Role of grasslands and grassland management for biogeochemical cycles and biodiversity. Setting up long-term manipulation experiments in France

G. Lemaire[1], J.F. Soussana[2], J.C. Emile[4], A. Chabbi[4], F. Louault[2], P. Loiseau[2], B. Dumont[3] and X. Charrier[4]
[1]Unité d'Ecophysiologie, INRA 86600 Lusignan, France, Email: lemaire@lusignan.inra.fr, [2]Unité d'Agronomie INRA, Site de Crouël, 234 avenue du Brézet, 63039 Clermont-Ferrand, France, [3]Unité de Recherches sur les Herbivores, INRA Theix, 63 St-Genès Champanelle, France, [4]Domaine Expérimental INRA, 86600 Lusignan, France

Keywords: N cycle, C cycle, soil organic matter, vegetation dynamics, greenhouse gas

Introduction Land use for grassland is recognised to have some beneficial effects for biodiversity and the environment: (i) regulation of the water cycle and protection of soils against erosion, (ii) accumulation of organic matter in soil and sequestration of atmospheric C, (iii) regulation of the N cycle and attenuation of the risk for N leaching, (iv) recycling of nutrients and improvement of soil quality, (v) improvement of biodiversity of vegetation, soil microbes and micro- and meso-fauna. All these effects depend upon the management of the grassland: cutting vs. grazing, stocking density, level of N inputs. Management decisions often result from short-term objectives, whereas the soil-vegetation interactions are long-term processes. Therefore, a steady state is usually not reached, which makes it difficult to determine the overall environmental effects of changes in land use and in grassland management.

Research questions and need for long-term experiments Long-term agro-ecosystem manipulation experiments are needed to relate changes in land use and management at the landscape level with their environmental consequences, which are partly determined by the fluxes, residence times and the balance of major elements, such as C, N and P. There is a need (i) to identify and characterise the compartments of the soil organic matter that play key roles, (ii) to quantify some of the key internal fluxes and to monitor at the boundaries of the system fluxes to the atmosphere and hydrosphere, (iii) to investigate the functional role of plant, microbial and soil fauna diversity with the aim of characterising the response of the whole system to the disturbance induced in the long term by contrasted management systems.

Long-term experimental design Two long-term experimental sites have been set up and will be starting in 2005. The first is located at Theix (Massif Central, 900 m a.s.l.) and comprises perennial semi-natural grasslands which have previously received intensive inputs. Three contrasting levels of herbage use will be compared without N fertiliser by manipulating stocking density (sheep and cattle grazing) in a randomised block design with four (2000 m^2) replicate paddocks. Further comparisons between grazing and cutting will be obtained by including mown plots at three contrasting levels of inorganic N supply. The second, at INRA Lusignan, will study ley farming systems. Sown grasslands of a mixture of perennial ryegrass, cocksfoot and tall fescue, with or without the addition of white clover, will be included for three or six years within an arable crop rotation (maize, wheat, barley) receiving different levels of N application. Two control treatments are included: the arable crop rotation alone, in order to analyse the effects of sown grasslands on soil dynamics and on environmental fluxes, and a long-term sown pasture.

On both sites, and for each treatment, herbage and crop production and exports of nutrients will be measured. The main soil state variables will be monitored at regular time intervals, as well as the diversity of plant and soil (microbes, micro- and meso-fauna) communities. Water balance will be calculated through profiles of soil water content using TDR probes and the soil solution will be regularly sampled by ceramic cups and plate lysimeters to determine its composition and to calculate fluxes. On nearby plots of about 3 ha and for some of the treatments, CO_2 and H_2O fluxes will be monitored using the eddy covariance technique. Collections of soil, plant and water samples will be kept and made available for further determination. A database system will be constructed for information exchange. Given the large size of the experimental plots, sub-plots can easily be accommodated to further analyse some of the key processes (e.g. by using isotopic tracers) and relate them to the state variables of the system.

Conclusion These new experimental sites for studying the long-term development of the soil-vegetation systems of grasslands under contrasting management regimes should give the opportunity to strongly integrate disciplinary research on vegetation dynamics, soil biology, soil physics and chemistry and sward-herbivore interactions. Previously such studies have too often been carried out separately in different experiments and at different sites.