IMPROVEMENT OF BLACK LOCUST (*ROBINIA PSEUDOACACIA* L.) IN HUNGARY

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Abstract

The paper presents a review of partly previous and partly original research results connected with black locust (*Robinia pseudoacacia* L.) improvement. Black locust is one of the most widespread stand-forming tree species in Hungary covering 20% of the country’s total forest area. However, the wood industry could not process the poor quality wood of common black locust in large quantities for a long time. Therefore, a multi-step selective breeding program was started to improve wood quality. During this program, for first step, some superior tree groups were identified in high quality seed stands and the best trees were selected. On this basis mono- and multiclonal cultivars were developed and cultivar comparative trials and growing trials were made. Propagation from root cuttings and tissue culture seems to be the best practice for reproduction of superior individuals or cultivars.

Yield studies on black locust state-approved cultivars suit for sawlogs production showed that there is no significant difference between the volume of the cultivars and the common black locust in stands of I–III yield classes at the final cutting age of 30–35 years. The difference in stand-value varies between 8 and 10% for the cultivars.

**Key words:** yield, black locust cultivars

INTRODUCTION

Black locust was the first forest tree species to be imported from North America to Europe at the beginning of the 17th century. It has a special history associated with the countries into which the species has been introduced. It has been cultivated and utilised most intensively in the Eastern European countries, including Hungary, Romania and Bulgaria.

The first afforestation in Hungary was carried out by the military administration in 1750 around the fort of Herkály near Komárom. The first large black locust plantations were established at the beginning of the 19th century on the Great Hungarian Plain to prevent wind erosion on loose sandy soils. Then, owing to the results achieved, black locust was spread all over the country, and at present it is the most widely used species in Hungary at afforestations, covering 20% of the country’s total forest area (350,000 ha). The most important black locust growing regions in Hungary are located in the South and South-western Transdanubian region (the hill ridges of Vas, Zala and Somogy counties), the sandy ridges between the rivers Danube and Tisza (Central Hungary) and Northeast Hungary (the Nyírség region) (Fig. 1.). There are two larger regions in the word,
foresters in 1936 (Raber, 1936), black locust breeding was intensified on a world scale.

Enhancing the improved cultivars in the everyday forestry practice is one of the major factors of the development of the black locust improvement and breeding process in Hungary.

The poor quality of common black locust timber (often bendy and forkly stem, low proportion of sawlogs, etc.) are well known. Thus, the main goal of black locust’s improvement process is to increase the stem quality and also the proportion of industrial wood.

VEGETATIVE PROPAGATION METHODS FOR BLACK LOCUST IMPROVEMENT

Propagation from root cuttings

The primary requirement for reproducing black locust clones and cultivars was to develop reliable vegetative methods. In the FRI a method for a large-scale production of black locust plants from root cuttings has been developed based on the strong sprouting ability of the roots. For this propagation method, root pieces cut into 8–10 cm, or chopped to 3–5 cm in length are used. These root pieces should be obtained from the producer of the variety or from a nursery where elite propagation material is produced. The longer root pieces are placed vertically into slits prepared beforehand. The top cut surface of the cuttings should be somewhat below ground level. When plants are silted after planting with a quantity of water corresponding to 10 mm precipitation or more, care is taken so that the upper ends of the cuttings remain under the soil surface, otherwise they might dry up. At the same time, the cuttings must not be covered with more than 1 cm soil. If the shoots have to come up from a greater depth the roots themselves or the shoot emergences might be damaged, succumb to fungal infection, and die. In the case of root sowing, root pieces should be sown like oak acorns in a furrow, with which is 10 cm wide and 4 cm deep. 25–30 root pieces are sown per meter. The thickness of the soil cover shall be uniform and not exceed 4 cm. The thin, short root pieces are planted at a depth of about 4–5 cm. Great attention has to be taken to prevent the drying out of the soil at that depth for any length of time. Root pieces for further propagation can be collected from the plants raised in the first year. For this purpose, they should be lifted with a large root system as possible. It is sufficient to have plants with 3 to 4 root stubs, each 5 cm long, and with rootlets.

Plant tissue culture method

Almost sixty new cultivars or selected clones were propagated during the last few years in the Micropropagation Laboratory of the Fruit growing and Ornamentals Research Institute at Budapest in collaboration with FRI. Plant tissue culture methods provide us new means to speed up the vegetative propagation of recently selected clones and give us the opportunity to establish healthy stock plantations. Brown (1980) was the first to report a successful in vitro method for the mass production of black locust. Enescu and Lucan (1985) started experiments in Romania in view of similar results. Balla, Vértés (1985) had the first success in the sterile production of four Hungarian state-approved black
locust cultivars. Balla et al. (1998) published an article on the improvement of the acclimation results of micropropagated black locust using symbiotic microorganisms.

Shoot cultures could be most conveniently initiated from actively growing juvenile shoots—e.g. from vegetative stool beds, but most of the actively growing shoot tips of the varieties propagated were collected from adult trees standing in a collection of clones and varieties of the FRI. May and June, perhaps September, is the most suitable time for the culture initiation. Shoot growth is most active in this period of the year. Disinfection is not difficult in the spring, growing open ground, without any plant protection. Shoot tips of 10–15 mm length, having apical and lateral buds, without any leaves survive the repeated disinfection in 1 % HgCl₂ solution containing a few drops of wetting agent (Tween 80) and are not damaged if properly rinsed with sterilized, destilled water.

The rooting of black locust clones is usually not successful on the media used for the rooting of fruit trees, 1/2 MS containing 1–3 ppm IBA, but good results could be achieved by adding 5 ppm of IAA instead of IBA, go. The rate of root formation is 60 to 90 % depending on the cultivars. The acclimation of black locust clones is performed under greenhouse conditions. The rooted plants are transplanted into Pindstrup (by Pindstrup Mosebrug A/S, Denmark) substrate. The ex-vitro plants need a relatively dry substrate and a high relative humidity to avoid losses by microbial diseases. The greenhouse cabinet used for acclimation purposes should be shaded during the summer months. Temperatures above 30 °C and below 15 °C may both cause severe damage. Black locust plantlets root thoroughly into the substrate and start to grow vigorously. The survival rate during the acclimatization is about 70–80 % and can be enhanced by microbial inoculation (Rédei et al., 2001a).

The disinfected shoot tips are directly put on the proliferation medium, where about 70 % of the cultures are found uncontaminated. Shoot proliferation actually starts 4–5 weeks after initiation of the culture, when the shoots are subcultured to the same fresh medium. The lateral buds begin to grow and develop into shootlets. 2–5 new shoots appear monthly at the basis of the older buds.

The field performance of micropropagated plants was comparable with the growth of trees produced from seeds at the age of 1.3. According to the variance analysis there was no significant differences in heights between the micropropagated plants and the seedlings at P=5 % level (F_{var}=1.42, F_{rep}=4.37) (Rédei et al. 2000 b).

IMPROVED BLACK LOCUST CLONES AND CULTIVARS IN HUNGARY

In the 1950's, the best black locust s ands were surveyed for similar type trees. During this work and since then, numerous pitches of 0.25–0.5 ha were found in extensive black locust forests with shipmast-like, straight stems are clearly distinguishable from the surrounding typical crooked trees.

Within the breeding program several cultivar comparative trials were established at Gödöllő Arboretum of FRI in 1964 on rusty brown forest soil. The objective of the trials was to compare the performance of cultivars from the Hungarian collection and abroad for growth and other important features. Trials were carried out according to the guidelines on the establishment and tending of black locust stands. Although the same number of plants of each clone represented each multiclinal cultivar, some clones might have been unequally represented as the best trees were favored in thinning operations. Up to now, trials of 190 cultivars with four replications have been established on 50 ha, where cultivars of various origin are investigated concerning their yield and flowering traits. In the beginning, the propagation of the clones was carried out by grafting, and later by cuttings. Seedlings raised from the registered seed stand of common black locust grown in the Nyírség sandy region and in the sandy ridges between the rivers Danube and Tisza served as control (Kereszties, 1988).

Mono- and multifloral cultivars were developed and a seed orchard was established from the selections. According to the basic selection goal, cultivars can be classified into three groups (cultivars having a state-approved status in 2000 are in bold face):

Main goal: production of logs suitable for sawmilling (target product: sawlogs).
The best cultivars are: 'Nyírség', 'Kiskunság', 'Jászkisérő', 'Ütő', 'Állalás', 'Pénzgombó', 'Rajtömöcsök és Görí'.

Main goal: production of poles and props (main products: pitprops, vine and orchard props, fence poles, hop poles). Best cultivars: 'Zalai', 'Császártöltési', 'Szajki', 'Hg-4146', 'Kisökú' and 'V/dt-46'.

Main goal: improvement of bee pastures and decorative planting. Best cultivars: 'Rózsaszín-AC', 'Debroen-2', 'Hálványrózsaszín', 'Debroen-3-4', 'Mátasi 1-3'.

Some cultivars are suitable for both forestry and honey production. Such double-use cultivars are 'Zalai', 'Kiskunság', 'Császártöltési', 'Égölvészi' and 'V/dt-46'.

The range of sites optimal for black locust growing is rather limited in Hungary. Therefore, black locust is often grown on sub-optimal sites. Moreover, opportunities for black locust growing are highly influenced by the climatic conditions and extremes (temperature and precipitation, water supply and unfavourable soil conditions). On the lowlands that are the most valuable regions for black locust growing, the annual precipitation is not more than 500–550 mm, most of which falls out of the growing season. Drought is thus a frequent phenomenon in the summer period, coupled with very high atmospheric temperatures (30–35 °C). The relative air humidity is usually between 20–50 % in July. Due to the filling up of basin-like lowlands in Hungary, site conditions change frequently even over small distances, causing a widely varied growth potential for black locust plantations. For this reason, there are no large, contiguous lands of homogenous site quality for this species and its growth and productivity may be very different in a large field.

Therefore, the main aim of the new selection work is to find and improve black locust clones (such as 'Kileshalom 56A 2/5', 'Császártöltés 61A 3/11' etc.) that have a good shape, provide quality wood material for industrial purposes, and can be adapted to changing ecological conditions as well (Rédei at al. 2001 b) (Table 1).
Table 1

<table>
<thead>
<tr>
<th>Location (subcompartment)</th>
<th>Nb of tree</th>
<th>age (yr)</th>
<th>height (m)</th>
<th>dbh1 (cm)</th>
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Where: b0 = stem length to be free of branches; lcesso = crown length; dbh (cm) = crown diameter (measured in two directions: N-S and W-E)

YIELD OF BLACK LOCUST CULTIVARS

The examinations of the stand structure and yield of improved black locust clones and cultivars were started at 1964 on the experimental plots established in the Arboretum of FRI in Gödöllő. In order to accurately describe the growth of the cultivars suitable for sawlog production ("Nyírség", "Kiskunság", "Jászkérő", "Pusztaszer", "Vigyázó"), detailed inventories were carried out each year until the stands reached the tenth year of age. Later detailed inventories were only carried out in every fifth year in 15 experimental plots. The inventories were based on the methodology developed by Birck et al. (1962). So that the growing process of stand structure factors can be better modeled. The stems of 4-4 dominant sample trees from each cultivar were analyzed by the method of Fekete (1951). Some other detailed stand inventories with a good stem quality from all over the country were also used to improve the database (Bujáts, 1984; Rédei, 1984b). By using all data, a numeric yield table of the cultivars for sawlog production was made. The yield table of the above mentioned cultivars contains data on yield and stand structure for the main and total crop and also for the crop to be removed in five equally wide yield classes. All yield classes have the same relative height growth level (Fig. 2). The relationships between the various stand structure characteristics were established graphically. This data set contains data up to 35 years of age.

![Fig. 2. The mean heights of the main crop of black locust cultivars over age by yield classes](image-url)

The yield and stand structure of black locust cultivars can be described by the following formulas and coefficients:

1. \[ H_{mc} = \text{mean height of the main crop weighted by the basal area (m)} \] (Fig. 2):
   \[ H_{mc} = 19.466 \times 95-57.085 \times 46 + \log (A) + 7.3577 \times 12.28 \times 20.28 + \log (A)^2 \]
   where \( A = \text{age of stand in years} \); \( H_{mc} \) at the age of 20 = 100%.

2. \[ D_{mc} = \text{the diameter at breast height of the main crop (cm)} \]
   \[ D_{mc} = (0.69880 + 0.00770) \times H_{mc} \] (r=0.809, n=100)

3. \[ N_{mc} = \text{number of stems per hectare of the main crop} \]
   \[ \log N_{mc} = 4.268 + 10.116 \times 50 + \log D_{mc} \] (r=0.942, n=100)

4. \[ B_{mc} = \text{basal area of the main crop (m}^2\text{ha}^{-1}) \]
   \[ B_{mc} = D_{mc}^2 \times \pi \times N_{mc} \]
   \[ 4 \times 10000 \]

5. \[ V_{mc} = \text{the volume of the main crop (m}^3\text{ha}^{-1}) \]
   \[ V_{mc} = B_{mc} \times HF \]
   where \( HF = \text{form-height quotient} \); \( HF = 1.604 + 0.423 \times 90 + H_{mc} \)
   (r=0.921, n=100)
6. $H_{\text{bc}}$ = mean height of the crop to be removed weighted by the basal area (m):
   $H_{\text{bc}} = 0.544 \times 50 + 0.925 \times 88 \times H_{\text{bcw}} (r=0.891, n=100)$

7. $D_{\text{bc}}$ = the diameter at breast height of the crop to be removed (cm):
   $D_{\text{bcw}} = (85.113 \times 23 -0.377 \times 05 \times A) \times D_{\text{bcw}} (r=0.917, n=100)$

8. $N_{\text{n}}$ = number of stems per hectare of the crop to be removed: calculated from the stem number reduction of the main crop every fifth year.

9. $B_{\text{n}}$ = the basal area of the crop to be removed (m$^2$·ha$^{-1}$):
   $B_{\text{n}} = \frac{D_{\text{bcw}}^2 \times \pi}{4 \times 10000} \times N_{\text{rc}}$

10. $V_{\text{n}}$ = the volume of the crop to be removed (m$^3$·ha$^{-1}$):
    $V_{\text{nc}} = B_{\text{nc}} \times H_{\text{f}}$

11. $H_{\text{nc}}$ = main height of the total crop weighted by the basal area (m):
    $H_{\text{nc}} = -0.096 \times 66 + 0.986 \times 13 \times H_{\text{bcw}} (r=0.923, n=100)$

12. $B_{\text{c}}$ = basal area of the total crop (m$^2$·ha$^{-1}$):
    $B_{\text{c}} = B_{\text{nc}} + B_{\text{rc}}$

13. $N_{\text{n}}$ = number of stems per hectare of the total crop:
    $N_{\text{nc}} = N_{\text{nc}} + N_{\text{rc}}$

14. $D_{\text{bc}}$ = the diameter at breast height of the total crop (cm):
    $D_{\text{bc}} = \sqrt{\frac{G_{\text{bc}} \times 10000 \times 2}{N_{\text{bc}} \times \pi}}$

15. $V_{\text{c}}$ = volume of the total crop (m$^3$·ha$^{-1}$):
    $V_{\text{c}} = V_{\text{nc}} + V_{\text{rc}}$

A comparison was made between the production of common black locust (Yield table: Rédei, 1984) and the production of the examined five cultivars (Table 2 and Fig. 3). It is clear that there is no significant difference in volume between the cultivars and common black locust at the planned final cutting age (30–35 years) in stands of I–III yield classes. The average deviation is 3.5% for the cultivars, which is negligible. It is not possible to profitably manage plantations established with selected black locust cultivars under poorer site conditions (V–VI yield classes).

The following tree classes were used to evaluate the stand-value of the black locust cultivars suitable for sawlog production:

<table>
<thead>
<tr>
<th>Age (year)</th>
<th>Black locust cultivars</th>
<th>Common black locust</th>
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<tr>
<td>I</td>
<td>II</td>
<td>III</td>
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<tr>
<td>30</td>
<td>286</td>
<td>242</td>
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<tr>
<td>35</td>
<td>311</td>
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</table>
Trees providing high-quality industrial wood. Straight, cylindrical, healthy stems reach the top of the crown; crooks are only tolerated in one dimension, no more than twice the stem diameter.

Trees providing industrial wood of lower quality. The stems are straight; forks are tolerated if they are present only in the uppermost third of the tree. Crooks are tolerated in one dimension only but no more than four times the stem diameter.

Trees suitable for short logs of poor quality. Stems are crooked and leaning; crooks reach max. six times the stem diameter in one dimension, and there is minor crookedness in a second dimension.

Trees suitable for fuelwood only. Stems are very crooked in more than one dimension; low branching, forked trees with stem defects, broken crown, stem rot are present.

We carried out stem quality evaluations in 15 experimental plots established with the investigated five black locust cultivars and in 5 experimental plots with common black locust. According to the results, the difference in stand-value varied between 8 and 10% for the cultivars.

CONCLUSIONS

Black locust has become the most important fast growing hardwood tree species in Hungary. Black locust has been best promoted by improving the quality of forests; to do this it is necessary to use selected clones and cultivars which have been bred with the end user in mind.

Experiments showed that black locust is a tree species with a great organogenic potential. The use of alternate vegetative plant production method, propagating plants by cutting or sowing root pieces and by tissue culture are advisable for producing clones (cultivars). Progress in tissue culture and plant regeneration allows propagation of new productive clones. Some experiments demonstrated that micropropagated trees can be successfully transplanted into soil, hardened and grown in the field. Micropropagated plants exhibited normal growth (160–200 cm in height) and apperance with high survival rate at age of 1.5. This propagation method can be used advantageously in the following areas of black locust improvement:

to improve new clones for clone tests,
to preserve old superior trees for clonal archives,
to establish seed production plantations (stands) and
to set up new seed orchards with micropropagated seedlings.

According to our initial yield studies the total volume of black locust stands at the age of final cutting can not be increased but it is possible to increase their value by using improved clones (cultivars). It means that the growing stock of black locust stands can not be increased by the above-mentioned cultivars at natural level.

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