Plants in Urban Areas and Landscape
Slovak University of Agriculture in Nitra
Faculty of Horticulture and Landscape Engineering
DOI 10.15414/2014.9788055212623.94–96

GROWTH AND PHENOLOGICAL OBSERVATIONS ON HUNGARIAN AND FOREIGN LINDEN VARIETIES

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In Central Hungary at Department of Floriculture and Dendrology, Corvinus University of Budapest Faculty of Horticultural Science in December 2009, using multiple *Tilia* taxa an alley was planted with the aim of comparison of new cultivars occurring in Hungarian nurseries. 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. The *Tilia* taxa are as follows: *Tilia americana* 'Redmond', *Tilia cordata* 'Greenspire', 'Savaria', *Tilia platyphyllos* 'Favorit' *Tilia tomentosa* 'Szeleste', 'Zentai Ezüst'. Comparative evaluation is planned primarily for their site adaptability and stress-tolerance. For the cultivar evaluation we plan to carry out detailed investigations on phenology (date of sprouting, sprouting dynamics, bloom dynamics, leaves drying, coloration of the leaves at the beginning of autumn, leaf fall) and trunk diameter. We also measured the yearly height growth of the selected cultivars. The aim of the research is the selection of the most tolerant taxa.

Keywords: *Tilia cultivars*, phenology, stress tolerance, tolerance to urban conditions, adaptive strategies

Introduction

The importance of the urban trees is increasing because of their environmental benefits: shade, improved microclimate, dust and other pollutants deposition, CO_2 fixation, O_2 and vapor release. These benefits can be expected only from well-developed healthy trees, adapted well to site and climate. The global climate change resulted larger extremities in climatic conditions, especially in urban climate.

Linden trees are hardy and well adopted to Hungarian climate (Krüssmann, 1986; Retkes and Tóth, 2005; Tóth and Schmidt, 2006; Schmidt, 2008). *Tilia* taxa are popular in Hungary and are widely planted as urban trees. Moreover, several new cultivars are introduced by nurseries from different origin (Ifju, 2009; Barabits, 2010; Izer, 2010). Thus it is an urging task to evaluate their adaptability to our climate and soil condition as well as testing their urban tolerance.

As the aim of these studies, the Department of Floriculture and Dendrology, Corvinus University of Budapest in Soroksár Experimental Farm in early December 2009 using multiple taxa a *Tilia* alley was planted. After planting we have started detailed measurements on trunk diameter growth and height growth besides phenology, such as date of sprouting, sprouting dynamics, bloom dynamics, leaf drying, coloration of the leaves at the beginning of autumn and leaf fall. This paper presents the first results on phenological observations from early 2011 until 2014.

Material 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 alley was planted with the aim of comparison of new 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.

The trees were planted with 12/14 cm trunk circumference size in autumn 2009. In this research 48 trees were evaluated, 8 from each cultivar.

Trunk circumference has been measured each spring from 2010 to 2014. Measurement of height growth was carried out in 2013, early spring and late autumn. Phenological studies (sprouting dynamics, blossom dynamics, growth, fruit formation, leaf fall) in 2011 and 2013 were carried out by rating. The observations were continued on a weekly basis. The day of the main phases were indicated (Day of the Year – DOY) based on the results of the rating. Quantity of fruit formation was rated as 1 = there were maximum one or two fruits on shoots; 2 = there were more than two fruits on each shoots; 3 = two or more fruits were found in each nodes. The data was evaluated using Microsoft Excel software. One-way analysis of

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variance (ANOVA) was carried out in SPSS 18 (PASW 18) to see significant differences between the cultivars.

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, 2009–2010, 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, 2010–2011; 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, 2010–2011; Retkes and Tóth, 2005; Tóth and Schmidt, 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, 2010–2011; Retkes and Tóth, 2005; Tóth and Schmidt, 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 (Young, 2009–2010; Retkes and Tóth, 2005; Schmidt and Tóth, 2006).

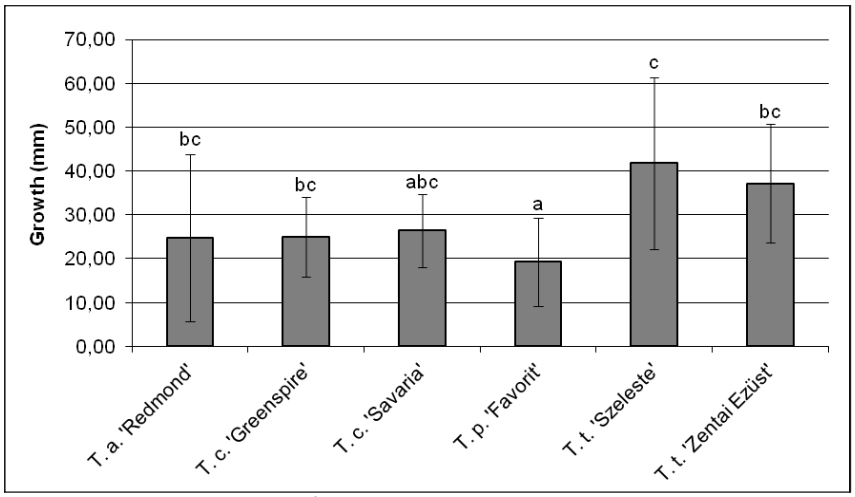

Figure 1 Trunk growth of linden trees between 2010 and 2014

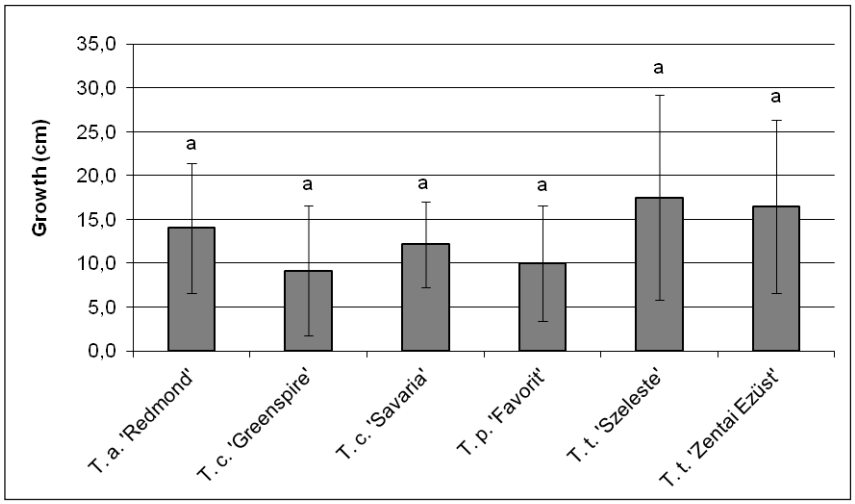

Figure 2 Height growth of linden cultivars in 2013

Results and discussion

Based on the results of the past five years, the largest trunk circumference gain was observed on *T. tomentosa* cultivars. *T. cordata* varieties and *T. Americana* 'Redmond' showed only modest growth. The less increase was observed on the *T. platyphyllos* 'Favorit' variety. Figure 1 shows the total growth of the linden cultivars trunk circumference.

Similar results were obtained with height growth (Figure 2) in 2013. The biggest increase in this case is shown by *T. tomentosa* varieties. The smallest increase was observed on *T. cordata* 'Greenspire' cultivar. According to Krüssmann (1986) and Tóth and Schmidt (2006) *Tilia cordata* grows relatively slowly but *Tilia cordata* 'Greenspire' variety

Table 1 Phenological stages of linden cultivars in 2011, based on the DOY

	T. a. 'Redmond'	*T. c.* 'Greenspire'	*T. c.* 'Savaria'	*T. p.* 'Favorit'	*T. t.* 'Szeleste'	*T. t.* 'Zentai Ezüst'
Elongated stage of buds with closed scales	93	100	105	97	95	95
Fully spread leaf	106	112	119	111	105	107
Opening stage of flowers	148	161	no Flowers	150	168	168
Complete leaf fall	314	307	307	314	314	314

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Table 2 Phenological stages of linden cultivars in 2013, based on the DOY

	T. a. 'Redmond'	*T. c.* 'Greenspire'	*T. c.* 'Savaria'	*T. p.* 'Favorit'	*T. t.* 'Szeleste'	*T. t.* 'Zentai Ezüst'
Elongated stage of buds with closed scales	99	108	110	105	98	105
Fully spread leaf	114	115	119	114	114	115
Opening stage of flowers	154	160	165	146	165	165
Complete leaf fall	304	297	297	304	304	304

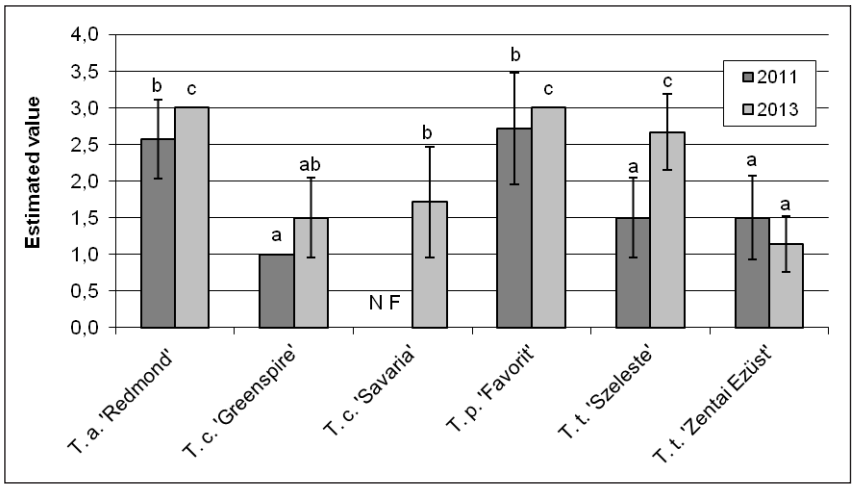

Figure 3 Fruit formation of linden varieties in 2011 and 2013

grows fast. This deviation can be an effect of the growing site.

The particular phenological stages are showed in Table 1 and 2. Based on two years results of sprouting dynamics strong tendencies cannot be found. Although in both years *T. americana* 'Redmond' and *T. tomentosa* 'Szeleste' varieties sprouted first. The latest budburst was observed on *Tilia cordata* 'Savaria' variety. The sprouting process was the fastest in case of *Tilia cordata* 'Greenspire'. The last stage of the budburst was observed in both year on *Tilia americana* 'Redmond' and *Tilia platyphyllos* 'Favorit' cultivars firstly. *Tilia cordata* 'Greenspire' was sprout a week later and *Tilia tomentosa* cultivars came afterwards. The blossom of the investigated cultivars reached over 20 days in both years, starting with Tilia americana 'Redmond' and *T. platyphyllos* 'Favorit', followed by *T. cordata* cultivars. Both *T. tomentosa* cultivars opened flowers as last of all cultivars. *Tilia cordata* 'Savaria' was not flourished in the year of 2011. The sequence for flowering of *Tilia platyphyllos, Tilia cordata* and *Tilia tomentosa* cultivars is coinciding with details written by Tóth and Schmidt (2006) and Tóth (2012) but according to these sources *Tilia americana* cultivars are flowering in the same time as *Tilia tomentosa*. The autumn leaf fall completed for the two *Tilia cordata* cultivars at the earliest, the other varieties a week later.

Figure 3 shows that in both years *Tilia americana* 'Redmond' and *Tilia platyphyllos* 'Favorit' cultivars produced the most fruits. Furthermore in 2011 *Tilia tomentosa* 'Szeleste' also produced a significant amount. In the other cases the amount of fruits on the trees was significantly less. In the year of 2011 on *Tilia cordata* 'Favorit' trees were no fruit formation (No Fruit – NF).

The evaluation of linden tree varieties is an important research area, and we plan to continue the research. We intend to repeat the phenological observations with additional evaluation of leaf surface, leaf canopy measurements using modern instruments. The differences between domestic selected varieties and adaptation features are visible on the current results. Domestic environmental conditions differ from the other countries so the species performance can be specific. Although we cannot draw a final conclusion about the past few year's data, the species which were bred to the domestic conditions, seemingly better adapted to the local site and climatic conditions, therefore their use can be recommended.

Acknowledgement

Our research was supported by TÁMOP-4-2.1.B-09/1/KMR-2010-0005 project and by Hungarian Scientific Research Funds OTKA 109361.

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