Life Cycle Environmental Impacts of Non-Cellulosic Fermentable Sugars for the Production of Biofuels and Chemicals

Biological Systems Engineering
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National Institute of Food and Agriculture

Introduction

Biofuels, and commodity biochemical rely mostly on fermentable carbohydrate from agricultural feedstocks, and usually the agricultural feedstock is a dominant source of environmental impacts as can be inferred from several studies (Tokunaga et al., 2014, Cai et al. 2013). Therefore, choosing a low environmental impact feedstock for fermentable carbohydrate is imperative to establish a sustainable biofuels and commodity renewable chemical industry (Figure 1).

In this research, we focus on the easily extractable sources of carbohydrates from energy cane, sweet sorghum, sugar beet and corn in the US and Brazilian sugar cane. The location of the study (Figure 2) is the gulf coast for the production of energy cane and sweet sorghum, the red river valley for sugar beet, Midwest in the US for corn, and southcentral Brazil for sugar cane. The boundary of the study includes the production of the agricultural feedstock, transportation of feedstock and the production of fermentable carbohydrate (Figure 3).

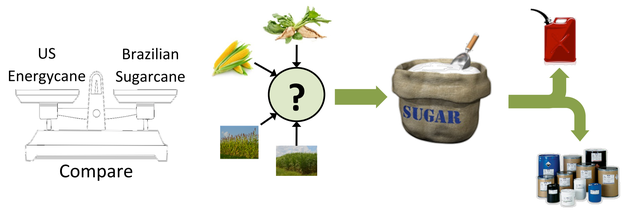

Figure 1. Currently viable sources of fermentable sugar for biofuel and commodity chemicals production to reduce environmental effects.

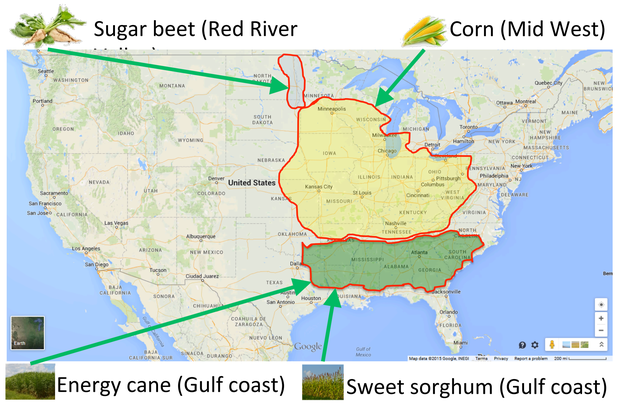

Figure 2. US domestic production regional boundaries.

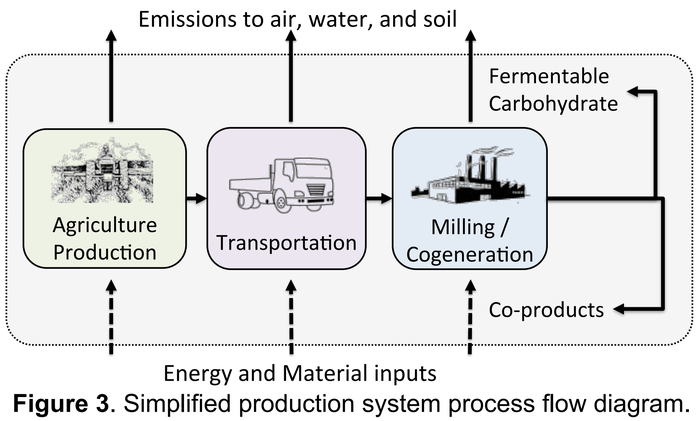

Figure 3. Simplified production system process flow diagram.

Results

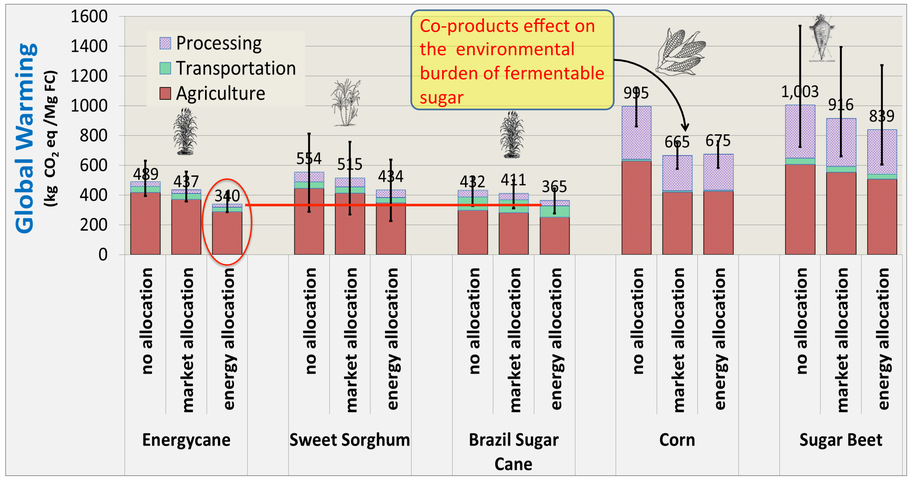

Figure 4. Energycane is the fermentable carbohydrate feedstock with the lowest **emission of greenhouse gas** when allocation is by energy.

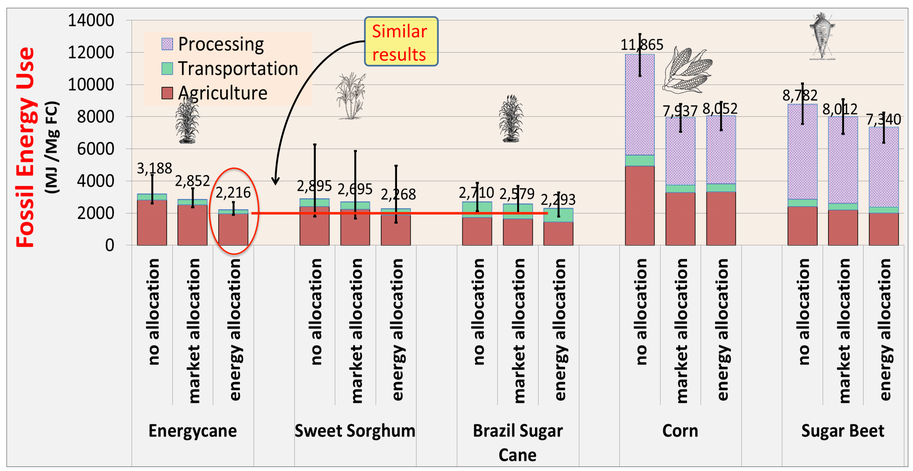

Figure 5. Energycane has the lowest use of **fossil energy use** for production of fermentable carbohydrates when allocation is by energy.

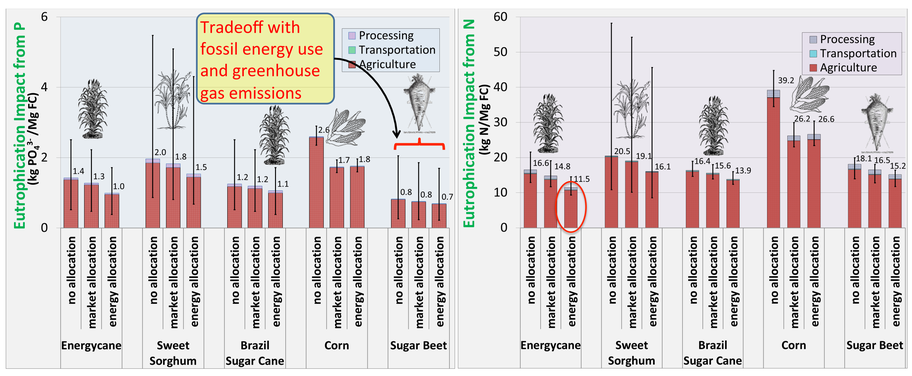

Figure 6. Sugar beet has the lowest freshwater **eutrophication impact**. Energycane has comparable eutrophication impact on fresh and saltwater to sugar beet.

Method

Environmental Life Cycle Assessment (LCA) was used to account for emissions and resource consumption from the main production phases starting from resource extraction to production of fermentable carbohydrate (Figure 3).

Conclusions

- Fermentable sugars from Energycane and sweet sorghum can be produced in the gulf coast with similar impacts to Brazilian sugar cane.
- Energycane and sweet sorghum have the lowest greenhouse gas emissions of the US feedstocks evaluated.
- Sugar beet has high greenhouse gas emissions and use of fossil fuel, but it has relatively low eutrophication potential.
- Sweet sorghum and energycane have comparable impacts, can grow under similar conditions, and requires the similar processing technology, so they can be coupled as feedstocks to increase mill utilization.
- Quantity of co-products reduces the impacts per unit of fermentable carbohydrate significantly.
- Agriculture is the activity with the highest emissions of greenhouse gas.
- Allocation by energy did not differ significantly from allocation by market values.
- Rather than identify a single solution, Life Cycle Assessment helps to illustrate the complexity of evaluating alternative, so that tradeoff and issue of shifting environmental burden in other countries are identified.

Planned Work

Assess the environmental impact of commodity chemical isoprene produced from the fermentable carbohydrates considered in this study

References

Tokunaga, K., & Konan, D. E. (2014). Home grown or imported? Biofuels life cycle GHG emissions in electricity generation and transportation. *Applied Energy*, 123-131.

Cai, H., Dunn, J. B., Wang, Z., Han, J., & Wang, M. Q. (2013). Life-cycle energy use and greenhouse gas emission of production of bioethanol from sorghum in the United States. *Biotechnology for Biofuels*.

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