{w-zb}	15.47^{fg}	0.21^{u}	1.73^{qrs}	3.15^{ghi}	3.72^{cde}	2.20^{c}	8.08^{j}	0.57^{l-q}	0.24^{m-r}	0.18^{o-r}	2.27^{ij}
Biga İncisi	1.09^{y}	30.21^{x}	47.15^{mno}	49.71^{k-n}	32.04^{hi}	17.08^{o-r}	22.10^{c-h}	13.15^{w-zb}	10.21^{zi}	15.64^{efg}	0.12^{u}	1.54^{rs}	2.52^{j-n}	2.87^{ij}	1.76^{e}	15.7^{a}	0.73^{lm}	0.28^{l-r}	0.20^{n-r}	4.22^{a}
Tosya Güneşi	1.60^{y}	35.77^{s-v}	49.62^{k-n}	54.82^{hij}	35.45^{fg}	16.49^{p-s}	20.57^{g-k}	14.94^{s-w}	7.69^{zn}	14.93^{g}	0.14^{u}	1.77^{qrs}	2.59^{jkl}	3.19^{f-i}	1.92^{de}	10.32^{ef}	0.58^{l-q}	0.30^{l-r}	0.14^{pqr}	2.83^{fg}
Sürek	1.70^{y}	33.27^{vwx}	45.45^{n-q}	55.82^{hi}	34.06^{gh}	20.62^{f-k}	22.67^{cde}	11.92^{ze}	10.07^{zi}	16.32^{def}	0.03^{u}	1.81^{qrs}	2.61^{jk}	3.39^{d-g}	1.96^{de}	12.09^{c}	0.68^{l-o}	0.26^{m-r}	0.18^{o-r}	3.30^{c}

M711 Kale	1.71^{y}	43.39^{o-r}	52.81^{ijk}	60.99^{g}	39.73^{e}	20.23^{h-l}	22.49^{c-g}	11.49^{zf}	8.31^{zm}	15.63^{efg}	0.03^{u}	2.32^{k-p}	2.62^{jk}	3.55^{c-g}	2.13^{cd}	11.97^{cd}	0.51^{l-r}	0.22^{n-r}	0.13^{pqr}	3.21^{cd}
Mean	1.89 ^{d}	36.14 ^{c}	54.66 ^{b}	73.28 ^{a}	41.49	19.01 ^{b}	21.26 ^{a}	14.29 ^{c}	10.45 ^{d}	16.24	0.22 ^{d}	2.00 ^{c}	2.90 ^{b}	3.45 ^{a}	2.14	10.48 ^{a}	0.60 ^{b}	0.27 ^{c}	0.15 ^{d}	2.87
LSD (P<0.05)	C: 2.45	SL: 1.19		CxSL:4.90		C:0.98		SL: 0.48		CxSL: 1.98	C:0.23		SL: 0.11		CxSL: 0.46	C: 0.25		SL:0.12		CxSL: 0.50
F values	C: **		SL: **	CxSL: **		C:**		SL: **		CxSL: **	C: **		SL: **		CxSL: **	C:**		SL:**		CxSL:**

Table 4. Root Na, K, Ca and K/Na of rice cultivars under different salinity levels.

	Na					K					Ca					K/Na				
	Salinity levels (mM)																			
Cultivars	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean
Halilbey	6.40^{zf}	53.75^{tuv}	96.56^{ij}	132.05^{d}	72.19^{c}	22.13^{ab}	9.77^{n-t}	7.05^{v-z}	5.05^{zc}	11.00^{de}	0.65^{v}	3.78^{mn}	7.09^{hi}	5.59^{j}	4.27^{d}	3.48^{a}	0.18^{h-m}	0.07^{j-m}	0.04^{lm}	0.94^{ab}
Osmancık-97	6.24^{zf}	24.43^{ze}	37.21^{za}	70.68^{opq}	34.64^{gh}	15.89^{c-g}	11.40^{k-n}	10.58^{l-q}	6.16^{yz}	11.01^{de}	0.57^{v}	2.04^{stu}	2.78^{o-r}	4.22^{lm}	2.40^{j}	2.56^{de}	0.46^{g}	0.29^{g-m}	0.09^{j-m}	0.85^{bcd}
Çakmak	6.18^{zf}	29.85^{zd}	52.62^{uvw}	64.02^{qrs}	38.17^{fg}	17.45^{c}	11.99^{klm}	12.19^{kl}	5.78^{za}	11.85^{bc}	0.57^{v}	2.43^{q-u}	3.40^{no}	3.72^{mn}	2.53^{j}	2.97^{b}	0.40^{ghi}	0.23^{g-m}	0.09^{j-m}	0.92^{abc}
Gönen	4.45^{zf}	22.81^{ze}	38.12^{z}	70.66^{pq}	34.02^{h}	8.86^{r-u}	7.61^{u-y}	8.94^{q-u}	8.83^{r-u}	8.56^{g}	0.41^{v}	1.87^{u}	2.58^{q-t}	4.67^{kl}	2.38^{j}	1.99^{f}	0.33^{g-j}	0.23^{g-m}	0.12^{j-m}	0.67^{efg}
Hamzadere	4.51^{zf}	56.17^{s-v}	55.32^{tuv}	110.51^{ef}	56.63^{d}	11.65^{klm}	10.54^{l-q}	15.36^{e-i}	9.15^{p-u}	11.68^{bcd}	0.43^{v}	2.51^{q-u}	4.68^{kl}	3.00^{opq}	2.65^{ij}	2.58^{de}	0.19^{h-m}	0.28^{g-m}	0.08^{j-m}	0.78^{de}
Efe	5.62^{zf}	38.70^{yz}	65.17^{qr}	107.01^{efg}	54.13^{d}	16.22^{c-f}	11.64^{klm}	11.73^{klm}	6.86^{w-z}	11.62^{bcd}	0.55^{v}	2.79^{o-r}	3.72^{mn}	7.21^{ghi}	3.57^{f}	2.89^{bc}	0.31^{g-l}	0.18^{h-m}	0.06^{klm}	0.86^{bcd}
Gala	4.81^{zf}	61.47^{rst}	41.88^{yz}	85.35^{lmn}	48.38^{e}	15.71^{d-h}	11.37^{k-n}	12.19^{kl}	3.04^{ze}	10.57^{e}	0.45^{v}	2.84^{o-r}	3.83^{mn}	6.77^{i}	3.47^{f}	3.32^{a}	0.18^{h-m}	0.29^{g-m}	0.04^{lm}	0.96^{ab}
Paşalı	6.08^{zf}	42.82^{xy}	45.43^{wxy}	132.04^{d}	56.60^{d}	16.86^{cde}	10.35^{m-r}	10.64^{l-p}	9.91^{n-s}	11.94^{bc}	0.58^{v}	2.65^{p-s}	3.79^{mn}	8.58^{bcd}	3.90^{e}	2.77^{bcd}	0.24^{g-m}	0.24^{g-m}	0.08^{j-m}	0.83^{bcd}
Edirne	7.93^{zf}	60.39^{r-u}	106.50^{e-h}	113.85^{e}	72.17^{c}	22.77^{a}	13.90^{ij}	5.47^{za}	6.38^{yz}	12.13^{ab}	0.73^{v}	4.17^{lm}	7.21^{ghi}	8.49^{cd}	5.15^{c}	2.87^{bc}	0.23^{g-m}	0.05^{lm}	0.06^{klm}	0.80^{cde}
Balaban	5.62^{zf}	91.43^{jkl}	92.26^{jkl}	99.39^{g-j}	72.18^{c}	10.61^{l-p}	11.06^{k-o}	8.24^{t-w}	7.74^{u-x}	9.41^{f}	0.36^{v}	3.88^{mn}	7.79^{efg}	9.14^{bc}	5.29^{bc}	1.88^{f}	0.12^{j-m}	0.09^{j-m}	0.08^{j-m}	0.54^{g}
Ülfet	8.70^{zf}	94.15^{jk}	103.04^{f-i}	160.12^{b}	91.51^{a}	23.29^{a}	14.08^{hij}	8.89^{r-u}	5.06^{zc}	12.83^{a}	0.78^{v}	4.10^{lm}	8.06^{def}	11.78^{a}	6.18^{a}	2.67^{cde}	0.15^{h-m}	0.09^{j-m}	0.03^{m}	0.73^{def}
Sarhan	7.08^{zf}	86.71^{klm}	141.96^{c}	97.10^{ij}	83.21^{b}	17.34^{cd}	12.52^{jk}	8.41^{s-w}	8.61^{s-v}	11.71^{bcd}	0.62^{v}	3.84^{mn}	9.19^{a}	8.44^{de}	5.52^{b}	2.45^{e}	0.14^{i-m}	0.06^{klm}	0.09^{j-m}	0.68^{ef}
Yatkın	6.98^{zf}	52.36^{uvw}	78.42^{nop}	208.66^{a}	86.61^{b}	14.75^{f-i}	9.56^{o-t}	10.68^{l-p}	9.74^{n-t}	11.18^{cde}	0.57^{v}	2.34^{r-u}	5.71^{j}	7.63^{fgh}	4.06^{de}	2.11^{f}	0.18^{h-m}	0.14^{i-m}	0.05^{lm}	0.62^{fg}
Biga İncisi	4.13^{zf}	22.94^{ze}	61.02^{rst}	78.90^{mno}	41.75^{f}	14.55^{ghi}	10.98^{k-o}	6.46^{yz}	3.06^{ze}	8.76^{fg}	0.42^{v}	1.96^{tu}	3.87^{mn}	5.57^{j}	2.95^{hi}	3.52^{a}	0.48^{g}	0.10^{j-m}	0.04^{lm}	1.04^{a}
Tosya Güneşi	7.59^{zf}	50.37^{vwx}	67.93^{qr}	91.43^{jkl}	54.33^{d}	15.65^{e-h}	9.20^{p-u}	6.78^{xyz}	5.98^{z}	9.40^{f}	0.60^{v}	2.10^{stu}	3.28^{nop}	6.57^{i}	3.14^{gh}	2.07^{f}	0.18^{h-m}	0.10^{j-m}	0.07^{j-m}	0.60^{fg}
Sürek M711	6.01^{zf}	34.47^{zb}	66.85^{qr}	104.67^{f-i}	52.99^{d}	16.84^{cde}	11.31^{k-n}	9.50^{o-t}	5.13^{zb}	10.69^{e}	0.53^{v}	2.39^{q-u}	4.10^{lm}	5.07^{jk}	3.02^{gh}	2.81^{bcd}	0.32^{g-k}	0.14^{i-m}	0.05^{lm}	0.83^{bcd}
Kale	5.94^{zf}	29.90^{zc}	55.60^{tuv}	98.60^{hij}	47.51^{e}	20.74^{b}	12.52^{jk}	6.56^{yz}	4.13^{zd}	10.98^{de}	0.51^{v}	2.41^{q-u}	3.69^{mn}	6.67^{i}	3.32^{fg}	3.49^{a}	0.42^{gh}	0.12^{j-m}	0.04^{lm}	1.02^{a}
Mean	6.13 ^{d}	50.16 ^{c}	70.93 ^{b}	107.36 ^{a}	58.64	16.55 ^{a}	11.17 ^{b}	9.39 ^{c}	6.51 ^{d}	10.90	0.55 ^{d}	2.83 ^{c}	4.99 ^{b}	6.65 ^{a}	3,75	2.73 ^{a}	0.27 ^{b}	0.16 ^{c}	0.06 ^{d}	0.80
LSD (P<0.05)	C: 4.14	SL: 2.01		CxSL:8.29		C:0.83		SL: 0.40		CxSL: 1.66	C: 0.32		SL: 0.16		CxSL:0.66	C: 0.14		SL: 0.07		CxSL: 0.27
F values	C: **		SL: **	CxSL: **		C:**		SL: **		CxSL: **	C: **		SL: **		CxSL: **	C:**		SL:**		CxSL:**

Table 5. Chl a, Chl b, Chl a+b and Carotenoid of rice cultivars under different salinity levels.

	Chla					Chlb					Chla+b					Caratenoid				
	Salinity levels (mM)																			
Cultivars	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean	0	40	80	120	Mean
Halilbey	0.210^{zn}	0.254^{zh}	0.140^{zac}	0.190^{zr}	0.199^{q}	0.069^{za}	0.114^{mn}	0.046^{zg}	0.214^{c}	0.111^{e}	0.280^{zm}	0.368^{zb}	0.186^{zv}	0.404^{x}	0.310^{o}	0.137^{zc}	0.157^{y}	0.094^{zk}	0.111^{zf}	0.124^{o}
Osmancık-97	0.246^{z}ı	0.414^{g}	0.215^{zm}	0.131^{zae}	0.251^{o}	0.089^{uv}	0.108^{p}	0.079^{x}	0.109^{p}	0.096^{j}	0.336^{zf}	0.522^{h}ı	0.294^{zj}	0.240^{zr}	0.348^{l}	0.154^{z}	0.243^{f}	0.130^{zd}	0.240^{zr}	0.147^{n}
Çakmak	0.342^{s}	0.372^{l}	0.222^{zl}	0.102^{za}ı	0.260^{m}	0.097^{r}	0.092st	0.068^{zb}	0.063^{zd}	0.080^{l}	0.440^{u}	0.464^{p}	0.290^{zl}	0.165^{zac}	0.340^{m}	0.211^{m}	0.226ı^{j}	0.137^{zc}	0.065^{zp}	0.160^{k}
Gönen	0.265^{ze}	0.552^{a}	0.369^{m}	0.125^{zaf}	0.328^{c}	0.067^{zc}	0.115^{m}	0.096^{r}	0.043^{zh}	0.080^{l}	0.332^{zg}	0.667^{b}	0.465^{p}	0.168^{zab}	0.408^{e}	0.171^{vw}	0.327^{a}	0.225^{j}	0.085^{zm}	0.202 ^{b}
Hamzadere	0.264^{zf}	0.504^{b}	0.368^{mn}	0.193^{zp}	0.332^{b}	0.073^{z}	0.142^{f}	0.097^{r}	0.121^{l}	0.108^{f}	0.337^{zf}	0.646^{c}	0.465^{p}	0.314^{zh}	0.441^{c}	0.170^{w}	0.301^{b}	0.222^{k}	0.117^{ze}	0.202^{b}
Efe	0.292^{z}	0.481^{c}	0.335^{t}	0.164^{zt}	0.318^{d}	0.112^{no}	0.127^{j}	0.123^{kl}	0.089^{uv}	0.113^{d}	0.405^{x}	0.608^{d}	0.458^{q}	0.253^{zo}	0.431 ^{d}	0.191^{s}	0.284^{c}	0.207^{n}	0.104^{zh}	0.196 ^{c}
Gala	0.306^{x}	0.390ı	0.265^{ze}	0.272^{zc}	0.308^{f}	0.134^{h}ı	0.132ı	0.092st	0.248^{b}	0.151^{b}	0.440^{u}	0.522^{h}ı	0.358^{zc}	0.520ı	0.460^{b}	0.194^{r}	0.233^{h}	0.163^{x}	0.162^{x}	0.188^{d}
Paşalı	0.383^{k}	0.448^{d}	0.362^{q}	0.180^{zs}	0.344^{a}	0.108^{p}	0.124^{k}	0.121^{l}	0.112^{no}	0.116^{c}	0.492^{lm}	0.572^{e}	0.484^{n}	0.293^{zk}	0.460^{b}	0.236^{g}	0.266^{d}	0.213^{m}	0.108^{zg}	0.205^{a}
Edirne	0.342^{s}	0.333^{u}	0.283^{za}	0.202^{zo}	0.290ı	0.111^{o}	0.083^{w}	0.064^{zd}	0.207^{d}	0.116^{c}	0.453^{r}	0.416^{v}	0.347^{ze}	0.410^{w}	0.407^{ef}	0.216^{l}	0.204^{op}	0.182^{u}	0.128^{zd}	0.182^{g}
Balaban	0.366^{no}	0.422^{e}	0.262^{zg}	0.145^{zab}	0.299^{h}	0.128^{j}	0.104^{q}	0.091^{tu}	0.074^{z}	0.099ı	0.495^{kl}	0.526^{g}	0.354^{zd}	0.219^{zt}	0.398^{g}	0.232^{h}	0.253^{e}	0.164^{x}	0.095^{zk}	0.186^{e}
Ülfet	0.302^{y}	0.275^{zb}	0.277^{zb}	0.155^{zu}	0.253^{n}	0.097^{r}	0.093st	0.112^{no}	0.105^{q}	0.102^{h}	0.400^{y}	0.369^{zb}	0.390^{z}	0.260^{zn}	0.355^{k}	0.192^{rs}	0.171^{vw}	0.172^{v}	0.096^{zj}	0.157^{l}
Sarhan	0.292^{z}	0.393^{h}	0.365^{op}	0.156^{zu}	0.301^{g}	0.092st	0.105^{q}	0.135^{gh}	0.087^{v}	0.105^{g}	0.384^{za}	0.498^{jk}	0.500^{j}	0.243^{zp}	0.406^{f}	0.184^{u}	0.236^{g}	0.223^{k}	0.097^{z}ı	0.184^{f}
Yatkın	0.237^{zk}	0.388ı^{j}	0.324^{v}	0.134^{zad}	0.271^{k}	0.072^{z}	0.136^{g}	0.128^{j}	0.049^{zf}	0.096^{j}	0.309^{z}ı	0.524^{gh}	0.452^{rs}	0.183^{zy}	0.367^{j}	0.151^{za}	0.228ı	0.189^{t}	0.088^{zl}	0.163^{j}
Biga İncisi	0.349^{r}	0.417^{f}	0.246^{z}ı	0.114^{zag}	0.281^{j}	0.152^{e}	0.128^{j}	0.068^{zb}	0.037^{z}ı	0.096^{j}	0.501^{j}	0.545^{f}	0.314^{zh}	0.150^{zae}	0.377^{h}	0.217^{l}	0.245^{f}	0.155^{yz}	0.078^{zn}	0.173^{h}
Tosya Güneşi	0.364^{pq}	0.342^{s}	0.217^{zm}	0.149^{zy}	0.268^{l}	0.094^{s}	0.108^{p}	0.141^{f}	0.076^{y}	0.105^{g}	0.458^{q}	0.450st	0.358^{zc}	0.225^{zs}	0.373ı	0.228ı	0.203^{p}	0.145^{zb}	0.094^{zk}	0.167ı
Sürek M711	0.344^{s}	0.363^{pq}	0.152^{zv}	0.386^{j}	0.311 ^{e}	0.135^{gh}	0.128^{j}	0.055^{ze}	0.462^{a}	0.195^{a}	0.479^{o}	0.491^{m}	0.208^{zu}	0.848^{a}	0.506^{a}	0.206^{no}	0.216^{l}	0.097^{z}ı	0.227ı^{j}	0.186^{e}
Kale	0.312^{w}	0.241^{zj}	0.266^{zd}	0.106^{zah}	0.232 ^{p}	0.135^{gh}	0.112^{no}	0.078^{xy}	0.050^{zf}	0.094^{k}	0.448^{t}	0.353^{zd}	0.345^{ze}	0.156^{zad}	0.325^{n}	0.198^{q}	0.182^{u}	0.164^{x}	0.071^{za}	0.153^{m}
Mean	0.307 ^{b}	0.388 ^{a}	0.275 ^{c}	0.171 ^{d}	0.285	0.104 ^{c}	0.115 ^{b}	0.094 ^{d}	0.126 ^{a}	0.110	0.411 ^{b}	0.502 ^{a}	0.369 ^{c}	0.297 ^{d}	0.395	0.193 ^{b}	0.234 ^{a}	0.169 ^{c}	0.105 ^{d}	0.175
LSD ($P<0.05$)	C: 0.0010		SL: 0.0005	CxSL: 0.0021		C: 0.0010		SL: 0.0005		CxSL: 0.0021	C: 0.0016		SL: 0.0007		CxSL: 0.0031	C: 0.001		SL: 0.0005		CxSL: 0.002
F values	C: **		SL: **	CxSL: **		C:**		SL:**		CxSL:**	C: **		SL: **		CxSL: **	C: **		SL: **		CxSL:**

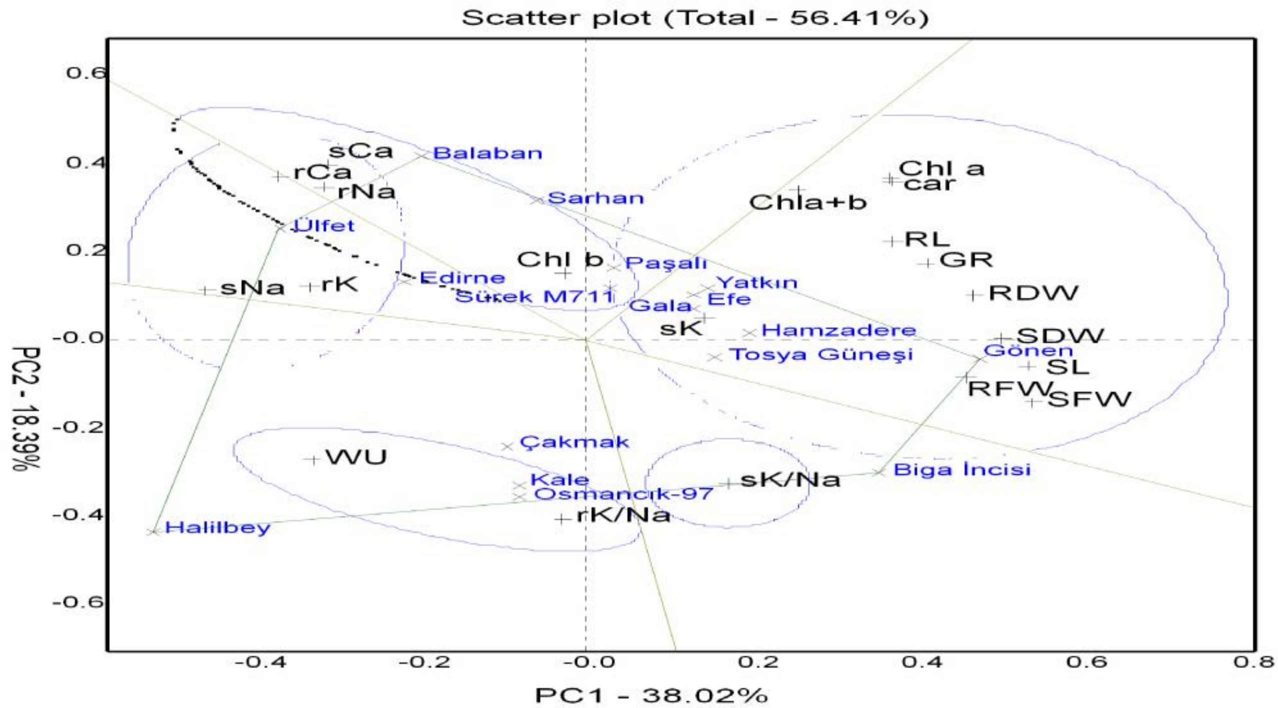

Figure 1. GGE biplot of the relationships among genotypes and traits under salt stres

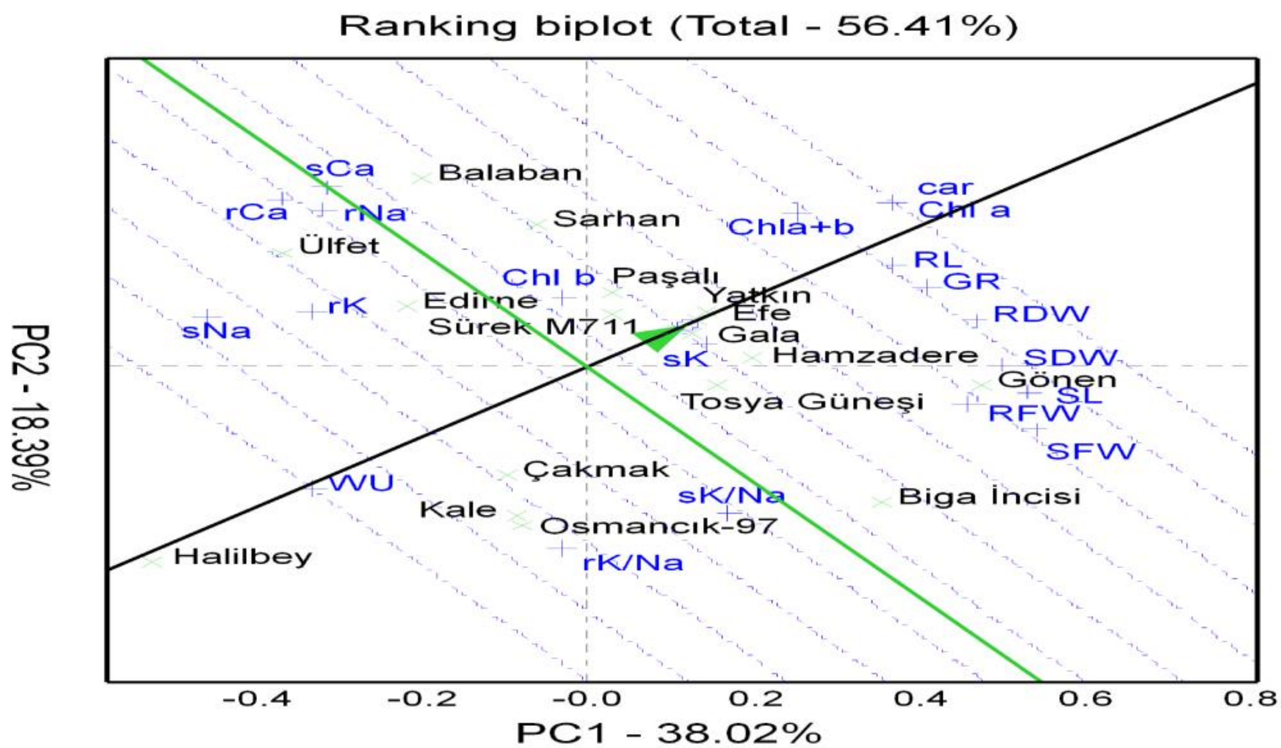

Figure 2. Ranking of genotypes on means of examined traits

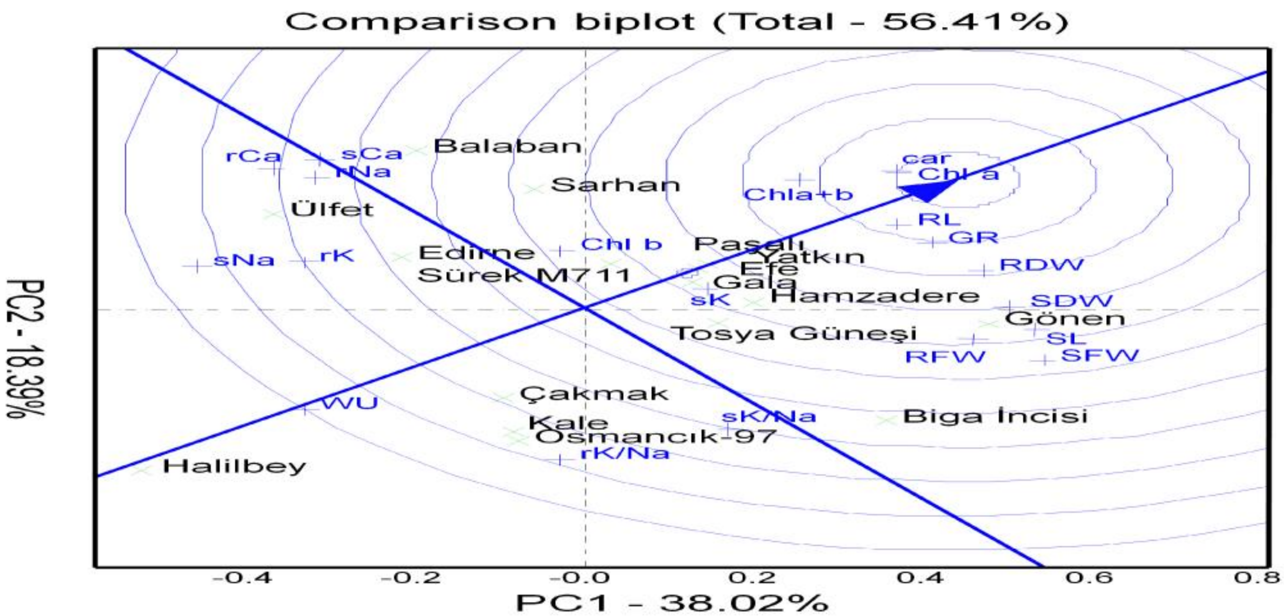

Figure 3. Comparison of genotypes on means of examined traits.

Conclusion: As a result of the study, the salt stress affected germination and seedling stages of the rice genotypes. The increased salt doses gradually decreased the seed germination and limited the rice germination and seedling development stages. The rice cultivars responsed differently to the salinity stress and the Gönen cultivar showed the best performance in response to salt stress for the investigated traits; thus, it might be considered to be a good parent in breeding programs and salt stress tolerance studies to be conducted under field or in vitro conditions. It is also concluded that Gönen cultivar could be recommended for the rice growing saline lands.

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