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Management of *Robinia pseudoacacia cv. 'Üllői'* – 'Üllői' locust

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Abstract – Black locust (*Robinia pseudoacacia* L.) is the most widespread introduced tree species in Hungary. Though it covers 24% of the country's total forest area, the wood industry has difficulties processing large quantities of this poor quality wood. To address this issue, the Hungarian Forest Research Institute (FRI) initiated a selective breeding program designed to improve black locust wood quality. The breeding was based mainly on the small, elite breeding populations of the so called "ship mast" locust, which possess solid, straight, fork-free stems. Mono- and multi-clonal cultivars were developed and cultivar comparative and growing trials were established. Among the selected cultivars, the cultivar 'Üllői' locust (*Robinia pseudoacacia cv. 'Üllői'*) proved one of the best. As a result, a comprehensive review on the management of 'Üllői' locust in Hungary was compiled. This study provides a contribution to the improvement of growing technology used for selected black locust cultivars.

Robinia pseudoacacia / 'Üllői' locust / selection / growing

Kivonat – Az 'Üllői' akác (*Robinia pseudoacacia cv. 'Üllői'*) termesztése: áttekintés. Magyarországon a fehér akác (*Robinia pseudoacacia* L.) az egyik legelterjedtebb exóta fafaj. Az ország erdőterületéinek 24%-át foglalja el, azonban a faipar nem képes az alacsony minőségű akác faanyagot nagy mennyiségben feldolgozni. Ebből következően, a honi Erdészeti Tudományos Intézet (ERTI) egy szelekciós nemesítési programot indított néhány évtizeddel ezelőtt a faminőség javítása érdekében. Egy- és többklónú fajtákat hoztak létre, valamint fajtaösszehasonlító és termesztési kísérleteket létesítettek. A kiválasztott fajták közül az 'Üllői' akác (*Robinia pseudoacacia cv. 'Üllői'*) fajta bizonyult az egyik legjobbnak. Ezt a tényt figyelembe véve, átfogó áttekintés készült az 'Üllői' akác magyarországi termesztéséről. A tanulmány hézagpótlólag járulhat hozzá a szelektált akácfajták termesztési technológiájának fejlesztéséhez.

Robinia pseudoacacia / 'Üllői' akác / szelekció / termesztés

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1 INTRODUCTION

Selecting new clones and cultivars able to provide industrial wood of good quality and volume were the main objectives of the first black locust breeding programme in Hungary in the 1960s. Superior tree groups have been identified in some seed origin stands. Graft material was taken from the plus trees and planted in test plots at Gödöllő (the experimental station of Forest Research Institute (FRI)). *Mono- and breeding populations* were developed and a seed orchard was established from the selections (Keresztesi 1983, Rédei et.al. 2001, 2002).

FRI coordinated the research programme. Results showed the *'Jászkiséri', 'Kiscsalai', 'Nyírségi', 'Üllői'* and *'Szajki'* cultivars proved the best in terms of volume expected at felling age (Keresztesi 1988).

Several countries have also started research programmes to improve black locust wood quality and/or increase the production of biomass for energy purposes. Black locust has also been considered a promising tree for animal feed, nectar production, and the re-cultivation of dry and devastated lands. At present, black locust breeding and improvement research is being undertaken in the United States (Bongarten et al. 1991), Greece (Dini-Papanastasi – Panetsos 2000), Germany (Liesebach et al. 2004), Poland (Kraszkiewicz 2013), Turkey (Dengiz et al. 2010), India (Sharma et. al. 2006), China (Dunlun et al. 1995), and South Korea (Lee et al. 2007). Countries are increasingly interested in black locust improvement and management with a focus on the species' response to climate change effects.

The main goals of this paper are as follows:

- Bringing together researchers and forestry professionals who are interested in all aspects of black locust improvement.
- Documenting available knowledge about 'Üllői' black locust.
- Facilitating future information exchanges on black locust clones and cultivars.

2 ORIGIN AND TREE CHARACTERISTICS OF THE EXPERIMENTS

'Üllői' locust (*Robinia pseudoacacia cv. 'Üllői'*) was bred by B. Keresztesi and his co-workers Z. Marjai, J. Fila, and Z. Bujtás at FRI in the middle of the 20th century (Keresztesi 1983, 1988). The cultivar was registered in 1982. The origin of 'Üllői' locust is related to J. Fila who called the attention to the occurrence of this cultivar. In March 1966, plus trees were selected from the forest sub-compartment Üllő 10D on rusty-brown forest soil developed on sand, deposited on meadow forest soil. Collecting scions was difficult because climbers could not establish a safety station on the tree due to their tapering stem and narrow crown (Keresztesi 1988).

The characteristics of 'Üllői' locust are as follows: Pinnata type, trunk is vigorous, cylindrical and straight to the top of the crown. A greenish-brown field with many light brown lenticels between two linear stripes are visible on its bark. We noticed many bark plates on old trees. Spines are tiny; circa 10 mm long. The foliage is erect and the short leaf-stalk has 17–19 leaflets. These are oval-shaped and widest in the middle part, while the tips are blunt at the end with small awns. Leaflets on the underside are glaucous. The largest leaflets are in the middle part of the compound leaf. The tree has short-bodied white flowers that produce variable amounts of bloom that follow the same blossom period as common black locust. It has average nectar production and very poor seed-binding; moreover, it provides a medium to low value bee pasture (Keresztesi 1988).

'Üllői' black locust is susceptible to late and early frosts; therefore, it is not recommended for sites in higher hilly zones and in areas where frost hollows are present.

Good results can be attained in regions where the mean annual temperature is above 8°C. Fine sands and light loamy soil types are good for these black locust cultivars, provided sufficient soil depth. Shallow soils, soils with a poor water regime and coarse sand, or soil containing many stones are unfavourable. Clay texture is also unfavourable due to its poor aeration and compact condition.

3 STUDY SITES

The first experimental stand of the 'Üllői' cultivar was established in 1967 at the FRI Gödöllő Arboretum. Successful vegetative propagation led to further field cultivation experiments with this cultivar, experiments which have been conducted in various parts of the country ever since. This study executed evaluations in 21 experimental forest subcompartments. These are located at Tét, Gödöllő, Isaszeg, Pusztavacs, Helvécia, and Szentkirály. The trial plots are located in either a Turkey oak -sessile oak forest climate or a Forest-steppe climate (according to the Hungarian climate classification categories). The ages of the 'Üllői' black locust stands range from 6 to 35 years. Research site locations are presented in *Figure 1*.

Figure 1. Location of the research sites

Table 1 lists the site description including location (forest subcompartment), site type, and the most important dendrometric characteristics (age, H, DBH, V, N, G, mean tree volume).

Table 1. Location, site type, and stand characteristics

Location, subcompartment	Climate	Hydrology	Genetic soil type	Depth of productive layer	Soil texture	Age (yr)	H (m)	DBH (cm)	DBH/H*100 (%)	V (m^3/ha)	N (tree/ha)	G (m^2/ha)	Mean tree volume (dm^3)	Yield class (Rédei, 1984)
Isaszeg 7D	3	1	46	4	3	6	5.5	4.9	89.09	23.00	2555	4.82	9.00	III.
Gödöllő, Arboretum	3	1	46	4	3	10	13.3	10.4	78.20	100.03	1672	14.20	60.25	I.
Szentkirály 40 F	3	1	15	3	3	14	14.9	12.2	81.88	133.52	1320	15.43	101.15	III.
Gödöllő, Arboretum	3	1	46	4	3	15	15.6	12.7	81.41	171.18	1672	21.18	102.38	I.
Helvécia 67B	4	1	15	4	3	19	17	18.7	110.00	283.10	950	26.09	298	III.
Gödöllő, Arboretum	3	1	46	4	3	20	19.7	19.7	100.00	182.34	1095	33.38	166.52	I.
Szentkirály 46 G	4	1	15	3	3	20	18.5	15.4	83.42	218.00	1200	22.32	181.67	III.
Szentkirály 47 H	4	1	15	3	3	20	17.5	15.3	87.27	225.10	1300	23.85	173.15	III.
Tét 16 K-I	3	1	46	3	3	21	17	17	100.00	162.27	752	17.07	215.78	III.
Tét 16 K-II	3	1	46	3	3	21	17.7	17.3	97.74	131.39	573	13.47	229.3	III.
Tét 16 K-III	3	1	46	3	3	21	17.5	18	102.86	149.67	606	15.42	246.98	III.
Pusztavacs 212 A	4	1	15	3	3	31	15.5	15.7	101.90	169.03	930	18.10	181.75	V.
Pusztavacs 213 B	4	1	15	3	3	33	18	20.6	114.85	196.95	540	18.03	364.72	IV.
Pusztavacs 213 C	4	1	15	3	3	33	18	18.2	100.90	164.99	620	16.04	266.12	IV.
Gödöllő 5G (137D) - 5/26	3	1	46	3	4	35	22	21.6	98.18	199.80	448	16.42	445.98	II.
Gödöllő 5G (137D) - 5/32	3	1	46	3	4	35	19.4	20.6	106.19	229.80	674	22.46	340.95	III.
Gödöllő 5G (137D) - 5/48	3	1	46	3	4	35	20.4	22	107.84	218.90	546	20.76	400.92	III.
Gödöllő 5G (137D) - 5/44	3	1	46	3	4	35	22.4	23.4	104.46	335.40	690	29.67	486.09	II.
Gödöllő 7 B-I	3	1	46	4	3	35	18.9	21.6	114.29	235.46	625	22.90	376.74	IV.
Gödöllő 7 B-II	3	1	46	4	3	35	20.7	22.1	106.76	237.15	567	21.75	418.25	III.
Gödöllő 7 B-III	3	1	46	4	3	35	20.8	22.2	106.73	192.75	451	17.46	427.38	III.
Gödöllő 7 B-IV	3	1	46	4	3	35	18.4	22.3	121.20	235.81	596	23.28	395.65	IV.

Climate: **3** Turkey oak – sessile oak, **4** Forest steppe.
Hydrology: **1** No additional water supply.
Genetic soil type: **15** Sand with humus, **46** Rusty brown forest soil.
Depth of productive layer: **2** shallow, **3** medium deep, **4** deep.
Soil texture: **3** sand, **4** sandy loam.

Distribution of the sample plots in the site index curves of the black locust yield table are presented in *Figure 2*. As the figure shows, most plantations belong to yield class I to III. This means 'Üllői' black locust can produce relatively high volume on good sites where the objective is the production of sawlogs. A high proportion of poles and props can be expected from yield IV plantations.

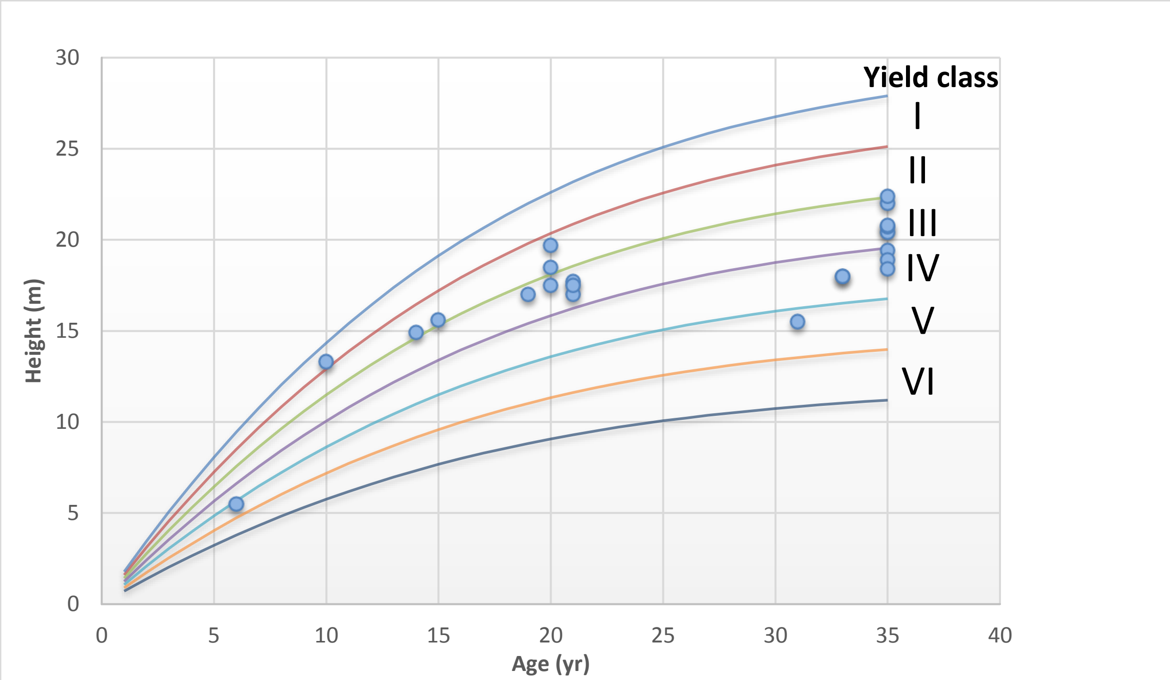

Figure 2. Experimental plots in the site index curves of black locust yield table (Rédei, 1984)

4 VOLUME EQUATIONS

Volume equations based on a single variable of DBH may be constructed from existing multiple-entry volume tables or from the scaled measure of standing or felled trees. Such equations are particularly useful for quick timber inventories because height and form estimates are not required and trees can be tallied by species and DBH only.

Volume equations based on DBH alone are sometimes compiled for inventories of relatively small areas, but this is not an essential condition; in some instances, "local" equations may be as widely applicable as "standard" equations. From 30 to 100 samples are usually considered a minimum number for small tracts, depending on the range of diameter classes to be included in the equation.

Figure 3-1 and *3-2* provide relationships of tree volume to DBH, and the same relationship transformed to a straight line, based on measurements of 55 'Üllői' trees at Pusztavacs region. The tree volume equations are subsequently used to estimate the average tree volume in each diameter class.

Figure 4 provides the relationship of mean tree volume (v) and DBH based on measurements of 22 'Üllői' black locust plantations (see *Table 1*). Multiply the mean tree volume by the number of trees per hectare to give the total volume per hectare. Multiply the volume per hectare by the stocked area of the plantation to obtain the total volume of the plantation.

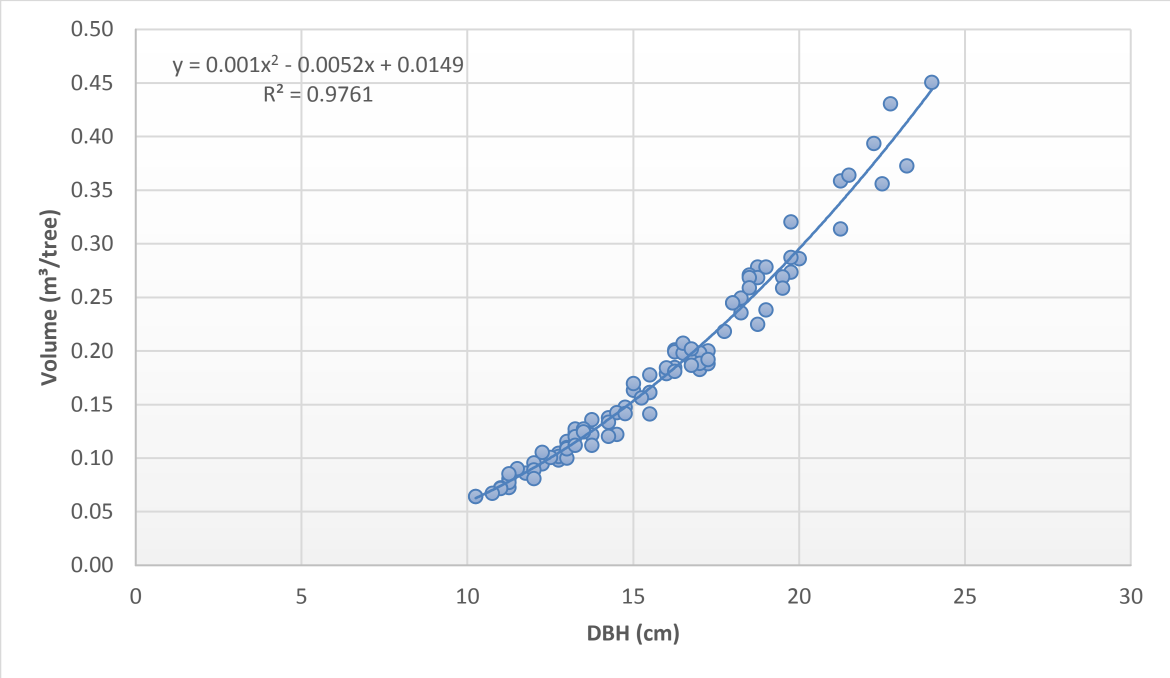

Figure 3-1. Curvilinear relationship of tree volume to DBH (based on measurements of 31 years old 'Üllői' black locust trees in Pusztavacs 212 A)

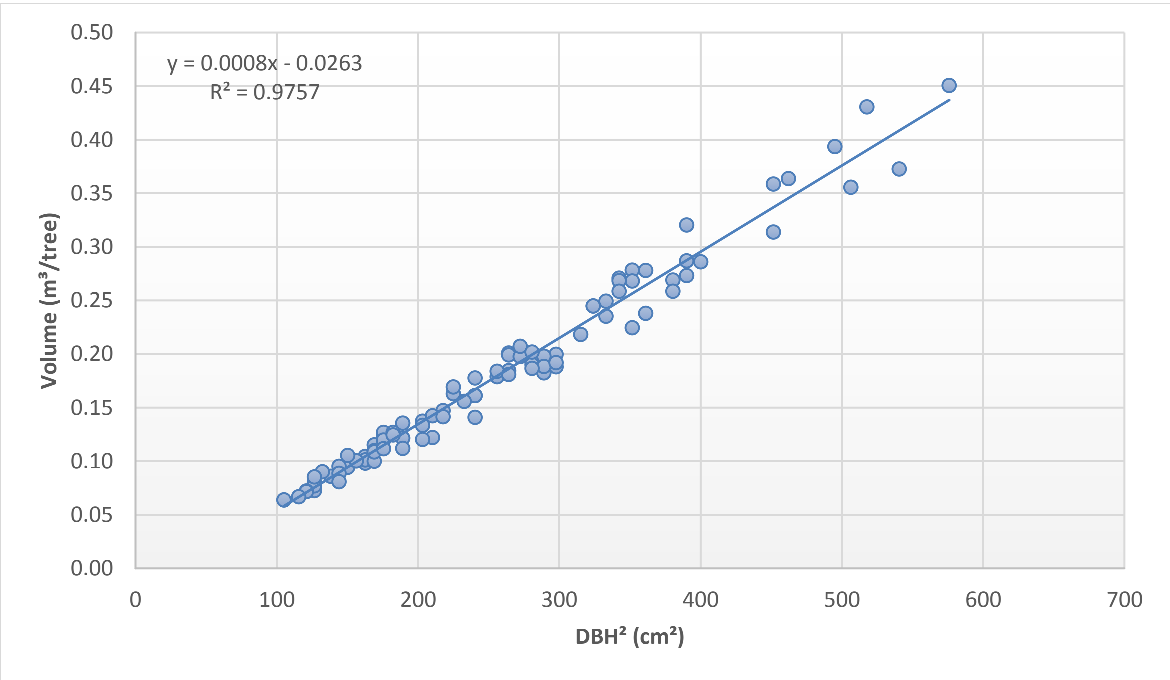

Figure 3-2. Straight line relationship of tree volume to single tree basal area of single trees (based on measurements of 31 year old 'Üllői' black locust trees in Pusztavacs 212 A)

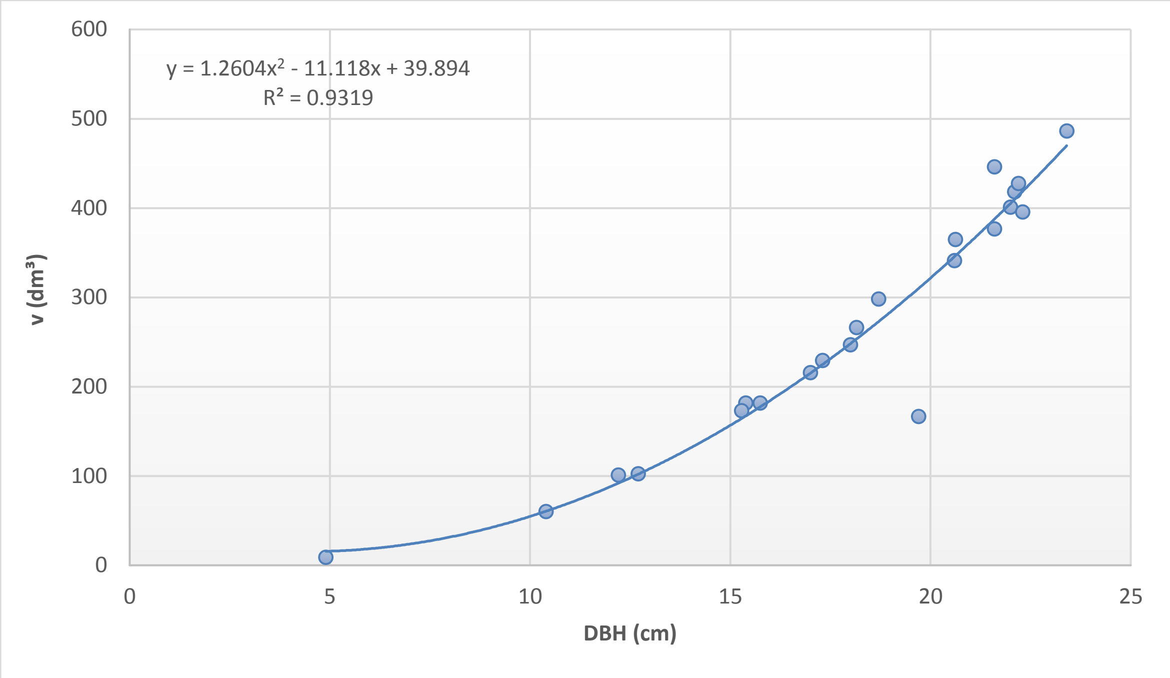

Figure 4. Curvilinear relationship of mean tree volume to DBH (based on measurements of 22 'Üllői' black locust plantations)

5 TENDING CUTTING MODELS

Tending techniques for black locust have been developed as a result of both advances in research and practical experience. A grouping of forest tending operations to form a tending regime can be made on the basis of results of long-term stand structure and forest yield trials. This is a great help for planning, prescribing, and controlling tending operations. The number of forest tending operations can be reduced by an effective forest tending regime and, at the same time, cleaning and thinning intensity can be increased. Introducing new cultivars as an alternative to commercial black locust growing has opened new perspectives for further development.

Tending principles for black locust stands established with cultivars are in some ways different from those established with common black locust seedlings or regenerated by coppicing. As in this case where stands are established with genetically uniform plants, initial spacing can be wider theoretically if there is no risk of game damage. Instead of a number of selective tending cuttings, a single comprehensive operation could rationalize the whole growing process (Rédei 2013).

Recommendations for tending cuts (enlargement of growing space) for 'Üllői' black locust plantations

Tending guidelines of stands established with selected black locust cultivars are different from stands established by seedlings or regenerated by coppicing. Tending phases typical for multiclonal common black locust stands with similar growth conditions (cleaning, thinning) are more difficult to separate for the "Üllői" black locust because the growth properties of monoclonal cultivars are theoretically identical. The particular aim of tending cuttings is to form the growing space for the optimal growth of the trees. When designing the ages and intensities of cutting, we relied on both the results of thinning experiments and the experience of forest managers working with this specific clone.

On good and excellent sites, altogether two enlargements of growing space are applicable to produce raw material for the sawmilling industry in stands planted in a 2.5×2.0 m spacing (5 m^2/tree growing space) (*Table 2.*). During the first enlargement of growing space (at the age of 9-10), tree number reduction is approximately 50%, so spacing will be 2.5×4.0 m (10 m^2/tree growing space) after the tending. The second enlargement of growing space (at the age of 16–17) also reduces the number of stems by 50%. During this process, the greater part of the yield is already suitable for industrial utilization. Hence, this growing technology can be considered economically profitable.

Prospective tree plantations of selected black locust cultivars tended according to the demonstrated model in *Table 3* are profitable only on excellent and good sites. If reduction of the rotation ages (20–25 years) is planned, the growing aims can be the production of poles, or saw logs of a lower size limit.

Table 2. Models of enlargement of growing space of selected black locust cultivars. Aim of growing: sawlog. Initial spacing: 2.5 x 2.0 m. Initial number of seedlings: 2000 plants/ha.

Label		Age	Height	Diameter at breast height	Number of trees	Expected total volume
			H	DBH	N	V
		(yr)	(m)	(cm)	(tree/ha)	(m^3/ha)
Yield Class I						
1.	Enlargement of growing space	9–10	14	13	1000	90
2.	Enlargement of growing space	16–17	20	18	500	130
3.	Harvest cutting	30	25	25	450	270
Yield Class II						
1.	Enlargement of growing space	9–10	13	11	1000	90
2.	Enlargement of growing space	16–17	18	16	500	120
3.	Harvest cutting	30	23	23	450	220
Yield Class III						
1.	Enlargement of growing space	9–10	12	10	1000	55
2.	Enlargement of growing space	16–17	17	15	500	80
3.	Harvest cutting	30	21	21	450	170

It is also important that *pruning* should be done on time and with skill in stands established with ‘Üllői’ cultivars. At a mean crop height of 2.5–3.0 m, all branches in the first 1 m of stem should be removed as well as any others that reach into the space between rows and hinder cultivation. Form pruning of the crown should also be done at this time. The second pruning is carried out when height is 5–6 m. Only rows remaining after the first cleaning need be pruned. The third pruning, to a height of 3–4 m, is due after the cleaning and is limited to final crop trees. The final pruning, up to a height of 5–6 m, is done after thinning.

Table 3. Models of enlargement of growing space of plantations established by selected black locust cultivars. Aim of growing: poles, prospectively sawlogs. Initial spacing: 3.0 x 3.0 m. Initial number of seedlings: 1100 pieces/ha

Label	Age	Mean height	Mean diameter	Number of trees	Expected volume
		H	DBH	N	V
	(yr)	(m)	(cm)	(tree/ha)	(m^3/ha)
Model I					
Before enlargement of growing space	10	13	10	1100	60
After enlargement of growing space	10	14	11	700	50
Harvest cutting	20	20	18	700	180
Model II					
Before enlargement of growing space	8	10	8	1100	35
After enlargement of growing space	8	11	9	750	30
Before enlargement of growing space	15	17	14	750	105
After enlargement of growing space	15	18	15	500	85
Harvest cutting	25	22	20	500	180

6 CONCLUSIONS

Common black locust may – to varying degrees – have negative properties such as warping and twisting, forked stems, and low industrial wood yield, which are all disadvantageous for cultivation.

Therefore, from the second half of the 20th century, the staff of the Hungarian Forestry Research Institute (FRI) has been engaged in the improvement of black locust cultivation technology, including the selection and cultivation of selected black locust cultivars. The primary purpose of these initiatives is to improve stem quality and increase wood and nectar yields. In the case of 'Üllői' black locust, the aim was to improve stem quality (Keresztesi 1988).

Even though black locust cultivars possess better qualities than common black locust, they are not widespread in the afforestation practice of forest enterprises. The reason is the relatively high costs of cultivar propagating material. Consequently, it is cheaper for forest managers to apply common black locust instead of cultivars. Hopefully, EU subsidies and local/national funding for the forest sector will change this situation in the future. The 'Üllői' cultivar is one of the most cultivated varieties, having about 15 thousand rooted cuttings at the Nyírerdő State Forest Shareholders Company in Nyíregyháza.

For some decades black locust has garnered greater attention in an increasing number of countries due to global climate change and the energy crisis, which have stimulated research on relatively rapid growing, nitrogen-fixing trees such as black locust. This short review posits the following conclusions:

(1) selected black locust cultivars like 'Üllői' can be grown well under semi-marginal site condition as well;
(2) vegetative propagation method – root cuttings – have proved to be as a suitable means in black locust clonal selection;
(3) by growing selected black locust cultivars, it is possible to increase the stem quality significantly by 12–25% on average (Rédei et. al. 2017).

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