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Energy Production on Farms - Sustainability of Energy Crops

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Abstract

This article reflects the results of a study on sustainability of energy crops. Contribution to the reduction of the greenhouse effect and other environmental effects were investigated for the Netherlands. The study assumed that energy crops are grown on set aside or grain land.

Generating electricity and/or heat from hemp, reed, miscanthus, poplar and willow have the best prospects. These crops are sustainable and may in the future be economically feasible. Ethanol from winter wheat has the most favourable environmental effects, but is economically not interesting. Liquid fuels from oil seed rape and sugar beet are not very sustainable.

1. INTRODUCTION

Energy from arable crops may be interesting for both agriculture and the environment. Energy crops can provide new opportunities for agriculture; for the environment it can mean a reduction in the greenhouse effect. The Dutch Centre for Agriculture and Environment (CLM) has investigated the contribution of energy crops on limiting the greenhouse effect.

The study was done for Dutch arable farming. CLM has investigated nine energy crops:
- winter wheat and sugar beet, for the production of bio-ethanol to replace petrol;
- oilseed rape, for the production of methyl-ester to replace diesel;
- the annual crops hemp and silage maize and the perennials reed, miscanthus, poplar and willow, for the production of electricity and/or heat.

Besides the contribution of these crops on reducing the greenhouse effect attention was also given to other criteria: the emission of nutrients and pesticides, contribution to aridity, erosion, utilisation of by-products and waste, use of space and the contribution to natural and scenic values.

2. ENERGY CROPS AND GREENHOUSE EFFECT

Presently biomass provides only 2% of the European energy requirement[1]. Since the seventies, the role of biomass in the energy supply has regularly been discussed. In the Netherlands this discussion was initially unfavourable for energy crops, principally due to the low profit and the high cost price of Dutch arable products. The attention drawn by the greenhouse effect and the poor economic circumstances of Dutch arable farming has brought the cultivation of energy crops to the fore once again. Recent studies have shown that energy crops can indeed limit the greenhouse effect[2].

Energy crops have two effects:
- avoiding emissions from fossile energy sources;
- fixation of carbon from CO2 in biomass.

Avoiding emissions from fossile energy sources

Energy from crops replaces fossile energy. Thus, the emission of CO2 caused by using fossile fuels is lowered. Carbon dioxide from the use of energy crops is part of a cycle: it was taken up during the growth of the energy crops. On the other hand cultivation, transport and processing also causes emission of greenhouse gases. The balance can be calculated in terms of the net avoided emission of CO2.

Table 1 indicates the net avoided emission of CO2. Generating electricity by burning reed, hemp, miscanthus and poplar has a great effect on the net avoided emission of CO2 per ha. Producing transport fuels from winter wheat, sugar beet and oilseed rape scores far less favourable on the net avoided emissions.

Fixation of carbon from CO2 in biomass

Energy crops temporarily fix CO2 from atmosphere in biomass. This also contributes to a reduction of an increase of the greenhouse effect. The fixed amount of CO2 correlates with the growth stadium of the crop. However, on a longer term the amount of fixed carbon from CO2 remains the same. On a long term scale, the contribution of fixed CO2 on limiting the greenhouse effect is therefore far less important than the contribution of the net avoided emissions from fossiele fuels. Table 1 shows that over a period of a hundred years the contribution of fixed CO2 is only a few percent of the contribution of the avoided emission from fossile fuels.

Table 1
Net avoided CO2 emission and CO2 fixation, for the Dutch central clay area[3]

energy crop	type of energy	net avoided CO2 emission (ton ha^{-1} yr^{-1})	CO2 fixation, (% of total net avoided CO2 over 100 yr)
reed	electricity, 50 MW powerplant	20.3	1
hemp	electricity, 50 MW powerplant	18.0	1
miscanthus	electricity, 50 MW powerplant	15.3	1
willow	electricity, 50 MW powerplant	14.6	2
maize	electricity, 50 MW powerplant	13.2	1
poplar	electricity, 50 MW powerplant	10.7	7
sugar beet	ethanol	6.9	1
winter wheat	ethanol	3.1	4
oilseed rape	methyl-esther	3.0	2

3. OTHER ECOLOGICAL EFFECTS

Basic assumption in the study is that energy crops are grown on the area that has been set aside and on part of the area that presently is used for grain production. The environmental consequences of this substitution are divided into *direct* and *indirect* effects. Here we just work out a few examples.

Direct effects

Direct effects have to do with the following question: is the environmental burden of energy crops higher than those of fallow land or grain cropping? Examples for direct effects are:

- The use of pesticides in winter wheat is relatively high. Hemp, reed, miscanthus, poplar and willow only need low quantities of pesticides. This means that substituting winter wheat by these crops leads to lower emissions of pesticides.
- Winter wheat and crops on fallow land require little water. Substitution by energy crops leads to increased water use and therefore contributes to higher aridity of the land. This may have negative effects on nature and on agriculture itself.

Indirect effects

Indirect effects are effects on other crops at farm level and effects on a regional and national level:

- At farm level, substitution of fallow and grain land by energy crops has effects on the emission of nutrients and pesticides and on erosion in the rest of the cropping pattern. On Dutch arable farms this concerns sugar beet and potato. In particular, fitting in perennial energy crops leads to intensification of the cropping pattern that may cause problems from an environmental point of view.
- Fitting in energy crops has consequences for natural and scenic values at farm level as well as at a regional level. For example winter wheat and oil seed rape have great potential natural values and can contribute to natural values at farm and regional level in a positive way.
- Growing energy crops also influences the Dutch animal breeding sector, because these crops compete with fodder crops for use of land. If arable farmers grow energy crops instead of grain, there will be less native grain on the market. As most of Dutch grain is processed into animal feed, this means that the imports of raw materials for animal feed will increase. The extra transport of raw materials for animal feed increases the CO_2-emission and causes an extra disturbance of the Dutch national mineral balance.

4. CONCLUSIONS

Table 2 summarises overall results on both ecological and economical sustainability of nine energy crops. Each of the used criteria for ecological sustainability (see §1) is given equal weight. Of course this choice is arbitrary: in practice, the ratios in each situation are different. Given unequal weight the ranking may slightly change. The ranking for economical sustainability is derived from results of other studies[2 4].

Table 2
Ecological and economical sutainability of growing energy crops in the Netherlands

energy crop	type of energy	ecological sustainability	economical sustainability
reed	electricity and/or heat	0/+	+
hemp	electricity and/or heat	0/+	0
miscanthus	electricity and/or heat	0	+
willow	electricity and/or heat	0	+
maize	electricity and/or heat	-/0	0
poplar	electricity and/or heat	0	+
sugar beet	ethanol	-	-
winter wheat	ethanol	+	-
oilseed rape	methyl-esther	-/0	-/0

+ : good long-term perspectives from an ecological and economical point of view
- : low perspectives, compared to the other energy crops

From table 2 we can draw the following conclusions:
- Liquid fuels from oilseed rape and sugar beet and electricity from maize score worst.
- Production of ethanol from winter wheat scores highest in terms of ecological sustainability. But economic studies reveal that the costs per ton CO_2 net avoided are rather high.
- Generating electricity and/or heat from reed, hemp, miscanthus, willow and poplar can be a sustainable way to reduce the greenhouse effect.

Generating electricity from crops will be profitable in the Netherlands in the near future, if the set-aside scheme of the European Union is continued and an environmental tax on energy or a subsidy per ton of avoided CO_2 is introduced. But opportunities for energy crops are better in other European countries, due to the intensive Dutch arable farming and high land prices. The long-term perspectives for energy crops are uncertain. Therefore it is advisable to investigate at a European level what other future functions for the land may be supplanted by energy crops.

5. REFERENCES

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