

Water, nitrogen and carbon balance of bioenergy crops: impact of crop species and cropping practices



Fabien FERCHAUD and Bruno MARY
AgroImpact Unit

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Main objective and hypotheses

Main objective:

To compare different agricultural systems for bioenergy production in terms of water, N and C balances

Two main hypotheses:

- ❖ 1) The functional diversity of candidate crops affects the sink-source relations within the agroecosystem and changes the water, N and C cycles

- ❖ 2) Cropping practices can modify those effects
 - N fertilisation
 - Harvest date of perennial crops

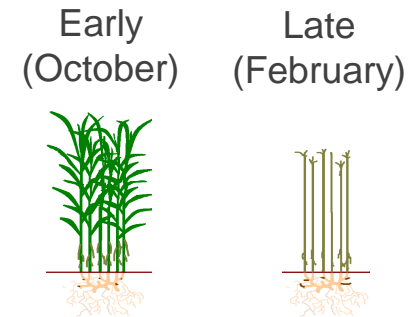
Experimental treatments

❖ Field experiment established in 2006 at INRA station in Estrées-Mons

❖ A wide range of bioenergy crops:

- *Miscanthus* × *giganteus*
 - Switchgrass
 - Fescue – Alfalfa
 - Alfalfa – Fescue
- } In rotation every 3 years
- Sorghum - Triticale
 - Triticale - Sorghum

❖ Two harvest dates (perennials)



❖ Two nitrogen treatments

Crop	Fertiliser-N rate (kg ha ⁻¹)	
	N-	N+
Miscanthus	0	120
Switchgrass	0	120
Fescue	85	170
Alfalfa	0	0
Sorghum	0	120
Triticale	60	120

Research questions

- ❖ **Q1: What is the impact of crops and cropping practices on water drainage and evapotranspiration?**
- ❖ **Q2: What is the impact of crops and cropping practices on nitrate leaching?**
- ❖ **Q3: What is the impact of crops and cropping practices on soil organic carbon (SOC) stock changes?**

Methods

- ❖ Water drainage and nitrate leaching
2007-2013



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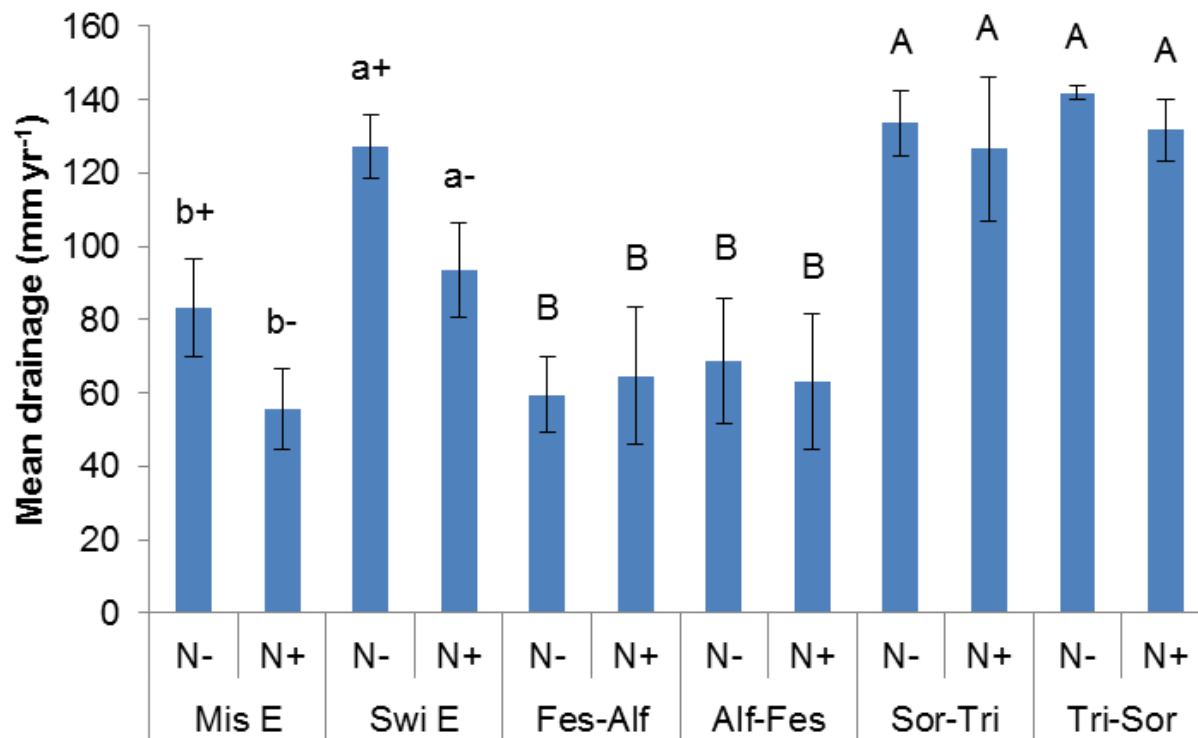
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- ❖ SOC stocks changes
2006 and 2011-12



Q1: Impact on water drainage and evapotranspiration

Mean annual drainage over seven years

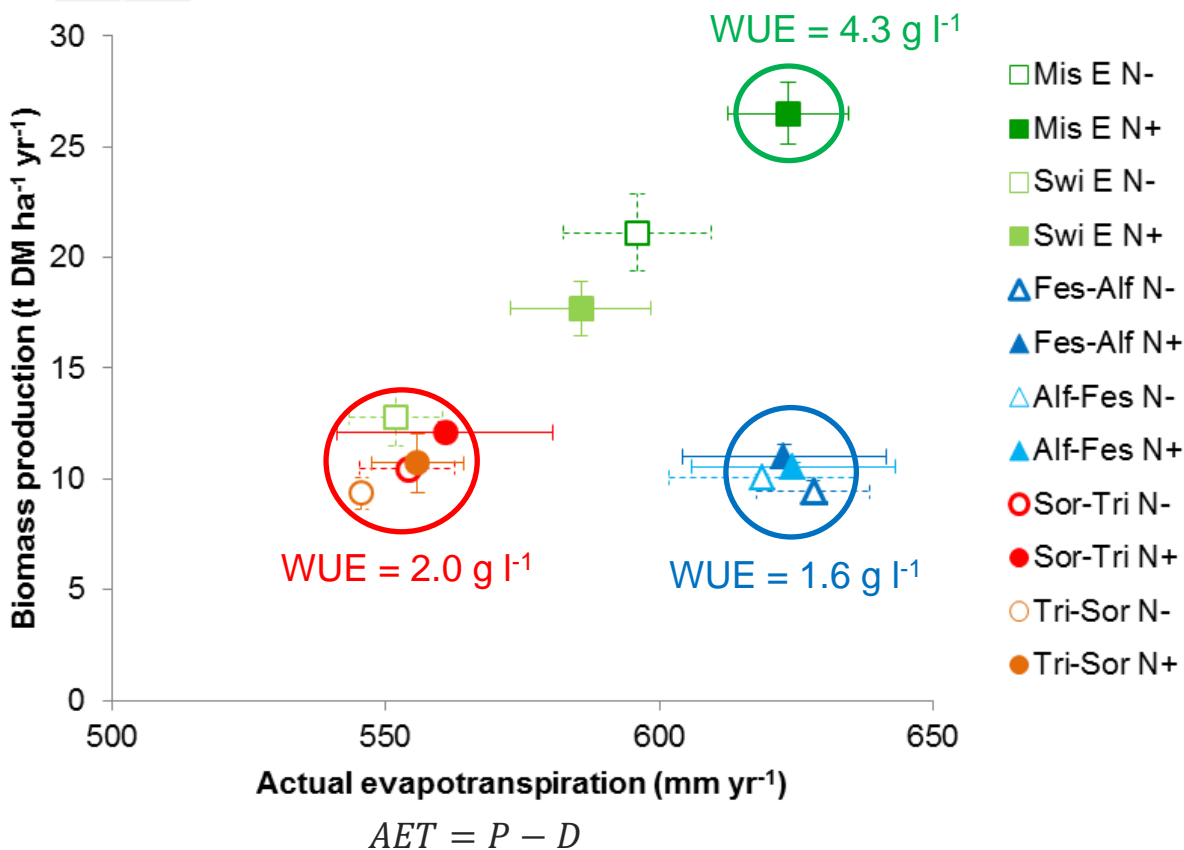


Different letters = significant differences between treatments ($p < 0.05$)

- Annual crops > semi-perennial crops
- Perennial crops: effect of crop and N fertilisation

Q1: Impact on water drainage and evapotranspiration

Water use efficiency of the cropping system

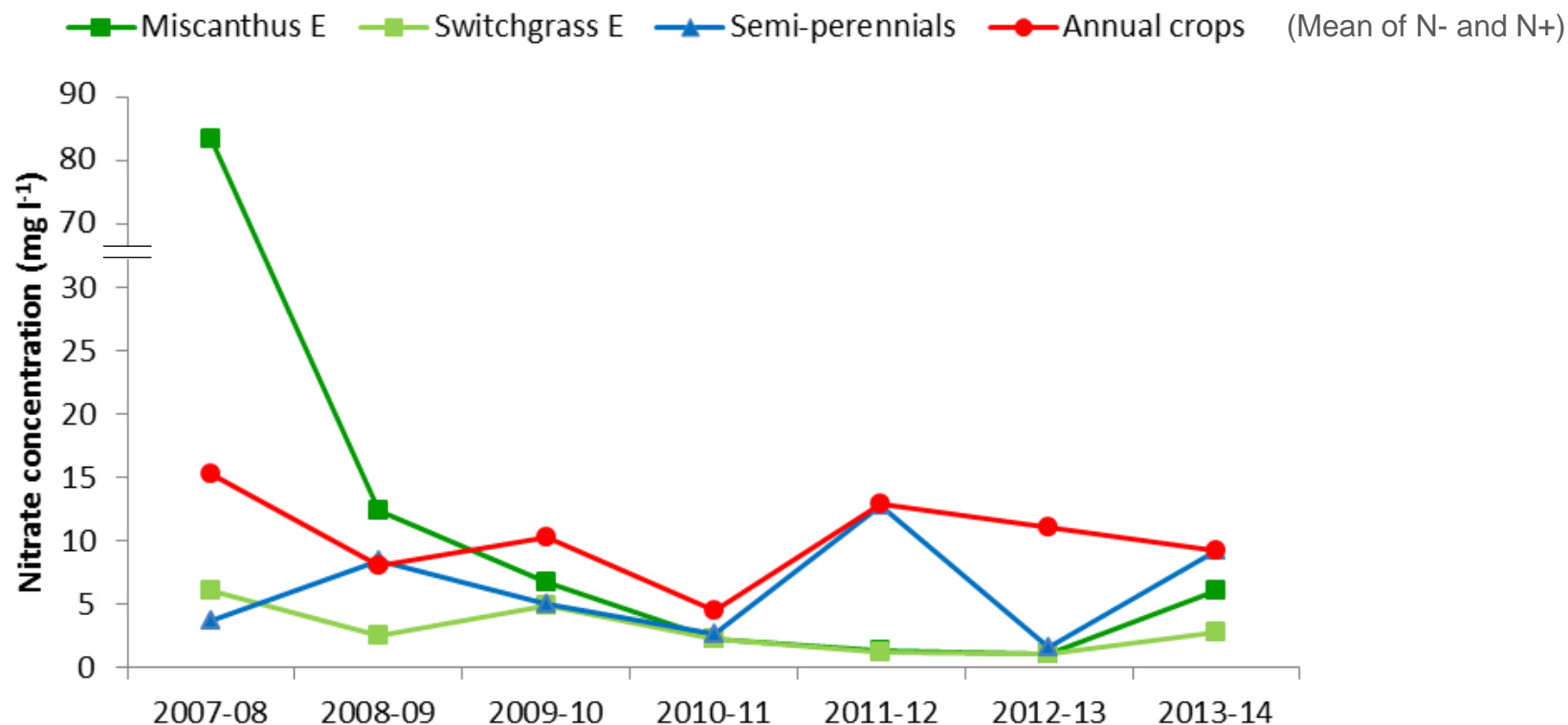


$$WUE = \frac{Production}{AET}$$

- WUE semi-perennial crops < WUE annual crops
- WUE perennial crops increases with biomass production

Q2: Impact on nitrate leaching

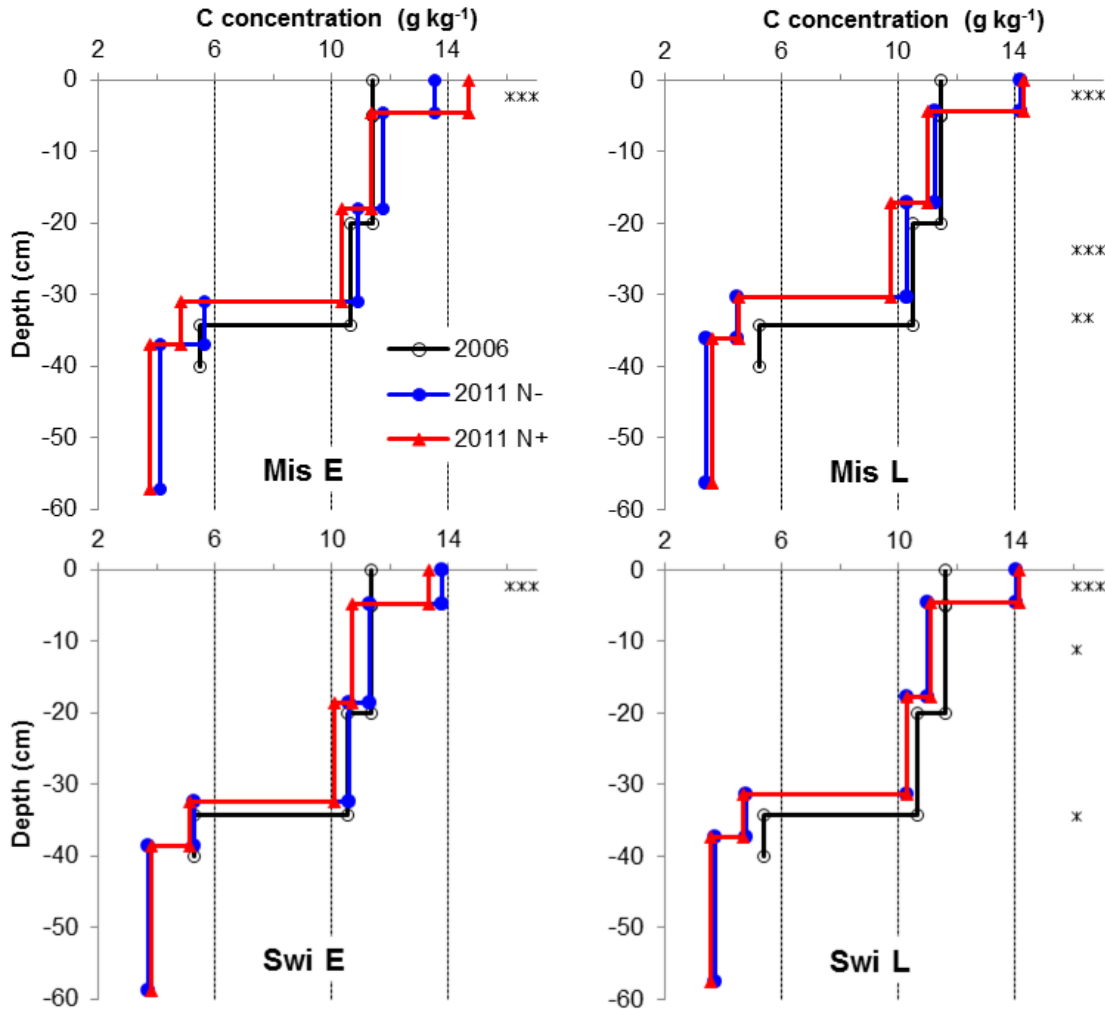
Evolution of the annual mean nitrate concentration in drained water



- Miscanthus E: high nitrate concentration in 2007-08
- Higher nitrate concentration in annual crops 5 years / 7

Q3: Impact on SOC stock changes

Carbon concentrations in 2006 and 2011 (perennial crops)

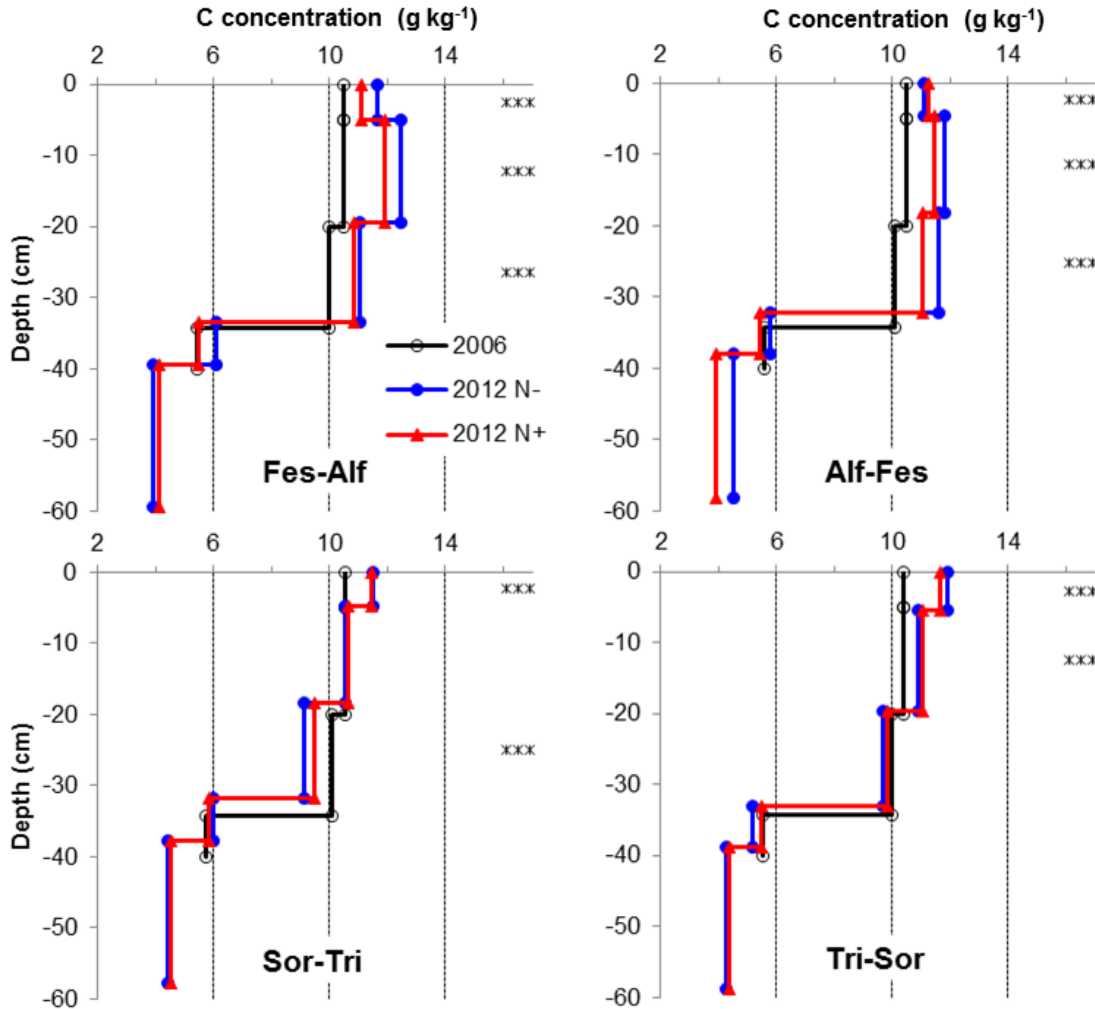


- Stratification of SOC concentrations under perennial crops:
 - ✓ Concentrations in L1 increased between 2006 and 2011 (+ 2.6 g kg⁻¹)
 - ✓ Lower layers: decreasing trend
- No significant effect of crop, N fertilisation or harvest date

Significant changes:
* = p<0.05; ** = p<0.01; *** = p<0.001

Q3: Impact on SOC stock changes

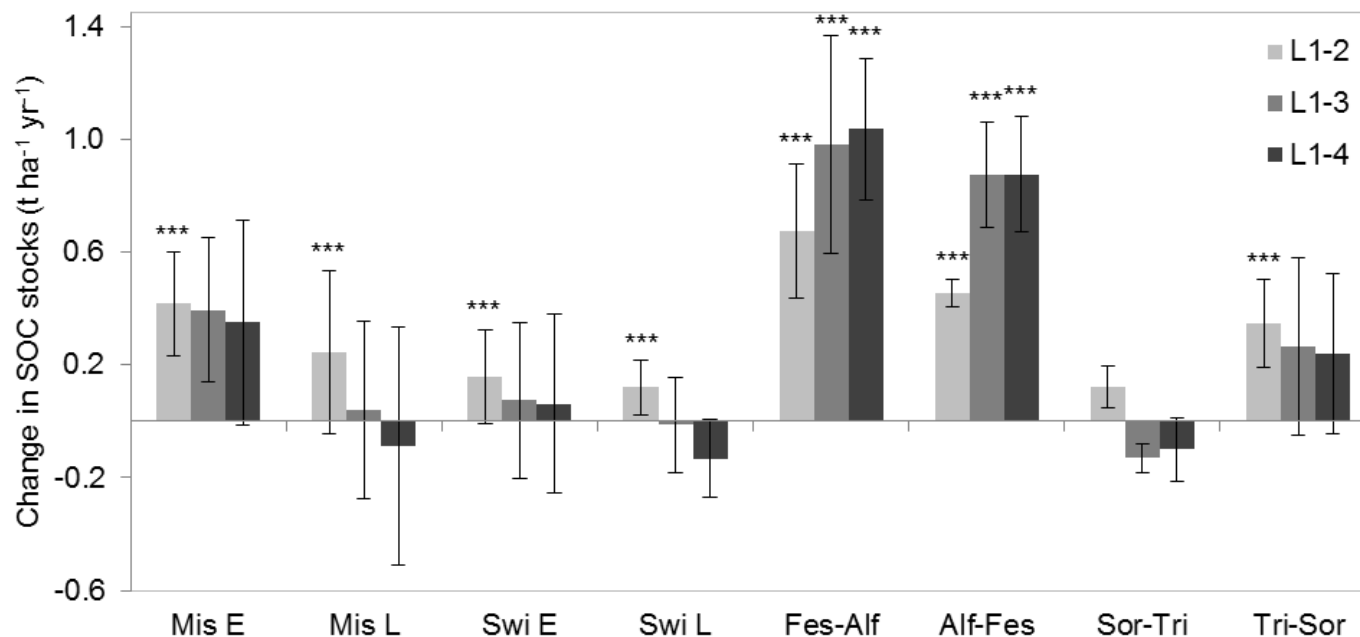
Carbon concentrations in 2006 and 2012 (other crops)



- Semi-perennial crops: SOC increased throughout the old ploughed layer (+1.2 g kg⁻¹)
- Annual crops: SOC increased in the upper layers and decreased in L3
- No significant effect of N fertilisation

Q3: Impact on SOC stock changes

Changes in SOC stocks between 2006 and 2011/12



- Significant increase in the old ploughed layer (L1-3 \approx 0-33 cm) under semi-perennial crops (0.93 ± 0.28 t ha⁻¹ yr⁻¹)

Conclusions and prospects

- ❖ **Perennial and semi-perennial crops had multiple benefits but no crop performed best for all criteria**
 - ❖ Perennial C4 crops:
 - High water use efficiency
 - Low nitrate leaching
 - But: *no SOC sequestration on the short term*
 - ❖ Semi-perennial crops:
 - Low nitrate leaching
 - SOC sequestration
 - But: *low water use efficiency and low drainage*

- ❖ **Results on SOC sequestration need to be confirmed on the long term and the determinism of SOC storage needs to be studied**

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Caroline



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