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# Assemblée Générale

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AnaEE Analysis and Experimentation on Ecosystems France

# How various types of organic waste sustain crop yields and drives C, N, P, and K dynamics in calcareous soil.


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# Diversity of *organic wastes (OWs)*

## *Origins of OWs*

OWs are organic waste products can be used in agriculture through applications on cropped soils either directly or after treatments.

From agricultures

Manure and effluents

From cities

Greenwaste & Household biowaste

From industries

Sewage sludge

## *Treatments of OWs*

(i) Biological treatments, composting/anaerobic digestion

(ii) Physical or chemical treatments as drying or liming

**Reference:** Marmo et al., 2004; Noirot-Cosson, 2017

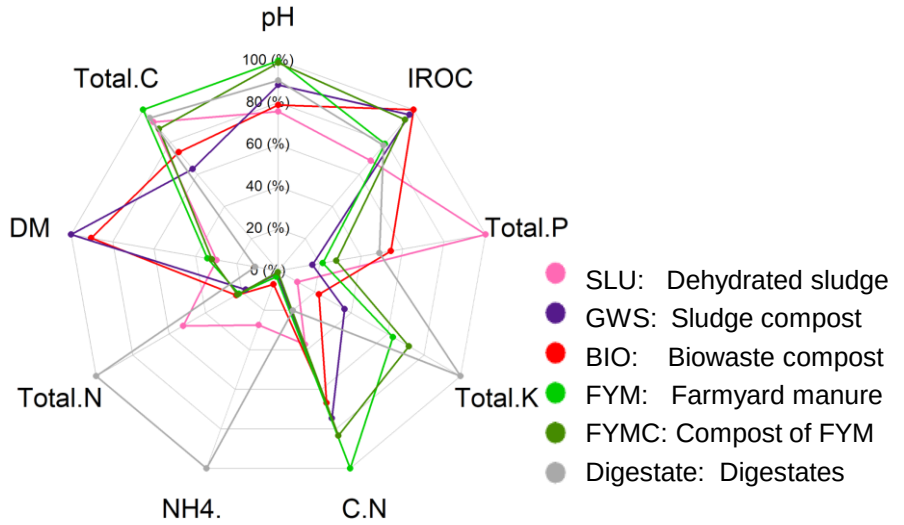
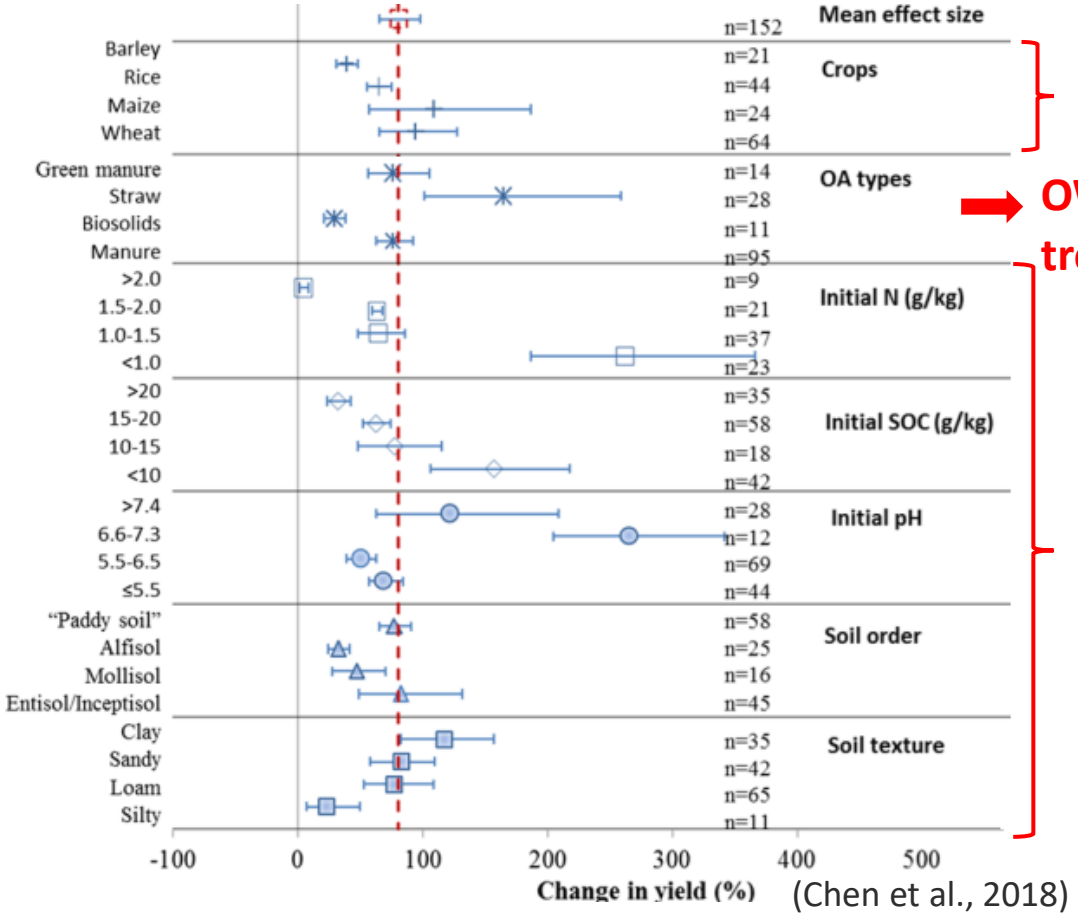



Fig.1 Characteristic of OW applied in Colmar

# Diverse effects of organic wastes

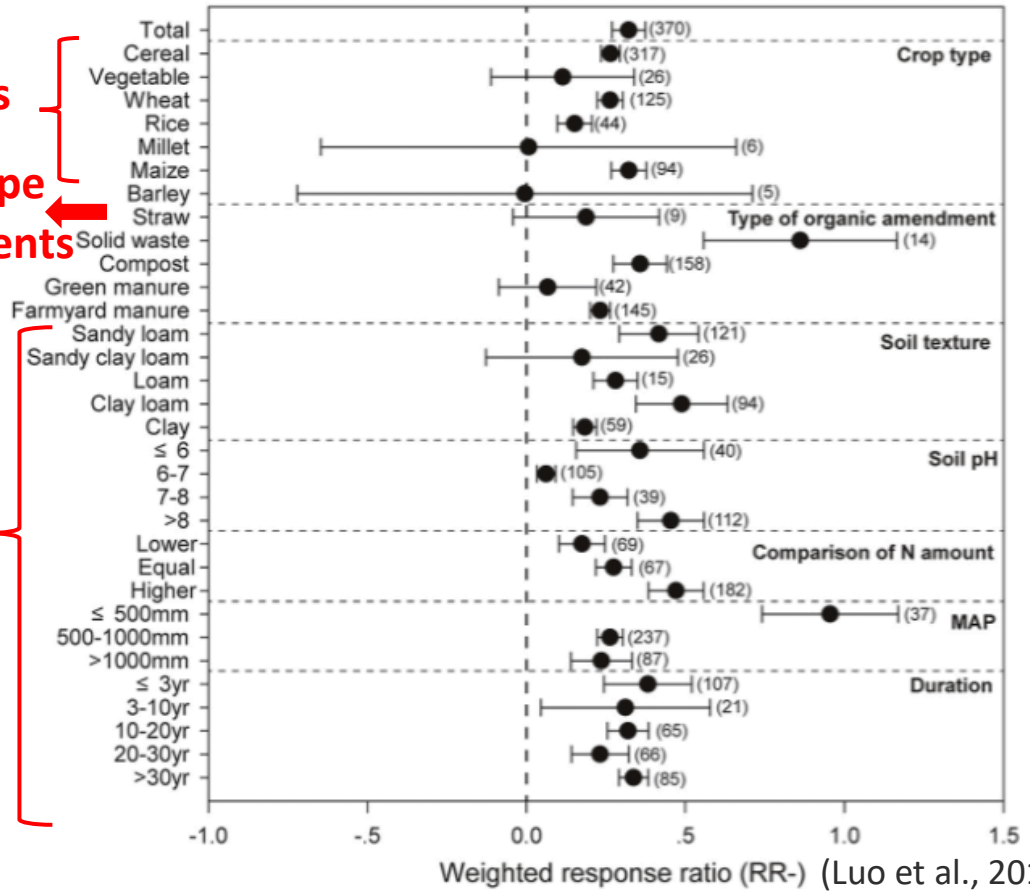
## Diverse effects on yields




(Chen et al., 2018)

Fig.2 Percent changes in plant yield over the whole duration

## Diverse effects on SOC:




(Luo et al., 2018)

Fig.3 Percent changes in SOC over the whole duration

**Reference:** Chen et al., 2018; Luo et al., 2018

# *Test the effects of OWs*

**Best method to test the effects of OWPs**

**-** long-term cropping experiments (LTEs)

- **Effects on crop and soil can last for several years**
- **Effects may could be detected after years**

**OW added in excess to strengthen the effects**

**Crop residues removed to strengthen the effects**

**Few experiments in calcareous soils**

# *Objectives*

1) Study the effects of repeated applications of raw or composted OW on crops and C, N, P and K dynamics in a calcareous soil

2) Identify the characteristics of OW linked to the variability of OW effects

# Materials and Methods

## Experimental design

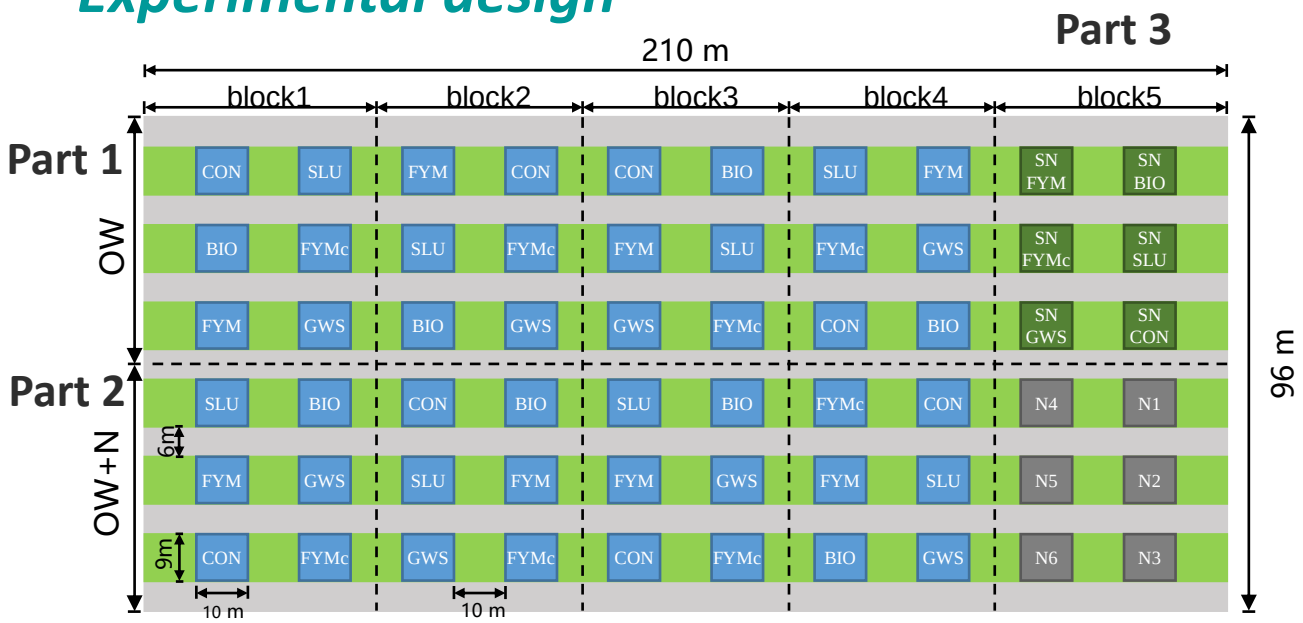



Fig.4 Experimental design in Colmar

SLU: Dehydrated sludge FYM: Farm yard manure
GWS: Sludge compost FYMC: Compost of FYM
BIO: Biowaste compost CON: Control

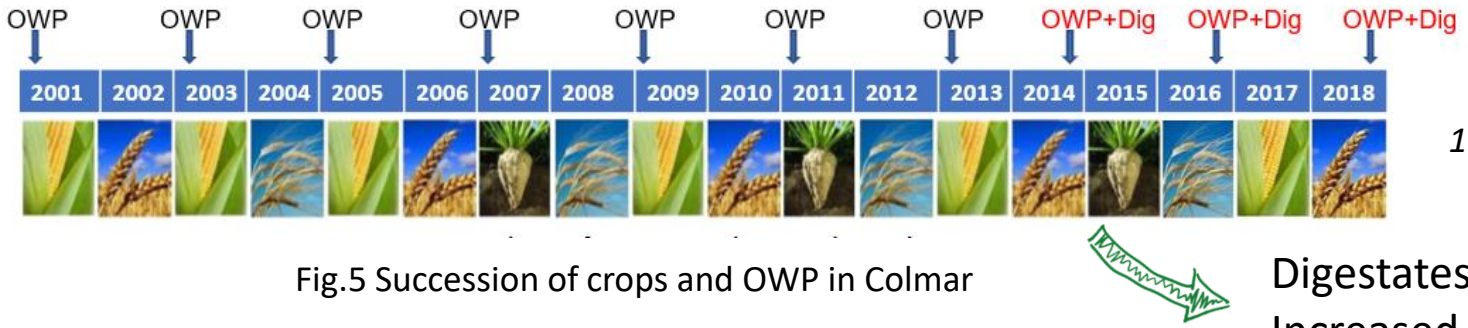



Fig.5 Succession of crops and OWP in Colmar

- **Soil, OW and crops are sampled regularly**
- **Analyzed the data from 2000 to 2018**
- **Anova analyses to identify significant differences between treatments**
- **Tested the relationship between OWs input and changes in soils characteristics**

*170 kg N/ha every two years*

Digestates application;
Increased OW rate in the N- experiment

# Results & Discussion

## *Yield:*

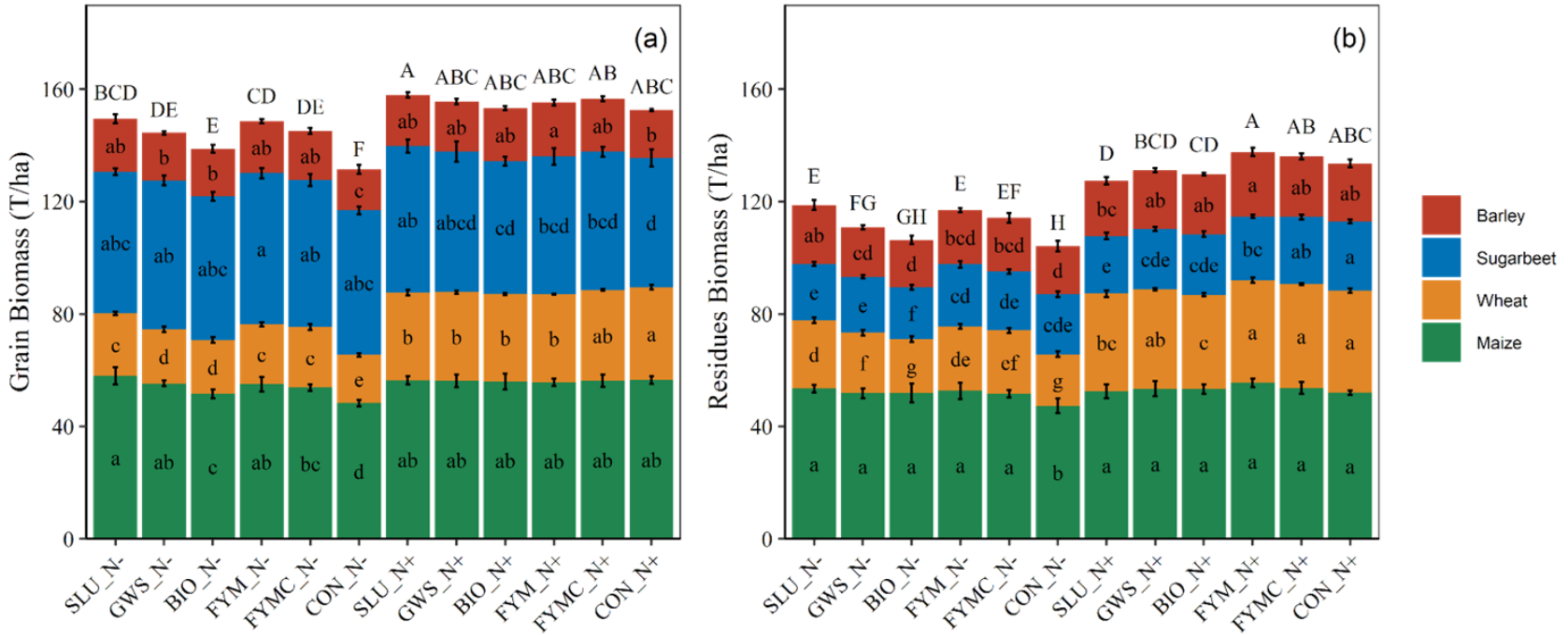
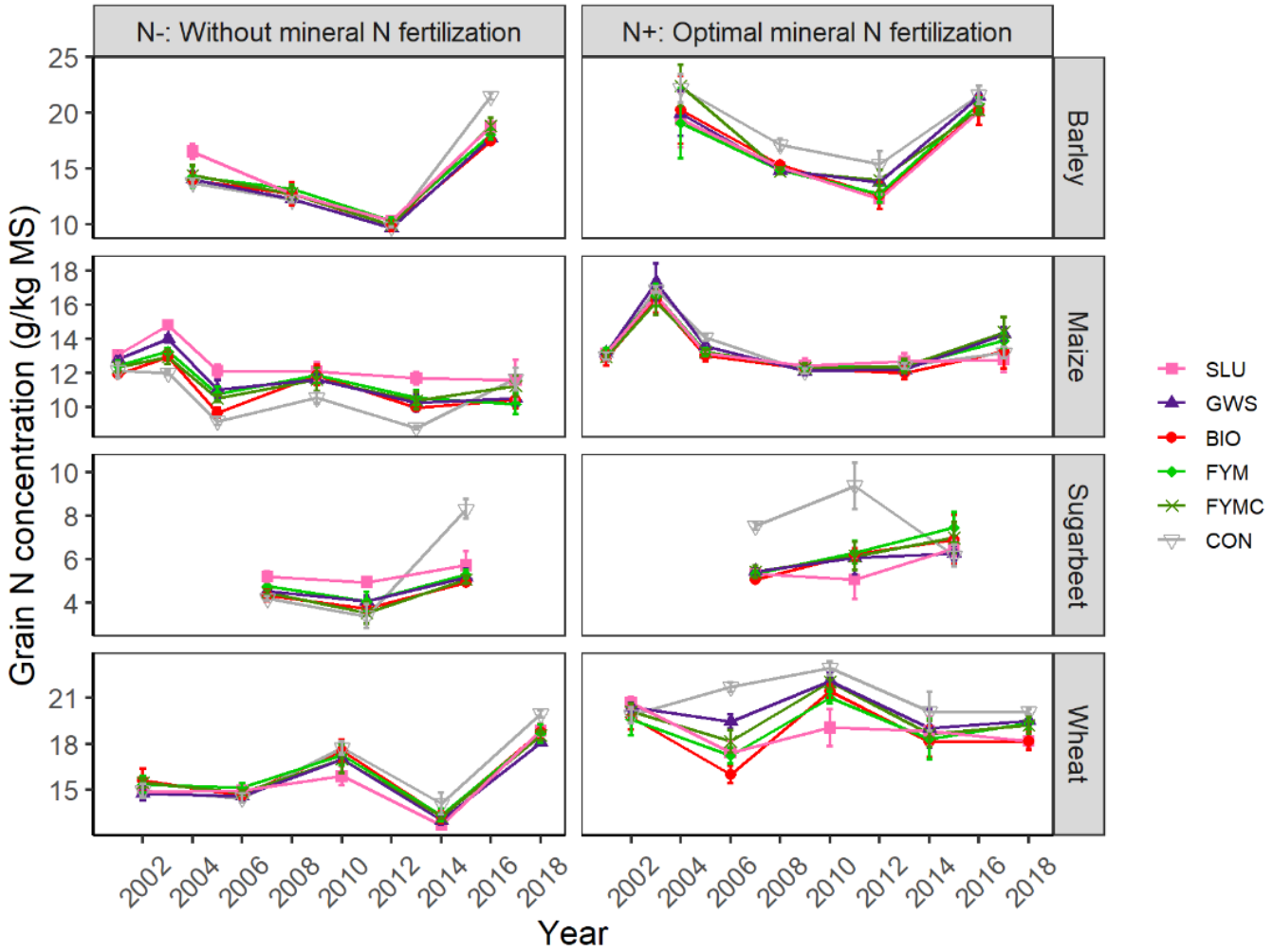



Fig.6 Cumulative harvested biomass and aerial residues biomass of barley, sugarbeet, wheat and maize.

- **OW application increased the grain biomass of maize, wheat and barley in comparison to no fertilization (CON_N-)**
- **OWs+N sustained crops yield to the levels of mineral fertilizer (CON_N+)**
- **N or OWs had no effect on Harvest index**
- **Digestates could maintain crop yield compared (CON_N+)**

# Results & Discussion

## *N concentration in crops harvests:*




- **OWs had no side effect on grain N concentration**
- **OWs+N increased the N content compared with OWs**
- **Potential of digestes to increased N content**

Fig.7 Concentrations of N in barley, maize, sugarbeet and wheat grain from 2001–2018 under the 12 treatments.

# Results & Discussion

## *Carbon change:*

Total C input:

Stabilized C input (PROC) (C input * humification coefficient) :

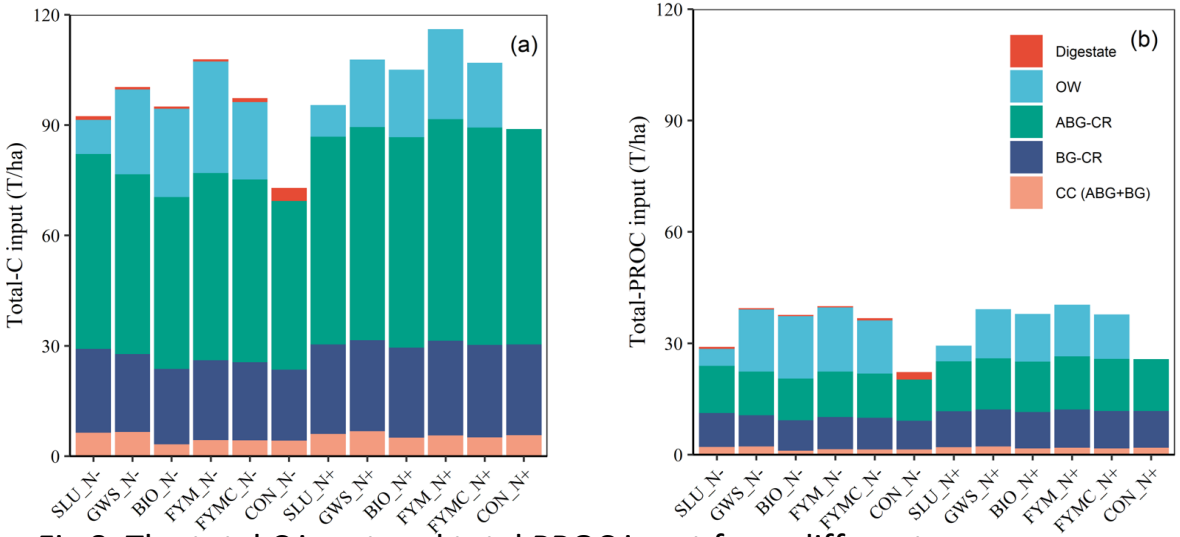



Fig 8. The total C input and total PROC input from different sources

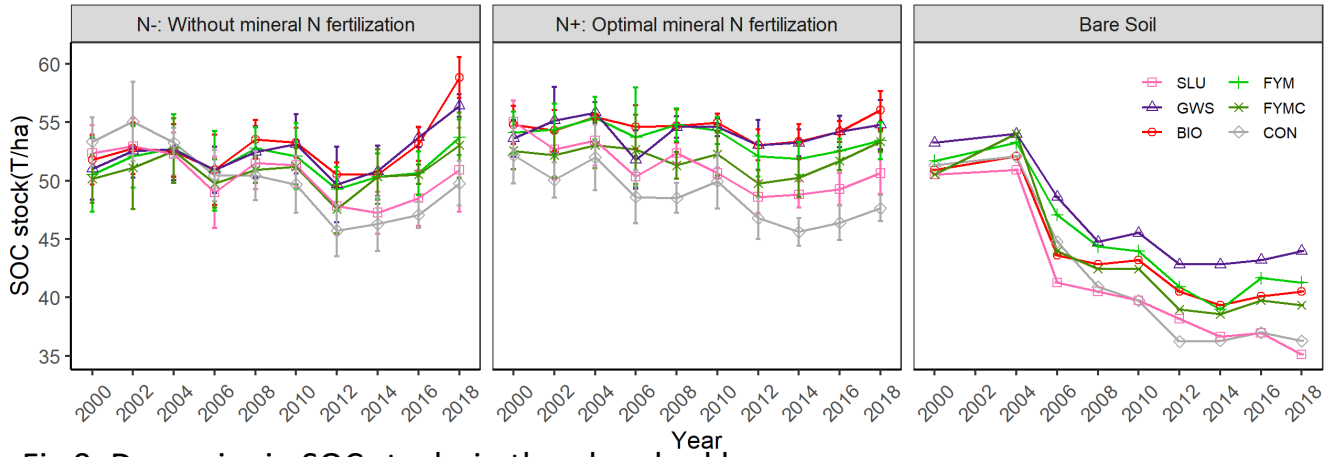



Fig 9. Dynamics in SOC stocks in the ploughed layer.

- **Crop residues C input are higher than OWs C input**
- **OW application maintain C stocks in comparison to the control treatments (decreasing C stocks)**
- **C stocks changes linearly correlated with C (PROC) input**

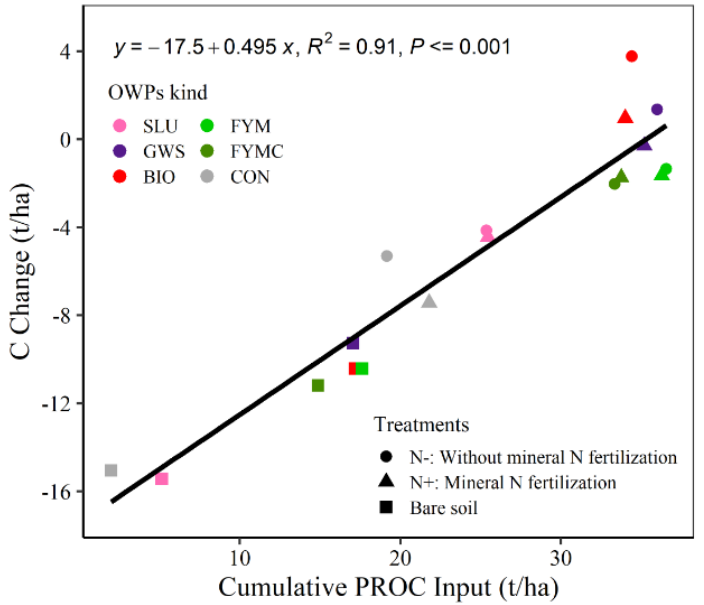



Fig 10. Relationship of Cumulative PROC VS C change

# Results & Discussion

## *Olsen-P dynamics :*

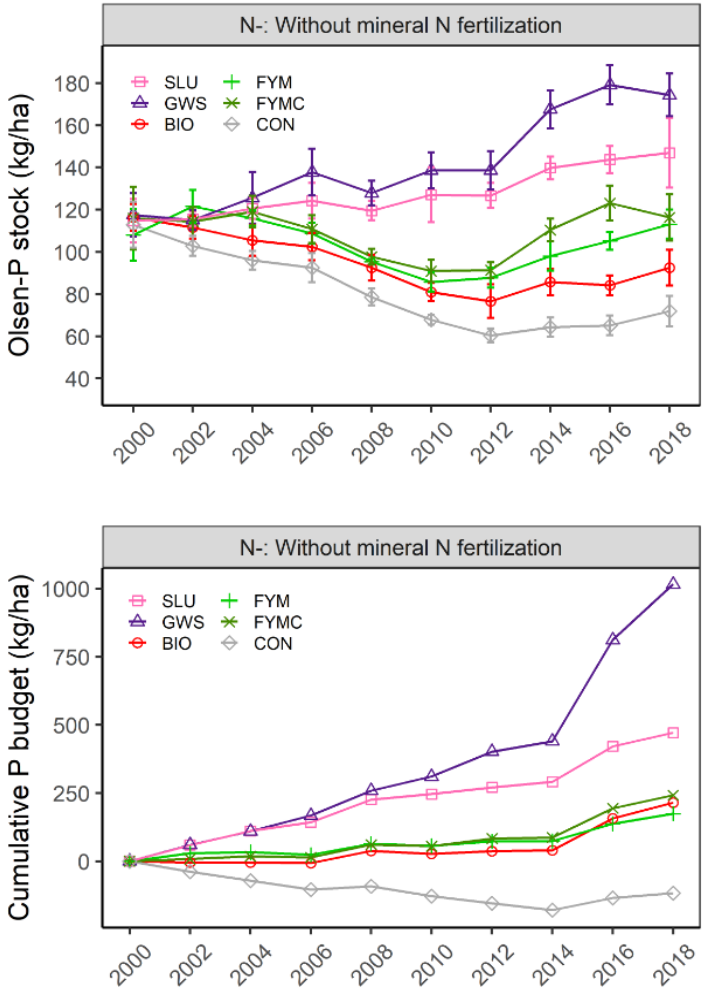



Fig.11 Cumulative Olsen-P stock and budget.

**Olsen P dynamics depend on P input and OW types in calcareous soils**

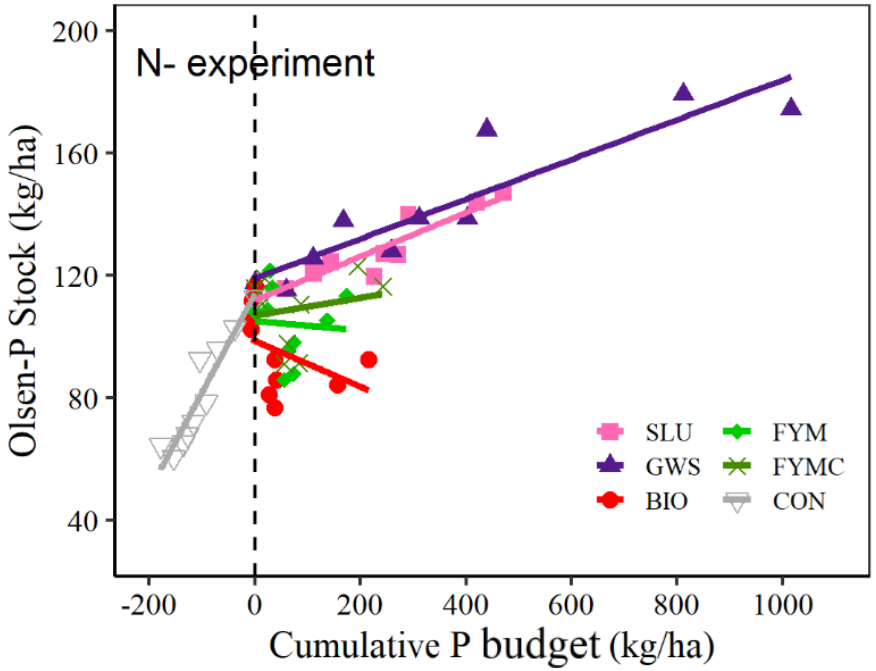



Fig.12 Relationship between cumulative Olsen-P stock and budget

Surplus of +100 kg P $ha^{-1}$ :

GWS/SLU : raised 6/8 kg Olsen-P $ha^{-1}$

BIO: decreased 8 kg Olsen-P $ha^{-1}$

# Results & Discussion

## *Exchangeable-K dynamics :*

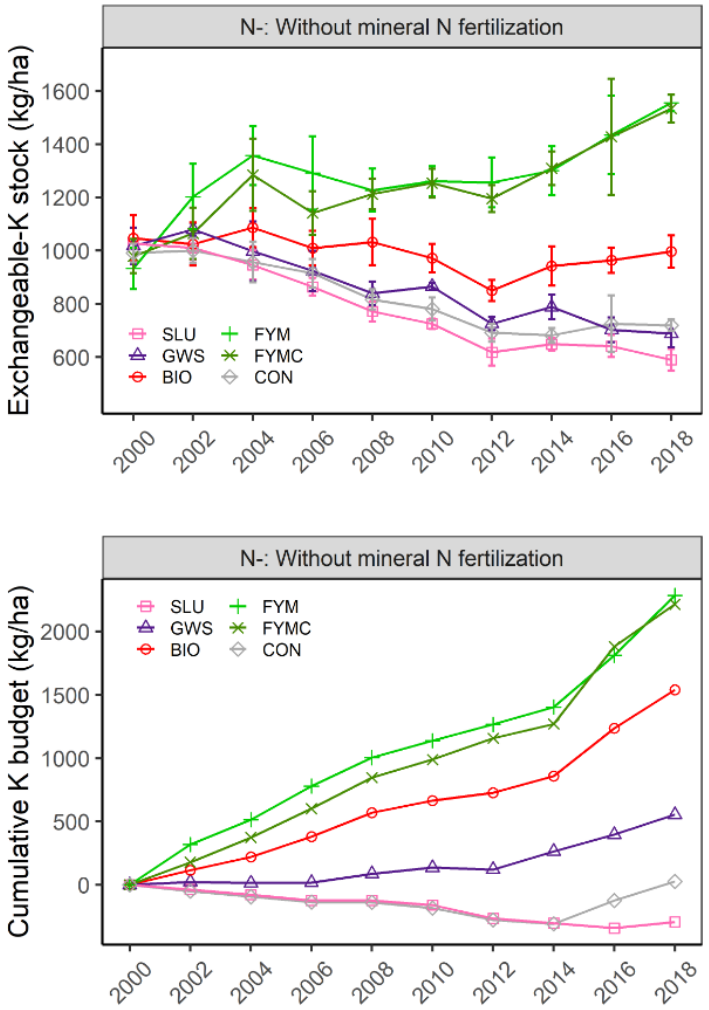



Fig.13 Cumulative Exchangeable-K stock and budget.

**Exchangeable K dynamics depend on K input and OW types in calcareous soils**

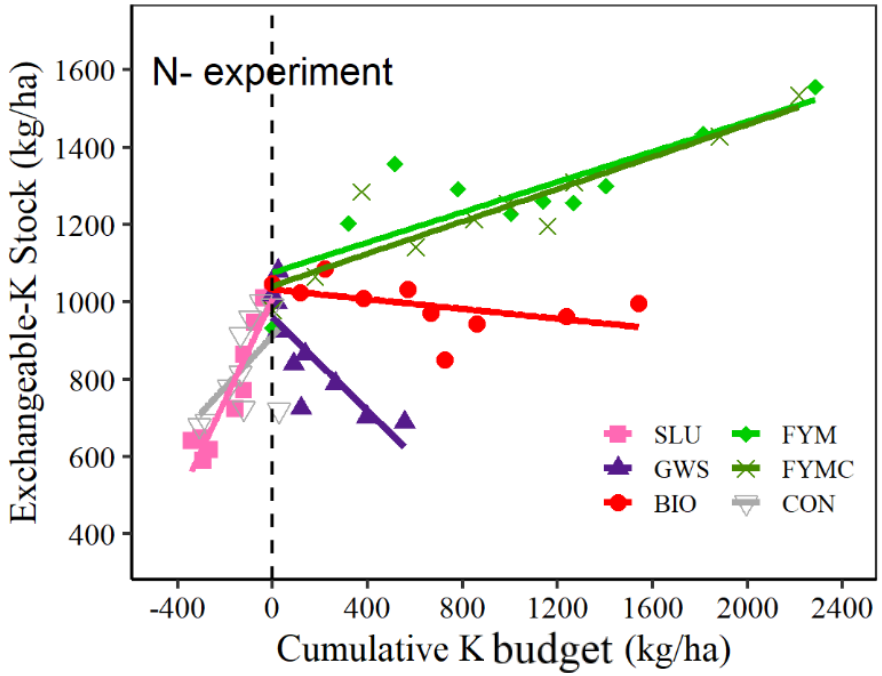



Fig.14 Relationship between cumulative Exchangeable-K stock and budget

Surplus of +100 kg P $ha^{-1}$ :

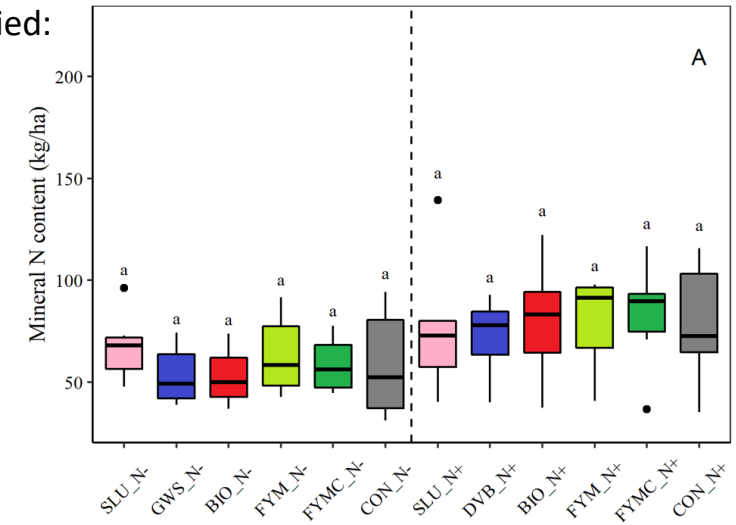
FYM/FYMC: raised 20/21 kg Exchangeable-K $ha^{-1}$

GWS: decreased 60 kg Exchangeable-K $ha^{-1}$

# Results & Discussion

## *Soil mineral N stocks (in early spring ):*

1st year after applied:




2nd year after applied:

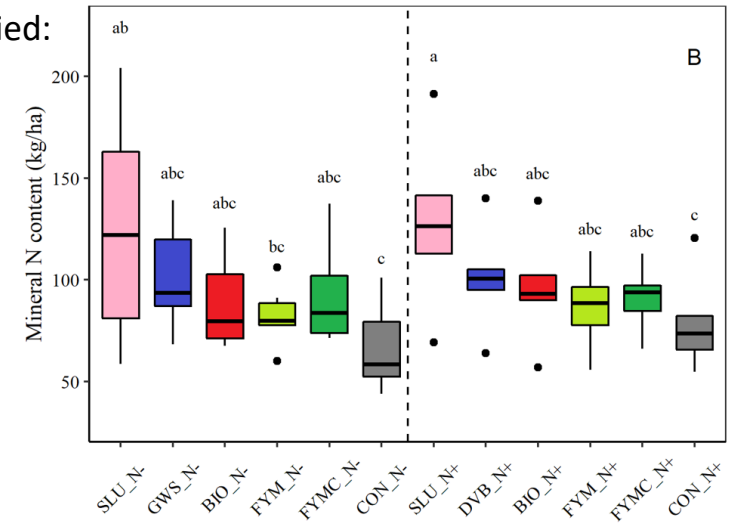



Fig.15 SMN stocks in early spring

N+ experiment

N- experiment

Table 1: Mean mineral fertilizer saved based on the N+ experiment and N fertilizer replacement value (NFRV) based on the N- experiment.

| OW | Mineral fertilizer saved (kg $yr^{-1}$ $ha^{-1}$) | | | NFRV (%) |
|---|---|---|---|---|
| | N | P | K | |
| SLU | 57.3 | 23.1 | 5.7 | 58 |
| GWS | 17.6 | 23.1 | 16.2 | 30 |
| BIO | 22.4 | 16.1 | 26.7 | 21 |
| FYM | 27.4 | 18.4 | 30.5 | 35 |
| FYMC | 18.8 | 17.7 | 30.5 | 32 |
| Digestate | - | - | - | 69 |

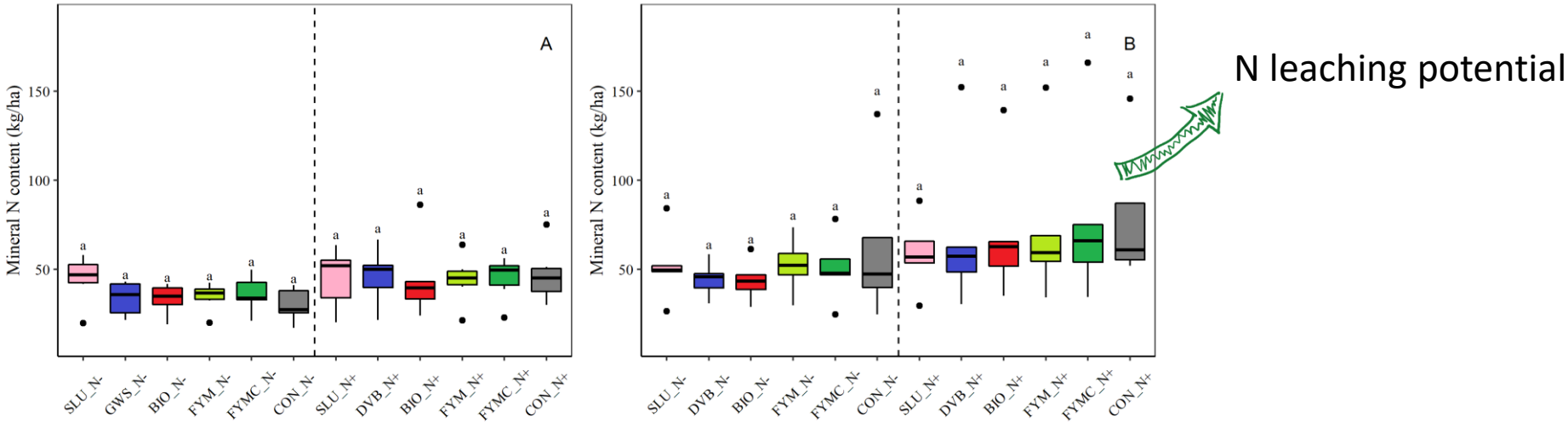
**SLU showed the highest N supply and saved the most N fertilizer.**

# Results & Discussion

## *Soil mineral N stocks (in late autumn):*

1st year after applied:

2nd year after applied:




N leaching potential

Fig.16. SMN stocks in late autumn

OWs did not increased the N leaching potential

# Conclusions

| | OW | OWs+N |
|---|---|---|
| Yields | Increased crops yield compared with unfertilized control (CON_N-) | Sustain crops yield to the levels of mineral fertilizer control (CON_N+) |
| Crops N content | No side effect<br>Digestes has potential to increased Crops N content | Increased compared with OW |
| SOC stocks | Increase SOC content (except SLU) | increase SOC content (except SLU) |
| P & K dynamics | Depended on the kinds of OWs | Depended on the kinds of OWs |
| Fertilizer saving & Replacement | SLU save the most N fertilizer;<br>SLU & GWS save the most P fertilizer ,<br>FYM & FYMC save the largest K fertilizer | NFRV: Digestate> SLU > FYM > FYMC > GWS > BIO |
| N leaching | Did not increase | Did not increase |

Thanks for your attention!

Merci beaucoup!