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Assessment of grapevine genetic resources based on physiological data

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ABSTRACT

One of the most important breeding priorities is the assessment and improvement of the resistance of cultivated fruit crop genotypes to environmental stressors. Abiotic factors often do not allow realizing the productivity potential of fruit plants, which entails a decrease in the efficiency of their cultivation and financial losses for producers. In this regard, varieties with increased resistance to extreme environmental conditions are of great importance. Therefore, it is necessary to develop and use practical approaches to study and isolate genetic sources of high stress resistance for use in plant breeding and introduction.

The aims of the studies were identifying the potential for resistance of grapevine genetic resources to abiotic stressors (through physiological diagnostics) and assessing new highly adaptive genotypes. We studied varieties and wild forms of grapevine differing in ecological and geographical origin to determine the main photosynthetic indicators (the total amount of chlorophyll, chlorophyll "a" / "b") in connection with their drought resistance. As a result of the study, grapevine varieties - (Ag Shany, Ag kishmishi, Tozlaiyjy, Girmizi kishmishi) and wild grapevine samples No.71, 17 No. 78, 25 No. 43, No. 74, 3 No.34 were identified as the most drought resistant. As a result of the study, relatively drought-resistant samples were identified, which are recommended for use in breeding work. Determination of the degree of plant resistance to extreme environmental factors will make it possible to assess the prospects of varieties of various fruit crops, including grapevine, for different soil and climatic zones of Azerbaijan.

***Keywords*:** Abiotic stress, chlorophyll, drought, environmental factors, grapevine, resistance.

INTRODUCTION

In Azerbaijan Republic the wild grape samples spread widely in large areas and on the banks and shores of rivers, lakes and sea and mountain slopes of Absheron, Nakhchivan AR, Ganja-Gazakh, Garabagh, Mil-Mughan, Shirvan, Talysh and etc. A number of researches were implemented in Khachmaz, Guba, Khudat, Nabran, Gusar, Shamakhi, Ismayilli, Aghsu, Oghuz, Gabala, Shaky, Zagatala, Lankaran, Fuzuli, etc. regions for studying the genetic resources of grape. At the same time as it may be noted that wild grape spread on the whole territory of Azerbaijan is very ancient formation. Wild grape - *V. vinifera* L. subsp. *sylvestris* (C. C. Gmel.) Hegi. of Azerbaijan is distinguished with specific characters. It is spread on the territory of Azerbaijan from 12 m below sea level (Kyur riverside, Salyan region) to 2000 m above sea level (Gusar region). There are two kinds of wild grapes in Azerbaijan: *typica* Negr. (with hairs) and *aberrans* Negr. (hairless). Hundreds (according to some information about more than 600) of landraces of grapevine are grown in the Republic (Musayev and Huseynova, 2016). White, red, black, pink colored table, technical and seedless grapevine varieties are cultivated here (Musayev *et al*., 2013; Maghradze *et al*., 2012; Musayev *et al*., 2019)

One of the most important breeding priorities is the assessment and improvement of the resistance of cultivated fruit crop genotypes to environmental stressors. The maximum productivity of cultivated crops is possible with an increase in their resistance to climatic stress. Abiotic stressors are the main limiting factor in agricultural productivity. There is a wide variety of fruit plants in Azerbaijan, including grapevines, which have great value as donors of high quality fruits and productivity and resistance to adverse external conditions. The usefulness and value of these crops lie in the fact that many of these plant species are adapted to growing in such difficult agricultural conditions as soil salinity, climate aridity and degraded or hilly field relief.

The meteorological conditions of the territory of Azerbaijan are often characterized by an insufficient amount of precipitation, saline soils, and a lack of moisture in the air and in the soil leading to a decrease in the activity of enzyme systems, disruption of water exchange, negatively affects photosynthesis, the assimilation of mineral nutrients by the plant organism. The violation of the basic physiological and biochemical processes led to the reduction of the productivity of plants. Abiotic factors more and more often do not allow realizing the productivity potential of fruit plants, which entails a decrease in the efficiency of their cultivation and financial losses for producers. In this regard, varieties with increased resistance to extreme environmental conditions are of great importance (Musayev *et al*., 2017).Therefore, it is necessary to develop and use effective approaches in order to study and isolate genetic sources of high stress resistance for use in plant breeding and introduction.

The main role in identifying the traits that determine its resistance to unfavorable environmental factors belongs to the physiological characteristics of plants. Determination of the degree of resistance to drought will make it possible to assess their prospects for different soil and climatic zones and to identify genetic sources with high stress resistance for their use in breeding and crop production. The use of physiological methods in combination with agro biological observations in fruit plantations makes it possible to reliably assess the degree of drought and salt tolerance of fruit trees, and to select stable and productive samples. The problem of adaptation of such valuable plants as sea buckthorn, grapevines, and other fruit crops deserves attention. The aim of our work was to study the content and ratio of one of the photosynthetic pigments - chlorophyll in the leaves of grapevine plants in connection with their drought resistance.

MATERIALS AND METHODS

The experiments were carried out in the department of fruit crops and physiology of the Genetic Resources Institute of the National Academy of Sciences of Azerbaijan. The objects of research were the leaves of the grapevine varieties and forms: Ag kishmishi, Gyrmyzy kishmishi, Tabrizi, Nakhichevan sary kishmishi, Hafizeli, Bayanshire, Shamakhy merendisi, Sary gile, Gush ureyi, Gizil uzum, Ag shany, etc., as well as wild grapevine samples.

The studies were carried out according to the methodological guidelines (Udovenko, 1988). One of the diagnostic methods of plant resistance to drought stress is to study changes for chlorophyll *(a + b)* in plant leaves under the influence of stress and to determine the degree of stress-depression of the pigment complex. Determination of the peculiarities of the pigment-protein complex of chloroplasts in plants under the influence of drought formed the basis of the method for diagnosing drought resistance.

The determination of plant resistance to drought was carried out according to some physiological indicators: the content and stress depression of the photosynthetic pigment complex (the content of the total amount of chlorophyll, chlorophyll *a, b*) in a sucrose solution simulating a lack of moisture. The assessment of plant resistance to drought by the magnitude of the decrease in the concentration of pigments was carried out using leaf cuttings placed in test tubes with sucrose solution (experiment) and water (control), after which, for the extraction of pigments, the material was placed in test tubes with 10 ml of 96% ethanol. Using a modern spectrophotometer (UV-3100PC, Japan), the optical density (D) of chlorophyll a and b in the total mixture of pigments was determined at two wavelengths (D665, 649), corresponding to the absorption maxima of pigments in this solution. Based on the data obtained, the ratio (in percent) of the concentration of pigments in leaf cuttings in an osmatic solution (experiment) to their concentration in water (control) was calculated. This ratio is a measure for determining the relative drought resistance of the compared objects - it is the higher, the greater the drought resistance of plants. Cluster analysis was determined by the coefficient of genetic proximity among the samples using the PAST computer program (Hammer *et al*., 2001).

RESULTS AND DISCUSSION

One of the indicators of the physiological state of plants associated with their productivity is the determination of changes in the pigment complex

Table 1: Physiological assessment of drought tolerance of grape samples

No.	The name of the variety and forms	The amount of chl. per unit leaf area, in mcg			
		Chlorophyll a+b		Change in the amount of chl-la under the influence of drought, in percent (%)	Degree of depression, in percent (%)
		Control	Sucrose		
1.	Ag kishmishi	1.38	1.67	121.0	0
2.	Tozlaiyjy	2.52	3.22	127.7	0
3.	Gyrmyzy kishmishi	2.62	3.13	119.5	0
4.	Tabrizi	1.76	1.88	106.8	0
5.	Misgaly	1.66	1.76	106.0	0
6.	Nakhichevan sary kishmishi	1.95	1.91	98.0	2.0
7.	Hafizeli	1.74	1.77	101.7	0
8.	Bayanshire	1.41	1.43	101.4	0
9.	Shamakhy merendisi	1.92	1.82	94.8	5.2
10.	Sary gile	2.07	1.92	91.8	8.2
11	Gush ureyi	2.03	2.16	106.4	0
12	Gizil uzum	2.75	2.40	87.3	12.7
13	Ag shany	1.19	1.79	150.4	0
14.	Madrasa	2.78	2.14	77.0	23.0
15.	Gara shany	1.80	1.31	72.8	22.2
	Wild grape samples				
1.	No 71	1.93	2.00	103.6	0
2.	17 No 78	2.08	2.32	111.5	0
3	No 74	2.77	2.97	107.2	0
4.	3 No 34	1.81	1.88	103.9	0
5.	18 No 13	2.92	2.98	102.0	0
6.	25 No 43	2.68	2.94	110.0	0
7.	10 No 79	2.84	2.81	99.0	1
8.	29 No 10	3.04	3.45	113.5	0
9.	27 No 80	3.16	2.81	89.0	11
10	1 No 4	2.57	2.13	83.0	17
11.	26 No 9	3.25	3.08	94.8	5.2
12.	No 72	2.25	2.28	101.3	0
13.	12 No 90	2.46	2.46	100.0	0
14.	5 No 32	1.30	1.24	95.4	4.6
15.	16 No 17	2.56	2.73	106.6	0
16.	31 No 13	2.94	2.99	101.7	0
17.	No 87	2.17	1.86	85.7	14.3

of the photosynthetic apparatus of leaves and the assessment of plant resistance to unfavorable factors, in particular to drought and salinity. The use of physiological methods in combination with agro biological observations in fruit plantations makes it possible to reliably assess the degree of drought resistance of fruit trees, and to select stable and productive samples.

In the adaptation and resistance of plants to unfavorable factors belongs to the structural elements of the plastid apparatus, as a material basis, providing its functional activity in changing

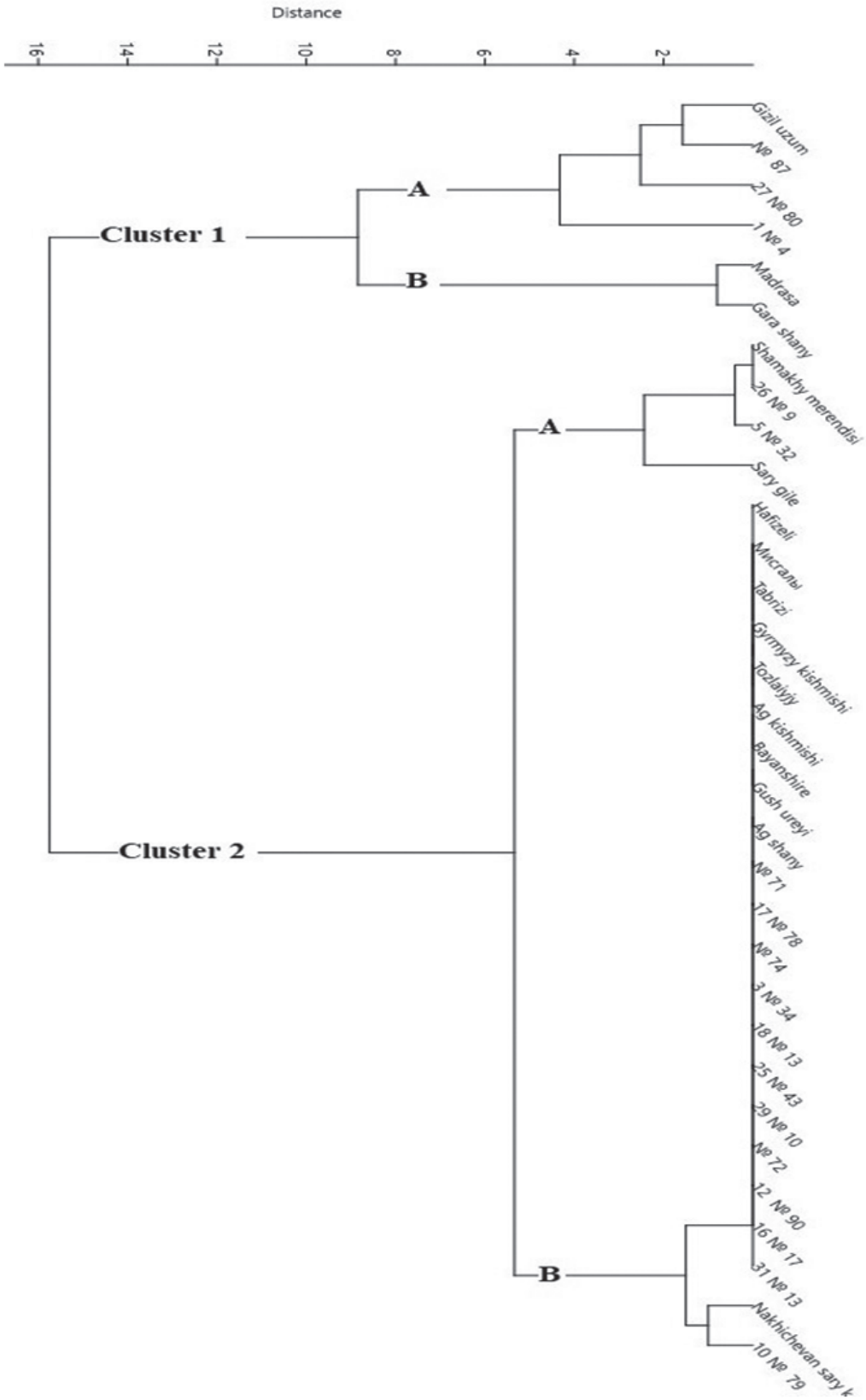

Fig. : Grouping of grapevine samples by grade change depression.

environmental conditions. The pigment system of plants is the basis for the photosynthetic conversion of solar energy into the energy of chemical bonds. The process of adaptation of plants to environmental factors of the environment is carried out at the level of cell organelles, in particular, chloroplasts, and the mechanisms of adaptation to these unfavorable factors in plants are different. The main photosynthetic pigments are chlorophylls (Chl), and carotenoids (Car) transfer additional energy to chlorophylls, performing a light-collecting function, performing a light-shielding function. The efficiency of the pigment system depends on the compliance of its structure and function with environmental conditions. Adaptation to abiotic stress factors can affect both the content of photosynthetic pigments and the ratio of their forms. At the same time, there are few data on changes in the pigment complex of plants under extreme abiotic conditions (Musayev and Huseynova, 2017; Ivanov *et al*., 2013). The inherent resistance of plants to regularly manifested unfavorable environmental factors is a mandatory feature and is carried out at the level of cell organelles, in particular, chloroplasts, and the mechanisms of adaptation to these unfavorable factors in plants are different. The pigment complex of the photosynthetic apparatus of plants is highly sensitive to changing environmental conditions. The efficiency of the pigment system depends on the compliance of its structure and function with environmental conditions (Musayev *et al*., 2017).

The research was aimed at identifying the influence of environmental extreme factors (drought) on the state of the main photosynthetic pigments, chlorophyll of grapevine plants in varieties that differ in ecological and geographical origin, as well as wild forms. The work evaluates the response to stressful actions of some varieties and wild forms of grapevines in order to study and isolate genetic sources with high stress resistance in terms of physiological parameters. The study of correlations between the amount of chlorophyll sum (a + b) and in the ratio (a / b) and changes in climatic factors in grapevine plants revealed changes in the content of the studied samples under the influence of drought stress. The following results were obtained (Table 1): 4 grapevine varieties - (Ag shany, Ag kishmishi, Tozlaiyjy, Girmizi kishmishi) were identified as highly drought-resistant. The degree of chlorophyll depression in the sucrose solution is completely absent in these varieties. The resistance of the studied samples to drought is confirmed by indicators that fluctuate within the range of 119.5% - 150.4%. The varieties of Tabrizi, Hafizeli, Misgaly, Bayanshire, Shamakhy merendisi, Nakhchivan sary kishmishi proved to be drought-resistant. Wild grapevine specimens, collection numbers No.71, 17 No. 78, 25 No. 43, No. 74, 3 No. 34 have been identified as highly drought tolerant.

It is known that the ratio of chlorophyll forms (*"a" / "b*") is an indicator of resistance to adverse environmental factors. Abiotic stress factors significantly affect the change in the pigment complex and the dynamics of the accumulation of the amount of chlorophyll. Changes in the pigment complex are explained, first of all, by a decrease in the labile form of chlorophyll, i.e. the amount of chlorophyll "*a*", while the amount of chlorophyll *"b*" is stable under these conditions. The change in the chlorophyll ratio ("*a*" / "*b*") observed in the research work can be considered an adaptive response (nonspecific) of the assimilation apparatus of plants to stress effects and, as a result, a decrease in the amount of the main photosynthetic pigment - chlorophyll "*a*" and an increase in the amount of the auxiliary form of chlorophyll "*b*" (Maghradze *et al.,* 2012).

The work also carried out a cluster analysis reflecting the physiological and genetic relationships between the samples studied by us (Fig.). As is known, cluster analysis is used to determine physiological and genetic similarities in terms of stress resistance and grouping of samples, i.e. creation of a database of the grapevine genetic resources studied by us. The results of the grouping of the samples obtained by us made it possible to distinguish 2 main clusters and to reveal the nature of the distribution of genotypes in the varieties and wild forms of grapevines studied by us. In each cluster, genotypes from different regions of Azerbaijan were grouped. The first cluster is Sub divided into 2 subgroups. Each subgroup consists of samples - variety Gizil uzum, form ^{1}87, 27^{1}80, 1 ^{1}. 4, varieties Madrasa and Gara shany, which were identified as moderately resistant: the degree of chlorophyll depression during drought is 12.7 – 23.0%. The second cluster turned out to be numerous, in which most of the samples studied by us are localized. This cluster contains 22 samples with high stress resistance, *i.e.* these samples were

assessed as highly resistant to drought stress (depression stress is 0%). Most of these samples, which are presented in the 2nd cluster, were taken from Nakhichevan. This cluster houses the grapevine form - 5 No. 32, Sary gile variety, form No. 87, varieties-Hafizeli, Misgaly, Tabrizi, Girmizi kishmishi, Ag kishmishi, Bayanshire, Ag shany and others. The second subgroup b included - forms 16 No.17 and 31 No. 13, variety Nakhichevan sary kishmishi and form 10 No. 79, that is, the first subgroup follows from the second, the second from the third. These samples are highlighted as resistant. Thus, from the constructed scheme, on the basis of the obtained results of cluster analysis, it can be concluded that 60% of the studied samples were resistant, 40% resistant and moderately resistant to stress. The presence of stress-sensitive samples was not recorded in our experiments.

The revealed results of the analysis indicate the presence of a number of general patterns in the deviation of the structural and functional parameters of the photosynthetic apparatus of plants under the influence of such unfavorable environmental factors as drought. Qualitatively the same type, common for all plants, the nature of the negative response of their photosynthetic apparatus to stress is expressed in a decrease in the content of pigments and in a general drop in the photochemical activity of chloroplasts. The magnitude of these deviations directly correlates with the level of tension of the stress factor and depends on the resistance of plants.

If we take into account the opinion that the response of the photosynthetic apparatus to an unfavorable external influence is nonspecific, common for plant organisms, character (Musayev *et al.,* 2017; Shishkanu and Titova, 1985), this suggests that the differences between genotypes that we have established are the levels of the response of the photosynthetic apparatus to the action of external factors, being reflection of unequal rates of internal structural and functional adjustment of plants to an unfavorable situation and characterize their adaptive ability and resistance to changing environmental conditions.

CONCLUSION

As a result of studying the genetic resources of wild and cultivated forms of the grapevine, the most drought-resistant samples were identified. These samples will later be used as donors in the breeding of new drought-resistant grape cultivars with high productivity and quality of berries.

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