GLOBAL AND LOCAL CHALLENGES IN THE CULTIVATION OF FOOD AND ENERGY CROPS

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Abstract
Energy and food production recourses have never been considered to be competitive elements in Latvia to date, however, active public and political discussion is within the context of globalization. With the participation in international agreements, the production of the "green energy" and limitation of green house gases has substantially affected the production of farms in Latvia. The present article examines the development of international discussion, as well as different scenarios of land exploitation alternatives are analyzed both by the amount of produced energy and profitability per ha^{-1}. The described results in the article show that utilization of cattle-breeding manure is less effective by output amount per identical amount of agricultural land area. Comparing the profitability of alternatives – food (winter wheat) or energy (electricity from maize), energy production is more profitable.
Key words: energy crops, biogas production, food – energy dilemma, opportunity cost.

Introduction

Traditionally to obtain heat, firewood (woods cover 50% of the territory) or natural gas (imported resource from Russia) were utilized, electrical energy was obtained mostly from the biggest hydroelectric power stations or imported (Russia, Lithuania, Estonia); in the fuel market, complete monopoly dominated. In the food production in Latvia, crop overproduction is reached. This raw material is partly exported (basically as a primary resource), and we can supply ourselves with dairy products although the export of goods and imports exist, while worse indicators are observed in meat supply, and there is a very high import proportion. At the same time, there are large areas of unused agricultural land in Latvia, indicating the possibility to expand the production of agricultural produce. Though, the supply of food in the world is not as optimistic. The number of inhabitants has reached 7 billion; moist tropical forests are being cut more and more to lay out new areas for food supply as well as to construct infrastructure, moreover, these areas are used to obtain energy, including cultivating energy crops which are used not only in the provision of necessary food energy for humans, but also these crops are used as raw materials to produce electrical energy, thermal energy or transport energy. In this context, the competition for land productive area that can be used to provide food and energy resources develops. There is a certain coherence in the theory of economics that with the growth of the number of inhabitants, the consumption of resources grows; in addition, the more developed country is, the bigger is its consumption of resources. If at the moment in the economy of the developed countries such as the USA, the EU, Japan certain exhaustion of development potential is being observed, then in such developing countries as China, India, on the contrary, explicit tendencies of economic increase is being observed, in addition, it must be considered that these are countries with a great number of inhabitants.

These processes have defined the topicality of this article; **the aim** of the article is to analyze the mutual competition for land in the cultivation of food and energy crops. To reach the aim, the following **tasks** have been advanced: 1) to emphasize the most substantial international documents that identify the necessity to increase the amount of food and renewable energy resources; 2) to analyze individual international studies in explaining the food and energy dilemma; 3) to analyze comparisons of land exploitation alternatives by produced energy (kWh – total economic energy and Kcal – food energy) and profitability per ha^{-1}.

Materials and Methods

The theoretical basis of the article is grounded on the study of international documents and materials of international research projects. The former researches and publications on renewable energy by the authors are used in this article, including the data obtained within the ESF project "Attraction of Human Resources to the Research of the Renewable Energy Sources", as well as data bases of statistical indicators, and Internet resources. The process of production of electric power in a cogeneration station is examined as a kind of renewable energy within the research where corn silage is used as a basic substratum, which is the most popular in Europe now and in Latvia it is the most popular and most cultivated energy crop to produce bio energy in cogeneration stations. In Latvia, the winter wheat is chosen as the basic raw material for foodstuffs; this cultivated plant can supply a big part of the consumed amount of flour in the country and a part of the produce is exported. In the mathematical calculations, the price lists of 2011 of Ltd. "Latagra", Ltd. "Latfert"

and Genuine Seeds of Latvia have been used, but for calculations of service expenses, the information on price levels for 2010 from the Latvian Agricultural Advisory and Training Centre have been used. The technological scheme of crop cultivation is taken from a practicing farm in Latvia. The monographic, inductive and deductive methods are used in the study, as well as the graphic method. The calculations of expenses of crop cultivation and production of basic products are made using the method of expense calculation modeling.

With the concept of energy crops, the authors have identified all those cultivated plants that are grown taking into account appropriate agrotechnical demands and that are used to obtain energy (thermal energy, electric energy and/or fuel).

Results and Discussion

Global challenge

During the last century's 80's, a new tendency appeared when the consumption of resources exceeded the capacity of its reproduction. By now the scientists have calculated that the mankind consumes resources by 30% more than it can generate within a year. The industrial period started the era of utilization of fossil resources. If till then mostly renewable resources were used, then by now these are mostly natural gas and oil which have become the main energy resources outpacing the amount of coal utilization. To ensure energy of different kinds, primary energy resources are essential – deliberate reserves of fuel and energy resources that can be applied directly or to obtain energy. Wherewith the questions concerning the obtaining of energy resources and their utilization for the needs of society are the central ones on a local, regional and global scale; and taking into account that the International Energy Agency anticipates that within the foreseeable future the demand for energy will only increase, these questions indisputably become more topical and at the same time more imminent (International Energy Agency, 2011). It is not planned in the immediate future to cultivate new deposits of fossil energy resources in large amounts, rather the amounts will decrease, of course, if new still unknown deposits are discovered. Moreover, as experience shows the cultivation of new fossil deposits becomes more expensive, they are found in deeper layers, in areas that are difficult to reach, which raises the price. 300 million years were needed to create the energy of mineral resources, but only in the next couple of years it is possible to expend the biggest part of energy resources up to the minimum. According to the predictions of British Petroleum, the oil may suffice for 40 years yet, afterwards to obtain the last of its resources, more energy will be needed than it is worth; but natural gas resources may suffice for 60 years yet. If the coal is to be used to compensate these resources then the resources of coal may suffice for 125 years yet. Such a situation will remain even if we calculate that during a year, the worldwide demand for energy increases only by 1% for oil and 1.5 % for natural gas, but it is a slower increase than currently.

If electric energy, thermal energy and energy necessary for transport are secondary to ensure human's basic needs, then food is a primary source of energy, the society cannot exist without it. In particular the issues on food supply in the international area became more acute in the last century's 90s. Searching for a solution in Italy in 1996 during the UNO summit, the so called Rome declaration was established on World Food Security. It foresees that everyone has rights for safe and rich in nutrients food that is adequate in amount and ensures the basic right for a human not to suffer starvation. During this resolution, the countries showed their political will to exterminate starvation in all countries of the world, foreseeing to reduce the number of people who daily receive insufficient nourishment till 2015 as well. (Rome Declaration on World Food Security, 1996) The number of people who suffered starvation in 2010 reached 925 million, mostly in developing countries. 26% of children till the age of 5 worldwide have insufficient weight because of insufficient nourishment. The EU in 2010 established a special program "EU Policy Framework to Assist Developing Countries in Addressing Food Security Challenge" that was created with a prediction that till 2015 the total demand for food will increase by 70% with the growth of population till 9 billion. (EU Policy Framework to Assist Developing Countries in Addressing Food Security Challenge, 2010) Further the food will have to be produced using smaller areas of agricultural land, water and also less pesticides, sustainable agro ecological production methods will have to be applied. The EU parliament, within the framework of the program for world food security, emphasizes the importance of political stability to improve food supply considering that world food crises is not only a previously unprecedented progressive human problem, but also the threat for peace and security worldwide (European Parliament, 2011), therefore it is essential to look for innovative ways of financing, to prevent trade restrictions and to decrease the debts of most affected countries. In this announcement, the question on price increase that is partly caused by the cultivation of energy crops on the agricultural lands was also accepted.

Beside the issue of food supply, an issue of sustainable development is distinct where one of dimensions is ensuring of human welfare, abatement of poverty at the same time respecting the limited powers of natural resources and ever increasing environmental problems. The issue on sustainability first in the international area appeared in 1987 in the report of the World Environment and Development Commission of the UNO "Our Common Future", but widely it has been used from the Rio de Janeiro conference "Environment

and Development" in 1992 where sustainable development is explained as development that ensures the satisfaction of present needs by not creating threat to the satisfaction of needs for next generations. (Rio Declaration, 1992) The international plan of actions for the 21st century *Agenda 21* was accepted there. Together with these issues, it was internationally defined that human welfare is essential including that human primary need for food is ensured at the same time respecting the limits of the eco system.

A real impulsive document for sustainable development in the international area is the Kyoto protocol established in 1997 (UNFCCC) that foresees that till 2012 all industrial countries attain the decrease in emission levels of gases creating the greenhouse effect by 5% in comparison with 1990. (Kyoto protocol, 1997) Also EU countries in this issue have undertaken even higher aims to decrease the emission of these hazardous gases by 8% till 2012, but till 2020 by 20% in comparison with 1990, to increase the part of renewable energy up to 20% in the total consumption of the EU, but for vehicles to use 10% of biofuel.

Now the year 2012 has just begun, so the achievement in this field cannot be completely evaluated. From the point of view of the scientists and practitioners, the performance of the aims in EU countries is more or less satisfactory, but worldwide in general there are substantial disagreements. The evidence is the fact that several countries have not ratified the Kyoto protocol; there are huge unsurpassable barriers between the position of the USA and China about these issues which are responsible for the 40% of the pollution of the atmosphere. The world leaders meeting in Copenhagen at the end of 2009 did not give either the answer how to solve these problems after the termination of the Kyoto protocol. (Climate Conference in Copenhagen, 2009) The proposed decrease in emission of hazardous gases from the USA is only 3-4% in comparison with 1990. The main objections of the USA and China are connected with the opinion that taking into consideration the regulations of Kyoto protocol, the economic growth of those countries will substantially be impeded.

A year later in the city of Cancun in Mexico, the idea of the establishment of the Green Climate Fund was accepted (the agreement of 190 countries), till 2020 it should contain 100 billion dollars with the idea that the money of the rich countries will be allocated to the countries that suffer the most from the climate changes. The fund will be supervised by the World Bank. It is foreseen that the rich countries should lower the emission of hazardous gases by 25-40% in comparison with 1990. (Climate Change: Post-Copenhagen …, 2010) The positive fact is that the document foresees to develop a plan how to stop deforestation of huge areas of forests, although there are no references about mechanisms, especially market restriction mechanisms how to influence that. In fact, the main success of this agreement is the attraction of the money resources of the rich countries to the solving of climate problems; this is the struggle with the consequences. The concentrating to the different kind of investments of the developed countries, for example innovative, technological solutions, is expressed to a lesser extent.

Together with the political solutions of the sustainability processes in the international area, there are scientific suggestions, prognoses and discussions on these issues. Presently a more or less uniting opinion:

1) That processes of global warming, by the decrease of a certain temperature, can cause irreversible consequences in nature, also in the national economies of many countries;
2) The amounts of fossil resources are limited, solutions for its replacement should be looked for, but there are great discussions if presently chosen alternatives are better from the point of view of the sustainability than former ones.

The competition of the cultivation of food and energy crops per area of arable land

The group of EU scientists using the Green-X mathematical model carried out a research how to use more effectively the potential of biomass to implement the set EU aims in the Kyoto protocol by examining the benefits from 3 implementation scenarios if the produced potential of energy resources is increased to 15, 25 or 30%. From the point of view of the scientists, the most cost effective way how to use biomass would be if by 2030 for heating 18% of it were used, for obtaining electric energy 12.5% and 5.4% for vehicle fuel. At the same time it is emphasized that more extensive use of the bioenergy would raise the cost for energy approximately by 20% and these costs would have to be covered by consumers. A grate attention is paid to new technological solutions that could serve as a provision to decrease the costs in the use of renewable energy, moreover, the scientists indicate that not only entrepreneurs should involve in this process with greater trust, but also banks, contractors, developers of the support schemes – government institutions etc. The coordination and integrated actions are needed among EU countries in the development of support mechanisms that would give lower transitional costs for consumers. (Economic Analysis of RES-E Support Mechanisms, 2004) The more extended use of the biomass potential in power industry raises certain concerns in the security of food production, in the existence of valuable forests and natural meadows that serve as a natural absorber of CO_2. In 2009, the group of scientists lead by *Timothy Searchinger* carried out a research using an agroeconomic world model where they wanted to find out what changes would cultivation of maize and switchgrass in huge areas in the USA create in the cultivation of other food crops in other countries of the world, with the basic idea that in other

countries the forest stands and natural meadows were turned into arable lands to compensate the lack of food. The main conclusion is that in 50 years the emission of greenhouse effect gases would increase than using the fossil fuel. Cultivating the energy crop in huge areas, in the soil of forests and meadows, the depositary of the natural CO_2 would be destroyed. The conclusion of the scientists is that several decades would pass till the gains from the enlarged potential of the renewable energy overcame the negative influence. Ethanol obtained from the maize doubles the emission of greenhouse effect gases in a 30 year period. This result raises doubts to exploit huge territories for cultivation of biofuel crop. Greater attention should be paid to the use of waste products. (Use of U.S. Croplands …, 2009) Moreover, by enlarging the areas for crop cultivation, it is foreseen that the inflow of nutrients into the natural watercourses, including nitrogen. As a result, the gains of nature protection are doubtful. The research of similar character was carried out by the researcher group of Catlin Arctic Survey drawing the correlation between the price of soybeans and deforestated areas. The higher was the soybean price, the larger areas of rain forests were cut out. This mutual coherence is invoked by the increase in demand for bioethanol for which the rural territories for soybeans are converted into the fields for maize to obtain bioethanol. By decrease of the soybean offer in the world's markets, the price of that resource increases.

There is also an opinion that cultivation of crops for needs of bioenergy is not such a big competitor for food production, emphasizing that there are plenty of uncultivated lands in the world including arable lands. German scientists (Nova, 2008; Grethe, 2008; Zeddies, 2008; Baltzeretal, 2008) assess the insufficient efficiency in soil exploitation as unused potential both from the point of view of the productivity of labour and from the possible productivity potential, for example, the average crop productivity is not even close to the possible optimal level in many countries, as the optimal average productivity 6.5 - 7 t/ha can be obtained in Poland, Japan, Lithuania, Belarus, Italy, Hungary, Romania, Latvia and Ukraine. Presently the obtained productivity actually is 3.5 – 4.5 t/ha. Largely, the nonexistence of crop rotation or cultivation of crop after crop several years in succession has been mentioned as the reason for foregone productivity.

However, it must be outlined that raising productivity can demand additional financial resources and the more infertile the soil in its natural way is, the more investments are needed, in particular cases these investments are not cost effective and it is not useful to cultivate the respective crop in these areas. Partly the cultivation of energy crop could reduce that demand because, for example, in Latvia high quality soil is needed to cultivate food cereals, besides the choice of energy crops is very wide, thus there are greater option possibilities also for poorer soils by finding the most appropriate for them.

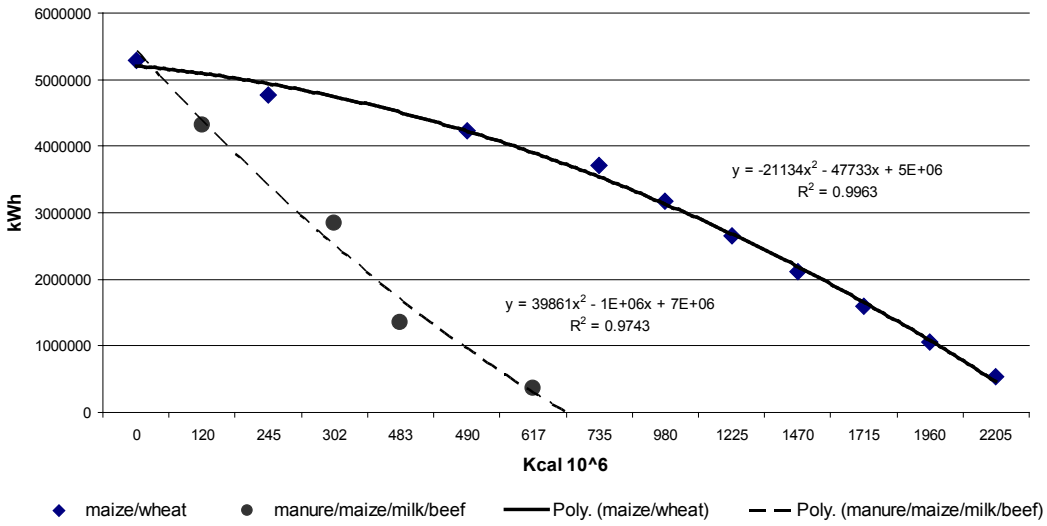
Analyses of energy and food productivity

To accept or deny the global challenge in the security of energy and food production, it is essential to evaluate this alternative at the micro level. It must be examined after what considerations the manager, farmer of the limited agricultural land resources follows.

The basis of the theory of economy is the solutions of the dilemma of limited resources. Malthusianists hundred years ago indicated to the possible collapse of common economy that was based on the limitedness of resources. However, the main essence of the resources has changed with time; land as a basic resource has been excluded from the function of production, as well as it has overgrown its meaning in production including social services that is the base for ecoservices. In the economic analyses, the social gains and loses which often directly (compensations, subsidies) influence the efficiency of production also have to be evaluated along with the economies of scale. To illustrate the previously mentioned, the authors have prepared production simulation where the results are summarized in Figure 1 with the help of production potentiality curves.

Two possible alternative scenarios have been examined. The first (in the Figure – maize/wheat) – the farmer has the choice to grow two crops – maize for energy production from biogas expressed in kilowatt-hours (kWh) or/and winter wheat for food expressed in kilocalories (Kcal). His arable fields (assumed 100ha), the farmer can sow with any of the mentioned crops. If the farmer sows only maize to obtain energy (point A), then he does not obtain food and vice versa (point B). The situations when the division of resources (land) between the crops occurs are shown between the extremities. Basically, the curve shows the character of efficient division of resources. The points to the right from the curve are not possible on the existent conditions, the points to the left from the curve are possible, but the resources are not valuably used. This is defined by the theory of economy. The second possible scenario characterizes a more complicated choice for the farmer (in the figure – manure/maize/milk/beef (among the points A and C)). He can divide the land for the production of food (milk, beef) by breeding cattle and simultaneously produce energy from manure (situation at the point B), or intensify the production of energy by allocating a part of the land for maize cultivation, approaching the point A along the curve. The results can be view in Figure 1.

The farmer exploits the land more efficiently if he produces maize or/and winter wheat. The scenario with cattle breeding substantially falls behind in estimations. Nevertheless, the livestock breeding scenario has several advantages which cannot be assessed within the model. Firstly, the dilemma of food -



Source: developed by the authors

Figure 1. **The curve of production potentiality in a farm**

energy is less explicit in livestock breeding because it provides to produce energy in the situation when the land for energy crops is not allocated. Secondly, the harmful ecological effect of cattle breeding waste (manure) is lowered. Thirdly, beef and grain in the economies of the developed countries are not strictly replaceable products that are characterized by the difference in the price for one item. Therefore, the expressed values Kcal are conditional. In a practical situation, the international market also acts, which can reduce the influence (government policy) on the situation.

Meanwhile the previously described model shows that obtaining energy only from cattle breeding manure is far less effective in obtaining production than cultivation of energy crops. Therefore, solving the issue of food supply, mixed versions are more effective than situations when only energy or food is produced. The use of cattle breeding manure in obtaining energy is sustainable from the point of view of environment maintenance and the competition for the exploitation of land resources between food and energy production. However, economically from the point of view of the cover of expenditure and business stability, the derived solutions (points between the points A and C) overall would be more effective. Therefore, at the micro level the modeling of production mix combining food and energy crops is an effective way how to achieve sustainable production and lower the risks acting in different markets (energy and food).

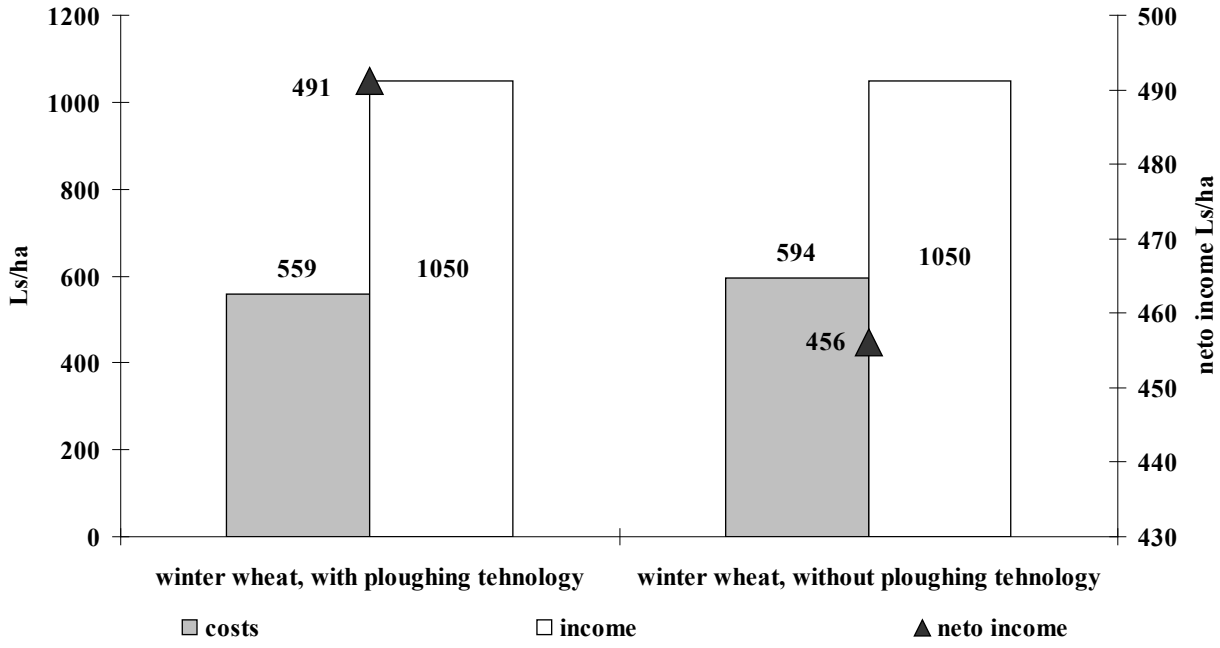
Analysis of energy and food profitability

In a real situation, the factors that define the behavior of the farmer to choose food or energy production are quite many. The complicity of the choice can be connected not only with the exploitation of land but also launching a difficult and new production related to high capital investments. Therefore, the analysis of productivity is essential, which would allow making a choice for energy production. The authors have made calculations with the aim to compare the productivity for producing maize for biogas or winter wheat for food.

Of course, the following modeling of the situation is abstract, as it foresees the obtaining of energy only from maize; the limitations of the land are not taken into account. It is assumed that all other expenses related to the production of biogas are 0.07 Ls kWh^{-1} that includes both capital and variable (without substratum) and administration costs. The main remark – the production unit of the biogas has to recover itself, as well as it must fulfill the agreement with the society on realization of electric and thermal energy. Thus the farmer together with the decision to produce biogas has solved this dilemma at least for 10 years. However, the margin of profitability will cause sharp development of biogas production units as well as increase in land price.

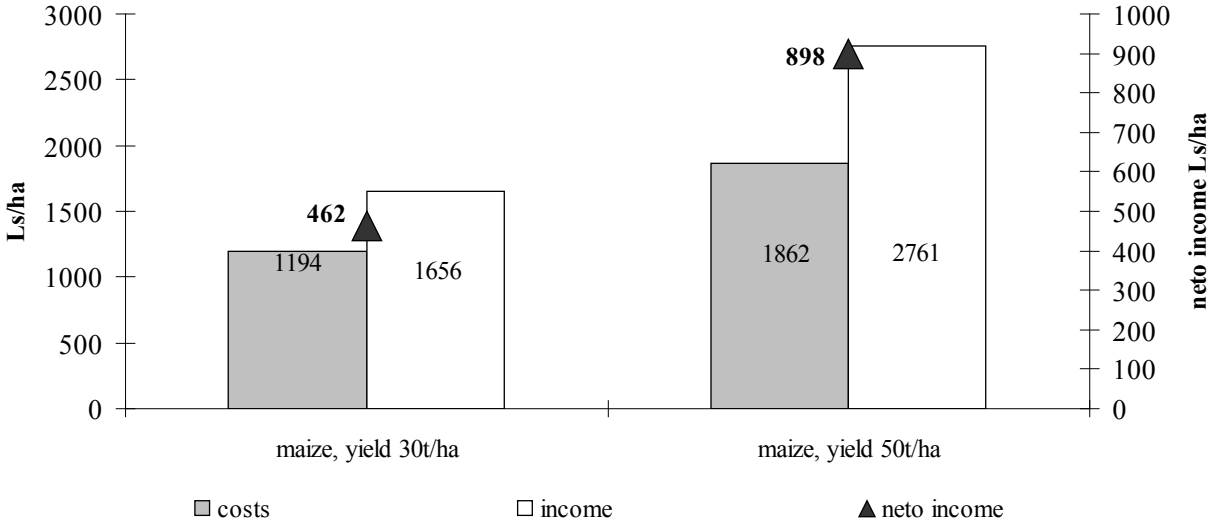
To compare expenses and profitability, an absolutely extreme situation has been chosen. Firstly, the productivity of winter wheat is high 7t ha^{-1}. Secondly, the biogas production unit distributes only electric energy. The sales price of winter wheat – 150 Ls t^{-1}. The results of the modeling of winter wheat profitability are shown in Figure 2.

The income from the sales of winter wheat in both cases shown in Figure 2 is equal because the sales price and harvest amounts from hectare are equal. Though there is a difference in costs that can be explained by different technologies – with ploughing and without ploughing. Therefore, a difference in net income appears that is made by subtracting cultivation costs from sales income. Administration costs are included as a constant sum of 6 Ls per hectare.



Source: based on the calculations of the authors

Figure 2. **Costs and income of winter wheat cultivation**



Source: based on the calculations of the authors

Figure 3. **Costs and income of maize cultivation**

So the income from hectare ranges from 456 to 491 Ls ha^{-1}.

The income of maize cultivation differs if it is cultivated to obtain bioenergy, as different cultivation technologies gave different results that is represented not only in costs, but also in the income. Thus by the productivity of 30t ha^{-1} of the green mass, it is possible to produce 11 117 kWh_{el} of electric energy, but out of 50t of green mass substratum – 18 528 kWh_{el}. TES efficiency for electric energy is 35%. The electricity purchase tariff is about 0.14Ls/kWh. In the power unities, that would be 1.39 - 2.32 kW ha^{-1}. Such a high fluctuation only indicates that if it is not possible to get high maize yields, other energy crop should be found which would provide higher amounts of energy and lower costs. Naturally, the net income is also varied from 462 to 898 Ls ha^{-1}.

By high productivity of winter wheat (7t ha^{-1}) and high prices of cereals (150 Ls t^{-1}), the decision to build a biogas production unit is not unambiguous. If maize productivity is 30t ha^{-1}, then extra risks the farm should undertake are not compensated; whereas by the productivity of 50t ha^{-1} such a decision can be considered as reasoned.

Conclusions

Internationally widely the issues related to the food supply security for world inhabitants and the necessity of change of energy resources with renewable have been updated at the same time respecting sustainable development, although there are several substantial disagreements in solving these issues especially that are related to the emissions of greenhouse effect gases and their reduction.

It is proved by the scientific studies that the cultivation of energy crops reduces the arable areas allocated for food and to compensate that forest areas are exploited, which is in conflict with the terms of sustainability. Moreover, it is emphasized that in many countries in the world, including Latvia, the potential of arable lands is not effectively used, as possible optimal productivities are not gained, there is also a proportion of unused arable lands.

The obtaining of energy only from cattle manure is less effective in production output than cultivation of energy crops. At the micro level, combining cultivation of food and energy is an effective way how to reach sustainable production and lower the risks by acting in different markets (energy and food).

High prices of cereals can be a sufficient reason to make energy production from maize less attractive. However, in absolute numbers, at present, the cultivation of energy crops to obtain electric energy in Latvia is more profitable than production of food.

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