Title: Developing a blueprint for low or zero nitrogen fertilizer use for low-emissions pasture-based dairy farming

Project start date: 4/1/2021 ***Project end date:*** 31/3/2026

Project Leader: Dr James Humphreys, Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Abstract:

Dairy farms account for approximately 20% of agricultural land use and approximately 15% of national GHG emissions in 2020. The objective was to investigate the potential to lower the carbon and ammonia footprints of Irish pasture based dairy production. Three experimental systems were compared involving farm-scale systems with 27 cows on 10.8 ha per year over three years (2019-2021).

The control system was based on standard practice on intensive Irish dairy farms: fertilizer N input of 275 kg/ha, with a 10% clover content in pasture, fertilizer N was applied as calcium ammonium nitrate (CAN) and urea, slurry was applied using a splash-plate. In the clover+NBPT urea system, fertilizer N was applied solely as NBPT-protected urea at an average annual rate of 96 kg/ha, the clover content of herbage was 22% and slurry was applied using LESS trailing shoe.

In the third system (Clover-Zero) no mineral fertilizer N was applied and the clover content of pasture was 30%, slurry was applied using LESS. The average EBI of the cows in the latter herd was €195 compared with €165 for the two other herds (Table 1).

	Intensive Control	Clover + NBPT Urea	Clover-Zero
Fertilizer N (kg/ha)	275	96	0
Fertilizer N type	CAN and urea	NBPT urea	N/A
Clover content of pasture DM (%)	10	22	30
Slurry application	Splash-plate	Trailing shoe	Trailing shoe
Herd EBI (€)	165	165	195
Annual pasture DM production (t/ha)	15.7	15.2	15.1
Annual concentrates fed (kg/cow)	493	493	493
Milk yield (kg/cow)	6,018	6,075	6,090
Protein (%)	36.0	36.2	36.3
Fat (%)	46.5	45.8	46.6

	Modelled results scaled up to a 50 ha farm		
Stocking rate (cows/ha)	2.56	2.47	2.45
Cows per farm	128	124	123
Total milk sold (kg)	767,636	748,961	749,579
Milk sales (€)	259,039	251,801	254,490
Total sales (€)	283,996	275,921	278,200
Fertilizer N (€)	12,967	4,055	0
Total variable costs (€)	99,099	89,486	84,709
Gross margin (€)	184,898	186,435	193,491
Labour costs (€)	51,260	49,539	49,457
Other fixed costs (€)	59,492	58,044	58,092
Net Margin (€)	74,146	78,851	85,941
Net Margin (€/ha)	1,483	1,577	1,719
GHG (kg CO2eq./L FPCM)	0.88	0.75	0.69
GHG emissions (t CO2eq./ha)	12.3	10.1	9.5
Ammonia (kg/t milk)	4.00	3.17	2.81

For the purposes of comparison of the environmental and economic performance of the systems the results were scaled up to a farm area of 50 ha, which is similar to the average area of a dairy farm in Ireland. Stocking rates of dairy cows in the scaled up model were based on pasture production on each system. Replacement heifers were contract reared. Pasture dry matter (DM) production decreased with lower fertilizer N input (Table 1).

The total volume of milk sold, the value of milk sold and total sales (including livestock) from the farm declined with decreasing intensity of production. On the other hand, variable costs were also lower with decreasing intensity of production, particularly fertilizer N. The cost of fertilizer N was the average cost between 2019 and 2021. The full cost of labour was included at an annual rate of 27 hours per cow at a cost of €15 per hour. Greenhouse gas, quantified either per L of fat and protein corrected milk (FPCM) or per ha, and ammonia emissions decreased with decreasing intensity of production.

Relative to the Intensive Control the two clover-based systems lowered GHG emissions per ha by 18% and 23% for the Clover+NBPT and Clover-Zero systems, respectively. Likewise these systems lowered ammonia emissions by 21% and 30%, respectively. The volume of milk sold decreased by 2.4% for both clover systems relative to the control. The higher EBI of the cows on the Clover-Zero system compensated with higher milk yield per cow to offset the lower stocking rate on this system. The two clover systems improved profitability compared with the control.

Conclusion: Adoption of clover instead of fertilizer N and low emissions slurry spreading along with higher EBI can substantially lower the carbon and ammonia footprints of pasture based milk production while maintaining or improving profitability.