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Above-ground dendromass of sprouted black locust energy plantations: a case study

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Summary: Black locust (*Robinia pseudoacacia* L.) can be considered as one of the most suitable tree species for establishing energy plantations due to its favourable growing characteristics such as vigorous growing potential in the juvenile phase, excellent coppicing ability, a relatively high resistance to pests. Based on national and international test results the mean annual increment of oven-dry weight of energy plantations regenerated by coppicing generally exceeds the first cycle plantations established by seedlings.

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Key words: black locust, coppiced stands, dendromass, energy plantations, yield

Introduction

In recent decades due to the scientific-technical development energy consumption has dramatically increased worldwide. The price fluctuation of oil directed the attention towards renewable energy sources. These include wood as reproducible energy source. In forestry the lossless technology came into view, the complex utilization of the tree. Soon the wood chip appeared as a new forest product. In Hungary about 15% of the total harvested volume remains in the cutting area and in many cases stumps remain in the soil as well. Both in the primary wood industry (sawmilling and panel industry) and in the secondary wood industry (furniture industry, building joinery and construction sector) large amounts of wood waste are generated during the mechanical wood processing. All of these by-products can take into consideration as wood chip raw material if the processing for that purpose is economical. In the case of oil substitution there is a great importance of such equipment that make the firing possible if a suitable boiler is available. These include wood gasification facilities as they allow heating with green chips including the complete elimination of the use of soil. These devices are simpler and less expensive than conventional combustion; their flue gas is less polluting the connected heat recovery equipment and the environment.

Under the Hungarian ecological conditions black locust is one of the most suitable tree species for establishing energy plantations. It has a high vigorous growth potential in juvenile phase, excellent coppicing ability both from root and stump, high density of the wood, relatively low moisture content and having good combustibility even when wet (Rédei et al., 2011). Thus, the use of chip for energy purposes may give a wide scope for the complex utilization of black locust. Compared with other fuels the wood of black locust has many advantages. When its wood is burning the polluting effect on the environment is minimal as its sulfur content is negligible (up to 0.01-0.03%). Its flue gas does not contain sulfuric compounds. Due to its high oxygen content (44-45%) it has low demand for combustion air with minimal loss of the flue gas. Its calorific value can reach 16 000 kJ/kg depending on the water content.

Characteristics of coppiced energy plantations

Woody energy plantations can be considered as the basic facilities of large-scale above-ground dendromass producing economically which can be operated by industrial methods using the appropriate growing technology. The woody energy plantation: tree plantation established for growing assortments which are suitable for energy production. These plantations are established in flat or hilly areas, good and medium sites under high operating conditions, terrains which are suitable for mechanical harvesting (harvestable areas). Regarding the growing system two versions are distinguished: artificial regeneration and coppice system. From economic point of view the coppice system is the preferred mode since the regeneration of plantations can be carried out by sprouts with minimal costs (Rédei et al., 2009). This type of plantation is established with high stem number (1.5-2.0 x 0.3-0.5 m planting spacing) using well-sprouted tree species. The first clear cutting can be done at the age of 4-5 years depending on the catting and ingathering mode, then the coppiced plantation can be cut again with same cycles, usually 5-7 cutting can be planned. Dr. Béla Marosvölgyi and dr. Lajos Halupa played an outstanding role in the development and practical implementation of this growing technology. However, on the basis of this novel black locust growing system considering the yield of the different cultivars in relation to initial spacing we have to underline that available test data are still limited.

Table 1. Above-ground dendromass os coppiced black locust energy plantations

Age, origin	N (db/ha)	H (m)	D1,3 (cm)	Growing stock		Mean annual increment of volume (m^3/ha/year)	Mean annual increment of oven-dry stem dendromass (t/ha/year)
				volume (m^3/ha)	oven-dry stem dendromass (t/ha)		
Common black locust, 1.5 × 0.3 m							
5 year old seed	20 852	4.1	2.7	56.3	34.9	11.3	7.0
Sprouted black locust cutted at the age of 5 years							
4 year old sprout	18 389	4.8	2.6	55.1	34.2	13.8	8.6
8 year old sprout	10 945	8.1	4.4	96.3	59.7	12.0	7.5
Common black locust, 1.5 × 0.5 m							
5 year old seed	11 986	4.1	2.9	34.8	21.6	7.0	4.3
Sprouted black locust cutted at the age of 5 years							
4 year old sprout	11 333	4.8	2.8	33.1	21.7	8.3	5.4
8 year old sprout	8 089	7.9	4.5	68.8	42.6	8.6	5.3

Materials and methods

Yield of coppiced black locust energy plantations: a case study

The trial was established in the subcompartment Helvécia 80 A (Central-Hungary, Danube-Tisza Interfluves). The subcompartment presents slightly wavy surface, humous sandy soil without ground-water influence. The planting material was selected from 1 year old seedlings with 100 cm of average height. Medium black locust yield site. The used spacing variations were 1.5 x 0.3 m and 1.5 x 0.5 m. The experimental stand-parts were removed at the age of 5, the regeneration was done by coppice. After that evaluation of above-ground dendromass yield were made in coppiced stand-parts at the age of 4 and 8. In some part of these work former FRI (ERTI) colleagues, Zoltán Bujtás and dr. Irina Veperdi also attended. The above-ground dendromass of experimental stand-parts can be found in *Table 1*.

Figure 1. One year old black locust energy plantation

Results

According to the data of spacing experiment reported here, with the average tree height of 4-5 m, the highest number of stems, most dense (>20 000 pc/ha initial stocking) plantation had the largest dendromass.

Based on the results of soil preparation experiments the use of costly deep cultivation of 50-70 cm is not justified before establishing of black locust energy plantation. The soil preparation by hard disk and the deep-ploughing of 30-40 cm are sufficient before planting. In the small number of cultivation experiments the most common planting spacing is 1.5 x 0.3-0.5 m *(Figure 1)*. The applicable planting spacing among other things is determined by the production target, growing cycle as well as the applicable machine type. The application of denser planting spacing (smaller interrow spacing) then the recommended one is usually not justified because according to the relevant data of spacing experiments

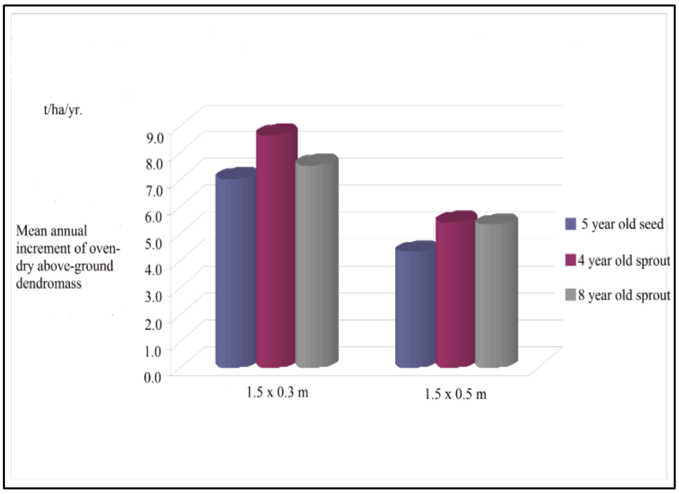

Figure 2. Above-ground dendromass is the function of the planting spacing and the age of the sprouted black locust stand-parts (Helvécia (80A)

the stem number more or less equalizes in the sprouted stands after the first cutting.

In the course of black locust energy plantation established by planting after the first cutting the bulk of above-ground dendromass of the first sprouted generation can be 23-26% higher (in our case study) than of the original planted stand at the age of 4 years.

The higher stem number per hectare resulted higher dendromass yield. At the same time, the datasets also show that coppices are not worth to maintain over 4 years because on the basis of evaluation carried out at the age of 8 in case of both planting spacing we achieved lower dendromass yield. Based on other supplementary tests in black locust energy plantations the mean annual increment of oven-dry dendromass culminates at the age of 4-5 years (Csiha et al. 2011). This fact is confirmed in *Figure 2* where the mean annual increment of above-ground dendromass of different spacing treatments can be seen based on different origins and ages.

Discussion

The most favourable date of the cutting cycle (rotation) besides the specific species (variety) is determined by a several factors together. Among them the most important are: site quality, planting spacing, cutting method, and the type of the applied harvester-chipper machine.

The higher the stem number per hectare and the smaller the growing space, the shorter the sustainable energy plantation and the shorter the cutting cycle. Plantations under favourable ecological conditions usually achieve the determining yield values in a shorter time so the maturity period under good site conditions may be somewhat shorter than under unfavourable site conditions.

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