BIOMASS AND BIOENERGY 38 (2012) 23–33

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Economics of energy crops in Poland today and in the future

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ARTICLE INFO

Article history:
Received 27 August 2010
Received in revised form
19 July 2011
Accepted 8 September 2011
Available online 6 October 2011

Keywords:
Willow (*Salix viminalis*)
Miscanthus
Biomass
Energy crops
Economics
Poland

ABSTRACT

Perennial energy crop development is just starting in Poland and there are great expectations on this sector to make a substantial contribution to the achievement of renewable energy targets defined in the European Union (EU) directive 28/2009/EC. Insights into the economics of energy crop production may lead to a better understanding of the dynamics of developments in the field.

This work addresses current and future economics of willow, *Miscanthus* and triticale (a whole crop) production for energy use in Poland. The economics of energy crops is set next to that of common cereal production for grain. Potential cost reductions of energy crops in the future are investigated with regard to the hypothetical impact of scale effect, as well as the combined effect of scale and technology developments.

Results indicate that for the assumed biomass prices applied, willow is profitable while *Miscanthus* and triticale generate loss. The volatility of cereal market prices is found to significantly affect the competitiveness of energy crops compared to grain production. Willow and *Miscanthus* are produced with lower costs compared to triticale. Furthermore, the economics of perennials are less susceptible to changes in agricultural inputs prices compared to annual crops. For the first farmers to cultivate energy crops, the costs are high, however, there are large opportunities for cost reduction due to the economics of scale and technology developments. With the expected increase in biomass market demand and biomass prices, energy crops should be profitably produced in the future.

1. Introduction

Energy crops are plantations that are established so that the harvested biomass can be used for energy purposes. They are considered to make a large contribution to the achievements of renewable energy targets in Poland. In 2007 renewable energy accounted for 4.8% (200 PJ) of the final energy consumption [1,2], while the target established for Poland by the Directive 2009/28/EC is set to be 15% in 2020 [3]. Solid biomass is currently the most important renewable energy source in Poland and constitutes 93% of total renewable energy production [1]. Its contribution will remain high in the future, exceeding 60% of the renewable energy mix in 2020, apart from the biomass that would be required for liquid biofuels and biogas production [4]. Limited use of forestry biomass is allowed for large-scale energy production in Poland [5], therefore dedicated energy crops are seen to be the most important biomass source to be exploited to reach the 2020 targets, both in energy production and transportation sectors.

Perennial crops are more favoured than annual crops due to the relatively high cereal yields per land unit, and are produced with less impact on the environment [6,7]. The current area of short rotation coppice and perennial grasses in Poland covers 8700 hectares [8] while the potential area for these type of crops

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doi:10.1016/j.biombioe.2011.09.011

was estimated to be approximately 1.6 million hectares [9]. This estimate includes reservation of the best quality soils for food production only, exclusion of nature conservation sites, and the considerations that sufficient rainfall and ground water availability must be ensured for the energy crops to produce optimal yields. Under Polish farming conditions, willow and *Miscanthus* proved to produce reliable yields [10–12].

The aim of this paper is to present the economics of biomass production from energy crops in Poland, namely willow (*Salix viminalis*), *Miscanthus* (natural hybrids) and triticale (*Triticosecale*) under 2007 market conditions. The competitiveness of energy crops is evaluated and compared to that of winter wheat and spring barley cultivated for grain. The paper includes four main sections. Section 2 includes a description of the calculation methodology, together with assumptions for the base case calculation and scenarios established to investigate biomass production costs in light of the likely economy of scale and technology development effects over time. Section 3 presents the results. A sensitivity analysis is applied for the evaluation of the effects of changes in yields and biomass prices on gross margins. Finally, discussion and conclusions are detailed in Section 4.

2. Method

2.1. Calculation method

For perennial crops, costs and incomes apply throughout the whole of the cultivation period. In order to compare the results achieved for perennial crops with annuals, a net present value (NPV) approach was adopted, as used before by [13–16], in which costs and revenues for willow and *Miscanthus* are converted to annual streams. The NPV approach does not indicate the liquidity constraints, which may be relevant for new perennial energy crops [17]; however, this was not investigated in the present study.

The calculations are established for reference year 2007. It was a very noteworthy year in terms of record levels of grain prices in Poland, as with other agricultural markets in the EU, however the production costs in agriculture in Poland showed only a moderate increase compared to 2006, i.e. with 8.7%, 11.8% and 3.5% for N, P and K fertilizers [18], respectively. Subsequently, in 2008 fertilizer prices increased by 60–75%, which also happened in most other EU countries. We calculate the biomass production costs for 2007, however, with regard to the grain price hike, we will compare the economics of energy crops to that of common cereals cultivation using grain prices from 2007 and 2006. The calculations do not include direct area payments offered to farmers under the Common Agricultural Policy, production subsidies, land costs or land taxes.

Currently willow and *Miscanthus* cultivation is regarded as a new type of farming activity and Poland has little experience in this area. However, the expected improvements in terms of scale effects and technology development over time will contribute to reductions in biomass production costs. Taking this into account, energy crop production costs are calculated for a base case and two scenarios, as follows:

- Base case: cultivation at small-scale (about 10,000 ha of energy crops in Poland) utilising production technology of today (year 2007).
- Scenario 1: large-scale cultivation (energy crop plantation area in Poland exceeding about 100,000 ha) with current production technology (year 2007).
- Scenario 2: large-scale cultivation (energy crop plantation area in Poland exceeding about 100,000 ha) with about 15–20 years of development of crop and cultivation methods at a large scale.

2.2. Assumptions for the base case calculation

The assumptions made for the base case calculations derive from a literature review, with special focus on Polish-specific information on energy crops production, i.e. yields, fertilization, chemical control and biomass prices. However, as there has been little development of the energy crops market in Poland so far, some assumptions are based on general expert knowledge in the field, i.e. brokerage, willow harvesting costs, plantation removal costs, etc. Table 1 presents an overview of plantation patterns.

Table 1 – Overview of plantations patterns for willow, *Miscanthus* and triticale.

Specification	Willow (harvesting 1 × 1)	Willow (harvesting 1 × 3)	Miscanthus (harvesting 1 × 1)	Triticale
Plantation lifespan	22 years	22 years	20 years	Annual crop
Plantation density	12,240 cuttings ha^{-1}	12,240 cuttings ha^{-1}	10,000 rhizomes ha^{-1}	180 kg/ha
Fertilization[a]	70:23:63 kg ha^{-1} N:P:K from 2nd year onwards, every year	80:30:81 kg ha^{-1} in the 2nd year and onwards in the 1st year of each harvest cycle, and 120 kg ha^{-1} of N in the 2nd year of each harvest cycle	84:42:84 kg ha^{-1} NPK from the 2nd year onwards after each harvest, every year	100:55:80 kg ha^{-1} of NPK, every year
Yield[b] DM (t ha^{-1} y^{-1})	7.0	9.0	14.0	11
Number of harvests[b]	21	7	19	Annually
Storage	No storage	No storage	Under roof	Under roof
Transport	30 km	30 km	30 km	30 km
Biomass price	€3.70 GJ^{-1}	€3.70 GJ^{-1}	€3.17 GJ^{-1}	€3.17 GJ^{-1}

a NPK is also applied in the 1st year of plantation lifespan, on average 20:10:30 kg ha^{-1}.
b Yields from first harvests are 30% lower for willow (4th year) and 50% lower for *Miscanthus* (3rd year) compared to mature plantation.