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PAR ABSORPTION ABILITY OF THE CANOPY OF YOUNG LINDEN (*TILIA* SP.) TREES

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Abstract

*The rate CO_2-fixation of the plant depends significantly on the absorption of available photosinthetically active radiation (PAR). The PAR absorption ability is determined by the size and shape of canopy and by the position of leaves. In this context, there may be notable differences between species and moreover varieties. The aim of our work was to compare the PAR absorption ability of different Tilia varieties. Our measurements were done in Soroksár, Budapest with AccuPAR LP-80 linear ceptometer in an experimental linden alley. Beside leaf area index (LAI) the instrument is able to calculate the ratio of photosinthetically active radiation (PAR) above and below the canopy, which is the PAR transmission ability of foliage (τ). With this information the PAR absorption ability of the canopy can be easily calculated. Measurements were done monthly in 2013 (March-September) and 2014 (March-October). In the sprouting period of 2014 – to ensure better traceability – measurements were done every two weeks. From among the 13 varieties which are in the experimental alley the results of 6 varieties (*Tilia americana *'Redmond',* T. cordata *'Greenspire',* T. c. *'Savaria',* T. platyphyllos *'Favorit',* T. tomentosa *'Szeleste',* T. t. *'Zentai Ezüst') will be presented in this paper. In 2013, the PAR absorption of investigated varieties reached their maximum in the early July (68-84 %). T. americana 'Redmond' was exception, because its maximum was in the middle of June (85 %). Then the light absorption ability of canopies decreased gradually. In 2014, after initial growing of values in the case of every varieties slight decreasing was found in early June, which reason lies in the end of blooming. Then, till the middle of June increasing values were measured again. The foliage development was monitored till the end of July, and the declining of PAR absorption was sensible in September caused by reduction of leaf area.*

Key words: *light absorption, linden varieties, PAR.*

INTRODUCTION

Linden species (*Tilia sp.*) represent an important genus in Central Europe (Radoglou et al., 2008) and are widespread planted under urban conditions in form of different cultivars. The following species are commonly planted for urban forestry in Hungary: *T. cordata* Mill. and *T. platyphyllos* Scop., (native to Europe forming climax forest); *T. tomentosa* Moench, (native to Southern Europe and Asia); *T. americana* L. (cultivars were introduced recently).

However, Schmidt (2003) reckons *Tilia* species as deep shadowing trees, there are little and inconsistent data on PAR absorption ability of linden cultivars.

PAR absorption ability depends first of all on leaf area index (LAI). LAI influences photosynthetic and transpiration capacity of the whole tree (Oyarzun et al., 2007, Olchev et al., 2013), and in urban condition the air pollution on leaves as well (Mori et al., 2015). The PAR absorption ability effect on plants, which might be planted under the tree (Schmidt, 2003) and moreover on microclimate close to the tree and hereby it influences the human thermal comfort conditions, too (Lakatos et Gulyás, 2003, Kántor et al. 2009).

This is why we aimed in this work to evaluate this phenomenon on different linden taxa in order to gain information on the annual course of PAR absorption.

MATERIALS AND METHODS

In Central Hungary at the Experimental Farm of Corvinus University of Budapest Faculty of Horticultural Science in December 2009,

using multiple *Tilia* taxa an experimental alley was planted with the aim of comparison of Hungarian and foreign cultivars occurred in Hungarian nurseries. The orientation of the alley is N – S, the location is: N 47°22', E 19°09', elevation above sea level 103 m. The climate is typical of the central Hungarian flatland; yearly average temperature is 11.3 °C, total sunshine is 2079 hours per year, and precipitation is 560 mm per year. The soil type is light sandy, lime content is around 2.5 %, soil organic matter is low (0.8 – 0.9 %), pH is 7.7 - 8.1.

Our measurements were done with AccuPAR LP-80 linear ceptometer (Figure 1). It consists of an integrated microprocessor-driven datalogger and probe. The probe contains 80 independent sensors, spaced 1cm apart. The photosensors measure PAR in the 400-700nm waveband between 0 and 2500 μmol m^{-2} s^{-1}.

Figure 1. Measuring with AccuPAR LP-80 linear ceptometer (12.03.2014., Soroksár)

Beside leaf area index (LAI) the instrument is able to calculate the ratio of PAR above and below the canopy, which is the light transmission ability of foliage (τ). With this information the PAR absorption ability of the canopy can be calculated by the following equation:

$$\text{PAR absorption (\%)} = (1 - \tau) \cdot 100.$$

Measurements were done monthly in 2013 (March-September) and 2014 (March-October). In the sprouting period of 2014 – to ensure better traceability – measurements were done every two weeks.

The trees were planted with 12/14 cm trunk circumference size in autumn 2009. From among the 13 cultivars which are in the experimental alley the results of 6 cultivars will be presented in this paper, 8 trees from each cultivar.

Short description of the investigated Tilia taxa, in alphabetical order:

Tilia americana 'Redmond': Conical canopy, dense and compact growth. Young shoots are red. The leaves of T. a. 'Redmond' are slightly lighter green than the leaves on T. a. 'Nova' (Ifju, 2009-10., Krüssmann, 1986, Schmidt and Tóth, 2006).

Tilia cordata 'Greenspire': Straight trunk, 15-20 m high tree. Regular cone-shaped crown. Leaves are rounded and 6-10 cm in size, shiny dark green (Izer, 2010-11.; Krüssmann, 1986; Retkes and Tóth 2005, Tóth and Schmidt, 2006).

Tilia cordata 'Savaria': Hungarian selection. Conical canopy. The tip of young shoots slightly reddish, later turns brownish red. Characterized by many fragrant flowers (Izer, 2010-11.; Retkes and Tóth 2005, Schmidt and Tóth, 2006).

Tilia platyphyllos 'Favorit': Hungarian selection. 10 to 15 meters high, medium growth vigor, tall slender tree. Autumn leaves are yellowish (Schmidt, 2008).

Tilia tomentosa 'Szeleste': Old Hungarian selection. A vigorous growing variety, narrow oval, then expanded tree canopy, 20-25 m height. Young branches are greenish gray. The leaves are more or less rounded (Izer, 2010-11, Retkes and Tóth 2005, Schmidt and Tóth, 2006).

Tilia tomentosa 'Zentai Ezüst': Hungarian selection. In the first years very slender with conical canopy, later columnar shaped variety. Conspicuously silvery leaves, tolerates polluted environment (Retkes and Tóth, 2005; Schmidt and Tóth, 2006).

Under our investigations we could compare two years as well, when rainfall was very different in vegetation period (Figure 2).

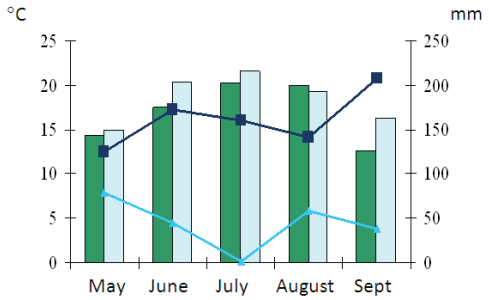

Figure 2. Temperature and rainfall in 2013 (dark column, light line) and 2014 (light column, dark line), Soroksár (Budapest)

Data were evaluated using Microsoft Excel software. One-way analysis of variance (ANOVA) was carried out in SPSS 18 (PASW 18) to see significant differences between the cultivars.

RESULTS AND DISCUSSIONS

In 2013, measurements were done monthly and started on 20th March, when the trees were still leafless (Figure 3). PAR absorption increased in every cultivar continually during the spring until the middle of summer then it started to decline. The maximum was detected in the early July (68-84 %) expect *T. americana* 'Redmond', because its maximum was in the middle of June (85 %). *T. americana* 'Redmond', *T. platyphyllos* 'Favorit' and *T. tomentosa* 'Zentai Ezüst' had the highest PAR absorption maximum (84-85 %), while the lowest top value was measured on *T. cordata* 'Greenspire' specimens (68 %)., In 2013, significant differences were found between above-mentioned cultivars only in summer time.

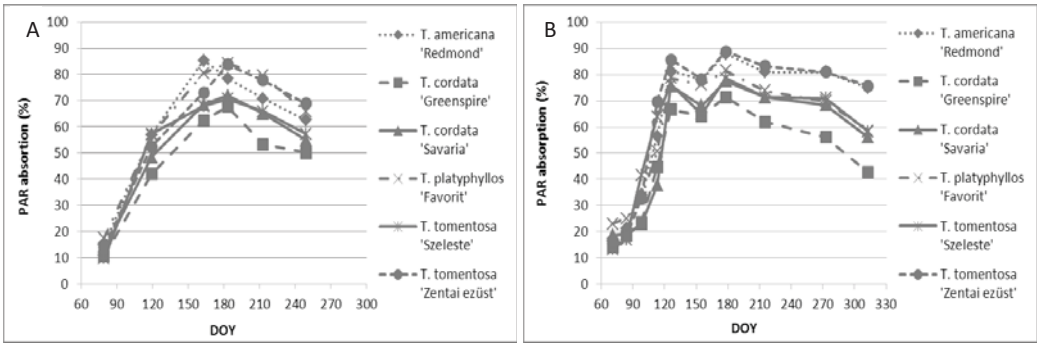

Figure 3. Annual changing of PAR absorption on different *Tilia* cultivars in Soroksár (Budapest), in 2013 (A) and in 2014 (B). DOY: day of the year

To ensure better traceability, measurements were done every two weeks in the sprouting period of 2014 (Figure 3). Similarly to 2013, it was a quick growing in PAR absorption in the spring. However, slight decreasing was found in early June in every cultivar, which reason lies in the end of blooming. It was able be detected because of the more frequent measurements. Significant difference was detected firstly between cultivars in the end of April. In this time the highest PAR absorption was measured on the two *T. tomentosa* cultivars ('Szeleste' 64 %, 'Zentai Ezüst' 70 %), while the lowest on *T. cordata* 'Savaria' (38 %). Maximum values were detected on every cultivar in the end of June (71-89 %). However, differences were not justified statistically there was notable variance in PAR absorption between the lowest (*T. cordata* 'Greenspire') and the highest (*T. tomentosa* 'Zentai Ezüst') cultivars.

CONCLUSIONS

The significant higher precipitation in 2014 causes some differences in the two examined years. The foliage of water-consuming *T. americana* 'Redmond' fell down slower in 2014 compared to 2013 when the weather was dry and hot. Leaf falling was similar on the other species in both years expected *T. cordata* 'Greenspire', which leaves fell down faster in 2014, due to supposedly a hard *Mycosphaerella microsora* infection.

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