Use of the NDICEA model in analysing nitrogen efficiency

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Introduction

In organic arable farming, N management is a complicated matter. Farming systems based on solid manure application in late summer offer a particular challenge in meeting the crop N demand while maintaining low, acceptable levels of N losses. In order to meet these goals, a good understanding of the N dynamics is necessary. Modelling N dynamics can be of great help.

Materials and methods

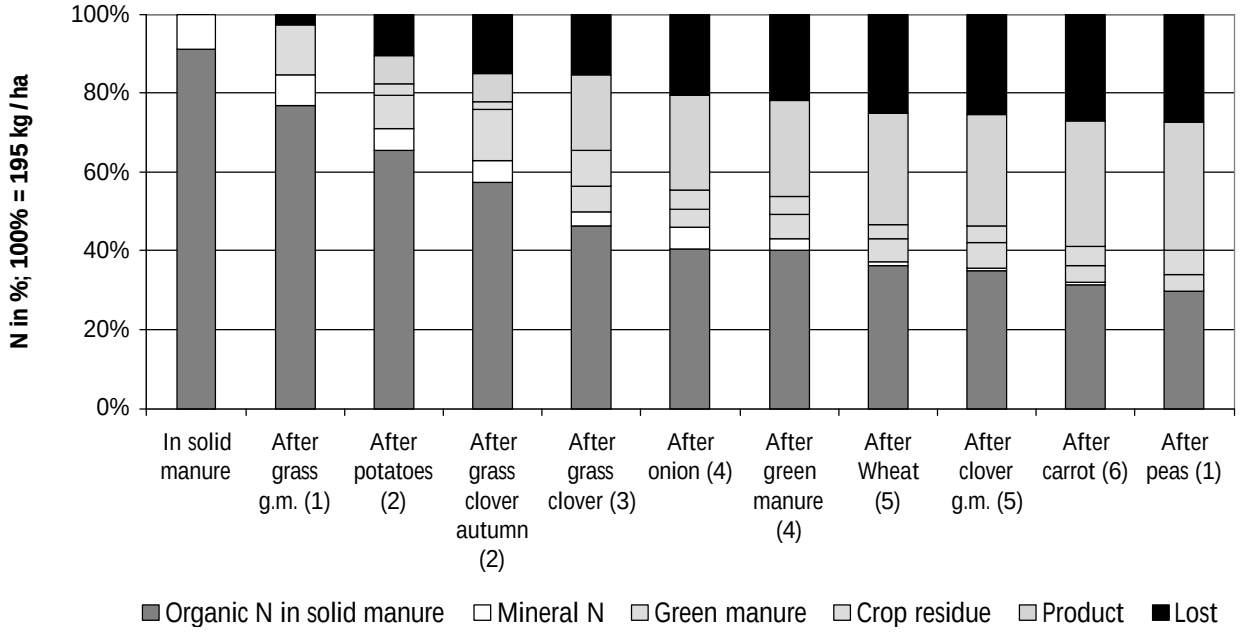
The experimental farm OBS in Nagele, The Netherlands, is located in the relatively new "polder" on a clay topsoil and loamy subsoil with optimal drainage conditions. It has a conventional and an organic section. The organic section has a six-year crop rotation including one and a half year grass-clover. A data base of all available data of the six fields during ten years has been used for this study. The data have been used as an input for the NDICEA model (Koopmans and Bokhorst, 2000). This two-layer model with a time-step of one week integrates sub-models for the mineralisation of soil-bound organic matter, water-balance and crop growth (Habets and Oomen, 1993). The validation of the model has been described by Koopmans and Bokhorst (2002).
The site-specific calibration of the model has been made for all six fields separately. The resulting calibrated soil parameters of the six fields showed slight differences only, except for the denitrification parameter (data not shown). This supports the assumption of homogeneous soil conditions over the six fields. For the analysis of the N dynamics, the average of the six field-specific soil parameter sets were used as well as the average agronomic data (sowing date, harvest date, yield, manure et cetera). In the same way, the average data of the conventional section of the OBS farm have been used to compare the two systems.
In the NDICEA model every organic matter input is treated separately in the calculation procedure, so the nitrogen dynamics can be studied in detail. Because of this, 'virtually labelled' manure or fertiliser N can been followed in both systems throughout a complete rotation cycle.

Results and discussion

Soil organic matter content and N mineralisation from organic matter are higher in the organic section.
The average crop N uptake is 196 and 190 kg ha^{-1} yr^{-1} for the organic and the conventional section. Total N uptake (including green manure) is 247 and 238 kg ha^{-1} yr^{-1} respectively and 122 and 138 kg ha^{-1} yr^{-1} is taken out of the systems in products. These data do not differ much between the two sections. The reason of this is, that the generally lower yields in the organic section are compensated by the high N uptake of peas and clover.
The N input of both systems is completely different. The input in the organic section is 98 kg ha^{-1} yr^{-1} by manure application and 62 kg by N_2 fixation (clover, pea). For the conventional section this is 140 kg ha^{-1} yr^{-1}, all as fertilisers. N efficiency, calculated as the ratio between N output (by products) and input (by manure and fertiliser), is 1.24 and 0.98 for organic and

conventional, respectively. If N_2 fixation and N deposition (29 kg ha^{-1} yr^{-1}) are taken into account as input, the N efficiency is 0.64 (organic) and 0.81 (conventional).
The experiment with the 'virtually labelled' N shows that in the organic system about 33% of the initial N application is still in the system after a six year rotation (figure 1), compared with 15% in the conventional system after a four year rotation (not shown).

Figure 1. Organic section. Destination of N in % during crop rotation
In summer after peas and before grass (green manure) framyard manure is applied with 195 kg N.
In brackets at the horizontal axis: the year-number of the crop in the rotation



Summarising conclusions

The conventional section has a higher N efficiency but both sections meet the legal requirements of maximum N loss.
The organic section has a more intensive internal N dynamics and internal N supply (fixation) with a higher level of soil organic matter and a delayed N release. The delayed N release and the more intensive internal N dynamics might support yield stability and suppression of soil-born diseases, which might be the subject for further research. The relatively high N efficiency is a combined result of good yields, use of green manures, adequate timing of agronomic activities and a good soil structure.

References

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