

# Study on the Stability of World Diversity of Cultured Species *G. hirsutum* L. to Salination

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## Abstract

The paper presents the results of a study of salt tolerance in some different eco-geographical samples of the cotton germplasm collection of the Institute of Genetics and Experimental Biology of the Academy of Sciences of the Republic of Uzbekistan. According to the results obtained, the studied samples were divided into several groups depending on their salt tolerance. Salt tolerant and unstable samples were found in all studied ecological and geographical groups, but differed in the frequency of distribution.

## Keywords

Cotton, Germplasm, Salt Tolerance, *G. hirsutum* L., Testing, NaCl, Environmental Geographical Origin, Salination

## 1. Introduction

Exposure of plants to abiotic stresses such as high salinity, drought, extreme light and temperature leads to the major loss in crop productivity worldwide. Among the various abiotic stress factors, soil salinization is the biggest threat to inland agriculture. A study on global land use pattern reveals that 7% of the world's land area, amounting to 1000 million hectares, has become saline [1]. In the present scenario, salinity caused by human interference, through use of poor-quality irrigation systems, is a major concern for researchers around the world. Therefore, apart from the need for proper irrigation practices, a concerted effort to understand the effects of salinity on plants, development of genetically engineered crop varieties and superior salt-tolerant cultivars are essential to combat the world's salinization problem [2]. Salinity stress affects plant growth, as well as development processes such as seed germination, seedling

growth and vigour, vegetative growth, flowering and fruit set [3]. Salt stress can affect physiological processes from seed germination to plant development, resulting in reduced growth and yield. The complexity of the plant responses to salt stress can be partially explained by the fact that salinity imposes both ionic and osmotic stress as well as nutritional imbalance [4].

Understanding the effects of salinity stress on cotton growth and physiology is a prerequisite for successful salinity management and control. Salinity effects on cotton plant may vary with the growth stage and extent and time of salinity stress. Biological or economic yield reduction is the main effect of salinity at the whole-plant level, and is usually attributed to various physiological and biochemical processes at the cellular or molecular levels [5] [6] [7]. Although salinity effects occur at almost all growth stages, including germination, seedling, vegetative and mature stages of field-grown cotton, it is generally believed that germination and young seedling stages are more sensitive to salinity stress than other stages [8]. Seed germination and emergence of cotton are generally delayed and reduced by salinity [9].

Soil salinity is one of the most important problems in Uzbekistan. Due to the drying of the Aral Sea, the area of saline soils in Uzbekistan is expanding every year. Scientists are faced with the task of identifying the most resistant varieties of crops to salinization. Cotton *G. hirsutum* L., is one of the most important agricultural crops in Uzbekistan.

The presence of the rich collection of the cotton gene pool at the Institute of Genetics and Experimental Plant Biology of the Academy of Sciences of Uzbekistan, recognized by the international community as one of the most unique in terms of the diversity of the cotton gene pool [10] [11] [12], where samples from different ecosystems are preserved in a viable state, *Gossypium* L., ensures the success of applied research, obtaining promising lines, varieties.

The varietal diversity of the species *G. hirsutum* L. is characterized by wide distribution and is cultivated in all cotton-growing countries of the world of the subtropical zone due to its ecological plasticity (subdivided into 20 or more agroecological groups), relative resistance to pests and diseases, as well as productivity, fiber quality. To identify resistance to salinization in the early stages of ontogenesis, a number of methods have been developed and applied. Salinity tolerance can be determined by the rate of seed germination in saline [13] [14]. The reaction of seeds of various varieties to germination in a solution of salts makes it possible to diagnose salinity resistance, which manifests itself at the earliest stages of development, and to identify samples promising for a deeper study of their resistance.

Due to their resistance to environmental stress factors, to diseases and pests, ecological plasticity, as well as productivity, high technological qualities of fiber, varietal variety of tetraploid species (*G. hirsutum* L.) is a valuable genetic resource to reduce the vulnerability of agricultural production. It is important to note that the varietal agro-biodiversity of these species is characterized by a large

polymorphism, as well as a wide range of variability of hereditary traits and properties, and therefore are the most valuable starting material for the cultivation of improved varieties [15].

The aim of the present study was to screen a set of cotton genotypes for adaptive potential for salinity stress among diploid and tetraploid species of the world diversity of the cotton gene pool based on various assessment methods to accelerate the selection process.

## 2. Material and Methods

The material for the study was the seeds of cotton cultivars of the variety *G.hirsutum* L. selected from the genetic collection of the Institute of Genetics and PEB. To analyze the salt tolerance of the studied samples, we used plastic Petri dishes with a diameter of 8 cm, put two layer filter paper, and then sown the seeds. There were four repetitions for each salinity treatment at 50, 100, 150 mM NaCl against the studied samples of the cotton collection gene. The seeds sprouted in fresh water, and the pots were stored in a thermostat for 4 weeks at a temperature of 26°C - 38°C. Watering the seedlings with NaCl solution at 50 mM, 100 mM, or 150 mM started 5 days after emergence. Salinity processing was carried out every third day.

## 3. Results and Discussion

As a result of environmental tests, in the conditions of Uzbekistan, the morphological and biological traits of the varietal diversity of cultivated tetraploid species of the genus *Gossypium* L. from various ecological and geographical groups were evaluated and the most valuable useful traits as donors for use in genetic selection projects were identified.

The European ecological and geographical group is represented by varieties from Ukraine, Romania, and Bulgaria. Hungary, Czechoslovakia, Greece, Spain and Portugal. The variety specimens of these countries are characterized by a small amplitude of variability of morphological characters, such as the height of the main stem, the height of the first fruit branch, the total number of nodes, the length of the growing season. Among them, early ripening varieties of cotton were identified with a vegetation period of 112.0 - 114.0 days (A-3792, 4736; A-843; A-3754, 433). The degree of susceptibility to wilt in the studied samples is different. Variety specimens from Bulgaria (50.0% - 70.0%) and Czechoslovakia (20.0% - 70.0%) are most affected by the wilt (**Table 1**). Samples of these countries are also characterized by the largest amplitude of variability and average indicators of economically valuable traits (**Table 2**). Among the variety specimens from Ukraine, Bulgaria, and Greece, a number of samples with a high fiber yield (40.0% - 42.9%) were revealed. The high yield (41.4% - 42.7%) and the shortest fiber length (25.4 - 26.4 mm) are characterized by varieties from Spain and Portugal. Among the Bulgarian samples, one sample was identified with a fiber length of 35.4 mm (A-3655, S-433).

**Table 1.** Economic valuable traits of *G. hirsutum* L. variety.

№	Country	mass of raw 1st box, g	1000 seed weight (g)	Fiber yield, %	Fiber length, mm
	1	2	3	4	5
Central Asian Ecological and Geographic Group					
1	Uzbekistan	4.0 - 7.5	90.0 - 150.0	34.3 - 43.9	25.7 - 35.9
European Ecological and Geographic Group					
2	Spain	6.0	112.0	42.7	25.4
3	Portugal	5.9	110.0	41.4	26.4
4	Ukraine	4.2 - 6.8	100.0 - 110.0	37.6 - 42.6	28.9 - 30.2
5	Bulgaria	4.5 - 6.5	107.0 - 120.0	35.0 - 40.0	26.4 - 35.4
6	Iran	5.2	115.0	34.9	27.3
7	Greece	5.5 - 6.9	114.0 - 133.0	33.6 - 42.9	32.0 - 33.0
8	Hungary	5.0 - 6.5	110.0 - 125.0	32.0 - 38.0	30.0 - 34.6
9	Romania	6.0	132.0	31.0	21.2
10	Czech	4.9 - 6.9	100.0 - 150.0	29.0 - 38.5	26.4 - 33.0
Asian Ecological and Geographic Group					
11	Vietnam	4.9	110.0	40.0	34.3
12	Turkey	5.4 - 6.0	115.0 - 120.	38.4 - 38.6	33.7 - 36.3
13	Korea	4.6	104.0	36.8	30.0
14	China	5.0 - 7.5	90.0 - 125.0	34.0 - 42.0	22.0 - 33.0
15	India	5.0 - 7.5	110.0 - 125.0	34.0 - 40.0	28.0 - 33.0
American Environmental Geographic Group					
16	Philippines	7.0	120.0	41.0	35.0
17	Brazil	5.0 - 6.4	110.0 - 120.0	38.9 - 43.7	29.3 - 31.7
18	Argentina	5.0 - 5.9	115.0 - 130.0	38.9 - 43.0	29.0 - 35.0
19	Cuba	5.0	105.0	38.7	36.3
20	Mexico	4.8 - 7.0	95.0 - 130.0	37.6 - 45.0	26.6 - 39.0
21	USA	5.0 - 7.6	110.0 - 160.0	36.5 - 44.0	25.8 - 35.6
22	Colombia	5.4 - 6.4	110.0 - 130.0	35.5 - 39.7	32.6 - 35.2
African Environmental Geographic Group					
23	Mali	4.8	98.0	43.0	30.0
24	Syria	4.8 - 7.0	105.0 - 120.0	40.0 - 44.0	23.5 - 34.0
25	Somalia	6.8	120.0	39.9	26.0
26	Uganda	6.0	110.0	38.6	27.8
27	Burundi	5.0	108.0 - 110.0	38.3 - 40.2	30.6 - 35.0
28	Tanzania	5.0 - 6.0	108.0 - 127.0	37.6 - 42.0	28.6 - 35.9
29	Yemen	5.0 - 6.5	105.0 - 115.0	36.9 - 41.9	31.5 - 33.9
30	Senegal	4.3	110.0	35.4	27.7
31	Ethiopia	4.8 - 6.3	105.0 - 125.0	35.0 - 40.0	33.0 - 35.0
32	Algeria	5.0	110.0	39.9	35.0
Australian Environmental Geographic Group					
33	Australia	4.0 - 6.7	100.0 - 130.0	36.0 - 40.0	25.5 - 35.2

**Table 2.** Growth of seedlings of cotton samples of the gene collection of different salinity resistance.

№	Samples	Country	Precipitation Saltsolution (NaCl)			
			Control (dis.water) cm	50 mM	100 mM	150 mM
1	Gulbahor-2 (cont.)	Uzbekistan	19.7 ± 2.5	6.5 ± 1.2	4.5 ± 0.4	3.2 ± 0.2
2	A-2174	Kyrgyzstan	22.6 ± 0.8	4.0 ± 1.0	3.3 ± 1.0	2.9 ± 0.7
3	A-2175	Kyrgyzstan	22.2 ± 0.8	11.6 ± 1.4	4.7 ± 0.7	3.9 ± 0.3
4	A-2176	Ukraine	16.0 ± 4.5	5.5 ± 2.0	5.5 ± 0.5	3.0 ± 0.5
5	A-2177	Ukraine	20.8 ± 2.3	7.1 ± 1.7	4.1 ± 0.8	3.2 ± 0.8
6	A-2178	Ukraine	21.6 ± 3.9	9.4 ± 2.5	4.0 ± 1.0	3.0 ± 0.6
7	A-2179	China	24.2 ± 2.1	13.3 ± 2.9	5.1 ± 0.6	3.6 ± 0.5
8	A-2180	China	19.1 ± 1.7	11.5 ± 2.7	2.0 ± 0.5	2.0
9	A-2187	USA	15.8 ± 4.6	12.5 ± 4.0	3.0 ± 0.6	1.0
10	A-2188	USA	18.9 ± 1.3	12.3 ± 1.4	3.1 ± 0.6	2.2 ± 0.6
11	A-2189	USA	20.8 ± 0.5	16.2 ± 0.6	4.2 ± 0.7	1.5
12	A-2190	USA	21.7 ± 1.0	15.5 ± 0.5	4.9 ± 0.8	2.8 ± 0.6
13	A-2192	USA	19.8 ± 1.9	10.8 ± 2.5	4.6 ± 0.4	1.6 ± 0.2
14	A-2194	USA	23.1 ± 1.3	10.0 ± 2.4	1.2 ± 0.7	0.7 ± 0.2
15	A-2184	USA	16.3 ± 4.3	13.0 ± 1.3	3.3 ± 1.1	1.0
16	A-2197	India	21.0 ± 0.9	11.7 ± 1.6	2.6 ± 0.4	1.3 ± 0.8
17	A-2200	Afghanistan	25.0 ± 2.0	12.6 ± 1.4	3.2 ± 0.2	1.0
18	A-2201	Afghanistan	22.3 ± 2.1	11.6 ± 0.6	2.0 ± 0.5	1.0 ± 0.5
19	A-2205	India	20.0 ± 2.8	11.5 ± 7.0	3.3 ± 0.4	0.7 ± 0.2
20	A-2210	USA	20.4 ± 4.1	4.8 ± 0.7	3.6 ± 0.8	0.7 ± 0.2
21	A-2212	USA	21.7 ± 2.9	6.4 ± 1.1	3.0 ± 0.3	0
22	A-2217	Azerbaijan	23.7 ± 2.5	6.7 ± 0.8	3.3 ± 0.6	1.9 ± 0.2
23	A-2218	Azerbaijan	21.5 ± 2.2	13.2 ± 0.8	5.6 ± 0.6	1.6 ± 0.3
24	A-2214	USA	24.5 ± 1.0	8.3 ± 1.5	5.5 ± 1.5	2.0 ± 0.5
25	A-2226	USA	17.3 ± 1.4	4.8 ± 1.4	2.9 ± 0.6	0

The Asian Ecological and Geographic Group is represented by the following countries: India, Iran, Turkey, Korea, Vietnam, Syria, and the Philippines. Varietal specimens of these countries are characterized by average, relatively aligned morphological indicators and mid-ripeness (**Table 1**). The length of the growing season varies from 116.0 - 125.0 days. An exception is the variety sample from Korea (A-4011, Rulliyen) that is characterized by ultra early maturity, the length of the growing season is 108.0 days. Varietal specimens from Asian countries are greatly affected by the wilt. Wilt infestation rates range from 50.0% - 80.0%. The variety specimen from Vietnam is most affected by the wilt, up to 90% (**Table 1**). Among the varietal samples from Syria, a number of samples with a high mass of raw cotton 6.5 - 7.0 g (A-3796, Hama 26/47; A-3800, Aleppo

(2) and others) and with a fiber yield of more than 42.0% - 44.0% (A-3801, Aleppo (6); A-3796, Hama 26/17, etc.) (**Table 1**).

The results should be presented in the past tense. So use “was” instead of “is” variety specimens from the USA, Mexico, Brazil, Colombia, Argentina and Cuba were studied from the American ecological and geographical group. Variety samples from the USA and Mexico have relatively low amplitude of variability according to the studied morphological characters. For example, in specimens from Mexico, the height of the main stem was 65.0 - 115.0 cm, the height of the first fruit branch was from 5.0 to 6.0 knots, the total number of knots was in the range of 20.0 - 30.0 pcs. It should be noted that the studied varieties of the American continent are characterized by early maturity and mid-ripening (the length of the growing season is on average 110.0 - 122.0 days), with the exception of varieties from Argentina, the length of the growing season of which varies between 118.0 - 120.0 days. They are mid-season and most affected by wilt (70.0% - 90.0%). The degree of susceptibility in the remaining representatives is medium to strong (40.0% - 90.0% (**Table 1**)). According to economically valuable signs, varietal samples from the USA and Mexico have high amplitude of variability. For example, varietal samples from Mexico have a mass of cotton - raw milk of one box varies within 4.8 - 7.0 g, weight of 1000 seeds 95.0 - 130.0 g, fiber yield 37.0% - 45.0%, fiber length 26.6 - 39.0 mm. A relatively low amplitude of variability is observed for varieties from Brazil, Colombia and Argentina (**Table 1**). It should be noted that varieties of the American continent They are characterized mainly by high yields, among which many samples were found with high indicators of the weight of raw cotton in one box 7.0 - 7.6 g (A-2293, Siniloa; A-3677, S-310, etc.), fiber yield, more than 40.0% - 45.0% (A-3877; A-3678, C-124-B, etc.), with a fiber length of more than 35.6 mm (A-3691, 100-A, A-3694, Deepi 118 *et al.*).

The samples from Algeria, Ethiopia, Burundi, Uganda, Tanzania, Mali, Yemen, Somalia and Senegal were studied from the African ecological and geographical group. According to morphological signs, samples of these countries have equalized indices. Indicators of early maturity and wilt resistance are somewhat different. Varietal specimens from Ethiopia, Mali, Somalia, Senegal, Uganda and Tanzania are characterized by mid-ripeness and are affected by wilt in the middle (30.0% - 60.0%) and strong (70.0% - 80.0%) degrees. Varietal specimens from Burundi and Tanzania are characterized by early maturity (the length of the growing season is 116.0 - 124.0 days). The variety sample from Uganda (A-3753, Cmpriseve ci) is characterized by early maturity, the length of the growing season is 110 days, but it is strongly affected by wilt (70.0%) (**Table 1**). Among the varietal samples from Ethiopia, Burundi, Algeria and Mali, a number of samples with a fiber length of 35.0 - 35.9 mm (A-4029, Deltapine 08314; A-4028, Co-O, etc.) were identified (**Table 2**). Average, relatively aligned indicators of economically valuable traits are observed in varieties from Yemen. The mass of raw cotton was 5.0 - 6.5 g, the weight of 1000 seeds 105.0 - 115.0 g, fiber length 31-, 5 - 33.9. In terms of fiber yield, relatively high rates are observed

(36.9% - 41.9%).

Varietal specimens from the Australian Ecological and Geographic Group were morphologically stable. Indicators of the length of the growing season ranged from 112.0 to 122.0 days. The degree of susceptibility to wilt, in the range of 30.0% - 90.0% (**Table 1**). In terms of economically valuable traits, a certain amplitude of variability is observed: the mass of raw cotton varies between 4.0 - 6.7 g, the weight of 1000 seeds is 100.0 - 130.0 g, and the fiber yield is 36.0% - 40.0%. with the fiber length varying from 25.5 - 35.2 mm.

To determine the resistance of plants to adverse environmental factors, they primarily use visual diagnostics of plant conditions: plant height, bushiness, growth rate, formation of the leaf apparatus, leaf color, etc. As a rule, such indicators are used for direct field or vegetation methods of cultivation. However, the complexity and duration of direct methods necessitated the development of laboratory methods for the diagnosis of plant resistance. These methods are based on changes in physiological and biochemical processes occurring in plants.

The collection was evaluated according to the method [5], which is based on a decrease in the growth rate in solutions of salt (NaCl) of various concentrations (50 mM; 100 mM; and 150 mM). According to the data obtained, these samples can be divided into two groups: the first group is stable and the second group is unstable. The data obtained are given in the table.

From the data presented in **Figure 1** it can be seen that samples A-724, A-726, A-950 and A-1015 from Uzbekistan turned out to be stable, and samples A-720 and A-987 are unstable (**Figure 2**).

Thus, it was established that the samples from the cotton collection: A-724, A-726, A-950, A-1015, A-1118, A-1374, A-1375, A-1381, A-1406, A-1410, A-1415, A-1417, A-1423, A-1557, A-1643, A-1649, A-1661, A-1662, A-1664, A-1670 and A-3924 showed high resistance to salinization. Also noted are salinity resistant collection samples: A-1556, A-720, A-987, A-1012, A-1018, A-1026, A-1032, A-1425, A-1428, A-1431, A-1530, A-1555, A-1559, A-1570, A-1648, A-1711, A-3937 and A-3923. The results of studies on the degree of salinity resistance of some germplasm samples are presented in **Table 2**.



**Figure 1.** Growth and development of cotton seedlings in samples of the gene collection of different salinity resistance Note: 1). A-724, 2) A-726 3) A-720, 4) A-950, 5) A-1015, 6) A-987.



**Figure 2.** Growth and development of cotton seedlings in samples of the gene collection of different salinity resistance Note:1) A-1406, 2) A-987, 3) A-1431, 4) A-1423, 5) A-1555, 6) A-1118.

#### 4. Conclusion

From the data presented in the table, it can be seen that samples A-2175 (Kyrgyzstan), A-2177 (Ukraine), A-2179 (China) showed high salinity resistance compared to the control, and the remaining varieties showed moderate or weak resistance compared to control.

#### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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