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TEMPORARY DEPOSITED OF DEPOSOL AS THE POSSIBLE AREA FOR SHORT ROTATION PLANTATION ESTABLISHMENT – MODEL CASE

Suzana MITROVIĆ[1], Milorad VESELINOVIĆ[1], Dragica VILOTIĆ[2], Nevena ČULE[1], Dragana DRAŽIĆ[1], Biljana NIKOLIĆ[1], Marija NEŠIĆ[2]

Abstract. *Open pit mine exploitation of lignite in the locality RB Kolubara is a major source of fossil fuels for electricity production in Serbia. Exploitation area in the space of RB Kolubara consists of several fields. The fields are in various stages of exploitation. One of the oldest and largest is the field of D. It is anticipated that the exploitation of this field will be completed in near future. Then the area becomes a place for depositing the excavated overburden from the other fields.*

This paper shows the model of the possible production of biomass for energy. Biomass was estimated in the short rotation plantations (SRP) of fast growing trees. The model provides cultivation of plantations at ten year long lasting depositing of the each 30 meters thick layer. In the model was used plants of Paulownia sp. and Populus sp..

The analyzed parameters in the model indicate that the potential of a temporary surface are good for biomass production and that the cultivation of such plantations is justified.

Key words: wood biomass, energy crops, *Paulownia* sp., *Populus* sp., deposol.

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1. INTRODUCTION

Faced with increasing negative changes caused by man's activities, the Earth comes in real danger of the collapse of all ecosystems (Stern, 2006). Disasters of Earth where it came to destruction of the existing ecosystems so far were a result of natural disasters. Nature is once again every time after that ensured that life back and develop in new forms and in a stronger intensity. The current situation is the consequence of one single species in the planet - man, one of the million species of life on earth. This is undoubtedly the greatest obligation to the people to take all possible actions to preserve the collapse of the planet.

Global warming, the greenhouse gas effect have for result a drastic destruction of biodiversity and finally poverty and hunger of the arcitect of these negative processes (Brown, 2008, MacCracken, 2008). The use of fossil fuels is one of the major causes of the negative effects of the present time. In regard to that biomass as a renewable fuel which is able to replace fossil fuels is part of an positive effort and a part of the solution. (Börjesson *et al*., 1997., Dubuisson and Sintzoff, 1998., Cannell, 2003.). Biomass is a fuel that does not have such a negative impact, and its use would preserve the negative effects of global warming and excessive issuance of greenhouse gases would be largely reduced. (Börjesson, 1999a., Börjesson, 1999b., Aronsson and Perttu, 2001., Keolian and Volk, 2005., Börjesson and Berndes, 2006.) In relation to that on the globally level have adopted a number of declarations, conclusions and initiatives for action. Based on these, the signatory states have assumed certain obligations. One of the most important is the obligations under the Kyoto Protocol. In order to meet the obligations under the Kyoto Protocol/following international agreements, the European countries has the target to reach a 20% share of the EU energy mix by renewable energy sources by the year of 2020.

In this sense, the real possibilities of individual countries are already estimated. In most cases, the signatory states have a problem to fulfill commitments. In regard to that, research and evaluation of the possibilities of production of woody biomass as a fuel, in terms of increasing its amount in the total needs of the country, the Kolubara open pit with a new approach and accessible areas become very topical. Commence research in the future will make possible biomass production technology and reclamation of degraded areas, just exactly caused by digging fossil fuels - coal, are in immediate synergy to ensure maximum utilization of potentiality which are used according to selection of tree species as well as the area in which it establishing. The estimates of the European Environmental Agency (EEA, 2006) show that most of the potential biomass production in the EU during the next few years will rely on energy crops on agricultural land, which can account for more than half of the total biomass potential by the year of 2030.

2. METODOLOGY

Modeling of the case was conducted in the area of open pit RB Kolubara field D (Fig. 1) as one of the oldest exploitation field that is still in operation. It is assumed that in near future will stop exploitation of coal in this area and that area will be further used for a process of internal dumping of overburden. Considering the deep of the field (150m) and field size (2000ha) assumption is that the barren soil will be deposited in layers. In our case, the assumption is that one layer will be formed over ten years. (Fig. 2)). These areas are temporary, limited with short life span so that until the final layer the definitive reclamation of the area is not possible. In the model are calculated quantity of biomass that can be produced during filling of the internal waste disposal to its final shape.

Fig. 1. *Open pit RB Kolubara – area of field D*

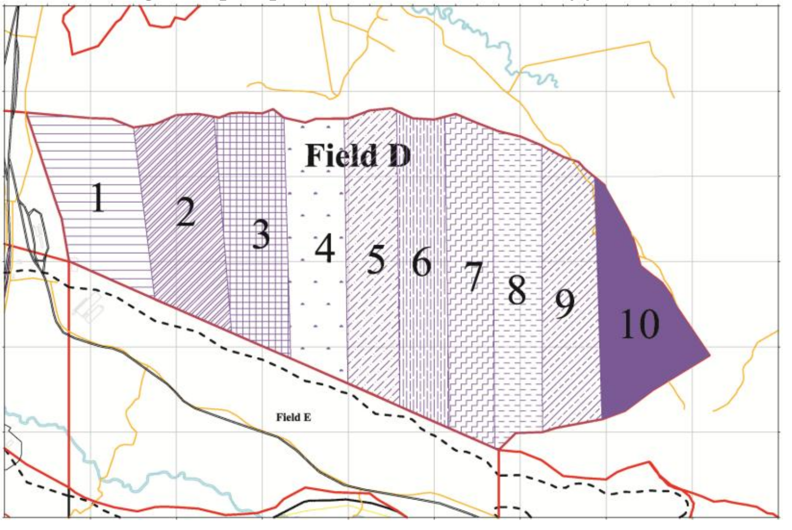
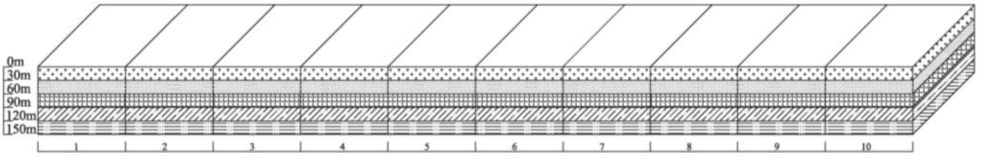


Fig. 2. *Schematic view of filling the field with deposol*



Based on our research (Veselinovic et al., 2010) and literature data was calculated potential of the space by planting species *Paulownia* sp. The obtained results were compared with potential production at the same space of the amounts of biomass poplar species that is planted in the experimental nursery areas Barosevac enhanced on the deposited overburden.

The predicted density of planting (Fig. 3) is adapted to the tree species that were used and the harvest, which is planned to be carried out every three years during the period of ten years of each of four predicted layers (Fig. 4).

Fig. 3. *Schema of planting density – a-Paulownia sp.; b-Populu sp.*

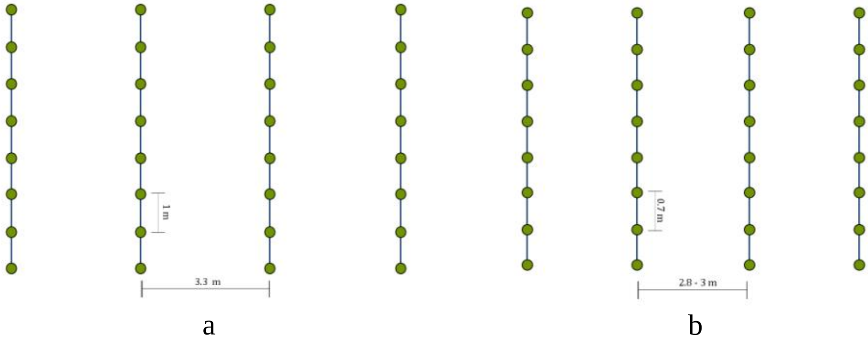
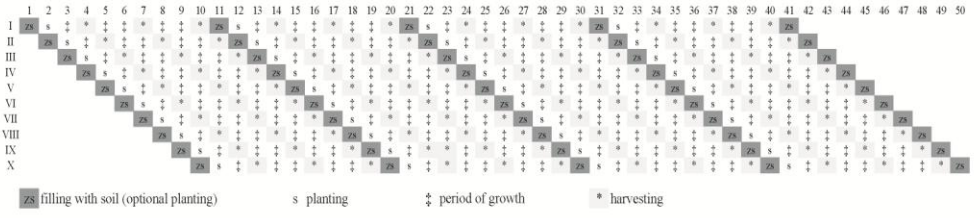


Fig. 4. *Dynamics of development of plantations over a period of 50 years*



3. RESULTS AND DISCUSION

The experiment of growth and suitability for raising energy plantations for biomass production of poplar species was performed in the nursery Barosevac. In Tab. 1 has shown the min and max and mean values obtained in the neck root diameter and height of the three-year monitoring of seedling growth parameters.

Table 1. *Seedling growth parameters of Poplar species*

	Year of growth					
	First		Second		Third	
parameters	neck root diameter (R/cm)	Height (H/m)	neck root diameter (R/cm)	height (H/m)	neck root diameter (R/cm)	Height (H/m)
Min	1,0	41	1,25	120	1,4	132
Max	2,95	315	5,7	461	7,7	610
Average	1,75	2,17	2,47	2,67	2,88	3,47

According to Hassanzad et all, (2007) for *Paulownia* sp. (Tab.2) has shown the min and max and mean values obtained in the neck root diameter and height of the three-year monitoring of seedling growth parameters.

Table 2. Seedling growth parameters of Paulownia species (*Hassanzad et al., 2007*)

	Year of growth					
	first		second		third	
parameters	neck root diameter (R/cm)	height (H/m)	neck root diameter (R/cm)	Height (H/m)	neck root diameter (R/cm)	Height (H/m)
Min	0,13	0,23	0,94	1,19	3,36	3,1
Max	2,64	2,28	6,94	5,35	12,1	7,7
Average	0,31	0,99	3,57	2,87	8,53	6,19

On the basis of the displayed values is evident that the *Paulownia* seedlings in the second year of growth exceed the values of height and values in the neck root diameter of *Poplar* seedlings. In the third year the difference is far more important. *Paulownia* seedling have double higher values in height and three time higher values of the diameter at the neck of the root then poplar seedlings.

In the third year -year of harvest in the experiment field, on a sample of 100 trees, was measured the weight of above-ground fresh biomass and weight of above-ground dry state of biomass of poplar trees (Tab.3). Conversion of biomass weight was based on the number of units of 7000 per hectare for planting density of 0,7 spacing in the row and 3m space between the rows.

Table 3. *Average values of the analyzed parameters of poplar trees*

weight of above-ground fresh biomass					weight of above-ground dry state of biomass				
(g)				t/ha	(g)				t/ha
trunk	branches	leaves	sum/stem	sum/ha	trunk	branches	leaves	sum/stem	sum/ha
860,33	189,17	485,33	1534,83	10,74	447,67	86,67	176,67	711,01	4,98

According to the Lawrence, J.S., (2011) model *Paulownia* sp. can be planted using mechanized or hand tool methods at 1m spacing in the row and 3,3 m space between the rows. In Tab. 4 is estimation of possible biomass production per each harvest.

Table 4. *Paulownia sp. biomas plantation model (1m x 3.3m spacing – 3000 stem/ha)*

Age et first harvest (year)	Age at each subsequent harvest (year)	Estimate average DBH at harvest (cm)	Estimate average volume yield /tree (m^3)		Estimate average volume yield /ha (m^3)		Estimate average dry matter yield /ha (t)	
			Trunk	total	Trunk	total	Trunk	total
3-4	2-3	10 (cautious)	0,035	0,045	105	136	27.3	35.36
3-4	2-3	12,5	0,059	0,077	177	231	40.02	60.06
3-4	2-3	15 (potential)	0,089	0,116	267	348	69.42	90.48

Taking into account that the deposol Kolubara basin is very poor with nutrients (Veselinovic et al., 2006.) to model our case we used the minimum value of the above models. According to our model in Tab.5 has shown the potential of quantities of biomass produced during the filling field D with deposol. The difference in the quantity of biomass of tested species was multiple for the benefit of Paulownia. In the model amount of biomass crops earned energy crops of *Paulownia* sp. during one layer cycle is more than whole established crops of poplar during the full filling of field D. This indicates that, in further development of our research *Paulownia* sp. have to be tested on the ground within the ecological conditions of habitats.

Table 5. *Model estimation of biomass potential production during the filling field D with deposol*

Species	Estimate average dry matter yield /ha (t)	Annual space (ha)	Estimate average dry matter yield /ha (t)/year	Estimate average dry matter yield /ha (t)/cycle	Estimate average dry matter yield /ha (t)/layer	Estimate average dry matter yield /ha (t)/field D
Poplar	4,98	200	996	2.988	29.880	119.520
Paulownia sp.	35,36	200	7072	21,216	212,160	848,640

Soil fertility is a characteristic that can be modified by adding fertilizers in order to improve crop productivity. Our studies with poplars (Tab.6) indicate that additional fertilizing increases the growth parameters (R - root collar diameter and height - H) above-ground parts of plants and that the differences are significant in the third year. These results are very significant because it is the third year which is the harvest year.

Further studies will define the methodology which has to achieve optimal biomass production in the sense of invested assets / value of the product.

Table 6. *The differences in measured properties of the Poplar seedlings between fertilizing (treatment) and non fertilizing (control)*

	Year of growth							
	Second				Third			
Parameters	R (mm)		H (cm)		R (mm)		H (cm)	
	treatment	control	treatment	control	treatment	control	treatment	control
sample	434	167	434	167	447	168	447	168
X ± Sx	$14{,}67^a$± 0,29	$14{,}24^a$±0,15	$257{,}44^a$±3,26	$255{,}01^a$±2,85	$16{,}15^a$±0,29	$16{,}01^a$±0,33	$284{,}1^b$±4,00	$269{,}71^a$±2,91
X ± Ss	4,03±0,16	3,62±0,10	59,74±2,30	70,81±2,02	4,47±0,21	7,75±0,23	61,52±2,83	69,11±2,06
V ± Sv	29,1±1,12	25,44±0,72	23,21±0,90	27,77±0,79	27,67±1,27	48,40±1,44	21,66±1,00	25,62±0,76

Other researchers have come to the same results that the fertility and other management is important for high biomass production in SRP (Tahvanainen and Rytkönen, 1999, Nixon et al., 2001, Jug et al., 1999, Hofmann-Schielle et al., 1999, Heaton et al., 1999, Vilotic et al., 2006).

4. CONCLUSION

Previous studies with fast growing species for raising energy plantations for biomass production indicate that the overburden dump area has great potential. Particularly suitable are "temporary" surface that lasts for ten years and cover again with a new layer of overburden. On such areas SRP have an irreplaceable role in the production of biomass but also as a means of biological reclamation of such terrains. Upon completion of filling the fields with spoil it possible to continue production of biomass from energy plantations and a longer period of time.

According to literature data SRP give a satisfactory amount of biomass and up to thirty years of the same plantation (Best Practice Guidelines, 2007) and after that can be accessed by a durable solution to the final biological reclamation. In this sense and in the sense of technological processes that can increase the amount of biomass research will be continued.

REFERENCE

Aronsson P. & Perttu K., (2001): Willow vegetation filters for wastewater treatment and soil remediation combined with biomass production. The Forestry Chronicle 77, 293–299.

Best practice guidelines (2007): Planting and Growing Short Rotation Coppice COFORD, National Council for Forest Research and Development, Dublin, Ireland

Börjesson P., Gustavsson L., Christersson L., Linder S. (1997): Future production and utilisation of biomass in Sweden: Potentials and CO2 mitigation. Biomass and Bioenergy. 13: 399-412.

— (1999a): Environmental Effects of Energy Crop Cultivation in Sweden - Part I: Identification and Quantification Biomass and Bioenergy 16: 137-154.

— (1999b): Environmental Effects of Energy Crop Cultivation in Sweden - Part II: Economic Valuation. Biomass and Bioenergy, 16: 155-170.

Börjesson P. & Berndes G. (2006): The prospects for willow plantations for wastewater treatment in Sweden. Biomass and Bioenergy 30: 428-438.

Brown, L. R. (2008): Plan B 3.0: Mobilizing to Save Civilization. Earth Policy Institute, W. W. Norton and Company. New York. 398 p.

Cannell M. G. R. (2003): Carbon sequestration and biomass energy offset: theoretical, potential and achievable capacities globally, in Europe and the UK. Biomass and Bioenergy. 24: 97-116.

Dubuisson X. & Sintzoff I. (1998): Energy and CO2 balances in different power generation routes using wood fuel from short rotation coppice. Biomass and Bioenergy, 15: 379-390

EEA (European Environment Agency (2006): How much biomass can Europe use without harming the environment) EEA Report No 7/2006

Hassanzad, Navroodi I., Rostami, T. (2007): Evaluation of the growth potential of Paulownia furtunei in Guilan Province. In: Steve Harrison, Annerine Bosch and John Herbohn, Improving the Triple Bottom Line Returns from Small-scale Forestry: Proceedings from an International Conference. *Improving the Triple Bottom Line Returns from Small-scale Forestry*, Ormoc, the Philippines, 197-204. 18 - 21 June 2007.

Heaton, R. J., Randerson, P. F., Slater, F. M. (1999): The Silviculture, Nutrition and Economics of Short Rotation Willow Coppice in the Uplands of Mid-Wales. Biomass and Bioenergy. 17: 59 – 71

Hofmann-Schielle, C., Jug, A., Makeschin, F. and Rehfuess, K. E. (1999): Short-rotation plantations of balsam poplars, aspen and willows on former arable land in the Federal Republic of Germany. Site-growth relationships. Forest Ecology and Management. 121: 41 – 55

Jug, A., Makeschin, F., Rehfuess, K. E., Hofmann-Schielle, C. (1999): Short-rotation plantations of balsam poplars, aspen and willows on former arable land in the Federal Republic of Germany. Soil ecological effects. Forest Ecology and Management 121: 85 – 99.

Keoleian G. A. & Volk T. A. (2005): Renewable energy from willow biomass crops: Life cycle energy, environmental and economic performance. Critical reviews in Plant Sciences. 24:385-406.

Lawrence, J.S., (2011):
http://www.toadgully.com.au/files/Paulownia%20Biomass%20Production.pdf

MacCracken, M.C. (2008): Prospects for Future Climate Change and the Reasons for Early Action. Journal of the Air and Waste Management Association 58: 735-786

Nixon, D.J., Stephens, W., Tyrrel, S.F., Brierley, E.D.R. (2001): The potential for short rotation energy forestry on restored landfill caps. Bioresource Technology. 77: 237 – 245.

Stern, N. (2006): Stern Review on the Economics of Climate Change. UK Treasury. 575 p

Tahvanainen, L., Rytkönen, V-M. (1999): Biomass production of Salix viminalis in southern Finland and the effect of soil properties and climate conditions on its production and Survival. Biomass and Bioenergy. 16: 103 – 117.

Veselinović, M., Dražić, D., Ratknić, M., Bojović, S., Golubović-Ćurguz, V., Nikolić, B., Katić, M. (2006): Biological Rehabilitation by Afforestation as the Possibility of Land Use Enhancement. International Scientific Conference In Occasion of 60 Year of Operation of Institute of Forestry, Belgrade, Serbia: Sustainable Use of Forest Ecosystems, The Challenge of the 21th Century, 8 - 10th November 2006, Donji Milanovac, Serbia, Proceeedings, plenary lecture, 80 – 87, ISBN 978-86-80439-07-5 CIP 630 (082)

Veselinović, M., Vilotić, D., Šijačić-Nikolić, M., Dražić, D., Golubović-Ćurguz, V., Čule, N., Mitrović, S. (2010): The Possibility Of Paulownia sp. Utilization In The Reclamation Of Degraded Land. International Scientific Conference "Forest Ecosystems and Climate Changes", March 9-10th, 2010, Belgrade, Serbia, Proceeding, 291-307 ISBN978-86-90439-23-5

Vilotić D., Vukovojac S., Šijačić-Nikolić, M. (2006): Effect of the Super Absorbent on Development of Paulownia elongata Seedlings, Proceedings of the JUFRO Divisopn 2 Join Conference: Low input breeding and genetic conservation of forest tree species, Antaliya Turkey, 9-13 Octobar, Edited by Fikret Isak (35).

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Summary

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In the model are calculated quantity of biomass that can be produced during filling of the internal waste disposal to its final shape. According to our model the potential of quantities of biomass produced from SRP of Poplar and Paulownia during the filling field D with deposol was estimated. The difference in the quantity of biomass of tested species

was multiple for the benefit of Paulownia. In the model amount of biomass crops earned energy crops of Paulownia during one layer cycle is more than whole established crops of Poplar during the full filling of field D. This indicates that, in further development of our research Paulownia have to be tested on the ground within the ecological conditions of habitats. Also further studies will define the methodology which has to achieve optimal biomass production in the sense of invested assets/value of the product.

Reviewer: Ph.D. Mirjana Šijačić-Nikolić