

Biomass from Short Rotation Energy Plantations of Black Locust on Tailing Dump of »Field B« Open Pit in »Kolubara« Mining Basin

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Abstract – Nacrtak

*In recent decades, the establishment of short rotation energy plantations is becoming ever more common in marginal sites, including tailing dumps of open pits in mining basins. During the exploitation cycle, not only do short rotation energy plantations produce woody biomass for energy production, but they also accumulate large amounts of carbon from the soil and air. In this case, the energy plantations are primarily environmentally friendly, which is accompanied by their economic importance. Black locust (*Robinia pseudoacacia* L.) has a number of advantages that justify its use in the establishment of energy plantations. The main objective of this paper is to assess the current state of energy plantations of black locust established in autumn 2008 on a tailing dump of the »Kolubara« mining basin (Serbia), as well as to determine the yield of dry matter of black locust per hectare. The data on the number of trees, diameter and height increments, the mass of trees per diameter class and the amount of biomass were obtained by the method of partial survey. The survey found a high percentage of survival of black locust seedlings (95.67%), the average diameter in the plantation (6.83 cm), medium tree height (7.15 m) and the absolute yield of dry matter (2.96 t/ha/yr). The results of this research on experimental energy plantations will be useful in the planning of future energy plantations in low-productivity sites, as well as in the selection of techniques and technologies for utilization of energy plantations.*

*Keywords: energy plantations, woody biomass, black locust, *Robinia pseudoacacia* L., reclamation, productivity*

1. Introduction – Uvod

An increase in mining activities leaves behind vast areas of degraded land. The process of surface mining completely changes the landscape and natural soils are removed from the site (Dražić 2002). The most significant conflict of mining with the environment refers to the occupation of agricultural and forest land by the process of open pit mining (Spasić et al. 2005). However, the occupation of land for surface coal mining is believed to be temporary, due to the fact that the land used is subjected to reuse after exploitation. In those terms, the area is subjected to morphological and landscape reclamation through the process of land recla-

mation, revitalization of nature and construction of necessary facilities (Pavlović 2013). The legislation in the field of mining, agriculture, forestry and environment, obliges the users of mineral resources to carry out reclamation of degraded land after the exploitation process. The most common form of reclamation is biological reclamation. It is a complex and time-consuming process that requires a multidisciplinary approach, previous analysis of the current situation in the field and performance in stages, including a subsequent follow-up process and constant corrections (Dožić et al. 2010). The establishment of plantations is the oldest form of reclamation of land damaged by human activity (Filcheva et al. 2000). When selecting

the species for biological recultivation, an emphasis should be placed on those species that produce biomass in a short period, and, if possible, the ones that are economically important (Singh et al. 2002). In recent decades, the establishment of short rotation energy plantations on tailing dumps of open pits is gaining importance (Danilović et al. 2013). During the exploitation cycle, not only will the short rotation plantations for energy produce woody biomass for energy, but they will also accumulate large amounts of carbon from the soil and air (Quinkenstein et al. 2012).

2. Research problems and objectives

Problematika i ciljevi istraživanja

The highest production of carbon dioxide is the result of combustion of the currently most important and most commonly used energy sources, including fossil fuels, coal and oil. The European Union Directive 2009/28/EC (OJ L 140) on the promotion of the use of energy from renewable sources seeks to reduce the use of fossil fuels at the expense of increasing those that are made from renewable resources, thus emitting a lower amount of carbon dioxide. Along with the international efforts to prevent climate change, the significance of woody biomass for energy also changes. It is transformed from a traditional and inefficiently used resource to a multi-useful resource for the production of clean energy (European Commission 2005). The cultivation of fast growing tree species in short rotation plantations can create conditions for the production of large quantities of biomass at competitive prices (Grünwald et al. 2009). In recent decades, the establishment of short rotation energy plantations is becoming ever more common in marginal sites, including tailing dumps of open pits in mining basins (Böhm et al. 2011a, 2011b, Brinks et al. 2010, Bungart and Hüttl 2001, Mantovani et al. 2012, Paulson et al. 2003, Quinkenstein et al. 2010, Redei et al. 2011). In this case, energy plantations are primarily environmentally friendly, which is accompanied by their economic importance (Danilović et al. 2013). Black locust (*Robinia pseudoacacia* L.) has a number of advantages that justify its use in the establishment of energy plantations (Redei and Veperdi 2009), including: a high growth potential at the juvenile stage, excellent coppicing ability, high wood density, high dry matter production, appropriate flammability of wood, relatively fast drying and easy cutting. Compared to other species, black locust grows successfully in all sites producing the largest amount of biomass (Barrett et al. 1990). Black locust has shown remarkable adaptability

in the biological recultivation of degraded land (Ashby et al. 1985).

The main objective of this paper is to assess the current state of energy plantations of black locust established on the tailing dump of the »Kolubara« mining basin in autumn 2008, as well as to determine the dry matter yield of black locust per hectare. The results of the research of this experimental energy plantation will be useful in the planning of future energy plantations in low-productivity sites and the selection of techniques and technologies for the utilization of energy plantations.

3. Materials and methods – Materijal i metode

The soil analyses were first performed on the surface of energy plantation in order to obtain data on physical and chemical properties of the soil and soil type. Soil surveys were performed at three locations, and soil samples in the state of disorder were taken



Fig. 1 Map of the Republic of Serbia and position of Kolubara district
Slika 1. Karta Republike Srbije i položaj Kolubarskoga okruga



Fig. 2 Short rotation energy plantations of black locust on tailing dump of »Field B« open pit in »Kolubara« mining basin

Slika 2. Energetski nasad bagrema kratke ophodnje na odlagalištu »Polje B« površinskoga kopa »Kolubara«

from two locations for the purpose of determining the chemical properties of the soil. A composite soil sample was taken at the depth of 0–30 cm at each location.

The data on the number of trees, diameter and height increments, the mass of trees per diameter class and the amount of biomass were obtained by the method of partial survey. The measurements were performed during summer 2013. A simple systematic sample was used for the selection of sample plots as the basic units. Six 20 × 20 m sample plots were selected, of which two sample plots were located on the edges of the plantation and four in its central parts.

The diameters of the trees were measured at a height of 10 cm above the ground (cutting zone) and classified in diameter classes with the range of 1 cm. The current diameter increment was calculated on the basis of the diameters measured. Five trees were selected within each diameter class. Their heights were measured and after that they were cut. The harvested trees were used to measure the mass and moisture content of the wood after harvesting. The moisture

content was measured using an electronic moisture meter type GANN Hidromette H65. The felled black locust trees were chipped using a mobile Schliesing 330 MX wood chipper. Trees from each diameter class were chipped separately, and then its mass was measured. The quantity of oven-dry wood chips was calculated on the basis of the mass of raw wood chips and moisture content after felling.

4. Research area – *Mjesto istraživanja*

The research was conducted in the area of the »Kolubara« mining basin in the Republic of Serbia, more precisely, on the outer tailing dump of the »Field B« open pit. The »Kolubara« mining basin is a public company of the Serbian Electric Power Industry. It is located about 50 km southwest of Belgrade in the lower reaches of the Kolubara River (Fig 1). It covers an area of 600 km², while the area of coal mining is 132 km². Coal is exploited at four open pits, including: »Field B«, »Field D«, »Tamnava-Zapad« and »Veliki Crljeni«. The location of the »Field B« open pit is in the southern part of the Posavsko-Tamnavska Plain. The total area of the »Field B« open pit is 885 ha, of which 260 ha are still an area of coal exploitation and 625 ha are a degraded area. A technical reclamation that has prospects of certain forms of biological production was carried out on about 350 ha of degraded area of the tailing dump. The type of soil on the area that is the subject of this research is deposol formed by overburden dumping. The plantation of black locust on the outer tailing dump of the »Field B« open pit was formed for the purpose of reclamation of a part of the dump and for biomass production. The area of the established plantation is 5.67 ha and its shape is irregular. The planting of the black locust seedlings was carried out at a distance of 1.8 × 1.8 m in autumn 2008.

5. Research results – *Rezultati istraživanja*

The results of the analysis of the basic chemical properties of soil showed that the materials concerned are dumped lime-free layers, ranging from neutral to slightly acidic in terms of acidity. Humus and nitrogen contents in these soils are medium. The phosphorus supply is low to very low, while the values of potassium content range from medium to high values. An analysis of the total content of some trace elements and heavy metals in the deposol showed that the amounts of all elements are usual, except for some increased levels of cobalt (Co) and significantly higher values for nickel (Ni) and chromium (Cr). The analyses of the granulometric composition clearly showed that the

Table 1 Number of trees by diameter classes**Tablica 1.** Broj stabala po debljinskim razredima

Sample plot <i>Pokusna ploha</i>	Number of trees per diameter classes (measured at 10 cm from the ground)													
	<i>Broj stabala po debljinskim razredima (mjereno na 10 cm od tla)</i>													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
	1.0–1.9 cm	2.0–2.9 cm	3.0–3.9 cm	4.0–4.9 cm	5.0–5.9 cm	6.0–6.9 cm	7.0–7.9 cm	8.0–8.9 cm	9.0–9.9 cm	10.0–10.9 cm	11.0–11.9 cm	12.0–12.9 cm	13.0–13.9 cm	14.0–14.9 cm
P ₁	0	5	3	15	22	15	20	17	12	4	1	1	0	0
P ₂	0	2	6	6	16	20	27	17	21	4	3	0	0	1
P ₃	0	7	11	14	20	18	18	15	11	4	3	2	0	0
P ₄	0	6	9	14	17	22	17	16	14	4	3	3	1	0
P ₅	0	5	3	8	18	16	18	22	13	2	4	2	0	0
P ₆	0	7	8	8	13	22	23	15	12	1	2	0	0	0
On one hectare <i>Na jednom hektaru</i>	0	133	167	270	441	470	512	425	345	79	66	33	4	4
On the entire area <i>Na cijeloj površini</i>	0	754	947	1 555	2 500	2 665	2 903	2 409	1 956	448	374	187	22	22

Table 2 Minimum and maximum diameters and standard deviations by sample plots**Tablica 2.** Najmanji i najveći promjeri i standardne devijacije po pokusnim ploham

Sample plot <i>Pokusna ploha</i>	Minimum diameter <i>Najmanji promjer</i>	Maximum diameter <i>Najveći promjer</i>	Standard deviation <i>Standardna devijacija</i>
	cm	cm	cm
P ₁	2.5	12.0	2.03
P ₂	2.0	14.2	2.02
P ₃	2.3	12.6	2.38
P ₄	2.1	13.3	2.43
P ₅	2.0	12.0	2.16
P ₆	2.1	11.1	2.02

deposol can be classified as clay in the first two layers (0–18 cm and 18–43 cm) and as clay loam in the other two layers (43–118 cm and 118–140 cm). The soil type is deposol, formed by disposing overburden and waste rock in order to reach coal deposits.

As indicated above, measurements were performed in six 400 m² sample plots, which accounts for 4.23% of the entire area of the black locust plantation.

The number of trees per sample plot ranged from 111 to 126, i.e. from 2 775 to 3 150 calculated per hectare.

The number of trees in the sample plots was used to calculate the number of trees in the entire area, which amounted to 16 742. When the number of trees was compared to the number of seedlings planted in autumn 2008 (17 500), it could be observed that, after five years, the percentage of survival of black locust seedlings was very high (95.67%).

The diameter measurement at 10 cm from the ground revealed that most of the trees were in the range of diameter class 2 to 8. This information is very important for the selection of machinery for the cutting and chipping of trees.

The average diameters at a height of 10 cm from the ground, within the sample plots are: P₁ = 6.73 cm, P₂ = 7.21 cm, P₃ = 6.51 cm, P₄ = 6.84 cm, P₅ = 7.01 cm, P₆ = 6.70 cm.

The results of the analysis of variance indicate that there are no statistically significant differences between the average diameters in the sample plots ($F = 1.57, p = 0.166$), i.e. measurement data in the sample plots represent a homogeneous group whose average values can be calculated.

The mean diameter at a height of 10 cm from the ground in the plantation, calculated on the basis of the

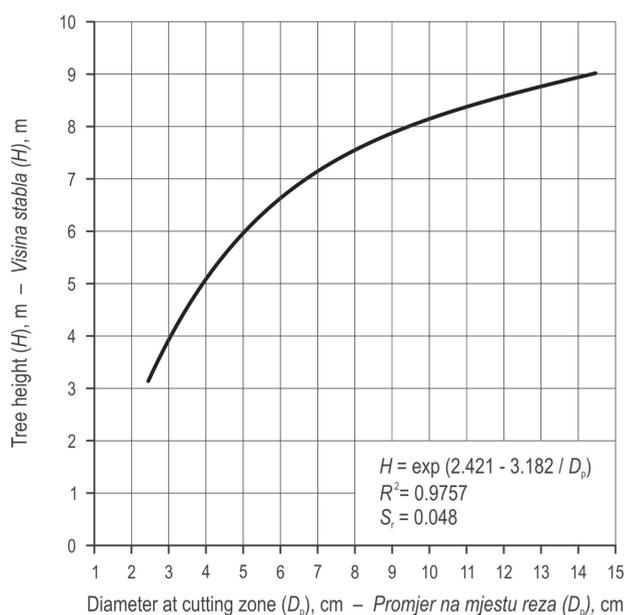
Table 3 Average tree height and average moisture content by diameter classes**Tablica 3.** Prosječna visina stabala i prosječna vlaga po debljinskim razredima

Sample plot <i>Pokusna ploha</i>	Diameter class, cm – <i>Debljinski razred, cm</i>													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
	1.0–1.9 cm	2.0–2.9 cm	3.0–3.9 cm	4.0–4.9 cm	5.0–5.9 cm	6.0–6.9 cm	7.0–7.9 cm	8.0–8.9 cm	9.0–9.9 cm	10.0–10.9cm	11.0–11.9cm	12.0–12.9 cm	13.0–13.9 cm	14.0–14.9 cm
Average tree height, m <i>Prosječna visina stabla, m</i>	1	3.1	4.5	5.5	6.6	7.1	7.5	8.0	8.1	8.6	8.4	8.4	8.3	8.9
Average moisture content, % <i>Prosječna vlaga, %</i>	1	54.1	57.2	56.15	55.8	55.9	59.1	53.8	56.6	56.05	56.5	58.2	57.2	57.7

weighted arithmetic mean, is 6.83 cm. Its minimum value is 2.0 and its maximum value 14.2 cm.

The average diameter increment of trees in the plantation is 1.37 cm.

The height of five trees was measured within each diameter class and the mean height of trees in each diameter class was calculated on the basis of the arithmetic mean. On the basis of the heights of trees sampled, it was found that the average height of trees in the plantation is 7.15 m. Tree heights per diameter classes show correlation with the diameter in the cutting zone (Fig. 3).

**Fig. 3** Correlation between tree heights and diameter classes**Slika 3.** Ovisnost visine stabala o debljinskom razredu

The moisture content of black locust trees was also measured in five trees from each diameter class, immediately after harvesting. The average moisture content of black locust trees was 56.81%.

The chipping of felled trees produced an average mass of fresh wood chips for each diameter class. On the basis of the average mass of wood chips by diameter classes and the number of trees within each diameter class, it was possible to calculate the mass of wood chips per hectare and the total mass of wood chips in the plantation.

The mass of wood chips per ha was calculated by summing up the mass of wood chips per diameter classes for the moisture content of 56.81%, and it amounted to 34 308.4 kg, i.e. 194 616.2 kg for the entire area.

Fig. 4 shows the dependence of wood chip mass on the diameter class, measured at 10 cm from the ground.

The mass of oven-dry wood chips of 14.82 t/ha after a five-year cycle of growth was obtained on the basis of the mass of wood chips in the raw state (at moisture content of 56.81%), and the mass of oven-dry wood chips per hectare per year amounted to 2.96 t/ha/year. The mass of oven-dry wood chips for the entire black locust plantation was 84.05 t.

6. Discussion – *Rasprava*

The establishment of short rotation energy plantations of woody species in Serbia has not yet gained enough importance and is mainly confined to individual scientific studies on small plots. However, with an increasing interest and activities in this field, a new branch of forestry has actually been developed, along with the development of the so-called »energy plantations«, with an aim of defining the most suitable tree

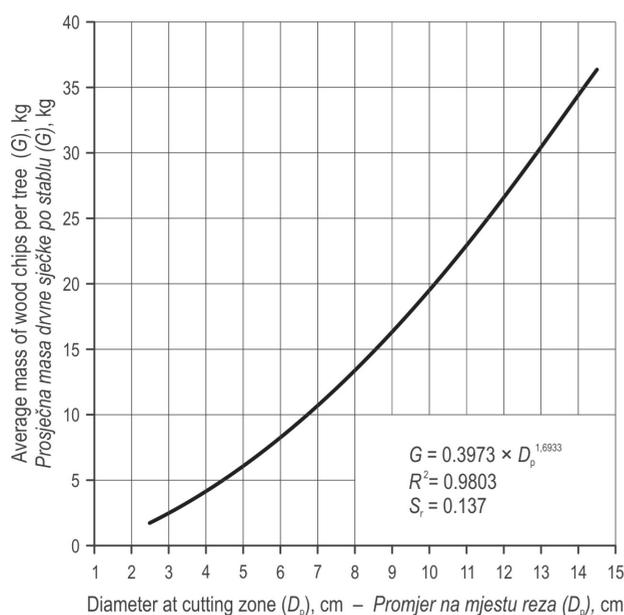


Fig. 4 Correlation between wood chip mass and diameter classes
Slika 4. Ovisnost mase drvene sječke o debljinskom razredu

species and cultivation conditions in plantations with a large number of plants per unit area (Klašnja et al. 2006). The method of planting and simple cutting at intervals of 2 to 6 years, as well as the possibility of utilization for 20–30 years without transplanting (Quinkenstein et al. 2012), make energy plantations very interesting in terms of biological reclamation of degraded soils and creation of economic profit.

The Mining Law of the Republic of Serbia (Official Gazette of RS, No. 44/95, 34/2006 and 104/2009) clearly stipulates that after the exploitation of mineral resources each company must carry out recultivation of the land according to projects within one year from the cessation of work. Since deposits are generally low-productivity soils, with a small amount of moisture in the surface layers, all forms of agricultural production are difficult and therefore unprofitable in economic terms. For these reasons, the solution should be sought in the establishment of energy plantations of tree species with a short rotation period, as their establishment would return the production function to the soil.

These facts served as guidelines to the management of the »Kolubara« mining basin in Serbia who decided to form a black locust energy plantation on an area of 5.67 ha in autumn 2008. The percentage of the seedling success of black locust seedlings on the tailing dumps of the Kolubara mining basin is above the average recorded in similar sites and other countries. After five years, the survival rate of black locust seedlings in the plantation established on the »Field B« outer tailing dump in 2008 was 95.67%. By comparison, the survival rate of black locust seedlings in the experimental energy plantations on the tailing dumps of the »Welzow-Süd« coal mine (Germany) was 84% after four years (Böhm et al. 2011a), on the tailing dump of the »Welzow II« mine (Germany) it was also 84%, while on the tailing dump of the »Sedlitz« lignite mine (Germany) it amounted to 98% (Grünwald et al. 2009). A very high survival rate of black locust seedlings of 97% was also achieved on the tailing dump of

Table 4 Average mass of wood chips per tree, mass of wood chips per hectare and total mass of wood chips by diameter classes

Tablica 4. Prosečna masa drvene sječke po jednom stablu, masa drvene sječke po jednom hektaru i ukupna masa drvene sječke po debljinskim razredima

Sample plot <i>Pokusna ploha</i>	Diameter class, cm – Debljinski razred, cm													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
	1.0–1.9 cm	2.0–2.9 cm	3.0–3.9 cm	4.0–4.9 cm	5.0–5.9 cm	6.0–6.9 cm	7.0–7.9 cm	8.0–8.9 cm	9.0–9.9 cm	10.0–10.9 cm	11.0–11.9 cm	12.0–12.9 cm	13.0–13.9 cm	14.0–14.9 cm
Average mass of wood chips per tree, kg <i>Prosečna masa drvene sječke po stablu, kg</i>	1	1.45	3.33	6.37	8.58	8.55	12.69	15.01	18.89	23.33	24.89	27.60	30.01	31.78
Mass of wood chips per hectare, kg <i>Masa drvene sječke po hektaru, kg</i>	1	192.8	556.1	1 719.9	3 783.8	4 018.5	6 497.3	6 379.2	6 517.1	1 843.1	1 642.7	910.8	1 20.0	1 27.1
Total mass of wood chips, kg <i>Ukupna masa drvene sječke, kg</i>	1	1 093.3	3 153.5	9 905.4	21 450.0	22 785.8	36 839.1	36 159.1	36 948.8	10 451.8	9 308.9	5 161.2	660.2	699.2

the Kostolac mining basin (Serbia) (Đorđević-Miloradović et al. 2012).

In the experiment observed, the planting spacing of 1.8 m between the seedlings in a row and 1.8 m between the rows is bigger compared to the spacing in short rotation energy plantations in some European countries. During the establishment of short rotation energy plantations in Germany, black locust was planted in double rows at a distance of 0.75 m. The distance between the plants in a row was 0.85 m, and the distance between two double rows was 1.8 m (Böhm et al. 2011b). During the establishment of energy plantations of black locust in Hungary, the seedlings were planted at a distance of 1.5×1.0 m (Redei et al. 2011).

The average diameter of trees in a plantation, measured at 10 cm from the ground, i.e. in the zone of cutting, was 6.83 cm. The diameter size of the cutting zone plays an important role in the choice of techniques and technologies of work to be applied in cutting and chipping. Handler and Blumauer (2010) found that a special Biomasse Europa header mounted on a Claas Jaguar 890 (370 kW) forage harvester can be used for the felling of trees with diameters of up to 130 mm. A Salix HS2 header mounted on a Claas Jaguar 900-830 (250 kW) forage harvester can be used for the felling of trees with diameters of up to 80 mm, the headers Woodcut 1500 on a Krone Big X (370 kW) forage harvester and 130 FB on a New Holland FR 9000 (397 kW) forage harvester can be used for the felling of trees with diameters of up to 150 mm (Ehlert et al. 2012). In this research, most tree diameters were found to be in the range of diameter class three to nine. Böhm et al. (2011a) studied a black locust energy plantation at the age of four years, with a density of 9,200 plants per hectare, and found that the average diameter in the zone of cutting was 4.4 cm.

Tree heights per diameter classes show correlation with the diameter in the cutting zone. The average height of trees in the plantation is 7.15 m. The average height of trees in a four-year-old energy plantation of black locust in Germany is 4.0 m (Böhm et al. 2011a).

The data on the average moisture content of harvested trees show high moisture content immediately after harvesting. Such a high moisture content of the wood is the result of the fact that the survey was carried out in summer, when the physiological processes in the tree are the most active. As a rule, tree felling and chipping in energy plantations should be performed in winter months, i.e. during dormancy when the moisture content in the wood is the lowest.

Depending on the climate and site conditions, dry matter yield of black locust in short rotation energy plantations ranges from 3–10 t/ha/year (Grünwald et

al. 2009, Quinkenstein et al. 2010, Redei et al. 2011). The dry matter yield of wood chips from the black locust energy plantations on the tailing dump of the »Field B« open pit is 2.96 t/ha/year, measured five years after plantation establishment. There was no cutting, so that the area is in the form of a plantation, i.e. each plant has a single stem. After cutting the energy plants, a large number of shoots will appear from each stump. According to a research conducted by Grünwald et al. (2009) in Jänschwalde, dry matter yield increases in subsequent production cycles. In their research, the yield in the first rotation period, after three years, amounted to 3 t/ha/year on average, in the second cycle, after six years, the yield was 6 t/ha/year, and in the third three-year cycle, it was between 7 and 8 t/ha/year.

7. Conclusion – Zaključak

The black locust energy plantation in the area of the »Kolubara« mining basin is the first plantation of this type in the territory of the Republic of Serbia. Although the area of the energy plantation is relatively small (5.67 ha), there have been a number of scientific studies in this area that will be valuable for the planning of further biological reclamation of the land degraded in the process of surface mining and disposal of overburden. In addition, the results of measurements of taxation elements of the trees in the plantation will serve as a starting point in determining the best length of the rotation period, the choice of methods of utilization and machinery for the cutting and chipping of black locust. The dry matter yield of black locust per unit area is the basis for examining the cost effectiveness of the establishment and utilization of these short rotation energy plantations.

The following results should be noted on the basis of the research carried out in the black locust energy plantation on the »Field B« open pit of the »Kolubara« mining basin:

- ⇒ The survival percentage of black locust seedlings after five years is 95.67%;
- ⇒ The average diameter at a height of 10 cm from the ground in the plantation is 6.83 cm;
- ⇒ The average diameter increment of trees in the plantation is 1.37 cm;
- ⇒ The average height of trees in the plantation is 7.15 m;
- ⇒ The average moisture content of black locust wood was 56.81% after harvesting;
- ⇒ The oven-dry mass of wood chips after a five-year growth cycle is 14.82 t/ha, and the oven-dry mass of wood chips per hectare amounts to 2.96 t annually.

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Sažetak

Korištenje biomase iz energijskih nasada bagrema

U posljednjim desetljećima osnivanje kultura kratkih ophodnji postaje sve uobičajenije na marginalnim tlima, uključujući i odlagališta površinskih kopova. Tijekom ciklusa eksploatacije kulture kratkih ophodnji ne samo da proizvode drvenu biomasu za proizvodnju energije već i akumuliraju značajne količine ugljika iz tla i zraka. U navedenom slučaju kulture kratkih ophodnji za proizvodnju energije primarno su okolišno prihvatljive, što je upotpunjeno i njihovim gospodarskim značenjem. Obični bagrem (*Robinia pseudoacacia* L.) ima mnoge prednosti koje opravdavaju njegov izbor za osnivanje kultura kratkih ophodnji za proizvodnju energije. Osnovni je cilj ovoga rada procijeniti trenutno stanje bagremove kulture kratke ophodnje osnovane u jesen 2008. godine na odlagalištu površinskoga kopa »Kolubara« (Srbija), ali i utvrditi prinos suhe tvori običnoga bagrema po hektaru. Na pokusnim je plohama utvrđen broj stabala, promjer na mjestu reza (10 cm od tla), visina, prirast te masa stabla i količina biomase po debljinskim razredima. Utvrđen je visok postotak preživljavanja bagremovih sadnica (95,67 %), prosječni promjer stabala (6,83 cm), srednja visina stabala (7,15 m) i prinos standardno suhe drvne tvori (2,96 t/ha/god). Rezultati će ovoga istraživanja, provedena na pokusnoj kulturi kratke ophodnje za proizvodnju energije, biti vrlo korisni pri planiranju osnivanja budućih kultura kratkih ophodnji za proizvodnju energije na nisko proizvodnim tlima, ali i za odabir tehnika i tehnologija pridobivanja energijskoga drva iz kultura kratkih ophodnji.

Ključne riječi: kulture kratkih ophodnji, drvena biomasa, obični bagrem, *Robinia pseudacacia* L., rekultivacija, produkcija

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