Apparent recovery of urine-N in grassland on sandy soils

Corré, W.J.[1*], Groenigen, J.W. van[2] & Beek, C. van[2]

[1] *Plant Research International, P.O. Box 16, 6700 AA Wageningen, the Netherlands*
[2] *Alterra, P.O. Box 47, 6700 AA Wageningen, the Netherlands*

[*] *E-mail: wim.corre@wur.nl*

Abstract

In order to answer the question whether a ban on grazing in autumn could substantially decrease the nitrate leaching from dairy farming on sandy soils in the Netherlands, a field experiment and a lysimeter experiment were established. The main measurements included the apparent nitrogen recovery in the crop and the nitrate leaching, measured as the nitrate content of the upper groundwater in the field and the leaching at 60 cm depth in the lysimeters. Nitrate leaching was increased in urine patches, but the effect of the date of application on the nitrate leaching was relatively small. Hence, also a policy of no grazing in autumn will probably only have a limited effect on nitrate leaching.

Keywords: grassland, grazing, leaching, nitrate, nitrogen, sandy soil, urine

Background and objectives

Fulfilling the Nitrate Directive of maximum 50 mg per litre in the upper groundwater is a persistent environmental problem in dairy farming on sandy soils in the Netherlands. Limited grazing is seen as a promising option to reduce nitrate leaching under grassland while maintaining the production level. In urine patches locally large amounts of N are deposited on grassland. The utilisation of this N is limited, especially at the end of the growing season. Hence, urinary N is an important source of soil mineral N, vulnerable to leaching. However, to what extent grazing might cause enlarged nitrate leaching has not yet been measured in the Netherlands. The supposed relation between grazing and nitrate leaching is not based on measurements of nitrate leaching, but on measurements of soil mineral N in autumn (Vellinga *et al.*, 2001). Furthermore, in many experiments with urine patches appreciable balance deficits are found, i.e. a large part of the N deposited is not accounted for when the apparent N recovery is calculated, and most experiments were established at higher N fertilisation rates than currently used in practise. The effects of application date on N utilisation, nitrate leaching and N balance (apparent nitrogen recovery, ANR) were studied in a field experiment and in a lysimeter experiment with artificial urine patches.

Materials and methods

In the field experiment artificial urine with 80% of the N as urea was applied in a quantity of 400 kg N ha^{-1} on 10 m^2 plots on six dates between 31 May and 22 October in permanent grassland on a light sandy soil at the experimental farm 'Cranendonck'. Measurements included apparent nitrogen recovery (ANR) in the crop, development of mineral nitrogen contents of the soil and nitrate contents of the ground water after winter. The results were compared with calculations with the model 'NURP' (Vellinga *et al.*, 2001). In this model the nitrate leaching is calculated on the basis soil mineral N in autumn. The basis of the calculation of nitrate leaching is an exponential relationship between date of urine deposition and soil mineral N and a linear relationship between soil mineral N and nitrate leaching.
For the lysimeter experiment (depth 60 cm, diameter 20 cm) undisturbed soil was taken from permanent grasslands on sandy soils at the experimental farms 'Cranendonck' and 'De Marke'. Artificial urine was applied in a quantity of 400 kg N ha^{-1} on three dates in autumn. Measurements included volume and nitrate contents of the leachate, ANR in the crop, stubble and roots and soil mineral and total N. In the lysimeter experiment ^{15}N labelled urea was used, results on this topic are described in Van Groenigen *et al.*, 2005.

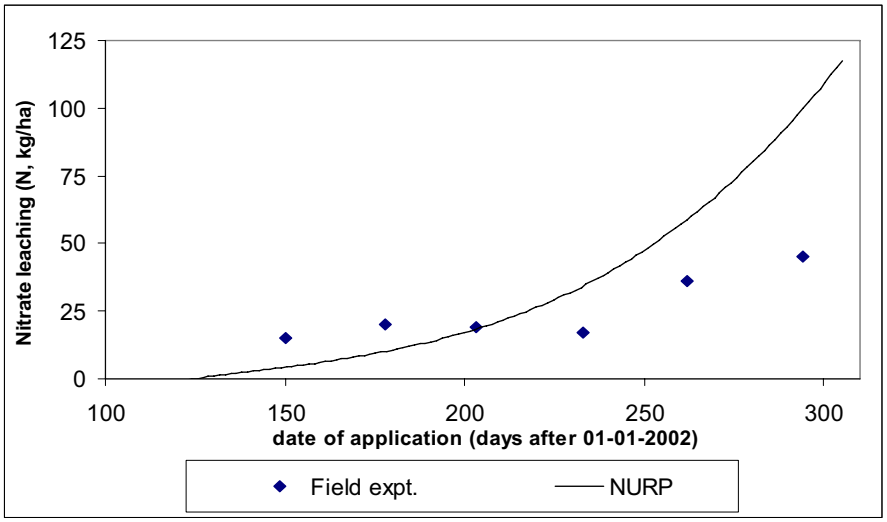

Figure 1. *Nitrate leaching from urine patches, data from the field experiment and model calculation (NURP).*

Results and discussion

In the field experiment urine patches showed increased nitrate leaching, resulting in a positive effect of limitation of grazing on nitrate leaching. The date of application of urine, however, had only a limited effect on nitrate leaching in comparison to model calculations, as shown in Figure 1. Overall, nitrate leaching and N utilisation in the crop were small, resulting in large balance deficits, as shown in Figure 2. These deficits, actually N not accounted for, were including ammonia volatilisation, which can be estimated at 10% on average for Netherlands conditions. The balance deficits did originate in the period shortly after application, a period in which neither leaching nor denitrification was likely to be of significance.

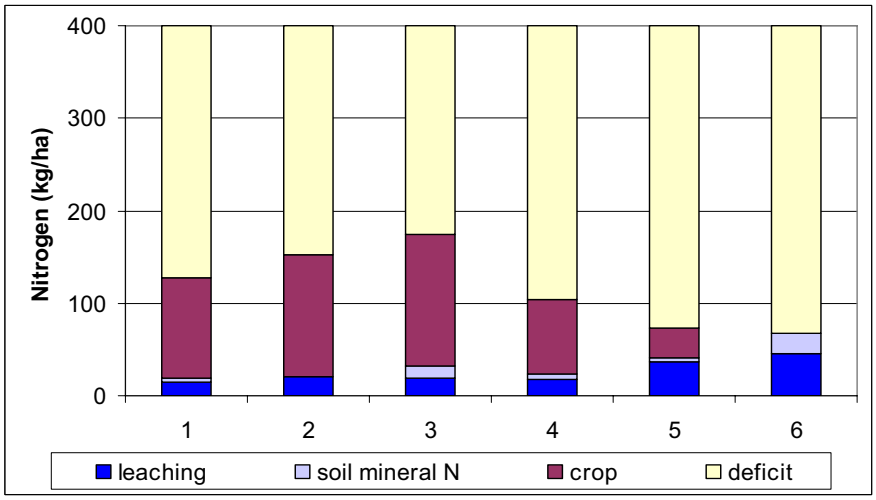

Figure 2. *Balance for urine-N in urine patches in a field experiment on a sandy soil in spring 2003, applied at different dates in 2002. Dates: 31 May, 24 June, 22 July, 22 August, 19 September, 22 October.*

The results of the lysimeter experiment are shown in Figure 3. Compared to the field experiment, the ANR in the crop reached the same level and the nitrate leaching was increased. This resulted in smaller but still significant balance deficits.

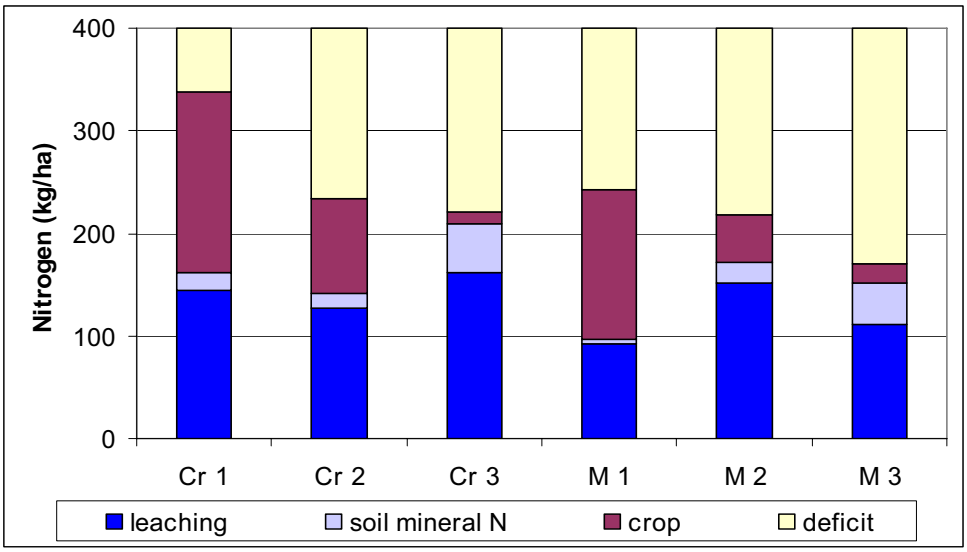

Figure 3. *Balance for urine-N in a lysimeter experiment with undisturbed grassland soils from two sandy soils in spring 2005, applied to lysimeters at different dates in 2004. Soils: C = Cranendonck; M = De Marke. Dates: 6 September, 4 October, 1 November.*

The difference in leaching level between the two experiments might be caused by uncertainty of the representativeness of the sampling of the groundwater in the field experiment or by processes decreasing the nitrate content of percolation water between a depth of 60 cm and the groundwater level.
The relatively limited effect of the date of application of urine patches on nitrate leaching indicates that other management practices in dairy farming will probably have a larger effect on nitrate leaching than a ban on grazing in autumn. The most effective practice is probably a combination of moderate N fertilisation and limitation of grazing to the day period with supplemental feeding of roughage with a high energy/protein ratio, like silage maize. Furthermore, grazing must be proportional to grass production. When grass intake is decreased due to a too high stocking rate to production ratio, more urine patches will be present compared with the calculations, with an increased nitrate leaching as a result.

Conclusions

Urine application increased nitrate leaching, but the effect of the date of application was limited. Hence, also a policy of no grazing in autumn will probably only have a limited effect on nitrate leaching.

References

Groenigen, J.W. van, C.L. van Beek, E.W.J. Hummelink, G.F. Koopmans & W.J. Corré, 2005.
Nitrogen loss pathways from urine patches in relation to timing of application; results of literature review, lysimeter experiment and field experiments. This volume.

Vellinga, Th.V., A.H.J. van der Putten & M. Mooij, 2001.
Grassland management and nitrate leaching, a model approach. *Netherlands Journal of Agricultural Science*, 49: 229- 253.