Effect of cultivation of clover based grassland on N losses to groundwater on a clay-loam soil

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Introduction Implementation of Nitrate Directive (91/676/EEC) in Ireland has constrained farmers to lower losses of nitrogen (N) to water. Cultivation of long-term permanent grassland increases the rate of mineralization of soil organic N and thus promotes N losses via leaching and denitrification. The objective of this experiment was to examine the impact of cultivation of permanent grassland on losses of N to water on a clay-loam soil (42% clays in the upper horizon) at Solohead Research Farm (52˚51'N, 08˚21'W).

Materials and methods The effect of cultivation of grass-clover swards in three dairy production systems on losses of N to ground water was studied over a one year period (August 2008-August 2009). Monitoring was conducted in a randomised complete block design with 2 factors. There were two cultivation treatments: (i) cultivated and reseeded grass-clover swards [cultivated] and (ii) permanent grass-clover swards [uncultivated]. There were six replicated plots of both cultivated and uncultivated swards within each of three systems. The systems of dairy production compared had: (i) a mean calving date of 17 February, stocking density of 2.15 cows/ha, receiving 90 kg/ha annual fertilizer N input; (ii) a mean calving date of 17 February, stocking density of 1.6 cows/ha, receiving no fertilizer N input and (iii) a mean calving date of 16 April, stocking density of 1.6 cows/ha, receiving no fertilizer N input. During the summer of 2008 five sampling units constructed from plastic pipe were installed in each plot (> 1ha). The depth of the wells ranging from 0.8m to 2.4m below ground level was based on ground water (GW) depth. Wells with screen openings on the lower 0.20 m of the pipes, covered by a cotton filter were sealed with bentonite on the soil surface. Sampling was conducted 18 times, fortnightly during the winter drainage period and after periods of high rainfall during other times of the year. All the resident water was removed from the wells and wells were allowed to recharge for two hours before sampling. The water samples from each plot were bulked. Concentrations of total oxidised N, nitrite N, ammonium N were determined by Aquakem 600A. The total N concentration was determined by LECO CN 2000 analyser. Meteorological data were recorded at the meteorological station located at the farm. Effective drainage during experimental period was calculated using model of Schulte *et al*. (2005). Nitrogen losses for each treatment were quantified. Concentrations of nitrate N, organic N and ammonium N were subjected to ANOVA (SAS Institute, 2009) examining the effects of milk production system, cultivation, sampling date and all their interactions.

Results Total rainfall for the period from August 2008 to August 2009 was 1364 mm and effective drainage was 705.5mm. Nitrate N concentrations were well below maximum admissible concentration (MAC; 11.3mg dm^{-3}; Table 1). There were no effect of cultivation and dairy production systems on the concentrations of nitrate N, ammonium N and organic N in the shallow GW. Most of water samples (>0.97) had organic N and ammonium N concentrations exceeding the limits for Kjeldahl N (organic N + ammonium N) for drinking water (1.0 mg /L) defined by (EC 80/778). There were no differences in the quantities of ammonium N and organic N lost from the cultivated and uncultivated treatments. The annual quantity of nitrate N lost from the cultivated treatment were almost double (P<0.05) that from the uncultivated treatment. Organic N losses represented by far the largest proportion (>0.7) of the total N leached from the cultivated and uncultivated grass-clover swards.

Table 1 Mean NO_3-N, Organic-N and NH_4-N concentrations (mg dm^{-3}) and total annual losses of N to groundwater

	Concentrations of N (mg dm^{-3})			Total loss of N (kg N ha^{-1} $year^{-1}$)		
	nitrate N	ammonium N	organic N	nitrate N	ammonium	organic N
Uncultivated	0.356	0.213	2.543	2.127	1.401	15.029
Cultivated grassland	0.371	0.245	2.747	4.102	1.571	15.565
Significance	NS	NS	NS	P<0.05	NS	NS
SEM	0.068	0.042	0.176	1.218	0.303	1.519

Conclusions There were no effect of cultivation and system of dairy production on the concentrations of nitrate N, ammonium N and organic N in the ground water. The quantities of nitrate N lost by leaching were lower than reported in a previous study (Humphreys *et al.*, 2008) This may be largely attributed to high rainfall, wet soil conditions and relatively high soil temperatures during summer months, which promoted denitrification of nitrate in this heavy clay loam soil. In the present study, organic N was by far the largest pool of N lost from the soil to ground water.

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