

THE MECHANISMS OF THE ADAPTATION OF THE TYPES OF THE APPLE TREE OF DIFFERENT ORIGIN TO THE ABIOTIC FACTORS OF THE SUMMER PERIOD

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Abstract

Questions of the adaptation of the types of the apple tree of different ecologo- geographical origin and different ploidy to the conditions of the south of Russia are examined. It is revealed, that the types of the apple tree of domestic selection possess the large reserve of the potential possibilities to be adapted to the drought in the comparison with the introduced types of the foreign selection

Key words: *apple, drought, tolerance, proline, abscisic acid, guard cell*

1. INTRODUCTION

The apple tree - basic industrial culture of horticulture of Russia, which is characterized by adaptability, by profitability, by responsiveness to the intensive technologies of conducting gardens, by year-round use and it is the popularity of fruits in population.

The analysis of the prevailing assortment of apple tree in the North-Caucasian region shows that in spite of the essential renovation, the sufficiently extensive and renovated quality composition of apple tree do not satisfy completely the requirements of contemporary industrial intensive horticulture, it does not possess the entirely necessary combination of high adaptability to abio- and to the biotic stress factors of medium with the indices at the optimally tolerance level of productivity and quality of fruits [1- 3].

In connection with this is necessary the study and introduction into the assortment of the new promising types, including of local selection, most fitted out to the constantly changing conditions of environment, and which possess high stability to by basic biotic and to abiotic stress factors [4-7]. An increase of the stability to the unfavorable conditions of the living environment of fruit plants is possible only on the basis of detailed study of their physiological special features, knowledge of the mechanisms, which ensure their capability for adaptation.

Purpose of this work - to reveal the special features of the physiological biochemical and anatomomorphological mechanisms of the adaptation of the types of the apple tree of different ecologo-geographical origin to the abiotic factors of summer period.

2. MATERIALS AND THE METHODS OF THE STUDIES

The study carried out in 2013-2014 yr. on the base privately held company OPF "Central", FGBNU of NCRRIH&V, Krasnodar. The subjects of studies were the types of the apple tree of different origin served: Aydared (USA), Ligol (Poland), Persikovoe, Prikubanskoe (Russia, NCRRIH&V) 2009 yr. landing on the stock SK 4 with the diagram of landing 0,9 X 4,5; type Rassvet ($2n=2x$), Fortuna ($2n=2x$), Souz ($2n=3x$), the Rodnichok ($2n=3x$) (Russia, NCRRIH&V) of 2000 yr. landing and the type of Erly Mak ($2p=2x$) (USA), the Deyton ($2n=2x$) (USA) of 1998 yr. landing on the stock M 9 with the diagram of landing 2 X 5.

The tests of leaves selected in the morning hours of the summer months of vegetal period (since June until August), the determination of general liquid-water content of leaves, the content of the free and connected forms of water, proline, cations of calcium, saccharose conducted according to procedures [8 - 9], the content ABA - employing the modified by us procedure. Index of palisades determined as

the ratio of the depth of palisade to spongy mesophyll. Micro-objects they studied and photographed with the aid of the microscope “Olympus” BX 41 according to procedure [10].

3. RESULTS OF STUDIES AND CONSIDERATION

Summer periods in OPF “Central” Krasnodar 2013 - 2014 yr were hot. Already in May the temperature of air in 2013. it reached 32°S and in 2014. 35°S, in July and August 35 - 37°S. A quantity of fallen sediments in August on the comparison since June and by July was reduced and in August 2014 was noted drought (sediments - 0 mm at a temperature of air of 36°S). The reduction of sheet apparatus in the majority of the studied types of apple tree was noted for the duration of summer period 2013 and 2014 yr. (fig. 1).

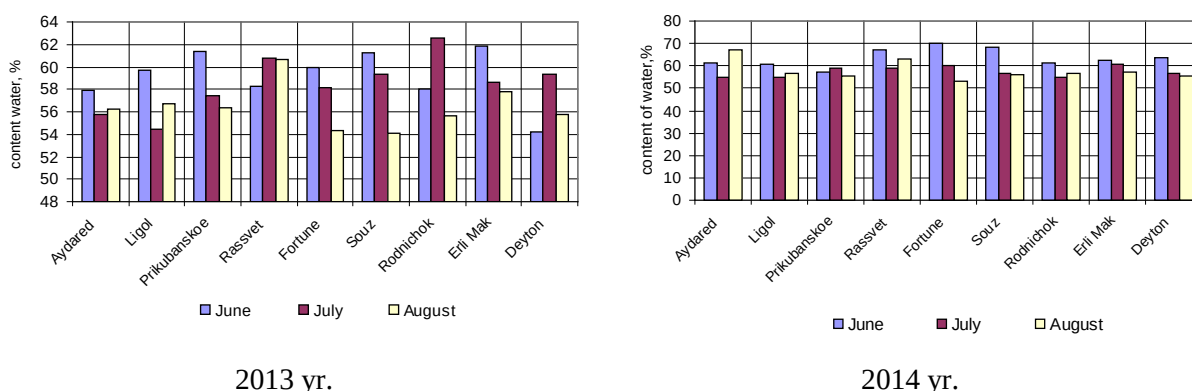


Fig. 1 Liquid-water content in leaves of apple tree in the summer period of 2013-2014 yr.

The types of Rassvet, Souz, Rodnichok, Aydaled and Erly Mak were characterized By larger content of water under the conditions of August drought 2014 yr. The change in the relationship of the connected and free forms of water in leaves serves as the index of the stability of plants to the low moisture receipt in the conditions of summer period (fig.2).

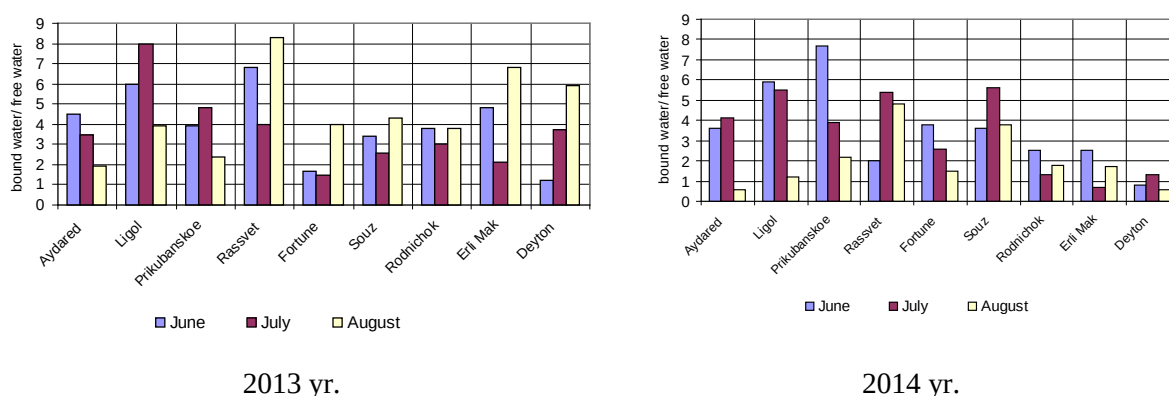


Fig. 2 The dynamics of the ratio of bound water to the free in the summer period

Under the conditions of the best moisture receipt 2013 yr. this index is most stable in triploids Souz (K= 2,6-4,3) and Rodnichok (K= 3,0-3,8). With the offensive of drought in August 2014. this index in

the majority of types is reduced in the comparison since July, moreover is less in triploids, and also diploid types Rassvet, Fortuna, Deyton it increases in the type of Erli Mak.

A reduction of the content of the connected form of water, from one side makes it possible to assume the activation of metabolic processes in connection with the adaptation, since the less changes the relationship of bound water to the free, the greater the adaptive potential can possess type. An increase in the content of the free form of water in August in the majority of the studied types (except types Rodnichok and of Erli Mak) makes it possible to also assume more active transpiration which can be connected with the state of stoma aperture ($K_{\text{correl}} = 0,49$).

In July the size of the closing cells of the stoma of leaves of the studied types of apple tree conversely correlates with the content of free ABA in leaves ($K_{\text{correl}} = -0,7$), and the connection between these indices in August weakens ($K_{\text{correl}} = -0,3$) (Fig. 3).

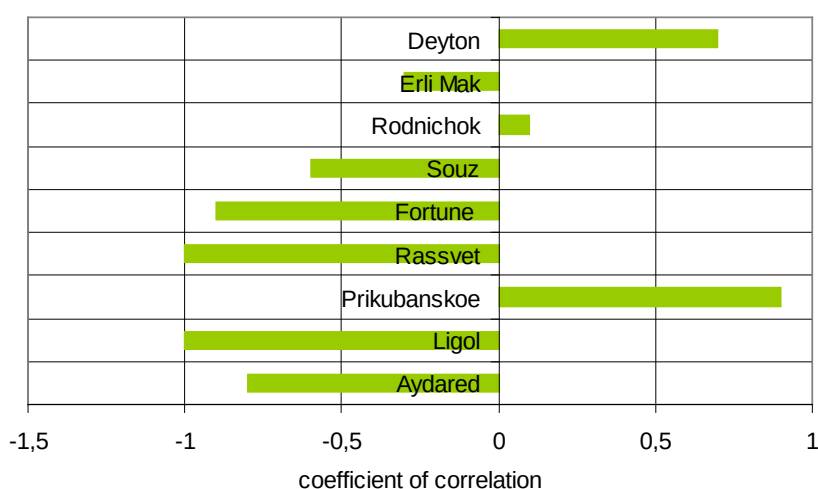


Fig. 3 The dependence of the content of free water in leaves of apple tree on the size of the closing cells of the stoma under the conditions of the summer period of 2014.

In this case a change in the size of the closing cells of stoma in the studied types in August on the comparison since July directly correlates with a change in the content ABA ($K_{\text{correl}} = 0,44$) in leaves.

The determination of correlation of dependence between these indices indicates other mechanisms of the regulation of the content of the free form of water in types Rassvet, Prikubanskoe and Deyton. The accumulation ABA under the conditions of low moisture receipt contributes to the decrease of stomatal apparatus.

The dependence of the dynamics of a change in the relationship of the content of bound water to the free from the dynamics of a change in the content of proline and saccharose in cytosol, and also from the size of the closing cells of openings allows to assume that the mechanism of the stability of leaves of apple tree to the dehydration under the conditions of 2014 g. it is caused by direct correlation dependence with the content:

- in the type of Aydaled of proline ($K_{\text{correl}} = 0,54$) and saccharose ($K_{\text{correl}} = 0,86$), with the size of the closing cells of stoma ($K_{\text{correl}} = 0,7$);
- in the type of Ligol - saccharose ($K_{\text{correl}} = 0,43$), with the size of the closing cells of stoma ($K_{\text{correl}} = 1,0$);
- in type of Prikubanskoe - with size of the closing cells of stoma ($K_{\text{correl}} = 0,7$);

- in type of Souz - saccharose (Kcorrel. = 0,98), with the size of the closing cells of stoma (Kcorrel. = 0,65);
- in type of Rodnichok - proline (Kcorrel.=0,79);
- in the type of Erly Mak - saccharose (Kcorrel.=0,8);
- in type of Deyton - saccharose (Kcorrel.=0,99);
- in type of Rassvet - proline (Kcorrel.=0,42)), with the size of the closing cells of stoma (Kcorrel. = 0,96);
- in type of Fortuna - by size of the closing cells of stoma (Kcorrel. = 0,95).

In types Rassvet, Rodnichok, the Fortuna, Souz, Erly Mak and Deyton in July are noted an increase in the content of the cations of Ca^{2+} in cytosol of the cells of leaves, while in the types of Aydaled, Ligol and Prikubanskoe - in August. In this case in triploids the Souz, the Rodnichok also of diploid Rassvet a change in the content of the cations of Ca^{2+} correlates with a change in the content ABA in leaves under the conditions of the summer period of 2014.

Should be noted an increase in the content of proline and saccharose in leaves of the studied types of apple tree in July and a notable increase in the content of proline with trace quantities of saccharose and decrease of the content of starch in August in types Rassvet, Fortuna, Souz, Rodnichok, Deyton and Erli Mak.

Reduction of the content of proline in the types of Aydaled, Ligol observed in August 2014 under the conditions of thermal shock, is characterized their low heat resistance under the conditions of the summer period of 2014. (table. 1).

Table 1 Content of second messenzherov ABA and cations Ca^{2+} in leaves of apple tree under the conditions of the summer of 2014, Krasnodar.

Copr	Content Ca^{2+} , mg/g			Content ABA,mg/kg			$K_{\text{correl}}^{\text{ABA end } \text{Ca}^{2+}}$
	June	July	August	June	July	August	
Aydaled	0,06	0,29	6,32	2,9	0,8	0,5	-0,63
Ligol	0,09	0,23	2,51	3,5	2,9	0,8	-0,99
Prikubanskoe	0,06	0,17	1,73	3,8	3,9	1,8	-0,99
Rassvet	0,07	2,24	0,16	3,1	4,3	1,9	0,87
Fortune	0,07	1,04	0,35	3,8	3,3	2,4	-0,12
Souz	0,13	0,76	0,29	2,3	3,4	1,7	0,82
Rodnichok	0,22	4,07	0,31	3,6	5,4	3,5	1,00
Erli Mak	0,01	3,01	0,27	3,5	2,1	2,3	-0,67
Deyton	0,01	1,03	0,65	4,3	0,6	3,7	-0,87

An increase in the content of starch in leaves of the studied types in July in the comparison since June (besides type Rassvet) will be coordinated with reduction in the activity of amylase complex. The content of starch in leaves is reduced in type of Rassvet, which can be connected with the predominance of its hydrolysis above the synthesis.

Given data make it possible to assume the activation of different signal systems in connection with the development in August 2014 aqueous stress, which is confirmed by a change in the content ABA, in

the cations of Ca^{2+} , osmoprotectors of proline, saccharose, protein, starch in leaves, by the size of the closing cells of stoma and by the number of stoma per unit of the area of sheet plate.

Content of pigments (chlorophyll of a+b) in 2014 with a sufficient moisture receipt (June, July) are more in the types of Aydaled, Rassvet, Souz, Rodnichok (4,12 - 6,79 mg/g), and under the conditions of drought (August) - in the types of Aydaled, Prikubanskoe, Rassvet, Fortuna and Erly Mak (4,22 - 8,69 mg/g). The study of the anatomo- morphological structure of the sheet plate of the types of the leaf lamina of tree of different ecologo - geographical origin carried out during the summer vegetal period one time per month (10.06.14, 15.07.14 and 20.08.14).

It is revealed, what in the studied diploid types of apple tree overall thickness of leaf lamina was 177,0 - 200,8 micrometer, in triploids 204,9 - 241,8 micrometer ($\text{NSR}_{0,95} = 24,09$); the thickness of cuticle and upper epidermis in the studied diploid types was 10,0 - 11,0 micrometer; the triploids have 11,1-11,6 micrometer ($\text{NSR}_{0,95} = 0,48$); a quantity of openings per unit of sheet surface in diploids was 212-269 micrometer; in triploids - 275-287 micrometer ($\text{NSR}_{0,95} = 18,64$); the length of openings in diploids was 53-56 micrometer, the triploids have 52-53 micrometer ($\text{NSR}_{0,95} = 1,55$); the width of openings in diploids was 30-34 micrometer, in triploids 29-31 micrometer ($\text{NSR}_{0,95} = 1,75$).

It is established that in the triploid types of apple tree of Souz, Rodnichok of local selection the xeromorphic signs, connected with the drought resistance appeared to the larger degree in contrast to the studied types of foreign selection. Studies showed that the greatest predominance of the layer of palisade parenchyma above the spongy is noted in types Souz and Rodnichok (index of palisades = 1,22 - 1,47) (Fig. 4).

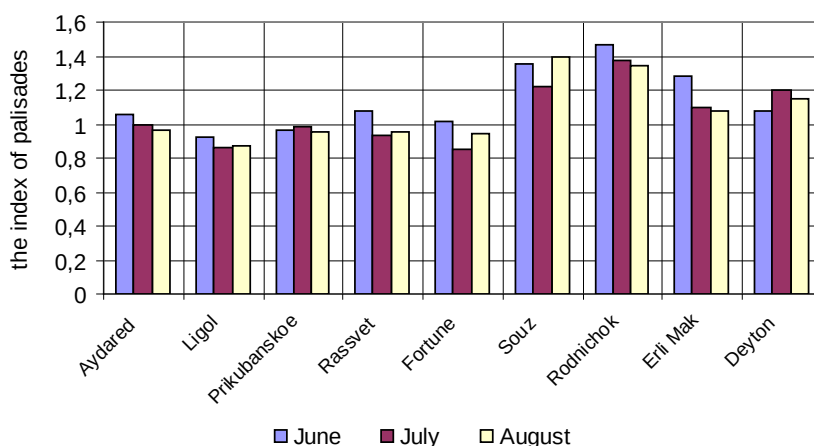


Fig. 4 Dynamics of the index of palisades of leaves of apple tree in summer period 2014 yr.

The obtained results make it possible to assume the best adaptation to the drought in the types of the apple tree of domestic selection and especially in the triploid types of apple tree Souz and Rodnichok.

CONCLUSIONS

The anatomo- morphological and physiologo - biochemical studies, carried out in the ecological conditions of 2013-2014, they showed that the triploid types of apple tree Souz and Rodnichok, and also diploid type Prikubanskoe of regional selection possess grow prettier by the capability to be adapted for the changing conditions of water supply. The adaptation of these types of apple tree to the abiotic factors of summer period is achieved with the aid of the physiologo - biochemical and anatomo- morphological mechanisms of stability - by increase in the content of the connected form of water, proline, saccharose, cations of Ca^{2+} , ABA, which fulfill protector function, by the manifestation of the xeromorphic signs of leaf lamina, by an increase in the index of palisades. Evaluating the physiological state of the types of apple tree according to the physiologo - biochemical

and anatomo - morphological parameters it is possible to assert that the type of the apple tree of the selection of regional selection, especially triploid, possess the large reserve of the potential possibilities to be adapted to the drought in the comparison with the introduced types of foreign selection.

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