Nitrous Oxide Emissions from Dairy Pasture Systems in New Zealand

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Introduction Animal excreta deposited during grazing are the single largest source of nitrous oxide (N_2O) from agriculture in New Zealand . N_2O gas is formed in soils during nitrification and denitrification processes and these processes are affected by many soil and climatic factors (e .g . , soil water-filled pore space (WFPS) and nitrate concentrations) . There are a number of possible management options that can reduce N_2O emission from dairy farms (Clark *et al* . 2005) . These options include using restricted grazing regimes to reduce excreta-N deposited onto wet soil and using low-N feed supplements (e .g . maize) as an alternative to using N-rich pasture . A dairy farm system study was carried out to evaluate effects of these options on N_2O emissions . In this paper we summarise N_2O emission data and environmental efficiencies in terms of N_2O emissions per unit of milk production obtained from this study .

Materials and methods The study site contained white clover-based pasture (perennial ryegrass , *Lolium perenne* ; white clover , *Trifolium repens*) on a poorly drained loam soil . Farm systems included : 1) Control : a normal rotational pasture grazing regime with a stocking rate of 3 .0 cows ha^{-1} ; 2) Maize supplement : a rotational grazing regime with a stocking rate of 3 .8 cows ha^{-1} . About 5 tonnes DM ha^{-1} of maize silage were brought in annually ; 3) Stand-off : Same grazing regime and stocking rate as the control , but cows were kept on stand-off pads for 18 hours each day with grazing for 6 hours on pasture during the winter period . Measurements of N_2O were made for two years on the grazed pastures , maize growing land and stand-off pad (Luo *et al* . 2008a ,b) . The New Zealand IPCC inventory methodology was used to calculate indirect N_2O emissions from leached and volatilised N .

Results Nitrous oxide emission rates exhibited marked seasonal variation , largely explained by changes in soil WFPS (Figure 1) . Annual N_2O emissions from the grazed dairy pastures were 4 .7 , 4 .0 and 3 .4 kg N_2O-N ha^{-1} for the control , maize supplement and stand-off treatments , respectively . The N_2O emission rate from the maize growing land was 2 .1 kg N_2O-N ha^{-1} , and this was equivalent to emission of 0 .1 kg N_2O-N per tonne of maize silage . Emissions of N_2O also occurred from the stand-off pad . Total annual N_2O emissions (including both the field measured and calculated direct and indirect emissions from all components of the farm systems) were 7 .7 , 8 .0 and 7 .0 kg N_2O-N per hectare of dairy farm on the control , maize supplement and stand-off farm systems (Table 1) . Total N_2O emissions per kg of milk production from the maize supplement and stand-off farm systems were 22% and 9% lower than that from the control system , respectively .

Table 1 *N_2O emissions and environmental efficiency indicators (Luo* et al . 2008*a ,b)* .

	Control	Maize supplement	Stand-off
N_2O emissions ($kg\ N_2O\text{-}N\ ha^{-1}\ yr^{-1}$)	7 .7	8 .0	7 .0
Change in N_2O emission compared to control (%)		4	-9
Milk solids ($kg\ ha^{-1}\ yr^{-1}$)	13 ,437	17 ,925	13 ,437
Efficiency indices ($kg\ N_2O\text{-}N\ tonne^{-1}$ milk)	0 .57	0 .45	0 .52
Gain in efficiency (%)		22	9

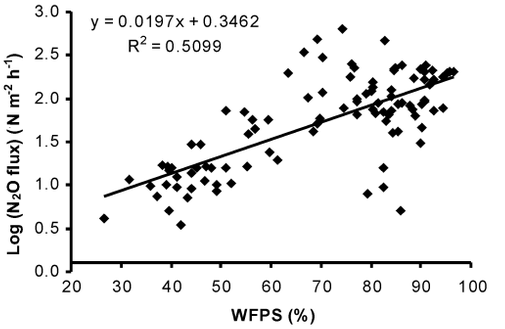

Figure 1 *N_2O emissions as affected by soil WFPS .*

Conclusions The results confirm that the use of low-N feed supplements or restricted grazing regimes during wet winter are effective at reducing N_2O emissions from dairy farms in terms of N_2O emissions per unit of milk production .

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