THE STUDY OF REFLECTION SPECTRA AS AN INDICATOR FOR ENVIRONMENTAL STRESSES ON FRUIT TREES

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Abstract

Objective of the study is to evaluate the activity of photosynthetic apparatus of some fruit trees in the area of Tirana in the presence of environmental stresses to which are exposed. The measurements were carried out with three types of leaves (sun, half-shade and shade) of two different pear varieties: Santa Maria and Abbas. The shape of the Chlorophyll fluorescence emission spectra and reflection spectra, as well as the values of certain ratios exhibit characteristics changes between analysed leaves. This demonstrate structural and functional modifications as a result of adaptation to different light environment. All parameters and ratios allow to characterize differences between different pear varieties evaluating the effects of growth conditions or stressors on the functionality of photosynthetic apparatus.

Key words: Fruit trees; reflection spectra; photosynthetic pigments.

Introduction

Spectral characteristics, fluorescence and reflectance, describing the possible changes and damages to the structure and function of photosynthetic apparatus in the presence of environmental stress, provide data on the quantum conversion of solar and photosynthetic activity in leaves. Chlorophylls are green photosynthetic pigments which allow plants to get energy from light. In the process of growth plants are exposed to a variety of stressors that directly or indirectly affect the function of photosynthetic apparatus in leaves (Babani and Lichtenthaler, 1996; Lichtenthaler and Babani, 2004; Lichtenthaler *et al*. 2000). High temperature and high light combined with other stresses and pollution reduce the activity of photosynthetic apparatus.

Plant adaptations to different exposed light environment during their growth affect development of the entire plant and particularly to chloroplasts and their structure, thylakoid arrangement as well as the relative amounts of the photosynthetic pigments, the chlorophylls and carotenoids. Thus these adaptations implicate both structural and functional differences (Lichtenthaler *et al*., 2000; Lichtenthaler *et al*., 2013). Sun leaves with their sun chloroplasts (low and narrow grana stacks) possess higher values for the ratio Chl a/b and lower values for the weight ratio total chlorophylls to total

carotenoids, ratio (a+b)/(x+c), as compared to shade leaves with their shade chloroplasts (broad and high grana stacks) (Lichtenthaler and Babani, 2004). Within a tree crown there also exist the leaves of the north crown of trees termed blue-shade leaves which differ in their reception of light quality and quantity from sun and shade leaves. These leaves are receiving only blue sky light but never full sun light (Lichtenthaler *et al*., 2013). In addition, trees possess half-shade leaves which are in the shade during the major part of the day, but that also receive full sunshine for a short period during the course of the day.

The purpose of this study is to evaluate the activity of photosynthetic apparatus of some fruit trees in Tirana area in the presence of environmental stresses to that are exposed.

Material and methods

Plants

Measurements were carried out with leaves selected on three kinds of positions (sun - south part of crown, blue shade - north part and half-shade/shade - inside a tree crown) of two different varieties of pear Santa Maria and Abbas that belong to the group of species *Pyrus Communis L* pears and family of a rose. Both varieties are characterize by a very good harvest without serious problems of diseases and pests, fit well in dry land without water, field and hill. The Santa Maria pear is a summer variety resistant under suitable conditions for at least three months; ripening period is on June, are characterized by an average grain size and yellow color. Abbas variety is resistant to two months; the grain size is larger than the first variety with color yellow to red, ripening period is late August early September.

Pigment determination

Leaf pigments were extracted with 100% acetone in the one circular piece of 9mm in diameter cut from the leaves using a mortar. The pigment extracts were centrifuged for 5 min at 500 X g in glass tubes to obtain the fully transparent extract. The pigment contents, Chl a, Chl b and total carotenoids, were determined spectrophotometrically from acetone extract using the extinction coefficients and equations re-determined by Lichtenthaler (Lichtenthaler 1987; Lichtenthaler and Buschmann, 2001). The represented values are the mean of six determinations from six leaves.

Reflectance spectra

Leaf reflectance (R) was recorded from upper side of the leaf in a spectral range from 400nm to 800nm with a spectral resolution of 2nm with a spectrophotometer equipped with an integrating sphere attachment (Bushmann *et al*., 2012; Gitelson *et al*., 2003). Leaf reflectance spectra were recorded against barium sulphate as a white reference standard. Leaves were placed on black velvet used as a background which has a reflectance less

than 0.5% over the spectral range of measurements. Reflectance (R) was represented as the ratio of the radiation intensities reflected by the leaf sample and the white standard respectively. The leaf spectra were taken in the intercostal fields between the larger leaf veins. These spectra represent an integrated signal over several square centimeters.

Results

Photosynthetic pigments

For leaves of Abbas pear variety selected in the period May, can be demonstrated that the contents of Chl a, Chl b, Chl (a+b) are higher. Also the photosynthetic pigment contents of chlorophylls and carotenoids on the period May in both varieties, Santa Maria and Abbas, represented higher values in sun leaf (south part of crown tree) than other leaf types (Tab. 1).

Table 1. Levels of Chl a+b and total carotenoids (x+c) per leaf area unit as well as the pigment ratios Chl a/b and chlorophylls (a+b) to carotenoids (a+b)/(x+c) between sun, blue-shade, shade/half-shade leaves of *Santa Maria* and *Abbas* variety trees. Mean values of 6 determinations per leaf-type.

Leaf-type	**Chl a+b (mg dm^{-2})**	**Chl a/b**	**(a+b)/(x+c)**
***Santa Maria* - May**			
Sun	6.301 ± 0.012	2.67	4.28
Blue-shade	5.444 ± 0.012	2.49	4.26
Half-shade/shade	4.833 ± 0.019	2.15	4.48
***Abbas* – May**			
Sun	7.236 ± 0.046	3.040	4.089
Blue-shade	4.464 ± 0.011	2.528	5.342
Half-shade/shade	4.094 ± 0.010	1.968	5.689

The ratios of the photosynthetic pigments, Chl a/b and (a+b)/(x+c), that reflect the light adaptation of the photosynthetic apparatus (Lichtenthaler 2013) shown different values in the three leaf types. In sun leaves the mean values of the ratio Chl a/b are higher as compared to blue-shade and shade leaves (Tab. 1). Sun leaves displayed lower values of the ratio (a+b)/(x+c) as compared to two other leaf types (Tab. 1). Abbas variety in comparison with Santa Maria variety shows higher values of concentrations of photosynthetic pigments. These variations among three types of analysed leaves are related to the chlorophyll content being lower in shade leaves and higher in sun leaves (Tab. 1).

Reflectance spectra

Reflectance spectra of the three types of leaves of both pear varieties exhibited a higher reflectance between 500nm and 650nm, in the green-to-orange range of the spectrum, and mainly at wavelengths between 680nm and 740nm in the near infra-red. In addition reflectance spectra exhibited a low reflectance between 400nm and 500nm in blue part of visible spectra and also near 680nm in red part of visible spectra (Fig. 1). The observed variations correspond to the absorption region of the in-vivo chlorophyll bands.

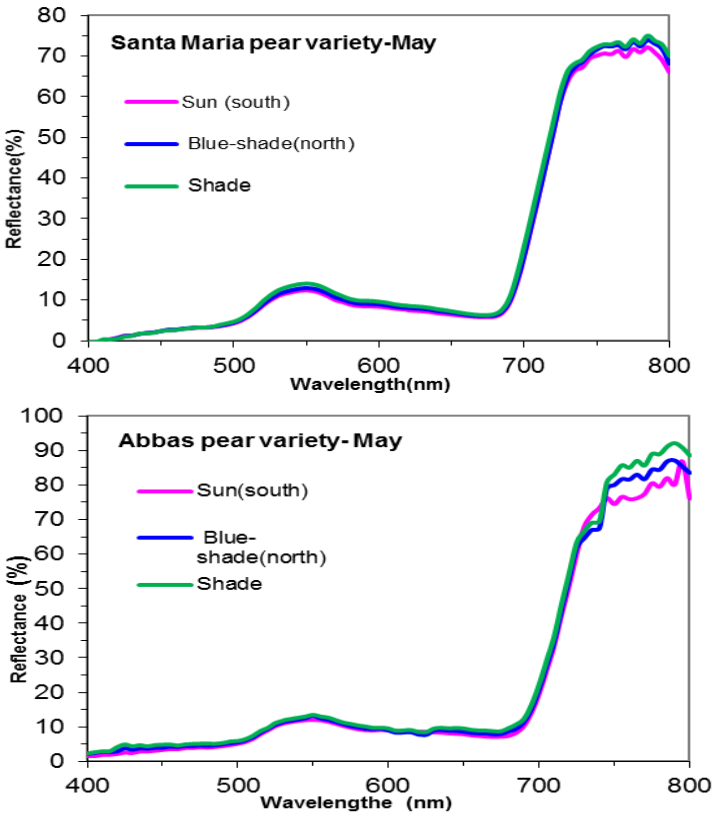

Figure. 1. Reflectance spectra of the sun (south part), blue-shade (north part) and shade/half shade leaves of Santa Maria and *Abbas* pear variety on May. Mean of 6 reflectance spectra per leaf-type.

Table 2. Levels of reflectance between sun, blue-shade, shade/half-shade leaves of *Santa Maria* and *Abbas* variety trees in the period May. Mean values of 6 determinations per leaf-type.

Leaf-type	**R550**	**R700**	**R750**	**R800**
***Santa Maria* - May**				
Sun	10.2 ± 0.32	13.6	47.7	48.4
Blue-shade	11.4 ± 0.33	15.0	48.0	48.6
Half-shade/shade	13.0 ± 0.20	17.1	49.7	50.2
***Abbas* - May**				
Sun	12.1 ± 0.04	19.5	74.5	76.1
Blue-shade	13.6 ± 0.58	20.9	80.0	83.5
Half-shade/shade	14.3 ± 0.63	22.3	83.1	88.6

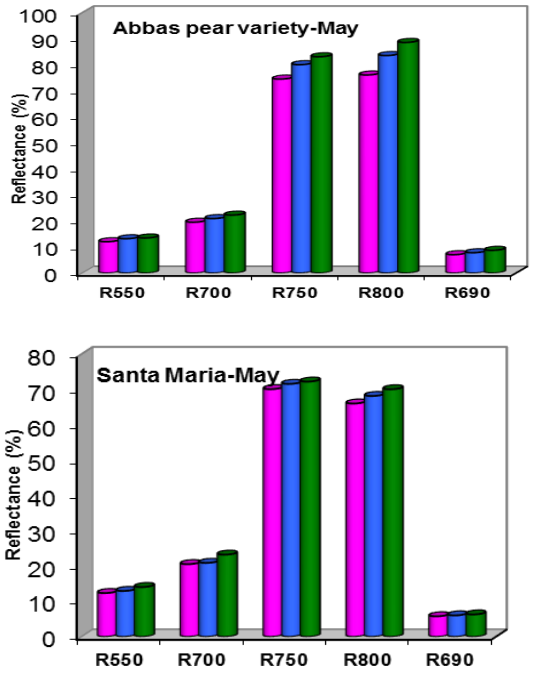

Figure 2. Levels of reflectance of the sun (south part), blue-shade (north part) and shade/half shade leaves of Santa Maria and *Abbas* pear variety on May. Mean of 6 reflectance spectra per leaf-type.

In May, higher values of R550 propagated reflectance represent the Abbas variety compared to the Santa Maria variety. High values are associated with the high photosynthetic development of the Abbas variety in this period compared to the Santa Maria (Tab.2).

The reflection spectra of two varieties exhibit the highest value in the green-orange range of the spectrum of shade leaves compare to two other leaf types. Also, could be observed a blue shift of the "red edge" (inflection point of the rise of signal at wavelengths between 680nm and 740nm) towards shorter wavelengths to the shade leaves.

The higher values of reflectance in the green-orange range of the spectrum detected in the leaves of Abbas variety compared to the Santa Maria variety could be explained by the differences on chlorophyll content too. Higher signals of reflection spectra of shade leaves of Abbas pear variety on May (Fig. 1), a period with optimal growth conditions, could be related to the higher leaf water content as comparing to the sun and blue-shade leaves.

Conclusions

Photosynthetic pigments content of leaves selected from two pear varieties, at Tirana area (Zhurje) represented higher value on optimal growth conditions on May. Pigment contents on the period May in both analysed varieties, Santa Maria and Abbas, displayed higher values in sun leaf (south part of crown tree) than other leaf types. The values of the pigment ratio Chl a/b were higher while of the ratio (a+b)/(x+c) are lower in sun leaves as compared to blue-shade and shade leaves in both varieties. Results presented on pigment content and photosynthetic activity of green leaves show that the fully developed green leaf chloroplast photosynthetic apparatus and its function depending on the environmental conditions and stresses to which plants are exposed exhibit changes. than vegetation.

The reflection spectra of two varieties exhibited the lowest value in the green-orange range of the spectrum of sun leaves compare to blue-shade and shade leaves and a blue shift of the "red edge" towards shorter wavelengths to the shade leaves demonstrating that the reflectance signals of leaves are determined by leaf pigment content and pigment absorption properties.

The observed variations between analysed pear varieties, Santa Maria and Abbas, could be explained by the differences on chlorophyll content too leaf changes in fruit trees in the three positions: south, north and shade are observed by the phenomenon of widespread reflection. For the two varieties studied in the same period and in the same area, it is noted that the highest values of R550 have leaves in the shadow position. The May period for the Abbas variety is an optimal period of development of the photosynthetic apparatus compared to the Santa Maria variety.

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