Simulated short and long term effects of grassland reseeding on nitrate leaching

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Abstract

Intensively used grassland in the Netherlands is frequently reseeded by farmers to improve sward productivity, which may increase the risk of nitrate leaching. A simulation study has been conducted to determine both short and long term effects of grassland renewing on nitrate leaching. With the model N*fate* three 'treatments' have been simulated: no, spring (April) and autumn (September) reseeding and all major N fluxes at field level have been calculated for each year in a reseeding cycle of seven years. During the first year of the reseeding cycle the N leaching at autumn reseeding is strongly increased, but averaged over seven years N leaching is nearly equal to that of no reseeding, because lower leaching losses during the remaining six years of the reseeding cycle compensate for the higher losses of the first year. At spring reseeding N leaching losses are always below that of no reseeding, even during the first year, accumulating on average in a 15% lower N loss by leaching. Results make clear that short and long term effects of the whole reseeding cycle should be evaluated together.

Keywords: grassland, leaching, modelling, nitrate, nitrogen uptake, reseeding

Background and objectives

Intensively used grassland in the Netherlands is frequently reseeded by farmers to improve sward productivity (Conijn *et al.*, 2002), which often involves ploughing up grassland before resowing. In this situation the risk of nitrate leaching is enhanced, because a surplus of inorganic N usually occurs in the soil during the period between killing of the old sward and full establishment of the new sward. On the other hand, the increased productivity of the new sward increases the nitrogen use efficiency and may therefore reduce nitrate leaching. A simulation study has been conducted to determine the overall effect by calculating both short and long term effects of grassland renewing on nitrate leaching, including the influence of the time of ploughing.

Material and methods

The model N*fate* (*N*utrient *f*luxes in *a*gricultural soils and *t*o the *e*nvironment) has been used for this study. N*fate* calculates N yield, N losses and changes in the amount of N in the soil-crop system as a function of N inputs, soil/climate characteristics, crop species and management. The in/outputs of the model apply to the field level and refer to a whole year. N*fate* is a dynamic model, which means that the amount of N in the system may change after one time step (i.e. a year), which has consequences for the calculations in the next time step. In the model three N pools are distinguished (Table 1); Figure 1 pictures the major N fluxes that are used/calculated by the model. An outline of the model is given in Conijn (2004).

Table 1. Description of the N pools in Nfate (see Figure 1).

Name	Description	Details	Unit
NorgSoil	Amount of organic nitrogen in the soil organic matter	Age > 1 year, soil layer: 0-20 cm	kg N ha^{-1}
NminSoil	Amount of inorganic nitrogen in the soil	Rooted soil layer, measured in early spring	kg N ha^{-1}
Nplant	Amount of nitrogen in the plant	Below- and aboveground living plant tissue	kg N ha^{-1}

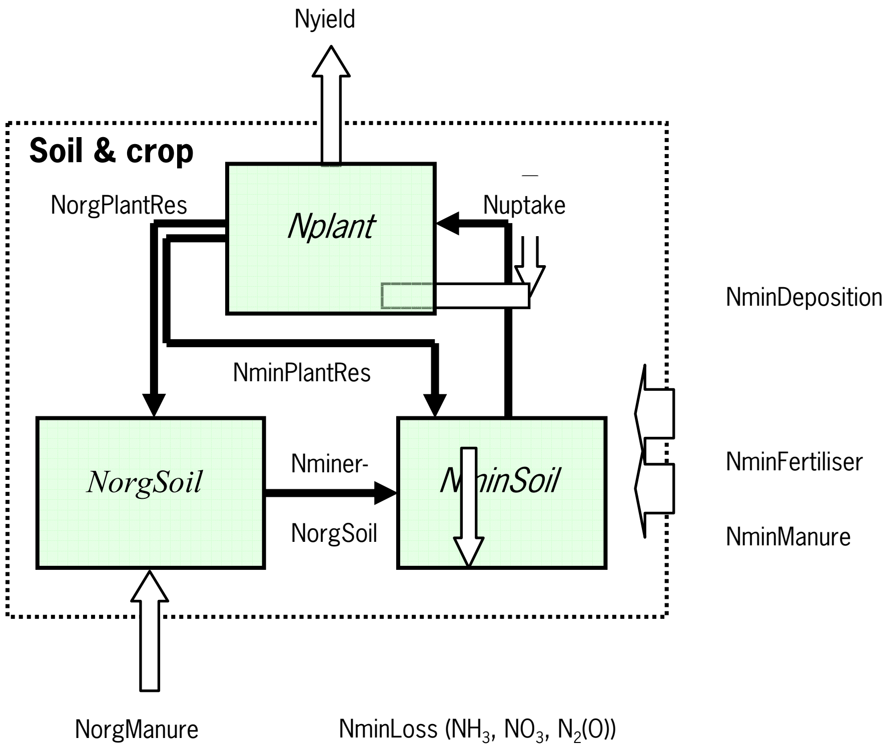

Figure 1. N fluxes and N pools in the soil-crop system of Nfate. Res is used as abbreviation for plant residues, which includes dead plant parts and field harvesting losses.

In this study the model is first used to calculate the equilibrium situation of permanent grassland on a dry sandy soil in the Netherlands with a mixed use of grazing and cutting. Level of N inputs has been derived from the proposed Dutch legislation for dairy farms in 2009. Three 'treatments' have been simulated with N*fate*: no, spring (April) and autumn (September) reseeding, where reseeding occurs once every seven years. Reseeding includes killing of the 'old' sward, which sets *Nplant* to zero by distributing the N content of *Nplant* among *NminSoil* and *NorgSoil*, and a gradual built-up of *Nplant* again up to the level of the 'old' sward during the years after reseeding.

Results and discussion

In the equilibrium situation the N pool sizes amount to circa 4700, 30 and 170 kg N ha^{-1} for *NorgSoil*, *NminSoil* and *Nplant*, respectively. Organic matter content in the upper 20 cm of the soil is 4.6%. Net grass yields equal 9.9 tonne dry matter ha^{-1} y^{-1} and 289 kg N ha^{-1} y^{-1}. Total N input and loss are 428 and 138 kg N ha^{-1} y^{-1}, of which 48 kg N is lost by leaching, resulting in a nitrate concentration of 59 mg l^{-1} in the groundwater. Results compare reasonably well with those from Schröder *et al.* (2005), who determined a yield of 285 kg N ha^{-1} y^{1} at a total input of 404 kg N ha^{-1} y^{1}, as average values of (sub)optimal conditions.

In Figure 2 the net N yield and amount of leached N is given for each year during the reseeding cycle, including the average over the whole period for the three reseeding 'treatments'. In the first year, both spring and autumn reseeding cause a drop in N yield relative to no reseeding, because it takes some time before a new sward is productive. Thereafter, the reseeded swards show higher net N yields (at equal N inputs) due to lower losses. Overall, the N yields of the reseeded swards, averaged for the whole 7-year period, differ only slightly from the non-reseeded sward. The amount of N leached during the first year at autumn reseeding is remarkably higher compared to the two other 'treatments'. It illustrates the mismatch between the release of N (partly from the 'old' sward) and the N uptake by the new sward during a period with a high precipitation surplus. On the other hand, spring reseeding is usually followed by a period of precipitation shortage together with a higher N uptake capacity by the new sward, which leads to lower N leaching losses. These results agree with the experimental findings of Velthof and Hoving (2004). After the first year calculated leaching levels of reseeded swards are lower than those from the non-reseeded sward because (a) N is immobilized by uptake into the roots and stubbles of the new sward and (b) more N is removed from the reseeded swards. Overall, averaged over seven years, levels of N leaching are similar for no reseeding and autumn reseeding, whereas it has decreased with 15% after spring reseeding.

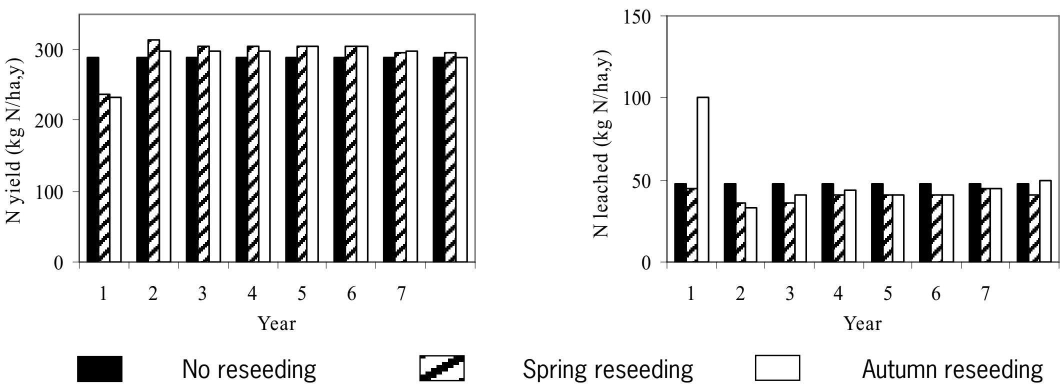

Figure 2. *Calculated net N yield and N leaching during a reseeding cycle of seven years. Ploughing and reseeding takes place in April or September of year 1. N fluxes refer to the period between 1 March of year x until 1 March of year x+1. Bars at the right hand side (beyond year 7) represent the average values for the 7-year period.*

Conclusions

The model N*fate* predicts for grasslands on dry sandy soils in the Netherlands that during the first year of the reseeding cycle spring reseeding causes no increase in N leaching, but autumn reseeding more than doubles the loss of N by leaching compared to no reseeding. However, averaged over the whole reseeding cycle, the results indicate that N leaching is reduced at spring reseeding, whereas at autumn reseeding it is nearly equal to that of no reseeding, despite the relative high losses in the first year. These results make clear that a whole cycle (from reseeding to reseeding) should be evaluated for an adequate estimation of the effect of grassland reseeding on total nitrate leaching.

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