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 (CH_4 + CO_2) → less organic matter returned to soil

+ Increased stability of digested organic matter returned to soil

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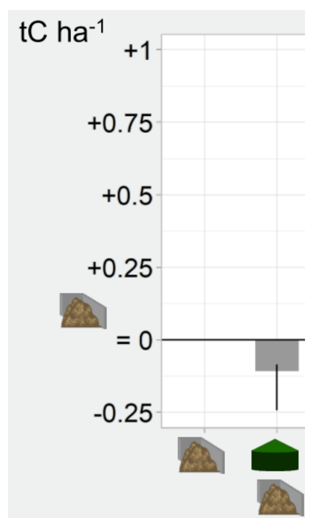
Without the introduction of additional biomass in AD:
Stable to slight ↘ of soil organic matter

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

Relative C storage after 20 years

(*Moinard, 2021*)



Raw cattle manure

Digested cattle manure

AD & soil organic matter

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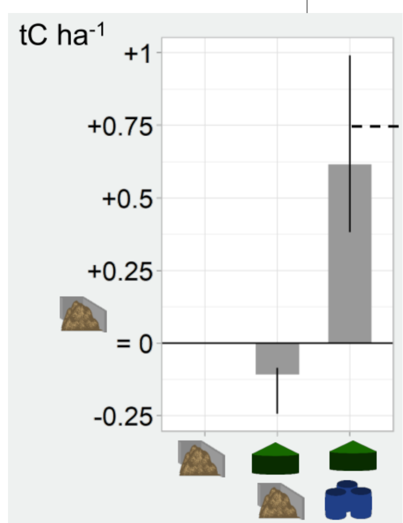
Without the introduction of additional biomass in AD:
Stable to slight ↘ of soil organic matter
(Levavasseur et al. 2023, Moinard, 2021, Thomsen et al., 2013, Wentzel et al., 2015)

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
(Levavasseur et al. 2023, Moinard, 2021)

Relative C storage after 20 years
(Moinard, 2021)




Raw cattle manure
Digested cattle manure
Digested cattle manure + imported organic wastes

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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- **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 <u>is used properly</u> (right period and rate), while cover crops grown for AD may limit nitrate leaching *(Launay et al., 2022)*
  - N_2O emissions: no clear effects *(Launay et al., 2022)*

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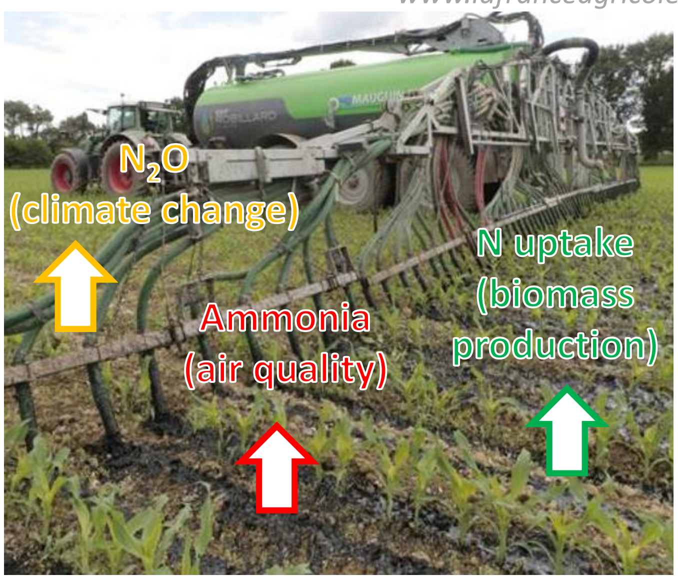

Nitrate
(water quality)

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 undisgeted biomass?
  - Some temporary toxic effects on fauna observed related to NH_3

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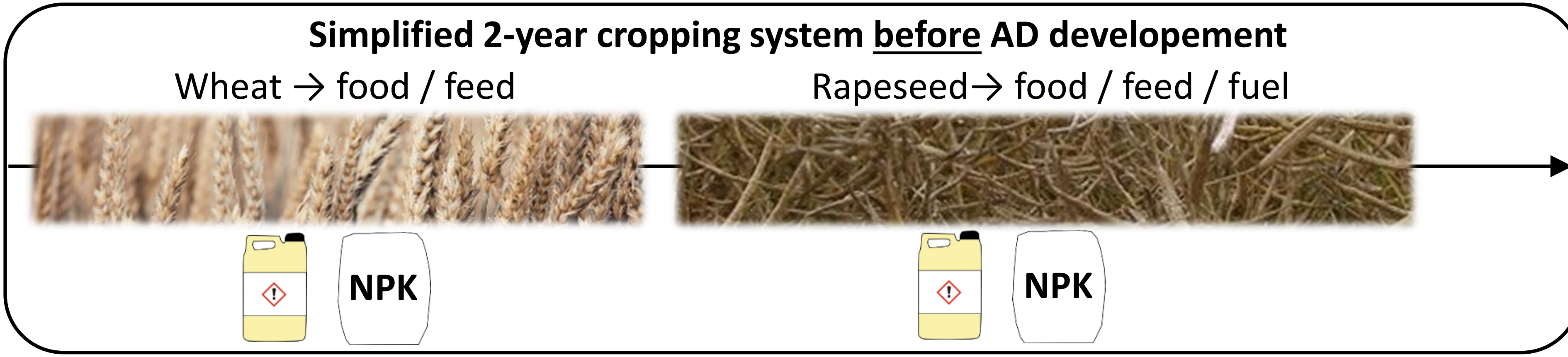
  - Some temporary toxic effects on fauna observed related to NH_3
- Limited and contrasting results on soil aggregate stability *(Cooke, 2023)*
- ↗ risk of soil compaction with digestate application compared to mineral fertilizer application *(Lantz and Börjesson, 2014)* → use of specific machinery
- 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



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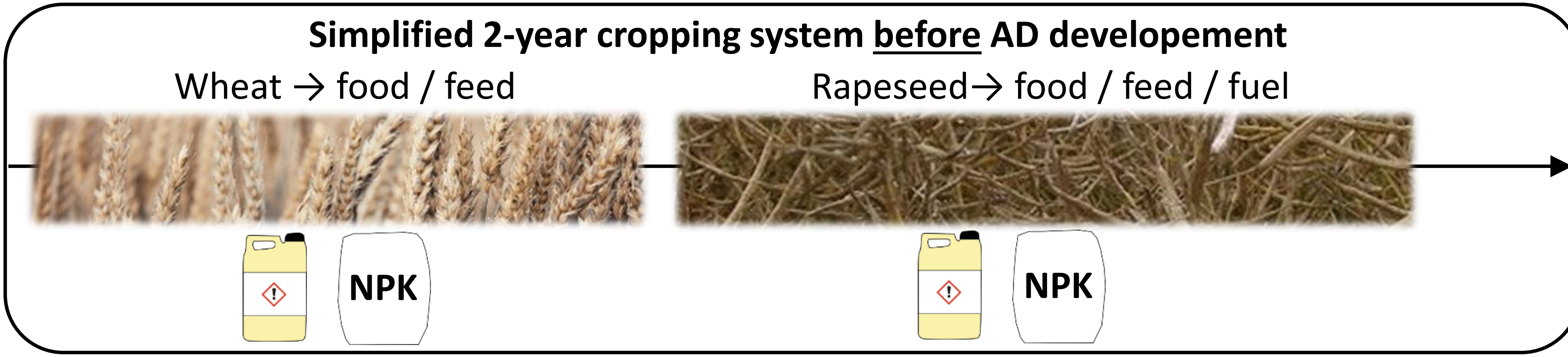

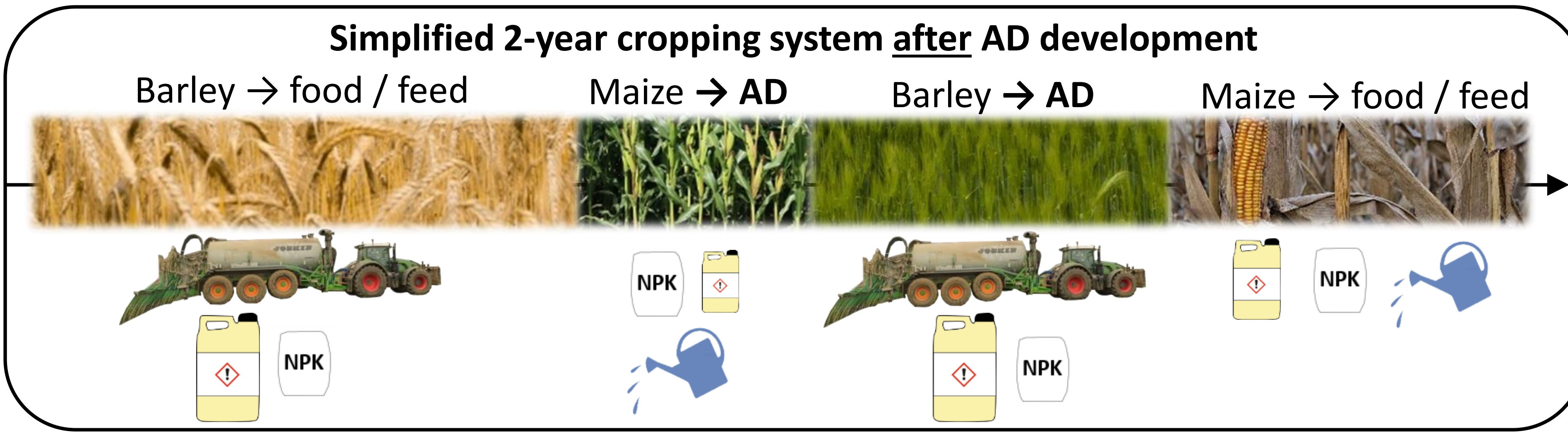

- Changes in crop rotation, competition with food / feed, ↗ soil cover
- Changes in fertilization, pesticide use, irrigation, soil tillage…

→ 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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