STUDY OF GRAPE RESISTANCE TO STRESSORS OF THE WINTER PERIOD IN THE SOUTH OF RUSSIA

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Abstract

In a changing climate physiological and biochemical regularities of the formation of the sustainability of varieties of grape of different ecologo - geographical origin to the stress of the winter period in the South of Russia were identified. A parametric characterization of varieties of grape differing in resistance to low temperatures on the second and third components of hardiness were given.

Key words: *grapes, low-temperature stress, the components of winter hardiness, physiological and biochemical principles, water content, starch, protein, proline, sucrose*

1. INTRODUCTION

Evaluation of metabolites of the plant organism and its adaptation to stressors is the great importance in the conditions of changing climate. This will select the most promising varieties for future use and are best adapted to the soil and climatic conditions of cultivation zones. Biological characteristics of varieties play the decisive role in the adaptation of plants to the harsh and variable external factors during the cold season. A distinguishing feature of adaptation is high lability of physiological functions and biochemical reactions, ensuring the viability of the plant organism [2-4]. One of the priorities in the field of plant physiology and biochemistry research is knowledge of regulatory systems and mechanisms to ensure the order and regulation of physiological processes, the ability of plants to adapt to the changing environment in a wide range of conditions. Activation of protective and compensatory and other adaptive reactions grapes, including the regulation and preservation of the relative constancy of the internal aquatic plants as one of the principal means to adapt to varying environmental conditions and effects of damaging factors is the important in the conditions of a constantly varying environmental factors [5-12].

The purpose of this work is to determine the physiological and biochemical patterns of adaptation of varieties of grape of different ecological and geographical origin as well as the parameters of biochemical indicators of their stability with respect to the second and third components of winter-hardiness to abiotic factors of the winter season in south of Russia.

2. MATERIALS AND METHODS

The studies were conducted on the basis of ampelographic collection FGBNO AZESV&H located in Anapa, agronomical station of technical varieties of grapes on the southern carbonate soil, and in the center of collective use and Physiology and Biochemistry Laboratory FGBSO NCZSRIH&V. Materials of research are plants of planting of 1995, the rootstock Kober 5BB. Forming is a sided spiral cordon of AZOS. The scheme of planting is 3 x 2.5 m [13]. Object of research – varieties of technical purpose grapes: early maturation of ripening is interspecific hybrid of Euro-American-Amur – Crystal, the average period of maturation - interspecific hybrids Euro-American group Dostoiniy and Krasnostop AZOS. Content of free and bound water is determined by the gravimetric method, carbohydrates, protein is determined by spectral method, composition and amount of organic, phenol carbonic, indoleacetic and abscisic acids is determined by method of capillary electrophoresis instrument Capel 104 P to characterize the adaptive stability of grape plants to low temperature and water stress winter of Anapa-Taman area [14-19]. Experimental data were processed with traditional methods of variation statistics conventional.

3. RESULTS AND DISCUSSION

To identify the linkages in the dynamics of change of physiological and biochemical processes of various genotypes of grapes in the cold period of the year an analysis of data on changing the qualitative and quantitative composition of biochemical substances, actively involved in the exchange and red-ox processes under the influence of low temperature stress on winter-hardiness of components for the period 2011-2014 years was made. To identify the physiological and biochemical patterns in the system "a perennial plant – natural environment" the effect of hydrothermal conditions of Anapa-Taman area on the content of water of vine grapes was studied, which showed that the period when the plants were in a state of deep rest (December) has been quite favorable in all analyzed years, the temperature was not lower than – 9°C. In February of 2012 and 2014, when the plants are moved into a state of enforced rest, the air temperature dropped to – 20 °C and – 17 °C, respectively, which caused plant stress. Analysis of the data showed that the content of water of the grapevines in December for the period of 2011-2013 years in the variety Crystal (Euro-Amur-American origin) depended on the minimum of air temperature ($C_{correl.}$ = 0.95), and the varieties Dostoiniy and Krasnostop AZOS (Euro-American origin) – the maximum air temperature ($C_{correl.}$ = 0.91 and 0.99, respectively) and the amount of rainfall ($C_{correl.}$ = 1.0 and 0.96, respectively) (fig. 1).

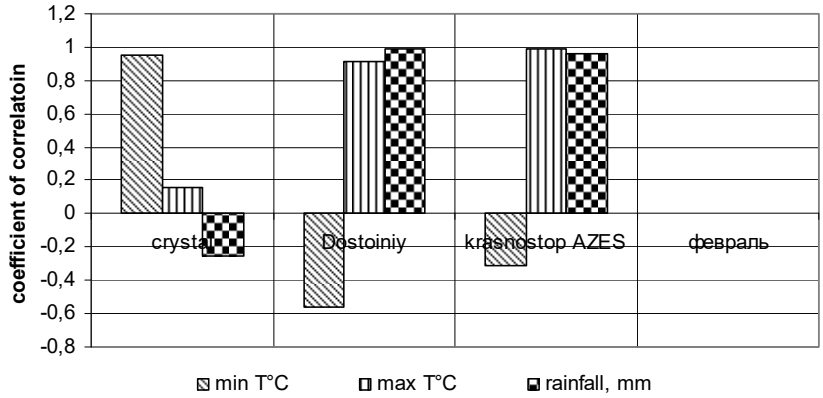


Fig. 1 - The dependence of water content in the vine on hydrothermal conditions of cultivation, December 2011-2013

First of all, it shows, that the stability of sort Crystal at low temperatures due to its origin from V. Amurencis (Amur wild grapes). This fact is confirmed by the constancy of the indicator "ratio related to the free forms of water" in the grapevines of sort Crystal in December for 2011-2013 years which indicates its tolerance, and reduction of this index in varieties Dostoiniy and Krasnostop AZOS – on their adaptation (fig. 2).

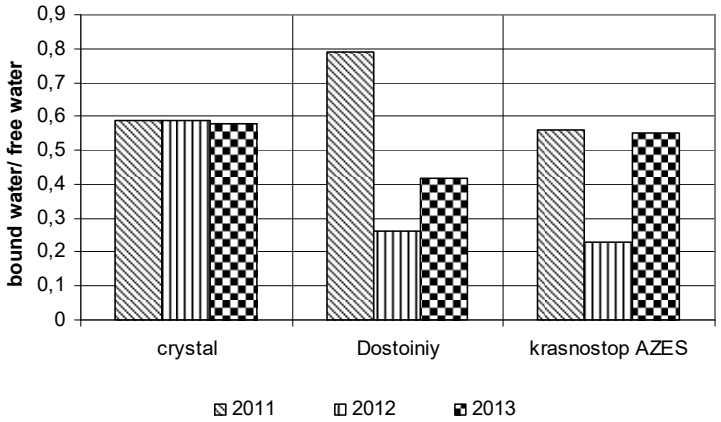


Fig. 2 - The content of bound water to free in the grapevine, December 2011 – 2013

We can assume that the water content defines mainly in the grapevine of the variety Crystal the depth of his rest, of the varieties Dostoiniy and Krasnostop AZOS the intensity of metabolic processes. The stability of plant cells to dehydration caused by the presence in them osmoprotectives (proline and sucrose): proline – polar amino acid, part of the protein cryoprotectives of cell membranes, the accumulation of which is correlated with resistance to low temperatures. Analysis of correlative connections between osmoprotectives and water-holding capacity showed that the water-retaining ability of the varieties of the Euro-American origin (Dostoiny and Krasnostop AZOS) depending on the content of a proline, and sucrose, and the variety Crystal (Euro-Amur-American origin) it is not independent content of osmoprotectives (fig. 3).

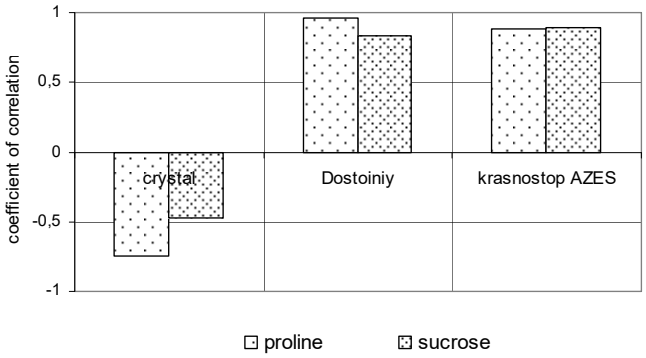


Fig. 3 - The dependence of the ratio of the content of bound water to free from the content of osmoprotectives in the grapevine, December 2011 – 2013

This suggests that the characteristics of adaptation to low temperature stress in varieties Dostoiniy and Krasnostop AZOS are inherited in a state of deep rest through the maternal line. Increased intensity of metabolic processes in varieties Dostoiny and Krasnostop AZOS allowing to stand under the conditions of low temperature stress characterized by a large protein content of the grapevine (fig. 4).

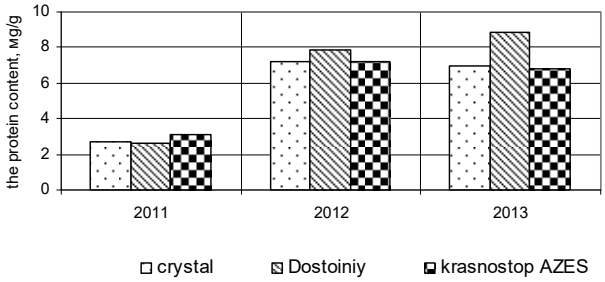


Fig. 4 - The protein content in the grapevine in December 2011-2013

This suggests that the mechanisms of resistance to the low temperatures of these varieties and of sort Crystal are differ. The study of the influence of the content of endogenous phytohormones IAA and ABA on the stability of the studied varieties to low-temperature stress found that the contents of the growth inhibitor of ABA ($C_{correl.}$ = -1) and the ratio of ABA / IAA ($C_{correl.}$ = 0.78) increase in it with decrease in the content of related and increase of the free water in the grapevine (fig. 5).

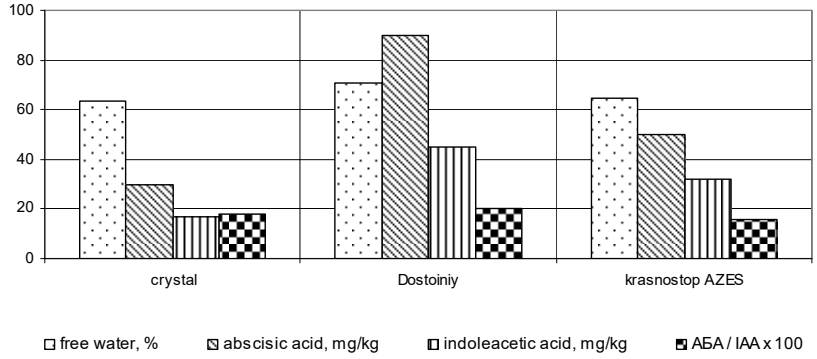


Fig. 5 - The content of endogenous phytohormones in the grapevine in December 2013

It is known that ABA is a stress hormone that plays a key role in the mechanisms of plant resistance to abiotic stressors. Varieties of Euro-American origin characterized by a high content of ascorbic acid and phenol carbonic inactivating free radicals under oxidative stress. Variety Crystal is characterized by a high content of anthocyanins and chalcones in grapevine that increase frost resistance. In February, grape plants were in a state of not deep rest. Under these conditions, variety Dostoiniy had a large water content (16.41 - 30.04%) than variety Crystal (15.94 - 27.95) and Krasnostop AZOS (10.44 - 28.42). At the same time a high level of correlation ($C_{correl.}$ = 0.9 -. 0.96) was marked with minimum air temperature. Indicator hydration of grapevines in February almost did not depend on the amount of rainfall, as evidenced by the ratio coefficient of correlation $C_{correl.}$= -0.1 - -0.2 (fig. 6.).

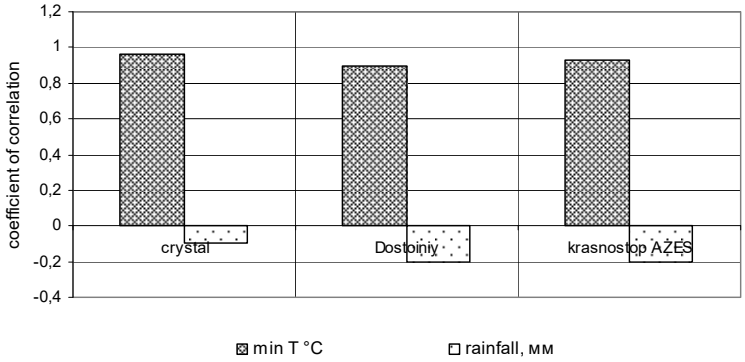


Fig. 6 - The dependence of water content in the grapevine from hydrothermal conditions, February 2011-2013

This suggested that a variety Dostoiniy earlier get out of the state of deep rest, and he proceeded more actively metabolism, which is indicated by a higher content of free-form water (54.21-80.43 %). At the end of February in 2014 year in comparison to December 2013 year, content of water in grapevine increased slightly in the variety Crystal – by 1.7 %, in the variety Dostoiniy – by 4.5 % and Krasnostop AZOS – by 1.0 %, which seems to be associated with a reduction in the minimum temperature -9 °C to - 17°C. The content of bound water in variety Crystal increased by 0.7%, which confirms its tolerance, in the variety Krasnostop AZOS – by 6.2%, suggesting that the hardening and in the variety Dostoiniy – decreased by 4.3%, which is probably, due to the activation of metabolic processes at a higher respiration rate. This is evidenced by a greater content of total organic acids of the Krebs cycle (fig. 7).

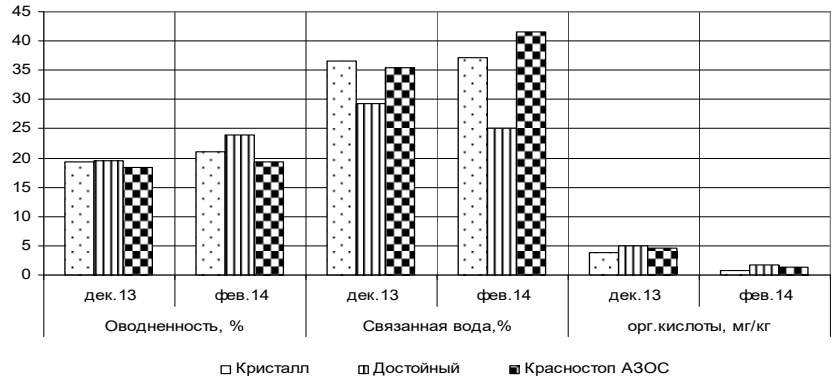


Fig. 7 - Characteristics of metabolic processes in the grapevine in December 2013 – February 2014

In February 2014 an increase in the content of variety Dostoiniy of anthocyanins was in 2.5 times and chalcones – 2.3 times compared with December 2013. Reduction of the amount of phenol carbonic, and the variety Dostoiniy was observed at varieties of Euro-American origin – ascorbic acid to protect cell membranes from damage. The increase of content of proline in the variety Crystal in 3.3 times, in the variety Krasnostop AZOS in 2.8 times and in the variety Dostoiniy in 0.4 times shows the increasing water-holding capacity of the cytoplasm and is a manifestation of a defensive reaction in their adaptation of the third component (not deep rest) of hardiness (table 1).

Table 1− Biochemical adaptation parameters of interspecies hybrids of grapes to stress winter period

Biochemical indicator	the period of deep rest	the period of not deep rest
Escaping water content of grain, %	18,30 – 31,87	10,44 – 30,04
The content of dry substances,%	68,13 – 81,70	69,96 – 89,56
The content of free water, %	63,02 – 81,25	43,26 – 90,38
The bound water content,%	18,65 – 36,98	9,62 – 56,74
The ratio of bound water/free water	0,42 – 0,79	0,08 – 1,31
The content of sucrose, mg/g	2,84 – 11,83	2,56 – 11,9
The content of starch, mg/g	3,19 – 15,24	4,24 – 11,22
The content of Proline, mg/kg	11,3 – 92,0	16,2 – 224,5
The protein content, mg/g	3,18 – 7,9	1,83 – 8,21
The content of free aminoacids, mg/g	0,13-0,66	0,1-0,45
The sum of cations, mg/g	1,73 – 3,34	1,78 – 2,82
The amount of carboxylic and ascorbic acid, mg/g	0,26 – 1,05	0,01 – 0,04

The analysis of long-term data allowed to give a preliminary forecast optima intervals varying biochemical parameters characterizing stability of grape plants of interspecific hybrids of different ecological and geographical origin Crystal, Dostoiniy and Krasnostop AZOS to stress factors of winter period in a state of deep rest and not deep rest.

Thus, for the period of 2012-2014 years physiological and biochemical parameters characterize the state of grape plants in natural environments are identified and high positive correlation between the biometric indicator – share of blossoming buds after over wintering and individual performance of the biochemical composition of the grapevines are found in the period of not deep rest in:

- interspecific hybrid Crystal containing the bound form of water and starch due to genetically determined;
- variety Dostoiniy with a free-form content of the water, due to the intensification of metabolic processes;
- variety Krasnostop AZOS with starch content.

CONCLUSIONS

Physiological and biochemical studies in the environmental conditions of 2013-2014 years have shown that varieties of grapes Crystal, Dostoiniy, Krasnostop AZOS have a good ability to adapt to changing environmental conditions. Adaptation of these varieties of grape to abiotic factors of the winter period is achieved by physiological and biochemical resistance mechanisms –increasing the content of the bound form of water, proline, sucrose, Ca^{2+}, ABA, performing the function of the tread. In assessing the physiological condition of varieties of grape by the physiological and biochemical, anatomical and morphological parameters it can be argued that the studied varieties have a large reserve of potential to adapt to stressors of winter period in the south of Russia.

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