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Tomasz CIESIELCZUK[1], Joanna POLUSZYŃSKA[2] and Monika SPOREK[3]

POTENTIAL USES FOR SOLID BIOFUELS FROM NON-FOOD CROPS

POTENCJALNE MOŻLIWOŚCI WYKORZYSTANIA STAŁYCH BIOPALIW Z ROŚLIN NIESPOŻYWCZYCH

Abstract: The Directive 2009/28/EC on the promotion of energy from renewable sources (RES), sets mandatory national targets so as to be able to achieve a 20% share of energy from renewable sources in gross final energy consumption in the Community in 2020, the aim of the Polish is to achieve by 2020 a 15% share of renewable energy in gross final energy consumption. Thus, use of fossil fuels for energy production should you gradually reduced in favor of renewable energy sources. Usually, however, the change in the method of heating or design of installations using renewable energy sources to incur significant capital costs. In addition, the economic balance during the operation also sometimes detrimental to the modern great human and environmental technologies. Therefore, you should look for low-cost renewable fuels that may be used in particular in those households where there is no possibility of the use of gas or heat delivered from sources of power plants. This paper describes the possibility of using untreated plant biofuels. After the species were taken into account: Canadian goldenrod (*Solidago canadensis* L.) and mugwort wormwood (*Artemisia absinthium* L.). These plants are considered weeds have many advantages enabling wider use for energy purposes.

Keywords: non-food plants, fuel, *Solidago, Artemisia*

Various initiatives around the world are made in order to counteract the observed climate changes. One of them is the promotion of renewable energy sources [1, 2]. Adopted in 2000 by the Council of Ministers, on energy development strategy it assumes that the share of renewable energy sources in Poland in 2020 in primary energy balance should be 15%.

Renewable energy sources that can be used to generate heat energy in diffuse sources constitute mainly of solar and biomass wood. Their annual resources in the world are estimated at about 420 billion Mg, which gives about 4500 EJ energy, with the potential of 100 EJ/a [3]. In the current practice, the extraction of biomass energy crops refers only to agricultural or forest crop. Many of these plants certainly have a high energy value. Biomass wood comes from wood plantations (willow, aspen, grey alder) and forests where it is obtained in the framework of pruning and cutting, and finally from wood processing (sawmills, carpenter). Agriculture provides mainly straw arising as waste in agricultural production [4] throughout the country, which reduces transportation costs. Nevertheless it requires significant volumes for storage and a special boiler adapted to its combustion. What is more, burned grains do not follow the normative regulations [5].

[1] Independent Chair of Land Protection, Opole University, ul. Oleska 22, 45-052 Opole, Poland, phone +48 77 401 60 20, email: tciesielczuk@uni.opole.pl
[2] Institute of Ceramics and Building Materials, ul. Oświęcimska 21, 45-641 Opole, Poland, phone +48 77 745 32 01, email: j.poluszynska@icimb.pl
[3] Independent Chair of Biotechnology and Molecular Biology, University of Opole, ul. kard. B. Kominka 6a, 45-032 Opole, Poland, phone +48 77 401 60 57, email: mebis@uni.opole.pl
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A solution that could find wider interest is the acquisition of plants that do not compete with crops intended for human consumption or for animal feed. These are characterized by high efficiency, collecting the right amount of lignocelluloses, having little habitat requirements and requiring no tillage. Such plants include goldenrod (*Solidago* sp.) and mugwort (*Artemisia* sp.).

Material and methods

Botanical characteristics

Goldenrod (*Solidago* sp.) is a commonly found plant in Poland. Both the Canadian goldenrod (*S. canadensis* L.) and late goldenrod (*S. gigantea* Aiton) are classified as invasive plants [6]. In inhabited ecosystems they displace native flora species and become dominant. Goldenrod owes its success in mastering new areas to a great tolerance to habitat conditions, strong growth, the production of large quantities of seed, ease of vegetative propagation and mechanisms of allelopathy. Covering large areas with high density shoots it contributes to the homogeneity of the landscape and the loss of biodiversity [7]. Among the species representing the type of mugwort (*Artemisia* sp.) quite commonly found is mugwort wormwood (*A. absinthium* L.). As a folk tradition it is often used for various treatments including treatment for gastrointestinal diseases and also used as an alcoholic extract for the narcotic purposes [8]. There is also data which suggests that it possibly supports the treatment of breast cancer in humans [9] and the possibility of the control of parasites in farm animals [10, 11].

Methods

In order to estimate the possibility of using these types of plants for energy purposes numerous calculations have been done including: the yield per hectare, the density of growth, dry matter content during the harvest, bulk density, ash content and calorific value. The dry matter content was determined by weighing, after drying at 105°C to stabilize the mass. The ash content was determined after dry mineralization at 550°C for 5 hours. The calorific value was determined using calorimeter machine KL-10 by PN-81/G-04513. Elementar analysis of the biomass was determined by a CHNS analyser varioMACRO cube made by the Elementar Company. The demand for the fuel needed was also determined during the heating season based on sample farms using a biomass stove. Additionally, an economic analysis was also performed based on the energy 1 MJ compared to other commonly used fuels.

Results and discussion

Characteristics of the obtained biomass

The results indicate a relatively high yields of plants studied (Table 1), in spite of the lack of agrotechnology, including no fertilization, weed control or irrigation.

In typical energy plant farming, in order to improve yields, some typical agricultural practices are used: weeding (especially important in the first period after planting crops), irrigation and fertilization. This type of growing is sometimes seen as the area used for neutralizing the municipal wastewater. This practice leads to the degradation of soil and groundwater contamination by biogens and easily soluble organic matter [12]. The calculated dry matter yield of goldenrod (Table 1) occurring in its wild state are comparable to the yields derived from willow crops, which stands at 6.8-14.7 Mg d.m./ha [13]. Only a few authors discussing the usage of goldenrod for energy purposes highly appreciate both the yield per hectare as well as their potential energy [14, 15]. The monoculture that we are dealing with, particularly in the case of goldenrod or mugwort, allows us after a few seasons to work out the optimum harvest date depending on the course of the aura in the growing season. The tractor rotary mower is sufficient for harvesting, a trimmer in small or hard to reach areas or, in special cases, even a scythe. Mowed plants can be moved manually or a loader wagon can be used. Basically, it should be done in the month of December, when the plants are already dried (later in decreased humidity) and the seeds sprinkled (Table 1). Mowed biomass shall be transported under the canopy where set in the form of loose sheaves or heaps should be dried for a period of 7-10 days, depending on the weather. The exception is the spring harvest, for which additional drying is not necessary. Subsequently, air dry biomass should be pre-shred into pieces 15-20 cm in length. This can be done manually or using simple machines formerly used to prepare the chaff. Grinding can be done also at the time of the harvest by a green fodder mower so-called "Orkane", but in this case, another drying method of fragmented biomass should be considered. The best in that case would be a ventilated and dry place.

Table 1

Main characteristic of analyzed plants (n = 3)

Plant	**Density [plants/m^2]**	**Yield [Mg d.m./ha]**	**Moisture of harvested plants [%]**			
			15.10	**29.10**	**16.11**	**2.12**
Solidago	121.7(29.0)	15.9(3.8)	58.5(0.3)	54.0(1.3)	57.9(1.3)	32.8(2.4)
Artemisia	13.2(4.7)	6.0(2.1)	58.7(0.8)	47.6(6.1)	39.3(3.9)	33.5(4.4)

Energy use

The calorific value of the uncondensed biomass of the analysed plants was similar at 16.24-16.49 MJ/kg (Table 2). This data is about 1 MJ/kg higher than their calorific value compared to the straw [16] and sand reed (*Calamagrostis epigejos* L.) [17]. The lower calorific value in comparison to the test plants was also recorded for various assortments of biomass of Scots pine (*Pinus sylvestris* L.), where for the needles it was 14.9 MJ/kg, for trunks 14.7 MJ/kg and for brunches 14.6 MJ/kg [18]. Particularly important is the low level of humidity of the prepared biomass, which prevents the self-heating of a pile and increases the calorific value. The content of organic biomass of the test was high (Table 2), and thus there is little amount of the ash formed, which makes the plants perfect for thermal recycling. A disadvantage in the use of this fuel is its low bulk density which is an important factor causing a need to collect it in a relatively large room, ensuring free flow of air through the plant prism. A decline in the efficiency of the boiler, usually adapted to coal, must also be assumed. A high total carbon content (TC) (44.6-44.8%) is lower than the value of TC parameter for brown coal (Table 2), but in the biomass, the proportion of organic carbon (TOC) is higher, constituting 94.4-96.0 and 91.4% (respectively for biomass and coal). Particularly important is the low sulphur content and a relatively high hydrogen content. Burning the analysed biomass can therefore produce from 1.6 to

5.04 kg SO_2/Mg d.m., which is less than the combustion of brown coal (14.24 kg SO_2/Mg d.m.) or hard coal even after taking into account the lower calorific value.

Table 2

Characteristic of biomass as a solid fuel source (n = 3)

	Carbon (TC) [%]	**Hydrogen (TH) [%]**	**Nitrogen (TN) [%]**	**Sulphur (TS) [%]**	**Burning heat [MJ/kg d.m.]**	**Calorific value [MJ/kg]**	**Organic substances [% d.m.]**
Solidago	44.8 (0.17)	6.46 (0.01)	0.37 (0.05)	0.198 (0.056)	18.12 (0.50)	16.49a	97.9(0.2)
Artemisia	44.6 (0.21)	6.30 (0.03)	1.54 (0.61)	0.252 (0.025)	17.87 (0.02)	16.24a	97.9(0.6)
Brown coal (Belchatow, Poland)	52.6 (0.04)	5.08 (0.05)	0.60 (0.01)	0.712 (0.077)	22.26 (0.10)	20.90	96.(0.2)
Hard coal (fine grain)	76.4(1.1)	4.71 (0.07)	nd	nd	30.55 (0.21)	29.27	94.1(0.3)

a - after correction for 10% moisture and hydrogen content; nd - no data

Taking into account the calorific value of plants (Table 3), the amount of energy that can be obtained from 1 ha fief monoculture was calculated and the potential amount of energy that can be obtained from the biomass of the test plants, which comes from fallow land in the territories of individual farms (409.6 thousand hectares). For ecological reasons, the preferred species is tansy, which is a native species considered as a monoculture or can be mixed with mugwort. Seeds of *Artemisia* constitute a valuable supplementary of winter feeding base diet for national avifauna. Self-sown seed is also a complement of vegetative propagation, which occurs through the growth of the rhizomes.

Table 3

Calorific value of plant biomass and energetically comparable amount of hard coal with mean energy 26MJ/kg

	Calorific value [GJ/ha]	**Energy P* [PJ]**	**Hard coal [thow. Mg]**	**Ecological effect [thow. Mg CO_2]**
Solidago	288.4	118.13	4,543.4	7,752.2
Artemisia	107.2	43.91	1,688.8	2,881.5

* the potential amount of energy obtained from burning plant monoculture of private fallow lands

Conclusions

Analysed non-food biomass is characterized by high calorific value. Small soil requirements, lack of natural predators, resistance to disease, and the lack of need for a typical energy crop cultivation technology, greatly reduces the cost of biomass. No competition with crops, lack of the need to transport over long distances and lack of recycling the resulting biomass (*eg* pelletising, briquetting) are additional factors that appeal in favour of the analysed plants. Analyzed plants could be a good source of energy, especially on non highly-urbanized areas.

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[1] Samodzielna Katedra Ochrony Powierzchni Ziemi, Uniwersytet Opolski
[2] Instytut Ceramiki i Materiałów Budowlanych
Oddział Inżynierii Procesowej Materiałów Budowlanych w Opolu
[3] Samodzielna Katedra Biotechnologii i Biologii Molekularnej, Uniwersytet Opolski

Abstrakt: Dyrektywa 2009/28/WE w sprawie promowania stosowania energii ze źródeł odnawialnych (OZE) ustanawia obowiązkowe krajowe cele, tak aby możliwe było osiągnięcie 20% udziału energii ze źródeł odnawialnych w końcowym zużyciu energii brutto we Wspólnocie w 2020 roku. Celem dla Polski jest osiągnięcie w 2020 roku 15% udziału energii z OZE w końcowym zużyciu energii brutto. Zatem wykorzystanie paliw kopalnych do wytwarzania energii powinno być stopniowo ograniczane na rzecz odnawialnych źródeł energii. Zwykle jednak przy zmianie sposobu ogrzewania lub projektowaniu instalacji wykorzystujących źródła odnawialne należy ponieść znaczne koszty inwestycyjne. Ponadto rachunek ekonomiczny w czasie eksploatacji także bywa niekorzystny dla nowoczesnych, korzystnych dla ludzi i środowiska technologii. W związku z tym należy szukać tanich paliw odnawialnych, które będą mogły być wykorzystywane w szczególności w tych gospodarstwach domowych, gdzie nie ma możliwości wykorzystania paliw gazowych lub energii cieplnej dostarczanej ze źródeł energetyki zawodowej. W niniejszej pracy przeanalizowano możliwości wykorzystania biopaliw roślinnych nieprzetworzonych. Pod uwagę wzięto rośliny z rodzaju: nawłoć (*Solidago sp.*) oraz bylica (*Artemisia sp.*). Rośliny te, uważane za chwasty, posiadają wiele zalet umożliwiających szersze ich wykorzystanie do celów energetycznych.

Słowa kluczowe: rośliny niespożywcze, paliwo, nawłoć, bylica