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Hauggaard-Nielsen, Henrik; Thomsen, Mette Hedegaard; Petersson, Anneli; Maarschalkerweerd, Christian van; Nielsen, Lars Henrik; Thomsen, Anne Belinda; Jensen, Erik Steen

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Henrik Hauggaard-Nielsen, Mette Hedegaard Thomsen, Anneli Petersson, Christian van Maarschalkerweerd, Lars H. Nielsen, Anne Belinda Thomsen and Erik Steen Jensen. Technical University of Denmark, RISØ National Laboratory, Biosystems Department, 4000 Roskilde, Denmark

Introduction

It is very much debated whether bioethanol is a sustainable energy resource that can offer environmental and long-term economic advantages over fossil fuels, like gasoline or diesel. From the present first generation bioethanol technology focusing on starch (from grain) fermentation GHG savings are only modest. The Danish Integrated Biomass Utilisation System (IBUS) has developed both first generation and second generation principal bioethanol technologies characterised by integration with an existing coal-fired Combined Heat and Power (CBH) plant.

To secure that bioenergy is produced from local adapted raw materials with limited use of non-renewable fossil fuels there is a need for integrating the biomass starting point into the energy manufacturing steps. Substitution of fossil fuels by crop biomass requires the right selection of plant species according not only to chemical quality for efficient conversion but also to secure the development of ecologically benign farming system including biomass for energy.

The aim of the present study was to question how to optimise GHG savings for bioethanol production using the IBUS technology.

Discussion

Looking at the entire ethanol production cycle, biomass production and thereby management is a very prominent source of GHG emissions, respectively 60-70 % of total LC emissions for wheat grain ethanol and 30-45 % for wheat straw based ethanol when utilizing the Danish IBUS concept.

Nitrogen (N) fertilization is responsible for more than 85 % of GHG emissions from wheat grain production in Denmark (Fig. 1). The energy intensive production of N-fertilisers and soil emissions of N_2O (directly linked to the application of N-fertilizer which is significantly increasing the nitrification and denitrification activity) contribute with approximately equal weight to the 85 % share. The remaining emissions primarily originate from diesel combustion for traction. Straw can be regarded as a by-product from existing cultivation and hence no incremental cultivation is required which is reducing GHG costs. Nevertheless, removal of straw has a negative impact on the carbon sink in the soil, which in turn is detrimental to the overall GHG balance for straw based ethanol production. However, soil carbon reducing effect of straw removal can be compensated for by benign choice of cultivation practise. In order to achieve sustainable ethanol production it is thus of outmost importance to focus on the choice of feedstock and the cultivation patterns.

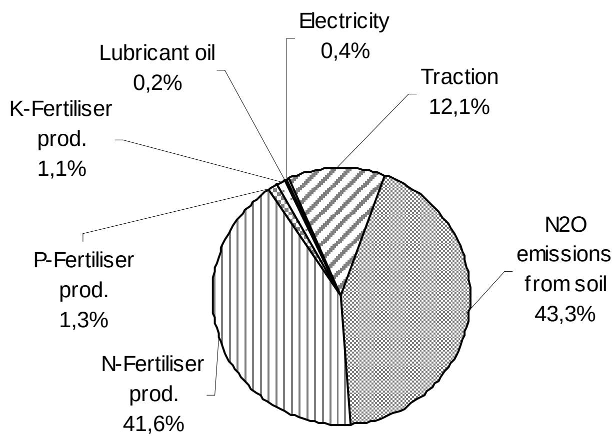

Figure 1. GHG emission sources from Danish wheat grain production taken from LCA Food (2006) and modified in order to be in accordance with the most recent IPCC guidelines (IPCC 2006) and their share of total emissions in percent

While the production of bioethanol from sugars and starch (grain) is straight forward, whereas the production from lignocellulose (straw) creates additional technical challenges. Straw contain cellulose and hemicellulose that are bound together by lignin. Cellulose and hemicellulose are both polymers built up by long chains of sugar monomers which first after pretreatment steps like e.g. heating up under pressure are ready for enzymatic hydrolysis following microbial ethanol fermentation. Bioethanol from straw can be produced from quite different species like winter rye (*Secale cereale* L.), crucifers like oilseed rape (*Brassica napus* L.) and legumes like faba bean (*Vicia faba* L.) although with different efficiencies (Petersson et al., 2007). However, there is a need to optimize the pretreatment and a strain or combination of strains or microorganisms for each raw material so that all sugars are effectively converted into bioethanol. Cereal species and crucifers are strongly dependent on soil N availability and can therefore from GHG point of view be expensive to produce. However, in areas with high levels of animal manure, crops with high N demand is important to limit N leaching. Contrary, legumes like faba bean can benefit the farming system via biological N_2 fixation inputs and by its effect as break crop for rotational cereal diseases, like crucifers, potentially reducing the need for both N fertilizers and pesticides. Other options reducing GHG emissions are the use of intercropping strategies manipulating plant interactions in time and space to maximize growth and productivity reducing the need for not only fertilization but also pesticide use due to crop diversification in both time and space.

Different crop species and cropping systems offer different ecosystem services, which should be validated together with their ethanol production potential. With appropriate crop management strategies utilization of straw generates GHG savings and the grains can still be traded as an important food source.

References

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