BIOMASS - IS IT A PART OF ENERGY STRATEGY IN MITIGATION OF GLOBAL WARMING?

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Abstract
There is dramatic evidence that various Greenhouse Gases are responsible for global warming and climate change. Agriculture can play a role both for reducing GHG emission and to sequester carbon. Agricultures primary aim is food and feed supply, but energy crops implementation needs changes in land use. There are many questions, 'pro and contra' uncertainties in this topic. Converting secondary biomass, plant residues to valuable energy products might be a solution. Energy potential of Hungary is approximately half-half of products and by-products. In this paper, along the predicted yield we were interested in the available secondary biomass quantities and the proportion of the parts of the plant in biomass, as well. In our research we used the method of simulation modelling.
Climate scenarios - pictures of how the climate may look in the future – we used were downscaled to Debrecen, an important centre of agricultural production in Hungary. We have used five different scenarios which give predictions for the middle of the century as weather inputs in the crop model 4M. 4M has been developed by the Hungarian Agricultural Model Designer Group. It contains several sub-models to describe the physiological interactions of soil - plant systems. The simulations were also run using the historical data of the scenarios reference period.
We have analyzed the simulated secondary biomass quantities and the proportion of the parts of the two most cultivated crops - corn and winter wheat - in biomass. Analyzing and comparing the simulated values, the results are very promising. Bioenergy gives Europe an opportunity to reduce GHG emission and secure its energy supply. With this paper we would like to call the attention to the importance of creating well-designed descriptive-forecasting systems, as well as defining the optimal preparing and response strategies to the conditions in change.

Introduction
It is evident that global climate change is one of the serious problems facing humans in the 21st century. Human activities have contributed significantly to the build up of concentration of harmful emissions in the atmosphere, with activities like fossil fuel combustion for energy. It is also clear that the most important solution to global warming is the dramatic reduction of fossil fuel use. One possible strategy to reduce green house gas emissions is the application of renewable bioenergy sources - in the form of biogas, liquid and solid biofuels – instead of non-renewable fossil fuels. There are significant variations in agro-climatic conditions among European regions. Thus spatial suitability for relevant crops is a strong limitation. Theoretical potentials of energy crops relates to agriculture lands available in certain region, crop varieties, environmental and meteorological conditions, length of the vegetation period, temperature, rainfall balances and soils types. Therefore we need studies for different circumstances in agriculture and land-use change, which helps us prepare for the future.

Biomass and biofuels
"Biofuels" is a term that commonly denotes liquid or gaseous fuels made from biomass. The biomass can have different sources: starches from cereals, grains and sugar crops, waste products from agriculture and forestry, etc. Ethanol obtained from biomass is one of the most promising sustainable transportation fuels. Bioethanol can be produced by any

biological feedstock that contains appreciable amounts of sugar or material that can be converted into sugar. In the EU, suitable feedstocks are wheat and sugar beets, but also grains like barley and corn. Biodiesel we can get by a chemical process that reacts plant oil or animal fat with methanol. Biogas is a mixture of methane and carbon dioxide resulting from the anaerobic fermentation of organic material recovered from sludge, manure and waste. The gas can be upgraded and compressed for use in vehicles equipped for natural gas. Advanced biofuels from biomass can be produced using several different technical processes; a wider variety of potential feedstocks would be available such as crops residues, trees, grass and also forestry residues. Agricultural residues include a wide range of plant material produced along with the main product of the crop. Examples of these types of residues that could be used for energy production are cereal straw, orchard prunings, corn stems and cobs etc.
Biogas is an environmentally friendly energy form. Biogas has got a large potential for reducing green house gas emissions. If it is produced from corn for instance, it performs much better than liquid biofuels. It reaches almost the results of best solid bioenergy carriers.
Europe is facing increased efforts for bioenergy production support, both based on existing resources and energy crops implementation. Germany is one of the positive examples of successful application of large amount of biomass into biofuels. The biggest production there is focused on biodiesel. It is important to emphasize, that there are biomass-power projects in Hungary as well, in Pécs, Borsod, Tiszapalkonya, Ajka. Debrecen is a city where local buses are already operated by biofuel. Heat and electricity from bio-based origin, together with transportations fuels production will soon star strong competing demands for solid biomass origin supply. Therefore the assessment of biomass resources supply and future biomass potentials are of great importance.

Materials and methods

Scenarios. Climate scenarios can be defined as relevant and adequate pictures of how the climate may look in the future. During our research, we applied the most commonly accepted scenarios presented in international reports, such as

- scenario BASE which is the base of all other scenarios with the parameters of our days
- scenarios created by Geophysical Fluid Dynamics Laboratory (USA), GFDL2535 and GFDL5564 (with a finer resolution),
- UKHI and UKLO (high and low-resolution equilibrium) and UKTR (high-resolution transient climate change experiment) worked out by United Kingdom Meteorological Office (UKMO).

The reference period for these climate scenarios is 1960-1990. For scenario generation, the so-called GCM-s (General Circulation Model or Global Climate Model) are used, in this work GCMs downscaled to Debrecen, the basic object of our calculations, because it's an important centre of agricultural production in Hungary. The scaling of the scenarios for the region Hungary was made in the frame of CLIVARA project (Climate Change, Climatic Variability and Agriculture in Europe).
4M model. In our modelling research we used the 4M model, which has been developed by the Hungarian Agricultural Model Designer Group from the various institutes in the country. It contains several models to describe the physiological interactions of soil - plant systems and offers a possibility of building up different system models in it for the specific purposes of the users need. The CERES model was chosen to be a starting point and was adapted to Hungarian circumstances. The simulations were run for the daily average temperature, precipitation amount and radiation forecasted by climate scenarios.

Modelling maize biomass for the future

Living under changing climate conditions we need to prepare for the future. Energy potential of Hungary is approximately half-half of products and by-products. Maize is an energy crop with significant by-production. We analysed the effects of changing temperature on the proportion of grain, leaf, corn-stalk and root in corn biomass by using the 4M model for different climate scenarios as weather inputs. Debrecen was the center of our research, as one of the most important centres of our agricultural production, as

well. We analysed the impacts of climate change on the growing periods of corn by using the 4M model for different climate scenarios. We examined the effects of changing temperature on the proportion of corn-stalk and leaf mass in biomass, as well. Using biomass as a substitute for fossil fuel is highly prioritized, but the primary aim of agricultural production is food and feed supply. Converting secondary biomass, plant residues to valuable energy products might be a solution. That's why we discuss the secondary biomass quantities (Figure 1). In averages (Table 1) UKHI shows the smallest values, GFDL2 and UKTR predict a little lower quantities, GFDL5 and UKLO higher values compared to the BASE scenario.

Table 1 - Average quantities available for biofuel production predicted by the model, using climate scenarios as weather inputs:

Scenarios	BASE	GFDL2	GFDL5	UKHI	UKLO	UKTR
Biomass (kg/ha)	4977	4254	5538	3842	5727	4665

Since scenarios are given for 31 years, we could analyse them statistically. We got the result that the UKTR scenario doesn't show significant difference comparing to the BASE scenario, the result for UKLO was very similar to the result of the GFDL5 scenario, which shows significant increase in the predicted quantities of secondary maize biomass comparing to the scenario BASE, but GFDL2 and UKHI show much lower values.

Table 2 - Average quantities available for biofuel production predicted by the model, using the meteorological data of the 1960-1990 reference period for the same region:

	biomass	secondary biomass
average	5018,3	2331,6

Comparing these results with the values for the reference period of the climate scenarios (Table 2), we can see that the quantities of the secondary biomass will be larger in the future. The average maize yield for the last decade for this region is 6518 kg/ha, it supports our conclusion that climate change might be good for maize production here.

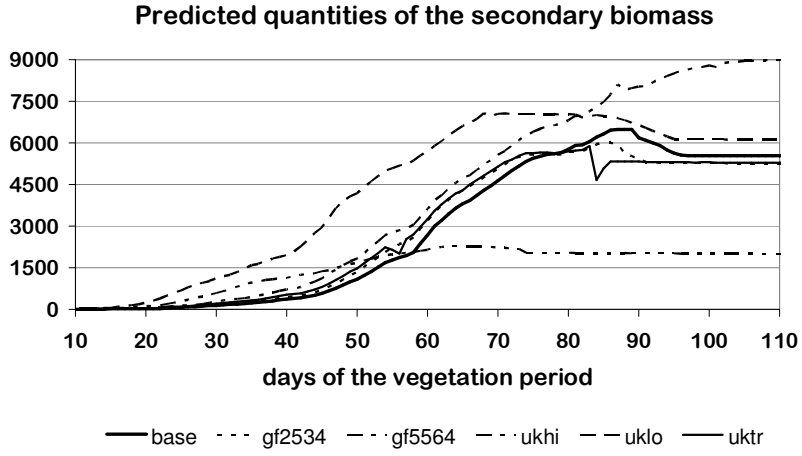

Figure 1. Predicted quantities of the maize secondary biomass, comparing six different climate scenarios for a randomly given year

We analysed the changes in the phenological phases of the plant, as well. Climate change has the effect of shortening the length of the growing periods, plus the starting dates of them are shifting to earlier dates.
The results for the proportion of the parts of the plant of the scenario GFDL2 were very similar to the results for the GFDL5, and the results for the UKTR doesn't show significant difference comparing to the BASE scenario. Next we present the results for the scenario BASE and GFDL5.

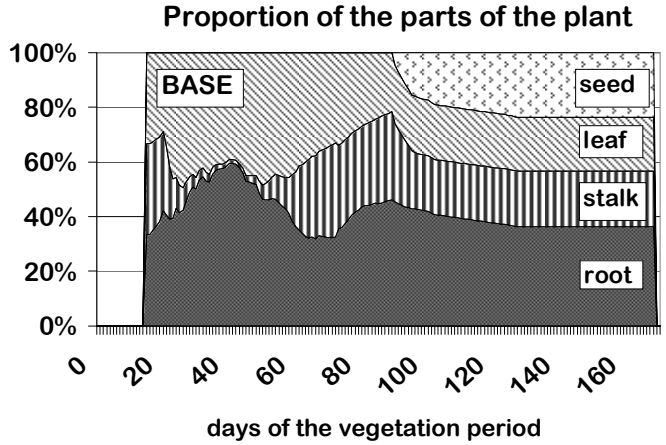

Figure 2 - Biomass proportions of the parts of the corn plant simulated by climate scenario BASE

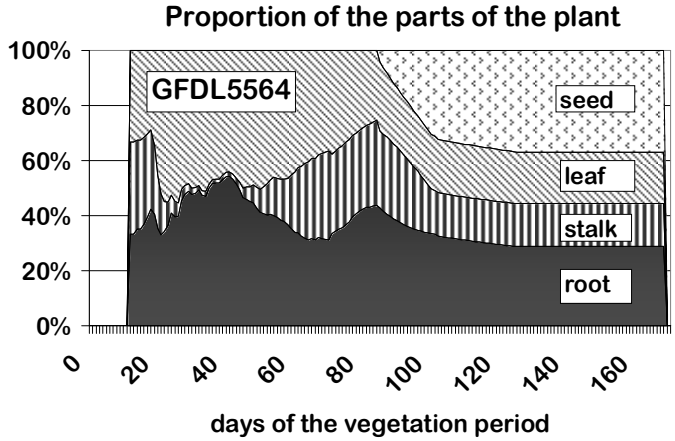

Figure 3 - Biomass proportions of the parts of the corn plant simulated by climate scenario GFDL5564

Conclusion and discussion

The recently released IPCC WGI fourth assessment report is illustrating human influence in warming effect on the global climate. Nowadays, world energy supply is dominated by fossil fuels. Biomass resource sectors such as agriculture are playing a very significant contributing role. In order to accomplish the Kyoto greenhouse gas (GHG) reduction targets, the modern utilisation of biomass has to increase rapidly. Bioenergy gives Europe the best opportunity to reduce GHG emission and secure its energy supply. However, the biomass production should not create additional pressure on the environment. Diversity in energy supply would bring greater economic security and stability for the environment and the society. Moreover socio-economic considerations of renewable energy production have become a trendy new standard, particularly in the field of biomass utilisation. No other renewable energy than biomass is so closely linked with mankind, nature and therefore with the climate and offers a wide playfield for socio-economic discussions. Energy crop has at the same time a high potential to create new jobs and

introduces high-tech applications into rural areas thus offering options to keep trained people in rural villages. Biofuels nowadays are less competitive than fossil fuels. But the largest increase in renewable energy use, in the coming years, will take place in the EU countries driven by strong governmental support. Building the new energy structure based on different bioenergy and RES sources should be the main target, where beside wind, solar and hydro, biomass become sintegrated part of the overall energy strategies with an important sustainable role for bioenergy and biorefineries to play. A terminology as biomass for food, feed, fibres, fuels, and future industrial applications is going to be realized and implemented at increasing speed in this and the coming decades. A full paradigm shift has started in this decade going from fossil fuel dependencies towards biomass and accompanying renewable energy recourses based economies for the societies. Energy crops production will have to compete for land areas with other crops. Energy crops production has been regarded as an interesting issue in most European countries. Research and field trials with different species of energy crops have been performed to estimate yields, growth rate, survival rate, harvesting technology, etc. At year 2030 it will be possible to meet the EU-27 energy demand up to 20% percent of all energy by biomass and biogenic waste, without harming the environment and without competition with food/feed production. Secondly, its role in climate protection is in systematically sequestering carbon dioxide in soils and in plant biomass. Most promising crops for certain agro-climatic conditions have been selected already in some countries. We investigate the potentials of agriculture residues in Hungary. Simulations give us a great opportunity. We think of oil seeds, but also wheat straw as energy sources. These all face several problems, e.g. the need of economical producing procedure, the straw available for energy purposes has to compete with straw requirements of agriculture, etc. The 4M model, which is developed for Hungarian circumstances, is being completed by modules for our modelling research of other energy plants.
Global warming is no doubt here. Fossil fuels are not only harmful but have limited source. With this paper we would like to call the attention to the importance of creating well-designed descriptive-forecasting systems, as well as defining the optimal preparing and response strategies to the conditions in change. The secondary biomass of plants are valuable byproducts, which can be used as sources of renewable energy. Analysing further possibilities of using renewable energy and finding other resources as well, is our important task in adopting to possible changes and saving our environment in the future. We plan to continue our research in climate change impacts in that direction.

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