REVIEW SCIENTIFIC PAPERS

Analysis of bioenergy production from Miscanthus grown on degraded area of landfill of Prelići, Čačak

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Abstract

As befits the subject matter, this paper analyse the results of biomass Miscanthus's production on degraded area of Prelići landfill Čačak and also experimental parcels near the town. Main goal of this paper is to establish the possibility of using energetical plants like these ones on degraded areas or lower quality lands. Analysis of the results shows us that it is possible to use biomasses as an alternative source of energy. By doing that, fertile grounds can be saved for production of food. First part presents the way of forming plants. Analysis of achieved results in 2012 is showed in second part, and in a third one is analysis from year 2013.

KEY WORDS: biomass, Miscanthus, energetical plants
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Introduction

RS Energy Development Strategy by 2015 ('Official Gazette' 35/05) promotes and encourages projects in the field of renewable energy sources (RES) so as to reduce energy dependence and promote rational use of fossil fuels. Local municipalities and their activities are very important for the application of this strategy. Having recognised the importance of reducing energy dependence, the town of Čačak has given the support to some energy efficiency projects. The Strategy of Sustainable Development of the town of Čačak is another document that helps to reduce energy dependence and is in agreement with the Biomass Action Plan. PUC 'Komunalac' Čačak, founded by the town of Čačak, have elaborated the project 'Establishment of biomass on degraded area of Prelići landfill' and the town of Čačak and Ministry of Environment have supported this project.

The idea of biomass production on degraded soils is based on the fact that the energy from these energy resources is pure energy. Providing pure energy by new technologies is realized through a zero carbon emission along with much lower sulphur dioxide and nitrogen oxide emissions.

As it is generally known, biomass is renewed faster than fossil fuels and its growth is easily controlled, though its quantities are limited. Active use of biomass residues, primarily forest resources, can damage the environment and induce landslides, soil erosion, etc. The potential for the use of biomass in our country has not been sufficiently explored, therefore it is necessary to establish biomass plantings but not to the detriment of food production acreages.

PUC 'Komunalac' Čačak has been allotted by the town of Čačak to manage the landfill of Prelići. The landfill (280,000 m^2) was initiated in 1973. The formation of the Regional Landfill 'Duboko' has provided conditions for closing down the Prelići landfill and has initiated re-cultivation of the entire surface for other purposes. The principal idea of the management board of PUC 'Komunalac' Čačak was to establish biomass production on the landfill, reduce the dependence on suppliers of fuels currently used for heating and, finally, cut down energy costs. Fuel prices are on the rise daily, the delivery is uncertain often depending on movements on the European and global markets. On the other hand, there is the consensus about the importance of active participation in environmental protection.

Material and methods

Energy plantings have a positive effect on environment and ecology in general as they serve as a means of rebuilding the degraded areas, re-cultivation of landfill Prelići in this particular case. Heat value of energy crops is high, ranging 15–20 MJ/kg dry weight, while heat value of lignite-coal is about 10.5 MJ/kg.

The economy of energy plantings targets to a 20-year exploitation period. The technology of establishment of these plantings is cheaper than the one used to exploit other forms of renewable energy such as waterpower plants, solar panels or wind generators. Globally, there are a number of energy crops cultivated.

Table 1: Major characteristics of biomass products originating from energy crops (TENBIORE project 2011)

Agricultural by-products	Annual average yield (t d.m./ha)	Water content at the harvesting time (%)	Theoretical energy output (GJ/ha)
Hemp	5-15	50-60	128-270
Giant reed	15-35	50-55	240-600
Miscanthus	15-25	15-20	260-440
Switchgrass	10-25	15-20	174-435
Poplar	8-20	50-60	144-360
Willow	10-15	50-60	178-276
Robinia (Black locust)	10-13	50-60	128-270

Characteristics of some biomass products from energy crops are given in Table 1. The criteria for the selection of an energy plant for planting establishment include as follows:

- Annual biomass yield;
- Moisture content at harvest time;
- Economic component of establishing and maintaining crops;
- Ecology and environmental protection.

The comparison of the given energy plants parameters and best growing practices recommend Miscanthus x giganteus as a favourable energy plant.

Planting establishment of Miscanthus x giganteus

Miscanthus x giganteus plant is a perennial, fast-growing hybrid grass that is native to Asia. It originated from the crossing of Miscanthus x Sacchariflours (diploid) and Miscanthus sinensis x (tetraploid).

In its appearance, Miscanthus X giganteus resembles Johnson grass and Italian cane. However, Miscanthus reaches even up to 4 metres in height, developing vigorous foliage as well as parenchyma inside the tree which gives it strength. Plants develop from rhizomes or underground rhizomes which do not spread uncontrollably into adjacent areas. It is recommended that planting establishment be at soil temperatures lower than 10°C, i.e. April or early May, in Serbia (Bellamyet al., 2009)

Figure 1: Biomass fuel and Miscanthus Pellets (8 mm)

If planting establishment is too early there is a risk of late frost damage, if planted too late, it may result in plants die back. Given low temperatures during dormancy, it is recommended that plants are planted deeper or covered with a protective layer of straw (Clifton-Brown,1997). Growing period is from early April, while harvesting is in mid-February or early March the following year, as humidity is lowest over that period.

The following aspects of Miscanthus X giganteus render it an environment-friendly crop (Clifton-Brown et al., 2001; Clifton-Brown et al.,2000; Christian et al.,2008)

- Increases soil fertility and through the root system provides uptake of water and harmful substances from the deeper areas of the soil;
- Improves morphological and microbiological soil properties;
- Being a perennial plant it allows the accumulation of plant layer;
- Its vigorous foliage provides habitat for birds and mammals not being a competitive food crop;
- has zero CO_2 emission.

It was observed that rhizomes-propagated Miscanthus X giganteus is less prone to frost damage compared to micropropagated Miscanthus x giganteus. Optimum planting density is 1 to 2 plants per m^2. Crop growth is initially slow due to low resistance to cold. Fully grown crop grows up to a 3–4 m height by the end of growing period, whereas the annual dry matter yield ranges from 10–30 t/ha, varying by agro-environmental conditions. Growing period is between the latest spring and the earliest autumn frosts (DEFRA, 2007; El Bassam, 2001; Eppel-Hotz,1998)

As plants grow, the aboveground biomass is growing faster in all aspects from the third growing period onwards. Full potential of Miscanthus is achieved from second to fifth leaf, depending on climatic conditions. Typically, maximum yield is reached in the second year in the southern EU countries, and the fifth in northern ones.

Quality and quantity of biomass of Miscanthus x giganteus is closely associated with harvesting time. Late September and early November is the period of maximum biological production. Over this period, the crop has high moisture content (about 60%) therefore is not suitable for storage and use (burning bales, briquette production, etc). Additional artificial drying of biomass raises final production costs. Delayed harvesting lowers the content of moisture and unfavourable components, improves quality of biomass burning, consequently leading to aging of leaves, shedding of plant tops and yield decrease.

The European Miscanthus Productivity Network reported on yields ranging from 7.7 to 26.3 t/ha in three-year old crops (Semere, Slater,2007).

Figure 2: Current state at the planting site of Prelići landfill

With regard to storage of harvested plant material, moisture content is a very important factor. High moisture content can promote development of mildew and mould leading to spontaneous burning in storage. Analyses show that Miscanthus can be safely stored after drying down to 15% moisture in open field or in a ventilated warehouse. If complete drying in the field is not available, additional drying is needed immediately after harvesting (if moisture content exceeds 25%), or during storage (if moisture content is up to 25%), if there is ventilation. At moisture contents in excess of 25% without ventilation the risk of spontaneous self-burning of stored plant material is possible (Semere, Slater, 2007).

Energy crops and biomass plantations have been established on several locations with different soil characteristics and altitudes for the research and promotion (Table 2).

Table 2: The list of Miscanthus trial planting sites

No	Planting site	Surface (acre)	Number of Rhizomes	Altitude (m)	Planting orientation	Germination percentage (%)
1.	Prelići landfill	200	26.130	260	W-E	80-90*
2.	Zablaće	2	250	230	S	80
3.	Gornja Gorevnica	1	120	317	S-E	80-90
4.	Rošci 1	3	380	593	S-W	80
5.	Rošci 2	2	250	762	-	-
6.	Sime Sarage	1	120	242	W-E	90
7.	Slatina	2	250	263	W	60-70
8.	Trbušani	2	250	257	S-W	80

** die back of individual plants at a plot part*

With regard to the facts above, the location of the Prelići landfill is of particular importance for the project. Analysis of the other locations revealed that Miscanthus should not be grown at altitudes exceeding 593 meters, e.g. at Rošci 2 site no rhizomes were successfully grown. The locations above also differ in soil characteristics therefore soil analysis on these locations was done and compared with that of Prelići landfill. The comparison of the results showed that additional fertilization to increase yields is not required on the latter. Additionally, soil analyses and theoretical data infer that Miscanthus is tolerant of a wide range of pH values, but also suggest that optimal pH ranges between 5.5 and 7.5 (Pude et al.,1997).

Figure 3: Miscanthus photographed on 14 June, 2012 at Gornja Gorevnica site

Analysis of achieved results in 2012

It is important to mention that year 2012. was extremely dry which is negative affected the crops, so in the analysis we can this year count as zero. By controlling the parcel in november 2012. it was found that the rhizomes are not dried up and that they are alive.

Table 3: Analysis of the of parameters of height and trunk diameter, length and width of the list obtained by by measuring in period 14-22.06.2012.

Planting site	Height parameter tree (cm)	Parameter Diameter tree (cm)	Parameter length list (cm)	Width parameter list (cm)
Prelići landfill	12,11	0,52	30,6	1,08
Zablaće	16,98	0,59	43,4	1,15
G. Gorevnica	18,06	0,45	41,5	1,24
Rošci 1	7,62	0,37	29	1,07
Rošci 2	-	-	-	-
Slatina	17,12	0,46	44	1,17
Sime Sarage	21,15	0,59	47,7	1,22
Trbušani	8,15	0,37	29,5	0,978

Table 3. shows us the development of the plants, which we obtained by measuring of height and trunk diameter, length and the width of list two months after planting

Analysis of achieved results in 2013

According to the soil analysis from 2012, it was decided that the parcels not perform further fertilization in order to increase yields in 2013. year.

After a relatively mild winters, controlling the planted locations, it was found that rhizomes are not freeze.

A large amount precipitations is suitably influenced on the crops, and it was determined that each of the rhizomes planted in 2013, has developed from 6 two 11 Miscanthus outcrops, figure 4.

The experimentally, in April 2013., we performed the planting of rhizomes (produced on the land Sime Sarage) older one year in land fill site Prelići.

Figure 4: Miscanthus filmed 26.06. 2013. in the landfill site of Prelići

In the time from 21 to 26.06.2013. was performed monitoring the state of plantings at all sites.

For all plots showed the increased presence of weeds, but could not access treatment with herbicides. Also, it was determined that Myscantus struggling with the same and develops faster and better from weeds.

Based on the been stated previously table 4 shows the condition of the plants, one year after planting at all sites. Parameters were obtained by measuring of height and trunk diameter, length and width of the sheet.

Table 4: Analysis of the of parameters of height and stem diameter, leaf length and width obtained by by measuring a period of 21 to 26.06.2013

Planting site	Height parameter tree (cm)	Parameter Diameter tree (cm)	Parameter length list (cm)	Width parameter list (cm)
Prelići landfill	50	0,6	60,60	2,00
Zablaće	159	1,40	85,9	2.26
G. Gorevnica	137	1,2	80,00	2,39
Rošci 1	57,5	1,0	61,10	2,20
Rošci 2	-	-	-	-
Slatina	130	1,20	84,1	2,30
Sime Sarage	162	1,50	88	2,36
Trbušani	129	1,30	79,50	2,30

Conclusion

Based on achieved results we have presented in this paper, we verify the possibility of the production of energy plantings in the landfill but also at other locations.

Also, we may conclude that in location Rošci 2, which is 593 meters above sea level, could not in time being establish miscanthus.

Relatively mild winter and spring 2013th with plenty precipitations helped plant Myscanthus-a (rhizomes) that not freez and that again developed very well during the growing seasons. Therefore, favorable climatic conditions plenty of the precipitation are positively influenced on the crops which can be conclude by comparing of the results obtained in 2012th and 2013th

Finally, we can conclude that is confirmed the possibility of establishing energy plantings on degraded areas. The study found that there are certain problems in the establishment of energy crops plantings in the territory of the landfill – substantial die back of plants was observed, which is the indicative of existing activities within the landfill. Similarly, severe drought during growing period does not favour plant growth. A heavy dependence on water supply was also evidenced because the landfill soil is composed of various animal, communal and industrial wastes which make it quite porous. These facts call to attention when estimating yields, as no precise conclusions can be made at this point.

More accurate results on yields and the possibility of using this biomass for heating will be determined at the end of 2014.year when will be done with_ the analysis on heavy metals. Also, we should mention the fact that 900 000 ha of land in the Republic of Serbia not been processed, out of which about 300 000 ha of degraded or low-quality.

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