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ESTIMATION OF PLANTING EFFICIENCY AND ENERGETIC WILLOW EXPLOITATION IN THE MIDDLE PART OF POLAND

Summary

Along with the Poland accession to the European Union, the strict environmental protection standards have been introduced. It forces the farmers to change the existing methods of heat energy obtainment from traditional materials into environmental friendly ones. One of the many methods that Poland has applied in order to gain the "green" energy is planting of energy crops such as Salix viminalis willow. This plant is widely considered to be the most useful for biomass production. Willow is a common species in our country, however, not long ago it has not been regarded as a renewable energy source. Only in the past decade, an interest in this matter has grown significantly.
This paper presents the analysis of the plantation establishment costs, its further exploitation and comparison of the profits from biomass sale which reflects the planting profitability. It has been stated that the highest incomes can be obtained from biomass sale and its replacement of the traditional energy resources. The most efficient willow planting occurs on the moist soils with the possibly high bonitation class.
***Key words**: energetic willow, Salix viminalis, renewable energy sources, RES*

1. Introduction

The European Union puts a strong emphasis on environmental protection and related with that development of non-conventional energy sources based on renewable energy sources RES [1]. This situation is resulting from the growing energy consumption, not only in the EU countries. Currently major part (about 80%) of this demand is covered from the fossil fuels such as coal, oil, natural gas or radioactive elements, etc. However, burning of fossils causes huge damages for natural environment, moreover the sources of their acquisition are still decreasing which makes them more expensive. The solution to this problem might be the development of RES usage, including biomass from the energy willow planting. This cultivation is worth of interest both in terms of environmental protection, reduction of CO_2 emission (co-author of the greenhouse effect) as well as many others additional benefits including economic activation of rural areas, increasing the profitability of agriculture and combating an unemployment on rural areas, brownfield lands exploitation, use of contaminated soils and sewage sludge [2] or available on a wider scale digested pulp from the biogas plants [3].

The *Salix viminalis* willow commonly known as an energetic one, seems to be the most appropriate plant for biomass production on energetic purposes in Poland [4,5]. The willow is a common species in Poland and until recently it was not regarded as a source of renewable energy. Only in the past decade, an interest in this matter has generally increased [6].

Bioenergy from fast growing willow species (in agricultural terminology: wicker) becomes a zone of commercial interest in the United States of America, in many European countries as well as in Poland since few years. Biomass production and its processing has a sustainable character and creates the opportunity of exploitation of agricultural areas, brownfield lands, excluded from the food raw materials production and defective – very often with high production potential, but periodically excessively humid or contaminated through the industry [7].

Clones (genotypes) used for plantation establishment should be mainly characterized with the intense growth, rapid shoots regrowth after harvest, diseases and pests resistance , high frost resistance, favorable shoots morphology, high yield of wood dry matter and high caloric value of the wood. Moreover they should reproduce vegetatively well. It is also worth to highlight that wrong choice of genotype, despite the selection of a suitable position and properly conducted agrotechnical operations can be the reason of significantly lower yields than expected.

2. Research aim

The aim of this study was to analyze the costs of willow plantation establishment, as well as its further utilization and comparison with the profits from the biomass sale. This information will be the base in order to determine the profitability of *Salix viminalis* cultivation in central part of Poland. There are many elaborations in the literature concerning the planttions start-up, cultivation, plantation care, whereas there is just small amount of papers related with research on ecoomic evaluation of profitability.

3. Materials and methods

Achievement of the assumed research objectives was possible through the realization of the following steps:
- survey on selected area, i.e. in three farms of different sizes which make it possible to obtain sufficient information related with energetic willow plantations,
- information was obtained from the farmers from Łódzkie voivodeship, covering the middle part of Poland.

According to the literature data it is a transition zone in terms of geological, geographical, climatic and natural condtions. The area of this region is mostly flat, voivodeship is characterized by minimal share of higher class lands i.e. class I and II (only 1.02%). In Poland this share is almost four times higher (3.83%). Łódzkie voivodeship has also lower share in arable lands soil class III and IV (53.6%) than national average (63.97%). However poor soils of class V,

VI and VIz, cover 45.18% of the area of voivodeship arable lands (in the country 32.29%). The poorest soils VI and VI z class, which should be eliminated from agricultural production cover over 17% which is more in comparison with national average (12%). Equally negative attitude of the good and poor soils occurs on the areas of permanent grasslands. Poor quality meadows and pastures cover up to 54.78% while in the country (42.64%) [8].

Above mentioned unfavorable conditions are the reasons that farmers from this voivodeship have to search for and develop in new specializations of the production.

- above mentioned information will be presented in the form of graphs and tables which will show economic aspects of energetic willow planting in 3 farms of different size, located in the middle part of Poland.

Fig. 1. One-year-old willow plantation. *Source: Photo from own archives*

Fig. 2. One-step willow harvest with the use of Claas Jaguar 83 chuff-cuter. *Source: Photo from own archives*

Fig. 3. The willow chips pile. *Source: Photo from own archives*

4. Research results

In order to calculate the costs of plantation start-up and profitability, three farms of different size and different areas of willow cultivation have been used. The above mentioned farms are located in different places of the same province.

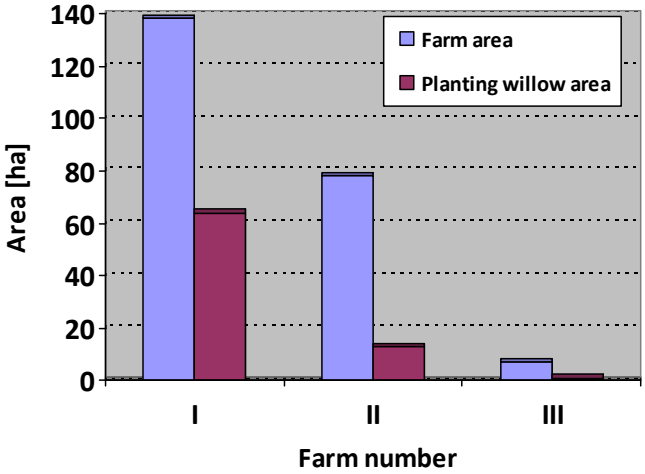

Fig. 4. The farms size and willow cultivation area [ha] *Source:* Personal study based on research

According to literature positions [9, 10, 11, 12] and Internet sources, cost of establishment of 1 ha energy willow plantation on agricultural areas amounts between over 5 up to 10 kPLN. Such significant differences are the result of the difference in the plants number per ha, different price of seedlings purchase, level of position weed infestation, different soils quality as well as other less significant factors. Hence the basic importance in preparation of the position for willow planting has mechanical or chemical weeds removal treatment and properly deep plowing [13].

Table 1. Farm profiles, year of plantation establishment, willow allocation and soil bonitation class

	Farm		
	I	II	III
Farm main profile	Plant production (willow planting)	Animal production Plant production	Staff working off-farm
Plantation establishment (year)	2000	2000	2003
Willow management	sale	sale	own purposes
Bonitation class	IV-VI	V-VI	III

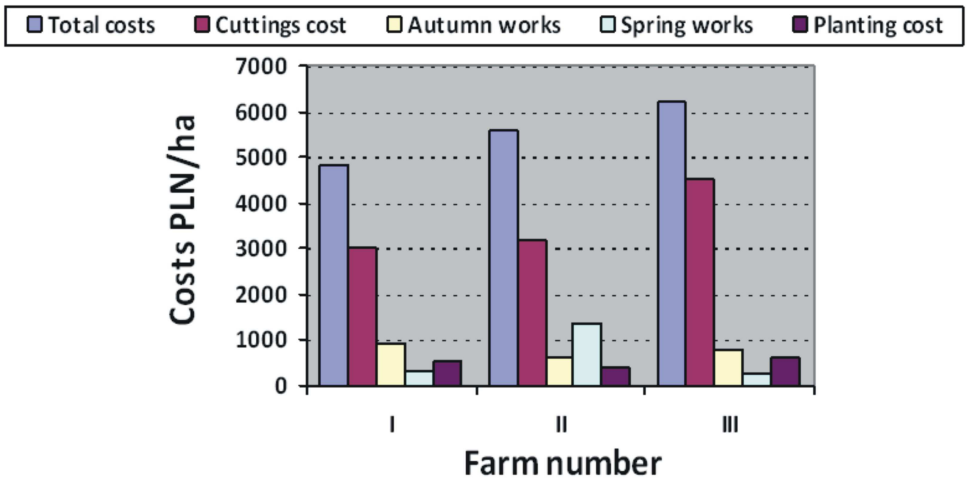

Fig. 5. Costs of plantation establishment according to the farm size

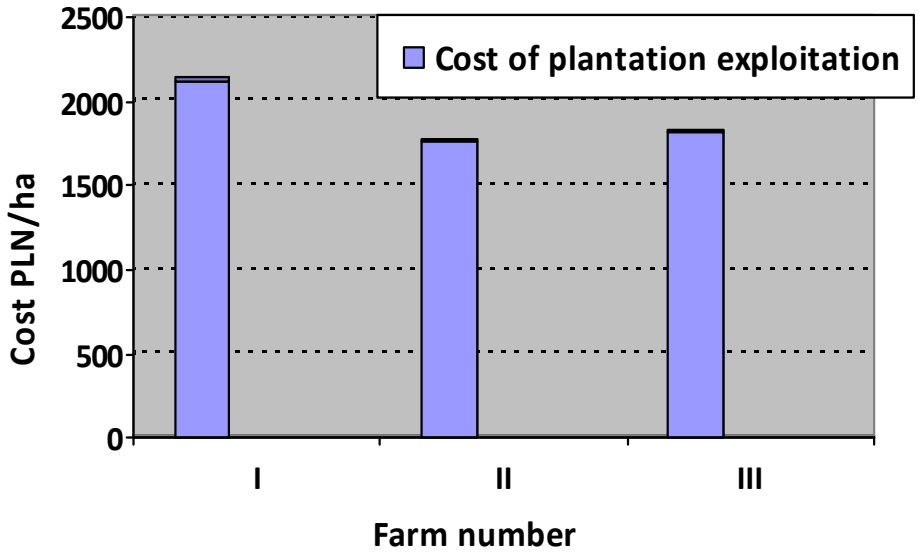

Fig. 6. Exploitation costs of the plantation

Table 2. Profitability of willow planting in selected farms

Lp.	Specification	Farm no.		
		I	II	III
1.	Production cost (PLN /ha)	2120	1760	1814
2.	Fresh biomass yields (t/ha)	33	30	20
3.	Production cost of 1 tone of willow chips	64	59	90
4.	Cost of 1 tone of fresh willow chips	170	150	300
5.	Income from 1 tone	106	91	210
6.	Income from 1 ha	3490	2740	2100
7.	Income from 1 ha per year	1745	1370	2100

In energetic willow planting the reimbursement of the costs spent on the establishment of the plantation is impossible in the first year of exploitation [14]. In dependence on the assumed harvest cycle, the reimbursement can start only in the second, third or even fourth year [15]. The main factors having considerable influence on the final income and planting profitability are obtained biomass yield and biomass price. The factor that can significantly accelerate the reimbursement of investment on plantation, is a sale of the seedlings from the plantation. Major part of costs concerning establishment of plantation is absorbed through the proper place preparation as well as seedlings purchase. The detailed analysis of plantation establishment costs and willow chips production is shown on Fig. 2. Planting density of 1 ha was at the level of 30-45 thousand. units/ha and the seedling price amounted 0.1-0.15 PLN.

The cost of plantation establishment amounted respectively I- 4830 PLN, II-5570 PLN, III-6190 PLN. The cost of seedlings purchase in the analyzed variants was respectively 62%, 57%, 73% of the total costs related with plantation start-up. It can be noticed that costs spent during the first year are considerably high, however according to lit-

erature data [8] should be spread over the period of 24 years of willow exploitation, which gives an annual load amounted I-201 PLN, II-232 PLN, III-258 PLN.

In case of farm no. III where the willow is used for own needs (farm self-heating) the price of 1 tone of fresh chips was not included. However the income from 1 tone was calculated on the basis of conversion of willow energy value in relations with coal dust energy value and market price. This conversion has been made because before an introduction of energy willow heating, this farm was using the culm for heating purposes.

If therefore the coal dust energy value amounts 24 GJ/t, willow value 16 GJ/t and market price of the coal dust of good quality 450 PLN /t, then it is possible to calculate the farm cost savings on each combusted tone of willow instead of coal dust.

$$X = \frac{16\frac{GJ}{t} \times 450\frac{PLN}{t}}{24\frac{GJ}{t}} = 300\frac{PLN}{t}$$

The income from implementation of the willow instead of coal amounts 300 PLN for each tone of willow used for combustion. The profit from 1 ha can be calculated: 300 PLN/t-90 PLN production costs=210 PLN multiplied by amount of tones of willow dry matter (10 t/ha) and finally the result for the farm III is 2100 PLN.

It is visible from the above Table that the most profitable is willow utilization for own purposes which is related with high price of the culm/coal dust. However in all investigated farms the income from the sale differs a lot, which is related with different production costs and obtained yields.

5. Conclusions

From the research made in the farms producing the willow we can conclude that the best income from 1 ha was received in farm no 1 working on the biggest area (over 60 ha). However, income calculated per 1 ton of produced willow biomass was obtained in case of the smallest farm no 3.

From the large-scale plantations it is possible to obtain significant cost savings because the planting material comes straight from the motherly plantation.

Willow planting allows to create new jobs related with plantation service and processing onto willow chips.

The most efficient cultivation occurs on the moist soil with possibly high grading class.

The willow plantation profits come from the sale of produced biomass, seedlings, plantation share for sewage sludge management and from the replacement of other heating fuels used for own purposes by the willow.

6. References

[1] Lipko K., Parczewski Z., Tatarewicz I., Klimpel A.: Długoterminowe prognozy popytu na energię i moc elektryczną w kraju dla potrzeb rozwojowych PSE Operator S.A. Elektroenergetyka - współczesność i rozwój, 2010, 1(3), 5-21.

[2] Dach J.: Wpływ intensywności napowietrzania osadów ściekowych na emisję amoniaku podczas kompostowania. Journal of Research and Applications in Agricultural Engineering, 2010, vol. 55(1).

[3] Czekała W., Pilarski K., Dach J., Janczak J., Szymańska M.: Analiza możliwości zagospodarowania pofermentu z biogazowni. Technika Rolnicza Ogrodnicza Leśna, 2012, nr 4.

[4] Sulima P., Przyborowski J.A., Stolarski M.: Ocena przydatności wybranych gatunków wierzby do celów energetycznych. Fragmenta Agronomica, 2006, 3(91), 290-299.

[5] Przyborowski J.A., Sulima P.: Wstępne badania nad tworzeniem mapy genetycznej Salix z wykorzystaniem markerów RAPD. Zeszyty Problem. Post. Nauk Roln., 2010, 555, 621-627.

[6] Grabiński J., Księżk J., Nieróbca P., Szeleżniak E.: Uprawa wierzby wiciowej i ślazowca pensylwańskiego na cele energetyczne. IUNG, Puławy, 2006.

[7] Szczukowski S., Tworkowski J., Wiwart M., Przyborowski J.: Wiklina (Salix sp.) Uprawa i możliwości wykorzystania. Wyd. ART. Olsztyn, 1998, s. 60.

[8] Szczukowski S., Twarkowski J., Stolarski M.J.: Wierzba energetyczna. Plantpress Sp z.o.o., 2006.

[9] Izdebski W. Skudlarski J.: Koszty pozyskania energii cieplnej z wybranych produktów rolniczych. Inżynieria Rolnicza, 2004, nr 3(58), s. 173-182.

[10] Dubas J. W. Grzybek A. Kotowski W. Tomczyk A.: Wierzba energetyczna - uprawa i technologie przetwarzania. Wyd. Wyższa Szkoła Ekonomii i Administracji w Bytomiu, 2004. ISBN 83-88587-71-4.

[11] Dubas J.W. Tomczyk A.: Zakładanie, pielęgnacja i ochrona plantacji wierzb energetycznych. Wyd. SGGW, Warszawa, 2005.ISBN 83-7244-617-2.

[12] Szczukowski S. Tworkowski J. Stolarski M.: Wierzba energetyczna. Wyd. Plantpress, Sp. z o.o. Kraków, 2004. ISBN 83-85982-86-8.

[13] Grabiński J., Księżk J., Nieróbca P., Szeleżniak E.: Uprawa wierzby wiciowej i ślazowca pensylwańskiego na cele energetyczne. IUNG, Puławy, 2006.

[14] Kwaśniewski D.: Techniczno-ekonomiczne aspekty zbioru na plantacjach wierzby energetycznej. Inżynieria Rolnicza, 2007, 6(94), 129-135.

[15] Baran D., Kwaśniewski D., Mudryk K.: Wybrane właściwości fizyczne trzyletniej wierzby energetycznej. Inżynieria Rolnicza, 2007, 8(96), 7-12.