Testing of lime tree (*Tilia cordata* Miller) clones

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ABSTRACT: Previous experiences with breeding of lime tree (*Tilia cordata* Miller) in European countries are shown in this paper. The first results were obtained from the evaluation of juvenile planting of lime tree (*Tilia cordata* Miller) in the Czech Republic, founded in the School Forest Enterprise Kostelec nad Černými lesy. Lime tree clones (initially cultivated *in vitro*) were evaluated for growth parameters and also according to the growth form of the different clones. Individual clones were also checked for mortality.

Keywords: clonal test; plant growth; growth form; *Tilia cordata* Miller

EUROPEAN EXPERIENCE

The lime tree (*Tilia cordata* Miller) belongs to the so-called Noble Hardwoods. On the international European scale they have been included in the programme EUFOR-GEN, in which the Czech Republic also participates. This programme, founded in 1994, is coordinated by the International Plant Gene Resources Institute (IPGRI) in Rome. In the framework of this programme one of the priorities was to attract attention to Noble Hardwoods. That was the reason why an international workgroup dealing with the protection and sustainable management of gene resources of these Noble Hardwoods was established in the framework of the European network in 1996. The greatest attention is paid to these tree species especially in Germany, in Austria and in France.

Tilia cordata in Hungary grows preponderantly in montane and submontane stage (BARNA 1996). The protection of genetic diversity is focused especially on protection *in situ*. There are 3 seed orchards of lime tree in Hungary and there are 100 different clones of plus trees in clone archives. The whole area of *ex situ* plantings is 4.2 ha. Further there are 33.2 ha of 23 approved stands for the collection of reproductive material.

According to KLEINSCHMIT et al. (1996) there are altogether 19 seed orchards with 39.3 ha in Germany, in which there are 501 clones of the lime tree. There are not any registered plus trees. Further 2 clone archives are mentioned with 85 clones and seed of the lime tree is obtained from 7 stands approved for seed collection. Annually 75 kg of seed is collected in these stands.

The lime tree is artificially reproduced in most places in Switzerland because of insufficient natural regeneration. There are problems with the insufficient quality of grown individuals (a high percentage of fork individuals, unsuitable stem shape) as far as a small plantation spacing is concerned according to ROTACH (1996). Insufficient are also the usable sources of seed, concerning their quantity and quality (phenotype of desired traits, gene diversity). The occurrence of *Tilia cordata* in Switzerland is only regional and in small populations. In future breeding activities will be focused preponderantly on finding suitable indigenous provenances and on the evaluation of their desired phenotype traits. The most suitable populations will be used as sources of reproductive material. A further step will be the foundation of productive seed orchards with managed selection aimed at unsuitable individuals. The main attention in Switzerland is paid to protection *in situ*, production seed orchards will only be a source of selected individuals with exceptional genotype.

The occurrence of *Tilia cordata* is dispersed in Denmark, preponderantly in the south of the country. The capacity of seed production for forest regeneration is very low, mostly due to unsuccessful fruit research. The physiological and genetic background of this problem has not been made clear so far, but according to pollen analyses the most important factor is climatic conditions. Most of the planted stands are based on imported seeds. Greater interest in *Tilia cordata* has been shown in the last years. In Denmark there is one clone archive and 2 approved stands for collection of reproductive material (CANGER, KJAER 1996).

PROKAZIN et al. (1998 in JENSEN, CANGER 1998) reported that *Tilia cordata* was the most widespread species of the lime tree in Russia. This species occurs in the whole area of forest steppe, covering the European part of Russia. 137 plus trees and 108.5 ha of breeding plantations were recorded there.

MAGHERINI and NIN (1994) published the results of experiments with germination of seeds and rooting of half-woody cuttings of 3 lime species (*Tilia cordata*, *Tilia platyphyllos* and *Tilia tomentosa*). Seeds were treated by

removing the pericarp, wetting in the cold, sterilization and application of gibberellic acid. Half-woody cuttings were without treatment or were treated with 600 and 10,000 ppm IBA. The *Tilia cordata* species had very low germination, maximally 17.4%. Cuttings from the shoot had a low potential of rooting, but IBA treatment increased the percentage of rooted cuttings from 43% to 61%. The application of IBA had only a small influence on the number and length of the roots. *Tilia cordata* showed the best results of rooting among the used lime species.

Cuttings of three lengths were taken for propagation of *Tilia cordata* – 6 cm, 6–10 cm, and 10–18 cm from three years old seedlings. The cuttings were treated with 1% IBA and rooted in a mixture of peat, pearlite, sand, etc. in the greenhouse with moistened air. A higher percentage of longer cuttings took roots with better quality of rooting (ELSNER 1992).

MAURER and TABEL (1995) published their methodological results concerning studies of isoenzymes of the lime tree. They described how to select plant material, how to prepare the enzyme extract and how it can be stored for a long time. Electrophoresis on starch gel (production of starch gel by a microwave method is described) was used for the separation of different enzyme forms. A practical application of this research is a possibility to define exactly the different clones of *Tilia cordata* in the seed orchard, by help of combination of phoreograms of tested enzymatic forms. The clone character of lime trees growing as decorative greenery on streets and along roads in the countryside can be determined similarly as well.

Minimal attention has been paid to the problems of variability of the lime tree in the Czech Republic so far. In the first half of the 1990s partial information was obtained about the phenotype variance of the chosen population, but no experimental plot has been founded there until now. That is why the foundation of provenance experiments is planned along with research on chosen autochthonous stands where information about genetically conditioned variability will be acquired in the framework of the Czech Republic. As a part of a project preparatory works will be carried out to found a new series of experimental provenance plots with *Tilia cordata* and *Tilia platyphyllos* (BENEDÍKOVÁ, MALÁ 2001).

MATERIAL AND METHODS

In autumn 1990 container-grown seedlings (in PE bags) of *Tilia cordata* cultivated *in vitro* were received from the Laboratory of Biotechnologies in Olešná. As early as in spring 1999 this material was exposed to the outdoor environment in Olešná. There were 95 clones of the lime tree (represented by 4 or 5 individuals, with total number of 451 plants). Primary explants were obtained from plus trees and breeding trees from several natural forest areas [Jihočeská pánev, Křivoklátsko, Český kras (Bohemian Karst) and Polabí]. Clones No. 1–4 are by origin from the natural forest area Jihočeská pánev, directly from plus trees, and clones No. 56–90 are from the seed orchard

Milevsko. Clones No. 5–19 from the natural forest area Křivoklátsko from breeding trees, clones No. 20–25 from the natural forest area Český kras from breeding trees, clones No. 26–55 and 91–95 from the natural forest area Polabí from breeding trees. The clones were grown as containerized seedlings for one year at Truba Tree Breeding Station and in autumn 2000 they were planted in the form of line planting in SFE Kostelec nad Černými Lesy, in the locality U Trubské hájenky, in stand 20 A 9 at a spacing of 1.5 × 1.5 m. The planting is fenced. All seedlings were marked by pegs for forest weed mowing.

Growth parameters and growth form were examined in *Tilia cordata* clones. In spring 2001 the growth form was evaluated in individual lime trees. At the end of the vegetation period (autumn 2001) the growth form was checked again (especially in less developed clones). The growth form was evaluated according to the categories: shrub form, branched stem and unbranched stem. This evaluation was repeated in autumn 2002 again.

In 2001 the height of individual trees was measured, in spring 2001 before bud burst and later on in autumn after growth termination. The basic statistical characteristics were calculated for the different clones. The statistical significance of the influence of the relevance of individuals to the clone and their height was determined by the analysis of variance (level 95%) in spring and in autumn 2001 and the increment in 2001. Duncan's test always followed.

RESULTS

Plant growth

In spring 2001 the average height of clones was from about 5.4 cm (clone No. 9 from Křivoklátsko) up to 35.8 cm (clone No. 65 from Milevsko seed orchard). In autumn the average height of clones was from 11.4 cm (clone No. 10 from Křivoklátsko) to 66.8 cm (clone No. 38 from Polabí). The average increment of clones in 2001 was from 0.3 cm (clone No. 64 from Milevsko seed orchard) up to 35.8 cm (clone No. 38 from Polabí) – see Table 1.

In spring 2001 clones from plus trees from the natural forest area Jihočeská pánev reached on average the height of 20.3 cm and in autumn 2001 25.8 cm, their average increment was 5.5 cm. In spring 2001 the lowest on average was clone No. 2 (14 cm) and the highest clone No. 3 (24.3 cm). In autumn 2001 the lowest clone on average was No. 2 (20.3 cm) again and the highest clone No. 3 (30.8 cm) again. The lowest plant growth in 2001 on average was observed in clone No. 1 (3 cm) and the highest in clone No. 3 (6.5 cm).

Clones originating from Křivoklátsko reached the average height of 15.5 cm in spring 2001 and 23.9 cm in autumn 2001, their average increment in 2001 was 8.4 cm. In spring 2001 clone No. 9 (5.4 cm) reached the lowest average height and clone No. 17 (25 cm) the greatest height. In autumn 2001 clone No. 10 (11.4 cm) reached the lowest average height and clone No. 5 (36.4 cm) the greatest height. In 2001 clone No. 19

Table 1. The average height of clones

Clone No.	Number of individuals	Mortality (plants)	Mortality (%)	Spring 2001 (cm)	Autumn 2001 (cm)	Increment 2001 (cm)
1	4		0	19.5	22.5	3.0
2	5	3	60	14.0	20.3	6.3
3	5	1	20	24.3	30.8	6.5
4	5		0	23.4	29.4	6.0
1–4	**19**	**4**	**21.1**	**20.3**	**25.8**	**5.5**
5	5		0	22.6	36.4	13.8
6	5		0	15.0	28.0	13.0
7	5		0	15.0	25.2	10.2
8	5		0	14.2	24.2	10.0
9	5		0	5.4	15.4	10.0
10	5		0	9.6	11.4	1.8
11	5		0	16.4	25.4	9.0
12	5		0	15.0	32.2	17.2
13	5		0	11.4	14.6	3.2
14	5		0	14.2	19.0	4.8
15	5		0	17.4	25.6	8.2
16	5		0	11.8	15.8	4.0
17	5		0	25.0	35.0	10.0
18	5		0	18.8	27.8	9.0
19	5		0	20.3	22.0	1.7
5–19	**75**	**0**	**0.0**	**15.5**	**23.9**	**8.4**
20	5		0	19.2	26.4	7.2
21	5		0	16.2	31.4	15.2
22	5		0	27.8	59.8	32.0
23	4		0	23.6	35.8	12.2
24	5		0	24.8	28.8	4.0
25	5		0	33.8	39.0	5.2
20–25	**29**	**0**	**0.0**	**24.2**	**36.9**	**12.6**
26	4		0	24.8	39.4	14.6
27	5		0	16.2	26.4	10.2
28	5		0	21.6	31.4	9.8
29	5		0	29.6	41.6	12.0
30	5		0	20.4	44.2	23.8
31	5		0	18.4	24.2	5.8
32	5		0	17.4	36.4	19.0
33	5		0	27.2	38.4	11.2
34	5		0	22.6	33.0	10.4
35	5		0	22.4	47.2	24.8
36	5	1	20	29.8	50.3	20.5
37	5		0	22.3	37.8	15.5
38	5		0	31.0	66.8	35.8
39	4		0	23.8	28.8	5.0
40	5		0	17.8	28.2	10.4

Table 1 to be continued

Clone No.	Number of individuals	Mortality (plants)	Mortality (%)	Spring 2001 (cm)	Autumn 2001 (cm)	Increment 2001 (cm)
41	4		0	23.8	48.4	24.6
42	5		0	21.0	34.2	13.2
43	5		0	24.4	34.4	10.0
44	5		0	23.4	57.4	34.0
45	4		0	26.6	44.0	17.4
46	5		0	24.8	37.2	12.4
47	5		0	24.8	36.6	11.8
48	5		0	27.4	29.4	2.0
49	5		0	32.8	36.8	4.0
50	5		0	30.8	54.0	23.2
51	5		0	23.8	33.4	9.6
52	5		0	19.8	29.8	10.0
53	5		0	30.4	35.6	5.2
54	5		0	20.0	25.0	5.0
55	4		0	21.8	27.5	5.7
91	5		0	10.6	16.0	5.4
92	1		0	18.0	19.0	1.0
93	4		0	16.3	30.3	14.0
94	5		0	9.5	15.0	5.5
95	3		0	15.7	17.3	1.6
26–55, 91–95	**163**	**1**	**0.6**	**22.6**	**35.3**	**12.7**
56	5		0	18.2	50.2	32.0
57	5		0	31.8	43.2	11.4
58	5	1	20	21.5	41.8	20.3
59	4		0	32.5	37.5	5.0
60	5		0	27.4	43.8	16.4
61	5		0	27.4	34.0	6.6
62	5		0	24.5	41.0	16.5
63	5		0	29.3	30.8	1.5
64	5		0	29.0	29.3	0.3
65	5		0	35.8	41.2	5.4
66	5		0	27.0	36.4	9.4
67	5		0	32.3	47.3	15.0
68	5		0	26.0	35.0	9.0
69	5		0	32.8	43.4	10.6
70	5	1	20	28.0	52.0	24.0
71	5	1	20	32.3	58.3	26.0
72	4		0	34.4	58.6	24.2
73	5		0	32.0	53.2	21.2
74	5		0	22.2	36.2	14.0
75	5		0	28.4	37.0	8.6
76	4		0	13.0	17.2	4.2
77	5	2	40	15.7	19.3	3.6
78	5		0	10.0	12.8	2.8

Table 1 to be continued

Clone No.	Number of individuals	Mortality (plants)	Mortality (%)	Spring 2001 (cm)	Autumn 2001 (cm)	Increment 2001 (cm)
79	5		0	21.6	26.0	4.4
80	4		0	13.2	16.6	3.4
81	4		0	24.3	26.5	2.2
82	4		0	17.0	21.8	4.8
83	5		0	20.0	27.6	7.6
84	4		0	13.0	40.3	27.3
85	5		0	22.8	35.8	13.0
86	4		0	10.0	21.0	11.0
87	5		0	20.0	39.0	19.0
88	5		0	17.8	37.6	19.8
89	4		0	24.0	39.0	15.0
90	4		0	15.0	23.0	8.0
56–90	**165**	**5**	**3**	**23.7**	**35.8**	**12.1**
Sum/Mean	**451**	**10**	**2.1**	**21.9**	**33.4**	**11.5**

Clones No. 1–4 – plus trees from the natural forest area Jihočeská pánev
Clones No. 5–19 – breeding trees from the natural forest area Křivoklátsko
Clones No. 20–25 – breeding trees from the natural forest area Český kras
Clones No. 26–55 and 91–95 – breeding trees from the natural forest area Polabí
Clones No. 56–90 – clones from the seed orchard Milevsko – plus trees from the natural forest area Jihočeská pánev

(1.7 cm) had on average the lowest increment and No. 12 (17.2 cm) the highest increment.

Clones originating from the Český kras (Bohemian Karst) reached on average the height of 24.2 cm in spring 2001 and 36.9 cm in autumn 2001, their average increment in 2001 was 12.6 cm. In spring 2001 clone No. 21 (16.2 cm) reached the lowest average height and clone No. 25 (33.8 cm) the greatest height. In autumn 2001 clone No. 20 (26.4 cm) was on average the lowest and No. 22 (59.8 cm) was the highest clone. In 2001 clone No. 24 (4 cm) had on average the lowest increment and clone No. 22 (32 cm) the highest.

Clones originating from Polabí reached on average the height 22.6 cm in spring 2001 and 35.3 cm in autumn 2001, their average increment in 2001 was 12.7 cm. In spring 2001 clone No. 94 (9.5 cm) reached the lowest average height and clone No. 49 (32.8 cm) the greatest height. In autumn 2001 clone No. 94 (15 cm) was on average the lowest again and clone No. 38 (66.8 cm) on average the highest. In 2001 clone No. 92 (1 cm) reached on average the lowest increment and clone No. 44 (34 cm) the highest.

Clones originating from Milevsko seed orchard (plus trees from the natural forest area Jihočeská pánev) reached an average height of 23.7 cm in spring 2001 and an average height of 35.8 cm in autumn 2001, their average increment in 2001 was 12.1 cm. In spring 2001 clones No. 78 and 86 (10 cm) reached the lowest average height and clone No. 65 (35.8 cm) the greatest height. In autumn 2001 clone No. 78 (12.8 cm) was on average the lowest again and clone No. 72 (58.6 cm) on average the highest. In

2001 clone No. 64 (0.3 cm) reached on average the lowest increment and clone No. 56 (32 cm) the highest.

Comparison of genetically identical material from plus trees and from the seed orchard:

Clone No.	Height in spring 2001 (cm)	Height in autumn 2001 (cm)	Increment 2001 (cm)
1–64	19.5–29.0	22.5–29.3	0.3–3.0
2–85	14.0–22.8	20.8–35.8	6.3–13.0
4–62	23.4–24.5	29.4–41.0	6.0–16.5

All clones reached on average the height 21.9 cm in spring 2001 and 33.4 cm in autumn 2001, and increment 11.5 cm in 2001. In spring 2001 clones originating from Český kras, from Milevsko seed orchard and from Polabí had on average the height above the average height of the whole comparative plantation; clones from plus trees from the natural forest area Jihočeská pánev and from Křivoklátsko were below the average height of the whole comparative plantation. In autumn 2001 the situation was similar, as well as in the case of average increment.

The analysis of variance showed a statistically significant influence of the relevance of individuals to the clone according to the growth height in spring 2001, to the growth height in autumn 2001 and to their increment in 2001. Duncan's test divided the clones into 29 homogeneous subgroups according to the height in spring 2001 (Table 2), into 26 homogeneous subgroups according to the height in autumn 2001 (Table 3) and into

Table 2. Duncan's test for height in spring 2001, classified by clones

	Homogeneous subsets		
Group 1:	9 76 10 86 78 94 91 13 16 2 77 84 80 8 14 6 7 12 90 95		
	Pooled mean =	12.0860	
	95% Confidence interval =	10.7687	13.4033
Group 2:	76 10 86 78 94 91 13 16 2 77 84 80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20		
	Pooled mean =	14.6209	
	95% Confidence interval =	13.5939	15.6479
Group 3:	10 86 78 94 91 13 16 2 77 84 80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83		
	Pooled mean =	15.4798	
	95% Confidence interval =	14.5139	16.4456
Group 4:	86 78 94 91 13 16 2 77 84 80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30		
	Pooled mean =	15.7919	
	95% Confidence interval =	14.8261	16.7577
Group 5:	91 13 16 2 77 84 80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42		
	Pooled mean =	16.4451	
	95% Confidence interval =	15.4532	17.4371
Group 6:	13 16 2 77 84 80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87		
	Pooled mean =	17.1899	
	95% Confidence interval =	16.2404	18.1394
Group 7:	16 2 77 84 80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34		
	Pooled mean =	17.8814	
	95% Confidence interval =	16.9694	18.7935
Group 8:	2 77 84 80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85		
	Pooled mean =	18.1649	
	95% Confidence interval =	17.2529	19.0770
Group 9:	77 84 80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44		
	Pooled mean =	18.5400	
	95% Confidence interval =	17.6417	19.4383
Group 10:	84 80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51		
	Pooled mean =	19.1402	
	95% Confidence interval =	18.2718	20.0086
Group 11:	80 8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89		
	Pooled mean =	19.3458	
	95% Confidence interval =	18.4774	20.2142
Group 12:	8 14 6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17		
	Pooled mean =	20.2874	
	95% Confidence interval =	19.4791	21.0957
Group 13:	6 7 12 90 95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70		
	Pooled mean =	20.8492	
	95% Confidence interval =	20.0490	21.6494

Table 2 to be continued

	Homogeneous subsets			
Group 14:	95 21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62			
	Pooled mean =	21.5267		
		95% Confidence interval =	20.7118	22.3417
Group 15:	21 27 11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45			
	Pooled mean =	21.7020		
		95% Confidence interval =	20.8904	22.5136
Group 16:	11 82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33			
	Pooled mean =	22.0458		
		95% Confidence interval =	21.2258	22.8658
Group 17:	82 93 15 32 40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22			
	Pooled mean =	22.6808		
		95% Confidence interval =	21.8929	23.4686
Group 18:	40 88 92 56 31 18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75			
	Pooled mean =	23.3267		
		95% Confidence interval =	22.5249	24.1285
Group 19:	18 20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29			
	Pooled mean =	24.0458		
		95% Confidence interval =	23.2258	24.8658
Group 20:	20 1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29 36 63			
	Pooled mean =	24.3648		
		95% Confidence interval =	23.5515	25.1780
Group 21:	1 52 58 54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29 36 63 53			
	Pooled mean =	24.5943		
		95% Confidence interval =	23.7810	25.4075
Group 22:	54 83 30 42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29 36 63 53 50			
	Pooled mean =	25.0170		
		95% Confidence interval =	24.1883	25.8457
Group 23:	42 74 28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29 36 63 53 50 57			
	Pooled mean =	25.4933		
		95% Confidence interval =	24.6464	26.3402
Group 24:	28 79 87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29 36 63 53 50 57 69			
	Pooled mean =	25.8455		
		95% Confidence interval =	24.9890	26.7019
Group 25:	87 19 35 5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29 36 63 53 50 57 69 59 38 49 73			
	Pooled mean =	26.5983		
		95% Confidence interval =	25.7588	27.4377

Table 2 to be continued

	Homogeneous subsets		
Group 26:	5 34 85 4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29 36 63 53 50 57 69 59 38 49 73 72		
	Pooled mean = 27.0548		
	95% Confidence interval =	26.1964	27.9132
Group 27:	4 44 23 39 41 51 89 3 81 43 24 26 46 47 17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29 36 63 53 50 57 69 59 38 49 73 72 25		
	Pooled mean = 27.5311		
	95% Confidence interval =	26.6524	28.4098
Group 28:	17 55 37 70 66 62 45 33 48 60 61 68 22 71 75 64 29 36 63 53 50 57 69 59 38 49 73 72 25 65		
	Pooled mean = 29.3176		
	95% Confidence interval =	28.2734	30.3618
Group 29:	62 45 33 48 60 61 68 22 71 75 64 29 36 63 53 50 57 69 59 38 49 73 72 25 65 67		
	Pooled mean = 30.3359		
	95% Confidence interval =	29.2131	31.4588

Table 3. Duncan's test for height in autumn 2001, classified by clones

	Homogeneous subsets		
Group 1:	10 76 78 13 94 9 16 91 80 95 14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28		
	Pooled mean = 23.8932		
	95% Confidence interval =	22.2482	25.5382
Group 2:	76 78 13 94 9 16 91 80 95 14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12		
	Pooled mean = 24.3981		
	95% Confidence interval =	22.7531	26.0430
Group 3:	78 13 94 9 16 91 80 95 14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51		
	Pooled mean = 25.0472		
	95% Confidence interval =	23.4256	26.6687
Group 4:	13 94 9 16 91 80 95 14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17		
	Pooled mean = 26.1410		
	95% Confidence interval =	24.5739	27.7080
Group 5:	94 9 16 91 80 95 14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85		
	Pooled mean = 27.1736		
	95% Confidence interval =	25.6559	28.6912
Group 6:	16 91 80 95 14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47		
	Pooled mean = 28.1694		
	95% Confidence interval =	26.6701	29.6686
Group 7:	91 80 95 14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49		
	Pooled mean = 28.5927		
	95% Confidence interval =	27.0935	30.0920
Group 8:	80 95 14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46		
	Pooled mean = 29.0202		
	95% Confidence interval =	27.5209	30.5194

Table 3 to be continued

	Homogeneous subsets		
Group 9:	95 14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37		
	Pooled mean =	29.6992	
	95% Confidence interval =	28.2236	31.1748
Group 10:	14 92 77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26		
	Pooled mean =	30.7730	
	95% Confidence interval =	29.3671	32.1790
Group 11:	77 2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84		
	Pooled mean =	31.1607	
	95% Confidence interval =	29.7498	32.5717
Group 12:	2 86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65		
	Pooled mean =	31.7560	
	95% Confidence interval =	30.3720	33.1400
Group 13:	86 82 19 1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58		
	Pooled mean =	32.1717	
	95% Confidence interval =	30.8017	33.5417
Group 14:	1 90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69		
	Pooled mean =	33.1500	
	95% Confidence interval =	31.7869	34.5131
Group 15:	90 8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69 60		
	Pooled mean =	33.4684	
	95% Confidence interval =	32.1076	34.8293
Group 16:	8 31 54 7 11 15 79 27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69 60 45 67 30		
	Pooled mean =	34.0162	
	95% Confidence interval =	32.6731	35.3593
Group 17:	27 81 55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69 60 45 67 30 35		
	Pooled mean =	35.3728	
	95% Confidence interval =	33.9593	36.7862
Group 18:	55 20 83 18 6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69 60 45 67 30 35 41		
	Pooled mean =	35.9018	
	95% Confidence interval =	34.4781	37.3255
Group 19:	6 40 39 24 4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69 60 45 67 30 35 41 70		
	Pooled mean =	36.7510	
	95% Confidence interval =	35.2895	38.2124
Group 20:	4 48 52 64 74 93 3 63 21 28 12 34 51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69 60 45 67 30 35 41 70 56		
	Pooled mean =	37.6640	
	95% Confidence interval =	36.1617	39.1662

Table 3 to be continued

	Homogeneous subsets		
Group 21:	51 61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69 60 45 67 30 35 41 70 56 50		
	Pooled mean = 40.0714		
	95% Confidence interval =	38.3850	41.7578
Group 22:	61 42 43 17 53 23 68 85 5 32 47 49 46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69 60 45 67 30 35 41 70 56 50 72 73		
	Pooled mean = 40.9502		
	95% Confidence interval =	39.2849	42.6156
Group 23:	46 59 88 37 33 75 25 87 89 26 84 66 62 65 29 58 57 36 69 60 45 67 30 35 41 70 56 50 72 73 44		
	Pooled mean = 43.7260		
	95% Confidence interval =	41.7721	45.6800
Group 24:	84 66 62 65 29 58 57 36 69 60 45 67 30 35 41 70 56 50 72 73 44 22		
	Pooled mean = 46.9327		
	95% Confidence interval =	44.6176	49.2478
Group 25:	60 45 67 30 35 41 70 56 50 72 73 44 22 71		
	Pooled mean = 51.1061		
	95% Confidence interval =	48.1999	54.0122
Group 26:	41 70 56 50 72 73 44 22 71 38		
	Pooled mean = 55.3333		
	95% Confidence interval =	51.9256	58.7411

Table 4. Duncan's test for increment in 2001, classified by clones

	Homogeneous subsets		
Group 1:	64 92 63 95 19 10 48 81 78 1 13 76 80 77 16 24 49 79 14 82 39 54 59 94 25 53 91 65 55 31 4 2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12		
	Pooled mean = 8.5292		
	95% Confidence interval =	7.4382	9.6203
Group 2:	92 63 95 19 10 48 81 78 1 13 76 80 77 16 24 49 79 14 82 39 54 59 94 25 53 91 65 55 31 4 2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32		
	Pooled mean = 8.7883		
	95% Confidence interval =	7.6973	9.8793
Group 3:	63 95 19 10 48 81 78 1 13 76 80 77 16 24 49 79 14 82 39 54 59 94 25 53 91 65 55 31 4 2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88		
	Pooled mean = 8.9614		
	95% Confidence interval =	7.8764	10.0464
Group 4:	48 81 78 1 13 76 80 77 16 24 49 79 14 82 39 54 59 94 25 53 91 65 55 31 4 2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58		
	Pooled mean = 9.4217		
	95% Confidence interval =	8.3182	10.5251
Group 5:	81 78 1 13 76 80 77 16 24 49 79 14 82 39 54 59 94 25 53 91 65 55 31 4 2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58 36		
	Pooled mean = 9.6543		
	95% Confidence interval =	8.5493	10.7593
Group 6:	78 1 13 76 80 77 16 24 49 79 14 82 39 54 59 94 25 53 91 65 55 31 4 2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58 36 72		
	Pooled mean = 9.8974		
	95% Confidence interval =	8.7940	11.0008

Table 4 to be continued

	Homogeneous subsets		
Group 7:	80 77 16 24 49 79 14 82 39 54 59 94 25 53 91 65 55 31 4 2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58 36 72 73		
	Pooled mean =	10.4379	
	95% Confidence interval =	9.3134	11.5623
Group 8:	14 82 39 54 59 94 25 53 91 65 55 31 4 2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58 36 72 73 70 50		
	Pooled mean =	11.4031	
	95% Confidence interval =	10.2475	12.5587
Group 9:	65 55 31 4 2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58 36 72 73 70 50 30		
	Pooled mean =	12.5654	
	95% Confidence interval =	11.3365	13.7942
Group 10:	2 3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58 36 72 73 70 50 30 41		
	Pooled mean =	13.2677	
	95% Confidence interval =	12.0072	14.5281
Group 11:	3 61 83 67 90 15 68 20 74 11 18 51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58 36 72 73 70 50 30 41 35		
	Pooled mean =	13.5572	
	95% Confidence interval =	12.3014	14.8129
Group 12:	51 28 75 8 9 17 43 52 7 27 34 40 69 86 33 57 47 29 23 46 6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58 36 72 73 70 50 30 41 35 84		
	Pooled mean =	15.0267	
	95% Confidence interval =	13.6485	16.4048
Group 13:	6 85 42 5 93 26 66 89 21 37 60 62 87 45 12 32 88 58 36 72 73 70 50 30 41 35 84 71		
	Pooled mean =	18.7557	
	95% Confidence interval =	16.9496	20.5619
Group 14:	26 66 89 21 37 60 62 87 45 12 32 88 58 36 72 73 70 50 30 41 35 84 71 22 56		
	Pooled mean =	20.9322	
	95% Confidence interval =	19.0292	22.8352
Group 15:	87 45 12 32 88 58 36 72 73 70 50 30 41 35 84 71 22 56 44		
	Pooled mean =	23.5934	
	95% Confidence interval =	21.4264	25.7605
Group 16:	32 88 58 36 72 73 70 50 30 41 35 84 71 22 56 44 38		
	Pooled mean =	25.3750	
	95% Confidence interval =	23.0638	27.6862

16 homogenous subgroups according to the increment in 2001 (Table 4).

Growth form

10 individuals out of 451 trees died in *Tilia cordata* planting by autumn 2001. 250 individuals (57%) showed a shrub growth form, 105 individuals (23%) had branched stems and 86 individuals (20%) had unbranched stems. All individuals of 18 clones had a shrub form of growth, but not a single clone had all individuals only with branched or unbranched stems (Table 5).

Not a single individual out of 441 clones died from autumn 2001 to autumn 2002 in the lime tree plantation. 198 individuals (46%) showed a bush growth, 117 individuals (26%) branched growth of terminal shoot and 126 individuals (28%) a direct development of terminal shoot. Only one single clone (clone No. 80) out of 95 was not represented by a single individual showing the shrub growth form. On the contrary, two clones had all individuals only with the shrub growth form (clones No. 23 and 92) – see Table 5.

In autumn 2001 and 2002 clones from plus trees from the natural forest area Jihočeská pánev had 27% and 40%

Table 5. The growth form in autumn 2001 and in autumn 2002

Clone No.	Number of individuals	Mortality (plants)	Shrub form				Branched stem				Unbranched stem			
			plants		(%)		plants		(%)		plants		(%)	
			2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
1	4		0	2	0	50	1	2	25	50	3	1	75	25
2	5	3	0	1	0	50	0	0	0	0	2	1	100	50
3	5	1	1	1	25	25	3	2	75	50	0	1	0	25
4	5		3	2	60	40	0	1	0	20	2	2	40	40
1–4	**19**	**4**	**4**	**6**	**27**	**40**	**4**	**5**	**27**	**33**	**7**	**5**	**46**	**33**
5	5		3	3	60	60	2	1	40	20	0	1	0	20
6	5		3	2	60	40	0	1	0	20	2	2	40	40
7	5		0	2	0	40	1	0	20	0	4	3	80	60
8	5		3	4	60	80	0	1	0	20	2	0	40	0
9	5		0	1	0	20	4	2	80	40	1	2	20	40
10	5		4	2	80	40	0	2	0	40	1	1	20	20
11	5		5	2	100	40	0	1	0	20	0	2	0	40
12	5		2	3	40	60	3	2	60	40	0	0	0	0
13	5		2	1	40	20	3	1	60	20	0	3	0	60
14	5		2	3	40	60	2	1	40	20	1	1	20	20
15	5		2	2	40	40	0	1	0	20	3	2	60	40
16	5		1	2	20	40	1	2	20	40	3	1	60	20
17	5		3	4	60	80	0	1	0	20	2	0	40	0
18	5		3	1	60	20	2	2	40	40	0	2	0	40
19	5		4	2	80	40	0	0	0	0	1	3	20	60
5–19	**75**	**0**	**37**	**34**	**49**	**45**	**18**	**18**	**24**	**24**	**20**	**23**	**27**	**31**
20	5		1	2	20	40	4	2	80	40	0	1	0	20
21	5		3	2	60	40	2	1	40	20	0	2	0	40
22	5		3	3	60	60	2	1	40	20	0	1	0	20
23	4		1	4	25	100	1	0	25	0	2	0	50	0
24	5		2	1	40	20	0	0	0	0	3	4	60	80
25	5		0	3	0	60	1	1	20	20	4	1	80	20
20–25	**29**	**0**	**10**	**15**	**34**	**52**	**10**	**5**	**34**	**17**	**9**	**9**	**31**	**31**
26	4		1	1	25	25	0	1	0	25	3	2	75	50
27	5		1	2	20	40	2	1	40	20	2	2	40	40
28	5		1	4	20	80	2	0	40	0	2	1	40	20
29	5		0	1	0	20	2	2	40	40	3	2	60	40
30	5		3	2	60	40	2	1	40	20	0	2	0	40
31	5		2	1	40	20	3	1	60	20	0	3	0	60
32	5		0	1	0	20	2	0	40	0	3	4	60	80
33	5		2	1	40	20	3	2	60	40	0	2	0	40
34	5		2	2	40	40	2	3	40	60	1	0	20	0
35	5		4	2	80	40	1	1	20	20	0	2	0	40
36	5	1	3	1	75	25	0	2	0	50	1	1	25	25
37	5		2	2	40	40	3	0	60	0	0	3	0	60
38	5		1	3	20	60	2	1	40	20	2	1	40	20
39	4		1	3	25	75	1	0	25	0	2	1	50	25
40	5		4	2	80	40	1	2	20	40	0	1	0	20
41	4		3	2	75	50	1	1	25	25	0	1	0	25

Table 5 to be continued

Clone No.	Number of individuals	Mortality (plants)	Shrub form				Branched stem				Unbranched stem			
			plants		(%)		plants		(%)		plants		(%)	
			2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
42	5		4	3	80	60	1	1	20	20	0	1	0	20
43	5		5	3	100	60	0	2	0	40	0	0	0	0
44	5		3	1	60	20	2	2	40	40	0	2	0	40
45	4		1	2	25	50	1	1	25	25	2	1	50	25
46	5		2	4	40	80	1	0	20	0	2	1	40	20
47	5		3	2	60	40	1	3	20	60	1	0	20	0
48	5		1	1	20	20	2	2	40	40	2	2	40	40
49	5		1	3	20	60	2	1	40	20	2	1	40	20
50	5		2	3	40	60	1	1	20	20	2	1	40	20
51	5		4	1	80	20	1	2	20	40	0	2	0	40
52	5		3	2	60	40	0	2	0	40	2	1	40	20
53	5		5	4	100	80	0	0	0	0	0	1	0	20
54	5		4	2	80	40	1	2	20	40	0	1	0	20
55	4		3	1	75	25	0	3	0	75	1	0	25	0
91	5		5	2	100	40	0	1	0	20	0	2	0	40
92	1		1	1	100	100	0	0	0	0	0	0	0	0
93	4		3	1	75	25	1	2	25	50	0	1	0	25
94	5		2	2	40	40	2	2	40	40	1	1	20	20
95	3		3	2	100	67	0	0	0	0	0	1	0	33
26–55, 91–95	**163**	**1**	**85**	**70**	**52**	**43**	**43**	**45**	**27**	**28**	**34**	**47**	**21**	**29**
56	5		5	2	100	40	0	1	0	20	0	2	0	40
57	5		2	2	40	40	2	2	40	40	1	1	20	20
58	5	1	3	1	75	25	1	1	25	25	0	2	0	50
59	4		1	1	25	25	1	2	25	50	2	1	50	25
60	5		4	4	80	80	0	1	0	20	1	0	20	0
61	5		5	2	100	40	0	1	0	20	0	2	0	40
62	5		5	2	100	40	0	2	0	40	0	1	0	20
63	5		3	1	60	20	1	1	20	20	1	3	20	60
64	5		4	3	80	60	0	1	0	20	1	1	20	20
65	5		2	2	40	40	3	2	60	40	0	1	0	20
66	5		2	1	40	20	3	2	60	40	0	2	0	40
67	5		2	4	40	80	3	0	60	0	0	1	0	20
68	5		3	4	60	80	2	1	40	20	0	0	0	0
69	5		5	2	100	40	0	2	0	40	0	1	0	20
70	5	1	3	1	75	25	0	1	0	25	1	2	25	50
71	5	1	2	2	50	50	2	0	50	0	0	2	0	50
72	4		4	2	100	50	0	1	0	25	0	1	0	25
73	5		5	3	100	60	0	1	0	20	0	1	0	20
74	5		4	2	80	40	1	1	20	20	0	2	0	40
75	5		5	3	100	60	0	1	0	20	0	1	0	20
76	4		2	1	50	25	0	3	0	75	2	0	50	0
77	5	2	3	2	100	67	0	0	0	0	0	1	0	33
78	5		2	2	40	40	1	2	20	40	2	1	40	20

Table 5 to be continued

Clone No.	Number of individuals	Mortality (plants)	Shrub form				Branched stem				Unbranched stem			
			plants		(%)		plants		%		plants		(%)	
			2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
79	5		3	3	60	60	1	1	20	20	1	1	20	20
80	4		4		100	0	0	2	0	50	0	2	0	50
81	4		4	1	100	25	0	2	0	50	0	1	0	25
82	4		3	2	75	50	1	1	25	25	0	1	0	25
83	5		3	2	60	40	2	2	40	40	0	1	0	20
84	4		3	3	75	75	0	1	0	25	1	0	25	0
85	5		5	2	100	40	0	0	0	0	0	3	0	60
86	4		0	2	0	50	3	1	75	25	1	1	25	25
87	5		3	2	60	40	0	2	0	40	2	1	40	20
88	5		3	3	60	60	2	1	40	20	0	1	0	20
89	4		3	2	75	50	1	1	25	25	0	1	0	25
90	4		4	2	100	50	0	2	0	50	0	0	0	0
56–90	**165**	**5**	**114**	**73**	**71**	**46**	**30**	**45**	**19**	**28**	**16**	**42**	**10**	**26**
Sum Mean	**451**	**10**	**250**	**198**	**57.1**	**45.4**	**105**	**117**	**23.1**	**26.3**	**86**	**126**	**19.8**	**28.3**

Clones No. 1–4 – plus trees from the natural forest area Jihočeská pánev
Clones No. 5–19 – breeding trees from the natural forest area Křivoklátsko
Clones No. 20–25 – breeding trees from the natural forest area Český kras
Clones No. 26–55 and 91–95 – breeding trees from the natural forest area Polabí
Clones No. 56–90 – clones from the seed orchard Milevsko – plus trees from the natural forest area Jihočeská pánev

proportions of individuals with shrub growth form, 27% and 27% with branched stem, and 46% and 33% with unbranched stem. Clones originating from the natural forest area Křivoklátsko had proportions of individuals with shrub growth form amounting to 49% and 45%, with branched stem 24% and 24%, with unbranched stem 27% and 31%. Clones originating from the natural forest area Český kras (Bohemian Karst) had proportions of individuals with shrub growth form amounting to 34% and 52%, with branched stem 34% and 17% and with unbranched stem 31% and 31%. Clones originating from the natural forest area Polabí had 52% and 43% proportions of individuals with shrub growth form, 27% and 28% with branched stem and 21% and 29% with unbranched stem. Clones from Milevsko seed orchard had proportions of individuals with shrub growth form amounting to 71% and 46%, with branched stem 19% and 28% and unbranched stem 10% and 26%.

DISCUSSION

Plant growth

Average height increment of clones in 2001 was from 0.3 cm (clone No. 64) to 35.8 cm (clone No. 38). The range of average increment values was 35.5 cm. In spring 2001 the range of measured heights was 30.4 cm and in autumn 2001 it was even 55.4 cm. This striking height variation is caused by large differences between the clones. It is necessary to remind that it was possible to compare 95 clones.

The results of measurements of clones from Milevsko seed orchard are especially interesting, they were on average the highest after the clones from Český kras (Bohemian Karst) in spring 2001 and in autumn 2001. This is especially true with regard to the fact that 3 clones directly from plus trees from the natural forest area Jihočeská pánev are identical with the clones in the seed orchard. Clone material from the seed orchard is always higher. Clones No. 1 and 64, No. 2 and 85, No. 4 and 62 are identical.

It can be supposed whether secondary vegetative propagation (grafting – *in vitro* culture) does not have any influence on the initial growth rate in this juvenile stage in the case of clones originating from the seed orchard. It will be necessary to carry out long-term observations of the clone material to confirm this possibility.

Growth form

After the end of the vegetation period 2002 only 2 clones out of the overall number of all evaluated individuals of 95 clones were with all individuals showing the shrub growth form. In the previous year there were only 18 clones with this form. It is a distinct decrease in the proportion of clones with this shrub growth form. This trend was also shown in the overall decrease in the proportion of this growth form in comparison with 2001 from 57%

to 45% in favour of the other evaluated forms. In plants with branched stems the overall proportion increased from 23% to 26% and in individuals with unbranched stems even from 20% to 28%. This development corresponds to the predictions concerning the changes in time in percentage proportions of the different growth forms (HAJNALA 2002), in favour of the forms with recognizable main stem.

The decrease in the proportion of individuals with shrub growth form occurred mainly in clones originating from the seed orchard. There was a decrease from the highly above-average proportion in 2001 to an average proportion in 2002. It is questionable whether the increased proportion of this growth form is not connected with the secondary vegetative propagation of graftlings. Besides this there was an increase in the proportion of shrub growth form in clones originating directly from plus trees from the natural forest area Jihočeská pánev and in clones originating from Český kras (Bohemian Karst).

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Testování klonů lípy malolisté (*Tilia cordata* Miller)

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ABSTRAKT: V práci jsou uvedeny dosavadní zkušenosti se šlechtěním lípy malolisté v evropských zemích. V ČR byly získány první výsledky z hodnocení juvenilní výsadby lípy malolisté založené na Školním lesním podniku v Kostelci nad Černými lesy. Klony lípy malolisté, vypěstované *in vitro*, byly hodnoceny v růstových parametrech a také podle formy růstu jednotlivých klonů. Dále byla kontrolována mortalita jedinců.

Klíčová slova: klonový test; růst; forma růstu; *Tilia cordata* Miller

Lípa malolistá (*Tilia cordata* Miller) patří mezi tzv. ušlechtilé listnáče (Noble Hardwoods), kterým je v současnosti věnována v Evropě značná pozornost. Dosud získané poznatky o rozšíření ušlechtilých listnáčů, jejich variabilitě a šlechtitelských a genetických aspektech jsou nejen u nás, ale i v Evropě nedostatečné a kusé.

Ušlechtilé listnáče jsou v mezinárodním evropském měřítku náplní programu EUFORGEN, jehož účastníkem je i Česká republika.

V souvislosti s výzkumnou činností zabývající se listnatými dřevinami na Školním lesním podniku v Kostelci nad Černými lesy byla založena pokusná výsadba klonů lípy malolisté vypěstované *in vitro*. Jednalo se o 95 klonů lípy (zastoupených čtyřmi nebo pěti jedinci). Primární explantáty byly získány z výběrových a šlechtitelských stromů z několika přírodních lesních oblastí (Jihočeská pánev, Křivoklátsko, Český kras a Polabí). Jihočeský materiál je z velké části původem ze semenného sadu Milevsko. Klony byly jeden rok pěstovány jako obalované sazenice na Šlechtitelské stanici Truba a na podzim r. 2000 pak vysazeny formou řadové výsadby.

U klonů lípy malolisté byly zkoumány růstové parametry a byla sledována forma růstu. Na jaře r. 2001 proběhlo měření výšky jedinců, které bylo opakováno na podzim po ukončení růstu. Na podzim r. 2001 byla také zkoumána forma růstu jedinců lípy. Šetření na formu růstu bylo opakováno opět na podzim r. 2002. Forma růstu byla hodnocena podle kategorií: keřovitá forma, větvený kmen a nevětvený kmen. V průběhu všech měření byla sledována mortalita jednotlivých klonů.

Měření výšek ukázalo, že klony původem ze semenného sadu Milevsko byly v průměru nejvyšší po klonech z Českého krasu na jaře 2001 a na podzim 2001. Klony původem ze semenného sadu Milevsko dosáhly na jaře 2001 průměrné výšky 23,7 cm a na podzim 2001 35,8 cm. Klony původem z Českého krasu dosáhly na jaře 2001 průměrné výšky 24,2 cm a na podzim 2001 36,9 cm.

V roce 2002 došlo k celkovému poklesu zastoupení jedinců s keřovitou formou růstu z 57 % na 46 %. Znatelné je zejména u klonů původem ze semenného sadu, kde došlo k poklesu v zastoupení této růstové formy ze 71 % na 46 %. Naproti tomu u klonů původem přímo z výběrových stromů z PLO Jihočeské pánve a u klonů původem z Českého krasu se projevilo zvýšení této růstové formy, a to o 13 % a 18 %.

Práce poskytla některé dílčí výsledky týkající se problematiky klonových testů lípy malolisté. V rámci výsadby bylo možné vzájemně porovnávat jednotlivé klony. Bylo tak zahájeno testování šlechtitelského materiálu, které bude dále pokračovat a navazovat na dané výsledky. Již i dílčí výsledky však ukazují na značný selekční potenciál tohoto materiálu.

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