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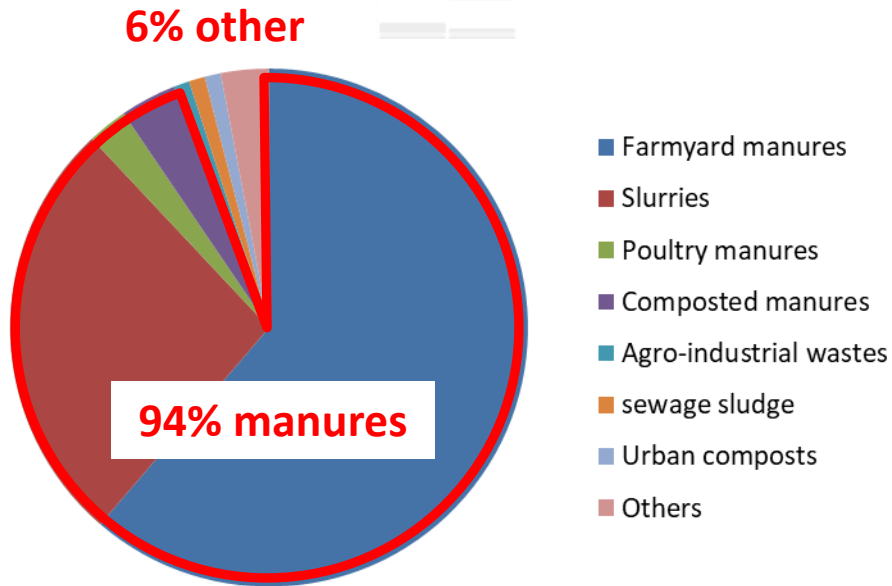
# POTENTIAL C STORAGE THROUGH THE RECYCLING OF ORGANIC RESIDUES: EXPERIMENTAL EVIDENCE AND POTENTIAL EFFICIENCY AT THE FRENCH NATIONAL SCALE

Sabine Houot<sup>1</sup>, C. Resseguier<sup>1</sup>, A. Michaud<sup>1</sup>, F. Levavasseur<sup>1</sup>, M. Albuquerque<sup>2</sup>, M. Poitrenaud<sup>2</sup>, Thierry Morvan<sup>3</sup>, Laure Bamiere<sup>4</sup>, Julie Constantin<sup>5</sup>, Camille Launay<sup>5</sup>, Michele Schiavo<sup>6</sup>, Olivier Rechauchere<sup>6</sup>, Sylvain Pellerin<sup>7</sup>

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# Organic residue recycling in agriculture



- **94% animal manures**
  - **6% Urban and industrial**
- **121 10<sup>6</sup> tons FM**
- **12 10<sup>6</sup> 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>



Detailed observation sites, instrumented  
Historical sites, few / not instrumented

# 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:

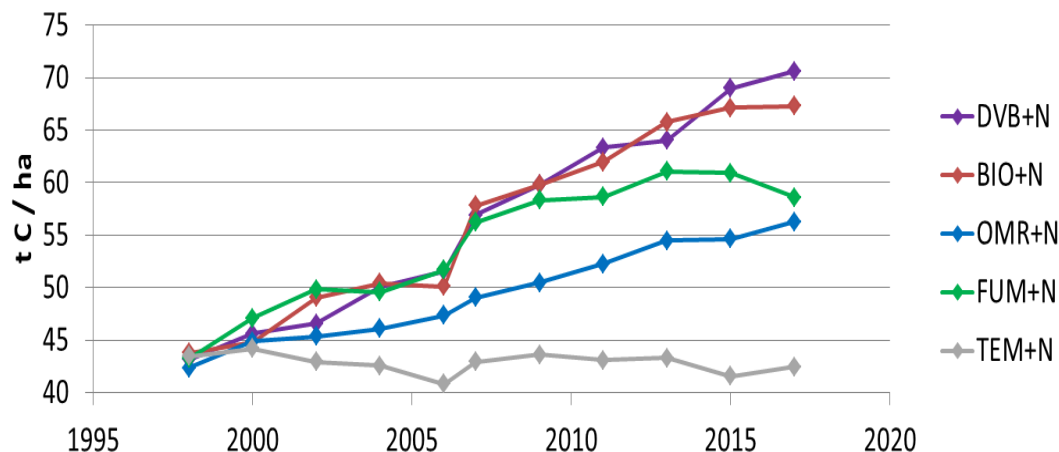
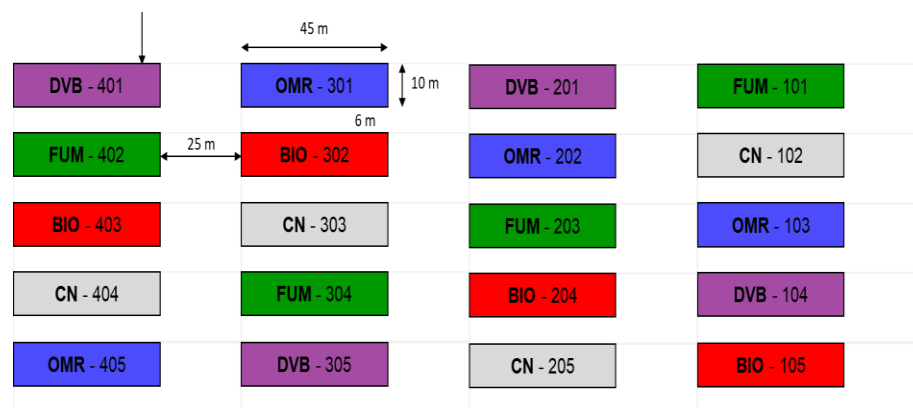
Composted sludge (DVB)

Biowaste compost (BIO)

Municipal solid waste compost (OMR)

Farmyard manure (FUM)

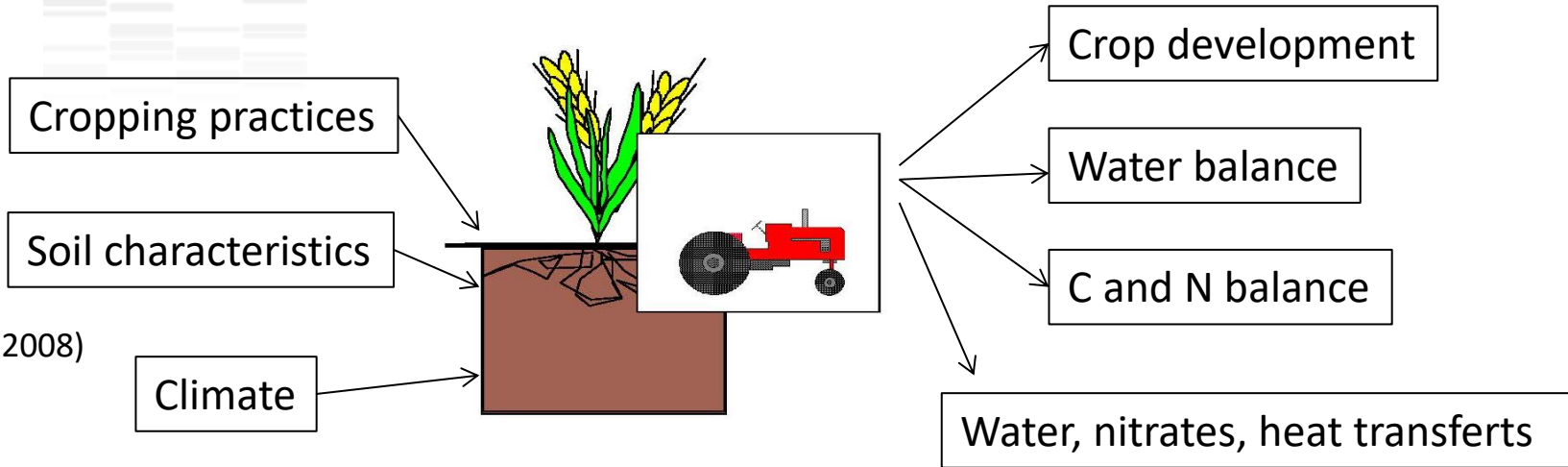
Control (CN)



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

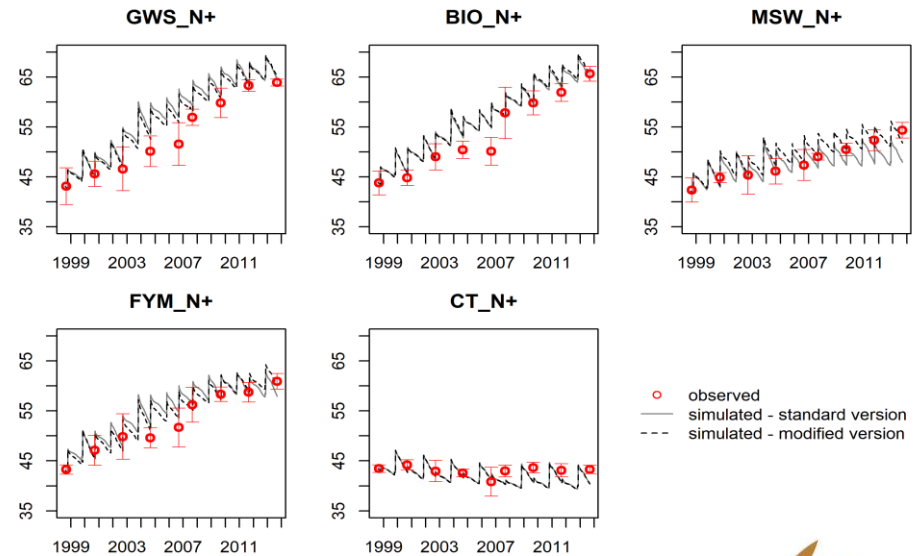
Levavasseur et al., in preparation

# Parameterisation of the STICS crop model



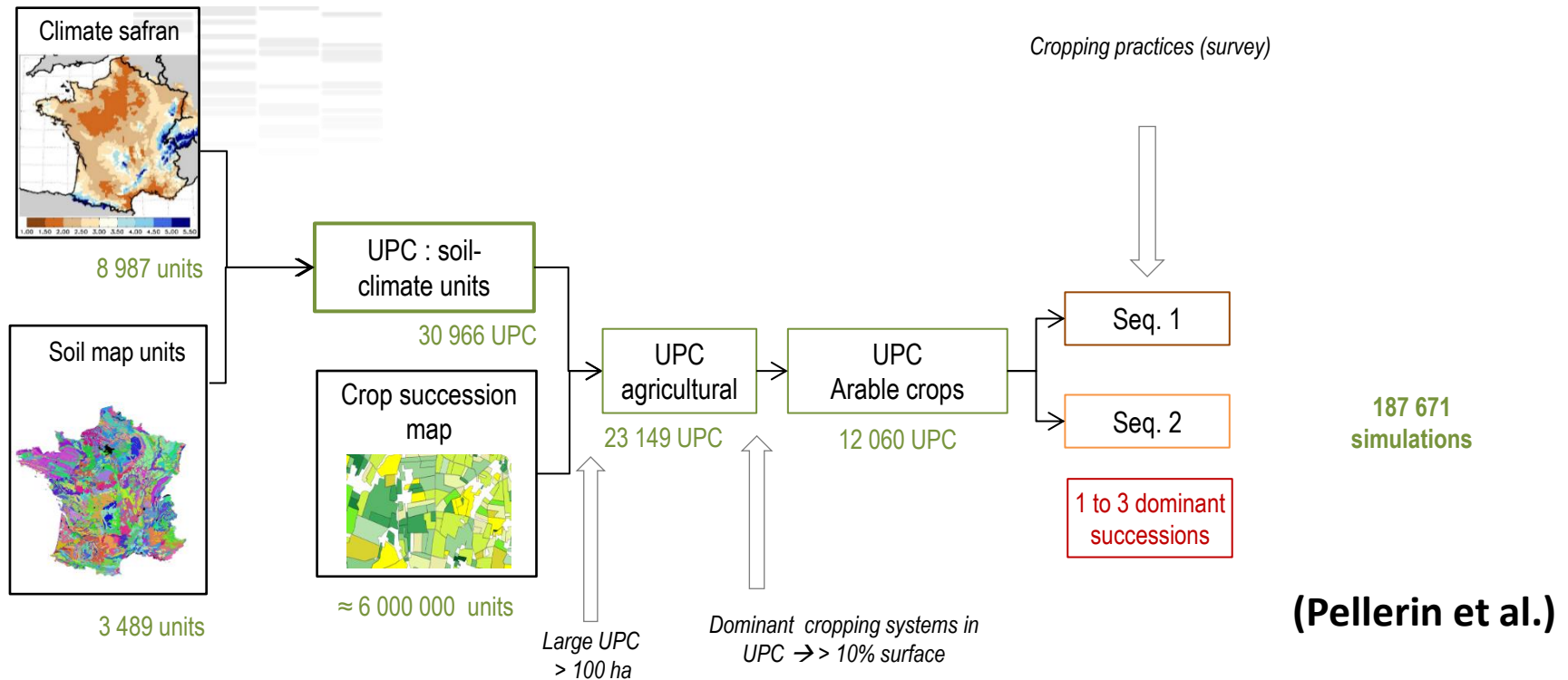
(Brisson et al., 2008)

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



○ observed  
 — simulated - standard version  
 - - - simulated - modified version

# Simulations with STICS model



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

# Actual and potential additional 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<sup>6</sup> 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)
<b>120.3</b>	<b>16.2</b>	<b>52.1</b>	<b>4.8</b>	<b>5.9</b>	<b>4.1</b>	<b>11.6</b>	<b>1.0</b>



# Actual and potential additional sources of organic residues (2)

Objective → Produce more composts and digestates

Data in 10<sup>6</sup> 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 additional sources of organic residues (3)

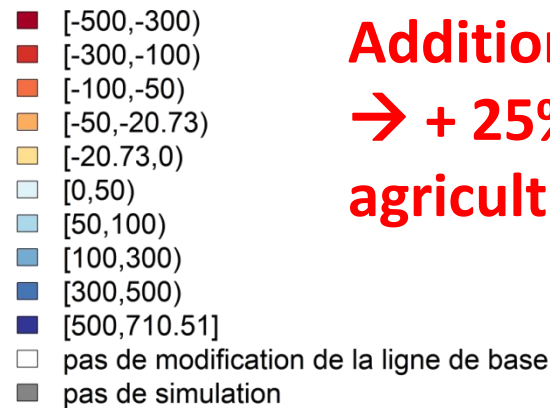
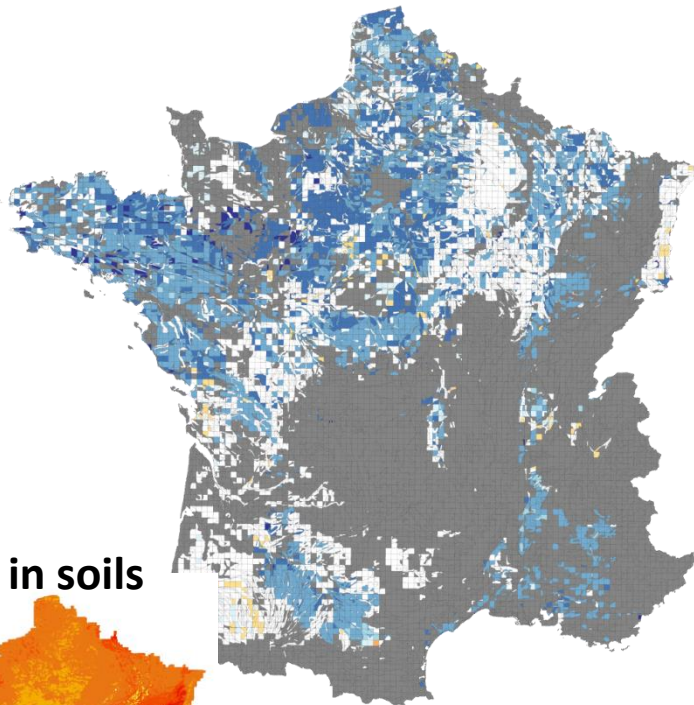
Potential additional production of composts and digestates

(10 <sup>6</sup> tons)	Today	Additional
GW composts	1	1.9
BLOW composts	1.2	2.9
SS composts	2	4.8
BLOW digestates		4.3
Total FM	4.2	13.9
<b>Total C associated</b>	<b>0.6</b>	<b>1.6</b>

Today, 12 10<sup>6</sup> tons of C, mostly in manures → Additional 1.6 10<sup>6</sup> tons of C

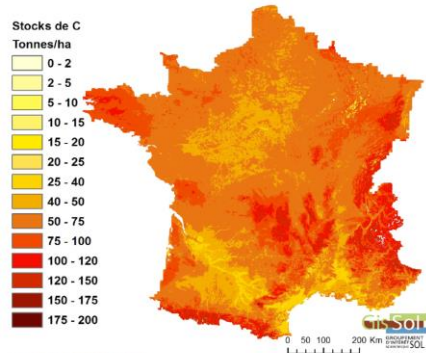
# Additional C storage (kg/ha/year) with the new sources of organic residues (0-30 cm)

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



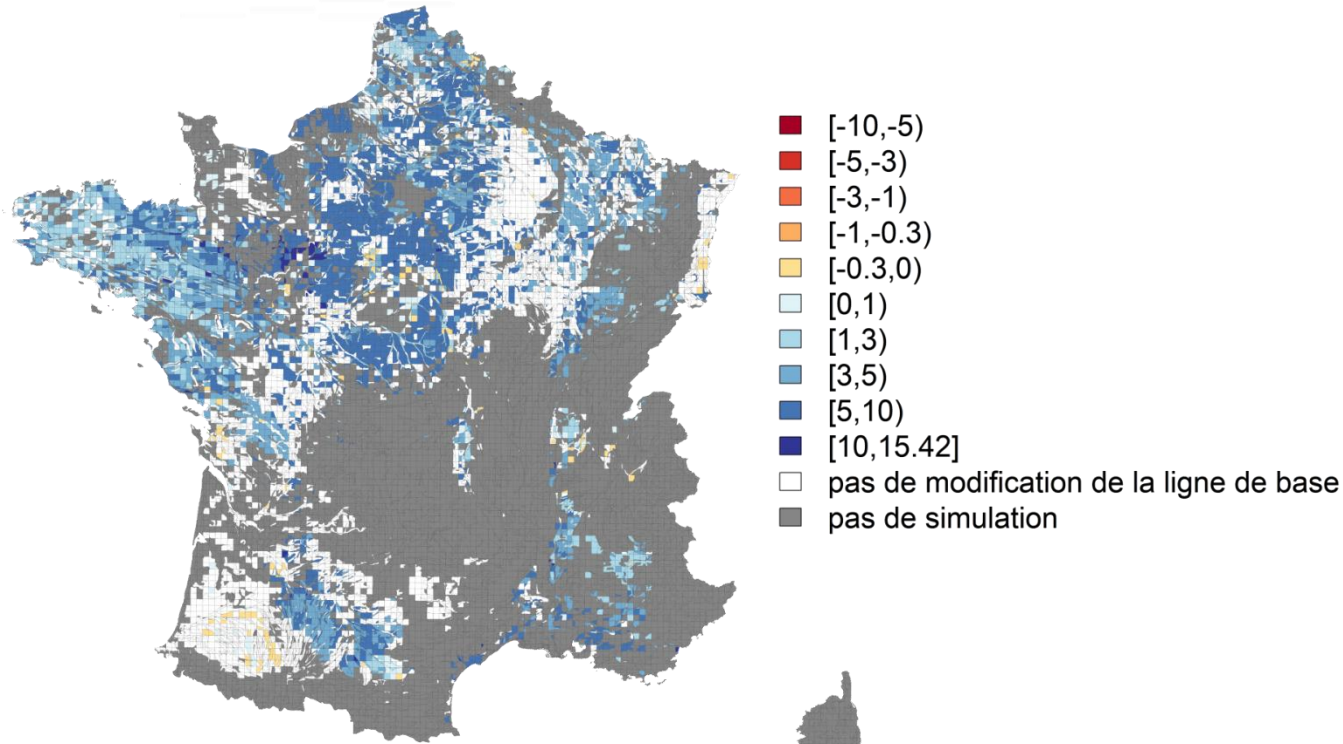
**Additional 4.2 10<sup>6</sup>ha  
→ + 25% of total  
agricultural surface**

## C stocks in soils



**Average C storage  
245 kg C/ha/year**

# Additional 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 additional composts already largely returned to soils
- Additional C only coming from sludge or biowaste was calculated → average of 26% of additional C storage
- **0.243 → 0.059 tC/ha/year**
- **4.5 ‰/ha/year → 1.1 ‰/ha/year**

## Total additional C storage

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

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

## Take home message

- Additionnal sources of organic residues: composts and digestates  
→  $1.6 \cdot 10^6$  tons of C per year
- Much lower than animal manures ( $12 \cdot 10^6$  tons of C per year) but necessary to recycle and interesting where animal breeding is lacking
- **Additional storage :  $0.3 \rightarrow 1.0 \cdot 10^6$  tons of C/year stored depending if GW are included or not (4 à 15% of total potential additional 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