Effect of Organic Fertilisation on the Nitrogen Leaching in the Grassland of the Czech Republic

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Abstract
Grasslands have an impact on the sustainability of nutrition in a country. In this paper the effects of organic fertilization on lysimetric water during a period of three years are presented. The experiment includes two fertiliser types – cow dung with dung-water and semi-liquid cattle manure with a graded load (0.9, 1.4 and 2.0 LU per hectare). The soil is sandy-loam, of the cambisol type, with semi-natural permanent grassland. We observed the content of $N\text{-}NH_4^+$ and $N\text{-}NO_3^-$ in the percolate. There was significantly higher leaching of ammonia and nitrate with the load of 2.0 LU and no statistically significant differences were found between the forms of organic manure applied. There were statistical differences between the estimated years. On the basis of the lysimetric water volume found and the concentrations of particular forms of inorganic nitrogen we reveal the annual washing-out of this nutrient from one hectare; it was 4.9 kg/ha for 0.9 LU, 4.8 kg/ha for 1.4 LU, and 6.1 kg/ha for 2.0 LU per year during the estimated period.

Key Words
Nitrite, manure, lysimeters, meadow.

Introduction

In the Czech Republic, there is 950 thousands ha of grasslands (23% of the agricultural area) and the most are situated in less favorable areas. The grazing and the cutting are traditional agriculture practices in these areas. But these managements can bring some environmental risks. With help of lysimeters we can claim which agriculture system is better from the nutrient leaching point of view. Lysimeters are excellent technical tools which are used for measuring of seepage water. For groundwater protection reasons the nutrient as well as pollutant content in the seepage water is from interest. The primary aim of lysimeter measurements on the base of analyses of percolated water is a monitoring of nutrient movement, especially nitrogen in soil. The least amount of mineral nutrients is fixed in soil solution by comparison with adsorbing complex and humus. Approximately 0.2 % of mineral nutrients are bound in soil solution.

Material and method

In the autumn of 2004 a small-plot trial on grassland with various types of management with animal fertilisation was established at Agroresearch, Rapotín, in the Czech Republic. The experiment is located on an east-facing slope 390 m above sea level and it belongs under the Hrubý Jeseník geomorphological division. The geomorphological subgrade is deeper diluvium of mica schist. The soil is sandy-loam, of the cambisol type (horizons Ao-Bv-B/C-C). The basic agrochemical soil proprieties are shown in Table 1.

Table 1. Agrochemical soil proprieties.

Diagnostic horizon	pH_{KCl}	CEC (mmol(p^+)/kg)	C_{org} (%)	Ratio C:N	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
Am	4.63	141	1.34	10.0	53	109	1799	124
Bv	4.60	130	0.73	9.5	78	62	1442	97
Bv/Cc	4.41	139	0.33	8.4	27	53	1753	131
Cc	4.44	151	0.19	10.5	29	45	1875	166

The mean annual precipitation in the locality is 693 mm, and the average annual temperature is 5.3°C; Table 2 shows data from the relevant season. In the locality there is semi-natural permanent grassland with these predominant species: *Dactylis glomerata, Poa pratensis, Lolium perenne, Taraxacum sect. Ruderalia*, and *Trifolium repens*.

Table 2 The precipitation and temperature in Rapotin during the season studied

Year	Month	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
2005	Precipitation (mm)	90.0	45.0	27.5	23.5	76.0	50.0	78.0	69.0	19.0	56	120	74.6
	Temperature (°C)	-1.3	-4.5	-0.7	8.9	12.7	15.6	18.3	15.7	13.4	4.9	3.1	-1.7
2006	Precipitation (mm)	36.1	63.7	62.7	62.2	63.5	78.1	52.0	110.0	7.2	24.5	59.1	68.2
	Temperature (°C)	-8.4	-2.6	-1.8	9.3	12.8	17.0	20.5	15.2	14.5	10.1	8.5	2.1
2007	Precipitation (mm)	68.5	49.7	40.0	4.7	66.3	49.2	69.2	68.2	54.2	34.1	67.9	37.2
	Temperature (°C)	3.2	2.7	5.0	9.7	11.4	17.7	18.9	17.7	11.0	7.2	1.6	-1.2

Plots with different pasture loads were arranged in a completely randomised block design with four replicate blocks. The plot size was 12.5 m^2. The plots were not grazed (grazing was simulated), but cut according to the grassland load, which was as follows:

A – cow dung + dung-water with a load of 0.9 LU/ha
B – cow dung + dung-water with a load of 1.4 LU/ha
C – cow dung + dung-water with a load of 2.0 LU/ha
D – slurry with a load of 0.9 LU/ha
E – slurry with a load of 1.4 LU/ha
F – slurry with a load of 2.0 LU/ha

(0.9 load unit LU corresponds to 54 kgN/ha and 2 cuts per year, 1.4 LU corresponds to 84 kgN/ha and 3 cuts per year, and 2.0 LU corresponds to 120 kgN/ha and 4 cuts per year)
The cow dung fertilisation was dosed in the autumn, dung-water after the first cut; half of the semi-liquid manure fertilisation was applied in the spring and the second half after the first cut. After every application we analysed the fertilisers and then, on the basis of the nitrogen contents, we counted the actual dosage. The lysimeters were at a depth of 0.4 m in an area of 0.25 m^2, in the four replications. In this paper we estimated the content of $N\text{-}NH_4^+$ and $N\text{-}NO_3^-$ in the percolate and the potential risk for the environment.The statistical analyses were performed with linear mixed models in the nlme and MASS packages in R software.

Results and discussion

The nitrate concentration in the environment is very variable during the year. Wessolek *et al.* (1994) describe nitrate leaching in sandy soils under different cultures. They show different nitrate concentrations in the root zone: in gardening soils 200-350 mg/L, in arable land 120-240 mg/L, and in soil under grassland without fertilisation < 40 mg/L. The values of nitrate concentration in the percolates were variable; from Figure 1 it can be seen that values over the pollution limit for drinking water (50 mg/L) were exceeded with the load of 0.9 LU only during the spring months.

The type of fertiliser had no influence on the nitrate leaching ($p = 0.0754$). The highest leaching was with the load of 2.0 LU (see Figure 2) and it was significantly higher ($p = 0.0089$) than the others. Gaisler (2003) presented nitrate concentrations from 4 to 15 mg/NO_3/L for the unfertilized grassland in the Czech Republic conditions in the same depth. There was found variability between the following years; in 2007 nitrate leaching was significantly ($p = 0.0001$) lower than in the other years, which corresponds to the lowest precipitation during this year (from March to December percolate was not present at a depth of 0.4 m).

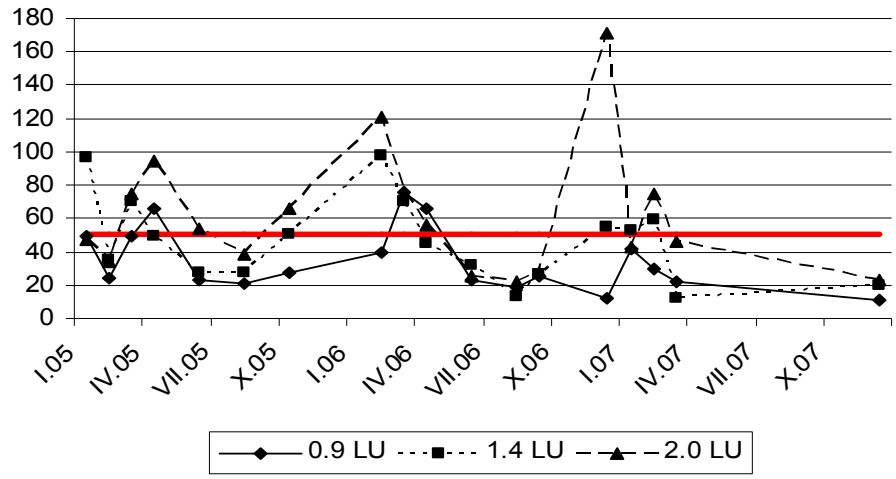

Figure 1. The nitrate concentrations in the percolate during the study period (mg/L)

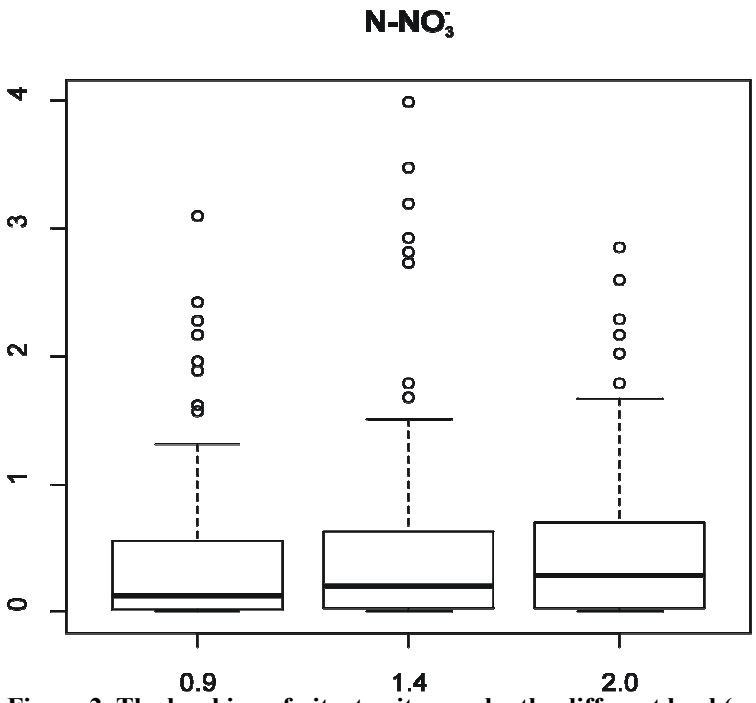

Figure 2. The leaching of nitrate nitrogen by the different load (mg/L).

The concentrations of ammonia were variable too. In Figure 3 can be seen that there was higher leaching of ammonia with the load of 2.0 LU ($p = 0.0599$). Compared to the following years, the leaching in 2005 was significantly higher ($p = 0.0442$) than in the other years; this could be caused by the high concentration of ammonia in precipitation during this year.

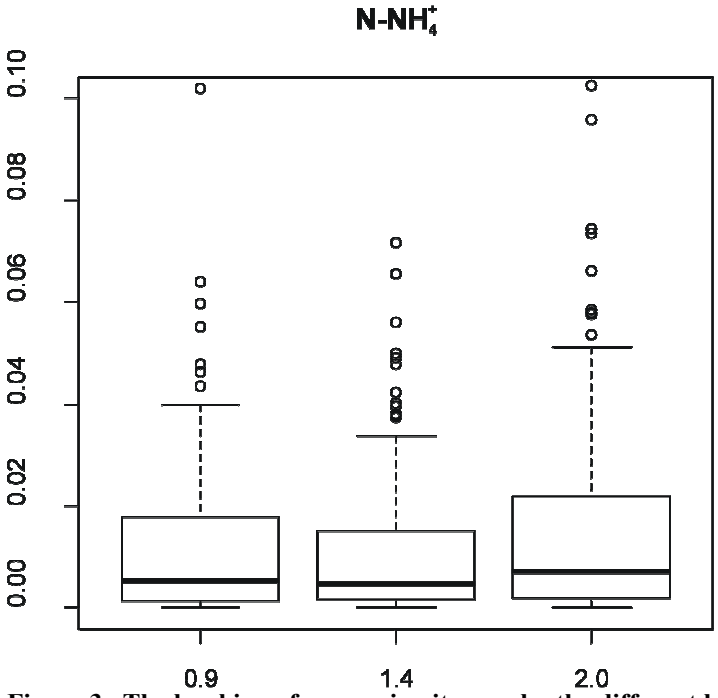

Figure 3. The leaching of ammonia nitrogen by the different load (mg/L).

We hold the summa of mineral nitrate soil washing as the most telling indicator of the environmental burden, because this value illustrates the nitrate discipline with regard to the water regime. Our results are shown in Figure 4. We quantified the annual leaching of mineral nitrogen as being on the level of 4.88 kg/ha/year in treatment with a load of 0.9 LU/ha, 4.77 kg/ha/year in treatment with a load of 1.4 LU/ha, and 6.13 kg/ha/year in treatment with a load of 2.0 LU/ha. The same linear influence effect of organic input amount on nitrogen leaching was described by Behrendt *et al.* (2003).

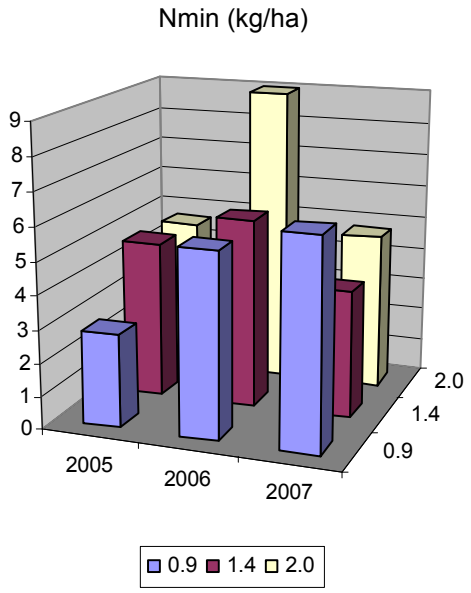

Figure 4. The leaching of mineral nitrogen by the different load (kg/ha).

Conclusion

We found no differences in nitrate and ammonia leaching between the estimated forms of organic manure; the highest leaching was with a load of 2.0 LU per hectare. From the environmental point of view grasslands are able to protect ground water against nitrate pollution with a load of 0.9 LU/ha during the year in our conditions.

Acknowledgements

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References

Behrendt A, Schalitz G, Muller L, Schindler U (2003) The dynamics of nutrients in an extensively used pasture – pasture and lysimetric experiments. In 'Proc. 10th Gumpensteiner lysimeter day, Gumpenstein, (A)' pp.129-132.

Gaisler J (2003) 'Vliv způsobu obhospodařování travního porostu na kvalitu lyzimetrických vod. In: Ekologicky šetrné a ekonomicky přijatelné obhospodařování travních porostů'. (Book of proc.: Prague).

Wessolek G, Reents H, Möller W, Müller P (1994) Interpretation of vertical nitrate depth profiles of sandy soils with different utilization. *Zeitschrift für Kulturtechnik und Landentwicklung* **35,** 10-20.