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INVESTIGATIONS ON ENVIRONMENTAL BENEFITS OF URBAN TREES AT CORVINUS UNIVERSITY OF BUDAPEST

Károly HROTKÓ*[1], Márk STEINER[1], Mihály FORRAI[1], György Endre TÓTH[1], Máté VÉRTESY[1], Ádám LEELŐSSY[2], Levente KARDOS[1], Magdolna Diószegi SÜTÖRINÉ[1], Lajos MAGYAR[1], Róbert MÉSZÁROS[2]

[1]Corvinus University of Budapest (CUB), Hungary
[2]Eötvös Loránd University (ELU), Hungary

Urban trees play important role in diminishing of air pollution, but the interactions between atmospheric contamination and trees may involve both positive and negative effects. Evaluation the environmental benefits of urban trees in a complex model require *in situ* measurements, but such measurements and data are almost completely missing. The characterization of interactions in this system will provide a conducing framework for predicting microclimatic factors and useful data of urban drafting and planning urban tree plantations. This is planned in the joint research project of Corvinus University of Budapest and Eötvös Lorand University. Based on our preliminary results we can conclude that the planned research promise collection of missing data and in the model simulation we can elaborate a complex model of interactions in the "plant – air pollution – urban site" multiple system.

Keywords: air pollution, LAI, photosynthetic activity, stomatal conductance, transpiration

Introduction

It is commonly accepted that urban trees play important role in diminishing of air pollution, but the interactions between atmospheric contamination and trees may involve both positive and negative effects. The atmospheric pollution under urban conditions causes serious human health disorders; however, related effects like discomfort and smog alerts both in winter and summer can cause complications in urban life. The evaluation of elements in a complex model requires *in situ* measurements on interaction, but such measurements and data are almost completely missing. The characterization of interactions in this system will provide a conducing framework for predicting microclimatic factors and useful data of urban drafting and planning urban tree plantations. Micrometeorological, plant physiological and atmospheric contamination measurements as well as detailed deposition, local scale dispersion and chemical models are intended to describe the status, the spatial and temporal variability, and the connections of the vegetation-atmosphere complex system in urban environment. Considering the complexity of the theme, researchers of the two universities (ELU and CUB) decided to cooperate in this topic; the research is supported by National Scientific Research Funds (OTKA). Our paper gives an overview on the preliminary results and plans of cooperative research.

Performance of Leaf Area Index (LAI) during the year

In our temperate climate conditions, the most urban trees and shrubs produce deciduous leaves. The influence of the leaf mass is effective only in limited period regularly from April to November. The changes in the leaf mass and leaf characteristics depend on species, cultivar, and vary by age and location. There is little information in the literature on the performance of leaf growth and distribution within the canopy of trees and shrubs of different ages. Radó (2001) refers to 3.4 to 9.6 LAI in closed forest stands, depending on age, but his data show the

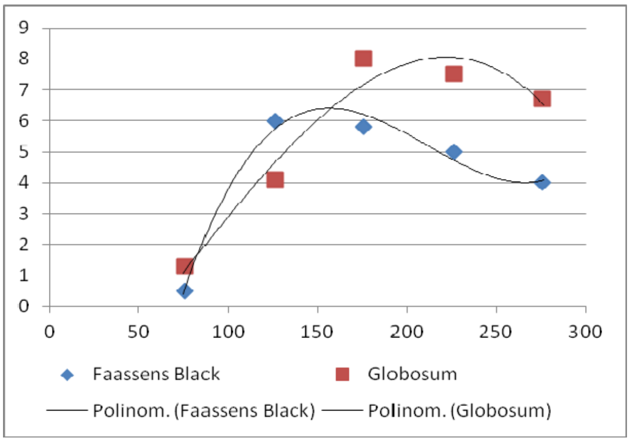

Figure 1 Performance of LAI on 30 years old *Acer platanoides* 'Faassens Black' and 'Globosum' during the year (x axis: day of the year)

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*Correspodence: Károly Hrotkó, Corvinus University of Budapest (CUB), Department of Floriculture and Dendrology, Hungary, e-mail: karoly.hrotko@uni-corvinus.hu

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LAI_{max} only, so do not give information about dynamics of LAI performance within the year. Our preliminary results (Gyeviki et al., 2012; Steiner et al., 2012) show considerable changes in the dynamics of the LAI performance during the year (Fig 1). In the frame of this project, we plane to specify the dynamics of LAI performance and other plant parameters in urban environment.

Investigation of microclimatological characteristics in typical urban areas

We plan measuring meteorological variables (air temperature, VPD, wind speed) at different height both above artificial surface such as asphalt, concrete, pathway or streets and above vegetation in downtown and suburb or outskirt conditions. Leaf temperature is the outcome of the energy balance at leaf level, which depends on leaf mass, size, shape, angle, reflectance properties, and on physical (incoming radiation, air temperature, wind speed) and biological (transpiration controlled by stomatal conductance) phenomena. From a human perspective, foliage temperature of urban trees is of particular interest due to their cooling effect on urban climate (Pauleit, 2003). According to Leuzinger et al. (2009) tree crown temperatures ranged from 24 °C (*Aesculus hippocastanum* trees located in a park) to 29 °C in *Acer platanoides* trees, located in a street.

Leaf gas exchange characteristics of urban tree species and cultivars

Knowledge about the CO_2 fixation and water vapour emission of trees and shrubs has to be confirmed with onsite instrumental examinations to get actual information. There are little reliable data about LAI values and photosynthetic activity of such trees and shrubs which are exposed to various stress factors (air pollution, drought, human impacts) in different environmental conditions (Radó, 2001). Urban climate, of course, creates different environmental conditions.

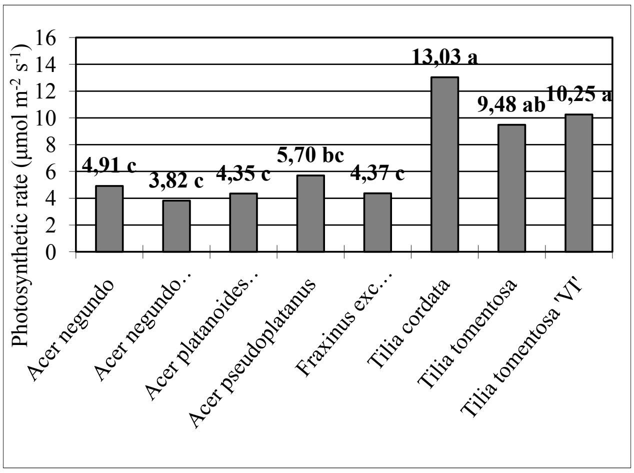

Figure 2 Photosynthetic rate in µmol m^{-2} s^{-1} with the mean values of the measured plants

Several studies emphasized the importance of environmental conditions for leaf gas exchange. Endres et al. (2009) found that light environment influence the CO_2 fixation. Fini et al. (2010) studied the effect of light environment to leaf gas exchange and found that response to shade is species-specific. Several studies on woody species have found increased photosynthetic activity in elevated CO_2 in controlled circumstances (Ceulemans and Mousseau, 1994; Curtis, 1996; Heath and Kerstiens, 1997).

By our preliminary investigations there are considerable differences found in net photosynthetic rate and transpiration rate in leaves of different species and genera (Fig. 2). As a consequence these plants provide different capacity of environmental benefits. We showed that transpiration rate was strongly influenced by leaf temperature, PAR, and stomatal conductance. Since these parameters are variable during the day and the vegetation period, an accurate comparison of genera, species or cultivars would be needed.

Table 1 Electric conductivity and concentration of some pollutants measured in soaking water of woody plant leaves in Budapest collected from Buda Arboretum (suburb) and traffic charged downtown streets (2013)

Species/location		EC in uS cm^{-1}	Salt total in mg dm^{-3}	c (NO_3^-) in mg dm^{-3}	c (NH_4^+) in mg dm^{-3}	c (Cl^-) in mg dm^{-3}	c (SO_4^{2-}) in mg dm^{-3}
Acer/Budai Arborétum	average	67.10	33.20	9.00	0.11	34.32	9.62
	deviation	3.34	1.37	1.00	0.00	4.10	0.64
Acer/Krisztina krt	average	150.40	75.83	8.33	0.18	53.25	6.56
	deviation	4.88	3.00	0.58	0.06	3.55	0.47
Tilia/Budai Arborétum	average	32.73	16.47	6.00	0.28	28.40	3.12
	deviation	9.12	4.55	0.00	0.06	0.00	0.27
Tilia/ Karolina út	average	49.37	24.77	4.67	0.46	41.42	4.60
	deviation	13.14	6.71	3.79	0.34	2.05	0.39
Distilled water	average	11.21	7.59	1.00	1.01	19.05	0.00

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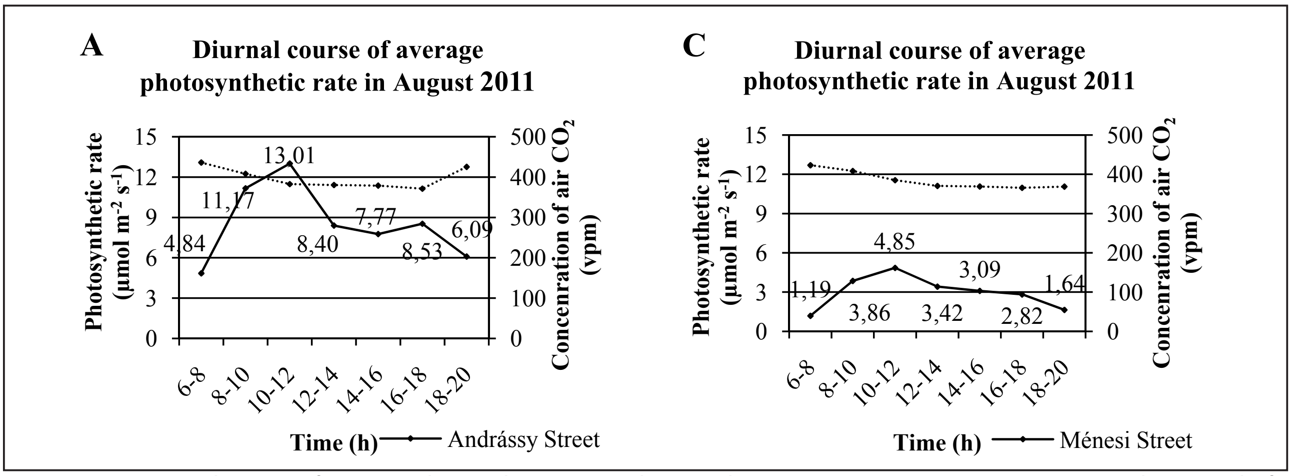

Figure 3 Diurnal course of average photosythetic rate and atmospheric CO_2 concentration on *Fraxinus excelsior* 'Westhof's Glorie' on Andrássy (A) and Ménesi Street (C) in August of 2011

The photosynthetic activity of leaves under different site conditions

Several publications are known about the photosynthetic activity of temperate zone trees, which are planted in urban conditions too, but none of them reports on measurements *in situ* urban conditions. Authors has reported on large differences between species, canopy and leaf position and environmental conditions. Our preliminary studies (Fig. 3) confirmed the large differences (Forrai et al., 2012a). Urban climate obviously creates different environmental conditions, which can modify the leaf gas exchange. Our preliminary investigation for leaves of *Fraxinus excelsior* 'Westhofs Glory' in downtown conditions showed higher photosynthetic rate compared to suburb (Forrai et al., 2012b). The net CO_2 assimilation of leaves during the light period of the day showed similar course to PAR exposition and stomatal conductance (Fig. 3). Leaves of trees in the downtown location received higher PAR, and showed higher stomatal conductance, and similar course in CO_2 assimiltion compared to suburb conditions.

As the LAI changes during the year, the dynamics of photosynthetic capacity show certain seasonal variability. To describe these temporal changes, we plan investigation during the whole vegetation period. Further measurements should focus on capacity differences of species and cultivars (some of the urban trees are grafted urban tolerant cultivars) and on site conditions of different locations (park, suburb streets, severe polluted downtown conditions).

Monitoring the deposition on the leaf surface caused by urban pollution

The atmospheric pollution under urban conditions impacts the human health however, related effects like discomfort and smog alerts both in winter and summer can cause complications in urban life. The major source of urban air pollution is the traffic by emitting CO_2, CO, Cl^-, NO_x and dust, soot particles causing several environmental damages on vegetation, buildings and human health. Trees are very efficient in trapping atmospheric particles, which is especially important for urban areas. Plant leaves have been used as indicators and/or monitors of trace metal pollution. Large differences in polluting deposition are found between location and tree species. Pollutant ion deposits are larger on leaves of trees in downtown conditions, but the differences between species are considerable too: ion deposits are larger on *Acer platanoides* 'Globosum' leaves than on *Tilia tomentosa*, except for (NH_4^+).

Summarizing our preliminary results we can conclude that the planned research promise collection of missing data and in the model simulation (Mészáros et al., 2009, 2010) we can elaborate a complex model of interactions in the "plant – air pollution – urban site" multiple system. The characterization of interactions in this system will provide a conducing framework for predicting microclimatic factors and useful data of urban drafting and planning urban tree plantations. The results of this project would also be very useful for the further development and refinement of environmental models.

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