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May energy crops help to mitigate climate change? Environmental and economic assessment of triticale cultivation as energy crop in Spain.

Life cycle assessment of Triticale (*Triticum ssp x secale cereale*) cultivation has been conducted to analyze its environmental contribution to mitigate climate change. To do so, all the burdens along the agricultural life cycle have been computed, from field works to fertilization and biocides including also transportation of raw materials and biomass transport to power plant or storage facility. Economic analysis of triticale has been carried out by calculation of production costs and its profitability. Those activities have been carried out within the PSE-OnCultivos project, financed by the Spanish National R+D Plan and *partially funded by the European Regional Development Fund (ERDF).*

Inventory has been performed using field data about agricultural practices in three different Spanish provinces (Navarra, Soria and Cáceres), covering 58 hectares under Mediterranean climate conditions. Economic and agricultural data from Navarra parcels have been supplied by Acciona Company, while Soria and Cáceres data plots come from Soriactiva nonprofit foundation. IPCC methodology (IPCC, 2007) has been used to estimate greenhouse gases emissions and cumulative energy demand is the chosen method to the energy balance analysis.

Scenarios	Unit	Navarra	Cáceres	Soria
Agriculture campaign		2011	2011	10 /11
Harvested area	Hectares	12.83	15.14	30.22
Yield	Kg/ha	7875	5548	8767
Applied seeds	Kg/ha	200	180	187
NPK fertilization	Kg/ha	250	150	354
Urea	Kg/ha	220		
NAC	Kg/ha			339
Organic Fertilization	Kg/ha			2658
Biocides	l/ha	0.013		0.23
Fuel consumption	l/ha	61.28	161.87	67.16

Table 1. Scenarios characteristics and map location

Stage	Operations
Field preparation	Chiselling and ploughing
Field work	Seeding and seed production (Mangado *et al.*, 2008; Polo, 2010)
Fertilisation	Fertiliser application on field
Biocides	Biocides application on field
Biomass harvest	Harvesting
Biomass collection	Baling and loading
Inputs transport	Seeds, fertilizers and biocides transport
Biomass transport	Biomass transport to facility gate

Table 2. Description of agricultural operations

Environmental behavior of the three analyzed scenarios shows fertilization phase as the most important contribution to global warming, both the manufacture of fertilizer and its application in the field. The next activity that contributes to the impact is related to seed production and sowing. The rest of the steps clearly generate less impact in the three provinces under study. (Figure 1). More detailed focus on aggregated data for the three scenarios, covering the most important gases that contribute to climate change, shows (in figure 2) that nitrous oxide is responsible of the largest emissions (expressed in kg of CO2 equivalents) followed by carbon dioxide emissions and to a much lesser extent, methane emissions.

Figure 1. GHG emissions of scenarios by stages (kg CO_2 eq/kg biomass)

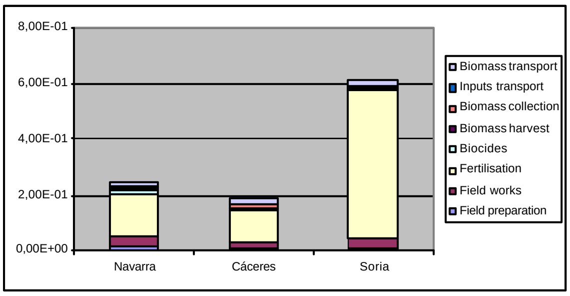
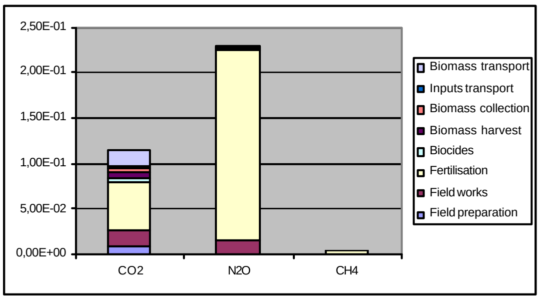


Figure 2. Aggregated GHG contribution by stages (kg CO_2 eq/kg biomass)



The distribution of the greenhouse gases emissions by location show the same pattern in all of analyzed plots. Nitrous oxide presents a clear relevance in global warning impact category (Figure 3). Analysing fertilization phase by dividing all the sub-steps (manufacture of fertilizers in the factories, nitrogen oxide emissions released when fertilizers are applied to the field and fertilizer distribution with agricultural machinery) gives as result the figures showed in Figure 4.

Figure 3. GHG contribution by scenarios (%)

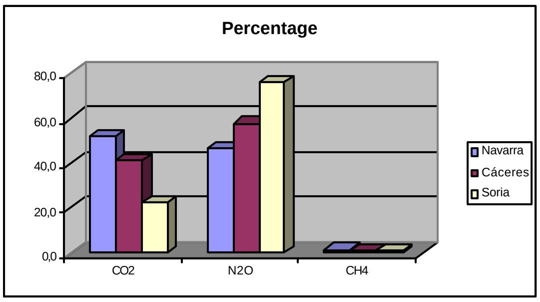
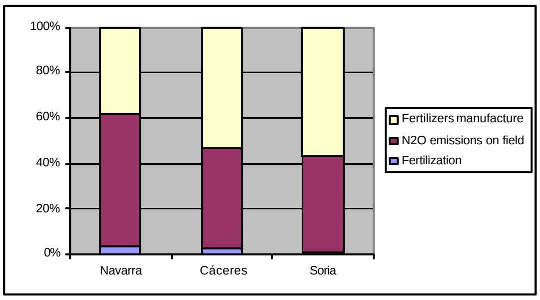


Figure 4. GHG distribution by sub-steps into fertilization phase (%)



Additionally, the economic analysis has shown that costs and revenues vary from one region to another. In general, the main component of the cost lies in the use of machinery and the main component of revenues lies in sales. The economic performance shows a current profitability about 305 €/Ha. This first approach seems to indicate that the profitability of this crop could be similar to a reference one so it could become a commercial crop.

Figure 5. Agricultural costs [€/Ha]

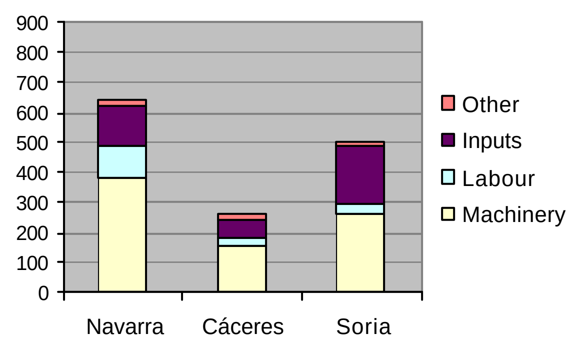
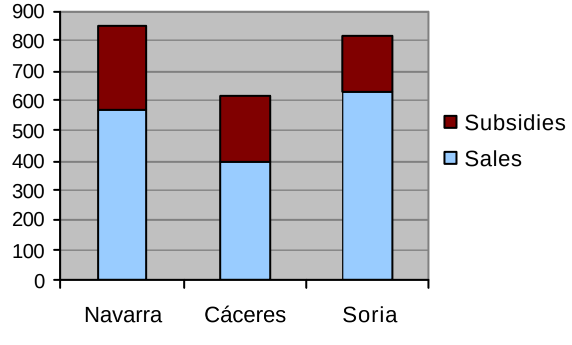


Figure 6. Agricultural costs [€/Ha]



Providing reliable data from demonstration plots on field would help to decisions planning about energy crops policy in the future. Fertilization phase clearly provokes the major impacts on climate change. Therefore, the incorporation of best practices in fertilizer factories and better understanding of N_2O dynamics in soils as well as the incorporation of climatic conditions into nitrogen oxide emission calculations are crucial.

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