Comparison of profitability and competitiveness of field crops suitable for energy production and woody energy crops

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Abstract
Considering the aims of the European Union the utilisation of biomass for energy purposes gets more and more attention, since the balance of CO₂ emission is quite favourable. In Hungary the Northern Great Plain region has heterogeneous agroecological endowments; the rate of less-favoured areas is also significant, which makes reasonable the profitability analysis of crops for energy production. In this article beside the conventional arable crops (corn, wheat, rape, sunflower), the profitability of woody energy plants (locust, poplar, willow) were examined, since the price of this energy can be considered as competitive in contrast to the gas or any other fossil fuel. In the course of enterprise analyses, brake even point was calculated, the competitiveness was analysed by multi-periodic linear programming model with and without subsidy.

Key words: energy orchards, production structure, simultaneous linear programming model

Introduction
Field crops can not only be raw materials for food and feed, but alternative fuels - bioethanol from corn and wheat, biodiesel from rape and sunflower - can also be produced (HENNIGES, 2004; EBB, 2006). Arable crops areas sown are still significant, and these are produced on those lands, where energy crops can also be grown (BABICZ, 2010).

In this article the competitiveness of the four most important Hungarian arable crop enterprises (corn, wheat, turnsole, rape) and energy crops (energy locust, energy poplar, energy willow) was examined.

In this article model calculations were made. It was analysed that how energy crops are competitive compared to arable crops with and without subsidy according their gross margins. Of course, by the involvement of conventional arable crops in the energy sector, we would not like to reduce the quantity of raw material needed for food production, but a novel solution is to be given for the deduction of the excess.

Material and methods
The data for the competitiveness analysis of conventional arable crops and energy crops were given by the Central Agricultural Office (MGSZH), Research Institute of Agricultural Economics (AKI), Ministry of Agriculture and Rural Development (FVM), and by a Hungarian company that plays an important role in producing raw material for bio energy. Our choice was based on the fact that this company is located in Eastern Hungary, in Szakoly and it was founded in 2007 for supplying the bio plant of South-Nyírség. During its 3-year operation it extended it activity for several regions of the country. Nowadays, it produces energy crops on 600 hectares. Part of this area is poldered, so these could be used for agricultural food production uneconomically, but from the point of energy production these areas are suitable for the production of energy willow and poplar species. The other part is sandy, where conventional agricultural production cannot be done because of the precipitation. For this soil type almost any of the locust species can be planted.

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For this research to reach the targeted aims, in practice used technological, production, cost and revenue data, and the amount of subsidies for crop production were needed. We built upon our own data collection for the enterprise technologies raw data needed for the linear programming and simulation model.

For the database of linear programming models unified crop production technologies were developed, which base was given by the companies. The resources needed for the technologies, and for the capacity vector of the linear programming model were determined by the resources of a company participating in this research. For modelling, sample technologies of 100 hectares were created (CSÁKI - MÉSZÁROS, 1981), which were compiled by Microsoft Excel.

The comparison of enterprises was made according to the cumulated gross margins, for which the data of the agricultural companies and Ministry of Agriculture and Rural Development were used. Gross margin was calculated by the difference of production value and direct variable cost. When determining the gross margin of energy crops, it was considered that harvest is not done every year. We calculated with a 3 year harvesting cycle for the locust and willow, and with 2 years for poplar. For all crops, from the second year by 5 percent revenue and 4 percent cost increase were calculated.

The competitiveness of crop cultures was examined by a multiperiodic production structure model, and for its assemblage, first of all, single crop production models were made for one year. After this, these models were built into a common LP model. Each year was bound by rotation cycle transfer variables.

The technologies are broken by decades. The examined interval is 12 years, which was justified by the more precise modelling of the perennial energy orchards. This linear programming model contains 120 variables and approximately 1000 constraints. The constraints by each year refer to the area, the machine work, the available labour force and requests to comply to rotation cycle’s rules.

In case of orchards, contrary to arable crop cultures, a special constraint had to be developed. If once a woody energy plant gets into the production structure it will remain on the same area for 15-20 years depending on the species.

In the objective function of the linear model the gross margin of 12 years was maximized.

When having assembled the model, we tried to make it in a way to reflect the reality as much as possible, and to be manageable from the point of mathematics and informatics.

The compiling of mathematical model led to a relatively large model also in case of simpler variables, so the use of aggregated variables was aimed to reduce the labour of model editing.

**Results and discussion**

The results of enterprise calculations

The cumulated gross margins were used for the comparison of the profitability of crop enterprises. Analysing the value of the cumulated gross margin, significant differences can be seen with and without subsidies (Figure 1. and 2.). In case of corn the highest cumulated gross margin can be reached by the end of 12th year among the arable crops. With subsidy this amount is 8441€ for one hectare, without subsidy it is 5540€. It is followed by the rape, which value is 6870€ with subsidy, and 3968€ without it by the end of 12th year. The lowest cumulated gross margin value can be reached by the sunflower (Figure 1.).

By determining the cumulated gross margin value of energy orchards, it becomes possible to calculate the return on investment. In case of energy orchards the first revenue can be counted for the 2nd and 3rd year, and the initial plantation payment can largely influence the time of return. With subsidy in the first cutting cycle positive gross margin can be realized in case of all three plants, while without subsidy only in the 4th (poplar), and in the 6th year (locust and willow). By the end of 12th year the highest gross margin can be reached by Swedish willow, which value is 9472€ per hectare. The lowest cumulated gross margin has the poplar, with the value of 8393€ (Figure 2.).

The income increasing effect of payments is specifically high in case of the wheat and sunflower (higher than 100%) and the lowest at corn (52,4%). Such large-scale difference cannot be demonstrated among the woody energy plants (Table 1.).
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Figure 1. Cumulated gross margin values of the conventional arable crops with and without subsidy in the examined 12 years

Source: own calculation

Figure 2. Gross margin values of energy crops with and without subsidy in the last 12 years

Source: Own calculation

Table 1. The subsidies income increasing effect of the examined crops

<table>
<thead>
<tr>
<th>Arable crops</th>
<th>Woody energy plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>Locust</td>
</tr>
<tr>
<td>52,4%</td>
<td>83,8%</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>Poplar</td>
</tr>
<tr>
<td>104,0%</td>
<td>83,8%</td>
</tr>
<tr>
<td>Sunflower</td>
<td>Swedish willow</td>
</tr>
<tr>
<td>132,3%</td>
<td>67,8%</td>
</tr>
<tr>
<td>Rape</td>
<td></td>
</tr>
<tr>
<td>73,1%</td>
<td></td>
</tr>
<tr>
<td>Turnsole</td>
<td></td>
</tr>
<tr>
<td>76,0%</td>
<td></td>
</tr>
<tr>
<td>Rape</td>
<td></td>
</tr>
<tr>
<td>67,8%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Own calculation

Competing the enterprises by applying multi-periodic linear programming model

The comparison of enterprises was executed with and without subsidy considering a sample farm of 500 hectares.

In case of the conventional arable crop cultures, we counted with the area payments, while for energy orchards beside this subsidy we could count with grants given for the plantation similarly to the previous calculations.

After solving the model considering the subsidy, we can see that in the first year of the planned production structure all crop culture got in (Figure 3.). In the production structure the major share had the cereals in app. 40%, after this come the energy orchards’ 26%, and the turnsole’s and rape’s 15-20 percent share. Regarding the crop structure for 12 years, the role of energy orchards will not change, since by a given plantation we engage the area for long term.

In the fifth year, compared to other years, a major change can be experienced since the rate of turnsole reduced to 9.5%, and the area of wheat increases from 20% to 25%. By running the model on 500 hectares for 6 years we can reach 3.81 million EURO maximum gross margin. This means that we can calculate for the average of 12 years with 635€ gross margin.
After solving the model not considering the subsidy a similar production structure can be achieved compared to that of with subsidy, and according to this, the conclusion can be drawn that these crop cultures are in the same competition with and without subsidy as well.

**Conclusion**

In this article the profitability and competitiveness of conventional arable crops and energy orchards, which are the main raw materials for energy production, were compared considering an interval of 12 years. Enterprise profitability analysis was made by the cumulated gross margins and built on the technology and resources of a sample farm of 500 hectares the examined crops were competed in a multi-periodic linear programming model. By the calculations, the national and domestic area payments were also considered that are available for the producers.

Considering the cumulated gross margins for 12 years, the order of Swedish willow, locust, corn, poplar, rape, winter wheat, and sunflower can be established among the crops with payments. Without subsidy the locust and the corn switch places, the other crops occupy the same places. The significance of subsidies is the greatest for the wheat and sunflower - so the income increasing effect is higher than 100% -, it is lower in case of the other crops, but the corn’s, which has the lowest value, is still above 50%. In the LP model presenting the competitiveness of each enterprise, the total share of woody energy plants of high income is 26%, and it is practical to utilise the remained area with conventional arable crops with and without payments as well. The harvesting cycle of woody energy plants plays an essential role in it, since it is 2-3 years, which means that especially in the initial period it will only give a positive cumulated gross margin balance in 2nd-6th year depending on the subsidy.

On the whole it can be stated that beside the conventional arable crops the woody energy plants are also competitive in the field crop production, which means a new opportunity for alternative biomass utilisation. However, it cannot be ignored that this statement is only valid primarily from the point of producers with payments. The further penetration of biomass energy use can only be successful if the end-product energy is competitive with the conventional energy sources.
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