Potential C storage through the recycling of organic residues: experimental evidence and potential efficiency at the french national scale

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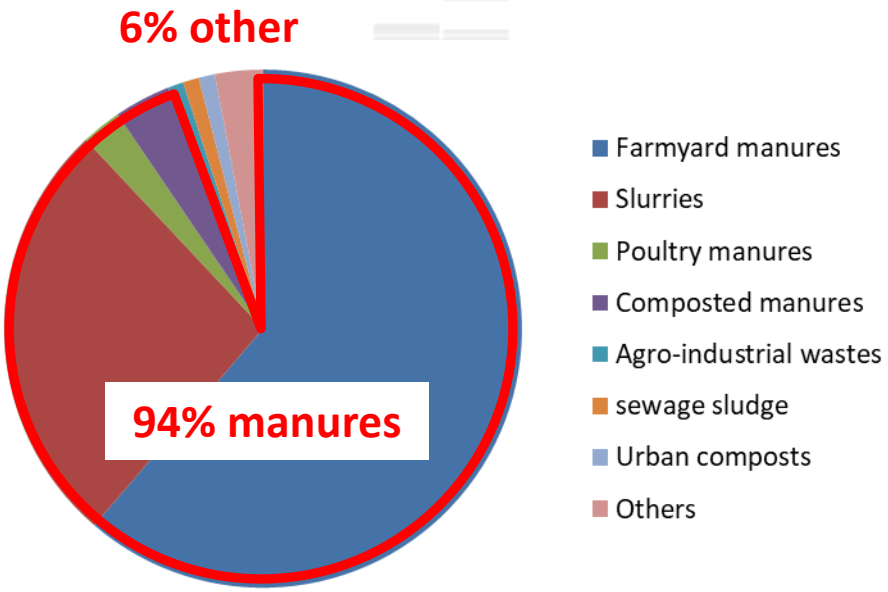
(1) INRA ECOSYS Grignon, (2) VEOLIA, (3) INRA SAS Quimper, (4) INRA ECOPUB Grignon, (5) INRA AGIR Toulouse, (6) INRA DEPE Paris, (7) INRA ISPA Bordeaux

Organic residue recycling in agriculture



- **94% animal manures**
- 6% Urban and industrial

→121 10^6 tons FM

→12 10^6 tons of organic C

(Survey of agricultural practices, 2011 in Houot et al, 2014)

- Potential ressource increase ?
- Increase of urban organic residue recycling

→organic C and nutrient recycling

→Part of circular economy

→ **What is the potential C storage in soils?**

- **Other crop and practice efficiencies for C storage → Pellerin et al.**

Evidence of the potential efficiency

Network of long-term field experiments

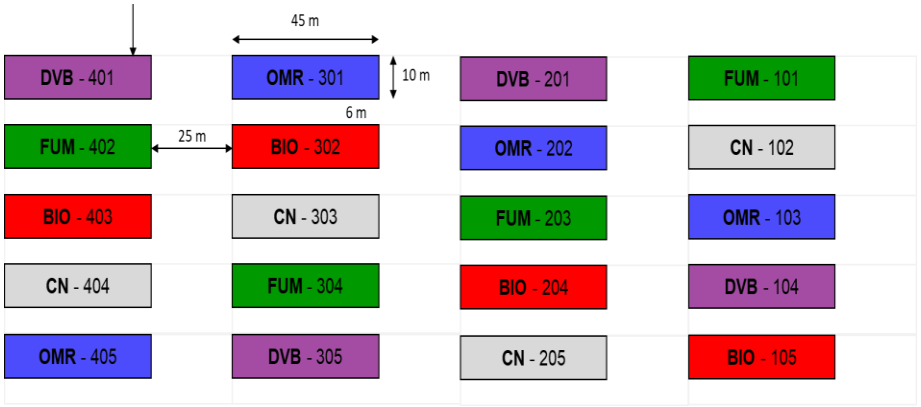
http://www6.inra.fr/valor-pro

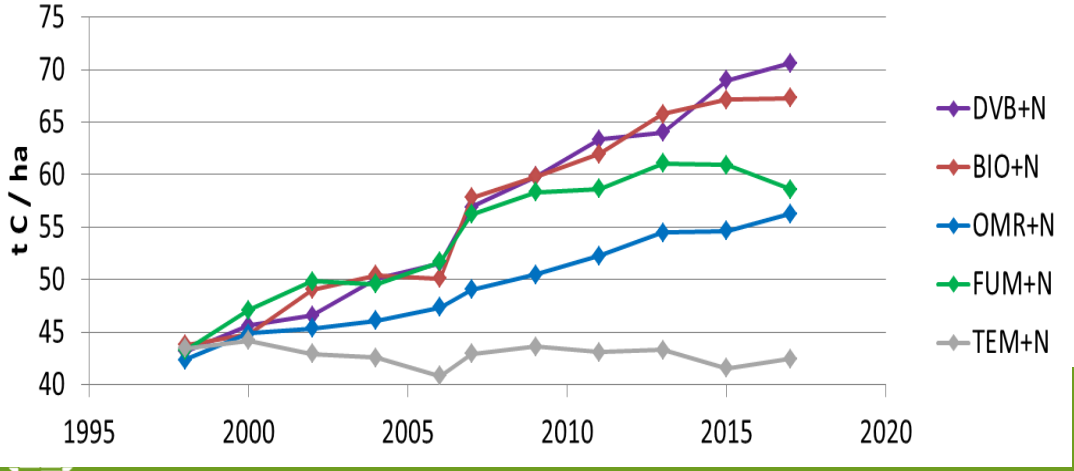
Evidence of C storage with regular organic residue application: QualiAgro site

- **France, Ile de France, started in 1998**
- **Loamy soil, temperate climate, Wheat- Maize succession**
- **OR Application:** Every 2 years , 4 t C/ha → **Twice usual application rates**

Treatments:

Composted sludge (**DVB**)
Biowaste compost (**BIO**)
Municipal solid waste compost (**OMR**)
Farmyard manure (**FUM**)
Control (**CN**)

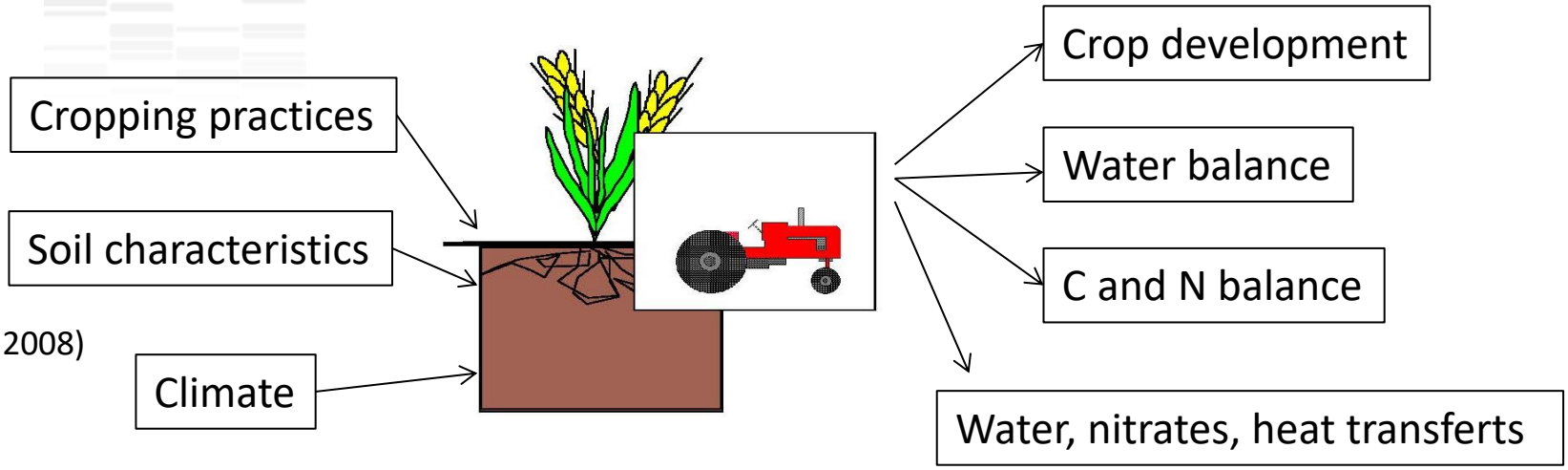




Evolution of C stocks: +1.5 to 2.5% /year

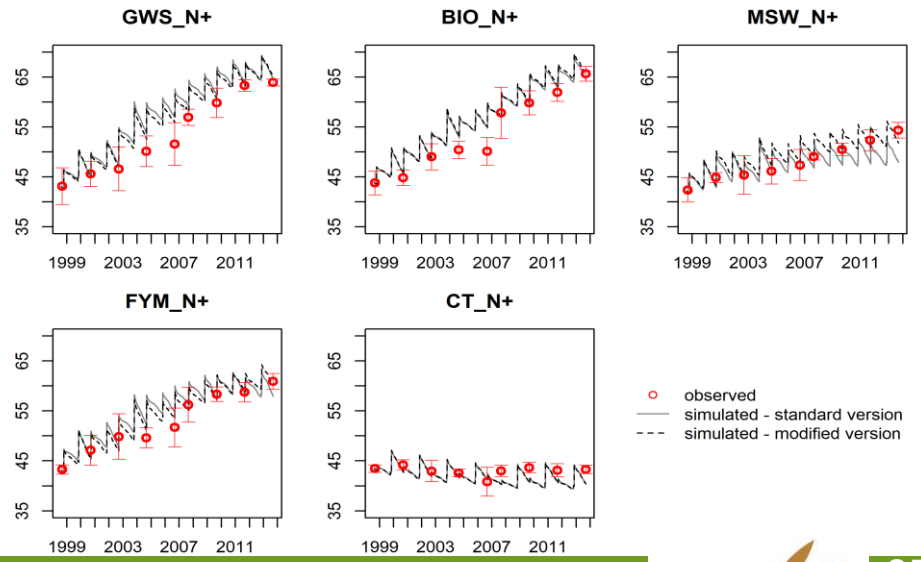
Levavasseur et al., in preparation

Parameterisation of the STICS crop model



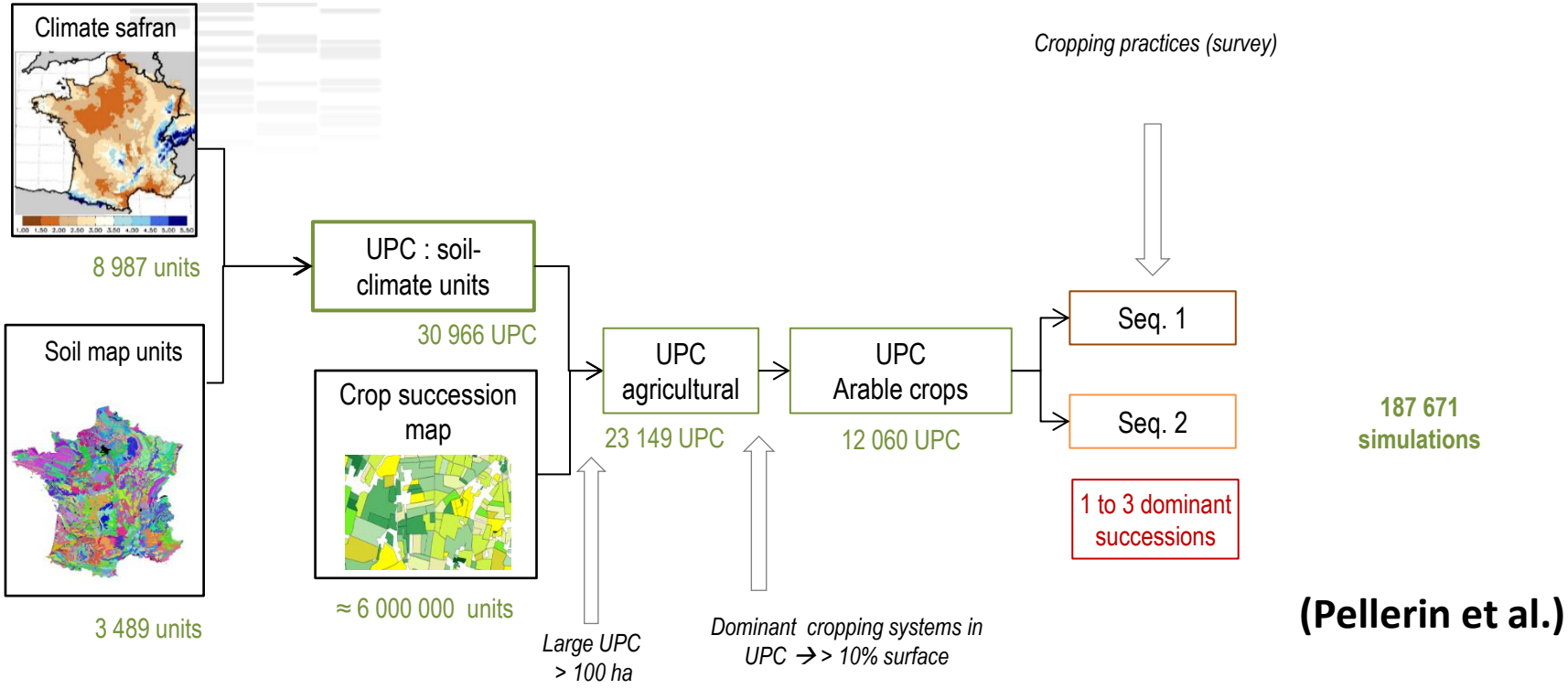
(Brisson et al., 2008)

- Organic residue decomposition
- Good simulation of crop production, **evolution of soil organic C stocks** ….
- Long-term experiments (QualiAgro) or laboratory incubations



Levavasseur et al., in preparation

Simulations with STICS model



- Crop succession with organic residues (sugarbeet, rapeseed, wheat, maize)
- Slurry: 30 m^3/ha; manure: 15 to 30 tons/ha….
- **5 10^6 ha: 29% total agricultural surface**
- **Baseline: + 8 kgC/ha year in crop successions with OR compared to successions without OR**

Actual and potential additionnal sources of organic residues (1)

Different sources of data:

- **Manures** : Marsac et al., 2018: ELBA, evaluation of agricultural biomass and survey of farmer practices
- **Industrial Residues, collected greenwastes (GW), Sewage sludges (SS), biowastes (BIOW):** SOLAGRO & INDDIGO, 2013. Potential biomass for anaerobic digestion (ADEME)
- **Total greenwastes**: SOLAGRO, 2014. Potential greenwastes (France Agrimer)
- **Already recycled sewage sludges and biowastes** : ADEME 2017

Data in 10^6 tons of fresh matters

Total manures	Industrial residues	Total GW	Collected GW (9 % of total)	total SS (20% MS)	Recycled SS (70% total)	Total BIOW	Collected BIOW (10% total)
120.3	16.2	52.1	4.8	5.9	4.1	11.6	1.0

Actual and potential additionnal sources of organic residues (2)

Objective → Produce more composts and digestates

Data in 10^6 tons of fresh matters

Total manures	Industrial residues	Collected GW	Total GW (9% total)	total SS (20% MS)	Recycled SS (70% total)	Collected BIOW (10% total)	Total BIOW
120.3	*16.2*	**4.8**	**52.1**	**5.9**	**4.1**	**1.0**	**11.6**

Already recycled

Increase of GW collection to 35%

Increase SS composting to 70% (30% today)

Increase BIOW separate collection to 50% of potential: 50% anaerobic digestion and 50% composting

Actual and potential additionnal sources of organic residues (3)

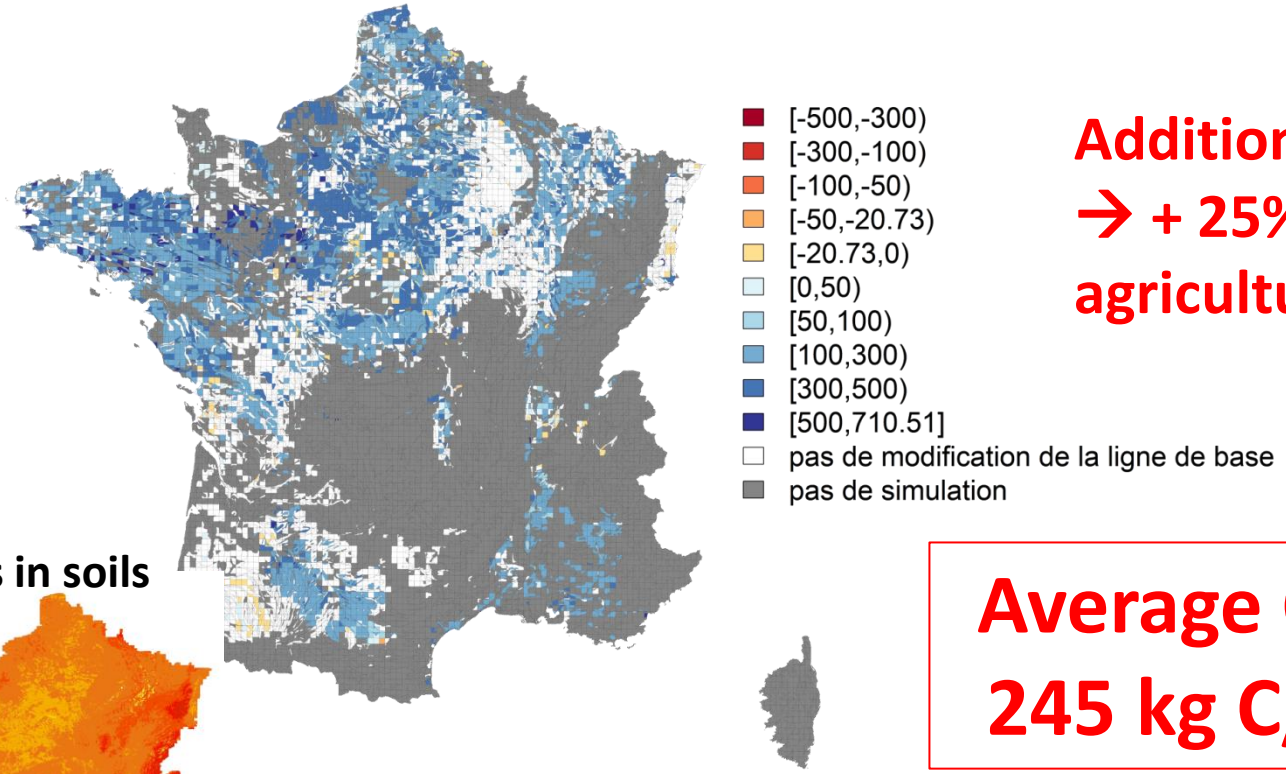
Potential additionnal production of composts and digestates

(10^6 tons)	Today	Additionnal
GW composts	1	1.9
BIOW composts	1.2	2.9
SS composts	2	4.8
BIOW digestates		4.3
Total FM	4.2	13.9
Total C associated	**0.6**	**1.6**

Today, 12 10^6 tons of C, mostly in manures → Additionnal 1.6 10^6 tons of C

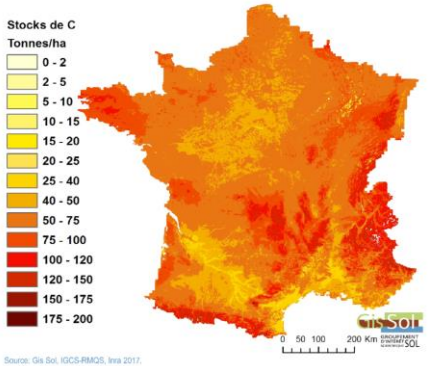
Additionnal C storage (kg/ha/year) with the new sources of organic residues (0-30 cm)

- Crop successions without organic residues
- Composts: 15 t FM/ha; Digestates: 25 m^3/ha, every 2.5 years



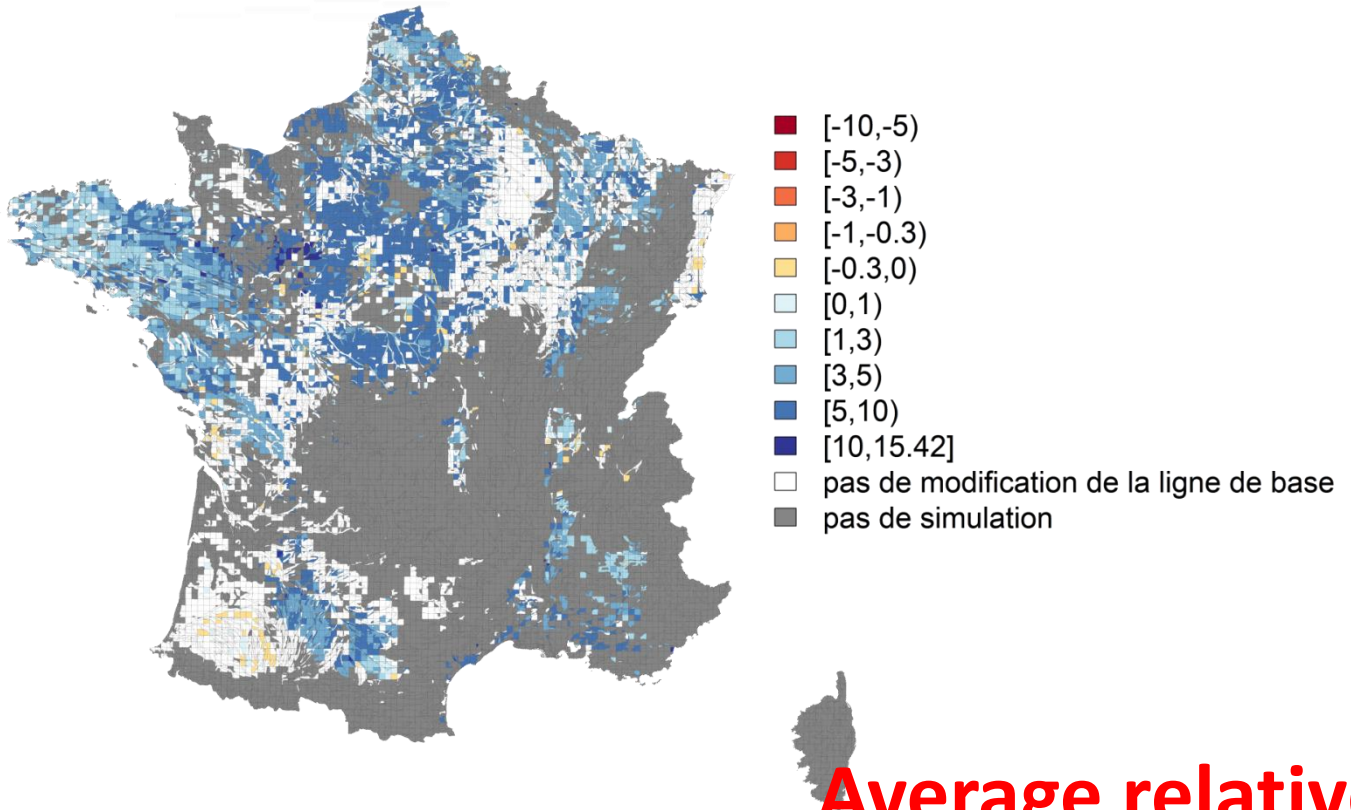
Additionnal 4.2 10^6ha → + 25% of total agricultural surface

C stocks in soils



Average C storage 245 kg C/ha/year

Additionnal relative C storage (‰/ha/year) with the new sources of organic residues (0-30 cm)



Average relative C storage 4.5‰/ha/year

But….

- GW used to produce the additionnal composts already largely returned to soils
- Additionnal C only coming from sludge or biowaste was calculated → average of 26% of additionnal C storage
- **0.243→ 0.059 tC/ha/year**
- **4.5 ‰/ha/year → 1.1 ‰/ha/year**

Total additionnal C storage

	Additional C	Surface	additionnal stored C	% of total*
Without GW	0.059 tC/ha/year	4.2 10^6 ha	0.257 10^6 t C/year	4.4 %
Including GW	0.243 tC/ha/year	4.2 10^6 ha	1.023 10^6 t C/year	15.6 %

* Total= 5.78 10^6 t C/year. Cover crops > agroforestry > longer meadows > direct sowing and **new organic ressources** (Pellerin et al., 2019)

Take home message

- Additionnal sources of organic residues: composts and digestates → 1.6 10^6 tons of C per year
- Much lower than animal manures (12 10^6 tons of C per year) but necessary to recycle and interesting where animal breeding is lacking
- **Additionnal storage : 0.3 → 1.0 10^6 tons of C/year stored depending if GW are included or not (4 à 15% of total potential additionnal C storage considering different practices)**
- Associated increase of crop yields but also of N leaching
- **One of the cheapest practices for farmers to increase C stocks in soils**
- Global mass balance of GHG has to be considered to calculate climate change mitigation (OK at field scale, impact of process?)
- Safe use of these new organic sources must be guaranteed