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ARTICLE

Responses of some ecophysiological traits of sessile oak (*Quercus petraea*) to drought stress and heat wave in growing season of 2003

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ABSTRACT The effects of drought and heat wave appeared in growing season of 2003 on some physiological traits of *Quercus petraea* were studied at the Sikfőkút research site. There were comparative measurements in the subsequent humid growing season of 2004. Drought reduced significantly the leaf mass increment of *Quercus petraea* in the dry year (2003) which was reflected in lower SLM too as compared to 2004. Chlorophyll content showed inter-annual and within-canopy variability. Carotenoid content was 1,5-2 times larger in spring than in summer. In summer of 2003 VAZ pool was larger especially in sun leaves than in 2004. Values of Fv/Fm were lower in 2004 than 2003 which indicated lasting drought effects on the photochemical activity of leaves of sessile oak.
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KEY WORDS

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chlorophyll fluorescence
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specific leaf mass

Numerous current scenarios on future climate change in Central Europe predict elevated temperatures and simultaneous reduction of rainfall in growing seasons which will increase the frequency and duration of summer drought (IPCC 2001). Climatic change and prolonged summer drought stress have been suggested as major contributing factors to the decline of central European forests in recent decades (Jakucs et al. 1986; Mészáros et al. 1993). Severe summer drought such as that which occurred in 2003 may have long-term consequences for the forest condition by making the trees susceptible to other abiotic and biotic stresses appearing simultaneously or in subsequent growing seasons (Koncz et al. 2005; Bréda et al. 2006). Drought and the co-occurring heat stress influence directly and indirectly the main plant metabolic processes, photosynthesis and respiration that are the basis of tree and forest productivity (Bassow and Bazzaz 1998; Flexas et al. 2004; Gessler et al. 2004; Mészáros et al. 2007). Tree species show a wide range of physiological adaptations to drought including the protective mechanisms of photosynthetic apparatus, accumulation of different compatible solutes and antioxidant systems which vary greatly among the species and ecotypes (Rennenberg at al. 2006).

The aim of this study was to characterize the physiological responses of sessile oak (*Quercus petraea*) to drought by monitoring the changes in the quantum yield of PSII and photosynthetic pigment in the canopy of adult trees in two subsequent dry (2003) and humid year (2004).

Materials and Methods

The investigations were performed in the Sikfőkút Research site in the Bükk Mountains, North Hungarian Central Range (320-340 m A.s.l.). The site is covered by a 90-95 year-old stand of sessile oak-Turkey oak forest (Jakucs et al. 1986). The mean annual temperature of the site (50 years) is 9.9°C and the annual precipitation is 601 mm. The bedrock is miocenic pebble and the soil is deep brown forest soil. Climatic factors were monitored by means of automatic sensors with dataloggers (Onset Co., USA) at the top of a tower above the tree canopy. Gaussen-Bagnouls' xerotherm index calculated on the basis of monthly rainfall and temperature ranged between 0.21 and 0,78 during the whole growing season in 2003 which reflected serious drought although it reached 2,3 in July due short heavy rains. However, in growing season of 2004 the values ranged between 1,1 and 2,3. Field measurements and leaf samplings were performed in the canopy of four trees growing close to the meteorological tower. Leaf area was measured by an AreaScope leaf area meter, leaf dry mass was measured after drying at 85°C. Fv/Fm chlorophyll fluorescence parameter indicating the maximum photochemical efficiency of PSII (Schreiber et al. 1994) was measured with a PAM 2000 fluorometer (WALZ, Germany) after 1 h dark acclimation. Photosynthetic pigments were determined in

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Table 1. Changes in leaf mass (Lm), specific leaf mass (SLM), leaf pigment content and maximal quantum yield of PSII Fv/Fm in two stages of leaf area development in 2003 and 2004.

	La	Lm g	SLM g dm^{-2}	Chl a+chl b mg g^{-1}(d.m.)	Total carote-noids mg g^{-1}(d.m.)	VAZ mmol mol^{-1} (chl a+b)	Fv/Fm
2003							
Sun leaves	< 30 %	0,039		3,043	2,107		0,7429
	100 %	0,305	0,92	4,452	1,081	72,51	0,8006
Shade leaves	< 30 %	0,055		2,443	2,095		0,7535
	100 %	0,255	0,49	7,650	1,546	31,52	0,8163
2004							
Sun leaves	< 30 %	0,079		2,565	1,478		0,6358
	100 %	0,394	1,25	3,736	0,904	48,24	0,7757
Shade leaves	< 30 %	0,095		2,503	1,551		0,7161
	100 %	0,354	0,65	5,993	1,310	28,92	0,7999

80% acetone extract. Carotenoids were measured by reversed phase HPLC method (UV/VIS HPLC, Jasco, Japan).

Results and Discussion

In the same stage of leaf area development (< 30%, 100%) the persisting drought in 2003 resulted in a large reduction of leaf mass (Lm) in both canopy layers of *Q. petraea* (Table 1). The specific leaf mass (SLM) of *Q. petraea* responded very sensitively to drought in 2003. Chlorophyll content was less influenced by different climatic conditions of the two growing seasons than leaf growth characteristics but strongly varied with the light gradient in the tree canopy (Table 1). Similarly to other tree species (Mészáros et al. 1998, Bassow and Bazzaz 1998) chlorophyll content per dry mass was smaller in sun leaves than in shade leaves and increased from spring until summer in both canopy layers. Fully developed leaves of sessile oak in summer contained higher concentrations of chlorophylls and carotenoids per dry mass in both canopy layers in 2003 than in 2004. It can be considered as a compensating mechanism for the reduction of leaf mass increment induced by the drought and heat stress.

The total content of carotenoids (Table 1) was high in spring which reflected the role of these components in the protection of developing photosynthetic apparatus of very young leaves against photo-damages. Higher carotenoid pool was found in sun leaves than in shade leaves. Total carotenoid content correlated negatively with the maximum photochemical efficiency of PSII (Fv/Fm) during the growing seasons (Table 1). Sun leaves were always characterized by more depressed middy values of Fv/Fm and larger VAZ cycle pool than shade leaves during the whole growing season of both years. In summer the VAZ pool was significantly higher in sun leaves in 2003 than in 2004 while VAZ pool of shade leaves exhibited only slight interannual differences.Unexpectedly leaves showed larger impairment of maximal photochemical efficiency and lower Fv/Fm in the wetter growing season of 2004 than in 2003. This indicated a lasting drought effect on the photochemical activity of leaves of sessile oak in the investigated site which contributed to the weakened vitality (Bréda et al. 2006) and increased susceptibility to phytophagous insects in the subsequent year.

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