A Practice applicable model for the Assesment of Management Impact on organic matter in arable soils

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Abstract

We present the HU-MOD-2 model for the assessment of management impact on organic matter levels in arable soils. The model aims at optimal applicability as a management support tool in framing practice and therefore requires only easily available input data. In validation, the tool proved to be capable of giving a rough estimate on soil organic matter changes in arable soils. Taking into account the low demand for input data, the modelling error seems tolerable for a practice applicable decision support tool.

Introduction

Much knowledge exists on the relevance of soil organic matter (SOM) as a factor in crop production. Still, the assessment of management impact on soil organic matter in arable farming practice is difficult. SOM heterogeneity in space is very large compared to short- and mid-term SOM changes, causing a considerable 'noise' in analytical assessments. With this contribution we want to present a model that calculates SOM loss in soils mainly based on nitrogen withdrawal with crop yields, and thus bypasses the need for detailed soil data to predict turnover rates. The model can therefore be used as a decision support tool (DST) in farming practice. A first version of the model has been presented in Brock et al. (2012). At that time, the model applied a bi-partite approach, were SOM loss was calculated based on net N withdrawal with crop yields, and SOM supply was calculated based on C input. The concept performed well in principal, but had difficulties under N limited conditions, when C input was high at the same time. Therefore, we revised the SOM supply submodel and included a stoichiometric approach considering both C and N fluxes in the soil-plant system. By doing so, the performance of the model could be improved. A full description of the model is in preparation (Brock 2014). We would like to outline the model here, as it may have great potential for decision support and environmental impact assessment in organic farming practice.

Material and methods

The original humus balance model HU-MOD has been described in detail by Brock et al. (2012), and the revised HU-MOD-2 version will be presented in detail soon (Brock 2014). Briefly,, the approach of the HU-MOD-2 model for SOM change calculation is:

SOMloss = f (N in crop biomass, effective N sources, mechanical impact, site conditions)

SOMsupply = f (C inputs, N inputs, site conditions)

In order to achieve optimal applicability in practice, the model only requires data on crops in rotation, yield levels, and fertilizer types and amounts. Further, basic site data are required (mean annual precipitation, estimate of the soil clay content and CN ratio). All other parameters included in the calculations (e.g. harvest residues, root biomass, symbiotic N fixation, C and N losses) are estimated by the model.

The revised approach was tested with the same data sets as the initial model version to allow for comparison, and with further data sets to improve validation power. Here we present the results from the model validation in the Organic Arable Farming Experiment Gladbacherhof (OAFEG, cf. Schulz et al. 2014) as an example, as this data set features the highest quality of both crop and soil data.

The experiment was started in 1998 and comprises three "farm type" treatments that differ in crop rotations and fertilization: A "mixed farm" (MF) with a 0.33 share of perennial legumes in the crop rotation and manure of 1 LU cattle ha^{-1}, a "stockless farm with ley" (SFL) and a 0.165 share of perennial legumes, and a "stockless cashcrop farm" (SFC) without perennial legumes in the crop rotation. In the "stockless" systems, all straw, catch crop and ley (SFL only) biomass is left on the field, wereas all straw is exported in MF. Yield data are available for all crops (including catch crops) in all years. Soil data are taken on an annual basis in two topsoil and two subsoil layers. All data are available on the plot level.

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We included the data set for the first two rotations (1998-2009). The model performance was tested applying linear regression.

Results

The modeling results correlated with observed SOC and STN change in topsoils (0-30cm) of the OAFEG (fig. 1). Both with SOC and STN, the regression coefficients are close to 1, indicating that the model in this experiment was even able to quantify absolute SOM change (NB: SOM balance indicates kg SOM-C – target *b* therefore is aprox. 0.1 with STN!).

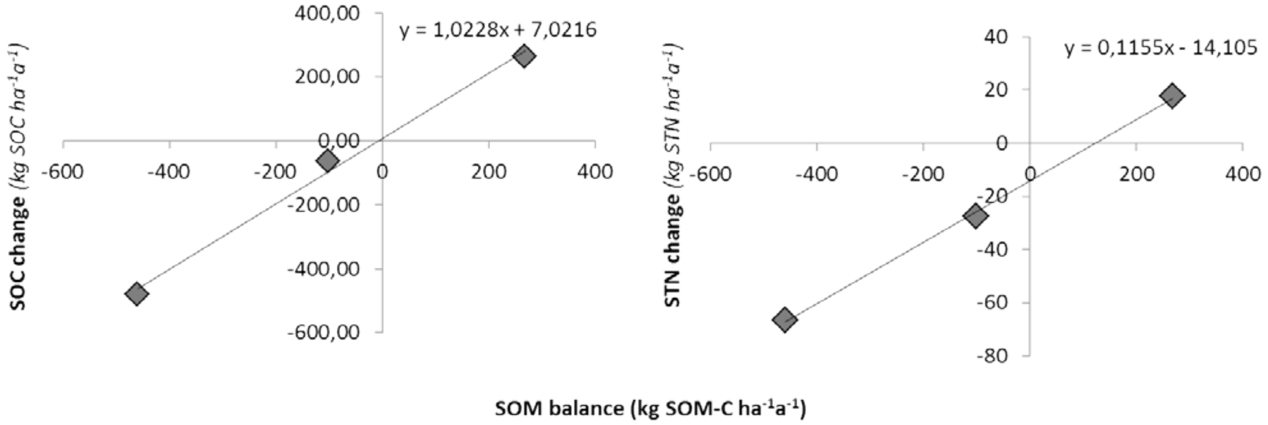

Figure 1. Relation between measured soil organic matter change (indicators: SOC and STN change in the 0-30 cm soil layer) and soil organic matter balances for 'farm type' treatments in the OAFEG long-term field experiment.

Discussion

The performance of the model in the OAFEG supports the model concept. Still, the high performance quality in that experiment must not be repeated under different site conditions, as important ecological drivers of SOM turnover are not –or not sufficiently- considered in the model for reasons of applicability as a practice tool. In fact, performance quality in other experiments usually was lower, even though the model in principal performed well at other sites, too (Brock 2014).

The most relevant sources of uncertainty in the model probably are the estimates of root biomass and symbiotic nitrogen fixation by legumes. Both parameters have a considerable impact on the model result. Still, they cannot easily be assessed under field conditions, and the state of knowledge does not allow for a sufficient parameterization under different site conditions.

Further, the basic model assumption is that the CN ratio of arable soils at a defined site does not change too much in the short or medium term and that the remainder of C and N form various inputs in soils can therefore be calculated referring to that site specific CN ratio. The applicability of this assumption is supported by the validation results. However, the model has only been tested under climate/soil conditions of central Europe up to now. It is possible that the assumption of a low short and medium term variability of CN ratios in arable soils must be revised in other climatic/soil regions, which would make a calibration of the model necessary. With a sufficient data base for this calibration (if demanded), the geographical applicability of the HU-MOD-2 should be easily extendable even to subtropical and tropical regions.

References

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