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The Dynamics of RNA Synthesis Depending on the Degree of Resistance of Plants to Drought

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Abstract

In an unfavorable situation, the rapid response of plants is gene expression. It is known that the expression of potential defense reaction genes in a stress-resistant cotton variety occurs faster than in a sensitive one. In this regard, it seemed important to us to study the nature of changes in RNA synthesis under drought conditions in cotton varieties, characterized by varying degrees of resistance.The degree of resistance of varieties to drought was studied by the method of seed germination in a sucrose solution that mimics physiological drought. According to the results of the study, under stress, the activity of RNA synthesis in experimental plants of drought tolerant varieties of cotton 9732I, 5010-V, S-6022 exceeds the control plants by 10.0%, 12.3% and 35.6%, respectively. Stress-sensitive cotton samples under stress show a decrease in RNA synthesis. So, for example, in the cotton variety Senare, the decrease in RNA synthesis in comparison with control plants was 12.2%, in the variety 5904-1 – 14.1%. Moreover, the higher the depression of the physiological parameter under stress, the greater the decrease in RNA synthesis. So, the smallest depression of the physiological parameter was noted for the variety S-6040-1 – 14.8%, in which the depression of RNA synthesis was 10.7%. In variety 741, characterized by the highest degree of suppression of seed germination under the influence of drought stress (75%), there is a significant decrease in RNA synthesis (35%). The data obtained indicate that stress factors affect the functional activity of the plant genome.

Keywords: Plant genetics; Gene expression; RNA synthesis

Introduction

High and low temperatures, drought, soil salinization, the presence of heavy metals usually disrupt the life cycle of higher plants, being the main factors limiting plant productivity. Due to global warming, the size of areas where plants are exposed to water deficiency increases. According to the intergovernmental panel on climate change, the average temperature on the planet by 2025 could rise by 1°C, and by 2100 - by 3°C. As a result, significant changes in the areas of wild flora, the geographical distribution of cultivated plants and the duration of the agricultural season may occur [1, 2].

Drought, worsening the nutritional conditions of plants, leads to a slowdown in the development of cotton, changes in the quality of raw cotton and fiber, reducing its length and strength, as a result of which the productivity of plants is significantly reduced.

Aims and Objectives

The Institute of Genetic Resources of the National Academy of Sciences of Azerbaijan is engaged in the collection, preservation and study of various plants. Cotton collection includes about 1500 samples. Identification of drought-resistant genotypes and the study of resistance mechanisms is necessary for the successful cultivation of cotton.

In recent years a number of studies have been published, reflecting a complex of classical physiological changes occurring in plants in response to stress and related to such important functions as photosynthesis, respiration, water metabolism [3-6].

Of considerable interest is the study of changes in resistance and the processes that accompany them in the initial period of influence on plants of unfavorable factors, since it is during this period that events occur that largely determine the entire subsequent course of resistance formation [7].

Almost all plants respond to stress factor by activating various groups of genes and synthesizing the proteins they encode: regulatory (chaperones), enzymes. The effect of drought leads to a decrease in the cells of free water, changes the membranes of cytoplasmic proteins and affects the functioning of protein enzymes. The activity of enzyme synthesis is reduced, and hydrolytic processes are activated. This leads to an increase in the amount of low molecular weight proteins. Soluble carbohydrates accumulate in the cells as a result of hydrolysis of polysaccharides. The amount of RNA is reduced. Prolonged exposure to stress can lead to changes in DNA structure.

The study of nucleic metabolism is of great importance in connection with the elucidation of the adaptation mechanisms of plant organisms to stress. RNA synthesis is an indicator of the gene activity of the nucleus and reflects the activity of morphogenesis in plants. Therefore, we investigated the resistance to drought of cotton samples by indicators of changes in physiological parameters under stress, as well as the activity of RNA synthesis in plants, which are characterized by varying degrees of resistance to stress.

Materials and Methods

The object of the study was taken 70 varieties of cotton G. barbadense L. Assessment of plant resistance to stress was carried out by seed germination in a solution of sucrose that mimics physiological drought [8]. The determination of RNA content was carried out

according to the method of Alekseev [9]. A cluster analysis of the degree of stress resistance of the studied genotypes was performed using the UPGMA method of the SPSS 16 program. The analysis results were statistically processed [10].

Results

The degree of plant resistance to abiotic stresses varies both in different species and in different varieties of the same species.A common plant response to drought is the activation of adaptive mechanisms to changing environmental conditions. The ability of plants to adapt to the negative effects of stress is due to its genotype. Differences between varieties in terms of resistance are genetically determined and hereditarily persist in a number of generations. Of the most convenient methods for mass assessment of the relative resistance of plants to adverse environmental factors - a method for determining seed germination in osmotic solutions.

As a result of the research, it was found that with the same intensity of the extreme factor, the varieties of the same species of cotton significantly differ in the amplitude of the physiological parameter. The reaction of varieties to the impact of an unfavorable environmental factor allowed us, within the limits of a species, to divide varieties into groups, determining a different degree of comparative stability.

Using cluster analysis of the research results, the samples were divided into groups with varying degrees of drought tolerance. Cotton varieties AP-154, 9732İ, 5010-V, S-6022, S-6002 - drought-resistant. In these samples there is no stress-depression of the physiological indicator (Table 1).

No	Varieties	Seed germination (%)				RNA, (mg %)	
		Control	Experience	(%) from control	Stress-depression, (%)	Control	Experience
1.	AP-154	76.0	76.0	100	0	105.0 ± 4.35	141.312 ± 2.92
2	9732I	92.0	92.0	100	0	117.944 ± 2.42	129.72 ± 1.59
3.	5010-V	100	100	100	0	107.64 ± 5.18	120.89 ± 1.35
4.	S-6022	95.0	95.0	100	0	123.832 ± 1.51	167.88 ± 2.61
5.	S-6002	92.0	92.0	100	0	109.48 ± 2.56	128.98 ± 1.44
6.	C-6040-1	89.2	76.0	85.2	14.8	125.304 ± 2.61	111.872 ± 3.43
7.	5904-1	78.5	50.0	63.7	36.3	120.152 ± 1.44	103.22 ± 1.77
8.	Senare	94.8	40.0	42.2	57.8	122.36 ± 2.43	107.46 ± 2.58
9.	741	80	20.0	25.0	75.0	112.056 ± 1.59	72.864 ± 1.68

Table 1: Changes in seed germination and RNA content in cotton varieties under drought conditions.

The ability of drought-resistant seeds to germinate under stress conditions reflects, on the one hand, the hereditary ability to germinate with relatively less water, on the other hand, by the presence of a high suction force, which ensures rapid absorption of the required amount of water. High suction capacity of seeds contributes not only to better germination with a lack of moisture, but also to the formation of a more powerful primary root system, which is important for the further life of plants during droughts.

Discussion and Conclusion

High resistance of cotton varieties to stress determines their ability to maintain a normal level of metabolism with a wider range of stress and a higher rate of development of protective metabolism. Resistant plants, compared to unstable, most quickly rebuild their vital functions in the direction of adaptation to adverse environmental conditions.

C-6040-1, 5904-1, Senare, 741 varieties were characterized by depression of seed germination in sucrose solution. Stress sensitive plants under the influence of a negative environmental factor are more conservative and unable to quickly change their vital functions, as a result of which they often die.

In adverse conditions the response reaction of plants is the expression of genes. A few minutes of the body in adverse conditions is sufficient for the restructuring of the genetic apparatus. In this regard, in plants of cotton, characterized by varying degrees of resistance to drought, the activity of RNA synthesis was studied.

As shown by research results under drought conditions, the activity of RNA synthesis in stress-resistant samples 9732I, 5010-V, S-6022 exceeds control plants by 10%, 13% and 36%, respectively. Drought-resistant varieties AP-154 and S-6002 under stress conditions exceed control plants of RNA synthesis activity by 35% and 18%, respectively (Table 1).

Stress sensitive cotton samples show a decrease in RNA synthesis. For example, in the Senare variety, the decrease in RNA synthesis in comparison with control plants was 12%, in variety 5904-1 - 14%. Moreover, the higher the depression of a physiological parameter under stress, the greater the decrease in RNA synthesis. The smallest decrease in the physiological index was observed in variety C-6040-1 - 10%, in which the inhibition of RNA synthesis was 10.7%. In variety 741, which is characterized by the greatest degree of suppression of seed germination when exposed to drought (75%), a significant decrease in RNA synthesis is observed (35%).

Thus, a relationship was found between the degree of sensitivity to stress and the synthesis of RNA.

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