The selection and cultivation of *Tilia* clones tolerating polluted urban environment

INTERNATIONAL JOURNAL OF HORTICULTURAL SCIENCE

AGROINFORM Publishing House, Hungary

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Key words: urban stress tolerance, Tilia, new Hungarian cultivar

Summary: Two urban stress tolerant *Tilia* clones were selected by the Department of Floriculture and Dendrology. The mother trees of the observed clones were found in an alley of linden trees, settled on a traffic island of a busy two-lane road.
Tilia hybrid 'Saint Stephen' has a beautiful cone-shaped crown, the leaves are bright green and they keep their green colour for much longer time than the leaves on the other trees in the alley. In the nursery the *Tilia* hybrid 'Saint Stephen' was budded on *T. cordata, T. platyphyllos* and *T. argentea* and it had good compatibility with every rootstock. The average height of the one year old buddings was 200 cm and the buddings kept their good growing capacity in the following years as well. They had an outstanding growing capability comparing with the other *Tilia* cultivars.
Tilia platyphyllos 'K3' clone has similar cone-shaped crown. The growing vigor and urban stress tolerance seems to be better than *Tilia* hybrid 'Saint Stephen'.

Introduction

The way of selection work

Selection of woody ornamentals, which seem to tolerate urban conditions became an important issue in the research objectives of the Department of Floriculture and Dendrology. Owing to researches at our Department, several urban stress tolerant woody ornamentals are available (*Nagy B.*, 1978; *Sipos E.*, 1978). The selection of *Tilia* species has been an emphasized topic. Until 1980 four stately approved *Tilia* cultivars were selected (*Sipos & Schmidt*, 1980). In the last decade environmental pollution increased considerably, that is why our research aimed to select urban stress tolerant woody ornamentals, conjugated with nice crown shape, tolerancy against pests and fast growing in the nursery. Until 1999 one new cultivar called *Tilia tomentosa* 'Zentai ezüst' gained stately approvement (*Schmidt*, 1992, 1998, 1999).

Tilia species have some attributes, which make them popular. Interspecific crosses offer a great amount of new hibrids that may have new attributes. Besides that linden trees are popular because of their balmy flowers blossoming from June until July. They grow really fast in nurseries and develop a straight trunk. They do not need much water and can live on soils of moderate quality.

The increasing quantity of polluting materials of the air – like carbon- or sulphur-dioxid with the great amount of dust – can shield the stomata of the leaves. Above a certain quantity of dust the rain does not wash it away and this leads to the slow death of the plant.

Among *Tilia* species *Tilia cordata* tolerates much less the environmental pollution, the next is *Tilia platyphyllos* and *Tilia* × *euchlora*. Contrasted with the former practice, which says *Tilia tomentosa* species tolerate best the heavily polluted streets of Budapest, but they are not better than *Tilia* × *euchlora*.

The aim of the selection work was to define some linden species tolerating urban conditions similar to the best known stress-tolerant trees like *Ailanthus, Celtis* and *Fraxinus*.

Nursery growth

The cultivars and some exotic-species of linden are propagated by budding. The most common method is chip-budding on 2–3 years old seedling rootstocks. *Tilia cordata* can be budded on the same rootstock or on *Tilia* ×

euchlora. *Tilia platyphyllos* and *Tilia tomentosa* cultivars can be budded on the same rootstocks. *Tilia americana* is usually budded on *Tilia tomentosa (Schmidt & Tóth,* 1996).

Tilia cultivars are usually budded in the first two weeks of August in Hungary. Owing to propagation already in July buds can sprout and the new, tender shoots freeze in the winter (*Schmidt & Komiszár*, 1987).

Another way of vegetative propagation of *Tilia* species is softwood cuttings. This way of propagating *Tilia* species is the most difficult one. There were some experiments carried out at our Department on root formation of *Tilia tomentosa*. The results show that most roots were induced when the shoots for cutting had been etiolated earlier under black foliage (*Schmidt*, 1980, 1982, 1982a).

The aim of our work was to examine and compare the yearly growth and compatibility of *Tilia* 'Saint Stephen' ('Szent István') and *Tilia platyphyllos* 'K3' clones on different rootstocks.

Material and method

Selection

First a new method of selection has been developed. Urban stress tolerant trees can be found by screening in the most polluted streets of the town. The selection area of the trees is in Budapest in an alley of linden trees settled on a traffic island of a busy two-lane road. The advantage of this traffic island situated in the central lane of the street where continuous traffic ensures continuous and heavy pollution. The growth of trees is not influenced by the shadows of the buildings.

The alley was planted 30 years ago. It consists of linden trees springing from a mixed and unknown seedling population. The monitoring of the alley has been going on for 15 years. During that time owing to pollution the majority of trees of the alley perished. The replacement was continuous with *Tilia tomentosa* seedlings.

During the monitoring we took attributes into account as follows:

- nice and standard crown shape
- circumference of trunk the tree reached until now
- full default of pests
- ability of keeping leaves on the branches for a long time

The last attribute has a great importance. We realized that after blossoming the leaves of most trees in the alley got brown and began to die. It means that the margin of the leaves get necrotic and it stretches to the whole surface of the leaf soon. At most of the trees it happens already during the summer and in September they have no leaves any more.

We monitored 70 specimens of the alley including the mother trees of *Tilia* 'Saint Stephen' (K1 clone) and *Tilia platyphyllos* 'K3' clone in 1999 on the score of keeping their foliage. We checked the alley three times a year and examined the photosynthetic surface of the trees.

Nursery growth

The first propagation of *Tilia* hybrid 'Saint Stephen' was made in the Tahi Ornamental Nursery in 1991. It was grafted on *Tilia tomentosa* rotstocks at a height of 120–140 cm. Since then *Tilia* 'Saint Stephen' was grafted on *Tilia platyphyllos* and *Tilia cordata* rootstocks as well. After defining the *Tilia* hybrid 'Saint Stephen' (K1 clone) as compatible with all three species, we decided to perform some other trials.

First the sprouting of *Tilia* 'Saint Stephen' buddings were examined in the year of grafting (1999).

Second the height of one year old *Tilia* 'Saint Stephen' buddings were compared with other cultivars budded on different rootstocks.

The third trial compares the height and stem circumferemce measured at 1m of two years old *Tilia* 'Saint Stephen' buddings with two years old *Tilia cordata* 'Greenspire'.

In the fourth trial the effect of the rootstock was examined on *Tilia* 'Saint Stephen' by budding it on *Tilia cordata* and *Tilia tomentosa*. Chip-buddings were made on the 15th of May 2000.

The fifth trial compares the yearly growth of *Tilia* 'Saint Stephen' with the yearly growth of *Tilia platyphyllos* 'Ági' and *Tilia euchlora*; all chip-budded on *Tilia platyphyllos* rootstocks in August of 1999.

The sixth trial compares the yearly growth of *Tilia platyphyllos* 'K3' clone with the growth of *Tilia tomentosa* 'Szeleste', *Tilia tomentosa* 'Zentai ezüst', *Tilia americana* 'Nova', *Tilia americana* 'Redmond' budded all on *Tilia tomentosa* rootstocks.

In the last three trials the length of the shoots were measured three times a year: the 25th of July 2000, the 9th of August 2000 and the 5th of October 2000.

The results were evaluated with the Ministat statistical program (*Vargha & Czigler*, 1999).

Results

Selection

Attributes of *Tilia* 'Saint Stephen', defined on the eldest exemplar are as follows:

The **crown shape** is normally tapered with a straight leader. The vitality of the eldest tree is shown by the circumference of the stem which is one of the best among the trees in the alley.

The **foliage keeping ability** is good in case of this tree. Compared with other specimens in the alley *Tilia* 'Saint Stephen' keeps its foliage 7–8 weeks longer and it resists better the polluted air. *Table 1.* shows the foliage keeping ability of the examined 70 trees in the alley. The results reveal that in May the 75.5% of the trees belonged to the category of trees having 76–100% green leafage. But at the end of September this number was only 8.6%. One of the trees giving such a good result is the mother tree of *Tilia* 'Saint Stephen'.

Table 1 – The decrease of the active foliage of the linden tree alley in 1999, which *Tilia* hybrid 'Saint Stephen' and *Tilia platyphyllos* 'K3' were selected from

Living leafage %	10th of May		24th of July		29th of September	
	piece	%	piece	%	piece	%
1–10	–	–	–	–	24	34.3
11–25	2	2.9	4	5.7	17	24.3
26–50	3	4.3	4	5.7	18	25.7
51–75	12	17.1	24	34.3	5	7.1
76–100	53	75.7	38	54.3	6	8.6
Together	70	100	70	100	70	100

Leaves are bright green above and dull green beneath. On the veins beneath there are some hairs characterised by 4 or 8 long ray cells (*Jámborné* et. al. 1999, 1999a, 2000, 2001, *Sinkó* et. al. 2000, *Reményi* et. al. 2001).

The **blossoming** is dated on the middle or end of June depending on weather. Flowers are medium size and smell balmy. Fruits are elongated with ribs and relatively small.

It seems to be resistant to red mites and free from fungus diseases.

Attributes of *Tilia platyphyllos* 'K3' defined on the eldest exemplar are as follows:

The **crown shape** is normally tapered, lower branches a little bit bend down. The expansion of the trunk is good.

The **foliage keeping ability** is very good of this tree. It keeps the leaves until October as well and drops them off simultaneously after getting yellow.

Leaves are large, dark green above and beneath. Off-white hairs are to find beneath in the forks of veins except of those the leaves are fully bold.

The **blossoming** is dated on the beginning or middle of June depending on weather. Fruits are elongated and of medium size with 5–6–7 ribs.

Nursery growth

Owing to the extremely warm autumn in 1999 some buds sprouted. *Table 2*. shows the percentage of sprouting buds in the year of the budding. The data in *Table 2* confirm that *Tilia* hybrid 'Saint Stephen' is not susceptible too much to sprout in the year of budding. In former years we did not find the buds sprouting in the year of budding except for cultivars *Tilia tomentosa* 'Szeleste', 'Ezüsthenger' and *Tilia platyphyllos* 'Ági'.

The *Table 3* shows the yearly growth of buddings on three different rootstocks. We can diagnose the cultivar *Tilia* 'Saint Stephen' as growing the best among cultivars examined. The sole cultivar growing better in 1999 was *Tilia americana* 'Nova'.

Table 4 shows the length of two years old buddings and the stem circumference of *Tilia* 'Saint Stephen' compared with *Tilia cordata* 'Greenspire'. Both cultivars were budded on *Tilia cordata* rootstocks in 1997. Stem circumference was measured at the height of 1m. It can be diagnosed that *Tilia* hybrid 'Saint Stephen' grew better than *Tilia cordata* 'Greenspire' and stem circumference was larger as well.

Table 2 – The sprouting of buds in the year of the budding (autumn 1999)

Cultivars	Sprouting %
Tilia platyphyllos 'Ági'	66
Tilia tomentosa 'Szeleste'	64
Tilia tomentosa 'Zentai Ezüst'	42
Tilia americana 'Redmound'	24
Tilia americana 'Nova'	18
Tilia* hybrid 'Saint Stephen' *(K1)	**16**
Tilia pallida	14
Tilia cordat 'Greenspire'	2.5
Tilia cordata 'Savaria'	6

Table 3 – The height of one year old buddings in %

Budding combinations	100–150 cm	150–175 cm	175–200 cm	Over 200 cm
On *T. platyphyllos* rootstock				
Tilia* hybrid 'Saint Stephen' *(K1)	**2**	**32**	**30**	**36**
Tilia × *euchlora*	43	55	2	–
T. americana 'Nova'	–	16	32	52
On *Tilia cordata* rootstock				
T. cordata 'Greenspire'	42	51	7	–
T. cordata 'Savaria'	56	36	8	–
On *T. tomentosa* rootstock				
T. tomentosa 'Szeleste'	11	61	38	–

Table 4 – Comparison of height and circumference of 2 years old buddings of *Tilia* hybrid 'Saint Stephen' and *Tilia cordata* 'Greenspire' in %

Cultivar	The height of the buddings				Stem circumference			
	>175	175–200	200–250	250–300	3/4	4/6	6/8	8/10
'Saint Stephen'	–	–	17	83	–	22	57	11
'Greenspire'	9	91	–	–	32	68	–	–

It can be diagnosed that *Tilia* 'Saint Stephen' produced a 2.5 times better yearly growth on *Tilia tomentosa* rootstock, than on *Tilia cordata* in May budding *(Figure 4)*.

In the fifth trial there were three different clones budded on *Tilia platyphyllos* rootstocks. Cultivar *Tilia platyphyllos* 'Ági' produced a little better yearly growth than *Tilia* 'Saint Stephen', but the differences are not significant. The shortest shoots were grown in case of *Tilia* × *euchlora*.

Best yearly growth were produced by *Tilia platyphyllos* 'K3' and *Tilia americana* 'Nova', but the differences are not

Figure 1 The mother tree of the *Tilia platyphyllos* 'K3' clone keeps its healthy foliage at 10th of October 1999

significant. The second best growth was produced by *Tilia americana* 'Redmond' and *Tilia tomentosa* 'Zentai Ezüst', followed by *Tilia tomentosa* 'Szeleste', which was the slowest grower in the group *(Figure 6)*.

Conclusions

Concluding from monitoring the trees in the selection area and cultivating them in a nursery the following attributes can be established:

***Tilia* 'Saint Stephen':**

- the shape of the crown is normally tapered and in case of young trees it has a form like a drop
- the foliage keeping ability is good, leaves are bright green and decorative
- the cultivar shows no phenomena of incompatibility budded on *Tilia platyphyllos, Tilia cordata* and *Tilia tomentosa* rootstocks
- sprouting the buds in the year of budding is normally not typical
- the cultivar produced one of the bests yearly growth on *Tilia platyphyllos* rootstock compared with other cultivars on different rootstocks
- compared with *Tilia cordata* 'Greenspire', *Tilia* 'Saint Stephen' grew better and produced larger stem circumference in case of two years old buddings
- *Tilia* hybrid 'Saint Stephen' grows better budded on *Tilia tomentosa* rootstock than on *Tilia cordata*
- the cultivar produced the best yearly growth compared with *Tilia platyphyllos* 'Ágí' both budded on *Tilia platyphyllos* rootstock. It grew better than *Tilia* × *euchlora*

The results described above supported that *Tilia* hybrid 'Saint Stephen' gained state approvement in 2000.

Tilia platyphyllos 'K3':

- the shape of the crown is normally tapered and lower branches a little bit bend down
- the stem expansion ability is very good
- leafage keeping ability is very good as well
- leaves are dark green, large and thick
- budded on *Tilia tomentosa* rootstock and compared with cultivars budded on *Tilia tomentosa* it has one of the best

Figure 2 Annual growth of *Tilia* hybrid 'Saint Stephen' in the Tahi Nursery in 2000

Figure 3 Ten years old tree of Tilia hybrid 'Saint Stephen' in the Tahi Nursery in 2000

yearly growth. The difference of the lenght of shoots between *Tilia platyphyllos* 'K3' and *Tilia americana* 'Nova' is not significant. *Tilia americana* 'Nova' is said to be the best grower in nurseries.

That is why *Tilia platyphyllos* 'K3' could be considered as a new candidate to become stately approved cultivar.

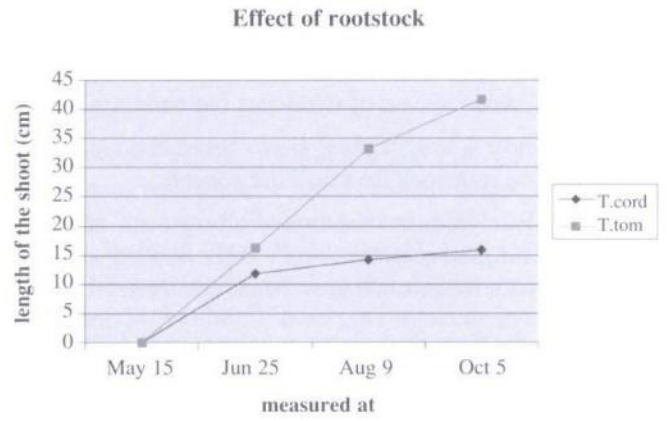

Figure 4 Effect of different rootstocks on *Tilia* hybrid 'Saint Stephen' one year old buddings in 2000

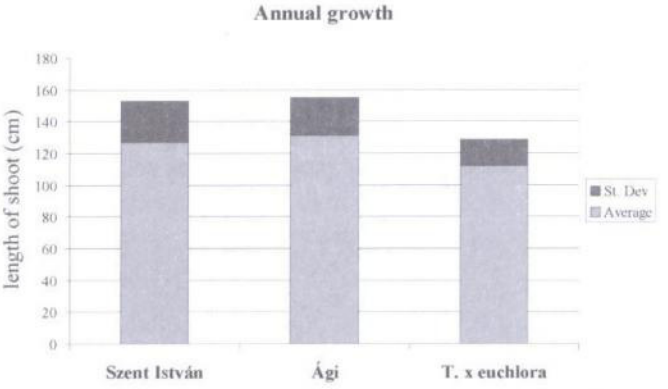

Figure 5 The annual growth of different *Tilias* on *Tilia platyphyllos* rootstock in 2000

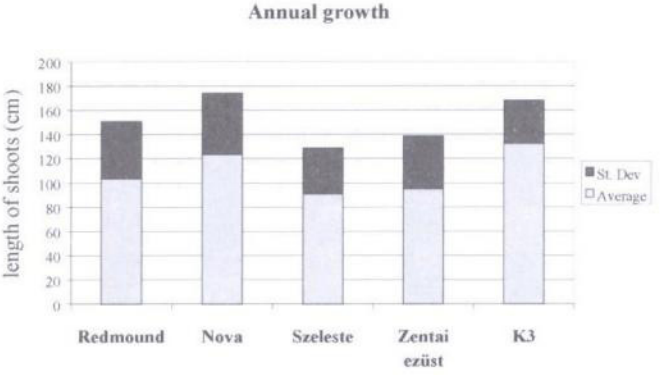

Figure 6 The annual growth of different cultivars on Tilia tomentosa rootstock in 2000

Acknowledgement

We would like to say special thanks to professor †Endre Probocskai and Elek Sipos for their kind help.

This work was supported by OTKA (Hungarian Sci. Res. Fund.) project No. T 026420.

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