

Nitrate leaching from soils under arable crops

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Introduction

Although arable land accounts for only a small percentage of the agricultural area in Ireland, there is still a concern about its contribution of nitrate to natural waters. There is a lack of Irish data on nitrate losses from tillage land, particularly in terms of the potential of abatement strategies to reduce the losses. Nitrate-N ($\text{NO}_3\text{-N}$) losses from winter wheat and spring barley at two N input levels were studied. On a second soil type, a winter cover crop (mustard) and reduced cultivation methods were assessed on their ability to reduce losses from spring barley.

Materials and methods

The study was carried out at Oak Park Research Centre, Co. Carlow, between 2002 and 2004. The first study site was situated on a clay loam soil (Knockbeg Series) at Knockbeg. Continuous spring barley (SB) and winter wheat (WW) were each grown with high (H) or low (L) inputs on 12.5 m by 30 m plots. There were three replicate plots each with 6 or 8 ceramic suction cups installed at 1.5 m depth. Soil solution was collected from these cups weekly from October to December and fortnightly from January to April for both the 2002-03 (Y1) and 2003-04 (Y2) drainage seasons. The second site, the Road Field, has a sandy loam soil (Athy Complex). Here, four spring barley treatments were established: ploughed with and without a cover crop (PL+CC and PL-CC), and reduced cultivation with and without a cover crop (RC+CC, RC-CC). Treatments without cover were sprayed to kill all vegetation. There were four replicate plots per treatment and 4 ceramic cups installed at a depth of 0.9 m per plot. Water samples were taken from the cups approximately fortnightly during the 2003-04 drainage season. Samples from both sites were analysed for $\text{NO}_3\text{-N}$ colorimetrically. Both analysis of variance and non-parametric tests were used to evaluate any differences between treatments.

Results

Results from Knockbeg are summarised in Table 1. During both years losses from spring barley were significantly higher ($p < 0.005$) than from winter wheat. The low input treatments in both crops tended to have higher $\text{NO}_3\text{-N}$ concentrations in the soil solution than the high input treatments, and during the first year this was significant ($p < 0.05$) in the case of the winter wheat. Results from the different treatments at the Road Field are summarised in Table 2. The use of a winter cover crop significantly reduced $\text{NO}_3\text{-N}$ leaching losses from both the ploughed and reduced cultivation plots ($p < 0.0005$). The results were less clear for the effect of cultivation method on $\text{NO}_3\text{-N}$ leaching. For the -CC treatments, the reduced cultivation plots had significantly ($p < 0.05$) higher $\text{NO}_3\text{-N}$ concentrations in the soil solution than the ploughed plots, but +CC plots

losses were higher, but not significantly, when the land was ploughed.

Table 1. Summary of soil solution $\text{NO}_3\text{-N}$ (mg/l) data collected during both years from Knockbeg.

Crop and N input (kg/ha)	Mean conc.		SD	
	Y1	Y2	Y1	Y2
S. barley - 105	12.3	18.5	10.4	14.8
S. barley - 138	14.4	14.6	9.3	9.9
W.wheat - 188	12.7	9.2	8.5	6.2
W.wheat - 225	8.7	8.7	7.3	5.9

Table 2 Summary of soil solution $\text{NO}_3\text{-N}$ (mg/l) data collected from the Road Field in Year 2.

Treatment	Mean conc.	SD
PL-CC	52	19
PL+CC	10	33
RC-CC	67	32
RC+CC	2	32

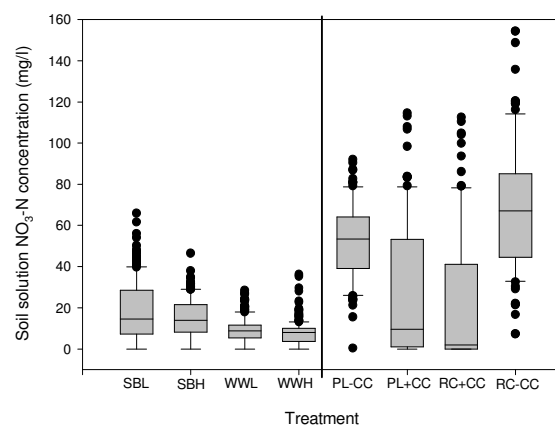


Figure 1. Box plot presenting soil solution $\text{NO}_3\text{-N}$ concentration data from the two sites during Year 2. The central box spans the quartiles, the line in the box is the median, lines above and below box are 1.5 x interquartile range (IQR), observations $> 1.5 \times \text{IQR}$ are plotted as potential outlier dots.

Conclusion

Although the data from the suction cups was highly variable (Figure 1), in concurrence with international experience, it was possible to detect significant differences between treatments. Nitrate-N concentrations in water leaving the root zone at both sites were high, particularly when the soil was left bare over the winter period. Losses were generally lower from the clay loam soil than from the sandy loam soil suggesting that remedial measures should focus particularly on light sandy soils. The higher losses from spring barley treatments indicate that careful overwinter management of land devoted to spring barley is required. Longer term research in this area is clearly merited, however the findings from this study suggest that the maintenance of ground cover on arable land over the winter period is beneficial in terms of reducing N losses.