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Ethanol from sugarbeet in The Netherlands: promising biofuel yields and GHG emission reduction

W.J. Corré [1] & J.W.A. Langeveld [1,2]

Background

The contribution of biofuels to combat climate change is debated as it may have negative effects on biodiversity and food prices while its potential gain in greenhouse gas (GHG) emission reduction is considered too low. Thus, feedstocks are called for that combine high biofuel yields and energy gains with significant GHG emission reductions. Sugarbeet, commonly cultivated in the EU, may meet these objectives. We evaluated biofuel yields, energy efficiency and GHG emissions of ethanol production from sugarbeet in The Netherlands.

Methodology

Sugar beet energy production and GHG emission reduction were calculated using observed crop yield and transportation data and literature figures on ethanol conversion[3,4]. The Energy Crop Simulation Model (E-CROP) was used to calculate energy yield and GHG emissions of three production chains: ethanol plus animal feed (option A), as (A) but fermenting pulp for biogas production (B), as (B) but also fermenting beet leaves (C). Biogas produced in (B) and (C) is supposed to replace natural gas. Option (D), ethanol production from sugar cane in Brazil[5] is added for comparison.

Results

Total tuber yield is 74 ton ha^{-1}, sugar yield including heads is 12.5 ton ha^{-1}. Ethanol and methane yield is 5.5 ton ha^{-1} ((A) to (C)) and 0.7 and 1.8 ton ha^{-1} respectively ((B) and (C)). Gross and net energy production are presented in Figure 1. Gross energy yield ranges from 176 GJ ha^{-1} for (A) to 276 GJ for (C). Net energy production varies between 93 GJ ha^{-1} (A) and 170 GJ (C). Similar patterns were found for GHG emission reduction: highest gross reduction (18 ton CO_2-eq. ha^{-1}) is realised in (C). Highest net emission reduction (10 ton CO_2-eq. ha^{-1}) is also realised in (C). Net energy production and net GHG emission reduction in (C) exceed those for Brazilian sugar cane ethanol (including ethanol transport to Europe).

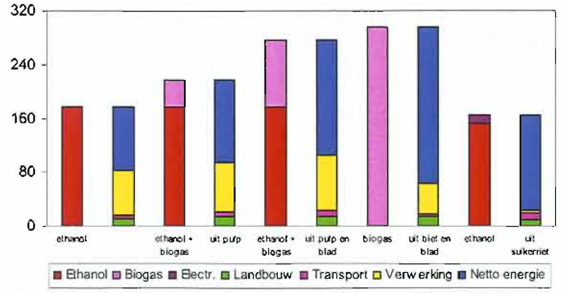

Figure 1. Gross and net energy production (GJ/ha) from sugar beet ethanol (A, B, C) and biogas (B, C) as well as sugar cane (D) production. See text for explanation.

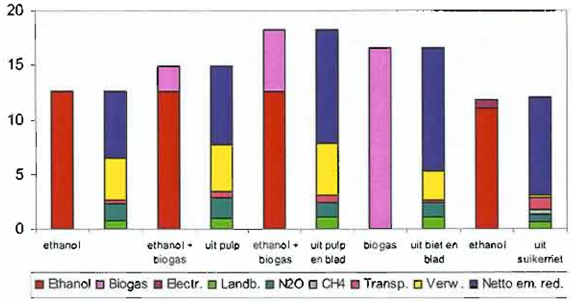

Figure 2. Gross and net GHG emission reduction (ton CO_2-eq./ha) for sugar beet ethanol (A, B, C) and biogas (B, C) as well as sugar cane (D) production. See text for explanation.

Discussion

High crop yields and efficient cultivation practices allow high energy yields per ha. Ethanol yields exceed those of other temperate crops and are similar or superior to sugar cane yield. Net energy yield and net GHG emission reduction of (C) exceed those of Brazilian sugar cane[5] (which suffers from inefficient burning of bagasse), and of lignocellulosic ethanol[6]. Net GHG emission is surprisingly high. Reduction of (B) is similar to that to lignocellulosic ethanol but inferior to Brazilian sugar cane, but reduction for (C) is similar to Brazilian cane and, hence, superior to lignocellulosic ethanol.

Conclusion

High yields and efficient beet production in The Netherlands allow surpsingly high energy and GHG reduction data. Combining ethanol production with crop residue fermentation realises an environmental performance that is similar or superior to those of lignocellulosic or imported Brazilian sugar cane ethanol.

[1] **Plant Research International B.V.**
P.O. Box 16
6700 AA Wageningen, The Netherlands
Tel: +31 317 47 59 09 – Fax: +31 317 41 80 94
E-mail: wim.corre@wur.nl

[2] **Current adress: Biomass Research B.V.**
P.O. Box 247
6700 AE Wageningen, The Netherlands
Tel: +31 6 520 58 537
E-mail: hans@biomassresearch.eu

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