Risk for N losses after harvest in tilled and untilled clays

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Abstract

There have been indications that the increase of mineral N and increased risk of leaching that has been observed in light textured soils after early tillage in autumn should be as pronounced in heavier textured soils. The results of this study in 24 soils ranging from loam to clay indicate that mineralisation is similar independent of texture and that the risk for losses is similar. However, leaching could be a smaller problem in clays and the main mechanism for losses would instead be denitrification.

Key Words

Nitrogen losses, nitrogen mineralization, soil texture, soil porosity, clay soil.

Introduction

Previous research has clearly shown that the risk of nitrogen (N) leaching on light-textured soils is related to the timing of autumn tillage. Early autumn tillage stimulates N mineralization and increases the mineral N content of soil under moist and relatively warm conditions (Adu and Oades 1978; Hassink 1994) that are normal for the autumn in Sweden. Since water fluxes in the soil are normally highest in autumn and winter, the risk of leaching therefore increases. On clay soils, existing data are more contradictory and there is often no increase in the amount of mineral N in the soil profile as a result of early tillage (Stenberg *et al.* 2005). Considering the possibility for weed management and the reduced risk of soil compaction with early tillage compared with later autumn tillage, there are advantages in not delaying autumn ploughing unnecessarily. The amount of N mineralized as a result of tillage is dependent on the amount of mineralizable N present, and thus the soil humus content can be expected to be a significant factor, as can the clay content, since clay both retains moisture and physically protects the humus from decomposition. This protection can be destroyed when the soil is cultivated and aggregates are broken up along partly new fracture surfaces.

In this project, we investigated how soil parameters affected accumulation of mineral N in the soil after early ploughing at the beginning of September compared with a control soil (not ploughed until November).

Methods

Twelve sites where pig manure was used in the crop rotation and 12 sites without manure were selected to span a range of soil textures from loam to clay and a range of humus contents. All 24 sites were located within a radius of ca: 15 km centred 100 km NW of Gothenburg, Sweden. The soil parameters measured were soil texture and humus content down to 90 cm depth, porosity, pore size distribution, and fresh and dry bulk density in the topsoil, the plough pan and the central subsoil. On the topsoil samples, NIR determinations and analyses were also carried out for determination of potential N mineralization. The amount of ammonium and nitrate in the 0-30, 30-60 and 60-90 cm soil layers was determined immediately before ploughing in both the early ploughed and late ploughed plots. The experiment was conducted in the autumns 2002-2004. The differences between treatments, years and depths in amount of nitrate, ammonium and total mineral nitrogen were visualised by box-whisker plots.

Results

Summer was somewhat wetter than normal in all three years but August and September (i.e. just before and after early tillage) were drier than normal in 2002 and 2003 (Figure 1). Rainfall was normal in autumn 2004. The clay content at the sites varied between 19 and 54 % in the topsoil (mean = 37 %) and up to 64 % in the subsoil. Humus content varied between 2.8 and 11.5 % in the topsoil but was only above 5% at two sites (mean = 4.2%).

No differences in mineral N could be found between manured and unmanured soils. The amount of mineral N in the soil profile in the drier autumns of 2002 and 2003 differed greatly from that in the normal rainfall autumn of 2004 (Figure 2). In September 2002 and 2003, the amount of mineral N down to 90 cm depth was on average 30 kg/ha in both treatments (range 12-74 and 12-97 kg N/ha respectively). By November, the

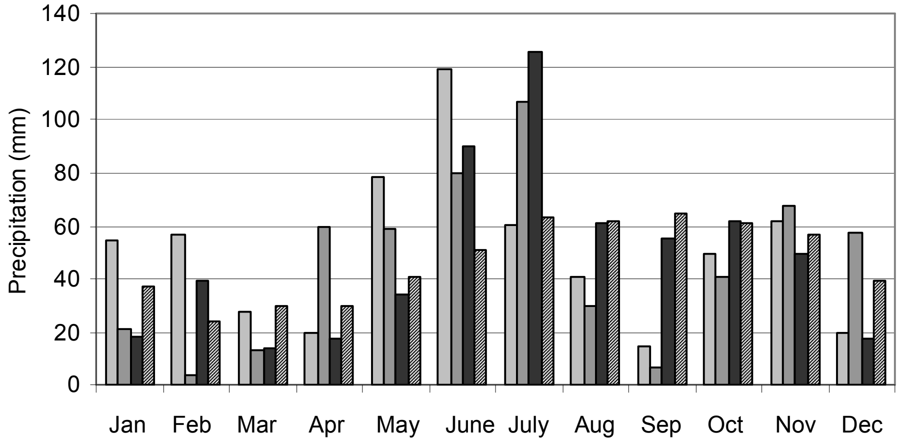

Figure 1. Monthly precipitation the three experimental years 2002-2004 and the 30 year average (dashed).

mineral N content had increased by an average of 10 kg/ha in the late-ploughed control and 30 kg/ha in the ploughed treatment. Thus early ploughing resulted in a 20 kg/ha higher accumulation of mineral N during the autumn. However, the variation in difference between the ploughed treatment and the late-ploughed control was large (-30-67 kg N/ha in 2002 and -8-57 kg N/ha in 2003) and this difference could not be explained by any of the soil parameters measured, apart from the fact that it was greatest at the two sites with the highest humus content.

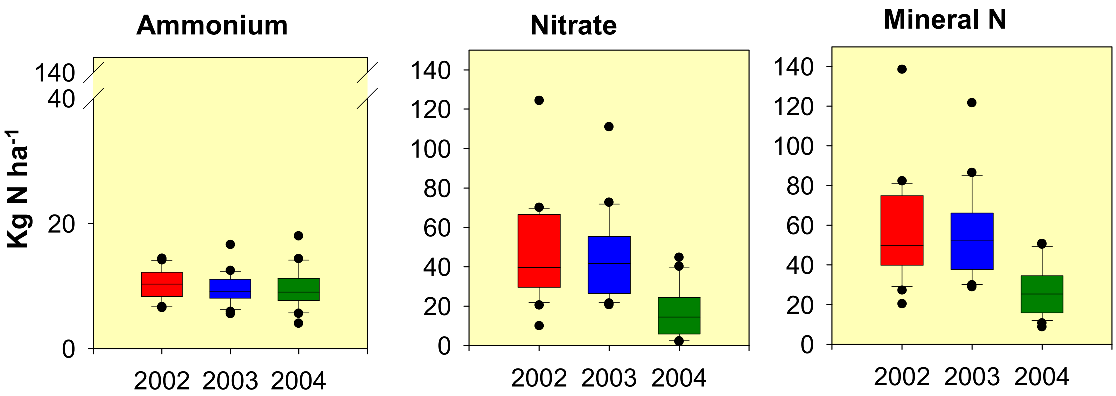

Figure 2. Box-whiskers plots over the amount of ammonium, nitrate and total mineral N (0-90 cm) at the 24 sites in November in the early tilled treatment. The line indicates the median, the box the 25th/75th percentile, the whiskers the 10th/90th percentile and dots individual outliers.

In 2004, no clear increase in mineral N between September and November could be observed. The levels of mineral N were also much lower in the top soil compared to 2002 and 2003. The difference was small in the sub soil (Figure 3). It was mainly the nitrate content that was smaller in 2004.

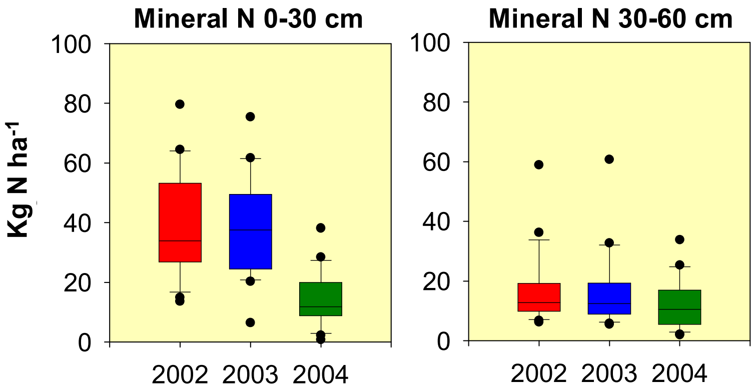

Figure 3. Box-viscars plots over the amount of mineral nitrogen in the top soil and sub soil at the 24 sites in November in the early tilled treatment. The line indicates the median, the box the 25th/75th percentile, the whiskers the 10th/90th percentile and dots individual outliers.

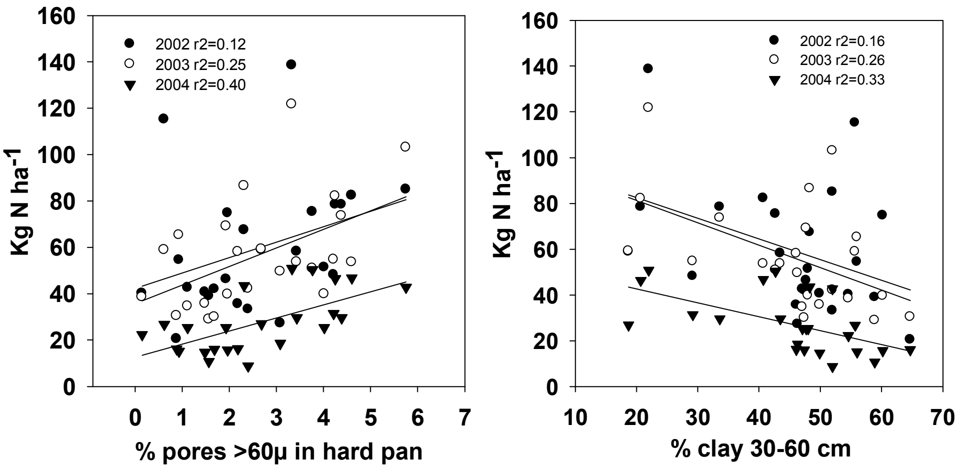

Figure 4. Year wise correlation plots between mineral nitrogen in the profile down to 90 cm and large pores or clay below the top soil, respectively.

Large pores and clay content throughout the profile and total N in the top soil explained the total amount of mineral N in November in the early tilled treatment to 60, 69 and 65% 2002, 2003 and 2004, respectively. Most important were pores >60µ in the hard pan and clay content in the upper sub soil (Figure 4). The correlations were not significant (p=0.05) 2002 and strongest 2004.

Conclusion

The most important conclusion from this project is that N mineralization in clay soils, due to tillage, does not differ from that in light textured soils. The increase in mineralization is as high as for light textured soil. However, the amount of N in the profile was much lower in November when autumn was not dry. We found it most probable that this was due to denitrification losses as there were no increased amounts of mineral N in the subsoil in the wet autumn and there was no reason to suspect a large decrease in mineralization this year. This was also supported by relationships between increased amounts of large pores and low clay content on one side and higher levels of mineral N in the top soil on the other as this promotes aeration and rapid drainage of excess water. This indicates that the risk for losses are not substantially smaller in clay soils compared with sandy soils, but the main mechanism is likely to be denitrification rather than leaching.

References

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