Long-term manure carbon sequestration in soil simulated with the Daisy model on the basis of a short-term incubation study

Yubaraj K. Karki, Christen D. Børgesen, Ingrid K. Thomsen and Peter Sørensen
Department of Agroecology, Aarhus University, Denmark

Objective

To calibrate the DAISY model (Abrahamsen & Hansen, 2000) for change in soil organic C and N content based on a short term incubation study and simulate the long term carbon sequestration of manure C in cereal cropping system after different manure treatments (+/- anaerobic digestion).

Introduction

- By anaerobic digestion of manure biogas is produced that can replace fossil fuels, but it may also influence carbon (C) sequestration in soil.
- Estimation of long term variation in the C pool in soil with regular application of digested and non-digested manure is important to understand the effect on soil fertility and greenhouse gas balances.
- The Soil-Plant-Atmosphere system model DAISY was applied to estimate soil C change based on an up-scaled laboratory incubation study.

Material and Methods

- DAISY was calibrated using published data of Thomsen et al. (2013) for C released in an soil incubation study of 247 days.
- The original study was conducted for two Danish soils: a loamy sand and a coarse sand supplied with non-digested and digested cattle manure (AOM).
- The digested and non-digested cattle manures were of the same origin.
- Long-term C simulations were made for continuous cereal cropping with and without 50 years of application of two types of manure, accounting for the 46% C loss during anaerobic digestion (543 and 1013 kg C ha^{-1} yr^{-1} in digested and non-digested manure). This also implied a similar application of manure N with the two manure types
- The two N application rates used in the simulations were: 160 kg N ha^{-1} (70 kg N ha^{-1} in AOM plus 90 kg N ha^{-1} in mineral fertilizer) and mineral fertilizer alone in a rate of 120 kg N ha^{-1}.

Results

Short term simulation

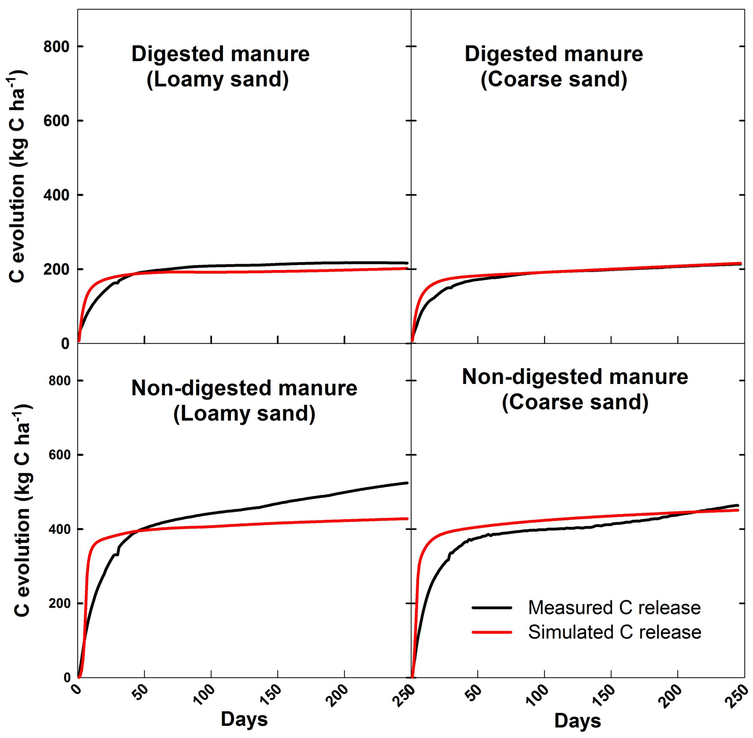

Figure 1. Measured and simulated cumulative C release from digested and non-digested manure after calibration of the DAISY model. The calibration was based on an incubation experiment of 247 days with constant temperature of 20°C and moisture at field capacity.

Long-term simulation

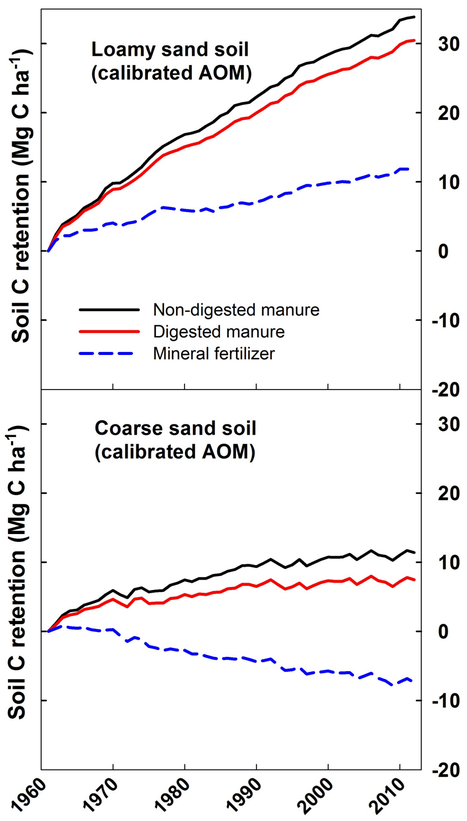

Figure 2. Long term simulations of net soil C change over 50 years in the two soils with application of digested and non-digested manure (160 kg N ha^{-1}) or with 120 kg N ha^{-1} in mineral fertilizer since 1961.

Net C retention

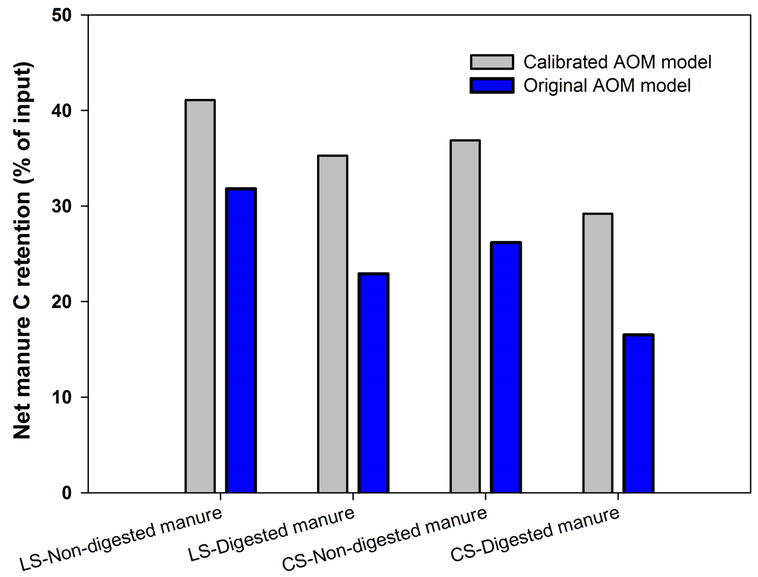

Figure 3. Net manure C retention after 50 years annual application of digested or non-digested manure simulated for a loamy sand (LS) and coarse sand (CS). The calculated retention is based on the initial C content of manure before anaerobic digestion and related to simulations with application of only mineral fertilizer .

Discussion and Conclusion

- Using calibrated model parameters the simulated net C retention in soil after 50 years annual manure applications was 29-41% when related to the original C in fresh cattle manure (Fig. 3).
- Application of non-digested manure resulted in a higher annual C retention than with corresponding digested manure and the lowest retention by use of mineral fertilizer (Fig.2).
- Use of standard parameters in the DAISY model resulted in lower simulated C retention than with calibrated parameters.
- The simulations showed 15-20% higher net C retention in soil after 50 years application of non-digested cattle manure compared with digested manure (Fig. 3). However, a comparison with corresponding stored manure was not available. Losses of C during manure storage should also be taken into account when comparing C sequestration in scenarios with and without anaerobic manure digestion.
- Simulated net retention of manure C was higher in the loamy sand than in the coarse sand as clay affects organic matter decomposition in the DAISY model.
- DAISY simulated increasing C content in the loamy sand soil for both manure or mineral fertilizer application which is in contrast to the long term decrease in soil C concentration that has been observed on this location (Askov LTE) (Bruun *et al*. 2003).

References

- Abrahamsen,P. & Hansen,S. 2000. Daisy: an open soil-crop-atmosphere system model. *Environmental Modelling & Software*, 15, 313-330.
- Bruun,S., Christensen,B.T., Hansen,E.M., Magid,J. & Jensen,L.S. 2003. Calibration and validation of the soil organic matter dynamics of the Daisy model with data from the Askov long-term experiments. *Soil Biology and Biochemistry,* 35, 67-76.
- Thomsen,I.K., Olesen,J.E., Møller,H.B., Sørensen,P. & Christensen,B.T. 2013. Carbon dynamics and retention in soil after anaerobic digestion of dairy cattle feed and faeces. *Soil Biology and Biochemistry*, 58, 82-87.

Contact information:

Yubaraj K. Karki
yubakarki@gmail.com

Christen D. Børgesen
christen.borgesen@agrsci.dk

Aarhus University
Department of Agroecology

INTERREG4A SYDDANMARK-SCHLESWIG-K.E.R.N.

STABIL Project

European Union
European Regional
Development Fund
Investing in your future