Creation of high-yielding salt-tolerant wheat varieties on saline soils in the territory of the Republic of Azerbaijan

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ABSTRACT:
In the selection work carried out to obtain salt-tolerant wheat varieties, (F4) and (F5) generation hybrid forms were planted and cultivated in different years under different ecological conditions. These hybrids were mainly planted in normal soil areas of the Garabagh Scientific Research Base of the Tartar region, as well as in saline soil areas of the Ujar region of the Soil Science Institute in 2022 and 2023. In the saline soils of Ujar region, sulfates were mainly (Na_2SO_4) 1.5%. After the grain ripening stage of vegetation was completed, the yield indicators of hybrid forms cultivated under normal conditions and in saline soils were comparatively studied according to the main structural elements of the spike, the weight of the spike, the grain and the number of grains. The yield indicators were calculated according to the tolerance index and the hybrids with less yield loss were evaluated as relatively salt-resistant. Thus, Gobustan x Sheki-1, Dagdash x Murov, Vugar x Barakatli -95, Qirmizi Gul-1 x Tale-38, Mirbashir-50 x Shiraslan-23. Barakatli-95 x Gobustan, Karabakh x Mirbashir-128, Karabakh-x Sharq showed more resistance than other hybrid forms in terms of yield indicators.

İNTRODUCTİON

One of the most important problems in the world is food shortage, and more than one billion of the world's population suffer from "chronic" hunger. Wheat (T.aestivum L., T.durum Desf.) is one of the most important and cultivated food crops on Earth, forming the basis of the population's diet. Wheat, being one of the 3 main widely cultivated cereals (rice, maize, wheat), is the main food source for about 2 billion people, more than 36% of the world's population. In 2050, the world's population is expected to exceed 9 billion, and the demand for wheat is expected to exceed 900 million tons. Meeting the increasing demand for wheat is extremely difficult against the background of increasing abiotic and biotic stress factors (temperature increase, drought or water shortage, soil salinization, etc.) as a result of global climate change. As a result of climate change on a global scale, the ecological situation on Earth has worsened, and biodiversity has been disrupted due to the gradual decrease in high-quality and productive land areas. As a result, threats have arisen for the ecosystem, and irreversible changes occurring on our planet have led to global warming, salinization and desertification of areas, as well as serious obstacles to the development of cultivated plants in our country. In particular, the salinization of soils over time is creating more serious threats. The limitation of suitable and productive land areas for agriculture poses a serious threat to meeting people's food needs [Khan et al., 2010]. Therefore, in order to solve these problems, extensive research is being conducted in the areas of efficient use of genetic biodiversity existing in the world, the search for new genetic sources, the involvement of wild ancestors, which are carriers of many positive traits, in the process of creating new varieties, etc., interspecific and intergeneric hybridizations are used. Academicians J.Aliyev and Z.Akperov have shown that many of the valuable folk selection samples created in Azerbaijan over a long historical period have been displaced by modern selection varieties (in some cases, genetically modified plants) and have been lost or are in danger of being lost. In order to eliminate this threat, targeted research work should be continued [Aliyev, Akperov, 2002]. The creation of new varieties that are productive and resistant to stress by using sustainable plant genotypes as initial material is one of the most important problems facing modern science. Therefore, the study of physiological and biochemical processes in plant metabolism is of great scientific and practical importance [Mecliche , Hanifi, 2015]. Currently, in our country, under the leadership of Academician J.A. Aliyev, high-level research is being conducted on salt tolerance on local and imported wheat varieties and varieties [Guseynova, Suleymanov, 2008]. Thus, based on the research work conducted in the world and in our country on salt tolerance, it can be concluded that it will indeed be possible to obtain salt-tolerant wheat varieties adapted to salinity in the future.

MATERİAL AND METODS

(F4) and (F5) generation hybrids were planted and cultivated on certain days corresponding to the sowing of October 2022-2023 in both the normal (October 22) of the Garabagh Scientific Research Base of the Tartar region and the saline soil areas of the Ujar region experimental support stations of the Institute of Soil Science (October 25). The object of the study was wheat cultivated in both normal (Tartar) and saline (Na_2SO_4 1.5%, Ujar) soil conditions (F4. 2022) and (F5. 2023) generations: 1-Lyagatli-80 x Mirbashir -128, 2-Gazyl wheat X Guneshli, 3-Tartar x Karabakh, 4-Taleh-38 x Red Rose-1, 5- Gobustan x Sheki-1, 6-Murov x Dagdash, 7-Bezostaya -1 x Red Rose-1, 8-Dagdash x Murov, 9-Nurlu -99 xLyagatli-80, 10-Garabagh x Karakilchig-2, 11-Sheki-1 x Gobustan, 12-Vugar x Barakatli-95, 13-Red Rose-1 x Tale-38, 14-Berakatli -95 x Vugar, 15-Qarabagh x Tartar, 16-Aran x Qirmizi Gul-1, 17-Mirbashir-50 x Shiraslan-23, 18-Qarabagh x Gobustan, 19-Berakatli-95 x Gobustan, 20- Gobustan x Qirmizi Gul-1, 21-Gobustan x Berakatli-95, 22-Gobustan x Qarabagh, 23-Qarabagh x Mirbashir-128, 24-Qarabagh x Sharq are hybrids.
The sowing area of each line was 1-8 m2 depending on the seed material. The experimental area was plowed under the experimental field before sowing with 100 kg of physical weight of organic fertilizer per hectare, and in the early spring during the bushing phase, 90 kg of ammonium nitrate (NH_4NO_3) fertilizer was applied as an active substance per hectare. During the vegetation period, samples were irrigated at the stages of tube emergence (22.IV), earing (19.V) and grain formation (08.VI) and agrotechnical maintenance work designed for the region was carried out in the experimental area. Observations on plants and structural elements of the product were carried out in accordance with the existing methodology. [Musayev, Huseynov, 2008].]. To determine the resistance of varieties to salinity stress, the stress tolerance index given by Rosielle and Hambelen in 1981 was used [Rosielle, Hambelen, 1981].
Tol = Yp-Ys   Here,
Tol – resistance;
Yp - productivity under normal conditions;
Ys - productivity under saline conditions.
Graphical presentation of the data was carried out using the MS-Excel program and the standard error was calculated in the same way. The least significant difference (LSD) test was performed using STATISTIX 8.1 at a probability level of 0.05.

RESULTS

One of the most useful indicators of wheat is grain yield. High salt concentration causes a decrease in grain yield. The study of yield loss as a main indicator of productivity is one of the main conditions. The study of this yield loss was studied as a result of applying the tolerance index formula. Both in normal and saline conditions (F4) and (F5) hybrids grown in different years under different ecological conditions were studied comparatively for their yield indicators. These indicators are reflected in the tables below (Table 1, 2)

Hyibrids (F4)	Ear weight (g)		Weight of grain (g)		Number of grains in ear	
	Tartar normal soil	Ujar saline soil	Tartar normal soil	Ujar saline soil	Tartar normal soil	Ujar saline soil
	2022	2022	2022	2022	2022	2022
Layaqatli-80 x Mirbashir-128	4.54±0.17	4.49±0.14	4.02±0.54	4.02±0.74	61±1.26	59±1.28
Golden wheat x Gunashli	3.13±0.07	2.24±0.11	2.31±0.72	1.42±0.23	39±1.26	31±1.24
Tartar x Karabagh	4.13±0.17	3.57±0.13	3.21±0.24	1.97±0.11	60±1.15	54±1.14
Tale-38 x Gyrmyzy Gul-1	3.49±0.27	3.32±0.13	2.44±0.62	2.40±0.16	48±1.28	46±1.19
Gobustan x Sheki-1	2.62±0.24	2.05±0.23	2.18±0.14	1.84±0.13	39±0.8 2	34±0.72
Murov x Daghdash	3.45±0.21	2.78±0.11	3.14±0.62	2.16±0.15	48±1.17	40±1.17
Bezostaya-1 x Gyrmyzy Gul-1	2.42±0.12	1.78±0.17	2.25±0.11	2.05±0.02	55±0.54	42±0.33
Dagdash x Murov	3.65±0.17	3.65±0.21	3.99±0.12	3.13.±0.11	65±0.54	63±0.43
Nurlu-99 x Layaqatli-80	4.41±0.19	3.98±0.09	3.13±0.16	2.74±0.15	62±1.48	60±1.33
Karabagh x Karakilchik-2	1.81±0.12	1.26±0.12	1.51±0.32	1.12±0.35	18±2.15	11±2.03
Sheki-1 x Gobustan	2.71±0.14	2.11±0.23	1.83±0.19	1.45±0.19	43±0.92	32±0.82
Vuqar x Barakatli -95	5.60±0.54	5.15±0.56	4.91±0.12	4.32±0.18	64±1.66	63±1.86
Gyrmyzy Gul-1-x Tale-38	3.33±0.17	3.10±0.23	2.52±0.31	2.22±0.12	53±2.62	50±2.68
Barakatli-9 5 x Vuqar	4.64±0.21	4.62±0.20	4.26±0.16	4.24±0.12	66±0.22	64±0.42
Karabagh x Tartar	4..32±0.22	4.30±0.22	3.52±0.14	2.53±0.14	55±1.53	51±1.63
Aran x Gyrmyzy Gul -1	2.26±0.14	1.92±0.18	1.84±0.21	1.35±0.22	53±0.72	42±0.75
Mirbashir-50 x Shiraslan-23	4.47±0.21	4.24±0.31	3.54±0.36	3.42±0.61	60±0.13	55±0.14
Karabagh x Gobustan	3.18±0.22	2.53±0.12	2.12±0.32	1.81±0.22	41±2.11	33±2.11
Gobustan x Barakatli-95	3.82±0.23	3.24±0.21	2.71±0.23	2.18±0.33	44±0.81	34±0.72
Gobustanx x Gyrmyzy Gul-1	3.79±0.30	3.27±0.33	2.78±0.54	2.43±0.44	38±0.22	31±0.44

Barakatli-95 x Gobustan	4.28±0.16	3.62±0.27	3.12±0.04	3.10±0.02	44±2.23	38±2.51
Kobustan x Karabagh -	3.32±0.24	3.13±0.23	2.82±0.41	1.34±0.51	45±0.42	33±0.44
Karabagh x Mirbashir-128	3.56±0.17	3.41±0.12	3.11±0.14	3.10±0.12	57±0.15	53±0.64
Karabagh-x Shark	5.42±0.15	5.18±0.12	4.21±0.11	4.01±0.11	67±0.33	65±0.16

Table 1. Characteristics of yield elements of (F_4) hybrids planted in normal soils of Tarter region.

Mean value of 3 replicates for each hybrid is p = 0.05 with n = 3, ± SD indicates mean standard deviation.

Table2. Characteristics of yield elements of (F5) hybrids planted in saliny soils of Ujar region.

Hyibrids (F5)	Ear weight (g)		Weight of grain (g)		Number of grains in ear	
	Tartar normal soil	UJar saline soil	Tartar normal soil	UJar saline soil	Tartar normal soil	UJar saline soil
	2023	2023	2023	2023	2023	2023
Layaqatli-80 x Mirbashir-128	4.52±0.15	4.47±0.13	4.04±0.82	4.04±0.82	63±1.28	60±1.23
Golden wheat x Gunashli	3.18±0.17	2.62±0.15	2.22±0.82	1.52±0.15	42±1.28	32±1.28
Tartar x Karabagh	4.22±0.15	3.65±0.17	3.23±0.14	1.93±0.14	64±1.05	55±1.05
Tale-38 x Gyrmyzy Gul-1	3.51±0.37	3.32±0.15	2.54±0.82	2.51±0.15	46±1.28	42±1.28
Gobustan x Sheki-1	2.81±0.26	2.12±0.24	2.14±0.14	1.74±0.14	32±0.8 2	24±0.8 2
Murov x Daghdash	3.62±0.22	2.95±0.15	3.24±0.82	2.12±0.15	52±1.28	42±1.28
Bezostaya-1 x Gyrmyzy gul-1	2.63±0.18	2.42±0.18	2.58±0.01	2.00±0.01	57±0.44	47±0.54
Dagdash x Murov	3.64±0.17	3.64±0.17	3.98±0.12	3.12±0.12	66±0.64	65±0.64
Nurlu-99 x Layaqatli-80	4.42±0.20	4.13±0.20	3.12±0.16	2.88±0.16	61±1.48	59±1.48
Karabagh x Karakilchik-2	1.84±0.16	1.33±0.16	1.61±0.35	1.11±0.35	20±2.05	11±2.05
Sheki-1 x Gobustan	2.83±0.34	2.18±0.34	1.83±0.29	1.44±0.29	47±0.92	45±0.92
Vuqar x Barakatli -95	5.56±0.58	5.45±0.58	4.81±0.14	4.52±0.14	66±1.76	65±1.76
Gyrmyzy Gul-1-xTale-38	3.42±0.37	3.14±0.37	2.51±0.34	2.32±0.34	52±2.64	49±2.68
Barakatli-9 5 x Vuqar	4.57±0.21	4.55±0.21	4.23±0.16	4.22±0.16	68±0.42	67±0.42

Karabagh x Tartar	4.34±0.32	4.32±0.32	3.72±0.24	2.73±0.24	56±1.63	52±1.62
Aran x Gyrmyzy Gul-1	2.43±0.17	1.81±0.17	1.94±0.13	1.45±0.21	54±0.78	44±0.78
Mirbashir-50x Shiraslan-23	4.65±0.31	4.33±0.31	3.62±0.66	3..54±0.66	62±0.15	58±0.15
Karabagh x Gobustan	3.57±0.25	2.52±0.25	2.22±0.42	1.90±0.42	42±2.12	35±2.12
Gobustan x Barakatli-95	3.64±0.13	3.13±0.23	2.71±0.33	2.11±0.33	46±0.71	41±0.71
Gobustanx x Gyrmyzy Gul-1	3.83±0.31	3.27±0.31	2.84±0.54	2.42±0.54	36±0.44	31±0.44
Barakatli-95 x Gobustan	4.31±0.28	3.63±0.28	3.11±0.01	2.78±0.01	44±2.82	40±2.82
Kobustan x Karabagh	3.44±0.31	3.12±0.31	2.91±0.54	1.35±0.31	42±0.44	31±0.27
Karabagh x Mirbashir-128	3.65±0.10	3.52±0.10	3.28±0.11	3.27±0.11	54±0.62	51±0.62
Karabagh-x Shark	5.64±0.14	5.49±0.14	4.13±0.10	4.05±0.10	66±0.56	64±0.56

Mean value of 3 replicates for each hybrid is p = 0.05 with n = 3, ± SD indicates mean standard deviation.

The yield indicators of hybrids (spike weight, grain weight and grain number) are reflected in the table showing the salt tolerance index (Table 3).

Table 3. Tolerance indices of yield elements of wheat hybrids

Hibrids	Ear weight (g)	Weight of grain (g)	Number of grains in ear
Layaqatli-80 x Mirbashir-128	1.11	0.72	11
Golden wheat x Gunashli	1.06	0.71	14
Tartar x Karabagh	1.53	1.32	26
Tale-38 x Gyrmyzy Gul-1	1.11	0.53	10
Gobustan x Sheki-1	0.33	0.42	8
Murov x Daghdash	0.67	1.12	1
Bezostaya-1 x Gyrmyzy Gul-1	0.21	0.21	20
Dagdash x Murov	0.03	0.75	1
Nurlu-99 x Layaqatli-80	1.19	0.24	15
Karabagh x Karakilchik-2	0.28	0.53	7
.Sheki-1 x Gobustan	0.19	0.39	2
Vuqar x Barakatli -95	0.11	0.29	1
Gyrmyzy Gul-1-xTale-38	0.32	0.19	4
Barakatli-9 5 x Vuqar	0.01	0.11	16
Karabagh x Tartar	0.11	0.99	21
Aran x Gyrmyzy Gul-1	0.62	0.49	10
Mirbashir-50x Shiraslan-23	0.32	0.01	4
Karabagh x Gobustan	0.72	0.32	7
Gobustan x Barakatli-95	0.48	0.62	5
Gobustanx x Gyrmyzy Gul-1	0.56	0.42	5
Barakatli-95 x Gobustan	0.74	0.01	4

Gobustan x Karabagh	0.16	1.59	13
Karabagh x Mirbashir-128	0.23	0.09	5
Karabagh-x Shark	0.23	0.08	4

The study of yield loss as the main indicator of yield is one of the main conditions. Hybrid forms were studied comparatively according to the yield indicators of plants grown in both normal and saline conditions, namely spike weight, grain weight and grain number. First, the tolerance index for salinity was found, and then the differences in yield indicators were revealed in the hybrids, for which a dendrogram was constructed for yield loss. When comparing the hybrid forms, it is clear that some of the hybrids were exposed to relatively less yield loss due to the effects of salt. The studied indicators are reflected in the following table and histogram images.
(Table 3, Figure 1)

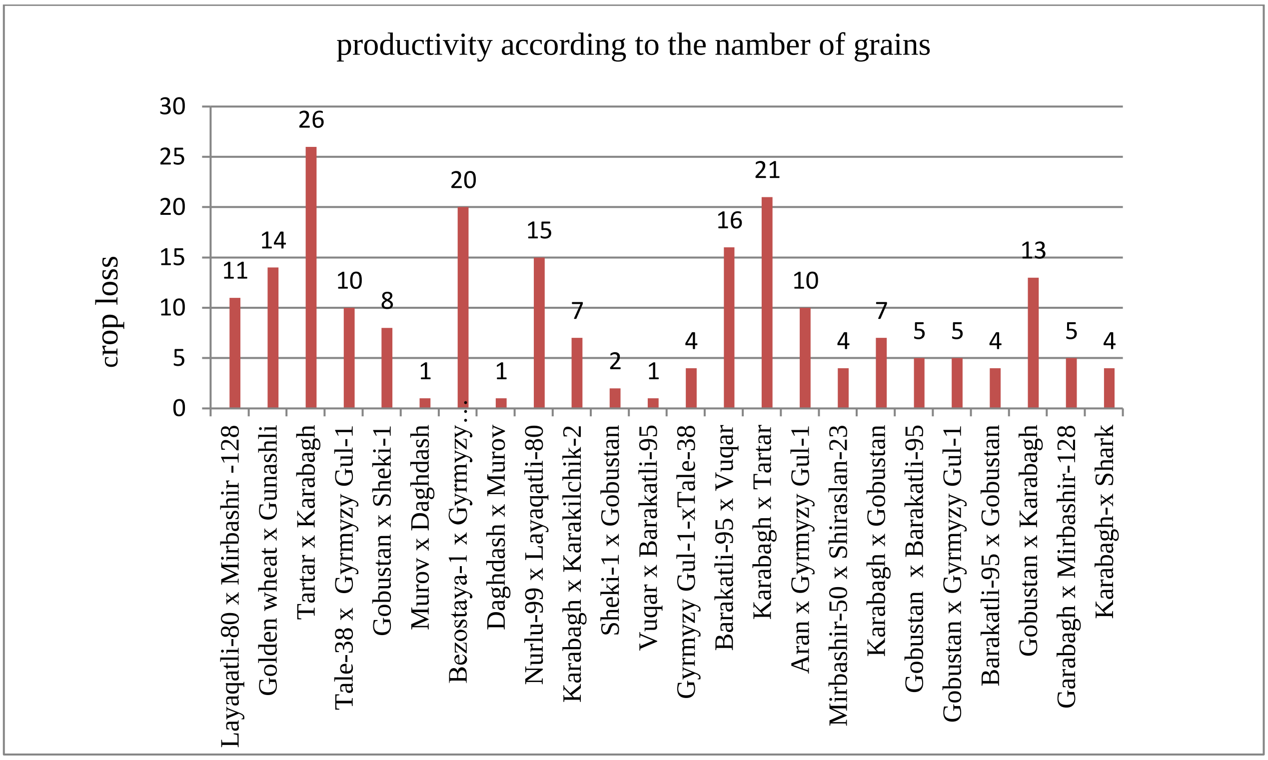

Fig 1. (F4) and (F5) hybrids yield indicators according to the tolerance index (by the number of grains)

Discussion

A comparative study of the main productivity indicators of (F4) and (F5) hybrids grown both in normal and saline conditions once again shows that some of the hybrids were tolerant to the effects of salt, with relatively less yield loss. A comparative study of the main productivity indicators of (F5) hybrids grown both in normal and saline conditions once again shows that some of the hybrids were tolerant to the effects of salt, with relatively less yield loss. Among the complex measures taken to obtain high yields from plants in salinizing soils, the selection of plants that can adapt to such soils occupies a special place [Бelovalova, 2011]. However, it has been established that the effect of salt may be less at one stage of development and more at another. According to most authors, the stage when plants are most sensitive to salinity is the beginning of ontogenesis. Plants are most sensitive to the effects of salt during the period when spikelets and tillering nodes are formed in cereals [Maas et al., 1997]. Studies conducted to study genes that control resistance under salt stress conditions have shown that the expression of these genes is enhanced at high salt concentrations and ensures plant resistance [Garratt etal., 2002]. The response of plants to stress factors is diverse and is a response provided by genetic material. Thus, genetic material regulates the rate and sequence of synthesis of the protein needed in stress conditions. A number of difficulties in the cultivation of salt-resistant forms are related to the complex and polygenic nature of genes for resistance to salt stress. In the process of evolution, protective mechanisms against environmental stress factors are formed in all organisms, including plants. Therefore, when assessing resistance to stress factors, it is necessary to take into account the individual characteristics of each plant genotype[Azizov, Khanyshova, 2019].

CONCLUSIONS AND OUTLOOK

When comparing the yield indicators of the effect of salt (1.5% Na_2SO_4) in the saline soils of the Ujar region with the yield indicators of hybrids planted under normal conditions in the Tartar region, it was determined that salinity had a negative effect on the main structural elements of the spike, causing yield loss. However, among the 24 hybrids studied, there are also lines with relatively low yield loss. Thus, Gobustan x Sheki-1, Dagdash x Murov, Vugar x Barakatli -95, Qirmizli Gul-1 x Tale-38, Mirbashir-50 x Shiraslan-23. In the Barakatli-95 x Gobustan, Karabakh x Mirbashir-128, Karabakh-x Sharq hybrids, the decrease in the weight of the spike and the number of grains was less, and the overall yield loss was less than in other hybrids. This gives reason to say that if these resistant hybrids are maintained, it will be possible to plant them in moderately saline soils in the future.

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