Effect of various concentrations of NaCl on physiological characteristics of first-generation hybrids of wheat genotypes

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The effect of various NaCl concentrations on germination ability and physiological indices of F_1 hybrids of wheat genotypes, which differ in productivity, drought tolerance and heights, has been studied. Wheat seeds were germinated in laboratoratory conditions at 0 mM, 50 mM, 100 mM and 150 mM concentrations of NaCl. With increasing salt concentration decrease in seed germination, in chlorophyll content, decrease in relative humidity of the leaves and the activity of photosystem 2 were observed in all samples. Salt effects were found to be different in various hybrids.

Keywords: *NaCl, wheat varieties, germination energy, germination percentage, chlorophyll*

Soil salinization is one of the significant environmental factors that limit the growth, development and productivity of plants. Currently, about 20% of all irrigated areas of the world are saline [1,2]. Salinity of soils constantly increases due to the rising groundwater level and improper irrigation in agriculture. Salinization of soil leads to water deficiency in the plant. Influencing the stomatal conductance of plants, water deficiency can affect the CO_2 fixation rate and, consequently, the intensity of photosynthesis. The decrease in the content of photosynthetic pigments- chlorophyll a and b, carotenoids, and in the activity of photosystems located in thylakoid membranes are assumed to relate to weakened assimilation of carbon dioxide. Under salt stress the chlorophyll b content was found to decrease more than chlorophyll b content, regardless of the plant genotype[3-7]. Salt stress, depending on the degree of plant tolerance, leads to a significant change in the activity of antioxidant systems of the cell.Salts have a double effect on the plant. First, they create a high osmotic pressure in the soil solution, providing a strong bond with water. This complicates water absorption by roots, causing osmotic stress. Second, ions of salt absorbed with water exert a negative impact on the plant metabolic processes [8]. Disturbance of growth and development of plants under salt stress is a consequence of some physiological responses of plants, including changes in the ion balance, mineral nutrition, stomatal conductance, photosynthesis rate and, ultimately, fixation and utilization of carbon dioxide [9].

Salinity is the major factor affecting plant metabolism, thereby causing changes in morphological, anatomical structure, physiological and biochemical conditions of plants. The first morphological response of plants to salt stress is the limitation in the development of roots and leaves. If salinity continues the plant development stops completely and eventually the plant perishes.

The study of salt effects on plant growth and development, evaluation of plant adaptation mechanisms to salt stress are very important issues for the effective use of saline soils. Adverse environmental conditions cause structural and functional changes affecting, first of all, vital activity of the organism [10]. An active reconstruction of intracellular connections occurs under adverse ambient conditions. Moreover, negative conditions lead to pivotal changes in physiological and biochemical processes proceeding in plants. Therefore, the comprehensive study of these processes is necessary for the evaluation of plant stress tolerance.

Considering the above-mentioned issues, the main purpose of the presented work was the comparative study of salt tolerance of bread wheat genotypes with contrasting productivity, drought tolerance and height based on their morphophysiological indices and establishing changes in leaf water regime, amounts of photosynthetic pigments and PSII activity.

Materials and Methods

For studies, the parental forms of Barakatli-95, Gobustan, Garabakh and their hybrids Gobustan x Barakatli-95 and Garabakh x Gobustan were taken. For the assessment of the morphometric and physiological parameters of drought tolerance, seeds of bread wheat varieties were germinated at various NaCl concentrations (0mM, 50 mM, 150mM,) using the roll method [11,12]. Seeds of each sample were maintained on the wet filter paper for 3 days in darkness and then in a 12h-light/ 12h-dark photoperiod for 11 days at 20-22^{0}C. Germination ability of the wheat embryo was examined during 7 days [10]. Based on some morphophysiological indices such as average root length, RWC, concentration of photosynthetic pigments and chlorophyll fluorescence indices, salt tolerance of the studied varieties were assessed on the 10th day of the germination stage. RWC in leaves was determined according to the method of Tambussi et al. [13]. Chlorophyll was extracted from leaves using 96 % ethyl alcohol and quantification of chlorophyll a, chlorophyll b and carotenoids was conducted at 665 nm, 649 nm and 440nm, respectively, using the spectrophotometric method of Wintermans et al. [14]. Leaf fluorescence indices were measured using the MINI-PAM (photosynthesis yield analyzer, Germany) device.

The energy conversion efficiency of PSII was calculated using the formulas $F_v = F_m - F_0$ and F_v / F_m [15].

RESULTS AND DISCUSSION

In spite of the negative impact of salt, a development relative to control variants was observed for bread and durum wheat genotypes with contrasting productivity, drought tolerance and height during 10 days. Various physiological methods are known for the determination of plant stress tolerance, which based on germination ability [10]. For the initial assessment of salt tolerance of bread wheat genotypes, germination ability of control and salt-treated variants was compared (Table). With the increasing in salt concentration, seed germination decreased in the varieties Barakatli, Gobustan and Garabakh 40%, 30% and 40%, respectively. In hybrids of Gobustan X Barakatli and Garabakh X Gobustan seed germination decreased 30% and 25%. Maximum germination showed the varieties Karabakh x Gobustan. Seeds are known to experience high osmotic pressure of the environment during germination and certain physiological properties of plants are determined by absorption ability of seeds. The content of leaf photosynthetic pigments was found to play a significant role in the function of photosynthetic apparatus and its productivity. A complex relation exists between photosynthetic productivity and amounts of the chlorophyll pigments. Salt stress disturbs chlorophyll structure and chloroplast membranes, leading to the violation of the structure and the decline in photochemical activity and light intake ability. Chlorophyll loses a part of its energy through the heat and fluorescence. But the energy waste increases due to the structural changes. Therefore, chlorophyll index is considered as the main parameter in experiments related to salinity [10]. Chloroplasts of the sensitive plants are destructed more under salt stress and therefore, the study of salt effects on photosynthetic apparatus is of great importance for the assessment of plant tolerance to stress factors and its relation to physiological parameters.

The changes in the content of pigments provide an important information about physiological status and adaptation of plants to changing environmental conditions [16]. The aim of our study was to evaluate the degree of stress effect based on the change in the pigment content of wheat leaves. According to the results of the experiments performed with leaves of 10-day-old seedlings of bread wheat varieties, the general amount of chlorophyll decreased with increasing salt concentration in the all varieties compared with the control. However, the highest chlorophyll content was observed in the variety ♀Gobustan X ♂Barkatly-95 (Table). With the increasing salt concentration, the content of chl a+b decreased in the varieties Barakatli, Gobustan and Garabakh 60%, 18% and 17%, respectively. In hybrids of Gobustan X Barakatli and Garabakh X Gobustan the content of chl a+b decreased 6% and 5%, respectively.

Table. The influence of various NaCl concentrations on the mophophysiological signs of parental and hybrids forms of wheat

Varieties	NaCl Mmol	Germination energy, %	Germination, %	Chl a+b, mg/g	Chla/b	Karotenoids,mg/g	RWC, %	F_V / M
Barakatli-95	0	70	90	11,4	3,2	5,8	85	0,8
	50	60	70	12,3	3,1	5,6	82	0,77
	100	30	60	7,4	2,8	5,8	79	0,75
	150	30	50	4,6	2,4	6,2	67	0,69
Garabakh	0	90	100	9,3	3,8	5,1	78	0,75
	50	70	90	9,7	3,7	5,8	74	0,74
	100	60	70	8,3	3,6	5,8	72	0,72
	150	70	60	7,7	3,4	5,3	71	0,7
Gobustan	0	100	100	11,4	3,3	5,3	75	0,73
	50	90	80	14,8	3,1	5,2	74	0,72
	100	60	70	12,7	3,2	6,4	72	0,71
	150	50	70	12,3	3,1	6,3	71	0,7
♀ Gobustan x♂Barakatli-95	0	60	100	18,5	4,5	5,3	77	0,71
	50	50	80	13,5	3,9	5,8	76	0,75
	100	50	75	18,7	3,4	6,4	75	0,74
	150	50	70	10,4	3,5	7,7	74	0,72
♀ Garabakh x♂Gobustan	0	70	100	15,7	2,6	4,9	75	0,76
	50	50	90	7,7	3,7	4,5	75	0,75
	100	40	85	8,9	3,6	4,6	74	0,74
	150	50	75	11,4	3,1	5,5	73	0,73

* Each value represents the mean ± SD (standard deviation) for the mean n = 3 independent experiments p = 0.05.

The effect of various salt concentrations on RWC of 10-day-old seedlings of bread wheat genotypes was studied (Table). With the increase in salt concentration, the content of RWC decreased in the varieties Barakatli, Gobustan and Garabakh 17%, 18% and 7%, respectively. In hybrids of Gobustan X Barakatli and Garabakh X Gobustan the content of RWC decreased 6% and 2%, respectively. In varieties Barakatli, Gobustan and Garabakh the content of carotenoids increased 7%, 4% and 4% respectively. In hybrids of Gobustan X Barakatli and Garabakh X Gobustan the content of carotenoids increased 45% and 12% respectively. Thus, wheat hybrids Gobustan X Barakatli and Garabakh X Gobustan were more tolerant to high salt concentrations than parent plants. An increase in the concentration of carotenoids at a high salt concentration may be associated with their protective role in the plant.

According to some authors, plants experience stress effects mainly due to the weakening function of the root system. Our results suggest that the manifestation of stress effects begins with the changes in seeds. The study of morphological and physiological effects of salinity would contribute to overcoming multiple issues related to negative effects of salt stress.

So salt stress was found to exert a negative impact on germination ability, leaf RWC, photosynthetic pigment amounts and PSII activity. The obtained results confirm that plant tolerance to stress conditions is a result of various adaptive responses.

Conclusion. Among the studied wheat, the hybrids♀ Gobustan X♂ Barakatly-95 and ♀Garabakh X ♂Gobustan were tolerant at a NaCl concentration of 150 mM.

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