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DETERMINATION OF THE SALT TOLERANCE CHARACTERISTICS OF SOME BREAD WHEAT CULTIVARS

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Abstract

The study was performed in 2012-2013 and 2013-2014 vegetation seasons in the Dicle University, Agricultural Faculty, Research and Application Field and open greenhouse conditions. In this study, dry plant weight, K^+/Na^+ rates, Ca, Fe, and Zn contents in green parts of different 5 bread wheat cultivars of foreign origin, and the standard bread wheat cultivar, which is cultivated commonly in Southeastern Anatolia Region, have been compared under salt stress in pots. In addition, the agricultural characteristics like Number of Heading Days, Plant Height, Plant Grain Yield and Thousand Grain Weight were measured both in field and pot experiments.

It has been determined in the study that average dry weight decreased at a rate of 43.5%, and the K^+/Na^+ rate decreased at a rate of 50.1% in all wheat cultivars that are cultivated in salinity conditions. The Calcium (Ca) content of all cultivars increased at a significant level with the salt application. While the zinc (Zn) content of the Muzik cultivar decreases in salt stress, the Zn contents of the other cultivars have increased.

Key words: *bread wheat cultivars, salinity, salt stress, salt tolerance, agricultural characteristics, plant ion content.*

INTRODUCTION

Turkey has the high potential of breeding varieties and wheat production because of its ecological structure and its being the gene center of wheat. The wheat has an important place as the basis of nutrition for people. Performing the production of quality and resistant wheat cultivars by using proper cultivation techniques are extremely important for producers and the industrialists (Aydemir et al., 2003).

Yield and quality in wheat are influenced by genocultivar, environment, and genocultivar X environment interaction at a significant degree. In order to obtain high yield in wheat, the genocultivar must have high yield potential and the environmental conditions must be suitable. Adequate and balanced nutrition of the fast-increasing population with the production obtained from the separating and decreasing agricultural fields is becoming difficult day by day. For this reason, determining the genocultivars that have high yield, quality and resistance properties and that adapted to the ecological conditions well are of vital importance in covering the increasing need of nutrition.

Generally various yield and quality criteria are assessed in bread wheat and durum wheat in plant breeding works. However, the improvements in forming resistance against salinity in plants have been limited so far. Some of the important reasons for this are the plant physiology being influenced by salinity in many ways and the tolerability of plants to salt being a quantitative characteristic defined by multiple genes (Borsani et al., 2003).

Today, 20% of the agricultural lands on Earth and 50% of the irrigated lands are influenced by salinity (Zhu, 2001). In our country, on the other hand, it is possible to observe salinity at various levels in 4.49% of the agricultural areas (Munsuz et al., 2001). 7.52% of the land in our country (5.8 million ha) is influenced by drainage problem at various levels. Salinity and alkalinity are observed in many areas, mostly in Central Anatolian Region and in alluvial coastal plains due to the disrupted drainage systems (Anonymous, 2006). When the salinity levels of the soil in Turkey are examined according to the regions it is observed that the slightly salty soils (0.15-0.35%, 1.5-3.5 g/l) are distributed mostly in Middle-South, Mediterranean, Middle-North and South-Eastern agricultural regions. The salinity problem in the Mediterranean and Southeastern agricultural areas, which cover the Ceyhan Plain and GAP Project, stem from the secondary cause, i.e. the salinity due to irrigation.

The negative influences of salinity are observed mostly in arid and semi-arid areas where mainly wheat and other cereal products which cover the food requirement of the world. Salinity causes important losses in crops every year. It has been reported that biotic and abiotic (hot, cold, drought and salinity) stress factors cause nearly 25% loss in crops in annual base (Gill et al., 2004). Salinity limiting the plant production at a significant level may occur due to natural factors (less precipitation, high-level vaporization, and the existence of salty rocks) and incorrect agricultural applications (incorrect irrigation methods, irrigation with salty water, the accumulation of chemical residues from industrial products, high-dose mineral fertilization) (Kalaji and Pietkiewicz, 1993). Global warming, which is the source of the biggest environmental problem encountered by the globe, also cause that the seasonal normal values or temperature and precipitation become irregular and lead to inadequate precipitation and high vaporization eventually leading to salinity of the soil.

The simplest influence of the salt on plants is leading to the decrease in the intake of the nutrients in the soil by the plant and the plant cannot make use of the water in the soil (Crawley, 1997). The plants cannot make use of the water due to the increasing osmotic potential in salty soils or the plants can only make use of small amounts of water because of the toxic effects of Na^+ and Cl^- which exist in excessive amounts in the soil (Greenway, 1973; Flowers and Yeo, 1981). The Na, which accumulates in plants in salt stress, inhibits the potassium intake, and the Cl^- especially inhibits the NO_3 intake and disrupts the ion balance of the plants (Siegel et al., 1980; Kirkby and Knight, 1987; Gunes et al., 1994; Inal et al., 1995).

Parallel to the disruption in the ion balance in plants that grow in salty conditions, there also appears changes in mineral concentrations of the plants that may be accepted as significant. The Na and Cl ions are less in the tissues of the plants that are not influenced or influenced relatively less by the salt stress, and the proline amount is more (Flowers et al., 1977). The disruption in the photosynthesis, respiration and similar activities due to the damage in the cells breaking down the cellular functions by excessive amount of salt is another result of the damages of salt (Leopold and Willing, 1984).

The Na^+ and K^+ content of the plant are used as the criteria of resistance to salt in wheat grown in salinity conditions (Ahsan and Khalid, 1999). Potassium has important effects on photosynthesis, enzymatic activity, turgor potential, cell enlargement, aboveground and underground organs growth, stoma mobility, transpiration and protein synthesis (Tisdale et al., 1993; Marschner, 1995). The increase of potassium concentration of the plant rises the resistance to salt (Hsiao and Lauchli, 1986). In addition, it is known that the high K^+/Na^+ rate in the plant is in direct proportion with the resistance to salt (Gorham, 1990; Ashraf et al., 1997; Sherif et al., 1998).

The plants that are resistance to salt during the developmental stages after germination are extremely sensitive to soil salinity germination period (Tekinel and Çevik, 1983). These characteristics must be taken into consideration in selecting suitable cultivars and species for salty areas.

In this study, the agricultural characteristics and some chemical and technologic properties of five different bread wheat cultivars that is cultivated commonly in the region and in dry conditions have been examined, and the plant ion contents of them have been investigated; and the changes in some minerals like K, Na, Ca, Fe and Zn in plants under salt stress have been observed.

MATERIALS AND METHODS

All of the annual precipitation in Diyarbakır, where the field experiments are performed, falls between October and May. There is almost no precipitation in summer months, and the relative moisture decreases at a significant level. The average annual precipitation as long years has been 488.1 mm, relative moisture is 53%, and average temperature is 15.8°C.

According to the climate data during vegetation period (2012-2014 growing seasons), the relative moisture (63.6%) and total precipitation values (537.8 mm) vary at a significant level when compared with the long years average values, and there have not been any differences among years in terms of average temperature.

The field studies were performed in 2012-2013 and 2013-2014 vegetation seasons in the Dicle University, Agricultural Faculty, Research and Application Field. The soils where the study was conducted had the inclination of the land varies among different parts, but usually between 1-2%, clayish loamy soil, slightly alkaline (pH 7.77), slightly calcic (7.81% $CaCO_3$), total salt level was harmless (0.073%), rich in potassium (0.42%), poor in organic matter (1.67%). the experiment area soils contain 2.14 ppm Mn, 0.19 mg kg^{-1} B and 0.37 ppm Zn.

The improved standard bread wheat cultivar (Adana-99) in the region and 5 bread wheat cultivars of foreign origin (Renan, Tigre, Skerzo, Flamenko and Muzik) were used as the material in the studies. The field experiments were planted in complete randomized blocks design with 3 replications. The distance between the rows was 20 cm, and 450 seeds were sown per m^2. Phosphorus was given to all parcels with the 6 kg/da ratio when the seeds were sown, and half of the 12 kg/da pure nitrogen need was given when the seeds were sown, and the remaining half was given during stem elongation period.

In the study, which was conducted under open greenhouse conditions, the wheat seeds were sown to the pots which contained 1600 g soil with 6 seeds in one pot.

Nitrogen was given in ammonium nitrate form at 200 mg N/kg soil level, phosphorus was given at 100 mg/kg soil level, and potassium was given at 125 mg/kg level to all of the pots as basic fertilizers. In order to create salt stress in the soil, 68 mmol (4 g) NaCl/kg soil was applied. After sodium chlorine application, the soil pH was measured as 7.4; Electrical Conductivity as 2.7 mS/cm.

After 10-week development period, two plants in a pot were removed with their roots and Wet Plant Weights were weighed. The plant samples were washed with re-distilled water in the laboratory and dried at 70^oC for 48 hours to determine their dry plant weights were grinded. The dried and grinded plant samples were subjected to wet burning in concentrated $HNO_3/HClO_4$ (4:1) mixture, and the Ca, Fe, and Zn were determined with Atomic Absorption Spectrophotometer. The K^+ and Na^+ in green parts were measured with Flame photometric Method (SOLAAR AA Series, Thermo Electron Corporation) (Kacar, 1972), and the determined values were rated.

The agricultural characteristics like "Number of Heading Days, Plant Height (cm), Plant Grain Yield (g) and Thousand Grain Weight (g)" were measured both in the field experiments and under open greenhouse conditions.

The data's obtained in the study were subjected to analysis of variance as used the TARIST Statistical Program, and differences between the averages were evaluated by Duncan Test (Duncan, 1955).

RESULTS AND DISCUSSIONS

It was determined that the average dry weights of the wheat cultivars grown in salinity conditions decreased at a rate of 43.5%, and the average K^+/Na^+rate decreased at a rate of 50.1%. Although Adana-99 and Tigre cultivars produced the highest amount of dry matter both in salinity and in non-salinity conditions, the cultivars which showed the highest decrease in terms of dry weight in salt stress was Flamenko (51%) and Skerzo (53%) cultivars. The Tigre and Adana-99 wheat cultivars showed the highest K^+/Na^+rate in salt stress, and the highest decrease was determined in Flamenko (59%) in K^+/Na^+ rates in salinity conditions. In Muzik and Tigre cultivars, no significant decreases were determined in terms of K^+/Na^+rate.

When the wheat cultivars were examined in terms of calcium contents, it was observed that the Ca contents in all cultivars increased at a rate of 31% with the salt application. No significant differences were determined in terms of Ca contents between the cultivars grown in salinity conditions. While an increase at a rate of 70% was observed in Ca content of Flamenko cultivar, the increase in Adana-99 cultivar was 10 % (Table 1).

The decrease in dry matter amount in Adana-99 (31%), which is the standard cultivar of the region; and the Tigre cultivar (34%) was at low level when compared with the other cultivars in terms of salt stress. It is possible to claim that Adana-99, Tigre and Skerzo cultivars are more advantageous in terms of potassium and sodium rate and ion balance. It was determined that Adana-99 and Tigre cultivars had advantages when compared with the other cultivars in terms of calcium content.

Significant differences were observed between the wheat cultivars in terms of iron (Fe) and zinc (Zn) contents of plants. The average iron (Fe) content at a rate of 0.63%, and the average zinc (Zn) content at a rate of 3.0% increased in salinity conditions. The Fe contents of Skerzo and Adana-99 cultivars decreased at a significant level in salt stress; however, the Fe content of Muzik cultivar did not change much in salinity and non-salinity conditions, and the Fe contents of Renan, Tigre and Flamenko cultivars increased in salt stress. The Zn content of Muzik cultivar decreased in salt stress, while it increased in other cultivars.

The increases in Ca contents depending on salt application in wheat cultivars may be explained with the calcium having an important role in excessive Na existence for carrying the K selectively to enable the plant durable against salt; and therefore, Ca intake also increases parallel to the increasing Na intake in salty conditions.

Kaiser et al. (1983), associated the decrease in growth with the decrease in nutrient and water intake; Wang et al. (2010) associated the harmful effects of salinity with water stress, ion toxicity and ion imbalance (inhibitions in K+ intake) or with the combination of these factors. In addition, Wang et al. (2010), claimed that the decrease in photosynthesis was related with the decrease in the stoma conductivity.

It was observed in NaCl (-) conditions that the plant grain yield of bread wheat samples varied between 2.60-3.44 g, and the highest plant grain yield was determined in Flamenko and Tigre cultivars, and the lowest plant grain yield was determined in Adana-99 sample, which is the cultivar grown commonly in the area.

The plant grain yield of wheat cultivars grown in pots under salt stress vary between 1.67-2.64 g in salinity conditions. Average plant grain yield of wheat cultivars grown in salinity conditions reduced by approximately 0.806 g (26.9%). The most reduction rate was observed about 1.19 g (41.6%) in Skerzo cultivar, 1.15 g (40.3%) in Muzik cultivar, the lowest reduction rate was observed in Adana-99 cultivar (Table 2).

Table 1. Means and groups formed among bread wheat cultivars regarding plant dry weights, **K^+/Na^+** ratio and Ca contents in NaCl (-) and NaCl (+) conditions

Cultivars	**Plant Dry Weight (g/plant)**			**K^+/Na^+ ratio**			**Ca (g/kg)**		
	NaCl (-)	**NaCl (+)**	**Average**	**NaCl (-)**	**NaCl(+)**	**Average**	**NaCl (-)**	**NaCl (+)**	**Average**
Renan	0.599 AB	0.318 CD	0.459 BC	1.781 C	0.880 C	1.330 C	3.447 B	4.427	3.937 AB
Tigre	0.625 AB	0.412 AB	0.519 AB	2.938 A	1.549 A	2.244 A	3.688 AB	4.298	3.993 AB
Flamenko	0.517 C	0.253 D	0.385 D	1.874 C	0.765 C	1.319 C	2.722 C	4.629	3.675 B
Skerzo	0.570 BC	0.263 D	0.416 CD	2.244 B	1.064 BC	1.654 BC	3.578 B	4.809	4.194 AB
Muzik	0.646 A	0.348 BC	0.497 AB	1.562 C	0.943 C	1.253 C	3.101 BC	4.400	3.750 B
Adana-99	0.643 A	0.440 A	0.542 A	2.652 A	1.302 AB	1.977 AB	4.248 A	4.698	4.473 A
Average	**0.600 A**	**0.339 B**		**2.175 A**	**1.084 B**		**3.464 B**	**4.543 A**	
LSD	0.092		0.065	0.589		0.417	1.010		0.714
CV (%)	32.40			45.41			20.51		

*The differences between the means shown by the same letter are not significant at the 0.05 level according to LSD test.

Table 2. Means and groups formed among bread wheat cultivars regarding Fe, Zn contents and Plant Grain Yield in NaCl (-) and NaCl (+) conditions

Cultivars	**Fe (mg/kg)**			**Zn (mg/kg)**			**Plant Grain Yield (g)**		
	NaCl (-)	**NaCl (+)**	**Ort**	**NaCl (-)**	**NaCl(+)**	**Ort**	**NaCl (-)**	**NaCl(+)**	**Av.**
Renan	55.020 C	58.400 AB	56.710 BC	11.718 B	12.112 C	11.915 D	2.88	2.12 BC	2.50
Tigre	56.537 BC	59.599 A	58.068 ABC	13.770 A	14.898 AB	14.334 AB	3.30	2.64 A	2.97
Flamenko	57.979 B	59.676 A	58.828 AB	13.161 AB	13.513 BC	13.337 BC	3.44	2.49 AB	2.96
Skerzo	61.915 A	58.659 A	60.287 A	14.425 A	14.680 AB	14.553 AB	2.86	1.67 C	2.26
Muzik	55.075 C	55.607 B	55.341 C	13.257 AB	12.254 C	12.756 CD	2.85	1.70 C	2.27
Adana-99	61.281 A	58.083 AB	59.682 A	14.449 A	15.748 A	15.099 A	2.60	2.47 AB	2.54
Average	**57.968 A**	**58.337 A**		**13.463 A**	**13.867 A**		**2.988 A**	**2.182 B**	
LSD	3.926		2.776	1.617		1.143	1.295		0.915
CV (%)	5.01			11.09			31.62		

*The differences between the means shown by the same letter are not significant at the 0.05 level according to LSD test.

While there were significant differences between the cultivars at a rate of 1%, in terms of heading time it was observed that the heading time of the bread wheats vary between 143-158 days in non-saline field conditions. The latest heading was observed in Renan, Skerzo and Muzik cultivars, and the earliest heading time was observed in Tigre cultivar in non-saline conditions.

The heading time of wheat cultivars grown in pots under salt stress vary between 128-136.3 days in salinity conditions. Average heading time of wheat cultivars grown in salinity conditions reduced by approximately 20 days (13%). This reduction rate was about 12 days (7.86%) in Tigre cultivar, 10 days (6.55 %) in Adana-99 cultivar.

It was observed that the Thousand Kernels Weight of the bread wheat samples vary between 28.37-60.52 g in NaCl (-) conditions. The highest Thousand Kernels Weight was observed in Flamenko cultivar and the lowest Thousand Kernels Weight was observed in Muzik wheat sample. The thousand kernels weight of wheat cultivars grown in pots under salt stress vary between 29.27-35.40 g in salinity conditions. Average thousand kernels weight of wheat cultivars grown in salinity conditions reduced by approximately 8.33 g (20%).

The most reduction rate was determined about 25.12 g (41.5%) in Flamenko cultivar, but the lowest weight loss with 3.57 g (10.4%) in Adana-99 cultivar. A non-statistically significant increase was observed in Muzik wheat cultivar.

It was observed that the plant heights of the bread wheat cultivars vary between 66.86-93.80 cm, and the highest plant height was observed in Adana-99, and the lowest plant height was determined in Muzik cultivar in NaCl (-) conditions.

The plant heights of wheat cultivars grown in pots under salt stress vary between 48.87-67.25 cm in salinity conditions. Average plant height of wheat cultivars grown in salinity conditions reduced by approximately 22.06 cm (27.2%). The most reduction rate was observed about 26.8 cm (28.6%) in Adana-99 cultivar, 26.7 cm (31.2%) in Tigre cultivar (Table 3).

Table 3. Means and groups formed among bread wheat cultivars regarding agricultural properties in NaCl (-) and NaCl (+) conditions

Cultivars	Heading Time (Day)			Thousand Kernel Weight (g)			Plant Height (cm)		
	NaCl (-)	NaCl (+)	Av.	NaCl (-)	NaCl (+)	Av.	NaCl (-)	NaCl (+)	Av.
Renan	158.00 A	128.0 B	143.00 AB	41.67 B	34.58	38.12 AB	90.15 AB	67.25 A	78.70 A
Tigre	143.00 D	131.3 AB	137.17 C	41.07 B	33.95	37.51 AB	85.46 B	58.73 B	72.10 B
Flamenko	153.66 B	134.0 AB	143.83 AB	60.52 A	35.40	47.96 A	71.76 D	52.20 C	61.98 C
Skerzo	157.66 A	132.3 AB	145.00 AB	43.35 AB	35.37	39.36 AB	78.43 C	60.06 B	69.25 B
Muzik	156.66 A	136.0 A	146.33 A	28.38 B	29.27	28.82 B	66.86 D	48.87 C	57.87 C
Adana-99	146.33 C	136.3 A	141.33 BC	34.30 B	30.73	32.52 B	93.80 A	66.97 A	80.38 A
Average	**152.55 A**	**133.00 B**		**41.55 A**	**33.22 B**		**81.080 A**	**59.013 B**	
LSD	6.343		4.485	18.822		13.309	5.832		4.124
CV(%)	07.97			33.29			20.54		

*The differences between the means shown by the same letter are not significant at the 0.05 level according to LSD test.

Adana-99 cultivar, which is grown commonly in the area, showed high plant height and high Grain Yield per Unit Area, and these characteristics are the indicator for its being preferred by producers in the region in further years.

The results of this study revealed that the assessment based merely on grain yield is inadequate.

It is observed that Adana-99, Tigre, Flamenko and partly Skerzo cultivars may be preferred in terms of the grain yield values in both NaCl (-) and NaCl (+) conditions.

CONCLUSIONS

In conclusion, salt is unwashed and accumulate in upper soil. This situation restricts the development of plant roots, causes the formation of abiotic stress in plants. Water intake and transpiration decreased.

There are significant differences in terms of growing and mineral matter content of wheat plants in saline conditions. Besides being not used as much water by plants, it can be said that plant growth can also be limited by ion uptake, and particularly by impairments in ion balance.

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