TEKA Kom. Mot. Energ. Roln. – OL PAN, 2009, 9, 93–98

JERUSALEM ARTICHOKE – POTENTIAL AND POSSIBILITIES OF USE IN POWER INDUSTRY

Waldemar Izdebski

Warsaw University of Technology, Faculty of Management

Summary. The paper presents evaluation of possibilities of Jerusalem artichoke's (sunroot, sunchoke) use for energy purposes. This evaluation considered possibility of this plant cultivation with use of its different varieties. Evaluation of economic efficiency of Jerusalem artichoke cultivation for energy purposes was prepared and legal circumstances considering direct payments for this plant were presented.

Key words: renewable sources of energy, biomass, Jerusalem artichoke, energy plants.

INTRODUCTION

The problem of energy production from renewable resources has been getting more and more importance due to the progressive economic development in Poland and in the world. Also requirements imposed by the European Union contribute to intensive aiming at an increase in proportion of energy from renewable resources in the power balance. As the result of this situation there has been more intensive research on possibilities of energy production from the renewable resources. Special interest is focused on biomass, which is the oldest and currently the widest used alternative source of energy. The conducted scientific research considers mainly such plants as: miscanthus, Virginia fanpetals, common osier or cereal plants. However, there is not much knowledge on the possibilities of Jerusalem artichoke's use for energy purposes. This plant is characterized by large potential of yield, comprehensive possibilities of its biomass use, small environmental requirements and small work input connected with its cultivation. All these conditions cause that Jerusalem artichoke has chances to become a plant of the future because it gives possibilities of not only plant production and industry development but also preservation of the environment. This paper presents comprehensive utility character of sunroot. The analysis shows the problem of this plant's use for energy purposes and information on its cultivation in Poland. The attention was also paid to the economic aspect of this plant's cultivation.

THE AIM OF THE STUDY AND METHODOLOGY OF THE RESEARCH

The aim of this paper was to carry out an analysis of possibilities of Jerusalem artichoke cultivation in Poland and economic evaluation of efficiency of this plant production for energy purposes in comparison to other energy plants. The study presents possibilities of comprehensive use of this plant. Also the problem was stressed connected with insufficient knowledge on the potential use of Jerusalem artichoke, especially in power industry.

The methodology of the study consists of materials, mainly scientific studies in form of the published articles, texts published in the Internet and selected laws connected with energy use of biomass, as well as economic analysis carried out by the author. Direct contact was established with a firm planting Jerusalem artichoke in order to get information on cultivation and possibilities of this plant's use in power industry, with a power firm using this plant and with the Plant Breeding and Acclimatization Institute.

THE ROLE OF JERUSALEM ARTICHOKE IN POLAND AND POSSIBILITIES OF ITS COMPREHENSIVE USE

Jerusalem artichoke (sunroot, sunchoke), despite the fact that it has a history as a cultivated plant, has still been a relatively unknown and underestimated plant. Sunroot was cultivated in North America by Indians from the Topinamboore tribe even before arrival of Christopher Columbus.

Sunroot got to Poland in the 17th century but it was mainly used for decoration. Nowadays Jerusalem artichoke is cultivated in North America, Europe, Russia and neighbouring countries as well as in China. It is usually used as a fodder plant and rarely for purposes of industry. So far it has been used as fodder for farm and forest animals in Poland. However its utility values have been slowly discovered, which has allowed for its different use.

This perennial forms succulent, underground tubers – they are spare parts. This underground part grows rapidly. One plant can form about 30-70 tubers of different sizes (Góral, 1999). Jerusalem artichoke reproduces vegetatively through tubers, which are a form of an underground stem. Stems of sunroot can attain height from 2 to 4 meters.

Jerusalem artichoke has another, extremely important role as reclamation function for devastated areas. It can be planted on old rubbish dumps or mine's heaps (Góral, 1997). Sunroot has an ability to absorb heavy metals from the ground and cumulate them in its biomass. It can be used as a biological filter in case of waters and sewages rich in nitrogen, potassium, and heavy metals. (Góral, 1999). This plant can attain a large height, from 2 to about 4 meters so it can be utilized as a great screen for communication lines or rubbish dumps. Jerusalem artichoke contributes to an increase in microbiological activity of soil and sewage sediment (Wielgosz, 1996). If plants grow on contaminated areas, then their biomass is not useful as fodder for animals.

However, taking into account preservation of the environment and economic development, the use of this unusual, rich in utilizable features but underestimated plant in power industry is the most important issue. Jerusalem artichoke, similarly as cereals, potatoes or sugarcane, is a species which can be used in production of bioethanol. Moreover, it should be noticed that not only Jerusalem artichoke's tubers can be used in power industry but its above-ground parts are also a valuable source of energy. They can be dried and after that burned in furnaces for biomass burning or can be burned with coal. Besides, there is a possibility of processing above-ground parts into special briquettes and pellets ussd for heating purposes. What is more, fresh above-ground parts of sunroot can be processed into biogas.

Yields of tubers and green mass, similarly as previously evaluated features, are strongly diversified according to their biotype. There occurred clones with a yield at the level of 19.2 tones of tubers per one hectare and 29.1 tones of tubers per one hectare. Yields of green mass have obtained extreme values at the level of 36.6 tones per one hectare and 56.1 tones per one hectare. On the basis of the prepared test it can be concluded that there is a significant variability of morphological features and capacity for yielding in the groups of different Jerusalem artichoke's biotypes. That is why possibilities of use of different materials in breeding of varieties with desirable utility features should be considered.

FINANCIAL SUPPORT FOR CULTIVATION OF JERUSALEM ARTICHOKE FOR ENERGY PURPOSES

There have been payments for cultivation of energy plants in Poland. They did not function right after our accession to the EU because new Member States were not taken into account in the Regulation 1782/2003. Payments were implemented in 2005 and were at the level of 54.46 euro/ha. In 2006 the rate was 70 euro/ha in the case of willow and multiflora rose. The European Commission declared in 2006 that there would be payments from the European budget at the level of 45euro/ha. The European support system for energy cultivations was implemented on January 1st, 2007. According to this system, each farmer cultivating energy plants can get special payments for energy cultivations, uder the condition of actual use of these plants for energy purposes. The evidence can be a contract agreement with a firm running purchase or processing of energetic resources into biofuels, biogas, electricity or other fuels. Entities, which enter into agreements with farmers for energy resources must be authorized. These authorizations are made by the Agricultural Market Agency.

RESEARCH RESULTS

The analysis, carried by the author (Table 1), is the basis for conclusion that the cost of setting up a sunroot plantation is 2077.7 zl/ha whereas the cost of maize cultivation for energy purposes is 1814.5 zl/ha and the cost of winter wheat cultivation 1792.9 zl/ha. It means that the cost of setting up a Jerusalem artichoke plantation was higher than that of maize cultivation by 12.6% and higher than winter wheat cultivation by 13.7%. It was determined mainly by the price of planting material and cost of tubers' planting. Financial input connected with Jerusalem artichoke cultivation in the second year was at the level of 964.6 zl/ha so it was lower than the cost of maize cultivation for energy purposes by 88.2% and lower than the cost of winter wheat cultivation by 85.9%. The values of these costs in the second year were mainly determined by costs of cultivation, fertilization and plants' harvest. It was caused by the fact that Jerusalem artichoke, as a perennial plant, keeps on a place through a few or even more than ten years.

Table 1. Labour input, costs of setting up and cultivation of maize, wheat and Jerusalem artichoke per one hectare – summary table (own calculations on the basis of the data oconcerning Jerusalem artichoke, Piskier, 2006)

Specification	**Maize**	**Jerusalem artichoke 1st year**	**Jerusalem artichoke 2nd year**	**Wheat**
Input of machines' work and own labour totally [h], of which:	9.5	13	5.5	10.8
Value of own tractor's work [zl]	360.9	496.6	210.1	412.6

Value of own labour input [zl]	85.5	120.9	49.5	76.3
Seed or planting material [amount]	2.0 js*	1.5 t	-	0.22t
Value [zl]	240,0	600.0	-	187.0
Mineral fertlizers [zl] N urea P_2O_5 superphosphate 18 % K_2O potassium salt 60 %	204.1 249.5 138.0	108.0 84.0 168.2	180.0 84.0 160.0	132.2 252.0 126.0
Value [zl]	591.6	360.2	432.0	510.2
Herbicide [zl]	215.5	-	-	356.8
Agricultural services [zl] single-grain sowing or seedling planter harvest	71 250.0	250.0 250.0	-250.0	250.0
Value	321.0	500.0	250.0	250.0
TOTAL	1814.5	2077.7	964.6	1792.9

* - seed unit

Table 2. Production efficiency of Jerusalem artichoke, maize and wheat for energy purposes (own calculations on the basis of the data concerning Jerusalem artichoke, Piskier, 2006)

Researched feature	**Maize**	**Jerusalem artichoke 1st year**	**Jerusalem artichoke 2nd year**	**Wheat**
Input contributed [zl/ha]	1814.	2077.7	964.6	1792.9
Yield [t/ha]*	8.	8.5	8.5	8.0
Yield of energy [GJ/ha]	142.	135.4	135.4	140.0
Production cost of energy unit [zl/t]	213.	244.4	113.5	224.1
Production cost of energy [zl/GJ]	12.7	15.3	7.1	12.8

* - with 15% of moisture

The highest level of energy per hectare was obtained in the case of maize. It is caused by higher heating value of this straw, which was 16 MJ/kg. Quantity of energy in the case of maize was 142.8 GJ/ha, winter wheat – 14.0 Gj/ha whereas for Jerusalem artichoke it was 135.4 GJ/ha. As the result, energy production gained from Jerusalem artichoke was lower by 5.2% in comparison to maize and lower by 3.2% in comparison to winter wheat. However, the research took into account such important element as costs of energy production. Cost of 1 GJ gained from maize was 12.7 zl/GJ, in the case of winter wheat it was 12.8 zl/GJ whereas in the case of Jerusalem artichoke it was 15.3 zl/GJ in the first year and 7.1 zl/GJ in the second year. It is worth stressing, that production costs of maize and winter are paid every year. Costs of energy production were high in the case of the first year of Jerusalem artichoke cultivation because of high input in setting up a plantation. However in the second year, when there were no costs of setting up cultivation, production profitability increased significantly. Production of 1 GJ of energy cost 7.1 zl/GJ so it was 27.5% lower than in the case of maize. Profitability of energy production from Jerusalem artichoke in the second year of cultivation increased by 53.6% in comparison to the first year. That is why it can be concluded that profitability of sunroot cultivation can raise in the following years because there can be larger quantities of stem yield. Comparison of these results is displayed in Table 2.

CONCLUSION

Jerusalem artichoke cultivation allows harvesting both above-ground and underground parts, which enables to use 100% of this plant. Above-ground parts of sunroot, after crumbling, can be directly burned. There is also a possibility to use fermentation of this plant's tubers in order to obtain bioethanol or use above-ground and underground parts for processing into biogas. That is why Jerusalem artichoke has wide perspectives of utilization in power industry.

Jerusalem artichoke has high potential of yielding. Provided there are right conditions for cultivation, high yields can be obtained. Use of suitable agro-techniques and selection of varieties can positively influence the chemical components of tubers as well as the obtained yield. The value of sunroot as energy resource can be raised in that way.

Sunroot is a perennial plant so costs of setting up a plantation are paid once for many years. Research showed that cost of setting up a plantation is higher by 33% that cost of setting up a plantation of maize. However, it should be stressed that this cost is paid every year in the case of maize whereas in the case of sunroot it is paid once in many years which causes that setting up a plantation of Jerusalem artichoke is more profitable. Costs connected with running a plantation of Jerusalem artichoke are lower in the next years by 31% than costs of setting up a plantation of maize. Production of energy from Jerusalem artichoke is lower by 5.2% than in the case of production of energy from maize. However, production costs of energy are lower in the case of Jerusalem artichoke because of lower cultivation costs of this plant in the following years. It results in higher profitability of energy production from sunroot than from maize.

REFERENCES

Góral S.: Topinambur – Słonecznik bulwiasty. Uprawa i użytkowanie. IHAR, Radzików, 1997, s. 2 – 12

Góral S.: Wartość użytkowa topinamburu. Zeszyty problemowe postępów nauk rolniczych. 1999, z. 468, s.89 – 94

Piskier T.: Nakłady robocizny i koszty uprawy topinamburu. Inżynieria Rolnicza. 2006, nr 11 (86). s.359-365

Wielgosz E.: Liczebność i niektóre parametry aktywności drobnoustrojów w osadzie ścieków komunalnych pod uprawą różnych roślin. Zesz. Prob. PNR 1996, 437, s. 337 - 40.

KARCZOCH JERUSALEM – POTENCJAŁ I MOŻLIWOŚCI WYKORZYSTANIA W PRZEMYŚLE ENERGETYCZNYM

Synopsis. W pracy dokonano oceny możliwości wykorzystania topinamburu (słonecznika bulwiastego) na cele energetyczne. Ocena ta dotyczyła możliwości uprawy tej rośliny w Polsce z wykorzystaniem różnych jej odmian. Dokonano również oceny efektywności ekonomicznej uprawy słonecznika bulwiastego na cele energetyczne oraz przedstawiono uwarunkowania prawne dotyczące dopłat bezpośrednich do uprawy tej rośliny.

Słowa kluczowe: odnawialne źródła energii, biomasa, topinambur, rośliny energetyczne.