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Technical Note

The life cycle emission of greenhouse gases associated with plant oils used as biofuel

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ABSTRACT

Life cycle assessment of greenhouse gas emissions associated with biofuels should not only consider fossil fuel inputs, but also N_2O emissions and changes in carbon stocks of (agro) ecosystems linked to the cultivation of biofuel crops. When this is done, current plant oils such as European rapeseed oil and oil from soybeans and oil palms cultivated on recently deforested soils have higher life cycle greenhouse gas emissions than conventional diesel.

1. Introduction

Hossain and Davies have reviewed the use of plant oils as fuel for compression ignition engines and the life cycle analysis (also called: life cycle assessment) of such oils [1]. They concluded that raw plant oils have considerable advantages over conventional, fossil fuel-based, diesel as regards life cycle greenhouse gas emissions. The studies that they used to support this conclusion focus on fossil fuel inputs in the plant oil life cycle.

However, the greenhouse gas emissions linked to fossil fuel inputs are not the only greenhouse gas emissions associated with the plant oil life cycle.

Firstly, greenhouse gas emissions may be associated with changes in carbon stocks of (agro) ecosystems linked to oil crop cultivation [2–7]. Such changes are partly directly linked to crop cultivation. For instance, growing rapeseed in Europe is, on average, on arable soils losing carbon [8] and oil palm plantations in South East (SE) Asia are usually on recently deforested soils [4–6]. In both cases changes in (agro) ecosystem carbon stocks lead to net emissions of carbonaceous greenhouse gases [4–6,8]. The effect on carbon stocks of (agro) ecosystems may also be indirect. This follows from the high inelasticity of demand for food and feed [3]. When there is a rapid expansion of oil crop production on existing arable soils to be diverted to biofuel use, much of the shortfall in supply of plant oil for food and feed has to be met by expansion of agricultural land elsewhere [3]. This in turn may lead to changes of (agro) ecosystem carbon stocks, which give rise to net emissions of greenhouse gases [3].

Secondly, the assessment of greenhouse gas emissions associated with the life cycle of plant oils should consider emissions of the potent greenhouse gas N_2O linked to cultivation of oil crops [9,10]. As data regarding the actual emission of N_2O, given the wide variety of conditions for oil crop cultivation, are very limited, a rather wide range of N_2O emissions should be used in life cycle assessment [8].

2. Life cycle assessments of current plant oils

Only a limited number of life cycle assessments are available not only considering life cycle fossil fuel inputs, but also N_2O emissions and changes of carbon stocks linked to the current cultivation of plant oil crops. Such studies deal with greenhouse gas emissions in two ways. One way is to focus on the time to 'pay back' carbon debts linked to large changes in carbon stock, for instance caused by deforestation [2]. The other way usually starts from the convention that such large changes of carbon stocks can be amortized over 20 years [6,8].

Studies dealing with changes of carbon stocks in the latter way are available for three current types of plant oil: palm oil from recently deforested soil in SE Asia [6], soybean oil from recently deforested soil in Brazil [8] and rapeseed oil from existing arable soil in Europe [8]. The study regarding European rapeseed oil [8] does not include indirect effects on carbon stocks following from the inelasticity of edible oil demand for feed and food. The conclusion from these studies [6,8] is that the greenhouse gas emissions associated with the life cycle of the oils considered are larger than the corresponding emission associated with conventional fossil fuel-based diesel.

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Studies dealing with the time to pay back the carbon debt associated with the use of current plant oils are available for palm oil and soybean oil, both from tropical regions [2,4–6]. In the case of palm oil, the time to pay back the carbon debt is probably in the order of 60–100 years when oil palms are cultivated on mineral soils after recent deforestation [2,4] and in the order more than one century to over nine centuries, when the oil palms are cultivated on peat [4–6]. When soybeans are cultivated for oil on recently deforested land, the carbon pay back time is in excess of 300 years [4]. These studies of carbon pay back times [2,4–6] are consistent with the outcomes of the life cycle studies amortizing large changes in carbon stocks over a 20 year period, as the pay back times estimated for palm oil and soybean oil are much in excess of 20 years.

3. Conclusion

When life cycle assessment of greenhouse gas emissions associated with biofuels not only considers fossil fuel inputs, but also N_2O emissions and changes in carbon stocks of (agro) ecosystems linked to the cultivation of biofuel crops, current plant oils such as European rapeseed oil, and soybean and palm oil from recently deforested soils have higher life cycle greenhouse gas emissions than conventional diesel.

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