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Oxygen Stress and Pigment Composition in Canarian Laurel Forest Trees

By

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Summary

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The pigment composition of the leaves of three evergreen tree species (*Laurus azorica, Myrica faya* and *Persea indica*) belonging to the canarian laurel forest were determined in situ in the early morning and at midday. The ratio variable to maximal fluorescence (Fv/Fm) decreased at midday in full sunlight to values of 0.7 in all species indicating photoinhibition. Together with depressions in Fv/Fm the shift in the xanthophyll cycle was clear in all three species. No significant variations between the early morning and midday were found in the xanthophyll cycle pool. The degree in which this cycle was de-epoxidized at midday had a trend to be larger in *Myrica faya* and *Persea indica* than in *Laurus azorica*. No variation in neoxanthin and lutein content during the day was observed. The chlorophyll a/b ratio did not show significant differences between early morning and midday but a tendency towards chlorophyll losses at midday could be found in all three species. The α-carotene/β-carotene ratio did not vary along the day. The total carotene content was lower in *Myrica faya* which did not contain α-carotene. Studies along the year and under different stress conditions, including the study of the antioxidative system, are needed to have a clearer understanding of possible different patterns in these tree species on the protection of the photosynthetic apparatus against the excess of light.

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Introduction

Under conditions where there is more light absorption than can be utilized through photosynthesis, excess of photons produces oxygen reactive molecules in chloroplasts, which oxidize target molecules leading to photoinhibition (ASADA 1994). This brings about a decrease in the quantum yield which can be shown by the chlorophyll fluorescence parameters as a decrease in the Fv/Fm ratio (LONG & al. 1994). Although the study of photoinhibition has been the focus of very much attention during the last years, those carried out under natural conditions are scarce. In the field, it is not still well determined in which proportion the decrease in the quantum yield is due to an excess of photoprotection through the xanthopyll cycle carotenoids or to the oxidation of the above mentioned molecules.

We present here the results of chlorophyll fluorescence measurements in connection with the xanthophyll cycle and other pigments concentrations in three tree species, belonging to the canarian laurel forest. This forest is mainly restricted to the most humid section of the northern slope in middle elevations where there is a cloud belt, having the typical appearance of a cloud forest (HOLLERMANN 1981). The pigment composition of canarian laurel forest trees have not, to our knowledge, been examined before. Only the leaves chlorophyll content through a vertical profile in the canopy was done previously (MORALES & al.1996a).

Materials and Methods

Sampling site: The study was done under natural conditions in the Agua García mountain, Tenerife, Canary Islands (see MORALES & al. 1996b). The site is a laurel forest with three main tree species *Laurus azorica* (Seub.) Franco, *Myrica faya* Ait. and *Persea indica* (L.) Spreng. A scaffolding tower gave access to the top of the canopy where chlorophyll fluorescence of sun leaves was measured in the early morning and at midday in the above mentioned species. At the same time samples for chemical analysis were taken. The sampling day was sunny. At midday the photon flux density was 1900 $\mu mol\ m^{-2}\ s^{-1}$, the temperature of 22 °C and the relative humidity of 65 %.

Chlorophyll fluorescence measurements: The minimal (Fo), maximal (Fm) and variable (Fv) fluorescence were monitored with a portable fluorimeter Plant Efficiency Analyser (PEA, Hansatech, UK) after the leaves had been covered for 30 min with a leafclip to be dark adapted.

Biochemical analysis: Leaves were frozen in liquid nitrogen in the field and lyophilized afterwards. Pigments were measured as cited in TAUSZ & al. 1996.

Statistics: Statistical evaluations were completed using Statistica (StatSoft, USA, 1994) software package. Differences between species and sampling time (early morning - midday) were calculated by two way analysis of variance (ANOVA) using species and sampling time as independent factors after verifying ANOVA assumptions: If within-group variances (Levene's test) were significantly different, logarithmic data transformation was performed previously. Small deviations of within-group normal distributions occurred in a few cases, but they usually do not adversely bias ANOVA's F-test. Cross-comparisons of groups were completed according to Scheffé's test. Results with $P>0.01$ are regarded non-significant as indicated in the figures. Sample sizes at each sampling time were 12 to 17 for *Laurus azorica*, 10 for *Persea* indica, and 8 for *Myrica faya*. Figures show mean values and standard deviations. No letter or the same letter in the columns indicate no significant differences ($P> 0.01$) among species at the same sampling time. values above

columns indicate significance of differences between morning and midday data within one species (no values = ns = non-significant, P> 0.01).

Results and Discussion

Canopy sun leaves of laurel forest trees have to cope with high light conditions during clear days but at the same time they should be capable of efficient photosynthesis in low light during extended periods of shading by clouds, a typical condition of this forest. During the day of the experiment, in which there was no other apparent additional stress, full sunlight reached the leaves and Fv/Fm values decreased at midday in the three studied species. This indicated a reduction in the photosynthetic quantum yield (photoinhibition) although the reduction was not very dramatic showing values of 0.70 (Fig. 1). Photoinhibition in the field without other stress factors has been registered in other species (see KRAUSE & al. 1995). Together with depressions in Fv/Fm the shift in the xanthophyll cycle was clear in all three species (Fig. 2 A). Fluorescence quenching could be due to the energy dissipation effect of zeaxanthin (ADAMS & DEMMIG-ADAMS 1994) and down-regulation of photosystem II, which serves as a protective of the photosynthetic apparatus, rather than to the destruction of photosystem II.

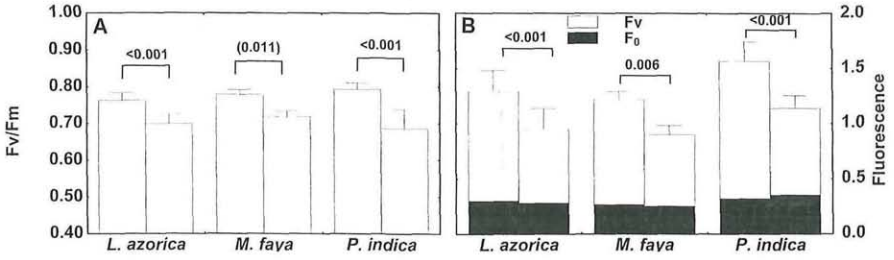

Fig. 1. Fluorescence data of sun leaves of three laurel forest species. Left columns: Samples taken in the morning; right columns: Samples taken at midday. A. Fv/Fm ratios. B. Fluorescence data (Fo, Fm, Fv). Statistical evaluations refer to maximum fluorescence (Fm = total columns).

No significant variations between the early morning and midday were found in the xanthophyll cycle pool. The extent to which this cycle was de-epoxidized at midday had a trend to be larger in *Myrica faya* and *Persea indica* than in *Laurus azorica* (Fig. 2 A, B). On these two species the degree of de-epoxidation in the early morning was also significantly greater. According to ADAMS & DEMMIG-ADAMS 1994 this could mean more protection on these two species in the morning because of the retention of zeaxanthin and antheraxanthin during the night. No variation in neoxanthin and lutein content during the day was observed (Fig. 2 C, D). The same finding was registered by WILDI & LÜTZ 1996 in

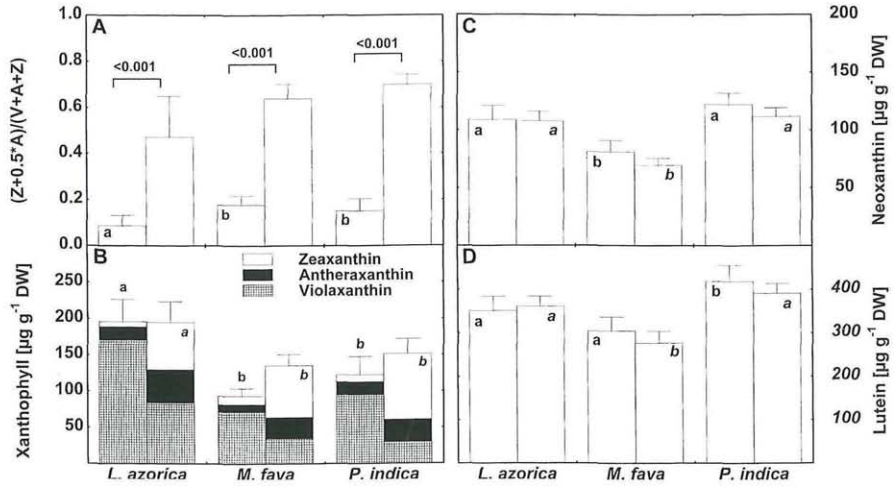

Fig. 2. Xanthophyll concentrations and relations in sun leaves of three laurel forest species. DW = leaf dry weight. Left columns: Samples taken in the morning; right columns: Samples taken at midday. A. Epoxidation status of the xanthophyll cycle. V = violaxanthin, A = antheraxanthin, Z = zeaxanthin. B. V, A and Z concentrations. Statistical evaluations refer to total pigments (V+A+Z). C-D. Neoxanthin and lutein concentrations.

alpine plants, accumulation of neoxanthin and lutein does not appear to be influenced by differences in light in a consistent pattern (DEMMIG-ADAMS & ADAMS 1992).

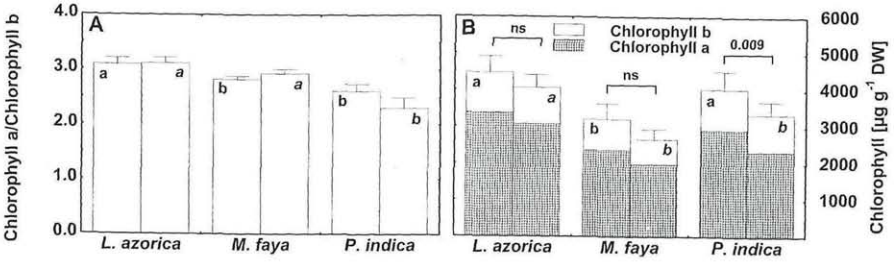

Fig. 3. Chlorophyll concentrations and relations in sun leaves of three laurel forest species. DW = leaf dry weight. Left columns: Samples taken in the morning; right columns: Samples taken at midday. A. Chlorophyll a/b ratios. B. Chlorophyll a and b concentrations. Statistical evaluations refer to total chlorophyll content (chlorophyll a+b).

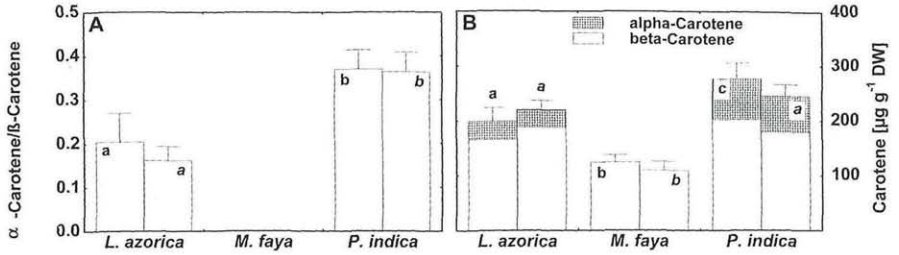

Fig. 4. Carotene concentrations and relations in sun leaves of three laurel forest species. DW = leaf dry weight. Left columns: Samples taken in the morning; right columns: Samples taken at midday. A. Carotene α/β ratios (*Myrica* did not contain α-carotene). B. α-Carotene and β-carotene concentrations. Statistical evaluations refer to total carotene content (α+β carotene).

The chlorophyll a/b ratio did not show significant differences between early morning and midday but a tendency towards chlorophyll losses at midday could be found in all three species (Fig. 3). The α-carotene/β-carotene ratio did not vary along the day. The total carotene content was lower in *Myrica faya* which did not contain α-carotene (Fig. 4). α-Carotene content is associated with shade and sun acclimatization (DEMMIG-ADAMS & ADAMS 1992). The biological significance of the lack of this pigment in *Myrica faya* leaves living in the same environment as the other two species it is not clear. Studies along the year and under different stress conditions including the study of the antioxidative system, are needed to have a clearer understanding of possible different patterns in these tree species on the protection of the photosynthetic apparatus against the excess of light.

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