Evaluating the Performance of Biobased Nitrogen Fertilizers using Dynamic Modelling

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Introduction

Biobased waste materials containing valuable nutrients, fibre, and carbon are often discarded or underutilized. These materials could be processed into potentially valuable **biobased fertilizers (BBFs).** However, using BBFs to substitute conventional synthetic fertilizers requires an understanding of their agronomic and environmental performance, which is currently lacking. Field-scale modelling can be used to evaluate the performance of BBFs.

Daisy is a process-based model capable of simulating the cycling of water, nitrogen, and carbon in the soil-plant-atmosphere continuum, and a versatile tool for evaluating the performance of different farming practices and technologies such as BBFs. The objective of this study was to evaluate the agronomic and environmental performance of BBFs using the Daisy model.

Methods

1. Eight biobased fertilizers (BBFs)

BBF	Raw material (s)
BA6	Plant-based (wheat, maize)
BIO	Meat and bone meal
BVC	Municipal organic waste
FEK	Chicken manure
OG2	Horn meal (pig bristles)
PAL	Clay rock flour + biochar
PCW	Potato cell water
SDG	biogas digestate

BBFs characterization

- Physicochemical analysis
- Lab incubation for C&N mineralization rates
- Lab experiment for NH_3 volatilization
- Field experiment for Mineral N Fertilizer replacement values (MFRV)

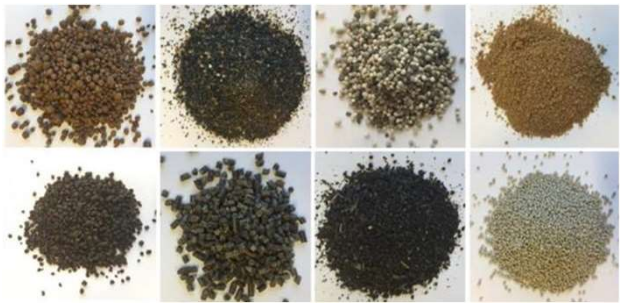

Fig. 1. Biobased fertilizers (Photo: Lærke W. Larsen)

2. Six cropping systems from different European regions were selected, varying in crop rotations, soil types, and climate.

3. Three mineral N fertilizer replacement scenarios were chosen
Agronomic: Based on 1st yr. MFRV from field experiments ($MFRV_{ag}$<100%)
Environmental: Assumed same MFRV as of mineral fertilizer ($MFRV_E$=100%)
Residual: In-between agronomic and environmental (avg. of $MFRV_{ag}$& $MFRV_E$)

4. Daisy model

- Calibrated for crop DM and N yield, and C and N mineralization of BBFs
- Used to simulate crop rotations with

(a) Mineral reference fertilization (baseline)
(b) Substitution of baseline with BBFs using 3 fertilizer replacement scenarios

5. Simulated outputs are presented as a response relative to the baseline

Conclusions

- The BBFs have the potential to replace mineral synthetic N fertilizer and maintain yields when applied according to the estimated 1st-year $MFRV_{ag}$.
- However, in this case, they are also likely to increase environmental N emissions, especially BBFs with low 1st-year $MFRV_{ag}$ (=higher N input)
- To protect the environment, the replacement of mineral fertilizers with BBFs should be based on MFRV closer to 100%, taking into account the marked residual effect of BBFs.
- The BBFs rich in org-N have the potential to enhance soil C&N storage.

Results

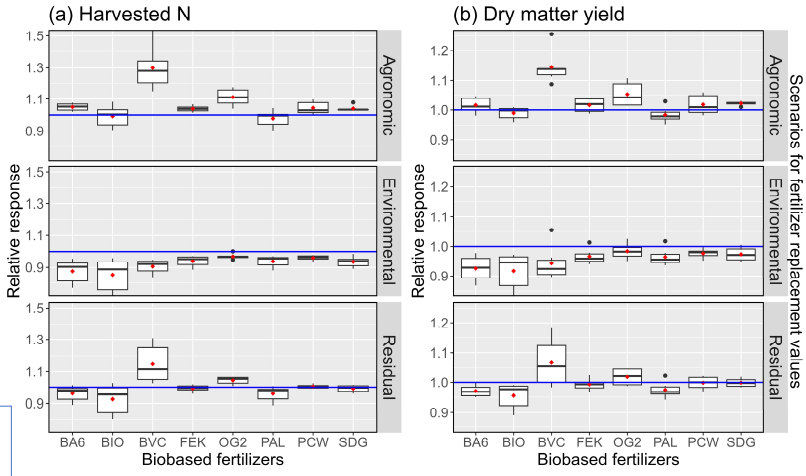

Fig. 2. Effects of biobased fertilizers on harvested N and dry matter yield under three fertilizer replacement scenarios relative to reference fertilization (blue line). Boxplots show cropping system variations (red point = mean).

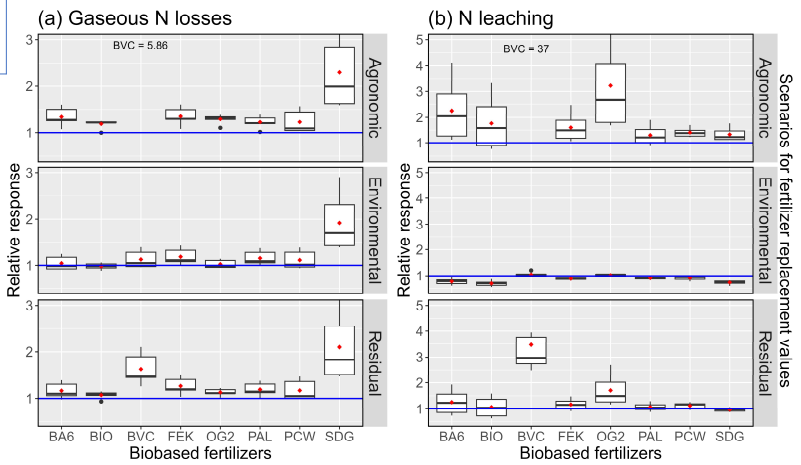

Fig. 3. Effects of biobased fertilizers on gaseous (N_2, N_2O, NH_3) and leaching N (surface, drain and matrix NO_3- flow) losses under three fertilizer replacement scenarios relative to reference fertilization (blue line).

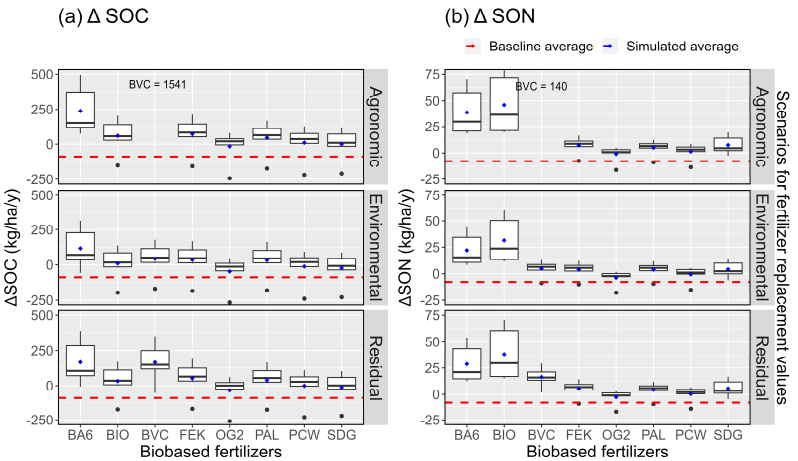

Fig. 4. Impact of biobased fertilizers on soil organic C and N stock changes under three replacement scenarios. Blue point: average across cropping systems. Red dashed lines: average stock changes with reference fertilization.

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