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Selection of promising black locust (*Robinia pseudoacacia* L.) cultivars in Hungary

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Abstract

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In Hungary the black locust (*Robinia pseudoacacia* Linnaeus) is one of the most important exotic stand-forming tree species growing mostly under unfavourable ecological conditions. Considering the climate change effects its importance is increasing also in many other countries. As a result of a selection programme several black locust cultivars have been improved for setting up cultivar trials. In the paper four black locust cultivars were evaluated in Central Hungary under arid hydrological and brown forest soil conditions. Significant differences ($P < 5\%$) were found in height, DBH, mean tree volume and average stem form value (SFV). At the age of 35 years the cultivar "*R.p. Jászkiséri*" appeared to be the most promising one for yield production and "*R.p. Zalai*" and "*R.p. Nyírségi*" for SFV.

Keywords: climate change; clonal approach; growth; yield

Black locust *(Robinia pseudoacacia* Linnaeus) is a species native to North America that has a long tradition of uses as an ornamental tree, forest tree, street tree, and is also favoured by beekeepers. The tree is naturalised in many parts of the world including Asia, Africa and several countries in Europe. Black locust is an early successional species readily colonising open grounds, but not regenerating in the shade, usually outcompeted by longer living hardwoods in the course of succession.

Since the introduction of black locust into Hungary this tree species has been closely associated with agriculture, and its wood could be utilized for many agricultural and domestic purposes. After World War II its importance changed because large-scale farms had lower demand for wood and the timber industry was not willing to buy black locust wood. It was necessary to improve the quality of final products of black locust forests to meet the demands of consumers. Therefore, new cultivars had to be produced by selection techniques and had to be introduced into the practical forestry use (Keresztesi 1988).

The strategy aimed to improve the quality of black locust stands, which were considered to be separate provenances. In the best black locust stands tree groups of shipmast stem form, then plus trees were selected by B. Keresztesi and his colleagues (Keresztesi 1988). The offspring of these selected trees were propagated in a vegetative way (root cuttings) and were grouped together into varieties. Thus, varieties are mostly composed of several clones, but there are also some one-clone varieties.

Propagation of cultivars was first planned by seedlings, but the seed orchards produced small quantities of seed. So it was necessary to develop techniques for vegetative propagation (with green cuttings, root cuttings and micropropagation) (Rédei et al. 2002; Szyp-Borowska et al. 2016).

At present research is being done partly by international cooperation to find the genetic background of quantitative and qualitative features of varieties of several clones. Clone identification markers are determined for this work at protein and DNA levels. The long-term aim is the investigation of the linkage between quantitative features and selected markers, as well as the determination of genetic factors responsible for quantitative features (Rédei et al. 2008).

Besides Hungary the black locust breeding and improvement are undertaken in the United States (Bongarten et al. 1991, 1992), Greece (Dini-Papanastasi, Panetsos 2000), Germany (Liesebach et al. 2004; Böhm et al. 2011), Slovakia (Chalupa 1992), Poland (Kraszkiewicz 2013; Wojda et al. 2015), Turkey (Dengiz et al. 2010), India (Sharma, Puneet 2006), China (Dunlun et al. 1995) and South Korea (Lee et al. 2007).

MATERIAL AND METHODS

Study site. Data used in this study came from a black locust clone trial established in the forest subcompartment located at Gödöllő 5G, central Hungary (47°36'N, 19°22'E) (Fig. 1). It has brown forest soil without groundwater influence. The annual precipitation amounts to only 500 mm in some years, of which less than 350 mm comes in the dry summer period (Fig. 2).

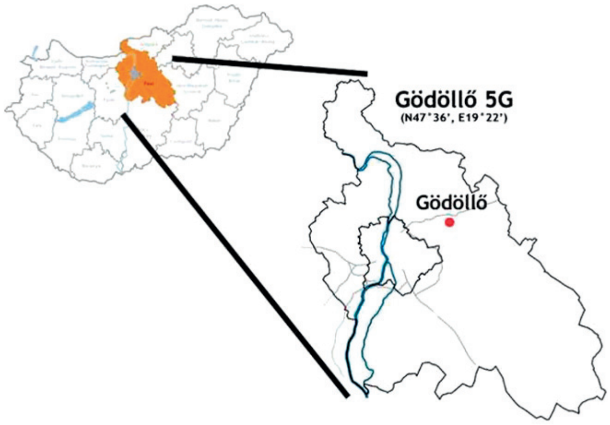

Fig. 1. Location of the study site

Material. The trial with three replications was established at a spacing of 2.0 × 1.0 m in 1970. Four black locust clones, i.e. "*R.p. Zalai*", "*R.p. Kiskunsági*", "*R.p. Nyírségi*", "*R.p. Jászkiséri*", as well as common black locust as a control were planted. Common black locust plants are produced by seeds. In Hungary 99% of the black locust reproductive material are produced by seedlings derived from phenotypically selected and registered seed stands. Each treatment corresponds to a plot of 20 by 25 m. A random block was designed where each block included all the different treatments (cultivars) once.

Methods. The following parameters were measured and calculated at the age of 35 years: number of stems, tree height, DBH over bark, stem volume and mean tree volume. The stem volume was calculated using the following volume function based on the volume table for black locust (Kolozs, Sopp 2000), as Eq. 1:

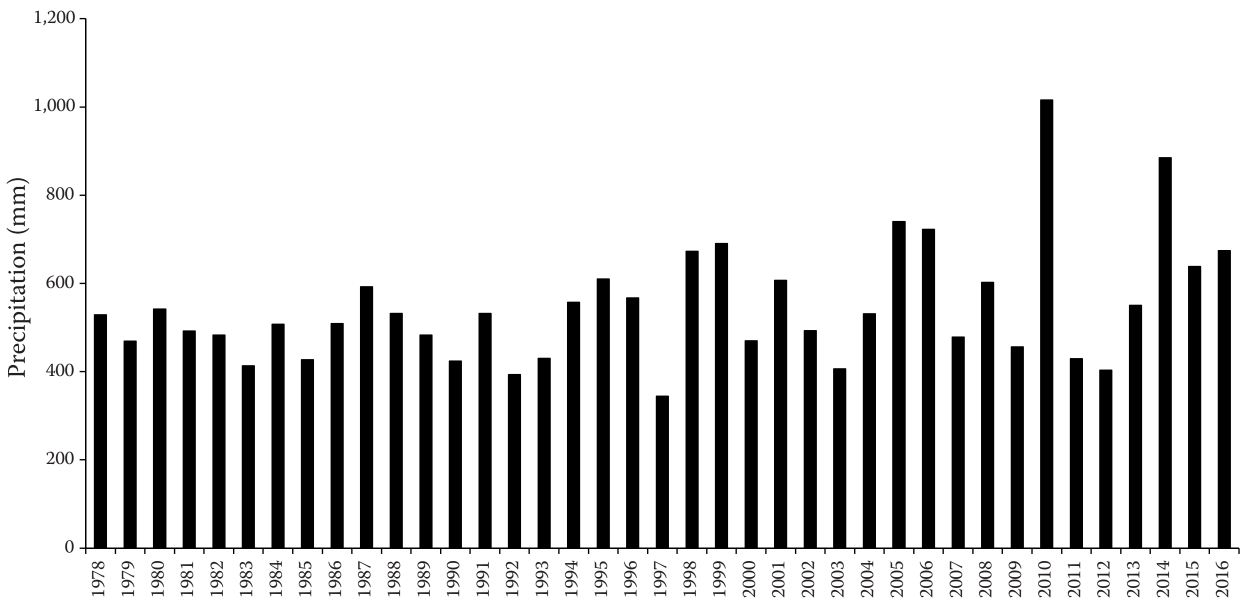

Fig. 2. The annual precipitation amount of the study site

$$V = 10^{-8} d^2 h^1 \left(\frac{h}{h-1.3} \right)^2 (-0.6326dh + 20.23d + 3,034) \quad (1)$$

where:

V – stem volume (m^3),

d – diameter at breast height (cm),

h – tree height (m).

The mean tree volume ($\overline{V}$ m^3 per tree) was calculated using the means of stem volume (h, DBH) for each of the experimental plots (Rédei et al. 2002).

The stem form classes used by us are as follows at the age of final harvesting:

(1) Straight, cylindrical, healthy stems, reaching to the top of the crown. Crooks are tolerated in one dimension only, not more than twice the stem diameter (x_1);

(2) The stem is straight, forks are tolerated, but only if they are in the uppermost third of the tree. Crooks are tolerated in one dimension only, not more than three times the stem diameter (x_2);

(3) The stem is crooked and leaning. Crooks may reach five times the stem diameter in one dimension and minor crookedness in a second dimension is tolerated (x_3);

(4) Very crooked in more than one dimension, low branching, forked trees with stem defects, broken crown or stem rot (x_4) (Rédei et al. 2012).

The average stem form value (SFV) was determined on the basis of Eq. 2:

$$\text{SFV} = \frac{x_1 n_1 + x_2 n_2 + x_3 n_3 + x_4 n_4}{n_1 + n_2 + n_3 + n_4} \quad (2)$$

where:

x_1, x_2, x_3, x_4 – stem form classes,

n_1, n_2, n_3, n_4 – tree numbers belonging to the single tree quality classes.

The data were analysed by IBM SPSS statistical software package (Version 22.0, 2013). One-way ANOVA was done for height, DBH, mean tree volume and stem form to consider the trial having a completely randomized design.

RESULTS

Tables 1 and 2 illustrate the statistical analysis of the most important parameters of stand structure (h, DBH, $\overline{V}$) and SFV at the age of 35 years. A comparison of mean h and mean DBH illustrated that the cultivar "*R.p. Jászkiséri*" reached the highest value (Figs 3a, b). The same result was obtained in mean tree volume (Fig. 3c), while the cultivar "*R.p. Zalai*" had the best SFV (Fig. 3d). Significant difference ($SD_{5\%}$) values for: h = 1.36 m, DBH = 1.27 cm, $\overline{V}$ = 0.066 m^3, SFV = 0.179.

For some decades black locust has been paid an increased attention in more and more countries for the following reasons. The global climate changes and the energy crisis have stimulated research on relatively fast-growing, nitrogen-fixing trees such as black locust.

DISCUSSION

At the moment the total area of black locust is globally about 4 million ha, of which about 2.5 million ha can be found in Europe. In the near future there are two continents where the fast spread of black locust can be expected. The one is the Asian continent with China and South Korea, while on

Table 1. Statistical analysis (ANOVA) of the most important parameters of stand structure at the age of 35 years

	Height		DBH		Mean tree volume		SFV	
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Clone	6.46	0.0126	20.437	0.0003	32.037	$6E^{-5}$	107.24	$1E^{-6}$
Block	0.03	0.9733	0.218	0.8091	0.196	0.8256	1.075	0.3858

SFV – stem form value

Table 2. The least significant difference test ($LSD_{0.05}$) of the most important parameters of stand structure at the age of 35 years

Cultivar name	Height (m)	DBH (cm)	Mean tree volume (m^3)	SFV
"*R.p. Zalai*"	20.8^{c}	19.9^{d}	0.335^{c}	1.12^{b}
"*R.p. Kiskunsági*"	22.6^{ab}	23.1^{bc}	0.486^{b}	1.20^{b}
"*R.p. Nyírségi*"	20.6^{c}	21.4^{cd}	0.384^{c}	1.16^{b}
"*R.p. Jászkiséri*"	23.4^{a}	26.8^{a}	0.665^{a}	1.29^{b}
Common black locust (control)	21.2^{bc}	23.8^{bc}	0.487^{b}	2.49^{a}

R.p. – *Robinia pseudoacacia* Linnaeus, SFV – stem form value

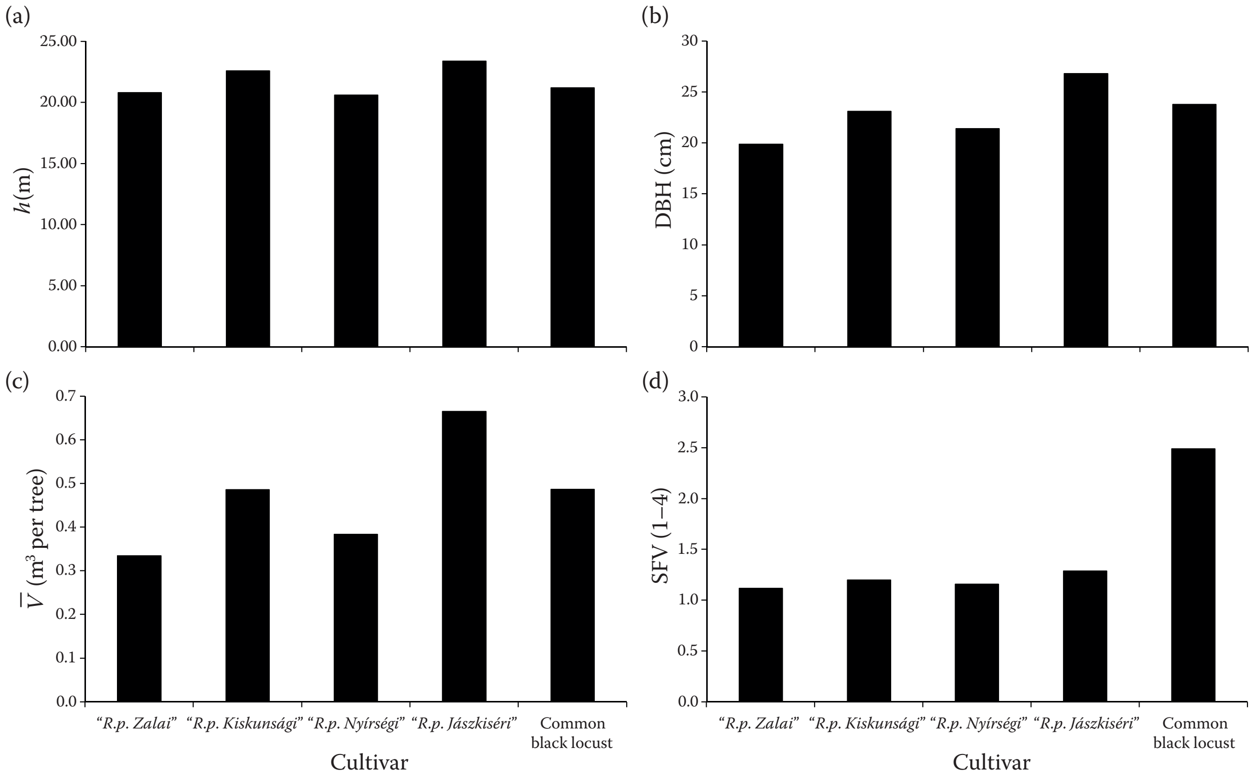

Fig. 3. Height – *h* (a), DBH (b), average mean tree volume – $\overline{V}$ (c), stem form value – SFV (d) data on 35-year-old black locust (*Robinia pseudoacacia* Linnaeus) cultivars as the means of plots

the European continent France, Turkey, Romania and Germany may be the most prominent black locust growers.

In Hungary the main target of selection breeding is to improve the quality of stem, to increase the output of industrial wood. The results are evaluated by timber volume and its value at felling age. Besides the varieties recommended for timber production as their primary function, there are others that have been improved for honey production or energy production. In comparison with Germany many stands of black locust are of bad quality concerning the stem form and thick branches. The breeding of black locust was focused on the selection of individuals with straight trunks and their vegetative propagation including tissue culture methods (Liesebach et al. 2004). Clonal breeding is one of the possibilities to provide material for commercial use (Rédei et al. 2002). Family selection may also be promising because of high family heritabilities for biomass, growth and morphological traits (Bongarten et al. 1992; Dini-Papanastasi, Panetsos 2000). Black locust tissue cultures have been successfully performed by many methods in many countries (Chalupa 1992; Dunlun et al. 1995). In Hungary experiments with black locust have shown that it is a tree species with the great regenerative potential from root cuttings or tissue culture (Rédei et al. 2002). These methods result in excellent uniformity within the clones from the selected trees.

This study leads to the following conclusions: (*i*) the growth and yield data at the end of the 35th growing season demonstrated that the selected black locust cultivars can be grown successfully under semi-marginal site conditions, (*ii*) vegetative propagation method, root cuttings, has proved as a suitable means in the field of black locust clonal selection, (*iii*) by growing selected black locust cultivars it is possible to increase significantly the stem quality and in such a way to increase the ratio of wood material used for industrial purposes (by 25–30% on average), (*iv*) application of genetic improvement may remove several hindrances to the widespread use of black locust in some potentially promising countries from the black locust growing point of view.

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