Effect of Salt Stress on the Productivity Indices of Wheat (*Triticum aestivum* L. and *Triticum durum* Desf.) Genotypes

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The effect of salt stress on productivity indices (weight of grain per 1m^2 area, 1000 grain weight, spike weight, weight and the number of spikelets in a spike) of local perspective bread (Giymatli-2/17, Nurlu-99, Azamatli-95) and durum (Garagilchig-2, Barakatli-95) wheat genotypes, regionalized in Azerbaijan has been studied. The research was carried out under field conditions. Salt stress was found to negatively affect productivity of varieties and structural elements of productivity. According to the tolerance indices (productivity under normal conditions, productivity under stress, mean productivity, geometric mean productivity, stress sensitivity index, stress tolerance index) Giymatli-2/17 is productive and medium tolerant, Nurlu-99 and Barakatli-95 are productive and tolerant, Azamatli-95 is medium productive and medium tolerant, and the Garagilchig-2 genotype is sensitive.

***Keywords**: Wheat genotypes, elements of productivity, stress tolerance index*

INTRODUCTION

Azerbaijan is one of the countries that suffer from severe salinity problems. Approximately 1.144 million ha of cultivated land is already salinized (Isgandarov, 2015). Wheat is the most important and widely adapted crop that contributes more calories and protein than any other crop. It is necessary to increase wheat production in Azerbaijan by raising wheat grain. The most efficient way to increase wheat yield is to improve salt tolerance of wheat genotypes, because increasing salt tolerance is much less expensive for farmers than using other techiques.

Salt tolerance of crops may vary depending on the growth stage (Maas and Grieve, 1994). In general, cereal plants are the most sensitive to salinity during the vegetative and early reproductive stages and less sensitive during flowering and grain filling stage (Maas and Poss, 1989). Yield formation of wheat is a complex process that depends on various stress factors during ontogenesis. Salinity caused a decrease in plant height, dry biomass, assimlation organs such as, leaf, stem, ear and parametres of productivity (ear lenght and mass, the number of ears, the grain number) (Francois, 1994). All of these limit plant productivity. The agronomic parametres of each genotype are the result of all physiological activities of plant during onthogenesis (Flowers, 2004). Therefore, analysis of productivity parametres is important for evaluating salt tolerance in wheat.

MATERIALS AND METHODS

In order to evaluate the salinity impact on the grain quantity of wheat, the field experiment was conducted. The seeds were obtained from the Research Instute of Crop Husbandry and harvested in the field, in two variants: control and stress. Soil salinity of stress variants was 0.9%, which is considered as a saline soil for glycophytes, including wheat. As a research material, local perspective *Triticum aestivum* L. (Giymatli 2/17, Nurlu 99, Azamatli 95) and *Triticum Durum* Desf. (Garagilchig 2, Barakatli 95) genotypes were taken. Measurements were carried out at grain maturity stage. Main spikes were separated from the others, the straw biomass and the weight of grain per1 m^2, the number of spikelets per spike, weight and lenght of spike, thousand kernel weight (TKW) were determined. Tolerance indicies were evaluted based on agronomic parametres:

Salt tolerance indices:

Stress Tolerance $TOL = y_p - y_s$ (Rosielle and Hamblin, 1981);

Mean Productivity $MP = (y_p + y_s) / 2$; (Rosielle and Hamblin, 1981);

Geometric Mean Productivity $GMP = (y_p * y_s)^{0.5}$; (Fernandez, 1992);

Stress Susceptibility Index $SSI = [1 - y_s / y_p] / [1 - \bar{y}_s / \bar{y}_p]$; (Fisher and Maurer, 1978);

Stress Tolerance Index

$STI = (y_p \cdot y_s) / (y_{\bar{p}})^2$ (Fernandez,1992)

Where, y_s and y_p are average yield of all genotypes under stress and optimal conditions, respectively. y_s and y_p are the mean yields of all genotypes evaluated under stress and non-stress conditions.

RESULTS AND DISCUSSION

The final harvest of total biomass can be divided in two components: the grain yield and the straw yield. The grain yield and straw yield are the principal criteria used by farmers to choose the salt tolerant accessions under salt stress. The major part of the straw production takes place during the early stage of growth cycle and it is related to the vegetative growth as the tiller number, the leaves number, the height of plants. In our study, the total biomass of straw ranged from 1526 to 1903 g/m^2 in Giymatli 2/17, 1572-1866 g/m^2 in Nurlu 99, 1464-1824 g/m^2 in Azamatli 95, 1300-1751 g/m^2 in Garagilchig 2 and 1838-2107 g/m^2 in Barakatli 95 (Table 1). The huge reduction in straw biomass was obsereved in salt sensitive Garagilchig 2 (25.7 %). The grain yield per 1 m^2 was reduced by an average 33% for the tolerant Barakatli 95 whereas it was reduced by 57% for the least tolerant genotype (Garagilchig 2).

On average, spike length, spike weight and TGW were reduced by 29%, 33%, 14% in Giymatli 2/17, 19%, 24%, 7% in Nurlu 99, 7%, 36.4%,6.3% in Azamatli 95, 8%, 21%, 6% in Barakatli 95 and 38%, 56%, 18% in Garagilchig 2. Obviously, a significant decrease occurred in Giymatli 2/17 and Garagilchig 2.

Improving the grain yield of wheat is the main target in plant breeding. Therefore, the evaluation of final grain yield and growth parametres is a critical aspect of breeding programs. The effect of salinity on tiller number and spikelet number during early growth stages has a greater influence on final grain yield (Maas et al., 1983). The negative effect of salinity on spikelet number and on tiller number indicates that they are sensitive at the vegetative stage. The number of spikes is highly correllated with the number of tillers. Whereas, the grain yield takes place mainly during the productive phase and it is essentially influneced by the spike number,the spike fertility during the grain-filling period. The reduction in plant productivity under salinity is caused by the osmotic effect, water deficiency and by toxic effects of ions such as Na and Cl leading to inability of plants to acquire water (Aldesuquy et al., 2012). The various yield components showed different responses to salinity. The TGW was the least sensitive to salinity, whereas spike weight was the most sensitive yield component, which is in agreement with observation in rice (Zeng and Shannon, 2000; Mahmood et al., 2009).

To evaluate response of plant genotypes to salt stress some indices based on a mathematical relation between stress and optimum condition such as, productivity under normal conditions (Y_p), productivity under stress (Y_s), mean productivity (MP), geometric mean productivity (GMP), stress sensitivity index (SSI), stress tolerance index (STI) have been used. Fernandez divided the reaction of genotypes, on the basis of their yields, into 4 categories under stressed and non-stressed conditions: group A are genotypes which have high yield under both of conditions; group B are genotypes which have a high yield under non-stressed conditions; group C including genotypes 2 which have a good yield under stressed conditions and finally group D are genotypes which have a low yield under both conditions (Fernandez, 1992). In our study, salt tolerance of plants was evaluated based on the indices given in Table.

Table 1. Agronomic parametres in wheat genotypes under non-stress and stress condition

Genotypes	Variants	Total biomass g/m^2	Grain weight g/m^2	TKW g	The lenght Of spike (sm)	The number of spikelet per spike	The weight of spike, g
Giymatli-2/17	I	1903±133	740±44	54.0±2.72	10.0±0.38	21.4±1.24	3.84±0.17
	II	1526±122	482±24	46.4±3.25	7.1±0.18	17.0±0.61	2.56±0.09
Nurlu-99	I	1866±93	684±47	48.0±1.63	10.0±0.32	17.0±1.02	2.64±0.13
	II	1572±94	430±21	44.6±1.56	8.1±0.28	15.0±0.43	2.00±0.07
Azamatli-95	I	1824±145	658±52	47.0±2.67	12.3±0.41	20.0±0.96	3.32±0.23
	II	1464±87	399±24	44.0±1.49	9.0±0.19	18.0±0.71	2.11±0.05
Garagilchig-2	I	1751±140	600±42	47.3±2.36	9.8±0.44	16.2±0.93	2.44±0.06
	II	1300±117	258±13	39.0±1.13	6.0±0.15	12.0±0.61	1.08±0.03
Barakatli-95	I	2107±168	654±39	51.0±2.12	8.7±0.41	20.0±0.58	3.02±0.19
	II	1838±128	435±22	48.0±1.29	8.0±0.21	19.0±1.33	2.38±0.13

I – control; II-stress

Table 2. Estimation of sensitivity rate of wheat genotypes under normal and stressed conditions.

Genotypes	Y_p	Y_s	*MP*	*GMP*	*Tol*	*SSI*	*STI*
Giymatli-2/17	740±44	482±34	611±37	597±30	258±15	0.88±0.03	0.80±0.04
Nurlu-99	684±34	430±22	557±39	542±33	254±17	0.95±0.04	0.66±0.03
Azamatli-95	658±32	399±24	528±42	512±31	259±13	0.98±0.05	0.59±0.03
Garagilchig-2	600±36	258±15	429±21	393±24	342±17	1.42±0.06	0.35±0.01
Barakatli-95	654±45	435±26	544±33	533±32	219±13	0.82±0.04	0.64±0.03

Mean comparison showed that Giymatli-2/17 with 740 g/m^2 under non-stress condition(Yp) and with 482 g/m^2 under stress condition (Ys) had the highest grain yield. Also Barakatli 95 and Nurlu 99 had the high grain yields under stress condition, whereas Qaragilchig 2 had the lowest grain yield under stress condition. According to TOL and SSI indices Garagilchig 2 is relatively sensitive to stress. According to studies, the genotypes with SSI more than 1 are considered the most sensitive to salinity (Clarke,1992; Golabadi et al.,2006; Mardeh et al., 2006). Moreover, the STI indice was lower in Garagilchig 2 (0.35).

Based on tolerance indicies, the accessions were divided in three groups: the lowest, the highest and the moderate salinity. Giymatli 2/17 was productive and medium tolerant, Nurlu 99 and Barakatli 95 were productive and tolerant, Azamatli 95 was medium productive and medium tolerant, and the Garagilchig 2 genotype was sensitive.

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Duz Stresinin Buğda Genotiplərinin (*Triticum aestivum* L. və *Triticum Durum* Desf.) Məhsuldarlıq Göstəricilərinə Təsiri

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Duz stresinin Azərbaycanda rayonlaşdırılmış perspektivli yerli yumşaq - *Triticum aestivum* L. (Qiymətli-2/17, Nurlu-99, Əzəmətli) və bərk-*Triticum durum* Desf.(Qaraqılçıq-2, Bərəkətli-95) buğda genotiplərinin məhsuldarlıq göstəricilərinə (1 m^2-də dənin kütləsi, 1000 dənin kütləsi, sünbülün kütləsi, 1 sünbüldə olan sünbülcüklərin sayı və kütləsi) təsiri öyrənilmişdir. Tədqiqatlar tarla şəraitində aparılmışdır. Müəyyən edilmişdir ki, duz stresi sortların məhsuldarlığına və məhsulun struktur elementlərinə mənfi təsir göstərir. Davamlılıq indeksləri (normal şəraitdə məhsuldarlıq, stres şəraitində məhsuldarlıq ,orta məhsuldarlıq, orta həndəsi məhsuldarlıq, stresə həssaslıq indeksi, stresə tolerantlıq indeksi) əsasında Qiymətli-2/17 genotipinin məhsuldar, orta davamlı, Nurlu-99 və Bərəkətli-95 genotiplərinin məhsuldar, davamlı, Əzəmətli-95 genotipinin orta məhsuldar, orta davamlı, Qaraqılçıq-2 genotipinin isə həssas olduğu müəyyən olunmuşdur.

Açar sözlər: *Buğda genotipləri, məhsuldarlıq elementləri, stresə tolerantlıq göstəriciləri*

Влияние Солевого Стресса на Показатели Продуктивности Генотипов Пшеницы (*Triticum aestivum* L. и *Triticum Durum* Desf.)

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Изучено влияние солевого стресса на показателы продуктивности (масса зерна, масса 1000 зерен, масса колоса, количество колосков в колосе, количество и масса зерен в колосе) мягкой (*Triticum aestivum* L.) и твердой (*Triticum durum* Desf.) пшеницы, районированной в Азербайджане. Исследования проводились в полевых условиях. Обнаружено, что солевой стресс влияет на продуктивность сортов и на структурные элементы продукта. На основание индексов толерантности (продуктивность в нормальных условиях, продуктивность в условиях стресса, средняя геометрическая продуктивность, индекс чувствительности к стрессу, индекс толерантности к стрессу) установлено, что генотип Гийметли 2/17 является продуктивным, средне-толерантным, Нурлу 99 и Баракатли 95 являются продуктивными и толерантными, Азаматли 95 - средне-продуктивным и средне-толерантным, а Гарагылчыг 2 - чувствительным генотипом.

Ключевые слова: *Генотипы пшеницы, элементы продуктивности, показатели толерантности к стрессу*