A DECISION SUPPORT FRAMEWORK FOR THE INTEGRATED EVALUATION OF AGRICULTURAL MANAGEMENT IMPACTS ON CROP YIELD, SOIL QUALITY AND ENVIRONMENT

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INTRODUCTION

Current agricultural management practices significantly affect crop growth and environmental quality in varying ways based on local agro-ecosystem properties. Integrated and optimal combinations of farm management are needed for agriculture to intensify sustainably. We develop a decision support system (DSS) to evaluate the overall benefits and trade-offs that management has on crop yield, soil quality and environment, using indicators for soil organic carbon (SOC), phosphorus and nitrogen cycles. The DSS integrates a range of soil, crop, and nutrient management practices along with an assessment of the influence of local agro-ecosystem properties (AEPs).

TOOL DESCRIPTION

At the current stage, an initial model framework is developed into a prototype, consisting of: (1) management and AEP input data, (2) model calculations, and (3) output of changes in response variables (Figure 1). Empirical relationships between management and impacts on crop yield, nitrogen use efficiency (NUE), and SOC changes are assessed using meta-analysis. Process-based modelling estimates changes in nutrient losses to air and water.

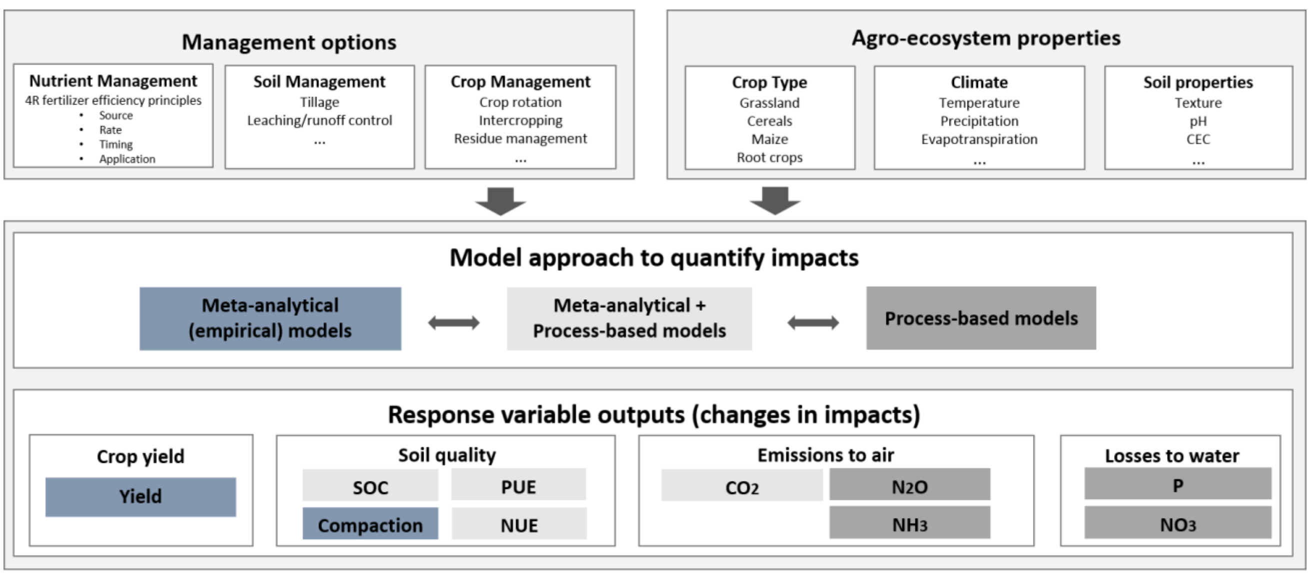

Figure 1. Conceptual overview of DSS (SOC = soil organic carbon; NUE = nitrogen use efficiency; PUE = phosphorus use efficiency)

At a later stage, phosphorous use efficiency (PUE) or soil P status will be integrated, and process-based models can supplement the medium-term meta-analytical models for long-term SOC, N, and P changes. Furthermore, the results of these models will be integrated into a DSS framework by means of multi-criteria analysis (MCA), since the selection of best management options is a multi-objective goal. The aim is to maximize agricultural intensification (e.g., fertilizer use efficiency, crop yield) and minimize negative environmental externalities (e.g., N and P losses to air and water), while relating (multiple) measures to (multiple) outcomes. Using the indicators mentioned as response variables, evaluation and weighting will be based on (1) various user goals (farmer, policy) and (2) the distance that current levels in the system are from target levels (crop yield, soil quality) or critical levels

(N and P losses). Other impacts, such as soil compaction (by a meta-analytical approach) or heavy metals (by existing model algorithms), will be integrated as well.

MODELLING APPROACH AND RESULTS

The first set up of the DSS has been focused on (1) assessing the impacts of measures on soil organic carbon (SOC) content and crop yields by meta-analytical approaches and (2) related uptake and losses of N by process-based modelling. Furthermore, site factors such as local AEPs are included in both to assess their influence on each management-impact relationship. As an illustrative example of the meta-regression for yield and SOC, consider the following equation set-up:

*ΔYield, SOC = **a***MP + **b***soil properties + **c***climate properties + **d***crop type + interactions*

where: *MP = management practices; see Figure 1 for soil, climate, and crop properties. Coefficients are estimated by meta-regression.*

We currently quantify medium-term impacts on SOC (a minimum of 5 years). So far focus has been on the effects of soil management (tillage) practices on soil carbon inputs and SOC changes. Existing meta-analytical approaches in literature will be improved by assessing the influence of AEPs (e.g. initial SOC status) and their interactions, and by extending the model as a function of time. In a second meta-analytical study, we focus on short-term effect sizes of yield changes due to management using yield data for at least one season. From yield changes, changes in N uptake can be estimated based on a fixed N content of crop types, assuming no changes in those contents in response to the management measures. Based on additional data of N added to the soil, this gives an initial idea of NUE changes as a function of management as well as soil status. In later stages of the research, a meta-analytical approach can be taken to improve these estimations. Where relevant, results of similar meta-analytical studies related to SOC and yield changes in response to management practices will be included (e.g. Haddaway et al., 2017; Han et al., 2016; Hijbeek et al., 2017). Based on results of changes in nutrient uptake from the above-mentioned approaches, changes in N (and later P) balance (nutrient input minus nutrient uptake) will be assessed using the MITERRA/INTEGRATOR model approach (Velthof et al., 2009). Related losses to the environment will be estimated in response to predicted changes in N and P surplus. At the conference, results of (1) meta-analytical techniques for modelling SOC, crop yields, and nutrient uptake changes and (2) N losses will be presented.

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