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EVALUATION OF MORPHOMETRIC TRAITS OF UPLAND COTTON GENOTYPES UNDER DIFFERENT CONCENTRATION OF NaCl

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Abstract. In this study, the effect of 2 different concentrations of NaCl on the morphometric parameters of 31 cotton genotypes belonging to *G. hirsutum* L (AADD; 2*n*=4x=52) species was evaluated. As a result of the comparative analysis, a wide variation of biometric parameters was observed. Out of the 31 samples studied at 100 mM salt concentration, total fresh height in 2 varieties, total fresh weight in 17 varieties, total dry height in 2 varieties and total dry weight in 19 increased compared to the control value, while in other varieties, the decrease of these indicators was determined. At 200 mM concentration of salt, all the studied parameters decreased compared to the control for all genotypes. As a result of the comprehensive assessment, Navai-9, Tashkent-2, Tashkent-3, Kırgızıstan-174, Prime and May-344 varieties of morphometric indicators at high salt concentration were evaluated as resistant genotypes, having the least change compared to the control.

Keywords: *Cotton, salinity, morphometric traits, tolerant.*

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Abbreviations:

TFH - total fresh height
TFW - total fresh weight
TDH - total dry height
TDW - total dry weight

1. Introduction

Salt stress is one of the most widespread abiotic factor globally limiting crop production and consequently reducing field crop productivity (Shrivastava & Kumar, 2015). Currently, 800 million hectares of land (6% of the global land area) are severely affected by salinity (Ismail *et al*., 2007; Alizade, 2022). Posing threat global food security, salt stress is estimated to affect ~30% of cultivated land over the next 25 years (Manikandan *et al*., 2019).

Cotton is a main agricultural crop that supplies the majority of the world's textile manufacturing sectors. Tetraploid cotton varieties of the species *G.hirsutum* L. are characterized by high yield, good fiber quality and other advantages (Mammadova *et al*., 2021). Global cotton fiber production generates significant economic income every year.

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The cotton growing industry is an integral part of the total national income of the Republic of Azerbaijan (Akparov *et al*., 2021)

Cotton, with a salinity threshold of 7.7 dS/m, is considered as a moderately salt-tolerant crop. However, the key restrictions that are impacted by soil salinity and alkalinity that limit cotton growth in the early phases of development include low yield, poor plant growth and germination (Sharif *et al*., 2019). Salt stress reduces biomass production by reducing leaf area, root and shoot weight, stem thickness and seed cotton yield (Munawar *et al*., 2021). It has been suggested that extensive measures should be taken during the early stages of growth to ensure sustained growth for the final fruitful harvest. Moreover, the level of tolerance varies among different cotton genotypes (Alizade, 2022). In this regard, the main goal of the study is to assess the resistance of different cotton genotypes and identify salt-tolerant genotypes.

2. Material and methods

Plant material

The objective of this study was to investigate the response of plant biometric indicators of cotton plants under different concentration of salt (NaCl) stress. The research was carried out at the Institute of Genetic Resources of the Ministry of Science and Education of Azerbaijan. 31 genotypes of cotton (*G. hirsutum* L.) belonging to different geographical groups were used as the research material (Table 1).

Table 1. List of genotypes used as research material

Genotype	Country	Genotype	Country	Genotype	Country
Ganja-160	Azerbaijan	Karabakh-11	Azerbaijan	Kırqızıstan-174	Kyrgyzstan
Ganja-114	Azerbaijan	Karabakh-12	Azerbaijan	Tashkent-1	Uzbekistan
Ganja-110	Azerbaijan	Flash	Turkey	Tashkent-2	Uzbekistan
Ganja-182	Azerbaijan	Lima	Turkey	Tashkent-3	Uzbekistan
Ganja-200	Azerbaijan	Carisma	Turkey	Navai-9	Uzbekistan
Ganja-195	Azerbaijan	Sezener-76	Turkey	Assos	Greece
Zafar	Azerbaijan	Beyaz altun 440	Turkey	Edessa	Greece
Bayraqdar	Azerbaijan	Select	Turkey	Prime	Greece
AP-317	Azerbaijan	CSN-12	Turkey	Cristina	Greece
Aghdash-3	Azerbaijan	PG	Turkey		
Barakat	Azerbaijan	May-344	Turkey		

Experimental design and stress treatment

Seeds of 12 local and 19 introduced Upland cotton (*G. hirsutum*. L.) genotypes were used as the research material. Seeds were soaked in distilled H_2O and then planted in pots filled with a perlite. Seedlings were grown in pots in a growth chamber under controlled conditions (temperature of 25 ºC, 16/8-h photoperiod and relative humidity of 75%) and were irrigated with half strength Hoagland solution (Hoagland & Arnon, 1950) until first real leaf stage. The seedlings were subjected to salt stress at the first real leaf stage by adding NaCl (100 mM and 200 mM) to the solution. Plants were harvested 5 weeks after salt application and were up-rooted carefully and washed properly. To dry the genotypes, the samples were placed in Kraft paper bags and placed in a oven at 80 ºC for 48 hours. Plant fresh height, fresh weight, dry height and dry weight were measured and compared with control. The dynamics of change of different germination parameters and

chlorophyll index of studied genotypes under salt stress were discussed in our previous studies (Alizade & Mammadova, 2023a; Alizade, 2023b).

Statistical analysis

Obtained data were statistically analyzed using Microsoft Excel, SPSS 26.0 (IBM Corporation, USA) software and Past 4.13. Each data point was the mean of three replications. The online tool iTOL (https://itol.embl.de/) was used to construct the dendrograms.

3. Results and discussion

The change of the morphometric indicators of the studied cultivars at both salt concentrations compared to the control is mentioned in Table 2. Although a wide variety of studied parameters was observed between genotypes at low salt concentration, a decrease of all indicators was determined at high salt concentration.

Table 2. Reduction of biometric parameters under stress of 100 mM and 200mM concentration of NaCl salt compared to control (%)

	Morphometric traits under 100 mM concentration of NaCl				**Morphometric traits under 200 mM concentration of NaCl**			
	TFH	TFW	TDH	TDW	TFH	TFW	TDH	TDW
Agdash-3	16,2	-9,93	16	-39	19,7	42,2	18,6	41,6
AP-317	12,1	-34,2	17	-45	29,9	18,3	23,8	17,4
Assos	11,1	10,4	9,1	3,79	22,6	17,8	17,7	22,7
Bayraqdar	17,4	4,86	16	3,51	34,1	24,3	33,6	27,7
Barakat	19,7	-13,1	19	-38	30,5	7,99	31	34,1
Beyaz altun 440	16,3	-9,57	15	-31	30,6	20,2	27,9	2,64
Carisma	13,4	14,4	12	14,9	40,5	44,1	42,7	35,2
Cristina	16,3	24,9	13	25	21,6	26,8	19	29
CSN-12	-4,1	2,49	0,8	2,16	32,6	32,3	39,7	17,5
Tashkent-1	14,5	15	19	-7,2	21,1	24,2	20,1	40,2
Tashkent-2	8,02	-23,7	3,5	-41	29	8,16	25,3	2,61
Tashkent-3	13,4	-57,7	6,7	-40	20,8	6,38	11,8	8,32
Edessa	19,3	-32,3	18	-19	41,3	24,8	40	24,1
Flash	7,33	-56,6	0,9	-6,6	31,9	4,34	29,8	58,5
Ganja-110	16,9	-45,6	4,2	-1	28,2	29,1	20,7	10,6
Ganja-114	5,6	-19,9	5,9	-1,6	29,5	26,4	31,1	5,51
Ganja-160	14,3	-8,44	14	-49	36,2	14,4	37,7	7,18
Ganja-182	14,6	5,5	11	12,7	36,2	42,4	36,9	20,3
Ganja-195	25,1	-32,4	26	-49	39,1	5,09	41,1	6,05
Ganja-200	28,1	6,96	35	3,01	39	29,4	40,8	30,7
Kırqızıstan-174	5,49	-23,8	5,9	-59	22,7	14,5	23,9	5,38
Lima	17,5	-17	22	-42	39,3	24,1	41	3,82
May-344	11,1	13,6	5,7	21,7	20,4	8,78	21,1	8,95
Navai-9	4,25	8,3	9,1	35,9	2,36	9,32	2,83	8,63
PG	13,9	-18,5	12	-14	39,6	39,7	42,5	27,1
Prime	15,3	3,6	11	-23	23,5	7	21,2	14,4
Karabakh-11	-4,1	-60,5	-11	-61	32,1	51	35,9	50,7
Karabakh-12	18,2	6,42	31	3,84	38,7	18,4	43	11,6
Select	14,2	4,14	21	11,1	21,1	17,9	18,6	45,5
Sezener-76	6,13	-29,3	-5,6	-53	36,4	23,4	26,6	7,23
Zafar	18,6	13	21	5,71	37,2	36,7	38,5	45,5

Under the stress of 100 mM concentration of NaCl, the total fresh height decreased in all studied genotypes, except Karabakh-11 and the introduced CSN-12 variety. Also under conditions of 100 mM concentration of stress, total fresh mass decreased in 14 genotypes, except for 8 local and 9 introduced varieties. It was determined that the total dry height was increased in 2 genotypes and the total dry mass was increased in 19 genotypes compared to the control.

At high salt concentration, the lowest value of TFH was recorded in Navai-9 and the highest value in Edessa varieties. The lowest and the highest value of TFW were recorded in Flash and Karabakh-11 genotypes, respectively. As a result of the analysis of the studied indicators of genotypes after drying, the highest value of TDH indicator was observed in Karabakh-12 and the lowest value in Navai-9 genotypes. According to the TDW indicator, Tashkent-2 and Beyaz altun 440 varieties showed high tolerance and Flash variety showed high sensitivity.

Based on the total value of morphometric indicators, cluster analysis was performed to identify resistant and sensitive genotypes under 2 different stress conditions and genotypes with complex positive signs were selected. During the study, an increase in total fresh weight and total dry weight was observed in all samples included in cluster I, selected as a sustainable group under stress conditions of 100 mM concentration of NaCl salt (Figure 1). In all the varieties included in the second cluster, a decrease in morphometric indicators was observed at different rates and they were evaluated as a sensitive group.

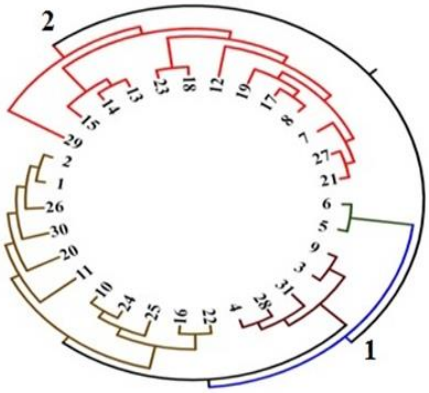

Figure 1. Cluster analysis of cotton cultivars according to morphometric indicators under stress conditions of 100 mM concentration of NaCl

1-Aghdash-3; 2-Barakat; 3-Ganja-110; 4-Ganja-114; 5-Kharabakh-11; 6- Tashkent-3; 7- Assos; 8- Select; 9- Flash; 10- Sezener-76; 11- Prime; 12- Tashkent-1; 13- May-344; 14- Cristina; 15- Navai-9; 16- AP-317; 17-Bayraqdar; 18- Kharabakh-12; 19-Zafar; 20-Ganja-160; 21-Ganja-182; 22-Ganja-195; 23-Ganja-200; 24- Kırqızıstan-174; 25- Tashkent-2; 26- Lima; 27- Carisma; 28- PG; 29- CSN-12; 30- Beyaz altun 440; 31-Edessa;

Varieties studied at high concentration of NaCl were grouped into 4 large groups. Navai-9 that included in the first group, was evaluated as highly resistant and had the least variability of morphometric parameters. Genotypes included in the second cluster were evaluated as a resistant group, showing tolerance according to specific biometric parameters. The genotypes collected in cluster III were moderately resistant to salt stress by taking an intermediate position on the change of morphometric indicators, while the cultivars collected in cluster IV were evaluated as sensitive genotypes at high concentration of salt and had a higher decrease in total morphometric indicators.

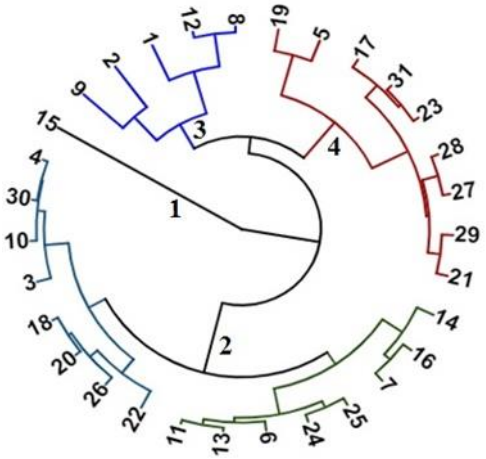

Figure 2. Cluster analysis of cotton cultivars according to morphometric indicators under stress conditions of 100 mM concentration of NaCl

1-Aghdash-3; 2-Barakat; 3-Ganja-110; 4-Ganja-114; 5-Kharabakh-11; 6- Tashkent-3; 7- Assos; 8- Select; 9- Flash; 10- Sezener-76; 11- Prime; 12- Tashkent-1; 13- May-344; 14- Cristina; 15- Navai-9; 16- AP-317; 17-Bayraqdar; 18- Kharabakh-12; 19-Zafar; 20-Ganja-160; 21-Ganja-182; 22-Ganja-195; 23-Ganja-200; 24- Kırqızıstan-174; 25- Tashkent-2; 26- Lima; 27- Carisma; 28- PG; 29- CSN-12; 30- Beya zaltun 440; 31-Edessa;

In our study, biplot analysis was performed, and it was found that the genotypes grouped according to the values of the studied components were gathered in different groups at different salt concentrations. As can be seen from the plot, Navai-9, May-344, Assos, Carisma, Cristina, Ganja-182, Select, Zafar, Prime, Bairagdar, Taskent-1 genotypes are grouped in one group according to the TDW and TFW components at low concentration of salt. Genotypes Kharabakh-12, Beyaz altun 440, Aghdash-3, Edessa, Barakat, Lima, Ganja-200, Ganja-195 were grouped in another group and located at a distance from other samples according to TFH and TDH parameters (Figure 3).

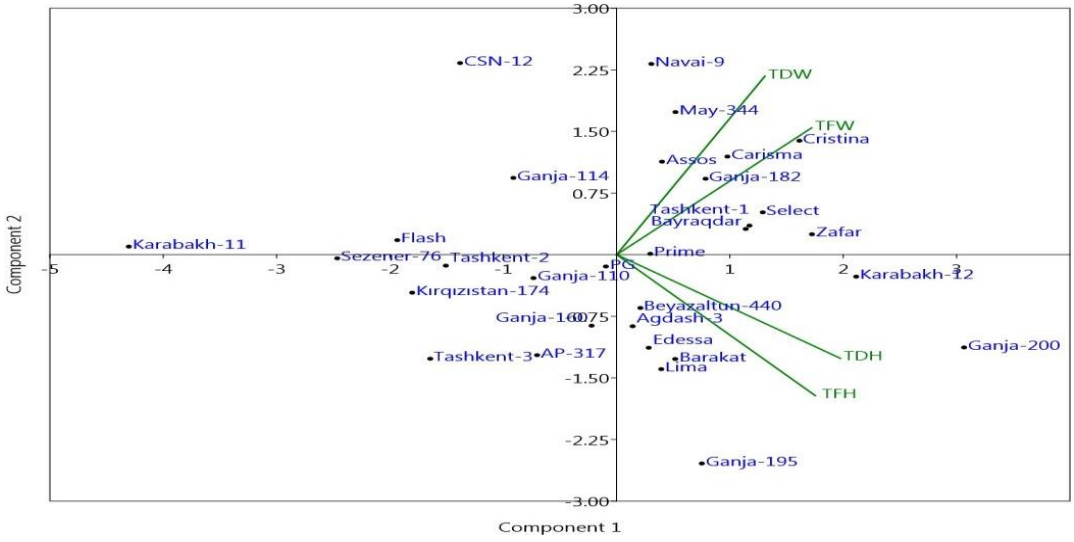

Figure 3. Biplot analysis of genotypes under 100 mM NaCl concentration

At high concentration of salt, Kharabakh-11, Zafar, Flash, Carisma, Ganja-182, Ganja-200, PG, Bayraqdar genotypes grouped according to TDW and TFW components, and CSN-12, Edessa, Ganja-114, Sezener-76, Ganja-160, Ganja-195, Kharabakh-12 and Lima genotypes were collected in one group according to TFH and TDH components and located at a distance from other samples (Figure 4).

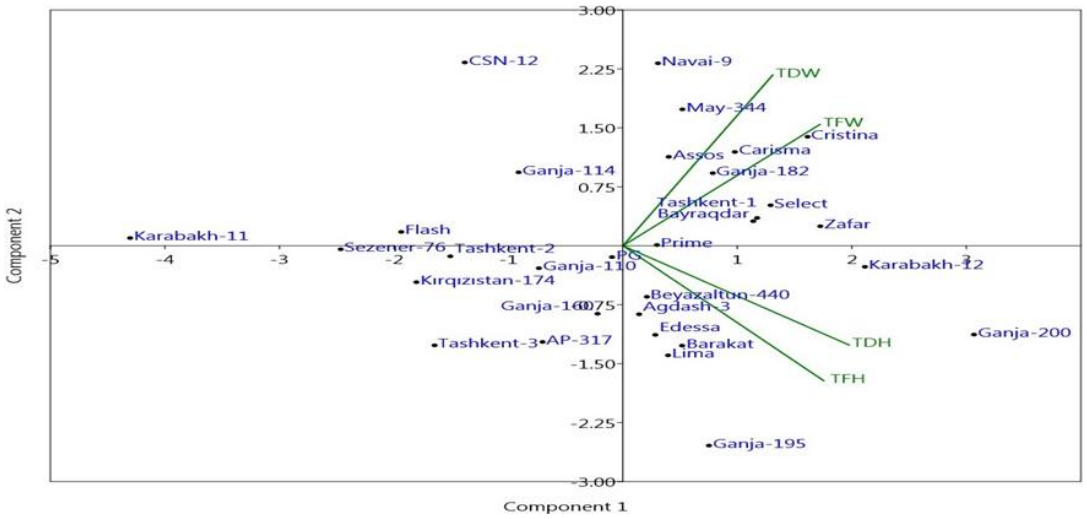

Figure 4. Biplot analysis of genotypes under 200 mM NaCl concentration

The results obtained in our study on the change of morphometric indicators were partially similar to the results of research conducted on cotton by Zafar et al. (Zafar *et al*., 2022) and by Yuan et al. (Yuan *et al*., 2019).

4. Conclusion

In the conducted research, a wide variation in the change of biometric parameters of genotypes under salt stress conditions was observed. At 100 mM concentration of salt, morphometric parameters both decreased and increased in some genotypes. With the increase of salt concentration, only a decrease of these parameters was observed for all studied samples. Biplot analysis showed that genotypes have different degrees of depression according to the studied parameters. As a result of the research, the Navai-9 variety from Uzbekistan was selected as a highly salt-resistant variety, having the lowest change of morphometric indicators among the samples. At the same time, varieties May-344 of Turkish origin, Prime of Greek origin, Kırqızıstan-174 of Kyrgyzstan origin, Tashkent-2, Tashkent-3 of Uzbekistan origin, with relatively low change of morphometric parameters were selected as resistant genotypes.

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