Effects of Salinity on Synthetic Wheat Genotypes

F. MOHABBATI

University of Tehran, Karaj, Iran, e-mail: mohabbatiran@yahoo.com

Abstract: To study the effects of salinity stress on the growth stages of synthetic wheat genotypes, an experiment was conducted, using a factorial experiment with three replicates. In a glass-house three synthetic and one native (known as TABASI) wheat genotypes were seeded in the pots containing homogenous soil. After vernalization in earring stage, all of the treatments were exposed to three salinity level induced by 0, 2.5, 5 g/l salt in tap water. Watering continued until the plants were harvested. Salinity raised the contents of Na^+ in the stem and the leaf but did not affect the grain. The content of K^+ in the stem did not vary, but showed an increase in the leaf. The K^+/Na^+ ratio in the leaves decreased. Concentration of chlorophyll a and chlorophyll b were reduced by salinity but the ratio Chl. a/Chl. b didn't vary. There were no significant differences in the number of grain in an ear but salinity led to significant reduction in total dry matter production. Selectivity increased in the stem and leaf, respectively. Synthetic wheat genotypes had high harvest index under salinity conditions and also the content of K^+ in the leaves at the most synthetic genotypes was higher than native in the native genotype TABASI. The study demonstrates that the synthetic wheat genotypes have high ability in compartmentation and allocation processes and that these genotypes can tolerate salinity as well as drought. The high selectivity that is the characteristic of these genotypes may enable them to produce an acceptable yield even under saline conditions.

Keywords: synthetic wheat; salinity stress; K+; Na+; chlorophyll

Abbreviations: Chl. – chlorophyll; ROIs – Reaction Oxygen Intermediates; S0 – tap water; S1 – tap water with 2.5 g/l salt; S2 – 5 g/l salt

Salinity as a factor limiting plant growth is becoming an increasingly important problem, especially in arid and hot lands. High soil salinity caused nutrient imbalances result in the accumulation of elements toxic to plants and reduce water infiltration if the level of one salt element (sodium) is high. Salt affected plants are stunted with dark green leaves which, in some cases, are thicker and more succulent than normal. Salinity tolerance is influenced by many plant, soil, and environmental factors and their relationships. Due to economic and/or environmental limitations (inadequate drainage), it may not be possible to leach salt from soil. In these situations, plants that are tolerant of the salinity level in soil are necessary.

Wheat is a staple crop all over the world; it needs to be managed to produce acceptable yield, especially in poor and saline lands. Synthetic wheat genotypes are the kind of wheat by which we can reach this goal. Salinity increases the content of Cl^- and Na^+ and reduces K^+ in shoot and root (6, 2, and 1). Reduction of K^+ in sensitive cultivars under saline conditions is higher than in salt tolerant cultivars and the ratio of K^+/Na^+ in sensitive cultivars is lower than in tolerant plants (7). There is a high correlation between the ratio of K^+/Na^+ and resistance to salinity in wheat cultivars (5). Plants that have higher K^+ content are salt tolerant (4). SANTA-MARÍA and EPSTEIN (2001) determined that increasing the K^+/Na^+ ratio in the flag leaf leads to salinity tolerance in wheat (3). One of the major mechanisms for salt resistance is low accumulation of Na^+ and high K^+ concentration in young leaves (3). Under saline conditions the contents of carot-

Table 1: Analysis of variance for all traits(* = significant in 5% , ** = significant in 1% and ns = no significant)

SOV	DF	Ms										Ms selectivity	
		Na^+ stem (mg/g)	Na^+ leaf (mg/g)	K^+ stem (mg/g)	K^+ leaf (mg/g)	K^+/Na^+ leaf (mg/g)	Chl. a (μ/g)	Chl. b (μ/g)	Chl. a/b	Number grain in an ear	TDM	Soil to stem	Soil to leaf
Genotype	3	0.038^{ns}	0.097^{ns}	101.77^{*}	3.01^{ns}	0.00006^{ns}	0.41^{ns}	0.191^{ns}	0.0308^{ns}	13.63^{**}	0.014^{ns}	0.148^{ns}	0.051^{ns}
Salinity	2	0.92^{*}	10.54^{*}	49.6^{ns}	7.5^{*}	0.0064^{**}	2.02^{*}	98.6^{*}	0.034^{ns}	3.18^{ns}	0.054^{**}	28.51^{*}	14.45^{ns}
Genotype × salinity	6	0.055^{ns}	0.26^{ns}	29.07^{ns}	1.52^{ns}	0.00012^{ns}	0.036^{ns}	0.318^{ns}	0.0057^{ns}	1.1^{ns}	0.004^{ns}	0.08^{ns}	0.175^{ns}
E	22	0.0298	0.139	15.9	1.8	0.000055	0.028	0.826	0.018	1.184	0.005	0.112	0.069
CV		24.19	17.85	10.91	15.97	0.73	22.88	17.98	12.81	17.57	5.75	8.09	8.5

Table 2: Mean comparison of salinity levels for evaluating traits

Salinity level	Mean of concentration								Mean of		Mean of selectivity	
	Na stem (mg/g)	Na leaf (mg/g)	K stem (mg/g)	K leaf (mg/g)	K/Na leaf	Chl. a (μ/g)	Chl. b (μ/g)	Chl. a/b	TDM (g)	Number of grain in ear	From soil to stem	From soil to leaf
S0	0.39 b	1.07 c	35.7 a	7.5 b	1.046 a	2.7 a	8.1 a	2.57 a	3.9 a	46 a	34 c	11.48 b
S1	0.84 a	2.28 b	38.8 a	8.5 ab	1.013 b	1.9 b	2.4 c	2.45 a	208 b	38 a	513.1 b	186.45 a
S2	0.89 a	2.9 a	35.0 a	9.1 a	1.001 c	2.2 b	4.6 b	2.58 a	2.3 b	33 a	1032.3 a	220.44 a

Table 3: Mean comparison of selectivity from soil to stem and leaf among the genotypes between S0 and S2 levels (S0 is tap water and S2 is tap water with 5 g/l salt)

Cultivar	Mean of selectivity					
	From soil to stem			From soil to leaf		
	S0	Mean difference	S2	S0	Mean difference	S2
Synthetic 1	28.93 a	± 2333	704 a	9.8 a	± 1747	181.0 b
Synthetic 16	38.62 a	± 1658	679 a	11.8 a	± 1816	226.1 ab
Synthetic 30	34.83 a	± 5093	1809 a	13.4 a	± 2160	302.8 a
TABASI	33.66 a	± 2677	935 a	10.7 a	± 1498	171.0 b

enoids and chlorophyll is lowered (10). The ratio of Chl. a/Chl. b increases because of the higher sensitivity of Chl. b to salinity in comparison to Chl. a (10). The reduction of chlorophyll is due to chlorophylase enzyme (10, 8).

In this study, my objectives were to determine how salinity affects physiological functions in wheat. My principle interest was to compare synthetic wheat genotypes with a native salt tolerant wheat cultivar. Results obtained in this study are similar to previous findings about drought tolerance of synthetic wheat genotypes. Villareal (11) mentioned that the biomass and kernel weight of synthetic wheat genotypes were significantly higher than other control genotypes.

MATERIALS AND METHODS

Three synthetic (1, 16, 30) and one native (TABASI) wheat were selected for this experiment. Trial was carried out in Agronomy green-house, Agriculture faculty, Tehran University in a pots contained homogenous soil, in a factorial experiment based on Randomized Complete Block Design (RCBD) with three replicates. After vernalization all of the treatments were exposed to three salinity level induced by adding 0, 2.5, 5 g/l salt to the tap water used for watering the plants until they were harvested. To avoid from salt accumulation in the soil a drainage management system was used. Sampling was conducted in earring stage. The amounts of K^+, Na^+, and chlorophyll were measured in flag leaf and stem.

Sampling. At earring stage and after harvesting the leaf and stem were rinsed with water and then with distilled water. Flag leaf and stem were dried separately for 48 h in 70°C in an oven.

Measuring the concentration of Na^+ and K^+. Dried samples were ground and 1 g from each ground sample was placed in electric oven for 4 h in 550 to 600°C to be burned completely. After cooling, 20 ml of 2N HCl normal was added to each sample. They were then placed in Erlenmeyer containers and put on water bath for 1–2 h at normal temperature. After adding enough distilled water to each sample to make the final volume 100 ml, all of the samples were placed in plastic containers. A flame photometer was used to measure the contents of Na^+ and K^+.

Measuring the concentration of leaf chlorophyll. 1 g of fresh leaf sliced from plant was ground and mixed with 4 ml acetone in a 50 ml glass tube and shaken severely for 10 s, then allowed to settle. Ten minutes later 3 ml distilled water and 3 ml ether were added. The samples were then shaken severely for 5 s and then left for the layers to sepa-

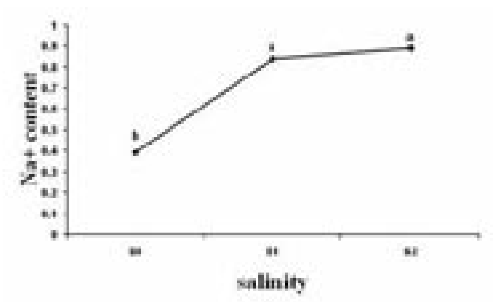

Fig. 1. Effects of salinity on Na^+ in the stem

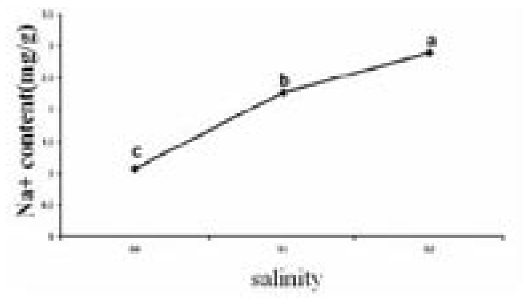

Fig. 2. Effects of salinity on Na^+ in the leaf

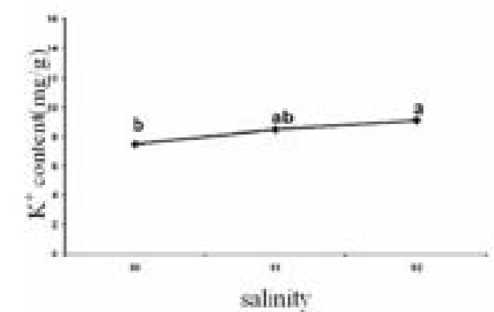

Fig. 3. Effects of salinity on K^+ in the leaf

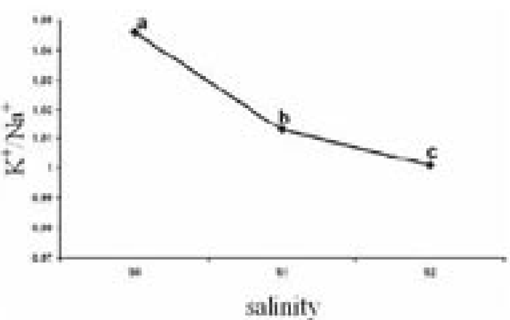

Fig. 4. Effects of salinity on K^+/Na^+ in the leaf

rate. One milliliter of the upper dark green layer was combined with 9 ml acetone before measuring its concentration of chlorophyll 'a' and 'b' using a Spectrophotometer UV-160 unit.

Selectivity. To calculate the selectivity: after measuring Na^+ and K^+ in the leaf, stem and soil, the following ratios were calculated:

$$\text{Selectivity (from soil to stem)} = \frac{K^+ / Na^+ \text{ stem}}{K^+ / Na^+ \text{ soil}}$$

$$\text{Selectivity (from soil to leaf)} = \frac{K^+ / Na^- \text{ leaf}}{K^+ / Na^+ \text{ soil}}$$

RESULTS AND DISCUSSION

There were significant differences among salinity levels for Na^+ concentration in stem but the interaction between genotype and salinity was not significant. There were no significant differences among the genotypes (Table 1). Salinity raised the Na^+ content in stem and this significance was obvious between S0 and S2 levels (Figure 1). Table 2 shows the mean comparison of Na^+ content in stem in 2 salinity level. Synthetic wheat 30 had the lowest Na^+ content in stem which may enable it to avoid the toxic effects of Na^+. There were no significant differences between salinity levels for stem K^+ but there are significant differences among genotypes. Low salinity level induced K^+ accumulation in the stem. Synthetic 16 had the highest stem K^+ under saline conditions. Salinity raised the amounts of Na^+ in the leaf (Figure 1) and this increase in three salinity level was significant (Table 2).

There were also significant differences among the salinity levels for leaf K^+. Salinity raised leaf K^+ significantly (Table 1). Salinity decreased the K^+/Na^+ ratio in the leaf and this decrease was significant (Table 1, Figure 4). Synthetic 30 showed the highest of K^+/Na^+ ratio which may contribute to its high resistance to salinity. The content of chlorophyll a and chlorophyll b decreased by salinity but showed an increase in S2 level which shows Chlorophyll resistance to high levels of salinity (Figure 5 and Figure 6); the differences were significant (Table 1). Reduction of Chl. b was more severe than that of Chl. a; this means that Chl. b is more sensitive to salinity as shown by SULTANA *et al.* (1999). The ratio of Chl. a/Chl. b didn't differ but the total amount of Chl. (a + b) was reduced by salinity (Figure 7). ROUT and SHAW (2001) mentioned that ROIs induced by salinity would cause a reduction in Chl. a and hence oxidative stress (9).

Total dry matter (TDM) production showed a significant reduction with increasing salinity (Ta-

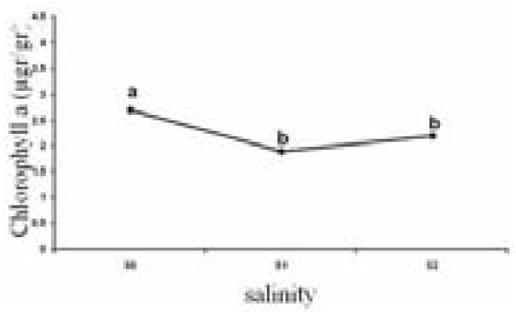

Fig. 5. Effects of salinity on chlorophyll a

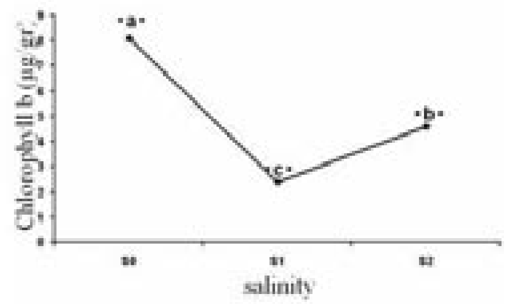

Fig. 6. Effects of salinity on chlorophyll b

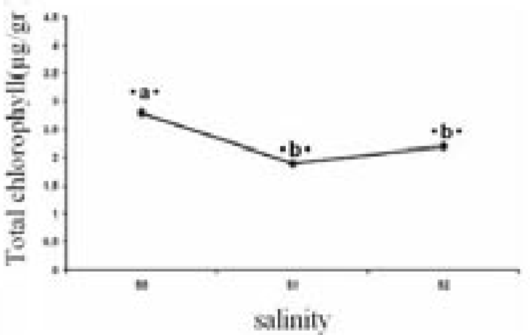

Fig. 7. Effects of salinity on total Chlorophyll

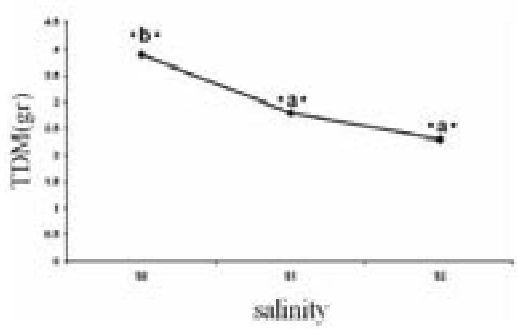

Fig. 8. Effect of salinity on total dry matter

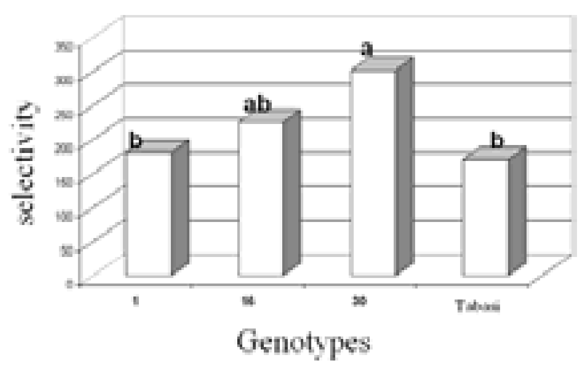

Fig. 9. Mean comparison of selectivity from soil to leaf among genotypes

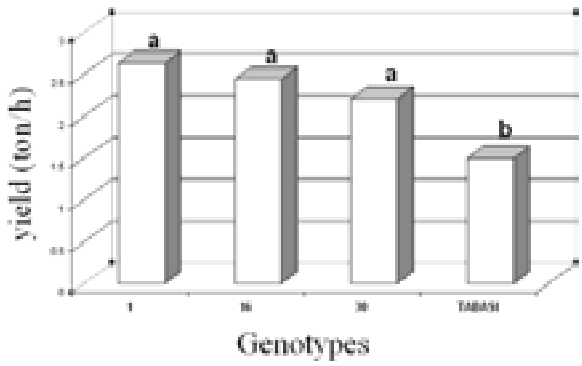

Figure 10. Effects of salinity level S2 on the production of genotypes

ble 1, Figure 8). Synthetic 16 had the highest TDM at S2 level.

Selectivity from soil to stem and leaf increased with salinity (Table 1) because of increased value of the ratio of K^+/Na^+ in the stem and leaf as soil salinity increased. Genotypes with high selectivity can tolerate salinity well. Synthetic wheat genotypes showed this property (Figure 9).

Yield as the most important and well known parameter for the wheat evaluation in stress condition in synthetic wheat genotypes was higher than native wheat (TABASI) (Figure 10).

Acknowledgments: I wish to thank Mr. Sayyed Saeed Moosavi, a PhD student in University of Tehran and Mr. Amin Naserchian for editorial assistance and other helpful suggestions. I also thank Mr. Ahmad Gharibzadeh for his valuable help to me.

References

Rout N.P., Shaw B.P. (2001): Salt tolerance in aquatic macrophytes: possible involvement of the antioxidative enzymes. Plant Science, **160**: 415–423.

Santa- Maria G.E., Epstein E. (2001): Potassium/sodium selectivity in wheat and the amphiploid cross wheat × *Lophopyrum elongatum*. Plant Science, **160**: 523–534.

Sultana N., Ikeda T., Itoh R. (1999): Effect of NaCl salinity on photosynthesis and dry matter accumulation in developing rice grains. Journal of Expeximental Botany, **42**: 211–220.