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European Biomethane Week: European Biogas Conference 2023

Breakout session 3: Fostering soil health with sustainable biogas systems

Wednesday 25 October 2023, Brussels

Digestate application and cropping system changes associated with biogas plant development

Variable effects on soil health depending on the baseline

Florent Levavasseur, Léa Boros, Sabine Houot

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Introduction

- Digestate = residual fraction of digested biomass in a biogas plant
- Variable digestate characteristics depending on the biomass digested and the considered fraction (raw, liquid, solid) *(Guilayn et al., 2019)*
- Digestate contains organic matter & nutrients
 - potential to increase soil organic matter and soil biological and physical properties
 - potential to replace mineral fertilizers (non-renewable resources)
- Digestate application is subject to nutrient losses like any fertilizers
- Effects a priori depend on cropping practices (rate, period...)



AD & soil organic matter

- ⊖ “Loss” of labile organic matter in the biogas plant ($\text{CH}_4 + \text{CO}_2$) → less organic matter returned to soil
- ⊕ Increased stability of digested organic matter returned to soil

AD & soil organic matter

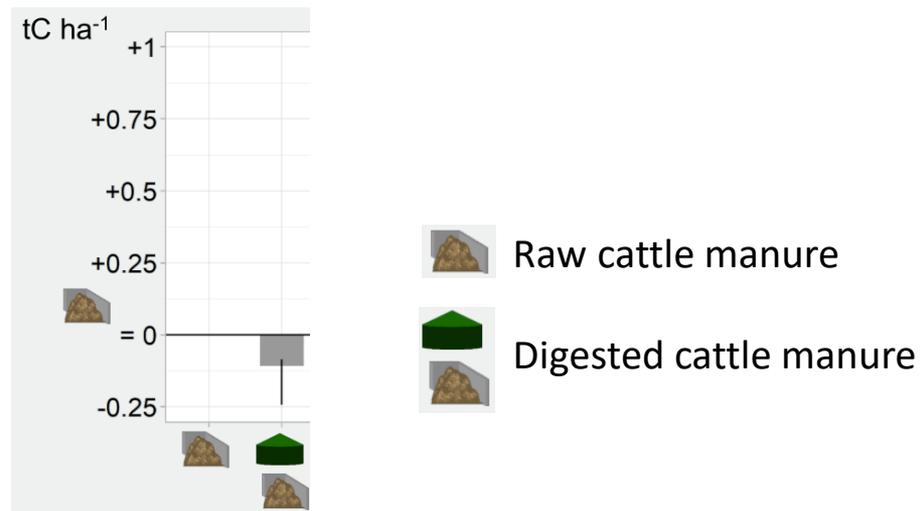
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Without the introduction of additional biomass in AD:
Stable to slight \searrow of soil organic matter

(Levavasseur et al. 2023, Moinard, 2021, Thomsen et al., 2013, Wentzel et al., 2015)

Relative C storage after 20 years
(Moinard, 2021)



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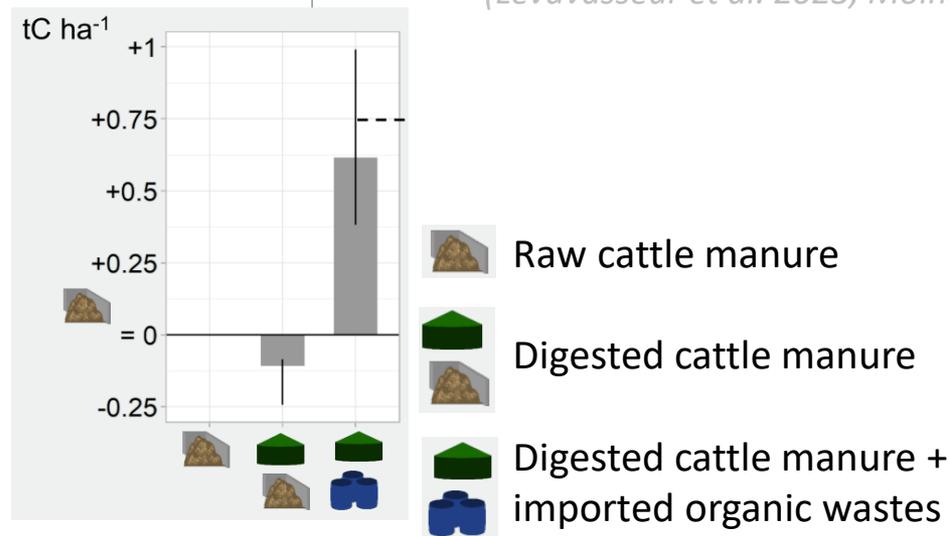
Without the introduction of additional biomass in AD:
Stable to slight ↓ of soil organic matter

(Levvasseur et al. 2023, Moinard, 2021, Thomsen et al., 2013, Wentzel et al., 2015)

Introduction of more biomass in the biogas plant (e.g., food wastes) and/or increased production of cover crop biomass for AD:
Slight ↑ of soil organic matter

(Levvasseur et al. 2023, Moinard, 2021)

Relative C storage after 20 years
(Moinard, 2021)



AD, soil nutrient supply and losses

- **Nutrient supply:**

- Higher N fertilizer value compared to undigested biomass, but usually lower compared to mineral fertilizer (*Gutser et al., 2005*)
- ↗ fertilizer savings (N, P, K...) with ↗ imports of organic wastes in the biogas plant with ↗ risks of excess nutrients at farm scale (*Moinard, 2021, Möller & Müller, 2012*)
- Potential competition for N between cover crops grown for AD and main crops (*Launay et al., 2022*)



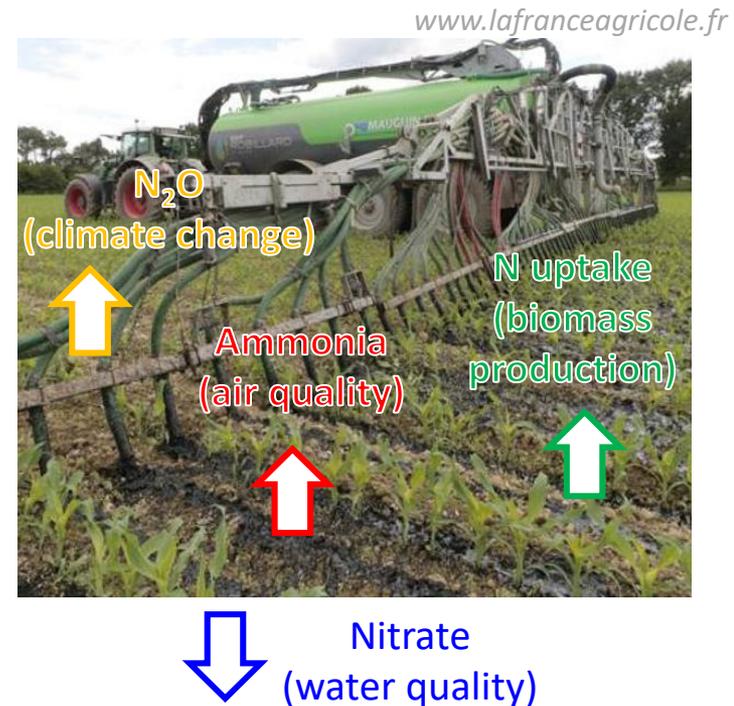
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- Potential competition for N between cover crops grown for AD and main crops (*Launay et al., 2022*)

- **Nutrient losses:**

- Ammonia volatilization: contrasted effects depending on digestate dry matter, pH and N mineralization (*Pedersen & Hafner, 2023*) → may be an important issue to limit
- Nitrate leaching: limited effect if digestate is used properly (right period and rate), while cover crops grown for AD may limit nitrate leaching (*Launay et al., 2022*)
- N₂O emissions: no clear effects (*Launay et al., 2022*)



AD, soil biology, physical properties and soil contamination

- Limited studies about the effect of digestates on soil biology (*Karimi et al., 2022, van Midden et al., 2023*)
 - Contrasting effects depending on the type of digestates, the control (inorganic / undigested organic fertilizer), the considered species...
 - Less stimulating effect than undigested biomass?
 - Some temporary toxic effects on fauna observed related to NH_3

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 - Less stimulating effect than undigested biomass?
 - Some temporary toxic effects on fauna observed related to NH_3
- Limited and contrasting results on soil aggregate stability (*Cooke, 2023*)
- ↗ risk of soil compaction with digestate application compared to mineral fertilizer application (*Lantz and Börjesson, 2014*) → use of specific machinery
- Soil contamination: similar issues than with undigested biomass



Umbilical spreading
www.bioenergie-promotion.fr

AD & changes in cropping systems

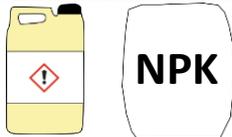
(PhD Léa Boros, ongoing work)

- Example of changes observed with AD based on energy cover crop

Simplified 2-year cropping system before AD development

Wheat → food / feed

Rapeseed → food / feed / fuel



AD & changes in cropping systems

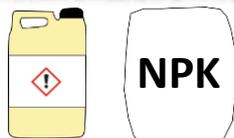
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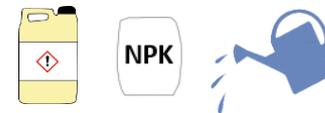
Simplified 2-year cropping system after AD development

Barley → food / feed

Maize → AD

Barley → AD

Maize → food / feed



- Changes in crop rotation, competition with food / feed, ↗ soil cover
- Changes in fertilization, pesticide use, irrigation, soil tillage...

→ Effects on soil health ? Environmental balance ? Climate change-resilience ?

Take-home message

- Imported biomass in the biogas plant cause the main effects of AD: increased soil organic matter, fertilizer savings...
- Relative effects of AD depend on the “control” situation : no fertilization, mineral or organic fertilization
- Changes in cropping systems and their impacts deserve to be better studied

Thanks for your attention

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