Changes in soil carbon stocks and distribution under perennial and annual bioenergy crops

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Introduction

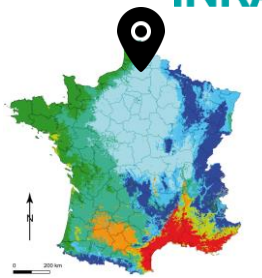
- Bioenergy crops are expected to provide biomass to replace fossil resources and reduce greenhouse gas emissions
- There is a wide range of candidate crops
- Impact on SOC is a key point in the evaluation of the greenhouse gas and environmental benefits of bioenergy crops

- **<u>Aim of the study:</u>**
  - ✓ Quantify the impact of different bioenergy crops under contrasted managements on SOC (stocks and distribution)

Experimental site and treatments

Field experiment established in 2006 in northern France

10.8 °C 677 mm yr^{-1} Deep loamy soil (Luvisol)



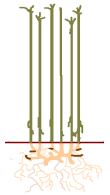
A wide range of bioenergy crops with different management practices

Perennial crops

Miscanthus or **Swi**tchgrass

Two harvest dates:

Early (October) **L**ate (February)



Semi-perennial crops

Alfalfa - **Fes**cue

Annual crops

Triticale - **Sor**ghum or maize

Two fertiliser-N rates:

Crop	Fertiliser-N rate (kg ha^{-1})	
	N-	N+
Mis	0	120
Swi	0	120
Fes	83	173
Alf	0	0
Sor	0	120
Maize	34	128
Tri	60	120

SOC stocks measurements

- Three sampling dates: 2006, 2011-2012, 2018

Soil cores:

6 cores per plot × 3 blocks
8 cm diameter

0-40 cm in 2006
and then 0-60 cm (5 layers)

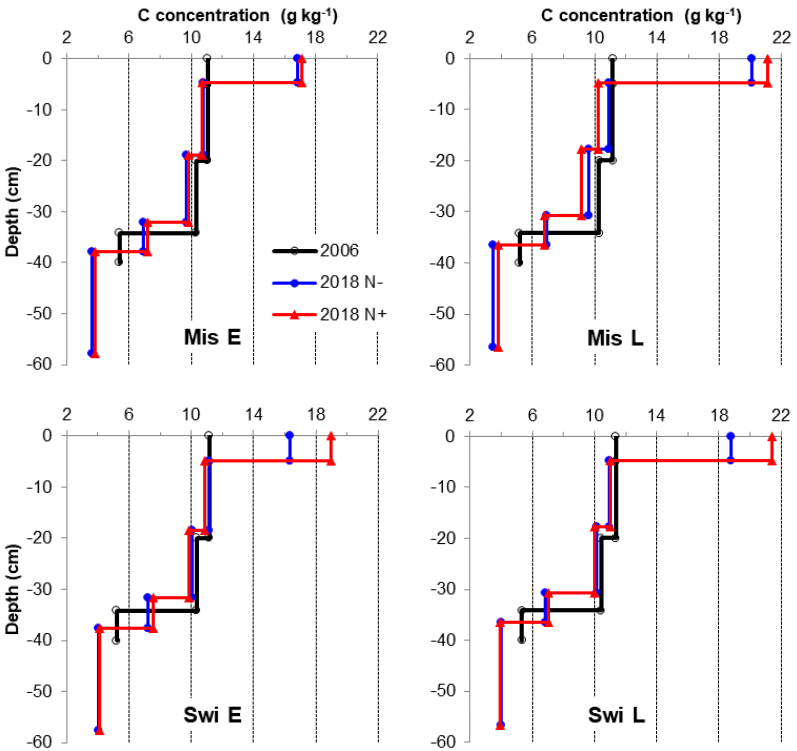
Bulk density:

Gamma probe and steel cylinders

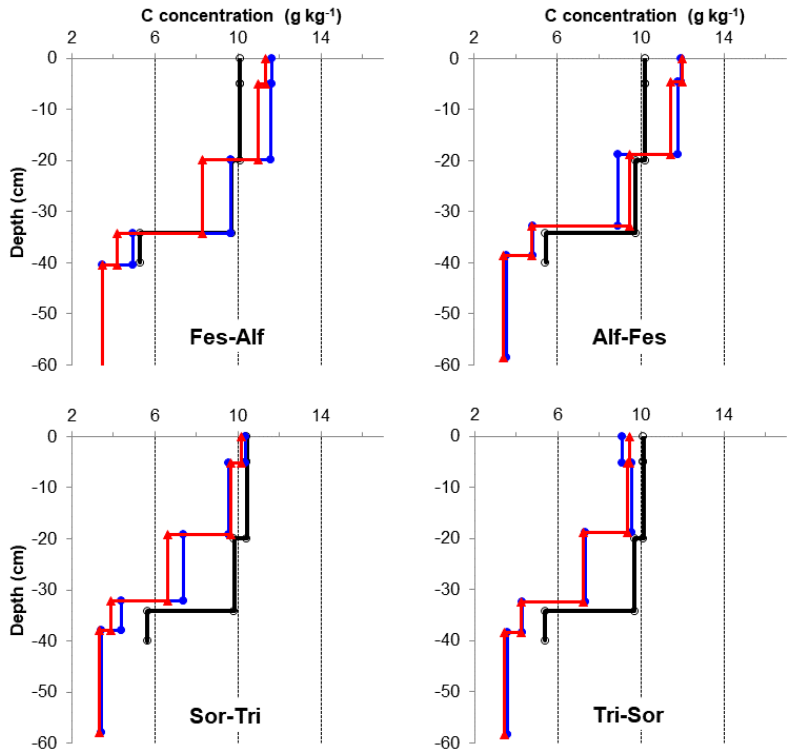
- C, N and $\delta^{13}C$ analysis
- SOC stocks calculated at equivalent soil mass (ESM) in all layers
- Soil particle-size fractionation for some treatments

SOC concentrations in 2006 and 2018

Perennial crops



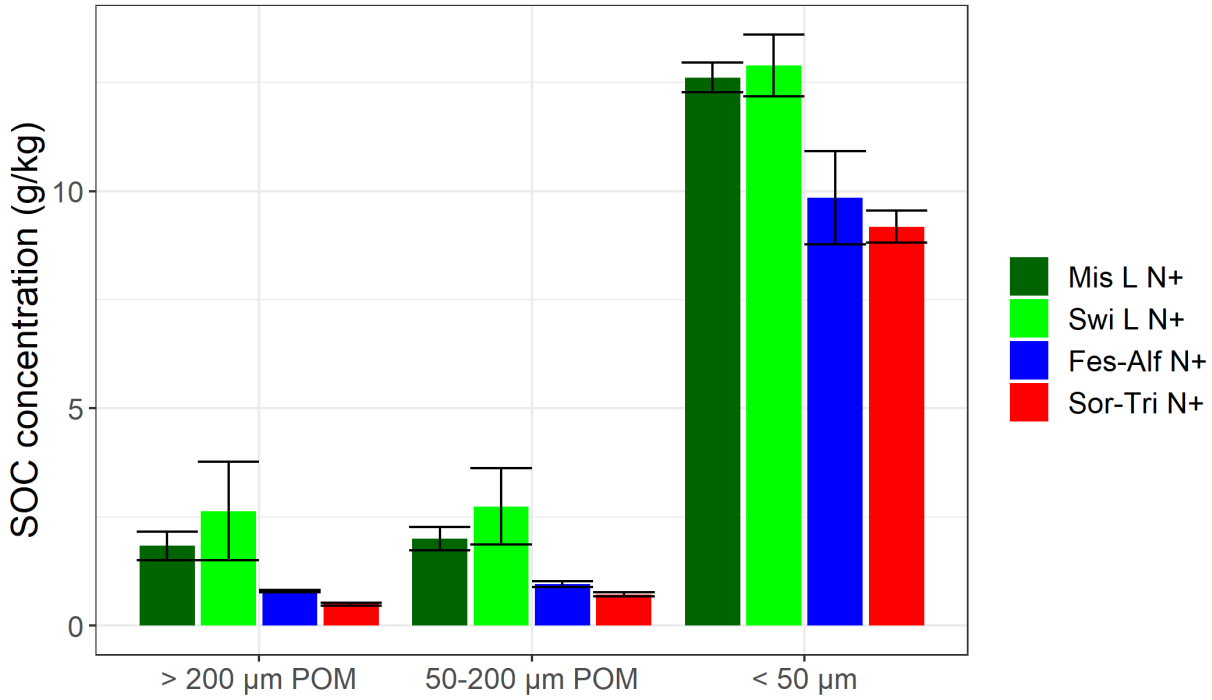
Other crops



- Significant increase in L1 (+ 7.6 g kg^{-1})
- Lower layers: decreasing trend
- No significant effect of N fertilization

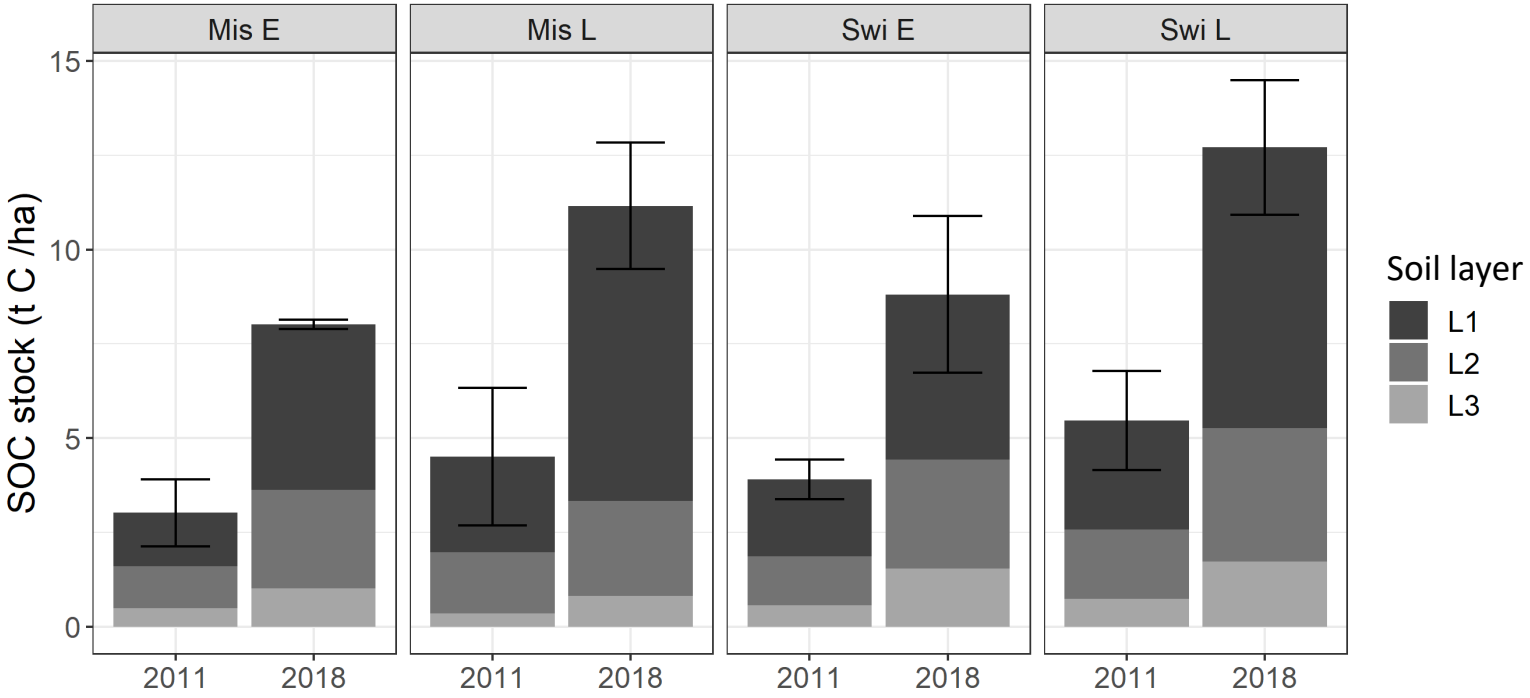
- Semi-perennial crops: significant increase in L1 and L2 (+ 1.4 g kg^{-1})
- Annual crops: decrease in all layers
- No significant effect of N fertilization

SOC fractions in 2018 (Layer 1 ≈ 0-5 cm)



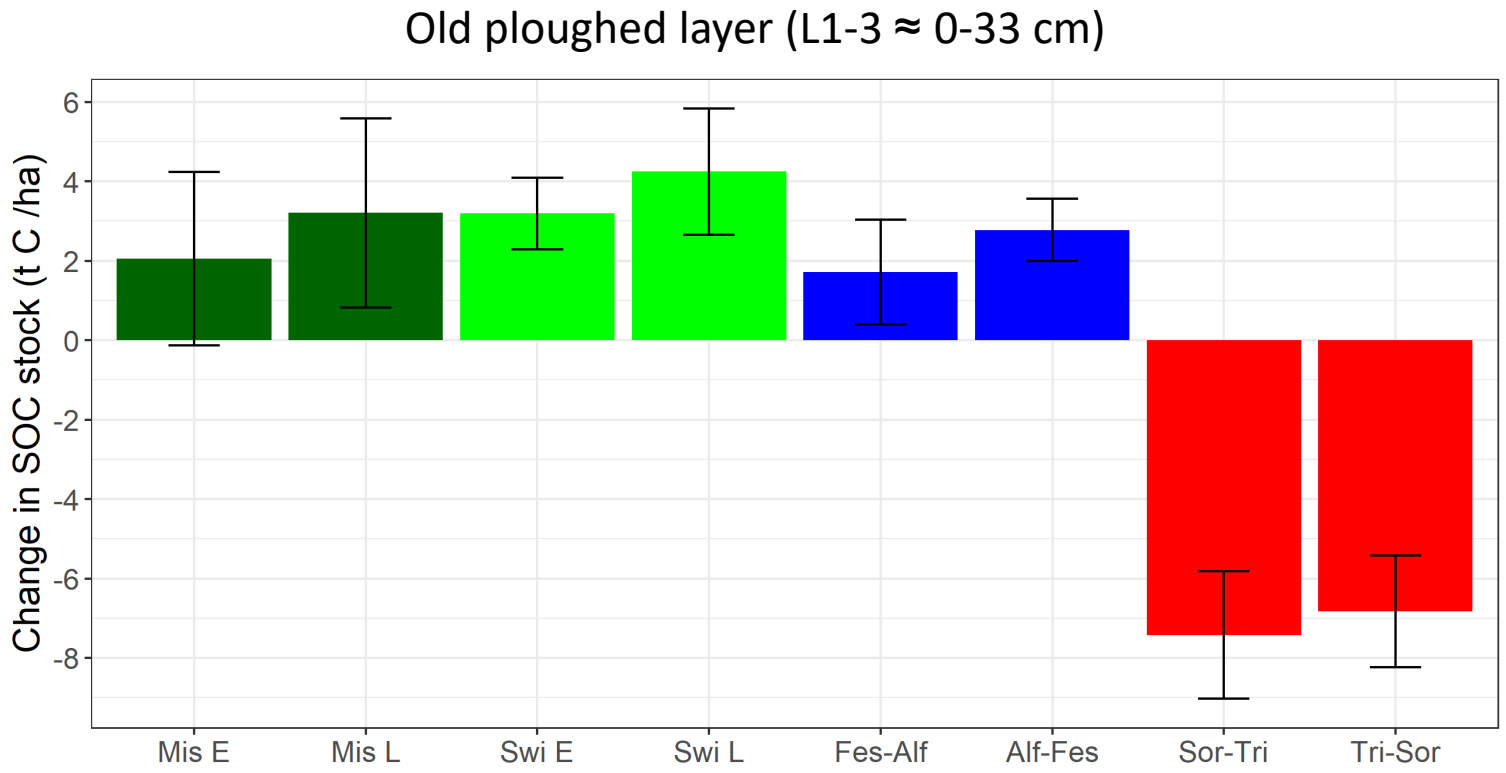
- SOC increase in L1 under perennial crops corresponded to an increase in coarse organic fractions (> 200 µm POM et 50-200 µm POM) but also in the more stabilized 0-50 µm fraction

Accumulation of new C4-derived SOC under perennial crops



- More than half of the new SOC (58% on average in 2018) accumulated in the surface layer (L1 ≈ 0-5 cm)
- Larger increase of new SOC under late (L) than early (E) harvest

Changes in SOC stocks between 2006 and 2018



- SOC stocks increased under perennial and semi-perennial crops:
  - ✓ +3.2 and +2.2 t C ha^{-1} respectively
  - ✓ +5.2 and +4.0 ‰ yr^{-1} respectively
- SOC stocks decreased under annual crops (-7.1 t C ha^{-1} => -12.7 ‰ yr^{-1})

Conclusions

- Contrasted impacts of bioenergy crops on SOC stocks:
  - ✓ perennial and semi-perennial crops increased SOC stocks
  - ✓ annual crops (whole plant harvested) decreased SOC stocks

- No significant effect of N fertilization on SOC stocks and distribution

- Stratification of SOC concentrations under perennial crops, with a large increase in the surface layer (L1 ≈ 0-5 cm):
  - ✓ observed for both POM and clay-silt size fractions
  - ✓ in relation to new C4-derived SOC accumulation, mainly occurring in L1 (importance of aboveground C inputs?)

- Perennial crops: higher increase of new SOC in late than in early harvest suggests higher C inputs in late harvest