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11TH HARDWOOD CONFERENCE PROCEEDINGS

Róbert Németh, Christian Hansmann, Holger Militz, Miklós Bak, Mátyás Báder

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The Role of Industrial Hardwood Production Plantations and Long-Term Carbon Sequestration in a Circular Economy via the New Robinia pseudoacacia 'Turbo Obelisk' Varieties

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ABSTRACT

Considering the changing climate and the tendencies which we have seen in recent years, it is ever more vital to adapt to these changing conditions. According to forecasts, an increasing amount of areas will be classified as low quality, marginal soils unsuitable for agricultural production and may even become unsuitable for several native tree species. The utilisation of these areas will most certainly prove to be of extreme importance from not only an environmental but also from an economical perspective. The demand of the hardwood market must be met in the long run and sustainable plantation-based forestry is the only solution.

At the same time, long-term carbon sequestration, forestry management and improved efficiency must be the ultimate goal, which can only be achieved through the research and development of fast, straight growing and resilient varieties, including the elimination of waste wood materials within a circular economy framework.

Building on the work of Dr. Imre Kapusi and after decades of research and development, Silvanus Group has successfully propagated the Robinia pseudoacacia 'Turbo Obelisk' variety group and developed the necessary cultivation technologies specifically for intensive industrial hardwood production plantations. Our two latest research projects, *2017-1.3.1-VKE-2017-00022* and *VEKOP-2.1.1-15-2016-00166* included consortium partners such as NYME, NYME ERTI, MATE, NÉBIH and were also heavily subsidized by the European Union, the Hungarian Government as well as the National Research, Development and Innovation Office.

In comparison to the Hungarian and traditional black locust varieties and cultivation technology, industrial hardwood production plantations established with our variety group and using our cultivation technologies can produce twice the timber yield of the traditional species in 15 years, whilst also producing a very high percentage of much higher quality, straight, defect free industrial hardwood. Our varieties and cultivation technologies can also be used 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 higher than that of natural forests.

Our varieties also have an outstanding tolerance to pollution, drought and low quality, sandy, marginal soils. This can also significantly increase the advancement of less developed regions and provide economic value in areas which are currently unutilised. In addition to plantation cultivation, it also produces delicious honey and provides a cost-effective solution for the establishment of protective forest belts, road-side plantings, quicksand fixation and soil renovation.

INTRODUCTION

Climate change mitigation and adaptation to the already existing effects of climate change require rapid and highly efficient measures. Most scientists agree that we have less than 10 years to drastically reduce

greenhouse emissions before the effects will be highly detrimental and hence it is vital to introduce new technologies and to develop new solutions for climate change adaptation and mitigation.

Long-term carbon sequestration is one of the most important pillars to achieving our goals. The establishment of fast-growing hardwood plantations with high carbon content whilst producing quality industrial timber is becoming vital, especially when considering the demand of the wood industry and the preservation of natural forests. This means that, in addition to the carbon sequestered by living forests, harvested durable and high-quality industrial timber also contributes to long-term carbon storage.

THE LONG-TERM CARBON SEQUESTRATION CAPACITY OF FORESTS AND PLANTATIONS

It is noteworthy to emphasize the importance of solar energy when the industrial and energetic use of biomass produced is also among the future goals. It is commonly known that plants-including trees-convert the inorganic nutrients taken from the soil into organic matter by the means of photosynthesis with the help of the energy of the sun for the structure of their wood and their vital functions. The carbon required for this organic matter is sequestered from the carbon dioxide content of the atmosphere. This carbon sequestration serves to reduce one of the most significant greenhouse gases in the atmosphere.

The average chemical composition of wood is as follows: Carbon (C): 49,2%, Oxygen (O): 43%, Hydrogen (H): 6,2%, Nitrogen (N):0,9%, other ash components: 0,7%. The fact that forests store solar energy and reduce air pollution is researched and highly valued all over the world. Sustainable forest management is the basis for preserving the carbon storage capacity of our forests. There are two main options for the expanding the carbon storage capacity of forests:

- Expansion of forest areas
- Increasing the amount of live timber volume per hectare (selection of specific fast-growing hardwood species, utilisation of special varieties, research and utilisation of new, efficient forest and plantation maintenance technologies)

The establishment of new forests or plantations can typically take place in dry, low quality marginal soils within the forest steppe climate, which are unsuitable for agricultural production. These are mostly semi-arid, dry sandy soils with low humus content with high temperatures, under which conditions only a few species of trees can form a continuous forest population. As a result of climate change and hence the increasing temperatures, it is vital to utilise species and even more importantly special varieties of these species in these areas.

The table below should be considered when establishing new forests, plantations or when renovating existing populations with different species in forest-steppe climates with semi-arid and arid, sandy soils.

Table 1: The growth and hence the Carbon Sequestration of Various Species on Various Soils

Column1	Column2	Column3	Column4	Column5	Column6	Column7
Species	**Production Capacity of Forest Land**	**Age**	**Standing Volume**	**Dry Matter Content**	**Carbon Content**	**Carbon Sequestration/ Year**
		Years	**m^3/ha**	**t/m^3**	**t**	**t**
Robinia ps. 'TURBO OBELISK'	Very Good	12	288	209.66	103.15	8.60
Robinia ps. 'TURBO OBELISK'	Good	12	210	152.88	75.22	6.27
Robinia ps. 'TURBO OBELISK'	Medium	12	335	243.88	117.55	9.80
Robina ps. 'TURBO OBELISK'	Very Good	20	480	349.44	171.92	8.60
Robinia ps. 'TURBO OBELISK'	Good	20	300	218.4	107.45	5.37
Common Robinia ps.	Very Good	20	335	243.88	117.55	5.88
Common Robinia ps.	Good	20	279	203.11	99.93	5.00
Common Robinia ps.	Medium	20	169	123.03	60.53	3.03
Common Robinia ps.	Good	30	348	253.34	124.64	4.15
Common Robinia ps.	Good	40	393	286.1	140.76	3.52
Common Robinia ps.	Very Good	40	460	334.88	164.76	4.12
Common Robinia ps.	Medium	40	255	185.64	91.33	2.28
Quercus robur	Medium	40	225	141.75	61.29	1.53
Quercus robur	Poor	40	158	99.54	43.04	1.08
Quercus robur	Medium	80	388	244.44	105.7	1.32
Pinus sylvestris	Good	40	415	211.65	105.91	2.65
Pinus sylvestris	Medium	40	302	154.02	77.07	1.93
Pinus sylvestris	Good	70	513	261.66	130.93	1.87
Pinus nigra	Good	40	387	197.37	98.76	2.47
Pinus nigra	Good	70	500	255	137.6	1.97
Populus canescens	Good	40	275	110	55	1.38
Populus x euramericana	Good	15	238	95.2	47.6	3.17
Populus x euramericana	Good	20	370	148	74	3.70

Source: Silvanus Group Data

In the table above, we examined the wood-yield of Robinia pseudoacacia varieties at a given age, considering low quality, sandy soils with low humus content in a forest-steppe climate. For comparability, we analysed the wood volume and carbon content of trees and different ages. The examination in different ages allows us to determine the species and varieties to be used in plantings as well as to determine the ideal rotation periods, in accordance with the desired goals.
It is clear from the table above that Robinia pseudoacacia has not competitors when it comes to timber yield and carbon sequestration within the same timber production capacity group when considering rotation periods of 15-20-40 years. It is also clear that the 'Turbo Obelisk' variety group greatly outperforms common Robinia pseudoacacia by as much as 100%+, despite the planting density being much lower for the vegetatively propagated variety group.

RESEARCH AND DEVELOPMENT OF THE ROBINIA PSEUDOACACIA 'TURBO OBELISK' VARIETIES

The main purpose of Robinia pseudoacacia breeding is to select varieties that make better than average use of the potential wood productivity of areas with poor conditions and to adapt to changing conditions as well as to produce high quality, defect free industrial timber. In addition, stem straightness is also a vital aspect as this largely determines the percentage of the wood which can be used as industrial wood, hence greatly contributing to long-term carbon storage. Large scale vegetative propagation methods had to be developed for the practical utilisation of the selectively bred varieties and it was also necessary to determine the optimal plantation technologies and rotation periods.
The special, Robinia pseudoacacia 'Turbo Obelisk' variety group and the developed plantation technologies meets all the global development goals and thereby also serves to mitigate climate change. Building on the work of Dr. Imre Kapusi and after decades of research and development, Silvanus Group has successfully propagated the Robinia pseudoacacia 'Turbo Obelisk' variety group and developed the necessary cultivation technologies specifically for intensive industrial hardwood production plantations. Our two latest research projects, *2017-1.3.1-VKE-2017-00022* and *VEKOP-2.1.1-15-2016-00166* included consortium partners such as NYME, NYME ERTI, MATE, NÉBIH and were also heavily subsidized by the European Union, the Hungarian Government as well as the National Research, Development and Innovation Office.
In comparison to the Hungarian and traditional black locust varieties and cultivation technology, industrial hardwood production plantations established with our variety group and using our cultivation technologies can produce twice the timber yield of the traditional species in 15 years, whilst also producing a very high percentage of much higher quality, straight, defect free industrial hardwood. Our varieties and cultivation technologies can also be used 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 higher than that of natural forests.
The purpose of creating woody plantations for industrial purposes is "to increase the supply of wood as a renewable resource, in addition to the tree cover, thereby reducing the pressure on indigenous forest stands caused by the increase in demand for wood. (National Forest Strategy 2016-2030.)
Our varieties also have an outstanding tolerance to pollution, drought and low quality, sandy, marginal soils. This can also significantly increase the advancement of less developed regions and provide economic value in areas which are currently unutilised. In addition to plantation cultivation, it also produces delicious honey and provides a cost-effective solution for the establishment of protective forest belts, road-side plantings, quicksand fixation and soil renovation.
We performed our calculations for the fast and straight growing Robinia pseudoacacia 'Turbo Obelisk' varieties, which tolerate a wide range of soil and weather conditions. (The carbon content of one m^3 of Robinia pseudoacacia is 1.79 times that of poplar.)
The initial data was established with the help of the measurements, calculations, and prognosis of Dr. Kálmán Pogrányi, and they cover a time interval of 20 years.
It is clear in terms of the expected wood yield and carbon sequestration that the 'Turbo Obelisk' variety group far outperforms traditional black locust as well as all the other species in its category.

THE CHARACTERISTICS OF THE ROBINIA PSEUDOACACIA 'TURBO OBELISK' VARIETY GROUP

The Robinia pseudoacacia 'Turbo Obelisk' variety group has an even better tolerance to low quality, marginal soils than the common species. This means that in areas where the common black locust's growth can be classified as weak, the growth of the 'Turbo Obelisk' varieties can be classified as good. This also means that the rotation period can be decreased due to the better growth.

The newly developed plantation maintenance technologies and the outstanding 'Turbo Obelisk' variety group also allows for high quality industrial pole wood and industrial roundwood production with a much higher output, hence decreasing the biomass or firewood output. This not only creates significantly higher value, but also allows for long-term carbon sequestration. This is due to not only its fast growth but its straight stem. This can also be extremely interesting from the perspective of the voluntary carbon credit market, as much more carbon can be sequestered with these varieties when compared to the common Robinia pseudoacacia species as well as when compared to other similar species.

As an example, when considering a 20-year-old common black locust population with excellent wood yield, approximately 36% of the timber falls within the size range of industrial pole wood or industrial roundwood. Since the stem is not straight but curved, the final industrial wood output will as low as 15-20%.

In comparison, when using the Robinia pseudoacacia 'Turbo Obelisk' variety group and the newly developed cultivation technologies, at the age of 20 years, 71% of the timber produced falls within the size range of industrial pole wood and industrial roundwood. In this situation, we can expect an approximate final industrial wood output of over 60%. This is due to the outstanding growth and form trait of the variety group as well as the plantation technologies.

Furthermore, when considering medium wood productivity, the yield of a 15-year-old common black locust forest or plantation does not allow to produce any industrial wood, whilst the 'Turbo Obelisk' variety group is already able to produce a significant amount of industrial wood at this age.

Based on the previous examples, when using the selectively bred 'Turbo Obelisk' varieties, we can expect significantly higher additional timber yield and longer sustainability due to not only the fast and straight growth of the varieties but also due to its higher tolerance to low quality soils, hence storing more carbon.

We must also consider "dead wood" as a long-term carbon storage.

The amount of harvested industrial wood plays a significant role in the storage of sequestered carbon. It makes a huge difference whether you are producing firewood/biomass or quality hardwood of which quality products can be made, resulting in true long-term carbon sequestration.

Further increasing the value of quality industrial wood is the natural durability of black locust hardwood: outdoors approx. 80 years, in constant humidity approx. 500 years, under permanently dry conditions approx. 1500 years.

DETERMINING THE MOST SUITABLE ROTATION PERIOD FOR THE 'TURBO OBELISK' VARIETY GROUP

The aim of the initial experiments was to achieve quality industrial wood in the shortest time possible, being approximately 15 years. The scientific basis for this was the selection of the clones specifically for extreme juvenile growth. After the culmination of the tree growth, the wood is harvested. Due to this, the rotation periods are much shorter, whilst the general rotation period for black locust in Hungary is around 30 years, and growth rate decreases significantly after that.

When determining the best time for harvest, it is worthwhile to examine the total standing wood yield of a plantation as well as the volume of the stump and the roots under the clear-cut level as a function of age and wood productivity.

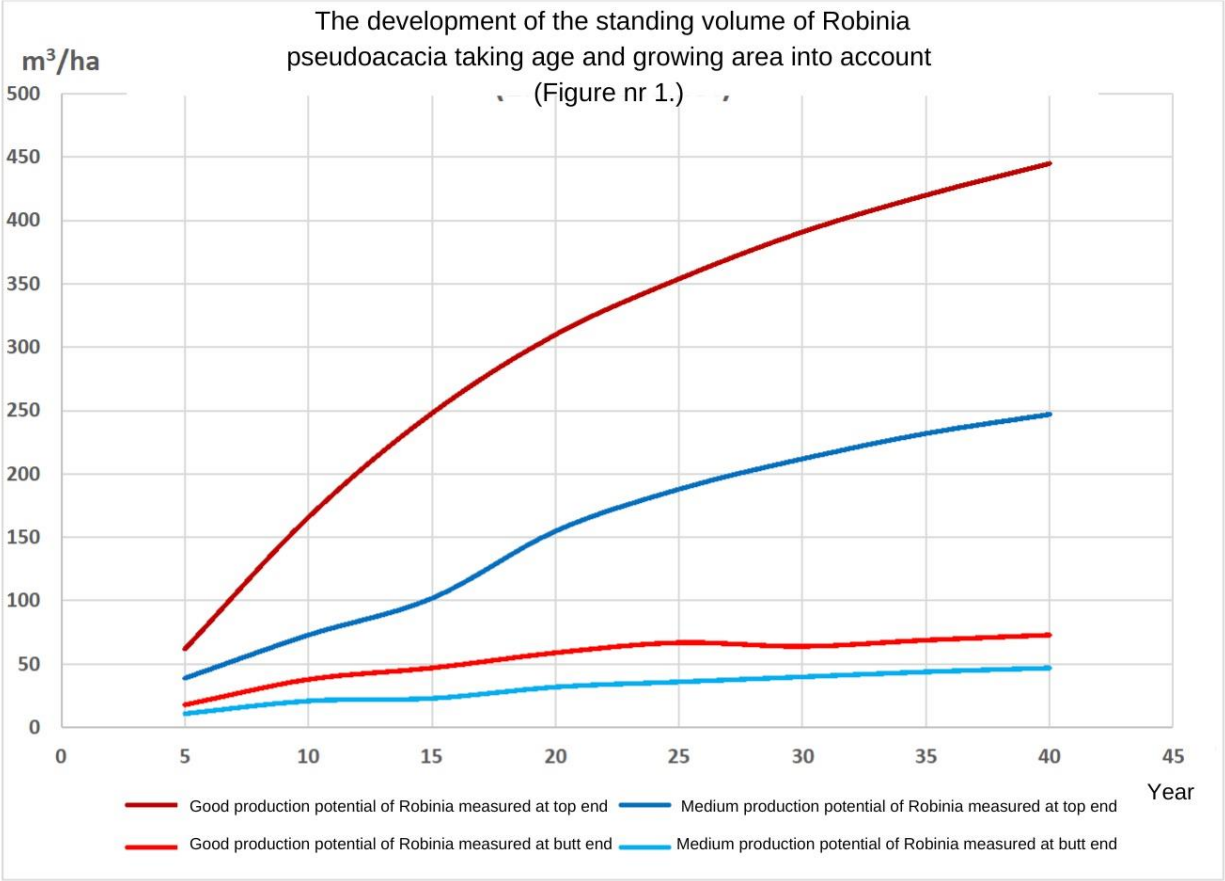
The graph clearly shows that the annual dynamics of the increase in wood volume in stands with good wood production capacity remains significant until the age of 40. We can take advantage of this dynamic but gradually slowing growth volume if we use the 'Turbo Obelisk variety group. This offers the opportunity to create serious additional yield and hence value.

In addition to the value of the produced wood, the time content of carbon storage in the wood material above the cutting board (standing) and below the cutting board (stumps and roots) increases significantly.

It should be emphasized that after harvesting, the proportion of quality industrial wood increases dramatically, which also increases the carbon storage capacity of the "dead wood".
It should be emphasized that the tree stand established from the 'Turbo Obelisk' variety group on traditional medium-yielding sites already has good growth and wood quality.

ENVIRONMENTALLY FRIENDLY UTILISATION OF TIMBER

During the utilisation of timber, it is vital to consider and ensure the environmentally friendly and optimal utilisation. This means that the output of industrial wood should be as large as possible. During the use of industrial wood, the carbon storage capacity of the wood can be preserved for several decades (e.g. construction grade timber). As a renewable energy source, biomass can be considered carbon neutral, which can replace fossil energy.
The optimization of the environmentally friendly utilisation of wood is determined by the size and quality of the wood material produced. Sawmill raw materials play the biggest role in preserving the carbon storage capacity of the extracted wood, but other industrial uses also ensure decades of storage capacity.



The Average Amount of Annually Sequestered CO2 per Hectare of Age Group for Robinia pseudoacacia with Good Tree Productivity, Taking into Account the Wood Volume Measured Under Butt End (Stump + Root)

Age group (year)	**0-5**	**6-10**	**11-15**	**16-20**	**21-25**	**26-30**	**31-35**	**36-40**
Average of Annually Sequestered CO_2 (t/ha/year)	21	33	24	19	14	9	9	6

It is clear from the above table that CO_2 sequestration slows after 20 years and slows even more significantly afterwards.

CONCLUSIONS

Robinia pseudoacacia is expected to become a dominant tree species for the establishment of forests and plantations on low quality, marginal, arid areas in the near future. Most of the agricultural lands are privately owned, and the owners are not always interested in creating forests or plantations, hence it is advisable to use the persuasive power of economic interest here, such as the voluntary carbon credit market.

Our findings, vegetative varieties, and cultivation technologies regarding the industrial wood production plantation utilization of the *Robinia pseudoacacia* 'Turbo Obelisk' varieties can greatly contribute to the preservation of natural forests and other vital environmental aspects whilst also meeting the increasing demand for quality hardwood. Perhaps the most important aspect is the outstanding carbon sequestration capability of the variety group, which can greatly contribute to the mitigation of the effects of climate change whilst providing a solution for the utilisation of areas which are otherwise unsuitable for agricultural production.

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