THEME 2

Agricultural practices that store organic C in soils: is it only a matter of inputs?

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INTRODUCTION

The benefits of increasing C storage in soils are recognized (soil quality, GHG attenuation and climate change adaptation).

Estimates of the effect of current and alternative cropping practices on soil organic C (SOC) stocks are thus particularly needed [6], especially for those in the framework of agroecology.

OBJECTIVES

Assess the effect of several alternative cropping systems on SOC stocks;

Identify the levers of SOC stock changes, i.e. increases in biomass inputs to soil and/or changes of C outputs by mineralisation.

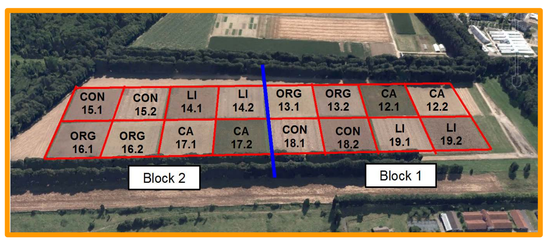


Fig. 1: Block 1 and block 2

Tab. 1: Comparing agricultural systems

Average 1998-2014	Conventional CON	Low Input LI	Conservation agriculture CA	Organic ORG
Tillage	Each year	1 year/2	No till	Each year
Mineral fertilisers	+++	++	++	0
N fertilization (kg ha^{-1} yr^{-1})	143	114	104	10
Pesticides	+++	+	++	0
Permanent plant cover	no	no	yes (fescue, alfalfa)	no
Wheat yield (t ha^{-1} yr^{-1})	9.7	8.9	6.7	5.4

METHODOLOGY

Long term experiments

Versailles 16 years, Luvisol, 4 cropping systems, wheat (+ rapeseed, pea, maize, alfalfa)

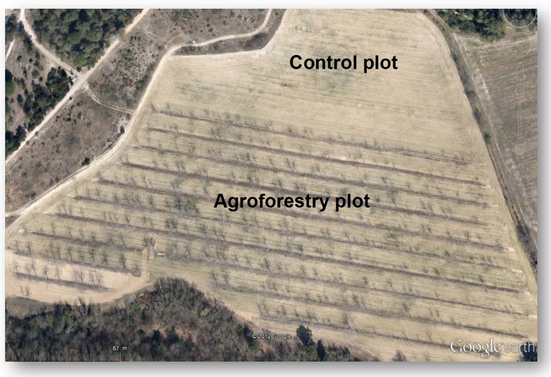
Restinclières 18 years, carbonated fluvisol, alley cropping, walnut trees intercopped with durum.

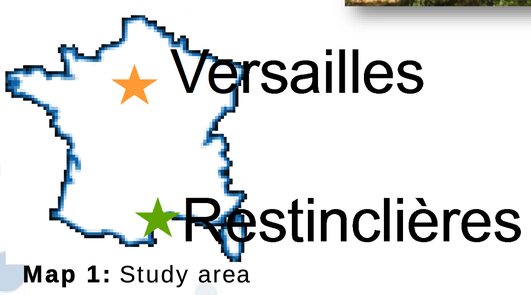
Measurements

C stocks C contents & bulk density to 0.6 or 2 m. Calculation = equivalent soil mass OC inputs to soil. Measured : yields in both sites, above ground and below ground biomass at Restinclières. Estimated : above ground and below ground biomass at Versailles OC outputs SOC mineralization in incubation.

Modelling

At Versailles, SOC dynamics was modelled using the two pools model AMG [5].





Map 1: Study area

MAIN RESULTS

SOC stocks

The rate of change in SOC stocks in the old ploughed layer compared to the reference system was CA: + 0.55, ORG: + 0.20 and agroforestry + 0.25 ± 0.03 t C ha^{-1} yr^{-1}.

Tab. 2: Comparing agricultural systems

La Cage	Depth	ESM	Conventional			Conservation agriculture			Low input			Organic agriculture		
	(cm)	*(t ha-1)*	SOC stocks *(t C ha-1)*											
1998	≈ 0-10	1300	12.8	±1.0	a	13.4	±2.5	a	13.3	±2	a	11.5	±1.4	a
	≈ 0-30	4300	40.4	±3.5	a	41.9	±8.7	a	43.6	±8	a	37.4	±4.3	a
2014	≈ 0-10	1300	13.1	±1.2	a	21.5	±2.9	b	13.7	±1.9	a	13.1	±1.3	a
	≈ 0-30	4300	41.7	±4.2	a	51.9	±6.6	b	43.9	±5.3	a	41.8	±2.6	a
Restinclières	Depth	ESM	Control			Tree row			Inter-row			Agroforestry		
	(cm)	*(t ha-1)*	SOC stocks *(t C ha-1)*											
2013	≈ 0-8	1000	9.3	±0.1	a	21.6	±1.0	c	9.8	±0.4	a	11.7	±0.3	b
	≈ 0-28	4000	35.8	±0.2	a	52.8	±1.4	d	37.9	±0.6	b	40.3	±0.5	c

OC inputs

Inputs of OC to soil were increased by about 32% (+1.32 t C ha^{-1} y^{-1}) in the CA system and by 40% (+1.11 t C ha^{-1} y^{-1}) in the agroforestry system, compared to their respective references.

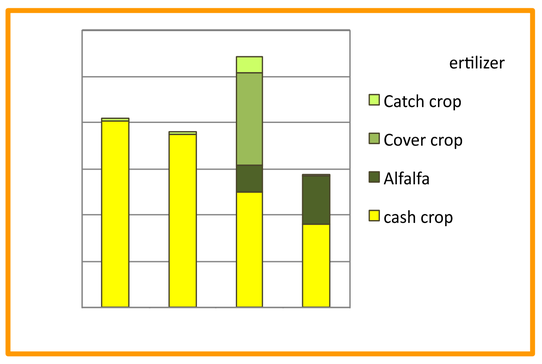


Fig. 2: Bar-chart

OC outputs

The mineralization rate of SOC in incubations did not differ between the different modalities compared at a given site. The model AMG successfully described the evolution of SOC stocks at Versailles site and the same mineralization rate of SOC could be used for both the CON (tilled) soil and the CA (un-tilled) soil, suggesting similar mineralization rates *in situ*.

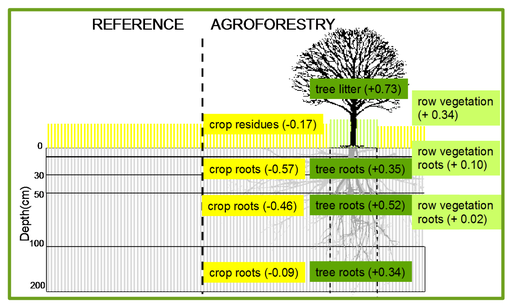


Fig. 3: Agroforestry

CONCLUSION

- Among tested cropping systems, alley cropping agroforestry, conservation agriculture and to a lesser extent organic agriculture led to increased SOC stocks, confirming litterature based estimates [4].
- Fresh OC inputs to soil were strongly increased in the conservation agriculture and agroforestry systems.
- Soil respiration was not measured *in situ*, but *in vitro* measures of SOC mineralisation showed no differences, and the modelling exercise suggested that mineralization rates were not affected by the absence of tillage.
- Small increases of SOC stocks in the organic agriculture system remain to be explained
- Results suggest that the main lever to increase SOC stocks is to increase the inputs of fresh OM (cover crops, trees, ..) rather than reducing tillage.