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The Influence Of Environmental And Climatic Stresses On The Fluorescence Of Fruit Trees

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Abstract- The objective of the study is to present the changes for the two pear varieties Santa Maria and Abbas, in the period of July, in the absence of water. The results regarding the concentration of chlorophylls, reflectance spectra and thickness will determine the differences between them in the same area.

Keywords — Fluorescence spectra; Chlb; Ch l (a+b); F690/F73.

I. INTRODUCTION

Photosynthetic pigments, green chlorophylls (Chl) and yellow carotenoids (x+c) represent isoprenoid pigments. They are found together with prenylquinins, galactolipids, sulfolipids, galactolipids as well as electron-carrying proneins in the photosynthetically active thylakoid membranes of chloroplasts [1],[2]. Ultrastructure, pigment composition and the functioning of chloroplasts under high or low light conditions. Quickly for some of the parameters shown and ends after 5 to 7 days after switching the plants from one to the other of the lighting conditions.The development of chloroplasts of each type, sun or shade, is also controlled by the quality of light, light blue induces the formation of sun-type chloroplasts and red light induces shade-type chloroplasts. Sun-type or HL-type chloroplasts of light-exposed plants have smaller antenna sizes than LL-type chloroplasts ([3], [4], [5], [6], [7], [8]. Various fluorescence parameters and ratios of chlorophylls have been accepted as non-invasive indicators of the function of the photosynthetic apparatus [9], [10], [11],[12], [13]. The shape of typical healthy green leaf chlorophyll fluorescence spectra has two broad maxima with one in the red spectral region around 685–690 nm and the other in the far-red
(near-infrared)spectral region around 730–740 nm. This spectral shape is related to two photosystems: PSII, which emits in both the red and far- red regions, and PSI, which emits mainly in the far-red, providing a relationship between fluorescence spectral characteristics, chlorophyll content, and photosynthesis [14], [15],[16]. The red peak is often lower than the far-red peak, due to re-absorption of fluoresced red light by chlorophyll within the leaf. The emitted SIF flux is a small signal relative to reflected solar radiation, representing about 2%– 5% of the reflected radiance in the near infrared [18]. The overall intensity of emitted SIF depends mainly on incoming radiation and chlorophyll concentration [17], [18].

II. MATERIAL AND METHODS

A. PLANTS

Measurements were made with leaves selected in three types of positions (sun - southern part of the crown, blue shade - northern part and semi-shade/shade - inside a tree crown) for the varieties: Santa Maria (pear) and Abbas (pear), part of a group of Pyrus Communis L pear species and the rose family. The study for two varieties was done in an area above water, in periods July.

B. 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 [19], [20]. The represented values are the mean of six determinations from six leaves.

C. FLUORESCENCE SPECTRA

To perform the measurements, the option can be selected: Emission (emission) - to obtain an emission or fluorescence emission spectrum. During this scan the excitation monochromator is fixed at a specific wavelength while the emission monochromator is shifted over a wide range of wavelengths. The resulting spectrum is referred to as the fluorescence emission (or emitted fluorescence) spectrum. During this scan the excitation monochromator is fixed at the wavelength of 470 nm (red light), while the emission monochromator is shifted from the wavelength of 660 nm- 800 nm with 2nm steps. The resulting spectrum is referred to as the leaf fluorescence spectrum. In the measurement, the selected signal amplifier is "Gain" x 300 and slits 2 nm.

D. THICKNESS

Measurement of the thickness of the samples (leaves) taken in three positions was accomplished by using a micrometer or Palmer Calliper. Micrometers serves to measure the thickness of the object that is clamped between point B of the screw and a stop C attached to the micrometer. The screw is turned by means of a step A that wraps the nut: the step of the screw is 1mm. The number of millimetres with which we have placed the screw on a scale located on the nut and detected by the cap is estimated. We estimate the parts of a millimetre by measuring the parts of a screw lead by a mark removed along a diode conductor and a scale where 30 divisions, we thus estimate the thickness of the leaf placed between two thin glasses, with the proximity of 1/ 20mm.

III. RESULTS

A. PHOTOSYNTHETIC PIGMENTS.

The mean values of the ratio Chl a/b are higher in sun leaves as compared to blue-shade and shade leaves **(Tab. 1)**. The ratios of the photosynthetic pigments, Chl a/b and (a+b)/(x+c), reflecting the light adaptation of the photosynthetic apparatus [21], showed different values in the three leaf types. The highest value of the chlorophyll content Chl (a+b) is presented by the variety Santa Maria (pear) compared to the variety Abbas (pear). It is also observed that the content of chlorophylls Chl (a+b) decreases in both varieties from sun leaves to blue-shade and shade leaves (**Tab. 1**). 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, known as ratio (a + b)/ (x + c), as compared to shade leaves with their shade chloroplasts (broad and high grana stacks). The decrease in the values of the ratio (a+b)/(x+c) is actually a very early indicator of stress found under conditions of exposure to high light as well as in the presence of other stress conditions.

Table 1. Content 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* varieties of pear trees

Leaf-type	*Chl a+b (mg dm^{-2})*	*Chl a/b*	*(a+b)/(x+c)*
Santa Maria			
Sun	8.80 ± 0.05	2.85	4.89
Blue-shade	6.38 ± 0.03	2.43	5.48
Shade	4.23 ± 0.03	2.15	5.50
Abbas			
Sun	7.18 ±0.05	2.54	4.06
Blue-shade	6.54 ±0.05	2.30	4.89
Shade	4.14 ± 0.06	2.25	4.72

B. FLUORESCENCE SPECTRA.

It is observed that the ratio of F690/F735 increases from the sun position in the shade (**Tab. 2**). The mean values of the fluorescence ratio F690/F735 of sun leaves of the two trees ranged from 1.031 to 1.035 and for shade leaves from 1.129 to 1.266 (**Tab. 2**). The shape of the fluorescence emission spectrum of chlorophylls and the relative height of the red fluorescence band F690 and the infrared fluorescence band F740, approximately at 730-740 nm, depends on the content of leaf chlorophylls on the one hand and on the other hand the wavelength of the excitation radiation, which is even more important (**Fig 1**).

Table 2. Fluorescence ratio, F690/F735 between sun, blue-shade, and shade/half-shade leaves of *Santa Maria* and *Abbas* varieties of pear trees

Leaf-type	***F690/F735*** (λ_{ex}=470nm)
Santa Maria	
Sun	1.035
Blue-shade	1.126
Shade	1.129
Abbas	
Sun	1.031
Blue-shade	1.182
Shade	1.266

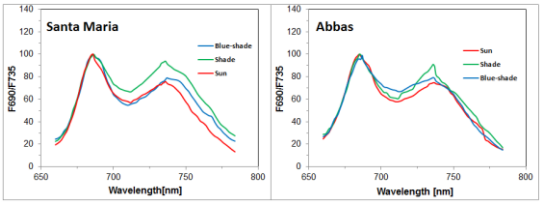

Fig. 1. Fluorescence spectra for Santa Maria (pear) and Abbas (pear) (λ_{ex}=470nm).

The highest value of the fluorescence ratio F690/F735 is presented by the variety Abbas (pear) compared to the variety Santa Maria (pear) (**Fig 2**).

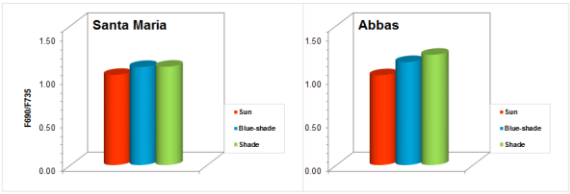

Fig 2. F690/735 ratio of fluorescence for variety Santa Maria and Abbas, June period

Thicker sun leaves with a smaller leaf area but a higher Chl content present lower F690/F735 ratio values than shade leaves. This is due to the fact that the red fluorescence band of chlorophyll F690 near 690 nm overlaps with the in vivo absorption bands of Chl a in thylakoid pigment-protein complexes and in

this case is reabsorbed to a higher degree in thick sun leaves. than in relatively thin shade leaves [22], [23].

C. THICKNESS

The thickness of the leaves in the two varieties presents higher values in the sun position. The changes are very small due to the period with optimal conditions for the development of the photosynthetic apparatus **(Tab. 3).** The highest thickness values are presented for the Abbas variety, sun position (**Tab. 3**). Shade and low light leaves are thinner and have a larger average surface area than sun or high light leaves. In fact, the total content of chlorophylls and their carotenoids per unit leaf area is significantly lower than in sun or high light leaves [24].

Table 3. Thickness of varieties, Santa Maria and Abbas, July period

Leaf-type	*Thickness*
Santa Maria	
Sun	0.336 ± 0.025
Blue-shade	0.297 ± 0.022
Shade	0.273 ± 0.018
Abbas	
Sun	0.338 ± 0.016
Blue-shade	0.287 ± 0.016
Shade	0.271 ± 0.018

For leaves of the sun where the intensity of radiation is high, the thickness is the highest and for leaves of the shade with low intensity, the thickness is the smallest (**Fig 3**).

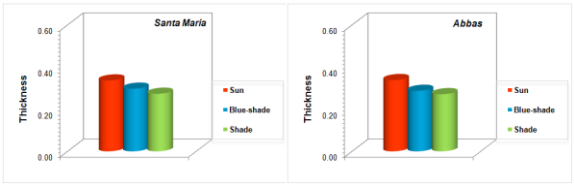

Fig 3. Thickness for variety Santa Maria and Abbas, July period

IV. CONCLUSIONS

It is verified from the data for leaves in the sun under the action of high solar radiation for two fruit trees:

1. High Chl (a+b) concentration, Chl a/b, low (a+b)/(a+c) ratio,
2. F690/F735 fluorescence ratio low,
3. The thickness of the leaves is high.

The values of the above-mentioned parameters provide information on the extent of stresses in the photosynthetic pigment apparatus during the summer period.

REFERENCES

[1] Lichtenthaler HK and Park RB (1963) Chemical composition of chloroplast lamellae from spinach. Nature 198: 1070—--1072

[2] Lichtenthaler HK and Calvin M (1964) Quinone and pigment composition of chloroplasts and quantasome aggregates from Spinacia oleracea. Biochim Biophys Acta 79: 30—40

[3] Grahl H and Wild A (1972) Die Variabilität der Größe der Photosyntheseeinheit bei Licht- und Schattenpflanzen. Untersuchungen zur Photosyntheses von experimentell induzierten Licht- und Schattentypen von Sinapis alba. Z Pflanzenphysiol 67: 443—453

[4] Fork DC and Govindjee (1980) Chlorophyll a fluorescence Transients of leaves from sun and shade plants. Naturwissenschaften 67:510—511

[5] Lichtenthaler HK, Kuhn G, Prenzel U, Buschmann C and Meier D (1982c) Adaptation of chloroplast-ultrastructure and of chlorophyll-protein levels to high-light and low-light growth conditions. Z Naturforsch 37c: 464—--475

[6] Lichtenthaler HK, Kuhn G, Prenzel U and Meier D (1982d) Chlorophyll-protein levels and stacking degree of thylakoids in radish chloroplasts from high-light, low-light and bentazon-treated plants. Physiol Plant 56: 183-—188

[7] Wild A, Höpfner M, Rühle W and Richter M (1986) Changes in the stoichiometry of photosystem II components as an adaptive response to high-light and low-light conditions during growth. Z Naturforsch 41c: 597—603

[8] Wild A and Ball R (1997) Photosynthetic unit and photosystems. History of research and current view (relationship and function). In: Dynamics of the photosynthetic unit under different light conditions, pp 92—110. Backhuys Publishers, Leiden.

[9] Papageorgiou G (1975) Chlorophyll fluorescence: an intrinsic probe of photosynthesis. In: Govindjee (ed) Bioenergetics of Photosynthesis, pp. 319-—371. Academic Press, New York

[10] Govindjee (1995) Sixty three years since Kautsky: chlorophyll a fluorescence. Aust J Plant Physiol 22: 131-—160

[11] Krause GH, Weis E (1991) Chlorophyll fluorescence and photosynthesis: the basics. Annu Rev Plant Physiol Plant Mol Biol 42: 313—--349

[12] Schreiber U, Schliwa U and Bilger W (1986) Continuous recording of photochemical and non-photochemical chlorophyll fluorescence quenching with a new type of modulation fluorometer. Photosynth Res 10: 51—--62

[13] Lichtenthaler HK and Rinderle U (1988a) The role of chlorophyll fluorescence in the detection of stress conditions in plants. CRC Crit. Rev. Analyt. Chemi. 19 (Suppl. I): 29--—85

[14] Murata N, Nishimura M and Tamiya A (1966) Fluorescence of chlorophyll in photosynthetic systems. III. Emission and action spectra of fluorescence - three emission bands of chlorophyll a and the energy transfer between two pigment systems Biochim. Biophys. Acta 126 234–43

[15] Bornman J F, Vogelmann T C and Martin G(1991) Measurement of chlorophyll fluorescence within leaves using a fibreoptic microprobe Plant Cell Environ. 14 719–25

[16] Pfündel E (1998) Estimating the contribution of photosystem I to total leaf chlorophyll fluorescence Photosynth. Res. 56 185–95

[17] Middleton E M, Huemmrich K F, Zhang Q, Campbell P K E and Landis D R (2018) Spectral bio-indicators of photosynthetic efficiency and vegetation stress chap. 5 ed P S Thenkabail, J G Lyon and A Huete Hyperspectral Remote Sensing of Vegetation Biophysical and Biochemical Characterization and Plant Species Studies (New York, NY: Taylor & Francis) 2nd edition III, 133–79

[18] Mohammed G H et al 2019 Remote sensing of solar-induced chlorophyll fluorescence (SIF)in vegetation: 50 years of progress Remote Sen. Env. 231 111177

[19] Lichtenthaler HK *(1987): Chlorophylls and carotenoids, the pigments of photosynthetic biomembranes. In: Douce R, Packer L (eds) Metods Enzymol 148, pp. 350-382. Academic Press Inc, New York*.

[20] Lichtenthaler HK, Buchmann C *(2001): Chlorophylls and carotenoids-Measurement and characterisation by UV-VIS. Current Protocols in Food Analytical Chemistry (CPFA), (Supplement 1), pp. F4.3.1-F4.3.8. John Wiley, New York.*

[21] Babani F., Lichtenthaler H.K., (1996): Light induced and Age-dependent of chloroplasts in etiolated barley leaves as visualized by determination of Photosynthetic Pigments, CO2 Assimilation rates and different kinds of Chlorophyll Fluorescence ratios. *J. Plant Physiol*., 148: f. 555-566.

[22] Gitelson Anatoly A, Merzlyak Mark N (1998) Remote sensing of chlorophyll concentration in higher plant leaves**.** Advances in Space Research 22(5):689-692

[23] Lichtenthaler HK, Wenzel O, Buschmann C and Gitelson A (1998) Plant stress detection by reflectance and fluorescence. In: Csermely P (ed) Stress of Life: from Molecules to Man, Annals of New York Academy Sciences 851: 271-285

[24] Lichtenthaler HK, Buschmann C, Döll M, Fietz H-J, Bach T, Kozel U, Meier D and Rahmsdorf U (1981b) Photosynthetic activity, chloroplast ultrastructure, and leaf characteristics of high-light and low-light plants and of sun and shade leaves. Photosyn Res 2: 115-141