Soil nitrogen - plant interactions as affected by grazing and water availability in semi-arid grassland of Inner Mongolia

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Inner Mongolian semi-arid grasslands are one of the main regions for raising livestock in P.R. of China. After decades of increasing land-use, overgrazing led to grassland degradation coming along with decreasing productivity and loss of soil organic matter and plant nutrients. Wind and water erosion affect mainly degraded grasslands and at present, huge areas suffer from degradation. Grassland productivity and a number of biogeochemical processes in this semi-arid ecosystem are primary limited by the amount and distribution of precipitation. The availability of nitrogen (N), which limits plant growth right next to precipitation, may also be affected by grazing. Thus ecosystems' responses, i.e. productivity and mineralisation, to precipitation and grazing are complex, and they also depend on soil fertility and the extent of plant biomass consumption.

Grazing effects on soil nitrogen–plant interactions were studied in field experiments with four different grazing intensities within an established grazing experiment in the semi-arid Xilingol steppe ecosystem. An ^{15}N *in situ* labelling experiment with intact soil cores was carried out to investigate the natural soil supply of mineral N and its uptake by grassland plants. Furthermore, a water and N manipulation experiment was performed to get insight into how the key regulators water, nitrogen, and grazing intensity affect soil nitrogen dynamics, and plant responses over the growing season, and the regrowth potential and nutritive values of the main grassland species. Plant responses comprised productivity and N concentration at the plant community level as well as the main species' biomass productivity and quality parameters, i.e. crude protein and organic matter digestibility.

The results of the present study confirmed the important role of precipitation, and precipitation interacted with grazing effects on soil N dynamics and plant responses. But overall, grazing mostly led to increased soil nitrate concentrations and also to higher gross nitrification rates. Despite slightly decreasing root biomass with more intensive grazing, the uptake of nitrate was not affected. Normally in wet periods, there is intensive gross soil nitrification activity as observed in the ^{15}N *in situ* experiment, so NO_3^- was observed to be the most important mineral N form for plant N acquisition. Rather small variations in precipitation patterns showed distinct changes in soil N dynamics and conditions for plant growth, thus, leading to a pronounced peak growth event in growing seasons like in 2007 or to more homogenous conditions like in 2008. With sufficient water and more homogenous distribution, mineralisation of soil N and plant productivity were found to vary in a quite synchronised way, whereas in a dry period, accumulation of nitrate in the soil and a low response in plant growth was observed. With the present study the general dominance of precipitation effects has been confirmed, but it has now been possible to uncover influences of interactions with effects of grazing. Furthermore, the results of the water and nitrogen manipulation experiment showed that there was no short-term regrowth promotion of certain species by the key regulators water and nitrogen that would have favoured any of the investigated main species over any other. In contrast, grazing intensification did cause a clear shift in the relative contribution of single species' biomass to the total amount of sward biomass. After regrowth that followed grazing of different intensity, species' quality parameters showed only small differences.

It can be concluded that in the short-term, intensive grazing accelerated N mineralisation processes and induced higher nitrate concentrations in the soil. In longer time scales grazing effects may be negative by changing species composition as to be seen in the promotion of the C4 grass *C. squarrosa* which will lead to forage shortage in spring caused by higher temperature demand for growth of this species. Such change would come along with increased risk of wind erosion due to no or low soil cover. It is also one of the conclusions of this study that in future, more attention should be drawn to the precipitation pattern, as it is one of the most important regulators of functions and productivity in semi-arid ecosystems, and it will very likely be further affected by future changes in climate.