The influence of strain of Holstein-Friesian cow and feeding systems on greenhouse gas emissions from pastoral dairy farms

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Introduction Presently, Ireland is above its national greenhouse gas (GHG) emission limit set under the Kyoto Protocol. One of Ireland's largest sources of GHG emissions is the agricultural sector (26%) (EPA, 2009). Within this sector, pastoral dairy farming is estimated to be a significant source (Lovett *et al.* 2008). Therefore, to meet the targets of the Kyoto Protocol and future reduction targets, pastoral dairy farms will be required to reduce GHG emissions. The purpose of this study was to investigate the effect different strains of Holstein Friesian cows and alternate pasture based feed systems have on GHG emissions from dairy farms.

Materials and methods Three strains of divergent Holstein-Friesian cows; high-production North American (HP), high-durability North American (HD) and New Zealand (NZ) were compared. The HP strain represents cows selected solely for milk production. The HD strain represents a breeding program where selection is based on improving a number of traits simultaneously; these include milk production, fertility and muscularity. The NZ strain represents the highest possible genetic merit expressed in the NZ genetic evaluation system (Breeding Worth). Each strain was allocated to one of 3 feed systems; high grass allowance (MP, control); high concentrate supplementation (HC) and a high stocking rate system (HS). The MP system had an overall stocking rate of 2.47 cows/ha and cows received 325 kg of concentrate in early lactation. The HC system had a similar overall stocking rate and N fertilizer input as the MP system, but 1,445 kg of concentrate were fed per cow. The HS system had a similar concentrate and N input as the MP system, but had an overall stocking rate of 2.74 cows/ha. The GHG emissions of the dairy production systems described were calculated using the Moorepark Dairy System Model (MDSM) of Shalloo *et al.* (2004) in combination with a new GHG emissions model (GHG model). The biological performance data required for the simulation was obtained from McCarthy *et al.* (2007). The MDSM, a whole farm simulation model of Irish grassland-based dairy systems, was used to define the parameters required by the GHG model. Parameters defined included; farm size, animal inventory, milk production, feed intakes, herbage quality (chemical composition), grazing season length, slurry, fertilizer and application of lime. The GHG model integrates the parameters defined by the MDSM with various GHG emission factors in Microsoft Excel to quantify emissions. The model calculates emissions of CO_2, CH_4 and N_2O in terms of their 100-year global warming potentials (CO_2 equivalents (eq)), which on a weight basis relative to CO_2 was set to a factor of 23 for 1 kg of CH_4 and 296 for 1 kg of N_2O. The GHG model is also designed to simulate emissions on two levels, firstly those arising directly from farming activities (on-farm GHG emissions) and secondly those that are produced off-farm but are attributable to the production system up to the point where milk leaves the farm gate. The main outputs of the GHG model are an estimate of annual on-farm and total (on-farm plus indirect) GHG emissions. The model expresses emissions on a farm, area (CO_2 eq, t/ha) and product (CO_2 eq, kg/kg milk and per kg milk solids (MS)) basis.

Results The product and area GHG emissions of all dairy farms were greater when quantified at the total level than the on-farm level (Table 1). The level where GHG emissions were calculated at, affected the optimum feed system and genotype. For example, the NZ strain in terms of product emissions. The HD and HP strain produced their least product emissions in the HC feed system. The NZ strain produced their least product emissions in the HS feed system. On average the HC system produced the greatest area emissions.

Table 1 On-farm and total GHG emissions (CO_2 eq) for 3 strains of Holstein-Friesian cows [high production (HP); high durability (HD) and New Zealand (NZ)] within the Moorepark (MP), high concentrate (HC) and high stocking rate (HS) feed systems

GHG		MP			HS			HC		
Indicator	Level	NZ	HD	HP	NZ	HD	HP	NZ	HD	HP
CO_2 eq, kg/kg milk	On-farm	0.801	0.805	0.862	0.796	0.801	0.869	0.757	0.720	0.760
	Total	1.065	1.067	1.142	1.045	1.055	1.144	1.069	1.012	1.065
CO_2 eq, kg/kg MS	On-farm	10.10	10.65	11.45	9.92	10.64	11.61	9.32	9.68	10.19
	Total	13.43	14.12	15.17	12.98	14.01	15.29	13.15	13.63	14.28
CO_2 eq, t/ha	On-farm	10.28	10.34	10.42	11.16	10.98	11.06	11.70	11.40	11.50
	Total	13.68	13.71	13.82	14.65	14.45	14.56	16.51	16.05	16.12

Conclusion The results show that farm product emissions do not always rank the same when estimated either as on-farm or total emissions. Thus, if effective strategies are to be developed, total emissions associated with a production system should be analyzed. The results also show how selection for increased milk production (HP strain) combined with increased concentrate supplementation within Irish grass based feed systems may result in greater total GHG emissions relative to selection on a combination of production and reproductive traits (HD and NZ strains) within feed systems with a greater reliance on grazed grass.

References Environmental Protection Agency (EPA). 2009. National Greenhouse Gas Inventory Report 2009. Johnstown Castle, Co. Wexford.
Lovett, D. K., Shalloo, L., Dillon, P., and O'Mara, F. P. 2008. Livestock Science 116, 260-274.
McCarthy, S., Horan, B., Dillon, P., O'Connor, P., Rath, M., and Shalloo, L. 2007. Journal of Dairy Science 90, 1493-1505.
Shalloo, L., Dillon, P., Rath, M., and Wallace, M. 2004. Journal of Dairy Science 87, 1945-1959.

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