Advanced Bioethanol Potential of a New Value Chain Based on Innovative Food/Energy Cropping System

Walter Zegada-Lizarazu, Andrea Parenti, Andrea Monti

Department of Agricultural and Food Sciences, University of Bologna, Viale G. Fanin 44 – 40127, Bologna, Italy. Corresponding author: walter.zegadalizarazu@unibo.it

Introduction

The majority of existing advanced ethanol value chains are sourced from marginal, underutilized and/or contaminated lands with dedicated perennial energy crops, short rotation coppice or from food crop residues. The contribution of such areas have to be significantly increased. In temperate areas of EU there is a broad venue for double cropping and therefore the development of advanced biofuels. The double cropping with crops rich in carbohydrates and with high yields, can lead to increased feedstock availability for biofuels, increased yield stability, complementarity of food/energy production with no competition, and a significant GHG emission reduction.

This study aims at evaluating the potential ethanol produced by a new advanced ethanol value chains sourced by agricultural residues and dedicated energy crops integrated in existing cropping schemes, avoiding competition with food crops and existing markets.

Materials and Methods

Innovative cropping systems

Main Crop	Use	Harvest time	Double crop: Biomass sorghum YR (%)	Double crop: Sunn hemp YR (%)
Barley	forage	May-June	25	25
	grain	June	25	50
Italian ryegrass	forage	April-May	0	0
	seed	June	25	50
Maize	grain	August	/	/
Oat	forage	April-May	0	0
Rapeseed	oil	June	25	50
Rye	forage	April-May	0	0
	seed	June	0	50
Wheat	forage	May-June	0	25
	grain	June	25	50
Triticale	forage	May-June	25	25

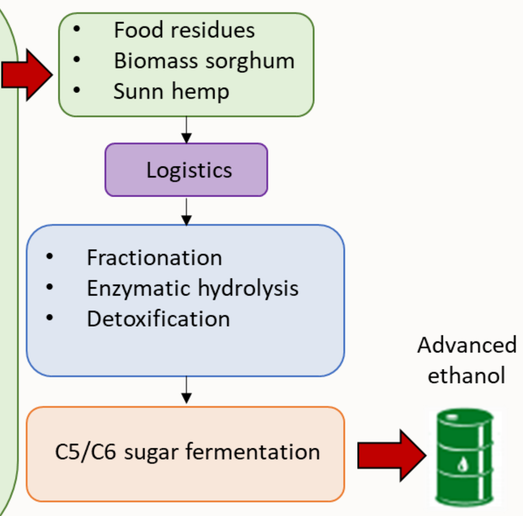

Figure 1. Value chain overview starting from innovative cropping systems (main crop + double crop) feedstocks until the final advanced biothanol production.

- Cropping systems: cultivation and harvest was carried out at the experimental farm of the University of Bologna and compared to existing literature.
- Logistics: as for food crop residues handling and storage are referred to the common practices of agricultural contractors for straw and hay with bales of the same size.
- Conversion: hydrolysis and sugar fermentation yield for the selected feedstocks is literature based.
- Emilia-Romagna simulation: a fine-grained (parcel level, LPIS data) spatial analysis based on geo-referenced data was carried out to calculate the regional feedstock availability. Three scenarios with increasing feedstock production were simulated in Emilia-Romagna:
    - **Scenario 1** (baseline): food residues (straw + stover) to advanced bioethanol
    - **Scenario 2**: food residues + double crops with low input (no irrigation) to advanced bioethanol
    - **Scenario 3**: food residues + double crops with higher input (irrigation) to advanced bioethanol

Results

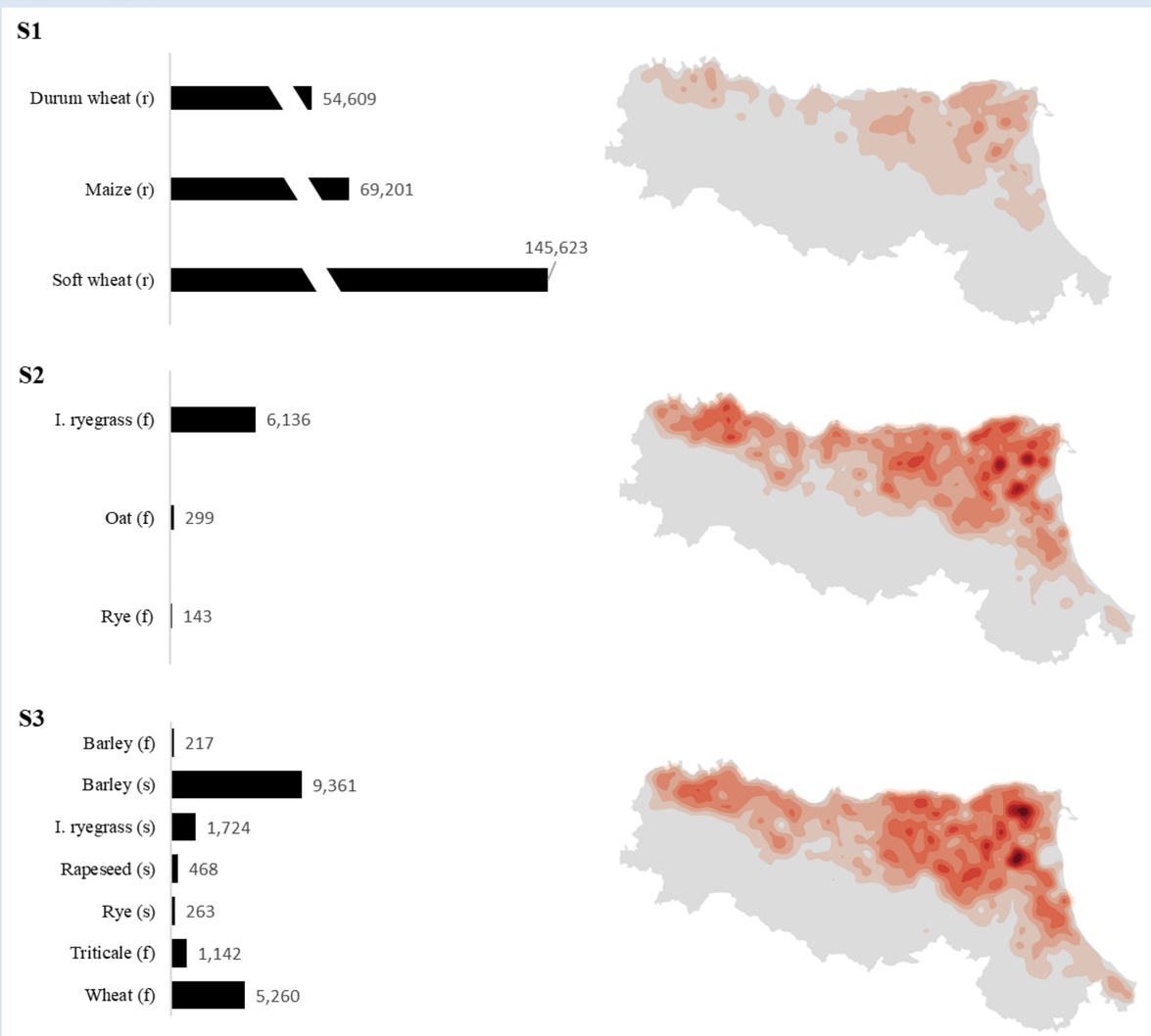

Figure 2. Emilia-Romagna regional mapping to detect available land for the defined double cropping schemes. On the left-hand side the winter cereal cropland in hectare, selected for double cropping. On the right-hand side, the aptial simulation of the biomass to bioethanol availability.

Results highlights that biomass sorghum was able to supply up to 20 Mg ha $^{-1}$ of dry biomass, which was double compared to sunn hemp, and stover. Straw yielded an average of 5 Mg ha^{-1}, even though it showed the highest total (C5, C6) sugar content compared to maize stover, biomass sorghum, and sunn hemp. In general, from S1 to S3 there is an increased feedstock availability (Fig.2), highly concentrated in the eastern part of Emilia-Romagna. The overall estimated ethanol produced per unit of land is highest for biomass sorghum then maize stover, wheat straw and sunn hemp. The potential bioethanol production estimation at the regional level ranged from 164 ML (S1) to 435 ML (S3) of ethanol which can replace from the 22% (S1) to 57% (S3) of the regional annual consumption.

Conclusions

The simulated value chain can potentially benefit of significant amount of feedstock from the innovative cropping systems, which can reduce the regional fossil fuel dependency in the short-term without affecting food production.

Acknowledgements: **BECOOL receives funding from Horizon 2020 (H2020) under the grant agreement No. 744821**