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The preservation of natural forests through the establishment of industrial wood production plantations via the new, fast growing Robinia pseudoacacia 'Turbo Obelisk' varieties and new cultivation technologies

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Abstract

After decades of research and development, Silvanus Forestry Ltd. and HungaroPlant Ltd. have successfully propagated the Robinia pseudoacacia 'Turbo Obelisk' variety group and developed the necessary cultivation technologies, specifically for intensive industrial wood production plantations.

In comparison to the Hungarian and traditional black locust varieties and cultivation technology, industrial wood production plantations established with our variety group and using our cultivation technologies can produce twice as much timber yield and industrial timber yield, considering 15-year rotation periods. These parameters are comparable with the performance of the widespread Eucalyptus and Pinus plantations in the subtropics. Our varieties and cultivation technologies, however, are also usable in subtropical, temperate, as well as tropical climates.

The outstanding yields achieved by the 'Turbo Obelisk' varieties and the extremely high industrial wood output can provide a significant contribution to the conservation and maintenance of natural ecosystems, whilst the CO2 sequestration per unit area per time is also several times that of natural forests. A particular advantage to emphasize is long term carbon sequestration due to the high percentage of industrial wood yield.

Increasing the exceptional tolerance of black locust against drought, pollution and low-quality soils, our varieties are exceptionally suitable for the utilization of marginal agricultural areas, the agricultural utilization of which would otherwise create an economical loss. This can also significantly increase the advancement of less developed regions.

In addition to plantation cultivation, it also provides a cost-effective solution for the establishment of protective forest belts, road-side plantings, quicksand fixation and soil renovation. Delicious honey production is also a possible revenue stream.

The global exploitation of the research findings has begun, having already successfully established test plantations in China, India, and Pakistan, as well as in several European countries.

Keywords: dry agricultural areas, micro-propagated black locust varieties, 'Turbo Obelisk', carbon sequestration

Introduction, scope and main objectives

Hungary has implemented a large-scale afforestation programme in the past hundred years as a result of which its forest areas have doubled from 11% to 22%. Afforestation predominantly took place on low yield arable land and abandoned pastures. Within the framework of this activity mainly black locust (Robinia pseudoacacia) and pine (Pinus nigra ARN. And Pinus sylvestris L.) forests were established. Additionally, other native species were also utilized (20%) and the area of wood production plantations using poplar (Populus x euramericana) is approximately 10%.

Black locust cultivation in Hungary and its challenges

The systematic planting of black locust forests began in the early 1800s in Hungary and then took greater momentum towards the end of the century. The importance of the species continued to increase significantly during the afforestation programmes which unfolded after the First World War and today, black locust accounts for approximately 500,000 hectares of the forests in Hungary, making up more than 25% of the total forest areas whilst accounting for an even higher percentage of year-round logging. Two-thirds of the black locust timber production accounts for medium quality wood material whilst the remaining is almost equally divided between high- and low-quality wood material.

Despite its important role in Hungary, black locust farming is extensive: seedling forests are established with 5000-7000 seedlings per hectare, only cultivated for the first couple of years and are clear-cut after 30 years with only 2-3 intermediate cuttings. The pursuit of low costs is also apparent during forest regenerations: a seed forest cycle is typically followed by two more cycles through coppicing, which of course results in a continuous decrease in wood quality.

Table 1: The production and utilization of black locust timber in Hungary, with 30-year rotation periods (source: RÉDEI (2006) and LETT et al. (2018))

Yield Class	Stems per hectare (SPH)	$D_{1.3}$ cm	H m	Clear-cut Volume brm³/ha	Interm. Cutting Volume brm³/ha	Total Volume brm³/ha	Growth brm³/ha/year	Dead-wood brm³/ha	Indust. Wood %	Fuel-wood %
Good	450	25	25	**280**	80	360	**12**	cca. 90	**30**	70
Medium	600	20	20	**190**	50	240	**8**	cca. 75	**25**	75
Poor	800	15	15	**115**	35	150	**5**	cca. 45	**15**	85

Currently, fuel-wood accounts for the majority of the 1.2 million m^3 black locust wood production annually, approximately 0.9 million m^3. Round wood and poles (for which there is large demand due to its outstanding durability) account for 0.25 million m^3, however quality is far from its potential wood quality and is full of wood defects, hence there is an extreme lack of high quality, large logs and the saw industry is only able to meet the minimal demands.

The traditional black locust production framework is only partially able, and in a declining manner, to meet the demands of the market and the principles of environmental consciousness, and hence new foundations must be built to increase quality and efficiency. The biggest concerns of low profitability, low quality, low quantity industrial wood and negative environmental impact must all be addressed. Our research shows that all of these issues can resolved by the establishment of industrial wood production plantations, for which the species shows ideal characteristics (fast growth, high demand for light, intensive surface root system, strong canopy formation at a young age, high tolerance for low quality, dry soils).

Objectives of our research and development

The aim of our research and development activity, which began more than 20 years ago (but builds on a much older genetic base) was to develop new black locust plantation cultivation technologies and methodologies with significantly increased efficiency when compared to traditional practices, whilst also focusing on the increasingly important environmental aspects.

The primary focus of our research was to select and propagate vegetative varieties of black locust capable of consistently producing high quality saw logs and pole material whilst the secondary focus was to create an optimized, clone-orientated technological environment, and hence the appropriate cultivation technologies. Our preliminary model calculations showed that to achieve success, we must propagate vegetative varieties and develop technologies with which we can at least double the (traditionally approx. 25%) quality industrial wood output of our plantations with a 12-15-year rotation period, planting 500-600 saplings per hectare. Under these circumstances, the total logged timber would increase fourfold, proportionately increasing carbon dioxide sequestration.

Methodology/approach

The genetic and technological characteristics of the species

The genetic wood quality of black locust, based on tendencies in Long Island, was first set forth by Raber (RABER, 1936) and then later proven through experiments by Hopp (Hopp, 1941, a).

Vegetative propagation provided the opportunity to research the genetic growth characteristics of different black locust varieties. As an example of prior research, one of the most well-known Hungarian clone variety group, the ship mast black locust is recognized for its outstanding formal qualities. However, when planted in experiments under controlled conditions alongside traditional black locust varieties, it did not show any difference in terms of growth volume and stem diameter (Rédei, 2008). Furthermore, laboratory studies at the University of West Hungary have also shown that changes in growth intensity have no significant effect on either the tissue structure or the mechanical properties of the wood.

In the case of black locust, all of its essential traits are genetically defined and there are also possibilities for multifactorial propagation with emphasis on characteristics such as strong juvenile growth, stem shape or wood quality.

When maintained as a plantation under our technological framework, the follow benefits can be recognized:

-The requirements of black locust in terms of proper soil aeration and its water management capabilities are well known, therefore a significant growth surplus can be visible in case of deep rotary tillage before planting and adequate mechanical soil management thereafter.

-The extension of the planting spacing to 16-20 m^2/sapling can significantly increase the diameter of the stem, whilst it has little or no impact on its height (Kapusi, Manuscript 1996, Pogrányi et.al 2019).

-The wide planting spacing used creates a necessity for pruning, which at the same time is also the basis for the increase in yield.

Considering the above, black locust, due to the basic characteristics of the species, the high genetic variability allowing for selective breeding and its compatibility with the plantation technological framework, shows great potential in modern wood production.

Breeding methodology

The creation of the genetic base of the Robinia pseudoacacia 'Turbo Obelisk' clone group is the result of the work of Dr. Imre Kapusi. The aim of his breeding activity was to create clone varieties that inherit the intense growth of juveniles to a significant extent on the maternal branch. To this end, in the 1980s, he selected approximately 50,000, 1-year-old stems with outstanding growth, which he then placed on experimental sites. The growth performance of the stems was assessed at the age of 8–12 years, resulting in the selection of the best 125 plus trees. Following this, the seedlings from the resulting seed lot (with open pollination) was planted for progeny testing. Seedlings from a common seed orchard were used as control. In certain cases, the progeny evaluations of the clones showed a significant, 100-200% increase in growth at years 6, 10 and 14.

The 'Turbo Obelisk' variety group stems from the evaluation of these progeny tests on medium quality soils when these plantations were 17 years old. In 2012, the research teams at Silvanus Forestry Ltd. and Hungaroplant Ltd., led by Jenő Németh, selected 70 plus trees for the establishment of vegetative clone varieties. The plus trees selected had outstanding diameters and heights ($d_{1,3}$ = 22-31 cm, H = 18-23 m) as well as superior stem and wood qualities. As these parameters were achieved under dense planting spacing (6000/hectare) and without any pruning or cultivation technologies, they showed great potential in achieving the same with 12-15-year rotation periods with the appropriate planting spacing and cultivation technologies. It was also proof that short rotation industrial wood production plantations were realistic with these varieties (Bach et al. 2016).

The progenies of the plus trees were propagated via micro-propagation and root cuttings and then further cultivated in our own nursery and facilities. In addition, we have also established a worldwide unique certified seed orchard with the progenies of these clones on more than 23 hectares in Szepetnek (Hungary), which has been producing seeds for more than 4 years (Turbo seedling variety).

Fig.1: Micro-propagated saplings planted in our nursery

Our first test plantation with the resulting saplings was established in 2013 (0.5 ha) which was then followed by further 2.5 hectares in Csemő, Hungary. Further test plantations were established afterwards all-around Hungary (for evaluations on different quality soils) as well as in China and Pakistan, with further test plantations on the horizon around the world. In 2018 our biggest plantations have been established in Hungary with the aim of further technological and variety research, on more than 30 hectares (significant subsidies from the Hungarian Government and the EU).

We continue to extensively study the relationship between growth and site factors under plantation conditions as well as homogeneity, wood quality, pruning requirements and technologies, variety resilience/tolerance and artificial nutrient replenishment and their effect on yield to refine our methodologies. In addition, we also research late flowering and high nectar yield varieties whilst also maintaining focus on fast and straight stem growth. Honey production can introduce an important, year-by-year side-revenue stream for investors once the plantation has started flowering.

Fig. 2: Flowering 4-year old 'Turbo Obelisk' clones on low quality, sandy soil

Fig. 3: 8-year old 'Turbo Obelisk' clones on low quality, sandy soil

Results

Planting spacing and final spacing

To adhere to the current planting regulations in Hungary (the establishment of plantations with wide spacing is only allowed with poplar varieties) our plantations have been established with medium spacing (2.8mx2m, 2mx2m). Due to the intensive growth of the 'Turbo Obelisk' varieties and hence the closing of the canopy after 2-3 years, it was inevitable to thin the plantation before year 5-7, in two stages, depending on soil quality and the initial planting spacing, reducing the stems to 500-600/hectare (final crop stems). The additional costs of these unnecessary works (merely imposed on us due to the planting regulations in place) were significant as it involved not only the thinning process but the removal of stumps (as it made efficient tillage impossible). Furthermore, the unnecessary additional planting, pruning and propagation material costs also need to be considered. This proved our hypothesis that the planting spacing, in the case of pole wood and logwood production, needs to be wider whilst also considering the soil quality and other factors. Based on the above and the results of relevant timber production research (Fekete 1960, Sopp 1974 and Rédei et al. 2011), it seems practical to use planting spacing of 16-20 m^2 in the future.

Pruning and wood quality

As mentioned earlier, due to the branching tendencies of the species, it is impossible to produce high value, quality hardwood with traditional cultivation technologies. This problem is also present in plantations established with the 'Turbo Obelisk' clones in wide spacing, as pruning is required not only to ensure high wood quality but also to achieve optimal growth (height) until the canopy closes. (When planted with wide spacing and without pruning, black locust tends to grow its canopy laterally and hence having a negative effect on height.) (Kapusi, Manuscript 1996)

Based on our observations on pruning and the results of systematic experimental work, the following can be stated:

-On medium quality soil, pruning is recommended systematically (cleaning and shaping) until height of 8 meters is reached, whilst on good quality soil pruning is recommended systematically until the height of 12 meters is reached.

-Pruning should be performed up until the above-mentioned heights are reached on a yearly basis, after which pruning should be performed 2-3 times until clear-cut, up to the above-mentioned heights.

-The unobstructed development of the leading shoot should be ensured by pruning and the thickening side branches must also be pruned to avoid knots.

-Wounds greater than 2 cm in diameter should be treated with wood preservative.

Pruning performed in the above-described manner ensures the best stem shape, near perfect healing of wounds and hence high quality, knot-free pole wood, logwood or industrial saw wood.

As pruning costs play a significant role, further selection and research should consider the branch structure of varieties (monopodial, branch-stem angle exceeding 45 degrees, etc.).

Growth and variety use

In terms of growth, as our oldest test plantation is 8 years old (on low quality soil) and our test plantations on a wider array of soil conditions are 4 years old, we are only able to share partial results which meet our preliminary expectations:

-As for the older population, a representative evaluation of the 'Turbo Obelisk' cloned variety group showed an average of 100% increase in growth and significantly straighter and better-quality stems when compared to the common seedling varieties planted alongside the clones for control. The average diameter of the clones at 5 years of age was 8.5 cm with height of 8.5 m.

Fig. 4: 13-year-old plus tree

-Following this the growth continued at approximately the same rate, with an average diameter of 13.5 cm with height of 13.5 m. (Meanwhile thinning took place to reduce the stems to 600/ha.) It is important to note that there are certain clones which have far exceeded these measures. Given the rate of growth, it can be expected that with 12-15-year rotation periods, the diameter of the variety group will average around 20 cm, with certain clones exceeding this by as much as 25%, in a very low quality, semi-desert soil.

-In our younger plantations, at 3 years of age, our clone group has shown growth of diameters averaging 2 cm and 2 m in height, with the OBE53, OBE34 and OBE6 clones being the most promising having exceeded these measures by 20-30%. (On larger areas with varying soil conditions, saplings planted on better soil quality areas clearly showed better growth.)

Conditions and nutrient supply

Based on our extensive site exploration activities, we can safely assume that the growth of black locust is affected by the aeration and hydrological conditions of the geological layer up to a depth of 10-12 meters, including the usage of groundwater. If the porosity of the above-described layer reaches an adequate level, and the deep penetration of the roots is not restricted (e.g., lime soil, gravel accumulation, strong salination etc.), the development of the species can be significantly affected by the water resources available up to that depth.

It also makes good use low nutrient soils, and its cultivation has a significant soil-improving effect. (Forgách 1926) This is due to the excess nitrogen produced by the nitrogen fixing bacteria on its roots.

Discussion

Following decades of research and development, we believe that we have successfully established the foundations of industrial wood production plantations with vegetative black locust varieties and hope that it will be adopted by general practices upon the completion of our research. The unique cloned varieties and the cultivation technologies which we developed greatly increase efficiency and yield and allow for the large-scale utilization of low quality, marginal soils around the world as it focuses on both economic and environmental aspects. We feel that it can become a realistic direction for reform within the sector and that it also offers opportunities in terms of agroforestry and high-quality honey production as side revenue.

We believe that the transition from traditional black locust cultivation to the above outlined methodology with our vegetative varieties could have a much greater impact than that of the similar transition which took place in Hungary decades ago with poplar for several reasons, even if we only consider the percentage of black locust forests in Hungary.

Black locust, and more specifically the 'Turbo Obelisk' cloned variety group, due to its deep root system and its low nutrient requirements, offers a viable solution for the intensive utilization of low quality, marginal, sandy soils where agricultural production is impossible or simply unprofitable and where forestation with species with high nutrient requirements are also difficult.

Finally, the variety group also has great tolerance for pollution and drought and hence is also suitable for city and roadside planting as well as the establishment of forest belts for the protection of cities or agricultural areas whilst it also has outstanding quicksand fixation and soil renovation capabilities.

Conclusions/ wider implications of findings

Our findings, vegetative varieties and cultivation technologies in regard to the industrial wood production plantation utilization of black locust varieties can greatly contribute to the preservation of natural forests and other vital environmental aspects whilst also meeting the increasing demand for quality hardwood. Based on wood density and durability it can also serve as a substitute for tropical hardwoods.

Governments and private entities have shown great interest in our research from around the world (China, India, Pakistan, Arab Emirates, Saudi Arabia), which shows the potential for our varieties with high ecological tolerance and high wood quality in a wide array of climates. It also has the potential to create value and work in poorer regions across the world whilst also contributing to our global fight against climate change through long term carbon sequestration due to its approximately 70% industrial wood output.

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References

Bach I., Horváth S., Németh J., Pataki B., Pogrányi K. 2016. Szelekciós nemesítéstől a mikroszaporított, ipari fa célú klónfajtákig*. Alföldi Erdőkért Egyesület, Kutatói Nap, Lakitelek*, pp: 7-10.

Fekete Z. 1960. Az akácosok újrafelvételezésének eredményei. *Erdészeti Kutatások,* 56(1-3): 3-43.

Forgách B. 1926. Az akác szerepe az Alföld fásításánál. *Erdészeti Lapok,* 65(6): 244-259.

Hopp H. 1941 a. Methods of distinguishing between the shipmast and common forms of black locust on Long Island. *U.S. Department of Agriculture, Washington D. C. Technical Bull* 742.

Huntley JC. Black locust. Available at: https://www.srs.fs.usda.gov/pubs/misc/ag_654/volume_2/robinia/pseudodoacacia.htm (accessed: 18.10.2021.)

Keresztesi B. 1965. *Akáctermesztés Magyarországon*. Budapest: Akadémiai Kiadó, 665 pp.

Lett B., Frank N., Horváth S., Stark M., Szűcs R. 2018. Amit a számok mutatnak - Erdők - Erdőgazdasági teljesítmények. Főfafajok vagyongazdálkodása. *Erdővagyon-gazdálkodási Közlemények* 10**.**, Sopron: Soproni Egyetem Kiadó, 77 pp.

Pogrányi K., Németh J. J., Bach I., Sovány M. 2019. A növőtér és a fajtahasználat hatása az akác fiatalkori növekedésére a csemői kísérleti terület (Csemő 339/C erdőrészlet) felvételi adatai alapján. *Alföldi Erdőkért Egyesület, Kutatói Nap, Lakitelek*, pp: 68-78.

Raber O. 1936. Shipmast locust a valuable underscribed variety of Robinia pseudoacacia. *U.S. Department of Agriculture, Circ.* 379.

Rédei K. 2006*. Az akác termesztés-fejlesztésének biológiai alapjai és gyakorlata*. ERTI: Budapest, 128 pp.

Rédei K. 2008. *Szelektált akácfajták termesztés-technológiája*. ERTI: Budapest, 35 pp.

Rédei K., Csiha I., Keserű Zs., Kamandiné V. Á., Rásó J. 2011. Nyírségi akácosok táji fatermési táblája. *Erdészettudományi Közlemények,* 1(1): 115-124.

Sopp L. 1974. Mageredetű akácosok és sarjeredetű akácosok fatermési táblája. In.: Sopp L. (eds), *Fatömegszámítási táblázatok*. Budapest: Mezőgazdasági Kiadó, pp: 279-290.