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Quantifying greenhouse gas emissions from beef cattle systems

Key external stakeholders:

Beef farmers, agricultural industry, research organisations, consumers, policy makers, environmental agencies, meat processing industry.

Practical implications for stakeholders:

This study showed that increasing stocking intensity via (1) increased fertilizer N application rates and (2) higher grass utilization rates lead to increased profitability on beef farms with only modest increases in greenhouse gas (GHG) emissions when expressed per kg of beef carcass produced. However, when expressed per ha of farmland utilized, GHG emissions increased substantially.

Main results:

The lowest total GHG emissions per kg carcass and per hectare were found at the lowest stocking intensity for both bull/heifer and steer/heifer systems of production. As stocking intensity increased, GHG emissions per kg of carcass increased modestly with the highest stocking intensity being only 4% greater than the lowest stocking intensity for both bull/heifer and steer/heifer systems. When expressed per ha, GHG emissions increased considerably and were 52% higher at the highest stocking intensity relative to the lowest stocking intensity for both systems.

Opportunity / Benefit:

This study showed that increasing stocking intensity led to increased profitability for beef cattle systems with a small increase in GHG emissions per kg of beef carcass. With increasing global demand for beef meat, the alternative pathways for the beef cattle sector are to intensify production or to expand farmland. Given the high carbon losses associated with farmland expansion, intensification is likely to yield lower GHG emissions per unit of additional beef carcass produced.

Collaborating Institutions:

Bord Bia

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1. Project background:

Stocking intensity is a key driver of profitability for beef cattle production systems. Where the level of individual animal performance is maintained, increasing stocking intensity will lead to a direct increase in farm profitability. However, concerns exist that increasing stocking intensities by increasing the level of nitrogen fertiliser application together with the associated higher organic nitrogen loading may result in increases in the GHG intensity (i.e. GHG emissions per unit of product) of agricultural products. The relationship of beef output per hectare and GHG emissions arising from variation in stocking intensities has been evaluated by a number of authors, however, much of this analysis was confounded by differences in animal or feeding system between scenarios. Nevertheless, results appear to indicate that GHG emissions per kg of beef do not necessarily increase at higher stocking intensities if nitrogen (N) application rates are not increased excessively. The objective of this study was to evaluate the effect of stocking intensity of spring calving suckler cow herds on the GHG emissions profile and economic performance. A life cycle assessment (LCA) approach was adopted since it is a method that evaluates the environmental impact of products according to international standards developed by the International Organisation for Standardisation.

2. Questions addressed by the project:

This study set out to identify, for spring calving suckler beef cow production systems taking progeny through to beef, the impact of stocking intensity on:

- productivity (carcass output) and profitability (net margin).
- greenhouse gas emissions generated per kg beef carcass and per hectare.
- the relative contribution of the alternative sources of GHG emissions.

3. The experimental studies:

Included within the analysis were direct GHG emissions generated on the farm and indirect GHG emissions (from the production of purchased inputs used on the farm and indirect nitrous oxide (N_2O) emissions from nitrate leaching and ammonia (NH_3) volatilization). Greenhouse gas emissions associated with activities after the farm gate (such as slaughtering, processing and distribution) were outside the boundary of the analysis. It was assumed that beef carcass takes the full GHG burden of the production system and therefore only one output (beef) and no co-products were defined for the farm system modelled. For this reason, no allocation (partitioning of inputs and outputs) was used in the current study. The model described in the current paper was developed using the software package SimaPro (PRe Consultants, 2012).

The scenarios modelled were suckler beef cattle production systems finishing heifer progeny at 20 months of age and male progeny as bulls at 16 months of age (i.e. bull/heifer systems) or steers at 24 months of age (i.e. steer/heifer systems). Following weaning, it was assumed that males finished as bulls were housed and offered a concentrate and silage diet until slaughter at 16 months of age with a carcass weight of 372 kg. Where males were finished as steers and females finished as heifers for slaughter, they were housed following weaning and offered grass silage ad libitum and 1 kg of concentrates daily. At the end of the first winter housing period, steers and heifers were turned out to pasture for a second grazing season, where they grazed predominantly perennial ryegrass swards on a rotational paddock system. Heifers were housed in September of the second grazing season, offered a diet comprising grass silage ad libitum and 3 kg concentrate daily and slaughtered at 20 months of age. Steers were housed in November at the end of the second grazing season, offered a diet of grass silage ad libitum and 4 kg of concentrate daily and slaughtered at 24 months of age. Respective carcass weights for steers and heifers were 397 kg and 317 kg,

4. Main results:

Output in terms of live weight, carcass weight and livestock sales was a function of stocking intensity and therefore, increased by 47% between the lowest and highest stocking intensity. Although costs of production also increased with stocking intensity, profitability was 90% greater at the highest stocking intensity relative to the lowest stocking intensity. Similarly, production costs and profitability were greater for bull/heifer systems than for steer/heifer systems. On average, net margin was 6% higher for bull/heifer systems relative to steer/heifer systems.

Total greenhouse gas emissions ranged from 20.1 kg carbon dioxide equivalents (CO_2e)/kg beef carcass for

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the bull/heifer systems at the lowest stocking intensity to 23.1 kg CO_2e/kg beef carcass for the steer/heifer system at the highest stocking intensity. Greenhouse gas emissions per hectare increased substantially as stocking intensity increased; for a 47% increase in stocking intensity, bull/heifer system GHG emissions increased by 53% and steer/heifer systems GHG emissions increased by 52%.

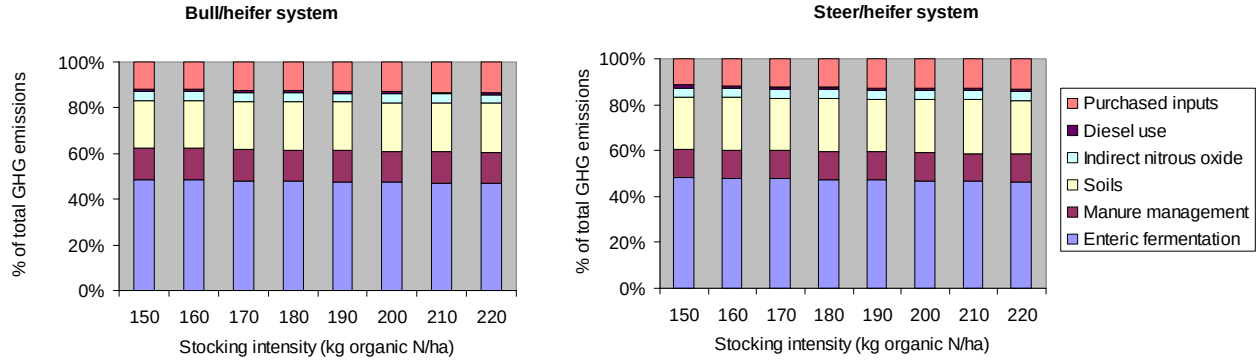

Figure 1. Relative contribution of the alternative GHG emission sources for suckler beef cow production systems taking progeny to beef in bull/heifer and steer/heifer systems.

As stocking intensity increased, the contribution of enteric fermentation and manure management to total GHG emissions reduced slightly (Figure 1). This was primarily associated with increases in inorganic N fertilizer application rates

5. Opportunity/Benefit:

The global demand for meat is predicted to increase by 21% by 2020 relative to 2010. In the case of beef meat, the increase is projected to be 17%. There are a number of alternatives for the global cattle industry to meet these demands but in broad terms the two main options are to 1) increase the intensity of production, thus producing more beef on the current beef cattle areas or, 2) divert additional land resources to beef cattle production. An important aspect of the results presented in the current study is the capacity of grass-based beef cattle production systems to increase beef output per unit area with only small increases in GHG emissions intensity (CO_2e/kg beef carcass). The alternative approach to increase output by means of land use conversion has been shown by a number of authors to have a significant impact on GHG emissions. Thus, for beef cattle production systems it is likely that any increase in net global GHG emissions that arise due to increasing productivity per hectare would be much lower than emissions from land use change.

6. Dissemination:

Scientific publications:

Clarke, A.M., Brennan, P. and Crosson, P. (2013) Life-cycle assessment of the intensity of production on the greenhouse gas emissions and economics of grass based suckler beef production systems. *Journal of Agricultural Science,* 151, 714-726

Clarke, A.M. and Crosson, P. (2012) The effect of stocking rate on the economic and technical performance and greenhouse gas emissions profile of suckler beef production systems. *Proceedings of the Agricultural Research Forum*, Tullamore, Co. Offaly, Ireland, 12-13 March 2012, p. 14

Clarke, A.M. and Crosson, P. (2012) An assessment of greenhouse gas emissions and economics of grass based suckler beef production systems. *Proceedings of the 8th International Conference on LCA in the Agri-Food Sector*, Saint-Malo, France, 1-5 October 2012, p. 106

Popular publications:

Crosson, P. and Clarke, A.M. (2012) Strategies to reduce greenhouse gas emissions from Irish beef cattle systems. In: *Proceeings of the Irish Grassland Association Beef Conference 2012*, Horse and Jockey Hotel, Horse and Jockey, Co. Tipperary, 4 September 2012, pp. 7-10.

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