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Preliminary study on the photosynthetic performance in leaves of two olive cultivars

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Abstract

*Olive is one of the most cultivated trees in the Mediterranean part of Croatia. The aim of this study was to compare some physiological and biochemical characteristics concerning photosynthetic apparatus in the leaves of two olive cultivars, Oblica and Leccino, to obtain preliminary data for further investigations of stress influence on their growth and productivity. It was shown that cv. Leccino was characterized by lower concentrations of chlorophylls and carotenoids than cv. Oblic*a. Also, decreased effective quantum yield of PSII ($\Delta F/F'm$) and increased non-photochemical quenching (NPQ) at high light conditions (800 μmolm^{-2}*s*$^{-2}$*) were measured in leaves of cv. Leccino. Based on presented results, we expect different stress responses of Oblica and Leccino leaves in further investigations.*

INTRODUCTION

Olive (*Olea europaea* L.) is very important fruit tree species in Croatia. The most cultivated olive cultivars are autochthonous cv. Oblica and Italian cv. Leccino. Under field conditions olive is exposed to high temperatures, high solar irradiance, high salinity and water deficit. Variations in environmental conditions might result in excess of reactive oxygen species (ROS) such as superoxide, singlet oxygen, hydrogen peroxide and hydroxyl radical. Such an increase in ROS amount usually results with oxidation of lipids, proteins and nucleic acids *(1)*. The most important pathways that produce ROS include photosynthetic apparatus, photorespiration and mitochondrial respiration *(2)*. To prevent damage, plants have developed several stress response strategies regulated by non-enzymatic and enzymatic reactions. Rapid defence responses include mechanisms that regulate photosynthetic electron transport and are responsible for adaptation of light-harvesting apparatus to avoid the formation of ROS. Adaptation is achievable by quick decrease of PSII quantum efficiency and by dissipation of excess energy as heat *(3)*.

This is a preliminary study of some physiological and biochemical traits in the leaves of two olive cultivars, Oblica and Leccino. The aim was to obtain initial data on the photosynthetic pigment content as well as on the photosynthetic performance of PSII under moderate and high light conditions. The obtained data will be used for further investigations of high-light and temperature stress influences on chosen cultivars with respect to their growth and productivity.

MATERIAL AND METHODS

Materials for the study were one-year-old leaves harvested from the middle crown of two-year-old olive (*Olea europaea* L.) trees. Two cultivars were investigated: cv. Oblica and cv. Leccino.

For photosynthetic pigment analysis twenty-five leaves were harvested from five trees of a single cultivar (5 leaves from each tree represented the composed sample and 5 repetitions were made from each composed sample) and extracted with ice-cold absolute acetone. The absorbance was measured at 661.6, 644.8 and 470 nm and photosynthetic pigment concentrations were calculated according to Lichtenthaler *(4)*.

Chlorophyll fluorescence was measured with a pulse-amplitude-modulated photosynthesis yield analyzer (Mini Pam, Waltz). Leaves were dark-adapted during 30 min before measurements and exposed to 500 and 800 $\mu mol_{PHOTONS} m^{-2}s^{-2}$, respectively. The maximum quantum yield (Fv/Fm), effective quantum yield ($\Delta F/F_m'$) and non-photochemical quenching (NPQ) were determined according to Schreiber *et al. (5)*. All measurements were done in five repetitions.

Statistical analyses of obtained data were performed using t-test. Each cultivar was treated as a single statistic sample that contained leaves from five olive trees (n=5). P-values < 0.05 were considered to be significant.

RESULTS AND DISCUSSION

Mean values of the photosynthetic pigment concentrations in leaves of cv. Oblica and cv. Leccino are shown in Table 1. Leaves of cv. Oblica had 1.14 times higher chlorophyll *a* concentration and 1.21 times higher values of chlorophyll *b* than cv. Leccino. Cv. Oblica also had significantly higher concentrations of total chlorophylls and total carotenoids, while there were no differences between the investigated cultivars regarding chlorophyll *a* to *b* ratio and total chlorophylls to carotenoids ratio. It is well known that chlorophylls and carotenoids concentration in leaves are influenced by environmental factors and developmental processes *(4,6-9)*. Furthermore, both types of pigments are directly involved in light harvesting processes in photosynthesis.

TABLE 1

Mean values of photosynthetic pigment concentration in leaves of Oblica and Leccino; Chl *a* – chlorophyll *a*, Chl *b* – chlorophyll *b*, Chl *a+b* – total chlorophyll, Car – carotenoids, Chl *a/b* – chlorophyll *a* to *b* ratio, Chl *a+b* / Car – total chlorophyll to carotenoids ratio, DM – dry mass, *– significant differences, NS – not significant.

	Oblica	Leccino	P(t)
Chl *a* [mg g^{-1} DM]	2,22 ± 0,24	1,95 ± 0,11	*
Chl *b* [mg g^{-1} DM]	1,22 ± 0,18	1,01 ± 0,06	*
Chl *a+b* [mg g^{-1} DM]	3,44 ± 0,22	2,96 ± 0,08	*
Car [mg g^{-1} DM]	0,78 ± 0,22	0,59 ± 0,06	*
Chl *a/b*	1,85 ± 0,41	1,93 ± 0,20	NS
Chl *a+b*/Car	4,72 ± 1,36	5,03 ±0,37	NS

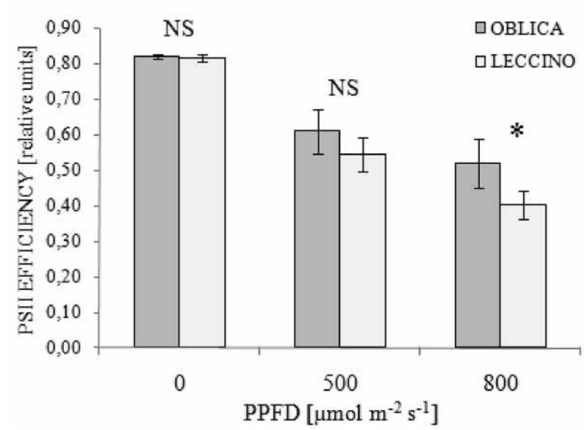

Figure 1. *The PSII efficiency calculated as maximum quantum yield of PSII (Fv/Fm; at 0 $\mu mol\, m^{-2}s^{-2}$) and effective quantum yield of PSII ($\Delta F/Fm'$) at 500 and 800 $\mu mol\, m^{-2}s^{-}$ in leaves of Oblica and Leccino; PPFD – photosynthetic photon flux density, *– significant differences, NS – not significant.*

Photosynthetic performance was evaluated by determining maximum quantum yield (Fv/Fm) and effective quantum yield of PSII ($\Delta F/F'm$) (Fig. 1). It appeared that there was no difference in Fv/Fm value and $\Delta F/F'm$ at 500 $\mu molm^{-2}s^{-2}$ between the two investigated cultivars, while reduced PSII efficiency in the leaves of cv. Leccino was measured at 800 $\mu molm^{-2}s^{-2}$. Effective quantum yield shows the overall efficiency of PSII reaction centres in light and is a good indicator of how plants respond to stress *(10, 11)*. Since different environmental stresses cause oxidative stress of chloroplasts and limitation of photosynthesis *(12)*, plants endeavour to avoid such damage by decreasing PSII quantum efficiency while excitation energy is dissipated as heat. Non-photochemical quenching (NPQ) is a measure of heat dissi-

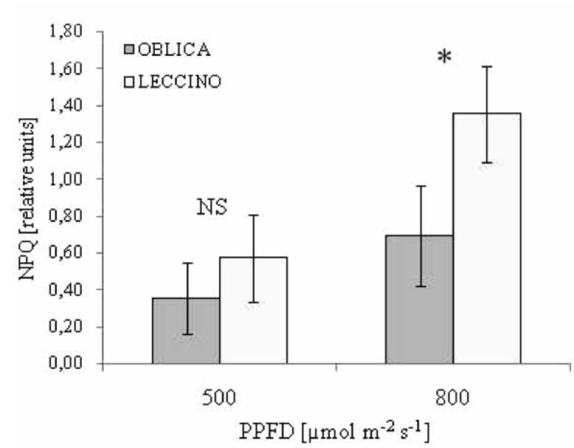

Figure 2. *The non-photochemical quenching (NPQ) in leaves of cultivar Oblica and Leccino at 500 and 800 $\mu mol\, m\, m^{-2}s^{-2}$; PPFD – photosynthetic photon flux density, *– significant, NS – not significant.*

pation relative to dark-adapted state, by which excess excitation energy is removed from PSII *(13)*. Results of NPQ measurements are shown in Figure 2. Cv. Leccino had significantly higher NPQ values (1.95 times) at 800 $\mu molm^{-2}s^{-2}$ than cv. Oblica. Different authors confirmed important protective roles of NPQ under a variety of stresses such as heat *(14),* ozone *(15)* and chilling stress *(16)*.

In previous investigations *(17, 18)* of cvs. Oblica and Leccino their different biochemical and physiological responses to salinity stress were reported. This preliminary investigation revealed favourable photosynthetic features of cv. Leccino compared to cv. Oblica. Decreased chlorophylls and carotenoids content combined with decreased effective quantum yield of PSII and increased NPQ at high light (800 $\mu molm^{-2}s^{-2}$) in cv. Leccino are responsible for its better photosynthetic accommodation to high light conditions than cv. Oblica. Based on the presented results, we expect different responses of cvs. Oblica and Leccino leaves in further investigations on high-light and temperature stresses.

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