Production, nitrogen exportation and nitrate leaching from managed grasslands in France

Anne-Isabelle Graux, Rémi Resmond, Eric Casellas, Luc Delaby, Philippe Faverdin, Christine Le Bas, Anne Meillet, Thomas Poméon, Helene Raynal, Dominique Ripoche, et al.

PRODUCTION, NITROGEN EXPORTATION AND NITRATE LEACHING FROM MANAGED GRASSLANDS IN FRANCE

GRAUX, A.-I.[1], RESMOND, R.[1], CASELLAS, E.[2], DELABY, L.[1], FAVERDIN, P.[1], LE BAS, C.[3], MEILLET, A.[4], POMEON, T[4]., RAYNAL, H.[2], RIPOCHE, D.[5], RUGET, F.[6], THEROND, O.[7], VERTES, F.[8], PEYRAUD, J.-L.[1]

[1] INRA-Agrocampus Ouest, UMR 1348 PEGASE, France; [2] INRA, UR 0875 UBIA, France; [3] INRA, US 1106 INFOSOL, France ; [4] INRA, US 0685 ODR, France ; [5] INRA, US 1116 AGROCLIM, France; [6] INRA, UMR EMMAH, France; [7] INRA, UR 1132 LAE, France ; [8] INRA-Agrocampus Ouest, UMR 1069 SAS, France

INTRODUCTION

This study (Graux et al., 2017) aims to quantify and map French grassland yield and N exportation resulting from cutting and grazing practices, for the existing diversity of grassland types, managements, soil and climate conditions, and to assess the risk of nitrate leaching associated with increasing applications of organic N (that include N applications by grazing animals). Results are intended to provide scientific elements supporting a French request for derogation from the actual organic N spreading limit, set in the Nitrate Directive at 170 kg of organic N per year and per hectare of Utilised Agricultural Area (UAA).

MATERIAL AND METHODS

Observed data from regular grass measurements in four French regions were analysed to provide reference values of the grassland production and N exportation. This first assessment was extended to France by simulating grasslands with a research version of the STICS crop model (Brisson et al., 2003; Ruget et al., 2006), named PâturSTICS. This model simulates daily the dry matter (DM), the N and water fluxes involved in the functioning of grasslands and crops in response to management, soil and climate conditions. The planned cut and grazing events can be adapted in the course of the simulation according to predefined rules of management and effective simulated grass growth. STICS was improved to account for animal returns on grasslands during grazing, and to better simulate the DM production and protein content of grasses and legumes. Simulations were performed across France at a high resolution grid composed of pedoclimatic units (PCU) obtained by crossing the spatial resolutions of climate (SAFRAN data - 8 km grid) and soil (1/1,000,000-scale soil geographical database of France - Soil Mapping Units of variable size). Thanks to the French Land Parcel Identification System and to the French agricultural statistics, and based on previous work (Ruget et al., 2006), the main grassland types and associated managements were determined for each PCU, then simulated with pâturSTICS over 30 years (1984-2013). Annual simulation results were aggregated and analysed in the light of reference values. To go further, additional simulations testing the consequences of an intensification of grazing on nitrate leaching were performed in 6 French departments where conditions to obtain derogation would be potentially met.

RESULTS AND DISCUSSION

The simulated yield and N exportation are in agreement with available reference values, with the exception of mountain regions where the model tends to overestimate observations, probably due to the non-inclusion in present simulations of the effects of snow and night frosts on grass growth and of slope on soil water resources. Most French grasslands export more than 170 kg N ha^{-1} yr^{-1} up to more than 400 kg N ha^{-1} yr^{-1}. The highest production (≥ 10 t DM ha^{-1} yr^{-1}) and N exportation levels (≥ 200 kg N ha^{-1} yr^{-1}) are observed in the following regions or departments: Bretagne, Normandie, Marne, Limousin, Vosges, Franche-Comté, the north-west part of Massif Central, French Alpes and the west of Pyrénées (Figure 1). Among these productive situations, Finistère, Morbihan, Vosges and the west of Pyrénées are also presenting the highest risks for nitrate leaching (Figure 1). These high-risk situations result from high simulated water drainage (≥ 500 mm yr^{-1}) and soil N mineralisation (≥ 200 kg N ha^{-1} yr^{-1}). The comparison of the observed (Vertès et al., 2007) and simulated responses of nitrate leaching to an increase of stocking rates showed that PâturSTICS tends to overestimate nitrate leaching, probably due to the

underestimation of soil N immobilisation and, to a lesser extent, to the possible slight overestimation of soil N mineralisation. However, the shape of the simulated response was in agreement with the observed curve, giving confidence in the analysis of the relative evolutions of risks in comparison with the Nitrates directive situation (170 kg organic N ha^{-1} yr^{-1}). Increasing the organic N spreading limit up to 200 kg N ha UAA $^{-1}$ yr^{-1} should lead to a moderate increase of nitrate leaching (≤ 20 kg of supplementary N ha^{-1} yr^{-1}) from grasslands in most situations.

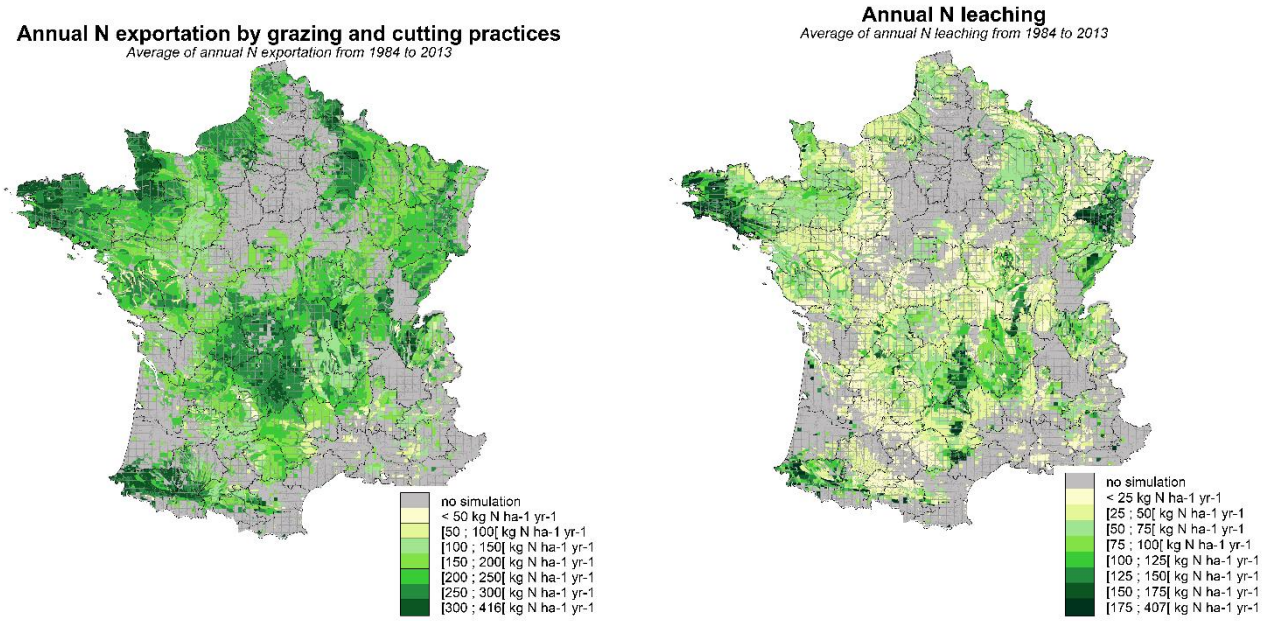

Figure 1. Simulated average annual N exportation and N leaching for French grasslands. Grey cells were not simulated as there are only few grassland surfaces at these locations. The variability of results linked to the diversity of grasslands, managements, soils and climate years is not presented here.

CONCLUSION

This work allowed providing a very detailed view of French grassland production and N exportation, as well as the associated N leaching risk, taking into account the diversity of situations, both in case of the actual grass management and of an organic N spreading increase on grasslands. Our results provide information to consider derogation from the actual organic N spreading limit in productive areas that are not exposed to high environmental risks. Nevertheless, the present results have to be treated with caution as they are subject to a degree of uncertainty due to the quality of inputs and to the current modelling limits.

REFERENCES

Brisson N., Gary C., et al., 2003. An overview of the crop model STICS. Eur. J. Agron. 18, 309-332.

Graux A.-I., Delaby L., Peyraud J.-L.(coordinateurs) et al., 2017. Les prairies françaises : production, exportation d'azote et risques de lessivage. Rapport d'étude, INRA (France), 75 p.

Ruget F., Novak S. et al., 2006. Du modèle STICS au système ISOP pour estimer la production fourragère. Adaptation à la prairie, application spatialisée. Fourrages, 186, 241-256.