ECONOMIC AND ENVIRONMENTAL ASPECTS OF CELLULOSE-BASED BIOETHANOL PRODUCTION IN HUNGARY

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Abstract: First generation bioethanol production and its use as fuel were characterized by a significant take-off in the mid-2000s. The fast growth was followed by a very sharp slowdown in line with the changed position of the European Union. The change of direction aims that priority should be given to the polysaccharide-based materials from the potential raw materials of bioethanol production, which are available not from crops, but in the form of agricultural and forestry waste and by-products.
The role, economic and environmental aspects of bioethanol as the fuel of the future arise open issues. With our examinations we want to contribute to respond to those questions which analyse the impacts and economy of the bioethanol production based on agricultural by-products. In this framework we compared the quantity of cellulose can be obtained from potential raw materials, we made economic calculations, and we analysed the impacts of raw material acquisition on landscape ecology. Our aim in all of this was to map the advantages and disadvantages of the second generation bioethanol production.

Keywords: bioethanol production, environmental protection, economic aspects

Introduction

Experiments regarding to cellulose-based bioethanol production have been ongoing for many years in several parts of the world. The technology has long been known and functional under normal laboratory conditions, however the industrial scale operation had waited until 2013. In October of this year the world's first, second generation cellulose-based bioethanol plant was opened in Crescentino, Northern Italy (http://greenfo.hu). In this way the technology has stepped out of infancy, however the pros and cons relating to the biofuels still remain on agenda. It is certain that the raw materials to be used for food or feed uses – although these are the most obvious raw materials in terms of production of fuels – do not belong to the environmental, clearly beneficial from an agricultural point of view or economical sources of bioethanol.
There will probably never be such fuel, which is inexpensive and environmentally friendly, does not endanger the interests of any sectors, has unlimited appropriate material basis as well as market for the final products and creates many jobs at the same time (Bai, 2011). Field trials, researches are ongoing on the subject of nearly all next generation biofuels, and it is unpredictable which procedure, to what extent and how quickly spreads in the world. In order to make better informed choices more detailed knowledge is necessary, inter alia, which potential raw materials of cellulose-based biofuel production could satisfy mostly the environmental and economical requirements. With our investigations we also wish to contribute to this objective.

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Materials and methods

We have been dealing with the cellulose content of the samples of the potential raw materials which are available on the sand ridge between the Danube and the Tisza. The cellulose content was measured according to the Hungarian Nutrition Codex, Volume II, Article 4.1. The cellulose content is calculated from the difference of all fibres and lignin.

In the economic assessments a calculation was made in details of working operation relating to the by-products harvest and delivery to the processing plant in order to ascertain the costs, amount of fuel and energy per 1 hectare. Corine Land Cover database was used for assessing the impacts of the necessary raw material supply for the bioethanol production on landscape structure, which provided information about the present composition of the forestry and agricultural land in the Danube-Tisza interfluve.

Results and discussion

The cellulose content of our test samples is varying between 250-640 g kg^{-1}. The cellulose content of the logs can basically be highlighted from the forestry products (fir, black pine, grey poplar and euramericana, acacia), which has always higher cellulose content than the cellulose content of the chips (Fig. 1.).

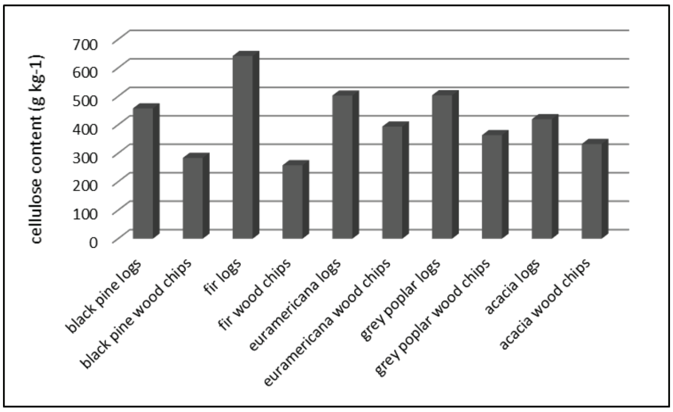

Figure 1.: Cellulose content of the forestry products

As shown in the Figure 1. the fir has the highest cellulose content in case of the tested samples (642 g kg^{-1}). On the areas of the Danube-Tisza interfluve hit by the decrease of ground water level, the drought-tolerant tree species (fir, black pine and acacia) have been in the focus of the forestry planting until recently. It should be noted that the planting opportunities of the indigenous tree species having greater water demand (e.g. poplar) is reduced at the same time. The recent destructions of the stands of fir (primarily black pine) and the European Union's campaign against acacia negatively affect the tree species covering the Great Plain in significant proportion. Nonetheless, presently these are potential raw materials, including the ethanol production. As a

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consequence, the demand for pine, particularly fir is likely to rise, which – in lack of new plantings of trees – can change the land cover. Therefore, it is important not to reduce the forest cover during the use of forest wood, which includes stands planted with species can be deemed aliens, where appropriate. The changes in the share of tree species (could) change the landscape pattern of the Danube-Tisza interfluve, modifying the material and energy flow of the landscape. The (landscape) ecological aspects have to borne in mind also in case of the forests of economic purposes, an approach from which the utilisation for bioethanol production does not necessarily mean a trend to be supported.

Among the potential raw materials from waste of the agricultural sector the cellulose content of the straw of various kind (barley-, wheat-, triticale-, peas straw), and the maize stalks, sunchoke stem and the pea pods are considered significant, close to 400 g kg^{-1}, respectively results above (Fig. 2.).

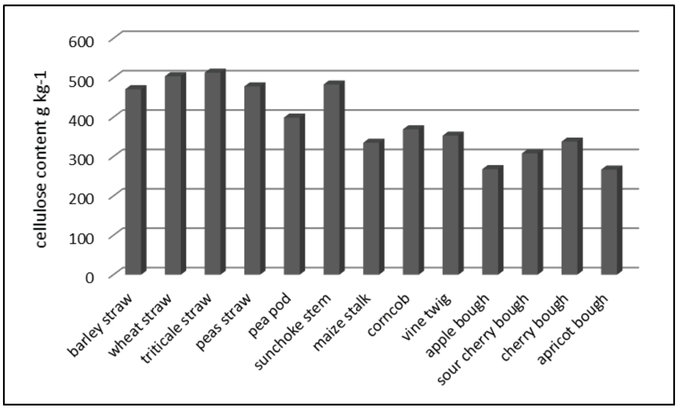

Figure 2.: Cellulose content of agricultural by-products

This magnitude of cellulose content is close to or reaches the cellulose content of the tree species of the forests, similarly to the cuttings of vines and orchards, which plantations cover a large area in the Danube-Tisza interfluve.

The use of organic wastes and by-products as raw materials for bioethanol production is not expected to affect the land use; however the removal of the major part of the biomass from the production area, the extraction from the system appears as lack in the energy balance of the landscape. In our economic calculations we have compared energy balances to each other in which the ethanol quantity that may be produced from certain raw materials has a key role. However it is highly dependent on the technological solutions applied at each stage of production. In our trial we calculated that in case of by-products from 1 t dry matter 0,200 t and from 1 t dry matter of wood 0,265 t ethanol can be obtained. The energy value of 1 kg ethanol was considered 28,6 MJ (Lukács, 2007). Based on the results the agricultural by-products provide the most economical raw material supply for the cellulose-based ethanol production. It derives from their high cellulose content and due to the fact that these products are subject to harvest and transport costs and energy use only, and no cost incurs to their production.

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On the basis of the data per yield unit it can be established that transport distance is an important factor of the economy of the raw material supply (Table 1.).

Table 1.: Energy balance of agricultural by-products depending on the transport distance

agricultural by-products	input energy GJ ha-1			net output energy GJ t-1 ethanol		
	transport distance (km)			transport distance (km)		
	10	25	50	10	25	50
cereals with ear- straw (baled)	1,0	1,1	1,3	26,7	26,5	26,2
maize stalks (cut)	1,2	1,4	2,2	27,5	27,3	26,5
sunflower stalks, rapeseed (baled)	1,3	1,3	1,7	26,7	26,7	26,1
grape vines, wood cuttings (wood chips)	0,6	0,6	0,8	26,9	26,9	26,4

Our calculations show that the raw material is appropriate to be produced within a 25 km road transport distance between the production area and the processing plant. The increase of costs and expenses in regard to the transport distance is higher in the case of products harvested by shredding having higher water content.

Conclusions

At present, the question of biofuel production, the pros and cons of the production and the use have given rise to heated debates worldwide (Demibras, 2009; Douglas, 2012 etc.). In order to the ensure the economy of the raw material supply and to limit the negative consequences of risk, there is a need for a well-regulated mutually beneficial cooperation. The most important question of the coordination of the interest is to set the buying-in prices correctly; it is appropriate to link the price to the cellulose content of the raw material. It is particularly essential to underscore that cellulose-based ethanol production is worth to establishing on the agricultural by-products; however the bioethanol production for motor fuel purposes and its use means a choice among the alternatives are considered now to be available. The long-term benefits of its use are still unclear, which is also modified by the complex environmental, landscape ecological relations in addition to the economy.

Regarding the whole issue¸ in addition to the economic issues, there are further environmental considerations concerning to the effects on the landscape structure, sustainability, and the wastes arising from production, treatment of by-products and possible further utilisation. These are dilemma requiring further researches, and the in-depth study may decide the fate of the use of the biofuels including the second-generation cellulose-based bioethanol.

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