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Original scientific paper

ADAPTIVE REACTION OF COTTON ACCESSIONS OF *G. hirsutum* L. AND *G. barbadense* L. SPECIES TO DROUGHT STRESS

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Adaptation, process of the adjustment of a plant to specific environmental conditions, is provided by physiological mechanisms (physiological adaptation), and at population level (species) by mechanisms of genetic variability, heredity and selection (genetic adaptation).Intraspecific and the interspecific physiological assessment of adaptation potential to drought stress was carried out on 267 collection accessions and varieties of a cotton (197 accessions of *G. hirsutum* L. and 70 of *G.barbadense* L.). Comparative study of the stress reaction of tested accessions to unfavorable environmental factors was carried out based on stress depression indices of viability of seeds in sucrose solution-imitating drought.As a result of the studies different sensitivity of plants to abiotic stress was determined. The amplitude of the changes of physiological parameter during stress allowed roughly divide cotton accessions within each species into groups by defining different degrees of comparative drought resistance of samples.Analysis of the percentage ratio of high drought resistant accessions within species, revealed differences between *G. hirsutum* L. and *G. barbadense* L. For the specie *G. hirsutum* L. percentage of accessions with high drought resistance was 9.1%, for specie *G. barbadense* L.-28.6%. *G. barbadense* L., in our view, is characterized by a greater potential for volatility and acclimatization to the new, unusual conditions, capable

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of better resisting the adverse effects of drought and has great promise for using in breeding.It was found that because of the stress in drought resistant varieties activation of RNA synthesis, increase of labile and decrease of stable DNA was observed which indicates an increase of the physiological liability and functional activity of the genetic apparatus. In susceptible varieties a reduction in the synthesis of RNA and DNA and displacement of DNA fraction ratio towards the stable were noted.

Key words: cotton, resistance, stress, drought, physiological parameters, nucleic acids

INTRODUCTION

Cotton belongs to genus *Gossypium* L. (which in Latin means "tree, giving the fibre") family *Malvaceae* Juss. According to current classification of genus F.M. Mauera *Gossipium* includes 35 species. Among them five species are cultivated: *G. hirsutum* L., *G. barbadense* L., *G. Arbareum* L., *G.herbaceum* L., *G. tricuspidatum* L.

G. hirsutum L., originating from Central America (Mexico), is the most commonly cultivated specie. *G. barbadense* L., originating from South America (Peru), is less widespread, mainly because of it's late maturance.

Cotton was imported into Azerbaijan from Iran, where according to some historical documents the crop has been cultivated since VI b.c. Originally cotton in Azerbaijan has been developed insignificantly and was based extremely on the local varieties of cotton - guzy (local name "Kara-koza" (*G. herbaceum* L.). Cotton growing, based on guzy, was low yielding; fiber of guzy was short and rude and did not meet the requirements of the textile industry. Then there was the replacement of the old local varieties with more productive and high qualitative cotton varieties of *G. hirsutum* L., and in some areas with warmer and prolonged period of vegetation-fine-fiber cotton varieties of *G. barbadense* L.

At present, an important task in the field of cotton growing is to ensure stability of the high yields when grown under unfavorable conditions. The drought is one of the commonly encountered unfavorable environmental factors affecting cotton, worsening conditions of plant nutrition, slowing down the development of cotton, changing the quality of raw cotton and fibers, reducing its length and fortress, resulting in a decrease of plant productivity. Therefore, a sufficient gene pool of stress-resistant varieties is an important element for the successful development of cotton growing. Genetic Resources Institute of Azerbaijan National Academy of Sciences focused on the collection, recovery, reproduction, evaluation and conservation of genepool of plant biodiversity, including cotton (ALIYEV and AKBAROV, 2002).

Adaptation, the process of adjustment of plants to specific environmental conditions, consists of two functionally different phases - stress reaction and specialized adaptation. The stress reaction focused on quick short-term protection of organism from death in stress condition and initiates formation of specialized (long-term) resistance mechanisms. The stress reaction has transit character and provides transition of a plant from normal to stressor metabolism by blocking metabolic pathways non-essential to the survival of the organism and formation of protection mechanisms, primarily, systems of shock response. Long-term adaptation of plants to this particular factor is aimed to enhancing the vitality by creating specialized mechanisms and ensuring the "normal" course of ontogenesis in the changed circumstances (KUZNETSOV, 2001).

A general response of living systems to the deviation from optimum environmental conditions is activation of adaptive mechanisms to changed conditions. All plants have evolved mechanisms to respond to changing environmental conditions (HIRT, 2009). Mechanisms of

adaptation vary depending on the genotype of the plants; the extremity and duration of stress; the stage of development and the plant age; and, the type of organs and cells (WAHID *et al*., 2007). Information about stress signal transduction is important for continued development of rational breeding to improve stress tolerance in crops (XIONG *et al*., 2002). Number of investigations on the stress reactions allow to reveal the relative resistance of different plants to negative environmental factors (differences of resistance level of genotypes relatively to each other, their belonging to certain groups of resistance) (GONCHAROVA, 2002; MAMMADOVA, 2010; MAMMADOVA and MAMMADOVA, 2011).

The degree of plant tolerance to stress varies among different species and different varieties of the same specie (LIZANA *et al*., 2006). As cotton has the highest sensitivity during seed germination (AKPAROV *et al*., 2006) we held intra- and interspecific assessment of the resistance degree of cotton accessions according to germinating ability of seeds.

Taking into account that the rate of seed germination in different stress and non-stress conditions is under genetic control (FOOLAD *et al*., 2001; FOOLAD *et al*., 2007), in some selected by us resistant and susceptible cotton accessions, the changes in the nucleic acid synthesis and fractional composition of DNA under drought stress was studied as well.

MATERIALS AND METHODS

Cotton accessions from the collection of Genetic Resources Institute of Azerbaijan National Academy of Sciences (197 accessions of *G. hirsutum* L. and 70 accessions of *G. barbadense* L.) were used as a research material. Physiological evaluation of stress resistance of cotton accessions to drought has been carried out according to the stress-depression of germination of seeds in a solution of sucrose (UDOVENKO, 1988).

Principle of the method consists in comparison of stress depression of physiological parameter of the investigated accessions in "physiological drought" condition, simulated with solution of sucrose. Seeds of experimental variants of cotton were germinated in solution of sucrose with the osmotic pressure of 7 atm (ALIYEV and MAMMADOVA, 2007). With the same level of drought the degree of seed germination reduction in different accessions differs, which makes it possible to diagnose resistance to drought, occurred in the earliest stages of development. Both an intraspecific and interspecific ratio of resistance level of accessions was studied.

Based on physiological assessment among studied cotton collection 5 varieties (table 1) differed for drought resistance (3 resistant and 2 susceptible) and characterized with high biological and agronomic traits (fiber length, fiber yield, early maturity, productivity) were selected for further genetic analyses. The amount of nucleic acids and fractional composition of DNA were determined according to ALEKSEEV (1973). To study the fractional composition of DNA stepwise impact on chromatin with solutions of different ionic strength and its deproteinization were implemented which allowed to split the cellular DNA to free or weakly bound, functionally active (DNA labile); completely blocked with histones (stable DNA); firmly linked (residual DNA) DNA.

RESULTS AND DISCUSSION

In the first series of investigations germination of seeds of different cotton accessions in drought conditions was studied. It was determined that in the same intensity of extreme factors the accessions of the same cotton species substantially differ for the amplitude of changes of physiological parameter. This shows the different sensitivity of cotton varieties to the abiotic environmental factors, their different resistance and adaptability.

Differences in stress-stress response of some accessions clearly presented in the Fig. 1.

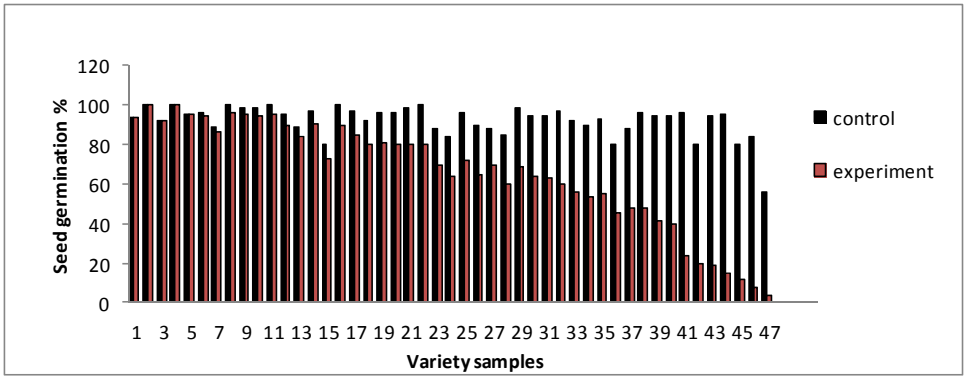

Fig. 1 Germination of seeds in cotton accessions of *G. hirsutum* L. under drought

1. S-5348	2. AzNIXI-170	3. 9732I
4. 5010-V	5. S-6022	6. AF-14
7. AP-347	8. Garabagh-58	9. AF-16
10. AP-342	11. 3038	12. AzNIXI-33
13. Agdash-232	14. Agdash-26	15. Garabagh-11
16. Ganja-114	17. AP-350	18. MA-62
19. AP-352	20. Akala-28	21. Felistan
22. AzNIXI-159	23. AP-347	24. AP-349
25. Delkerro	26. S-9001	27. AP-353
28. AzNIXI-198	29. AzNIXI-121	30. Akala 5
31. MA-4	32. AP-350	33. S-5497
34. AzNIXI-199	35. Antep	36. Khers-29
37. AzNIXI-175	38. Mughan- 281	39. AP-345
40. Senare	41. Tekh.Looth	42. 741
43. Allen-150	44. AzNIXI-165	45. APİ-197
46. APİ-200	47. An Samargand-3	

It is known that metabolism is a complex system of enzymatic reactions, related and interacting with each other and the environment. In the extraordinary circumstances, a living system is committed to preserving the integrity and to adapt directed. Overall response of plants to deviation of environmental conditions from optimal is the activation of adaptive mechanisms to changing conditions. Due to the presence of a number of features appeared in the process of phylogenesis, under the influence of natural selection resistant varieties are characterized by high protective and adaptive reaction, providing an opportunity of transition to a new sustainable level of metabolism. Resistant plants, compared with susceptible more quickly rebuild their vital functions in the direction of adaptation to unfavorable environmental conditions. Susceptible plants under the influence of negative environmental factors are more conservative and incapable of rapid change in their life functions; as a result, they often die. Increase of intensity of

metabolism, enzyme activity and physiological processes of resistant varieties is a protective function under stress (CUI *et al*., 2000; GASYMOV *et al*., 2012; KARIMOVA *et al*., 2008; LIZANA *et al*., 2006; RAHMANKULOVA *et al*., 2012; SRIVALLI *et al*., 2003;).

So, the reaction of various accessions to stress enabled us to divide roughly the cotton accessions within each species into groups with different degrees of resistance: resistant, moderate resistant, low resistant and susceptible. Genotypes of cotton, characterized with complete absence of stress depression of physiological parameter, were considered as drought-resistant. The germinating ability of seeds of drought resistant accessions in these conditions reflects the hereditary property of germinating at the relatively smaller quantities of water and the high sucking force providing rapid absorption of the necessary water quantity. High sucking power of seeds determines not only the best germination at a lack of moisture, but also a formation of more powerful primary root system that is essential for the further life of plants in drought.

For each plant were developed characteristic resistance mechanisms (complex of morphological and biochemical adaptation) through which an adaptation strategy is implemented. Comparative study of resistance indices of cotton varieties of *G.hirsutum* L. and *G. barbadense* L. identified differences in the percentage ratio of drought resistance level between the studied species (Fig. 2).

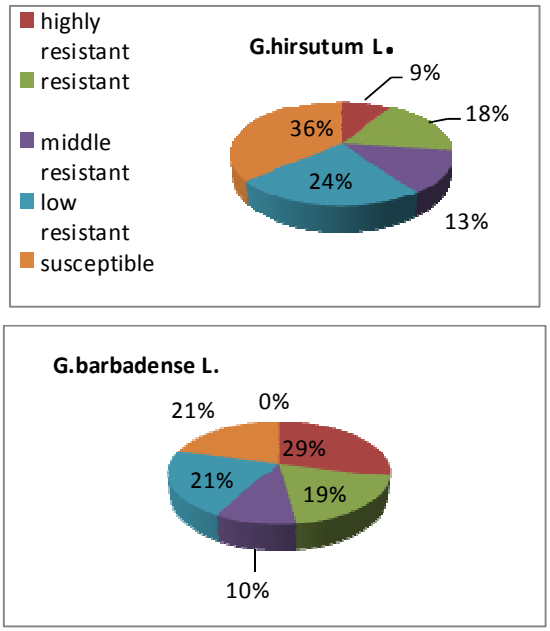

Fig. 2 Comparative indices of drought resistance of cotton accessions belonged to *G. hirsutum* L. and *G. barbadense* L.

The results of investigation showed that, the number of resistant accessions, which is characterized by the complete absence of stress depression of physiological index, was 9.1% for *G.*

hirsutum L. and 28.6% for *G. barbadense* L. *G. barbadense* L., in our view, is more capable to adapt to climate variability and acclimate in new and unusual conditions of existence, has great prospects and opportunities in breeding practice on creating new commercially valuable forms. What is certain is that the requirements of plants to the complex environmental conditions over a period of its ontogenesis were determined with a prior history of this specie. Among the cultivated forms *G. barbadense* L. is characterized by the lowest polymorphism, and this, according to the researchers confirms the relatively short evolutionary history (phylogenetic youth) (MUMTAZ, 2007).

It is known that a few minutes of the organism in unfavorable conditions is sufficient for restructuring of the genetic apparatus. In this regard, it was important for us to explore in the resistant (9732I, 5010-V and S-6022) and susceptible (Senare and 741) varieties of cotton, changes of nucleic acid synthesis and fractional composition of DNA in drought conditions (table 1).

Table 1. Indicators of seed germination and nucleic acid synthesis in cotton varieties under drought

	Varieties	№ catalogue	Seed germination, %				RNA, mg% on wet weight		DNA, mg,% on wet weight		
			control	experiment	in % of control	Stress-depression, %	Control	Experiment	Fractions of DNA	Control	Experiment
1	9732I	871	92,0	92,0	100	0	117,944±2,425	129,72±1,593	labile	5,506±0,11	6,011±0,09
									stabile	7,794±0,14	7,102±0,10
									residual	2,252±0,04	2,359±0,05
									total	15,552	15,472
2.	5010-V	211	100	100	100	0	107,64±5,184	120,89±1,352	labile	5,595±0,07	6,215±0,2
									stabile	7,661±0,22	7,049±0,08
									residual	2,299±0,07	2,465±0,04
									total	15,555	15,729
3.	S-6022	216	95,0	95,0	100	0	123,832±1,5061	167,88±2,61	labile	5,187±0,08	7,000±0,08
									stabile	9,283±0,11	8,228±0,060
									residual	2,021±0,0,04	2,376±0,06
									total	16,491	17,604
4.	Senare	775	94,8	40,0	42,2	57,8	122,36±2,43	107,46±2,58	labile	5,107±0,08	4,025±0,12
									stabile	8,494±0,10	9,407±0,07
									residual	2,501±0,03	2,004±0,03
									total	16,102	15,436
5.	741	712	80,0	20,0	25,0	75,0	112,056±1,593	72,864±1,68	labile	4,859±0,08	3,059±0,10
									stabile	7,093±0,09	7,954±0,07
									residual	2,101±0,04	1,702±0,06
									total	14,053	12,715

RNA synthesis or transcription represents the first phase of the realization of gene pool in the metabolism and morphogenesis. The intensity of this process is an indication of gene activity of nucleus and reflects the activity of formation of different forms. In drought conditions the activity of RNA synthesis in drought-resistant samples of cotton 9732İ, 5010-V, S-6022 exceeds the control by 10.0, 12.3 and 35.6%, respectively. A very different picture is seen in susceptible samples, for which a decrease of the RNA synthesis in comparison with control plants was observed. Similar results were obtained by ALIYEV and ABBASOV (2004) for bread and durum wheat varieties.

As it is seen from the table 1 in drought condition on leaves of stress resistant accessions in comparison with control plants, the amount of labile DNA increases, while the number of stable DNA decreases. For example, in variety 9732I the increase of the proportion of labile DNA was 9.2%, and the percentage of stable DNA decreases at the same level - 8.9%. In 5010-V variety these indicators were 11.1 and 8.0% and in S-6022 variety 34.9 and 1.4%, respectively.

DNA transitions from one state to another underlies the regulation of gene function of DNA and morphogenetic processes in the cell. They also reflect the changes in the physiological state of the cells. Labile chromatin associated primarily with metabolic processes occurring in growing cells or differentiated cells with an active physiological function. Factors stimulating growth and metabolic processes in the organism contribute to the labilization of chromatin.

Increase of active chromatin is explained by the accumulation of loci with identical function, or so-called "repetition" (gene copies) (RAHIMLI *et al*., 2011). These events can be qualified as partial genome reorganization. These changes in genetic systems of cells of resistant varieties lead to the intensification of all synthetic processes, including transcription, translation and gene expression, the activity of enzyme systems and other physiologic-biochemical and biophysical processes that increase the rate of metabolic reactions, directed to strengthening the morphogenesis.

A slightly different pattern of change is observed in the fractional composition of DNA in susceptible to stress accessions - decreasing of labile and increase of stable DNA. So, for example, on experimental variety Senare, for which stress-depression of germination of seeds was 57.8%, the amount of labile DNA decreased by 21.2%, while the amount of stable DNA increased by 10.7%. In variety 741 (stress-depression of germination of seeds was 75%) decreasing of labile DNA synthesis was significantly - 30.5%, while activating the synthesis of stable DNA was 12.1%. Probably, depression in the development of stress-sensitive accessions is caused by the transition of DNA to stable, less active state. Accordingly, these accessions are characterized by low intensity of RNA synthesis and weak morphogenetic activity of cells. It is known that factors inhibiting growth and metabolic processes contribute to the stabilization of the DNA. Stable chromatin is not specific for nucleus of embryonic cells, capable to be reproduced by mitosis. Commonly it is most stored in the nucleus of cells in a dormancy condition, in seeds, dormant buds, etc.

CONCLUSION

Thus, the conducted analysis enabled to diagnosis the resistance of cotton accessions to drought, appeared in the very early stages of development and select resistant and susceptible accessions within each species of *G. hirsutum* L. and *G. barbadense* L., for deeper study of their

sustainability. It was also revealed that during the seed germination period under drought stress fine-fiber cotton samples (*G. barbadense* L.) were more resistant.

As a result of researches on nucleic acids content in drought-tolerant varieties activation of RNA synthesis, increase of labile and decrease of stable DNA were observed. This fact can be due to the changes of the general and local synthesis of DNA, which lead to the increase of the dose of particular structural genes, some factions of the repeated sequences. On the contrary in susceptible accessions the RNA synthesis was decreased and the ratio of DNA fractions changed towards the stable.

Results obtained from this investigation showed that changes occurred in genome structure and functioning can be accepted as stress resistance indices of plants and can be used in explanation of plant resistance.

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REFERENCES

AKPAROV, Z.I., R.T. ALIYEV and A.D. MAMMADOVA (2006): Steadiness evaluating of cotton varieties to stress factors according to indicators of department. International Meeting "Photosynthesis in the Post-Genomic Era: Structure and Function of Photosystems", Moscow, pp. 256.

ALEKSEEV, V.G. (1973): The heterogeneity of the DNA of wheat seedlings and activity of the genome. Works of applied botany, genetics and breeding, *52*(1): 46-56.

ALIYEV, R.T. and M.A. ABBASOV (2004): Changes in genome structure of wheat varieties caused by drought and salt stress and effects of phytohormones on these changes. 4th international crop science congress / 26 September - 1 October 2004/ www.cropscience.org.au/icsc/ poster/3/6/1/1852_abbasovm.htm - 35k.

ALIYEV, D.A. and Z.I. AKPAROV (2002): Plant genetic resources of Azerbaijan. Proceedings of National Academy of Sciences of Azerbaijan, a series biol. sciences. *1-6*:57-68.

ALIYEV, R.T. and A.D. MAMMADOVA (2007): Diagnosis of relative drought tolerance of cotton in terms of stress-depression of seed germination in sucrose solution. International Scientific conference "Ecology: nature and social problems", Baku, BSU, pp. 222.

CUI, Y., B. A. ALOIS and J. OSCAR (2000): Expression of potential defense response genes in cotton. Physiol. and Mol. Plant Pathol, *56*(1): 25-31.

FOOLAD, M.R., P. SUBBIAH and L. ZHANG (2007): Common QTL affect the rate of tomato seed germination under different stress and nonstress conditions. International journal of plant genomics. 2007:97386. doi: 10.1155/2007/97386.

FOOLAD, M.R., L.P. ZHANG and G.Y. LIN (2001): Identification and validation of QTLs forsalt tolerance during vegetative growth in tomato by selective genotyping. Genome, *44*: 444–454.

GASYMOV, F.I., M.N. HALYGZADE, I.V. AZIZOV and N. GULIYEV (2012): Water regime and photosynthetic ability in wheat genotypes under drought conditions. Agricultural biology, *1*: 78-82.

GONCHAROVA, E.A. (2002): Ecological, genetic and physiological basis of fruiting in cultivated plants. IV International scientific-practical conference. Ulyanovsk, pp.166-169.

HIRT, H. (2009): Plant Stress Biology: From Genomics to Systems Biology (Wiley, West Sussex).

KARIMOVA, I., A. ERGASHEV and A. ABDULLAYEV (2008): Effect of soil drought on the carbohydrate content in different varieties and lines of medium staple cotton. Proceedings of AN RT. Biol. and medicine sciences series. Science, *2*: 31-36.

KUZNETSOV, V.V. (2001): General system of the stability and the stress signal transduction in the adaptation of plants to abiotic factors // Proceedings of the Nizhny Novgorod Institute named after NI Lobachevsky, ser.biol. Nizhni Novgorod, pp.64-68 2a.

LIZANA, C., M. WENTWORTH, J.P. MARTINEZ, D. VILLEGAS, R. MENESES, E.H. MURECHIE, C. PASTENES, B. LERCARI, P. VERNIERI, P. HORTON and M. PINTO (2006): Differential Adaptation of Two Varieties of Common Bean to Abiotic Stress. I. Effects of Drought on Yield and Photosynthesis. J. Exp. Bot., *57*: 685-697.

MAMMADOVA, A.D. (2010): Studying of the adaptive reaction of *Zea mays* L. accessions in drought and salinity condition // 2-nd International Symposium on Genomics of Plant Genetic Resources, Bologna, Italy, pp.270.

MAMMADOVA, A.D. and N.KH. MAMMADOVA (2011): The study of the adaptive capacity of collection accessions of cotton to the complex negative environmental factors. Topics in experimental evolution of orqanisms. Kiev, *10*: 269-273.

MUMTAZ, H. (2007) Identification of structural and functional genomic markers for fiber quality traits in cotton using interspecific population (*G. hirsitum* x *G. barbadense*). Mphil Thesis, QA Univ Islamabad Pakistan.

RAHIMLI, V.R., M.A. ABBASOV and M. SHIRI (2011): Effect of Drought and Phytohormones on Nucleic Acids Content in Drought Tolerant and Susceptible Barley Varieties. Trends in Applied Sciences Research, *6:* 96-101.

RAHMANKULOVA, Z.F., S.N. MAYEVSKAYA, M.K. NIKOLAYEV, E.V. SHUYSKAYA and P.Y. VORONIN (2012): Strengthening of photosynthesis in leaves of maize seedlings after a short drought. News KSTU, *27*: 113-122.

SRIVALLI, B., G. SHARMA and R. KHANNA-CHOPRA (2003): Antioxidant Defense System in an Upland Rice Cultivar Subjected to Increasing Intensity of Water Stress Following by Recovery. Physiol. Plant., *119*: 508-512.

UDOVENKO, G.V. (1988): Diagnosis of plant resistance to stresses: Manual, Leningrad, 227 pages.

WAHID, A., S. GELANI, M. ASHRAF and M.R. FOOLAD (2007): Heat tolerance in plants: An overview. Environ. Exp. Bot., 61:199–223.

XIONG, L., K.S. SCHUMAKER, and J-K ZHU (2002): Cell Signaling during Cold, Drought, and Salt Stress. The Plant Cell, *14*: 165-183.

ADAPTIVNA REAKCIJA VRSTA PAMUKA *G. hirsutum* ,L. i *G. barbadense* L. NA STRES SUŠE

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Izvod

Vršena su ispitivanja adaptacionog potencijala kolekcije od 267 genotipova i sorata unutar i između vrsta pamuka (197 uzoraka *G. hirsutum* L. i 70 *G.barbadense* L.).Uporedna ispitivanja reakcije na stress vršena sun a osnovu stress depresionih indeksa vijabilnosti semena na rastvoru saharoze koji su imitirali uslove stresa. Dati su rezultati ispitivanja različite osetljivosti na abiotički stress. Amplitude promena unutar svake vrste definisanjem različitih stepena fizioloških parametara u toku stresa dopuštaju podelu genotipova pamuka unutar svake grupe prema stepenu komparativne otpornosti na stress. Otkrivene su razlike između *G. hirsutum* L. I *G. barbadense* L. na osnovu analize procenta visoko rezistentnih uzoraka na stress unutar vrsta.Kod *G. hirsutum* L. provcenat uzorka sa visokom rezistencijom na sušu je bio 9.1% a kod vrste *G. barbadense* L.- 28.6% što ukazuje da ova vrsta ima veeći potencijal za aklimaticaziju na nove uslove, sposobnost bolje toleratnosti štetnih efekata suše I velili potencijal za oplemenjivanje. Utvrđeno je da se u toku stresa kod otpornih vrsta vrši aktivacija sinteze RNK i smanjenje stabilne DNK što ukazuje na aktivnost genetičkog aparata. Kod osetljivih vrsta je utvrđena redukcija sinteze RNK I DNK.

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