Comparing nitrogen fluxes in different cropping systems dedicated to lignocellulosic biomass production

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Introduction

To reduce anthropogenic greenhouse gas emissions and replace fossil fuels, UE policies support the production of 2nd generation biofuels *i.e* produced from lignocellulose of dedicated crops, like *M. giganteus*, or crop residues, like cereal straws. Modeling biomass production and environmental impacts of cropping systems dedicated to biomass production over the long term is needed to evaluate their sustainability. We used the agro-environmental STICS model (Brisson et al., 2008) after its adaptation to perennial crops (Strullu et al., 2014) to realize long term simulations.

This study aimed at comparing lignocellulosic biomass production and environmental impacts (nitrate concentration in drained water and N balance) of cropping systems based on annual or perennial crops.

Material and methods

- Simulations were run in three sites, varying for climate and soil characteristics, at Estrées-Mons (northern), Varanges (eastern) and Lusignan (western France).
- Simulated annual cropping systems were representative of local agriculture (**Figure 1**).
- For each sites, the results of simulations were validated with experimental data for *M. giganteus* biomass production and regional mean yields for annual crops.
- Six scenarios were simulated on 20 years (**Table 1**).

Figure 1: Representative annual cropping systems used for scenarios **S1-S2**

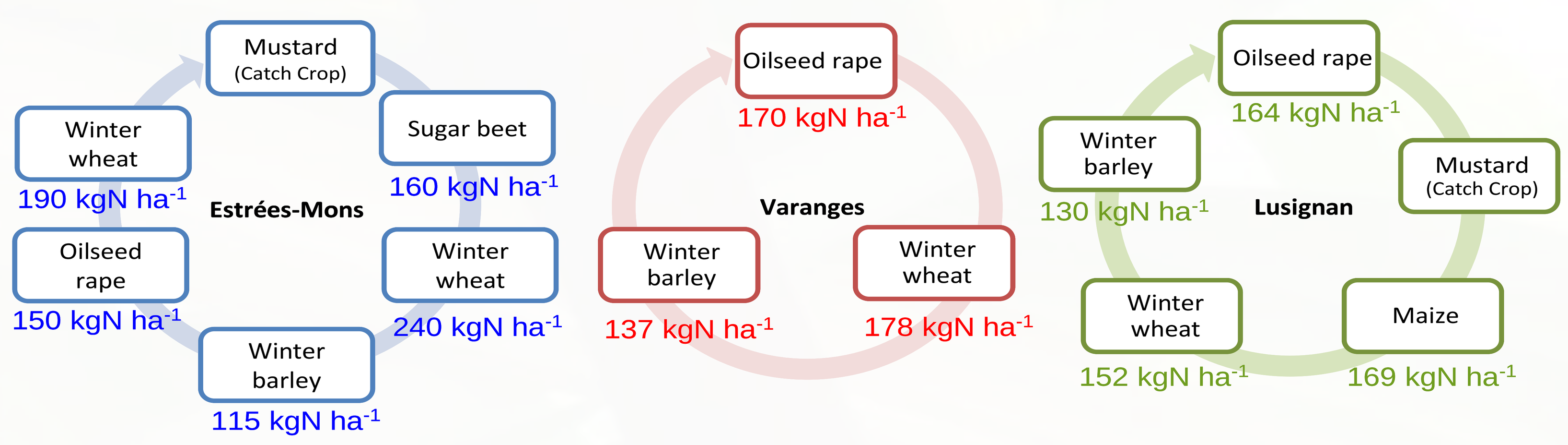

Table 1: Different scenarios (**S1-S6**) compared during this study.

Scenario	S1	S2	S3	S4	S5	S6
Crops	Annual crops (Fig. 1)		Perennial crop (*M. giganteus*)			
Lignocellulosic biomass	No	Yes (cereal straws)	Aboveground biomass (stems + leaves)			
Annual N fertilization	115 to 240 kg N ha^{-1}		0 kg N ha^{-1}	80 to 120 kg N ha^{-1}	0 kg N ha^{-1}	50 kg N ha^{-1}
Harvest date	Physiological maturity		October 15		March 1	

Results

1. Biomass production (Table 2)

- Biomass production was highest in scenarios **S3** to **S6**.
- Early harvest of *M. giganteus* resulted in a higher biomass production when N fertilization was applied (**S4**).

	Estrées-Mons	Lusignan	Varanges
S1	0.0	0.0	0.0
S2	4.6	3.4	4.0
S3	16.6	18.2	16.0
S4	21.7	18.9	18.1
S5	17.7	16.0	14.5
S6	18.4	16.1	15.6

Table 2: Annual lignocellulosic biomass production (t DM ha^{-1} yr^{-1}).

2. Amount of drained water and its nitrate concentration (Figure 2)

- Drainage and leaching were little affected by straw management (**S1** *vs* **S2**).
- Scenarios **S3** to **S6** improved water quality but can reduced water drainage.

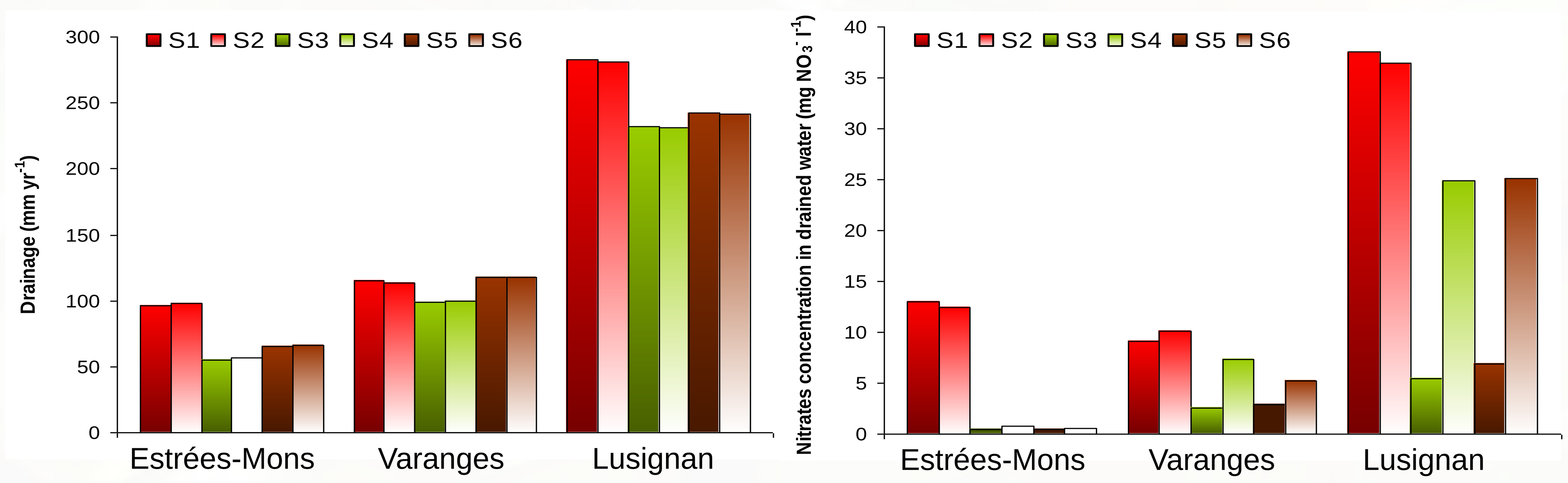

Figure 2: Annual water drainage (mm yr^{-1}) and nitrate concentrations in drained water (mg NO_3^- l^{-1}).

3. N balance (Figure 3)

- N balance = N inputs (N fertilization + N deposition) – N outputs (harvest)
- Removal of cereal straw lead to a 2 fold decrease of the N balance (**S1** *vs* **S2**).
- **S3** and **S4** lead to a negative N balance whereas **S4** and **S6** had a slightly positive N balance.

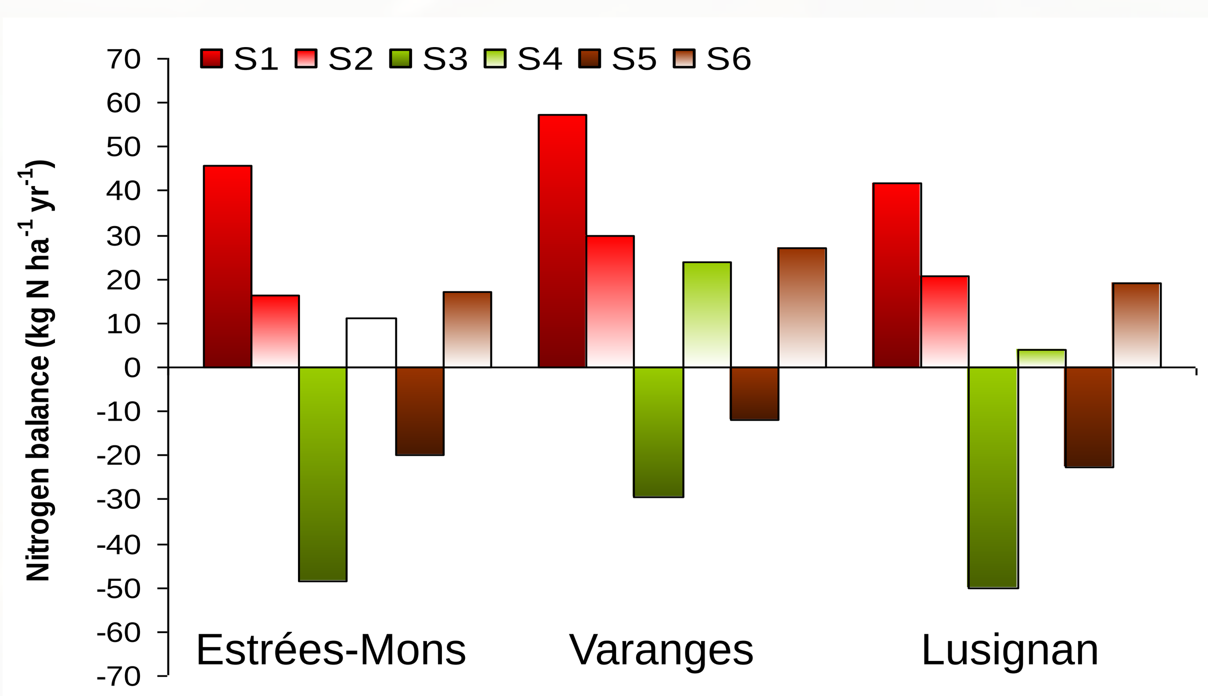

Figure 3: Annual N balance (kg N ha^{-1} yr^{-1}).

Conclusions

- **N fertilization is required to maintain soil fertility** and biomass production of perennial cropping systems on the long term.
- **Perennial cropping systems** with *M. giganteus* can **ally high productivity and water quality**.
- **Perennial cropping systems** could be used efficiently to **protect environmentally sensitive environments**.

References:
- Brisson N, Launay M, Mary B, Beaudoin N 2008. Conceptual basis, formalisations and parameterization of the STICS crop model. QUAE, Versailles, France 297p.
- Strullu L, Beaudoin N, de Cortazar-Atauri IG, Mary B 2014. Simulation of biomass and nitrogen dynamics in perennial organs and shoots of *Miscanthus × giganteus* using the STICS model. Bioenergy Research. DOI 10.1007/s12155-014-9462-4.

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