Review Paper
10.7251/AGRENG1701028I
UDC 634.26:581.132.1

COMPARATIVE CHARACTERISTICS OF PHOTOSYNTHETIC ACTIVITY OF NECTARINE CULTIVARS AND FORMS WITH DIFFERENT COLORED LEAF PLATE

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ABSTRACT

Genotypes of nectarine with red leaves were created in Nikita botanical gardens. They have commercially valuable properties and biological characteristics (resistance to powdery mildew, large-fruited, the ability of transmitting the trait of red leaves with constant result to progeny seed, etc.). The aim of our researches was to study the main indicators of photoactivity of leaf apparatus of nectarine with green and anthocyanin leaves coloration. Investigations have been carried out in 2010-2015 on intact leaf plates for three cultivars and forms of nectarine with green leaves – Rubinoviy-8 (control), Chemus, Krymtsuht 53-85 and 2 forms with anthocyanin coloration of leaf plate (NektadianaKrasnolistnaya 996-88, Krasnola 495-86). Photosynthetic activity was characterized by chlorophyll fluorescence parameters (Kautsky effect). The content of chlorophyll *a* and *b* were determined by spectrophotometry. The cultivar Rubinoviy-8 and the form - Krasnola 495-86 were selected according to intensity indicators of the primary reactions of photosynthesis. Anthocyanin forms concede cultivar Rubinoviy-8 in efficiency of the primary reactions of photosynthesis an average of 48-50%; but they exceed nectarines Chemus and Krymtsuht 53-85 with green color of leaves of 23-25%. The efficiency of energy supply in the "dark" reactions of photosynthesis in all varieties and forms of nectarine maintained within 41-46%. But the further ability to utilize received energy is most efficiently implemented at the nectarine cultivar Rubinoviy-8 and form Krasnola 495-86. The forms of red-leaved nectarine in comparison with traditional cultivars are distinguished by a great potential for retaining the stability and productivity of the functioning of the photosynthetic apparatus.

Keywords: *nectarine, leaves, photoactivity, fluorimetric indicator, chlorophyll.*

INTRODUCTION

The Nikita Botanical Gardens collected a large collectionof nectarine of cultivars and forms. It contains more than 156 genotypes. The collection comprises cultivars and formsfrom own breeding well as the introduced samples obtained from various regions of the world. Genotypes with red coloration of leaves account for 15%of total number.

An important input to the development of nectarine provided Shoferistov E. P.,doctor of biological sciences and leading researcher. Under his leadership there were elaborated basic principles of reference of this culture, introduced cultivars from natural regions of the Europe, China and America, alongside with greenle-aved plants were created nectarine genotypes with red colored leaf. Our team bred a range of promising cultivars with excellent combinations of economically valuable traits for using in the Crimean farm-garden industry. In 2015, we received the plant patents for 3 cultivars: (Rubinoviy 8, Nikitskiy 85, Krymchanin), setting out their growing in Russian nurceries (Shoferistov, 1999; Smykov, 2015).

It should be noted that the department of horticultural crops of Nikita botanical garden newly produced hybrids of red leaf peach with nectarine (P. *vulgaris* Mill. subsp. *Atropurpurea*(Schneid.) which were characterized by intense anthocyanin coloration of fruit pulp and leaves.

As a result of long term research there are allocated: 1) red colored leaves nectarines called Krasnola 179-81, Krasnola 436-85, № 703-89 and others capable to transmit constantly the trait of leaf red coloring to seed progeny; 2) red colored leaves nectarines that are resistant to powdery mildew (*Sphaerothecapannosa* Lev. var. *persica*Woronich) – 485-86, 495-86, 500-86, 501-86, NectadianaKrasnoli-stnaja 996-88 (Figure 1.)and others; 3) red colored leaves nectarines with large size fruit (110-130 g) – 487-89 (Figure 2.), 703-89, 485-86 and others (Shoferistov, 1995;Shoferistov E. and Ovchinnikova Iu.,2006).

a)

b)

Figure 1. Red leaves (a) and flowers (b) of nectarine Nektadiana Krasnolistnaja 996-88.

Figure 2. Fruit of nectarine 487-86

In world practice plants with anthocyanin coloration of leaves are widely used in ornamental gardening and small-stature clonal rootstocks are widely used (Usova, 1997; Romanov and Usova, 2007). Red leaf color is caused by anthocyans which alongside with chlorophyll and carotenoids are the main plant colorants of flavonoid group (Harborne, 1967; Harborne, 1976;Kulikov and Ivanova, 1976;Brouillard, 1993). The feature of red leaf color hasn't been studied sufficiently but at the same time it could be regarded as a universal method to increase agricultural plant productivity due to anthocyanins that take part in photosynthetic process of vegetal pigment. The interest in such non-traditional forms in horticulture arises in connection with the peculiarities of their functioning in the conditions of high temperature, moisture deficit and overall stability relating to productivity. Anthocyanins protect plants from ultraviolet radiation, increase frost resistance, rooting ability, asphyxiation and diseases and pests resistance (Romanov and Usova, 2007; Trutneva et al., 2012).

Current photosynthetic activity researches are commonly performed on greenleaved plants. In the main such researches were conducted on peach, nectarine, apricot, apple and others fruit species. These characteristics weren't studiedon nectarines withred leaves. Present research article represent the results of experiments conducted on green and red colored nectarineleaves of using fluorimetric indicators, indirectly characterizing the photosynthetic activity of pigmented structures.

The fluorescence and its kinetic components are often used for analysis of efficiency of photosynthetic processes in the leaves of higher plants (Edwards and Uoker, 1986). The most interesting is the technique based on photoinduction of chlorophyll fluorescence (Kautsky effect). Its essence lies in the fact that with the reducing of fluorescence intensity grows the intensity of photosynthesis, the higher the level and the more the duration of fluorescence, the less effective functions the photosynthetic apparatus of leaf. The indexes of intensity of photo-induced chlorophyll fluorescence (F) were evaluated on the basis of following principles, which, at the root, do not go against modern ideas about photoactive properties of leaf apparatus:

- the indexes F_m, F_0, F_v/F_0 – characterized the efficiency of primary of photosynthetic reactions in the leaves, related to functioning of light-harvesting chlorophyll-protein complex. The higher index value, the larger the potential of relative cultivar or form as to exercising of photosynthesis and photoactivity;
- the index $(F_m\text{-}F_{st})/F_m$ – served to display the degree of exercising secondary or "dark" photosynthetic reactions: the higher index, the more efficient function photosynthetic reactions related to productivity;
- indexes F_{st}, $T_{0,\ 5}$ – are used for indirect characterizing the efficience of secondary photosynthetic reactions, their value is in inverse proportion to photoactivity of this stage of photosynthesis

The aim of our study was to examine the main indicators of photoactivity of varieties and leaf apparatus of nectarines with green and red leaves coloring.

MATERIALS AND METHODS

The studies were conducted in laboratory conditions on intact leaf plates at 3 greenleaved nectarine cultivars and forms - Rubinovyi-8 (control), Chemus, Krimzucht 53-85 and 2 forms of nectarine with red colored lamina (Nektadiana Krasnolistnaja 996-88, Krasnola495-86). Changes in fluorescence intensity were carried out on a portable fluorometer "Floratest". Leaves were taken in triplicate of each cultivars and before measuring fluorescence parameters they were adapted to the dark during 8 minutes. In the spectral range of operation of photosynthetically active forms of chlorophyll (690 nm) multi photoinduction fluorescence curves were recorded (Kautsky effect) (Buschmann, 1986; Romanov et al., 2007; Stirbet, 2011). Following parameterswere recordedduring the experiment: F_0 -background or zero level of fluorescence; F_m - maximum fluorescence level, coincides the start of productive photosynthetic processes, CO_2 fixation and activation of enzymes of the Calvin cycle; F_{st} - fixed level of fluorescence, indicating the establishment of a stable and most intense level of photosynthesis; F_v - variable fluorescence, which indicates the difference of the maximum and fixed levels $(F_m\text{-}F_0)$, specifying the ability of the chlorophyll-bearing apparatus to provide photosynthesis; $(F_m\text{- }F_{st})/F_m$ - ratio of fluorescence induction; F_m/F_{st} - fluorescence decay rate (Brionet al.,2000; Korneyev.,2002). The content of chlorophyll a and b was determined by spectrophotometry(Gavrilenko et al.,1975).

RESULTS AND DISCUSSION

Using the indexes of efficiency of primary photosynthetic reactions, we could select nectarine cultivars Chemus, Rubinovyi-8 and the form Krasnola 495-86 (Table 1.). They differed from the other cultivars and forms by an increased pool of light-harvesting complex (Fm), as well as by more significant content of photosynthetically active chlorophyll forms (Fv/F_0). Its value was high at the green-leaf nectarine as well as at red-leaf form Krasnola 495-86. The average value of F_v/F_0 at these cultivars is higher by 32 % than at nectarine Krimzucht 53-85 and the red-leaf form Nectadiana 996-88. As we can see, among studied nectarine cultivars and forms there are plants, contrasting at photoactivity.

Table 1. Indexes of photosynthetic activity of nectarine cultivars and forms.

Cultivar/form	Photoactivity indexes, rel. un.						
	F_0	F_m	$\frac{F_v}{F_0}$	$\frac{F_m F_t}{F_m}$	F_v	F_t	$T_{0,5}$
Rubinoviy-8 (c)	43. 7±3. 2	75. 2±5. 4	0. 9±0. 2	39. 8±3. 8	38. 3±1. 2	48. 3±1. 2	28±2. 0
Chemus	17. 2±1. 3	50. 0±4. 1	1. 9±0. 4	46. 3±2. 5	32. 3±2. 6	26. 9±2. 1	19±1. 5
Krimzucht 53-85	17. 1±2. 5	35. 8±2. 8	1. 1±0. 3	42. 2±2. 3	18. 7±3. 2	20. 7±3. 0	24±3. 0
Nectadiana Krasnolistnaja 996-88	18. 6±1. 2	40. 6±4. 0	1. 2±0. 3	43. 0±1. 8	22. 2±1. 7	23. 1±4. 1	38±2. 0
Krasnola 495-86	25. 2±2. 3	62. 8±4. 7	1. 5±0. 2	42. 0±2. 6	37. 8±2. 2	36. 4±2. 6	53±1. 0

The high photoactivity level, peculiar to selected green-leaf nectarines Rubinoviy 8 and Chemus, is caused by an increased pool of light-harvesting complex (F_m). Moreover, the Rubinoviy 8 showed the highest value of F_0, averagely 2. 5 times more than other nectarine cultivars and forms. The light-harvesting complex volume (F_m) and the content of photosynthetically inactive chlorophyll forms, shown by the red-leaf nectarine Krasnola 495-86, is 1. 5 times higher than that of all others, exclusive Rubinoviy 8. It is to be noted that a higher light-harvesting complex volume does not affect the quantum photosynthesis efficiency (maximum photochemical quantum yield photosynthesis, Fv/ F_0). If anything, the light quantums utilization efficiency, displayed by Rubinoviy 8, is much weaker. Approximately, 1. 5-2. 0 times lower than that of the green- / red -leaf cultivars Chemus / Krasnola 495-86. As seen from the table 1, there appears to be no clear difference between the green- and red-leaf nectarine groups after the indicator Fv/ F_0. The efficience of energy transfer to secondary or "dark" photosynthetic reactions (index $(F_m-F_{st})/F_m$) remains in the range between 41 to 46 %. But the capacity for productive using of energy coming from the light-absorbing complex, is being realized in a most effective way by genotypes of nectarines Chemus, Krimzucht 53-85 and NectadianaKrasnolistnaja 996-88. On average, they use the energy arrived from primary photosynthetic reactions1. 5 to 2 times more effective for productive processes. It is being reached by means of the faster ($T_{0,5}$) and lower fall of intensity of the photo-induced fluorescence (F_{st}). At red-leaf forms NectadianaKrasnolistnaja 996-88 and Krasnola 495-86 was noted a less speedy fall ($T_{0,5}$) of the intensity of fluorescence. It is 1. 5 times slower than at control cultivar Rubinoviy and almost 2 times higher than at green-leaf cultivars Chemus and Krimzucht 53-85. Most probably this is caused by blocking energy transfer from light-harvesting complexes and by energy redirection towards the unproductive photosynthetic processes. A difference between green- and red-leaf nectarines in the light-harvesting complex volume, the quantum photosynthesis efficiency and the following "dark" photosynthesis processes suggest an effect of the red-leaf-pigments on the leaf apparatus photoactivity. The advantage (their increased concentration) in leaves, probably, affects the stability level of the chlorophyll-protein complexes in photosynthetic systems, which are exposed to a significant deactivation at high illuminance levels. That may cause an increased volume of light-harvesting complexes and a large number of photosynthetically inactive chlorophyll forms at red-leaf nectarines. We could detect that the red-leaf nectarine forms have a reduced content of chlorophylles*a* and*b*, their quantitative relationship were 1. 2 times lower than at green-leaf genotypes (Figure 3).

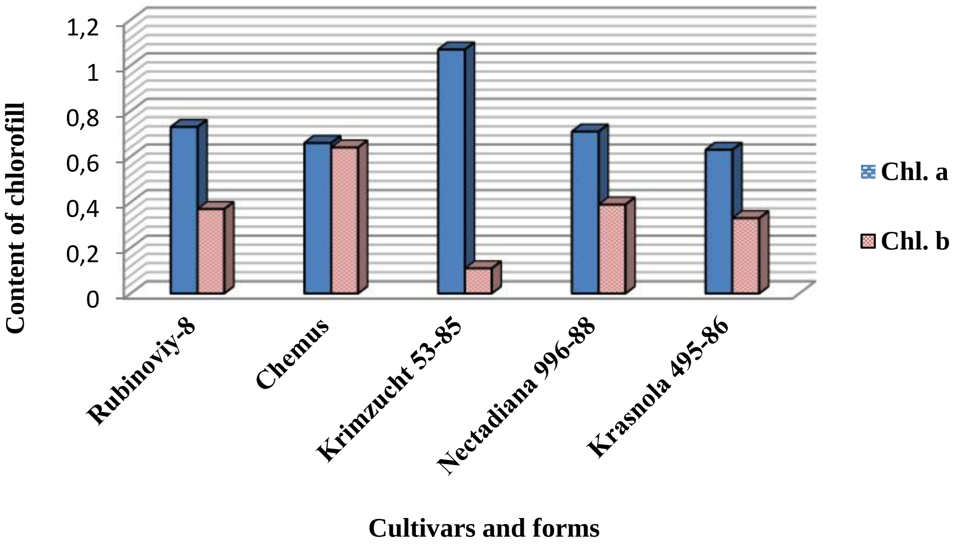

Figure 3. Content of chlorofill forms *a* and *b* in the leaves of nectarine cultivars and forms.

CONCLUSION

All together, both nectarine forms, with the red and with green leaves, are notable for sustainable parameters of photosynthesis. The red-leaf nectarine forms, in comparison with traditional cultivars, show reduced chlorophyll content but they have a great potential for maintaining sustainability and productivity of the function photosynthetic apparatus. The future research could clarify the role of red-leaf forms in productivity forming and remove defects in reducing photoactivity at the stage of secondary photosynthetic reactions.

ACKNOWLEDGEMENT

This study was funded by a research grant № 14-50-00079 of the Russian Science Foundation.

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