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CULTIVATION OF *SALIX VIMINALIS* WILLOW AND POSSIBILITIES OF IMPROVING THE ENERGY BALANCE OF EASTERN POLAND VOIVODSHIPS

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K e y w o r d s: willow biomass, *Salix viminalis* willow, eastern Poland, crop potential.

A b s t r a c t

The aim of this study was to analyze the possibility of improving eastern Poland energy balance by transforming the agricultural areas, destined for food production purposes, to crops with industrial purpose. The problem was analyzed in terms of perspectives, problems and challenges facing the eastern Poland voivodships in order to diversify energy sources. The direction was indicated, which, according to the performed analysis, gives the best chance of improving the present situation, in terms of energetic security and also improving the socio-economic conditions of the inhabitants of these regions. The expediency of exploring opportunities of producing energy from biomass, with particular reference to the *Salix viminalis* willow, was pointed out.

UPRAWA WIERZBY *SALIX VIMINALIS* A MOŻLIWOŚCI POPRAWY BILANSU ENERGETYCZNEGO WOJEWÓDZTW POLSKI WSCHODNIEJ

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S ł o w a k l u c z o w e: biomasa z wierzby, wierzba *Salix viminalis*, Polska Wschodnia, potencjał upraw.

A b s t r a k t

Celem pracy była analiza możliwości poprawy bilansu energetycznego Polski Wschodniej przez przekształcanie upraw rolniczych o przeznaczeniu żywnościowym na uprawy z przeznaczeniem przemysłowym. Zagadnienie przeanalizowano pod kątem perspektyw, problemów i wyzwań stojących przed województwami Polski Wschodniej w kwestii dywersyfikacji źródeł energii. Wskazano kierunek działań, które według przeprowadzonej analizy dają największe szanse poprawy obecnej sytuacji, zarówno w zakresie bezpieczeństwa energetycznego, jak i poprawy warunków socjalno-ekonomicznych mieszkańców omawianego regionu. Wskazano na celowość poszukiwań możliwości produkcji energii z biomasy, ze szczególnym uwzględnieniem wierzby *Salix viminalis*.

Introduction

Constantly rising prices of conventional energy sources (oil, natural gas, coal) prompt to search for alternative sources of energy. Renewable energy sources are becoming a substitute for its conventional sources (LESZ 2006). Poland, after joining the European Union (EU), was obliged to implement the Directive on the share of Renewable Energy Sources (RES) in the energy sector. Polish parliament approved the "Strategy for Development of Renewable Energy", which obliges to achieve 7% (in 2010) and 14% (in 2020) of the RES share in the country energy balance (NIEDZIÓŁKA, ZUCHNIARZ 2006, BIENIEK, ŻOŁNIERZ-RUSINEK 2008).

Currently, approximately 52% of energy used in Europe is imported from other continents and this share is prognosed to increase (DENISIUK 2006, *Charakterystyka obszarów wiejskich* 2008). According to DENISIUK (2006), as early as in 2015, 72% of energy will be imported to the EU. Given this, the idea of allocating agricultural lands for purposes of non-food production seems to be reasonable, especially since such actions may help to solve the problem of agricultural overproduction in eastern Poland, typically regarded as agricultural land (KUKUŁA, KRASOWICZ 2006, *Charakterystyka obszarów wiejskich*... 2008). Another appealing premise for the introduction of such crops is protecting the local population against the progressive impoverishment and exclusion, being effects of hidden unemployment (MYSZCZYSZYN 2001). In case of larger farms, it will allow diversifing their income and exploit uncultivated land. Non-agricultural activities of agricultural holdings are positive phenomenon. It reflects the process of adaptation of agriculture to market conditions and allows for the relative security in terms of possible crisis on markets for specific products (GĄSIOREK 2005, LESZ 2006).

Poland in the European Union is perceived as country with great possibilities of biomass production. It is estimated that up to 1.6 million ha of agricultural land can be allocated under that production. The current area of growing plants for solid fuels is estimated at about 10 thousand ha (VAN DAM et al. 2005, KUŚ et al. 2008). The use of biomass energy potential is dependent on many issues, among which the most important is economic factor, conditioning the formation of biomass projects. EU legislation regulates these issues in some detail (EU directives 2001, 2009). This applies to the principles of electricity market operation and methods of electric energy production. The percentage of energy from renewable sources in total energy production in Poland is 7.9% and is lower than the EU average, which is 10.3% (Eurostat 2008). It should be noted that as many as 94% of renewable energy produced in Poland is obtained from biomass (LESZ 2006, PAWLAK 2007). The degree of biomass use on a local scale depends largely on the correct identification of local production opportunities (SIEJKA et al. 2008).

Aim and scope of work

The aim of this study was to determine the natural and socio-economic determinants of agricultural development on eastern Poland territory in terms of non-agricultural farm activities and to search for opportunities to improve the energy balance of the eastern Poland voivodships.

The scope of work included the review of the challenges and opportunities facing the eastern Poland voivodships under the circumstances of future inevitable changes of the agrarian structure of Poland and in order to introducing alternative energy sources.

Problem justification

The development of technologies, as well as trends in research and development of energy-generating systems, and the priorities of the Commission of the European Union under the following acts: Green Paper (2000), the Kyoto Protocol (2005) and the European Directives (2001/77/WE, 2001/77/EC), tend to consider wider exploitation of renewable energy sources (Ścibisz 2006, Piechocki, Bieranowski 2007). Many studies show a high probability of a future energy crisis, the differences concern only its occurrence time forecast (15 to 25 years) (Roszkowski 2008). Under the Polish energetic law, local authorities are required to develop plans for heat and energy supply. These plans should also include the use of locally available renewable energy sources.

The most common method of obtaining electrical energy is to use the power grid, covering almost the entire country (Walski 2007). For thermal energy, electric heaters or charcoal/gas stoves are used and, more and more frequently, biomass stoves (Ścibisz 2006). Conventional energy sources may be replaced by its renewable sources and, in terms of integration with the European Union, active participation in the campaign of implementation of renewable energy can be an asset of Poland. The most important reason for promoting the production of biomass for energy purposes is the desire to tackle climate changes (Sołowiej 2006, Ścibisz 2006, Szwedziak 2010).

Changes in the era of economic development are forcing manufacturers and distributors of energy to explore new forms of fuels structure, especialy those more environmentally friendly. The use of biomass energy potential in both, the global and the local area, is dependent on many factors. The most important of these is the economic factor, conditioning the formation of biomass projects. The degree of using biomass on a local scale (e.g. a specified municipality) depends above all on the correct identification of possibility of

local biomass production (GRZYBEK 2007, SIEJKA et al. 2008, SZWEDZIAK 2010). The shift of the individual farm from classical methods of meeting its energy needs (power grid, coal stoves) to the use of renewable energy requires the economic analysis of the entire project. It must be based on determining the energy needs of the specified farm purposed to modernization and the evaluation of energy resources available within it, but the specificity of individual farms, in terms of the character of production, as well as their location, particularly predispose them to use renewable energy sources (SOŁOWIEJ 2006, ŚCIBISZ 2006). The use of agricultural biomass in most cases is contradictory to the basic purposes of agriculture, implied as the production of food. To convince farmers to cultivating willow, it must be profitable, at least as profitable as cultivating cereals.

Energetic use of rural areas implies a threat of disturbances on food markets. Despite this, establishments of willow plantations are becoming increasingly popular topic (*Charakterystyka obszarów wiejskich*... 2008). Growing energetic crops is part of a complex system, which is the national economy. At the macro level, it should therefore be considered in many aspects, including the principles and stages of implementation of the strategy of obtaining energy from renewable sources (ROSZKOWSKI 2008). Unfortunately, decisions concerning energetic crops production are currently being made using the results of incomplete energetic and environmental analyzes, often under the influence of constantly changing economic regulation system (donations system).

Energy efficiency of wilow plantations depends mostly on the agrotechnical procedures performed there (LESZ 2006, GRZYBEK 2007, PAWLAK 2007, ROLA et al. 2007). At plantations surveyed by Kwaśniewski (2008), willow cultivation required high initial material and resource costs, which may pose an additional problem in the impoverished farms.

Much of the energy potential of biomass is lost in the overall balance of energy flow through the area. According to the study of the Board of the Warmia and Mazury voivodship (2005), the condition of the profitability of willow transport from the field to the point of combustion is fulfilled if the itinerary does not exceed 80 km, thus willow-growing farms should be located possibly close to the location of existing combustion installations. It is therefore appropriate to define the conditions for decentralized heat and electricity production from local energetic resources (SIEJKA et al. 2008, SZWEDZIAK 2010).

Deepening economic integration of Europe is advantageous for countries and regions more developed, but also create a series of threats to the the less developing and peripheral regions. Polish accession to the European Union has highlighted the problem of the differences in development between the countries lying on one continent, as well as interregional differences at the scale of

the state, as well as at a whole Community scale. Depopulation trends are noted: population growth of area considered in whole is negative and slow exodus to other voivodships is observable (GUS 2004–2009, PAWLAK 2009). System transformation and industrial restructurization has resulted in declining the agricultural production potential (GUS 1995–2005). Country aid is directed to industrialized areas, to eliminate the negative effects of a changing economy. This resulted in a deepening interregional diversity (GREWIŃSKI 2008). Eastern Poland voivodships are characterized by the lowest level of per capita investment in the national economy in general (MIKOŁAJCZYK 2008). These conditions are reflected in the level of development of the eastern provinces, when compared to the rest of the country. It concerns the level of infrastructure development, as well as the attitude of their inhabitants to the enterprise, resulting in low levels of vocational activity (employment rate was 54.8% – GUS), low standard of living and low dynamics of economic development (www.mrr.gov.pl 2009). Introduction of energetic plantations in these areas can create employment opportunity in areas of construction, operation and service of renewable energy systems.

Characteristics of biomass from *Salix viminalis* willow

Energetic plants have a high annual growth, high calorific value, high resistance to pests or diseases and the relatively small soil requirements (NIEDZIÓŁKA, ZUCHNIARZ 2006). In agricultural practice, energetic plants can be grown on soils of different quality classes, successfully resisting the rising prices of food products (ROLA et al. 2007, GRZYBEK 2006). Willow plantations can be successfully set up on good soils – with quality classes I–III, but often soils of V and VI quality classes also meet the requirements of energetic plants. This is one of the ways of restoring and using lands, that are agriculturally degraded (KUŚ et al. 2008). From 1 ha of willow plantation one can get 20 tons of raw material with a calorific value equivalent to 10 tons of fine coal, thus producing wood in own farms saves the money spent on purchases of fuel, and in turn is equivalent to reducing the deficit in the household budget (GĄSIOREK 2005).

Cultivation of energetic plants is often placed on areas of great natural value, which will be lost as a result of the introduction of energetic crops. Growing energetic plants could take effect in a significant threat to biological diversity, because the area will be occupied in this way for 15 to 20 years (GRZYBEK 2006, NIEDZIÓŁKA, ZUCHNIARZ 2006). A characteristic feature of alternative crops is their pioneering and, therefore, not fully explored character. As indicated KORNIAK (2007), weed flora of willow is very similar in composition to the weed flora of northeastern part of Poland. It should be assumed though, that with the long cultivation of willow more specialized and burdensome weeds would

develop. It should be remembered, however, that the combustion of willow (as an alternative to coal) helps reduce solid and gas wastes in energy production, so it has also a positive impact on the environment. In addition, willow, a plant with large and rapid increments, collects pollutants from the soil, enriching the environment with oxygen; it also regulates water relations (GĄSIOREK 2005, GRZYBEK 2006).

There remain many other issues to be resolved, such as yielding in climatic conditions of the individual regions, or the decision-making processes related to supply chain management (JANOWICZ, KUNIKOWSKI 2008). An important factor is also the seasoning of willow. Seasoning should be performed until the proper humidity is reached – about 25%, in the place of cultivation (FRĄCZEK, MUDRYK 2008, www.ieo.pl). It allows increasing the purchase price and the value of raw material.

Possibilities of *Salix viminalis* willow cultivation in eastern Poland voivodships

Eastern Poland regions are characterized by low population density in comparison with the rest of the country. The data presented in Table 1 indicate that the urban population equals to 46.59% of the total population, with a nationwide rate of 61.5%. At the same time, these voivodships account for nearly one third of the country area. These areas are then sparsely populated – the total number of population is 4.789 million, what is slightly less than one fifth of the country population (*Ludność według płci...* 2004). Different levels of socio-economic development in Poland occur due to geographical location, natural abundance of individual regions (*Efekty polityki spójności UE w Polsce*.

Table 1

Chosen indexes characterizing eastern Poland voivodships

Indexes	Voivodship			Poland
	Lubelskie	Podlaskie	Warmińsko-Mazurskie	
Population [tys.]	2,185.2	1,202.4	1,428.7	38,173.8
Rural population [tys.]	1,168.2	493.6	569.9	14,690
Total area [ha]	2,508.877	2,018.975	2,322.011	31,267.938
Area of fallow[tys. ha]	27.2	17.1	20.1	498.4
Percent of the fallow area in arable land	2.9	2.3	3.0	4.1
Consumption of electricity [GWh]	5,169	2,609	3261	134,473
Consumption of heat [TJ]	25,566	10,613	11,954	426,131

Source: own study based on GUS data from years 2004 and 2009.

2009) and the fact that the eastern voivodships of Poland are characterized by the lowest level of capital expenditures "per capita" in the national economy in general (MIKOŁAJCZYK 2008).

The above considerations are inevitably reflected in the level of the eastern voivodships development when compared to the rest of the country. It should be noted though, that some of the features conditioning the slow development of the eastern Poland regions, also provide advantages in the context of the energetic crops introduction to this area. Among these features are:
– area of land not used for agricultural purposes,
– area of arable land with low soil quality class (i.e. IV, V and VI),
– sufficient human potential,
– appropriate science and research base.

The following subsections describe the specificities of the individual voivodships in the context of the above-mentioned conditions.

Warmińsko-mazurskie voivodship

The energy potential of energetic crops in the Warmia and Mazury voivodship is, according to PIECHOCKI and BIERANOWSKI (2007), equal to 47,250 TJ and is important in terms of energy balance of the area. Area of energetic crops currently cultivated in the region is about 300 acres and nearly the whole of this area is willow, while the forecast predicted that in Warmia and Mazury voivodship in 2009 will be grown 21 thousand ha of willow (*Program ekoenergetyczny województwa...* 2005).

Temporarily unused rural area in Warmia and Mazury voivodship was equal to 148.7 thousand ha in 1998 and 179.5 thousand ha in 2003. This amount is one of the largest, in comparison to other provinces (*Program ekoenergetyczny województwa...* 2005). If the human potential is added (such as high level of unemployment in rural areas), and appropriate science and research base (especially the University of Warmia and Mazury in Olsztyn), it appears that Warmia and Mazury voivodship has all the features predestening it for growing energetic plants.

Lubelskie voivodship

According to Biuro Planowania Przestrzennego in Lublin, willow cultivation is 2 times more profitable than growing wheat and six times more profitable than the cultivation of rye. This analysis, in contrast with the decline in profitability of agricultural production, results in a decrease in the income of farming families, and so it takes effect in noticable growth of establishments of

new energetic plantations in Lubelskie voivodship. It should be noted that these crops are used primarily for farms own purposes.

Areas of fallow and idle lands in Lubelskie voivodship in 2004 was equal to 77.7 thousand ha, i.e. 6.5% of the total rural area of the region (*Wojewódzki program rozwoju alternatywnych*... 2006). There are large areas of arable land (about 152 thousand ha) and grassland (about 60 thousand ha) in the region, belonging to the IV, V and VI soil quality class (*Wojewódzki program rozwoju alternatywnych*... 2006). Therefore, this region has large reserves of land that could be used for energetic crops.

Podlaskie voivodship

Forecasts of energetic crops in Podlaskie voivodship developed by Polish Society for Biomass predict their steady growth. Podlaska Fundacja Rozwoju Regionalnego (*Praktyczne aspekty*... 2006) predicted that in Podlaskie could be grown 3 thousand ha of willow in 2006 and 5 thousand ha in 2009. Anticipated areas of crops in Podlaskie voivodship have not been met. As other voivodships, Podlaskie in the cultivation of energetic crops sees the possibility of reducing unemployment. Knowing its energy demand, the region is trying to introduce modern technologies involving refining biomass and creating biocarbon of high calorific value (about 28–32 MJ/kg) (*Praktyczne aspekty*... 2006). This action will allow the transfer of territory stigmatization and lengthening the distance from the farmer to the intended recipient.

Current consumption of energy obtained from energetic plantations in the Podlaskie voivodship is about 55 TJ, and estimates suggested further dynamic growth to 2010. It was anticipated that in 2010 the energetic plantations will result in 2,698 TJ of energy obtained annually. The energy potential, possible to be obtained from energetic plantations is, according to IBMER prognoses, not less than 17,940 TJ (*Praktyczne aspekty*... 2006).

Summary and conclusions

1. In Poland grows area of lands not used for agricultural purposes. Therefore, unquestionable alternative to the traditional agricultural production is the use of these terrains for energetic crops. The amount of such production should take into account environmental specifications and the expectations and limitations existing in specific region.

2. Coherence of legal provisions and actions relating to renewable energy, giving it priority status, will intensify the growth of this sector, eliminating the risks of not fulfilling obligations imposed on Poland by the European Union.

3. There is a possibility of energetic use of willow in both, micro (fuel), and macroscale (increasing share of RES in the country energy balance). The production of this type may increase the significance of eastern Poland regions and help in stopping the impoverishment of society in the region – this particularly applies to holders of soils of lesser quality.

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