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RATE OF TRANSPIRATION AND STOMATAL CONDUCTANCE OF YOUNG BEECH (*FAGUS SYLVATICA* L.) TREES AT DIFFERENT LEVELS OF WATER SUPPLY

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Summary. The aim of the study was to determine the seasonal patterns of leaf transpiration (E) and stomatal conductance (g_s) of young beech trees in relation to the air pollution in two forest sites with different hydrologic regimes – Vitinya and Petrohan. In Vitinya – with a less amount of rainfalls, a progressive decrease in E and g_s from the beginning to the end of the growing season of 2009 was observed. A similar decrease in the two physiological parameters was found for Petrohan only in the summer. A significant non-linear correlation between g_s in the sunny leaves and SO_2 was found in Petrohan. At this site, g_s in all leaves was related with NO_X, while E was in a close correlation with the cumulative ozone exposure index AOT40.

Key words: air pollution, European beech, stomatal conductance, transpiration.

Abbreviations: AOT40 - a sum of the differences between hourly concentrations of O_3 greater than 40 ppb and 40 ppb over a given period for the 1-h values measured between 8:00 and 20:00 h.

INTRODUCTION

Gaseous air pollutants may inhibit or stimulate stomatal opening and transpiration. In a review by Winner et al. (1988) it was suggested that the response depended on species, concentrations and type of the pollutant, duration of exposure and interaction with the other environmental factors. For woody species, even small changes in gas exchange can be important, not only because of the longevity of trees and cumulative effects, but also because of changes in susceptibility to other stressors, particularly drought (Taylor and Dobson, 1989). Until recently very little work has been done on European beech, since hardwood species have been considered as less sensitive to air pollution. In the field, beech trees are affected by a

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number of biotic and abiotic factors and pollution may or may not be important in determining the physiology of this species (Andersen and Grulke, 2001).

In the present study, we have estimated the seasonal variations in the rate of transpiration and leaf conductance in sunny and shady leaves of young beech trees from sites with different hydrologic regimes in relation to air pollution.

MATERIALS AND METHODS

The experimental sites are located in the region of the Western Balkan passes Vitinya (42°47’20” N, 23°47’25” E) and Petrohan (43°08’06” N, 23°09’00” E) both at an altitude of 1100 m a. s. l. The climate in the two sites is continental and the influence of the mountain is well pronounced especially on the air temperature and amounts of rainfalls (Table 1). An automatic station provided a monitoring of O_3, SO_2 and NO_X concentrations. The values for the meteorological parameters were derived through a linear interpolation at a given altitude of the data for a long period (according to the Climatic Reference Book), corrected with the anomalies of 2009 (according to the National Institute of Meteorology and Hydrology). At each site three dominant 13-year-old beech (*Fagus sylvatica* L.) trees were selected for the experiment. Measurements of transpiration (E) and stomatal conductance (g_s) were performed monthly during the vegetation season of 2009, from 10:00 to 12:00 h (solar time) on three fully expended sun-exposed and shady leaves (six leaves per plant and three plants per site) using a portable gas analyzer Li-6400, (Li-Cor Inc., Lincoln, NE, USA), with a red-blue LED light source. At least 20 readings were taken for each leaf and parameter, i.e. 180 values per leaf position were used for data processing. A seasonal course of E and g_s was found with a polynomial regression $Y = ax^4 + bx^3 + cx^2 + dx + e$, where x is the number of an individual day within the vegetation period. A non-linear regression analysis was used to assess the relationship between physiological parameters and air pollution for the two experimental sites (Statistics: SYSTAT 7.0, SPSS Inc., Chicago, USA, 1996).

Table1. Site conditions (monthly and annual values of mean temperature, sum of rainfall, concentration of air pollutants and AOT40) in Vitinya and Petrohan from April to September, 2009.

Month	$T_{Petrohan}$ [°C]	$T_{Vitinya}$ [°C]	$Rain_{Petrohan}$ [mm]	$Rain_{Vitinya}$ [mm]	SO_2 [ppb]	NO_X [ppb]	AOT40 [ppb.h]
April 2009	6.3	7.2	120.33	55.20	4.81	11.76	5.58
May 2009	12.1	12.8	103.86	50.50	3.67	10.16	3.77
June 2009	15.4	16.1	157.99	95.20	3.64	10.02	1.33
July 2009	17.3	18.0	170.67	97.20	3.20	7.21	1.93
August 2009	17.1	17.5	93.72	78.30	1.71	7.31	2.95
September 2009	12.8	12.7	104.19	84.00	1.58	5.90	1.25
Annual	7.4	8.3	1467	773	3.62	8.78	16.81

RESULTS AND DISCUSSION

There was a well pronounced difference between the two sites in the seasonal trends of E and g_s (Fig.1 a, b). In Petrohan E was higher and after the drop in summer a second peak was evident in autumn for both sunny and shady leaves. At Vitinya - with 40 % less amount of rains compared to Petrohan - young beech trees had an early decline in E and g_s. However, in this site E was not able to recover after the summer drought. Remarkable differences between the two crown positions were distinguished – with higher values of E and g_s in the sunny leaves. A

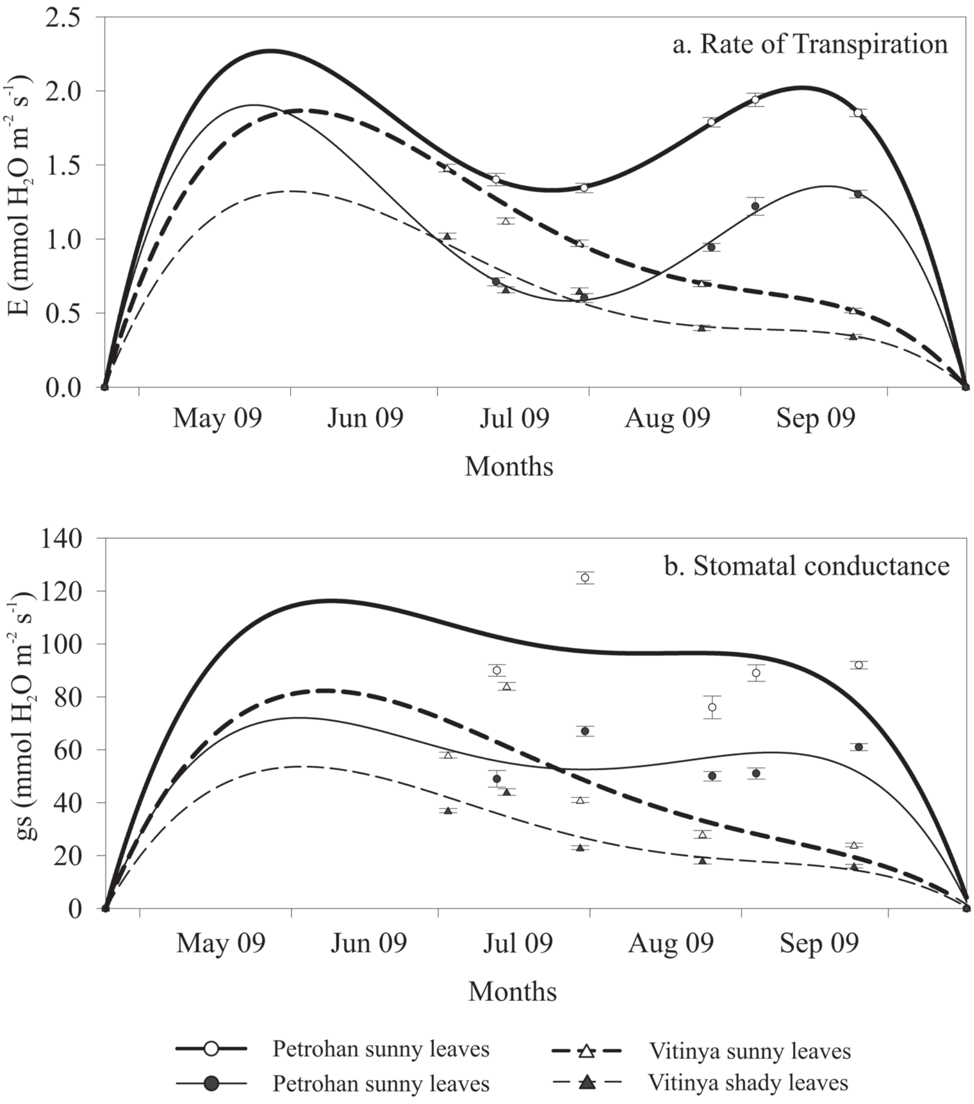

Fig. 1. Rate of transpiration and stomatal conductance in the sunny and shady leaves of 13-year-old beech (*Fagus sylvatica* L.) trees in Vitinya and Petrohan. Each data point represents the mean of nine leaves and 20 reading per leaf (N=180) ±SE. Points were fitted by polynomial regression $Y = ax^4 + bx^3 + cx^2 + dx + e$, where x is a number of an individual day within the vegetation period.

significant non-linear correlation with the air pollution was found only for the trees in Petrohan, where g_s in the sunny leaves was correlated with SO_2 (p=0.049) (Table 2). A strong relationship was observed between E and the AOT40 index in the sunny (p=0.007) and shady (p=0.002) leaves. In the two crown positions g_s was related to NO_X with a better significance for the sunny leaves (p=0.004). Ambient air pollution may result in both positive and negative effects on trees, related to the climatic conditions during the growing season (Muzika et al., 2004). Soja et al. (1996) found that abundant water supply made plants more sensitive than drought-stressed plants. The summer decrease of g_s and E in Petrohan, when the stomata were opened, could be explained with a low diffusion gradient of the water vapours in conditions of high relative humidity. Despite the significant relation of E and g_s with the air pollution in Petrohan, the complete recovery after the autumnal rainfalls suggested an absence of permanent functional damages. In Vitinya a complex effect is possible of the poor rainfalls and air pollution on stomatal closure. The closng response induced by drought overruled stomatal sensitivity to pollutants (Löw et al., 2006). The reduced g_s found in Vitinya may lead to decreased sensitivity to pollution stress as was suggested by Thomas and Kozlowski (1981).

Table 2. R^2 (non-linear regression analysis) for the effect of the air pollution on the transpiration (E) and stomatal conductance (g_s) in the sunny and shady leaves of 13-year-old European beech (*Fagus sylvatica* L.) trees in Vitinya and Petrohan from April to September, 2009.

R^2	$T_{Petrohan}$ [°C]	$T_{Vitinya}$ [°C]	$Rain_{Petrohan}$ [mm]	$Rain_{Vitinya}$ [mm]	SO_2 [ppb]	NO_X [ppb]	AOT40 [ppb.h]
$E_{Vitinya, sunny leaves}$		0.220		0.537	0.719	0.757	0.391
$E_{Vitinya, shady leaves}$		0.220		0.563	0.655	0.706	0.430
$g_{s\ Vitinya, sunny leaves}$		0.204		0.547	0.831	0.821	0.290
$g_{s\ Vitinya, shady leaves}$		0.214		0.549	0.726	0.755	0.379
$E_{Petrohan, sunny leaves}$	0.685		0.357		0.493	0.524	0.995*
$E_{Petrohan, shady leaves}$	0.638		0.357		0.069	0.098	0.999*
$g_{s\ Petrohan, sunny leaves}$	0.697		0.349		0.866*	0.976*	0.768
$g_{s\ Petrohan, shady leaves}$	0.696		0.248		0.758	0.869*	0.872

* - regression is significant at the 0.05 level.

In conclusion, young beech trees, growing in the site with better water supply are more sensitive to air pollution in relation to leaf transpiration and stomatal conductance.

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