

Black locust (*Robinia pseudoacacia* L.) energy plantations in Hungary

Dr. RÉDEI, K.

*Forest Research Institute
42-44 Frankel L. st., Budapest, 1023-Hungary*

Abstract

Establishment of plantations primarily for fuel production has been of international interest for many years. Energy fuel production experiments in Hungary have been conducted for a longer time. In the country the black locust (*Robinia pseudoacacia* L.) is one of the most important stand-forming tree species, covering approximately 20% of the forested lands and providing about 18% of the annual timber output of the country. In Helvécia (central Hungary, sand-soil region) an energy plantation was established using common black locust and its cultivars. The spacing variations of the common black locust were the followings: 1.5x0.3 m, 1.5x0.5 m and 1.5x1.0 m. At the age of 5 the closest spacing (1.5x0.3 m) produced the greatest annual increment in oven-dry mass (6.5 t/ha/yr). This exceeds the increments of the two wider spacings by 33% and 51%, respectively. Concerning to the results of the yield trial with black locust cultivars planted in spacing of 1.5x1.0 m, at the age of 5 the highest yield was produced by the cultivar 'Üllői' (8.0 t/ha/yr), followed by 'Jászakiséri' (7.3 t/ha/yr) and the common black locust (6.7 t/ha/yr).

Key words: *Black locust (Robinia pseudoacacia L.), energy plantations.*

1. Introduction

The annual wood harvested in Hungary is 8 to 9 million cubic meters. The demand for timber is high. It is used by the building industry, furniture industry and packaging and paper industries. Two to three million cubic meters of wood is used each year for energy fuel. Approximately 0.5 million cubic meters of used-wood products is annually consumed to produce heat energy for industry or directly marketed for the population.

Considering the total wood-consumption, 30 per cent is utilized for producing energy and 70 per cent is used as industrial raw material. Only about 70 per cent of the country's demand for timber can be met from current forests production although harvested wood volumes have increased at a faster rate than the wood-consumption.

The plantations, established for producing dendromass and managed on a short rotation in general, contribute to meet the demand of wood for energy purposes (HALUPA, KERESZTESI, RÉDEI, 1992).

The major advantages of establishing energy plantations are:

- They are renewable (continuous) and reproduce systematically.
- They provide an alternative for utilizing lands on which agricultural production is abandoned temporarily.
- They are environmentally compatible (protect against erosion and defoliation) if good growing technology is applied.
- They decrease the use of fossil energy sources, which pollute the environment with sulphur and ash.
- The ash of burnt wood can be used as nutrient for supplemental fertilizers.
- By establishing energy plantations on a large scale, the cost of geological research in connection with mining and mine openings can be reduced.
- They can be distributed in the country more uniformly than the fossil energy sources.
- Capital for establishment is considerable less and the length of time for a return on the investment is shorter than that of the fossils energy sources, especially compared to deep underground coal-mining.
- Their wood material can be used at most any time, and plantations can be established near the area of consumption, thus reducing the transportation cost.
- They could contribute to the employment of people in the given area.

In Hungary the purpose of establishing experimental energy plantations was to determine the species and cultivars that produced the highest yield on the available sites, and to develop the most productive and profitable technologies. On the basis of the results achieved by the experiments, we are able to answer many questions about growing energy plantations. We know more about which site, and which growing technology might best be used for energy plantations.

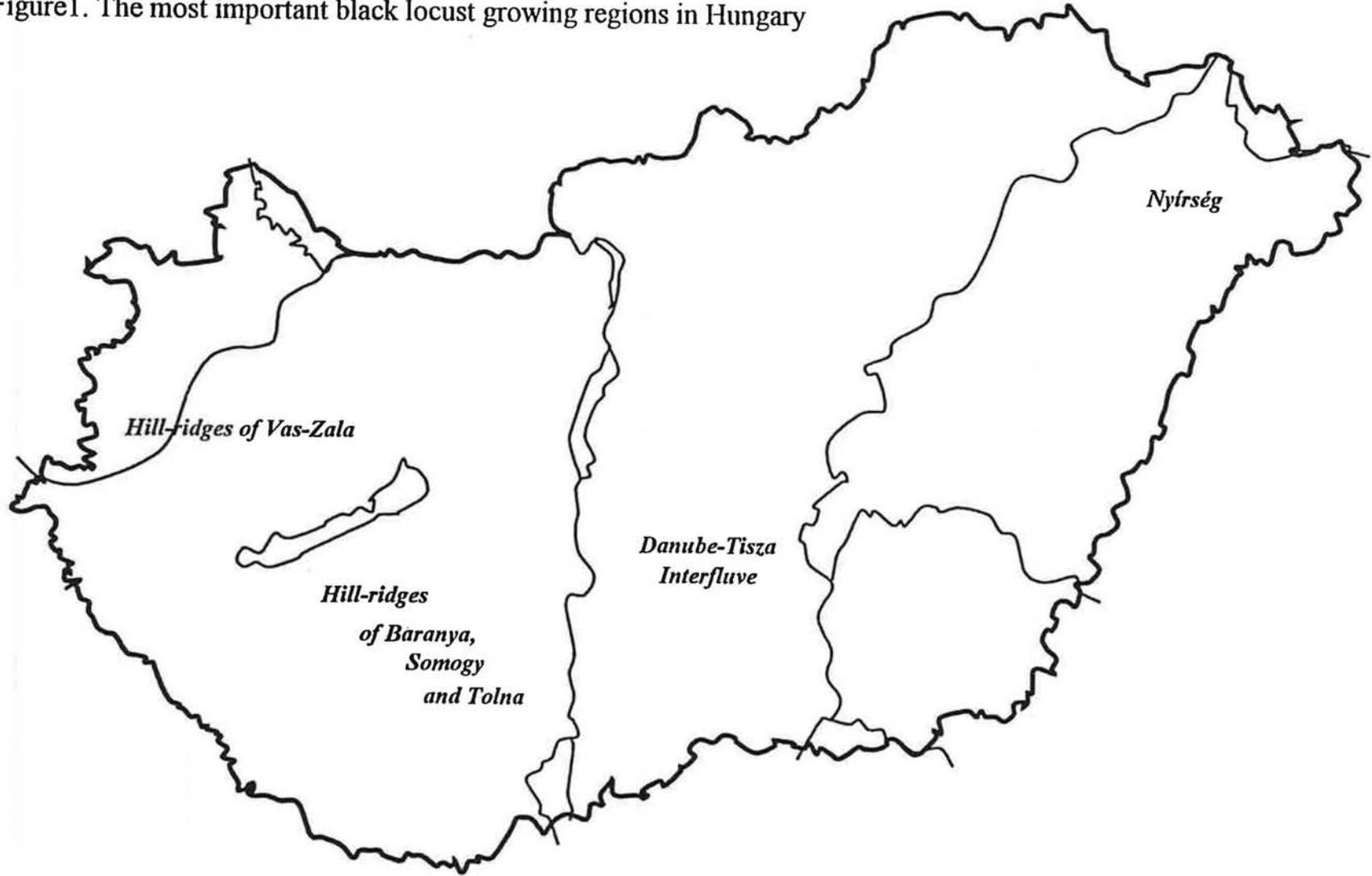
2. The role of black locust in establishing energy plantations

In Hungary, the black locust occupied 37.000 ha in 1885, 109.000 ha in 1911, 186.000 ha in 1938 and 327.000 ha in 1996. This is approximately 20% of all forested land in Hungary. One-third of black locust stands are high forest, while two-thirds are of coppice origin. In the 1960s, Hungary had more black locust forests than all the other European countries combined (RÉDEI, 1998).

Black locust timber can be used by industry (mining, construction, furniture) or by agriculture (post and pole wood), and black locust stands are the main basis for Hungarian apiculture and honey production. The black locust is one of the most suitable tree species for establishing energy plantations and for transforming existing traditional forests into energy forests. The most important black locust growing regions in Hungary are located in South and Southwest Transdanubia (hill-ridges of Vas-Zala country, hill-ridges of Somogy country), the Danube-Tisza Interfluve (Central-Hungary) and Northeast Hungary (Nyírség region) (Figure 1.).

In the future there are two bigger regions where the fast spread of black locust can be expected. In Europe, the Mediterranean countries (Italy, Greece, Spain and Turkey), while in Asia, China and Korea may be the most prominent black locust growers.

Figure1. The most important black locust growing regions in Hungary



The frequently expressed misconception that rapid growth rate is associated with low wood density is clearly disproved by black locust. Not only does the species have a very high density, 690 kg/m³ and higher, but it has a very rapid growth rate, 2-6 cm/day, which places it among the most rapidly growing plants in its juvenile stage. With this combination of both high density and volume increment black locust can achieve impressive dendromass yields over various rotation ages when grown on good sites. Moreover, because of its ability to fix atmospheric nitrogen, it requires little or no nitrogen fertilisation. Considering these growth criteria (volume and density) and the symbiotic associations of both bacteria and mycorrhizal fungi, black locust offers an excellent experimental organism for basic studies on growth control in woody plants, as well. More and more agricultural land is being taken out of use for food crops, some of which can be used for energy production plantations. Black locust is the very best tree species for this purpose, it has excellent energy production properties, such as (HALUPA, RÉDEI, 1992):

- vigorous growing potential in juvenile phase,
- excellent coppicing ability,
- high density of the wood,
- high dry matter production,
- favourable combustibility of the wood,
- relatively fast drying,
- easy harvesting and wood processing.

3. Methods and materials

In the last decade several energy production plantations have been established in Hungary. In these experiments several spacing treatments were tested and the common black locust as well as its cultivars were compared.

In an energy plantation trial with common black locust at the subcompartment Helvécia 80A (Central-Hungary, Danube-Tisza Interfluve) on slightly humous sandy soil without ground-water influence, three spacings - 1.5 x 0.3 m, 1.5 x 0.5 m and 1.5 x 1.0 m - were planted in three replications.

In the same subcompartment we set up a black locust cultivar trial, too. The following cultivars were used in a spacing of 1.5 x 1.0 m: 'Üllői', 'Jászakiséri', 'Nyírségi', 'Kiscsalai' and common black locust (control). The planting material was one-year-old seedling.

In each trial plot, the dbh ($d_{1.3}$) and height (h) of 50 marked trees, between the age of 2 to 5 years, were measured yearly. The total above-ground dendromass was determined for the mean tree by volume measurements by sections. The green dendromass was calculated for the whole tree including the trunk, while the oven-dry dendromass was determined only for the trunk. The trial at Helvécia is not on the very best site. The annual precipitation amounted to only 350 mm in some years, while in the dry summer period it was less than 150 mm, meaning that water supply was the minimum factor influencing the dendromass production. Thus, yield results are more characteristic for the quality of site than for the potential productivity of the particular tree species.

4. Results

The evaluation of the common black locust spacing trial can be found in Table 1.

Table 1. Evaluation of the common black locust spacing trial for energy production (Helvécia 80 A)

Factors		Mean		Moist		Oven-dry weight (t/ha)	Increment of Oven-dry weight (t/ha/yr)
Spacing (m)	Age (year)	H (m)	DBH (cm)	Volume (m ³ /ha)	Weight (t/ha)		
1.5x0.3	5	4.1	2.8	51.96	45.93	32.385	6.48
1.5x0.5	5	4.1	3.0	34.81	30.77	21.695	4.34
1.5x1.0	5	4.5	3.5	25.54	22.58	15.918	3.18

From the data it appears that there is a direct relationship between stem number and attained yield. This finding is based on the results of the first rotation taking the results at the age of 5 into consideration. The narrower the spacing, the greater annual increment is in oven-dry dendromass. In this experiment the same provenance - common black locust - was used. Therefore, we cannot speak about differences in the structure of woody tissue and density. The closest spacing (1.5 x 0.3 m) produced the greatest yield (6.48 t/ha/yr). This exceeds the yields (4.34 and 3.18 t/ha/yr) of the two wider spacings by 33% and 51% respectively.

Results of the yield trial of black locust cultivars can be seen in Table 2 at the age of 3, 4 and 5 years. By the age of 5, the highest yield was produced by the cultivar 'Üllői' (8.0 t/ha/yr), followed by 'Jászkiséri' (7.3 t/ha/yr) and the common locust (6.7 t/ha/yr).

Table 2. Evaluation of the comparative trial with black locust cultivars for energy production (Helvécia 80/A)
Spacing: 1.5x1.0 m

Factors		Mean		Moist		Oven-dry Weight (t/ha)	Increment of Oven-dry weight (t/ha/year)
Cultivars	age (year)	H (m)	DBH (cm)	volume m ³ /ha	Weight (t/ha)		
1. 'Üllői' black locust	3	4.0	3.1		14.5	8.881	2.96
	4	4.7	4.0		18.1	11.067	2.77
	5	6.4	4.9	65.1	56.7	40.060	8.01
2. 'Jászkiséri' Black locust	3	3.6	2.9		14.3	7.133	2.37
	4	4.3	3.8		17.1	9.216	2.30
	5	6.0	4.7	61.0	59.4	36.533	7.30
3. 'Nyírségi' Black locust	3	3.1	2.7		13.3	7.166	2.39
	4	4.1	3.4		19.9	10.407	2.60
	5	5.3	4.2	43.5	41.3	28.350	5.67
4. 'Kiscsalai' black locust	3	3.9	3.2		20.0	12.530	4.18
	4	4.5	3.7		24.7	15.336	3.83
	5	6.0	4.6	57.8	46.2	31.080	6.22
5. Common black locust	3	3.7	3.1		17.5	10.930	3.64
	4	4.7	3.9		25.5	15.943	3.99
	5	6.1	4.7	53.3	47.5	33.512	6.70

In the latest case the planting stock was of selected first class quality. The yield obtained from common black locust in the cultivar experiment is higher than the yield attained in the spacing trial. This fact can be attributed to the site condition.

5. Discussion

Dendromass yields from plantations are very promising but show great variation, depending upon site, species, and climatic region. In the USA black locust oven-dry volumes of energy plantations from different temperate climate regions ranged from 6 to 14 t/ha/yr (FREDERICK *et al.*, 1989). First rotation yields are usually lower than succeeding cuts at 5- to 10- year intervals (GEYER, 1992).

Further evidence of this statement can be found from the results of an energy-producing black locust plantation near Sopron (Hungary), where favourable water supply is present. The oven-dry weight produced by the age of 4 was 11.4 t/ha/yr. In that region this rotation was the best, because in the plantation of high tree density (closure was around 100%) the poorly growing shoots were backward or died off, thus stem number reduction by self-thinning resulted in decreased yield.

Black locust energy forests can also be established by coppicing. Advantages of energy forests established by coppicing: cost of establishment is low compared to costs of soil preparation, plantation and cultivation. From the developed root system of the previous stand, great dendromass can be produced within a short time period.

Disadvantages of these forests: the areal distribution of trees in coppice stands is not as uniform as in plantations established for this purpose. The quantity of the produced dendromass is lower and the length of growing time is highly influenced by the changing number of stems.

The first culmination of the annual increment in volume of black locust energy forests established from sprouts falls between the age of 3 and 5 years. Then, the annual increment declines and a new culmination comes about probably between age 9 and 12 years. A further maximum is expected later on, at about 15 years because of an even higher degree of mortality. Approximately one-third of the stems are lost at age 7 and 8. By the 12-13 years, the stem numbers decreased to less than half (HALUPA, RÉDEI, 1992).

The experiences carried out both in the planted and the coppiced energy plantations and forests indicate, that it is not reasonable to harvest them in the first three years, as the yield in oven-dry weight in the fifth year is twice - three times greater than it is in the fourth one. Harvesting in a too short time may increase the population of biotic pests, too.

In Hungary, as mentioned above, black locust is the most suitable tree species for establishing energy plantations. Under the country's site conditions the following tree species would also be suitable for this purpose: euramericana poplars (*P. x eur. cv.*

I-214, P. x eur. cv. I-45/51), *Ulmus pumilla*, *Ailanthus glandulosa* and *Eleagnus angustifolia*. On dry sites, marginal for poplar growth, black locust and poplar produce nearly the same volume. However, The oven-dry dendromass of black locust is higher because of its higher density.

On the basis of our experimental results, the quantity of dendromass depends on site, species and cultivars, as well as on the number of stems per hectare. These factors determine the optimum length of the growing cycle, too.

The results of the presented experiments are the initial steps in the complete evaluation of plantations and forests established for energy purpose. These results will be confirmed by other experiments to be carried out in similar site conditions and with similar cultivar composition.

6. Acknowledgement

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7. References

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