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Simulating leaching losses following incorporation of grass and grass-clover leys

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Dairy farms in Northern Europe often use systems with alternating leys and arable crops. Management of nitrogen (N) in these systems is especially difficult due to the input of organic manures and the residual effects of the leys. During the ley period, a considerable build-up of soil carbon (C) and N, due to crop residuals and cattle excretion, is often observed.

Ploughing of the ley is therefore followed by a large mineralization and thereby affecting the following crops. Several factors influence this residual effect, i.e. the age of the ley, clover content and the grazing or cutting strategy used. The mineralised N is taken up by the following crops, re-incorporated into soil organic matter or lost in some form to the surrounding environment. In order to maximise N use by crops and minimise the N lost to the environment, it is important to predict the residual effects of leys. Due to the residual effects, input of additional N can usually be reduced for the following 2-3 years after ploughing-in without yield loss.

Dynamic simulation models can be useful tools for predicting the residual effect of leys, but only if they have been calibrated and validated appropriately for this particular situation. The BIOMOD project has aimed at expanding, calibrating and validating two Danish dynamic simulation models, namely FASSET and Daisy, for a range of crop rotational situations occurring in organic farming. Here we report on the calibration results for an extensive experiment with residual effect and nitrate leaching following grass-clover leys.

Burrehøjvej experiment

The experiment is described in details by Eriksen (2001), so only a brief outline will be given here. The experiment was initiated in 1994 with six different treatments: two different types of leys: grass-clover and pure grass, which were either cut or grazed with cattle receiving low or high N diets (140 or 300 g N cow^{-1} d^{-1}). The grass leys received 300 kg fertiliser N ha y^{-1}, whereas the grass-clover received no additional N. These treatments continued for three years until April 1997 where they were ploughed and followed by three years with cereals. Spring barley, spring wheat and spring barley, all undersown with ryegrass, where sown in 97, 98 and 99, respectively. In each of the above treatments, three different levels of N input were applied: 0, 115 or 230 kg total N ha^{-1} in cattle slurry.

FASSET simulations

The FASSET model extended with a new soil organic matter model

(Petersen et al., 2003a, Petersen et al. 2003b) has been tested on the Burrehøjvej experiment. The simulations will in the near future be submitted for publication in an international journal (Berntsen et al., 2003).

In general the model captured some of the nitrate leaching and residual effects of the different ley types. Especially the yearly nitrate leaching the first and third year agreed quite well with observations, while second year leaching was underestimated.

The model predicted that the first year residual effect of the grazed fields was equivalent to 70 - 110 kg N ha^{-1}. Second and third year residual effects were equivalent to app. 50 and 12 kg N ha^{-1}, respectively. The simulated residual effects of the cut grass and grass-clover were significant lower than the grazed systems. The residual effect was thus in all years below 30 kg N ha^{-1}. The simulated residual effects were lower than the observed first year effects, while second and third years effects were quite satisfactorily predicted.

In addition, a number of scenario analyses have been performed. These show that the effects on nitrate leaching and ley residual effects of changing the parameterisation of the decomposition of the grass and clover residuals were small. However, it was shown that soil initialisation had very high impacts on the simulated nitrate leaching. This indicates that there is a need for further studies on soil with high CN ratios like the Burrehøjvej soil. Simulation of these soil types tends to show an incorporation of N in the soil organic matter whereby the CN ratios slowly approximates 10. This incorporation rate is quite critical for a correct simulation of these types of soils.

Daisy simulations

The standard Daisy model has a very long record of use for crop rotational simulations and hence we have compared its performance using the standard soil organic matter (SOM) sub-model in Daisy (as developed by Abrahamsen, 2000 and recalibrated by Bruun et al. 2002) called Daisy-St. with the newly developed CN-SIM sub-model (Petersen, 2003a, Petersen 2003b) called Daisy-CN-SIM, in order to verify whether the SOM submodel performance is the most critical for prediction of N mineralisation.

Both submodels have three types of pools, added organic matter (AOM) pools, soil microbial biomass (SMB) and soil organic matter (SOM), but they differ in pool distribution, fluxes and parameterisation.

Simulated SOM trends and soil mineral N dynamics did not differ markedly between the two submodels. However, we found that the temporal pattern of nitrate concentration in soil solution in these years to be much more dependent on the performance of the ryegrass catch crop simulations between the cereal crops. Even small changes in the catch crop modules may cause anything from large overestimation to slight underestimation of measured nitrate concentrations. Hence, our current work is now more focussed on identifying how to make more appropriate and robust catch crop modules.

References

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