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Resource use efficiency on dairy farms in Ireland

Key external stakeholders: Farmers, policy makers, research scientists, farming community

Practical implications for stakeholders:
The overall carbon footprint (CF) of the milk production was 1.23 ± 0.04 kg of CO_2 Equivalents, which is relatively low by international standards.
The most common weakness identified for improvement across all farms was soil fertility; 89% of fields were sub-optimal for soil P. Soil K or soil pH.
Improving farm sustainability is typically about getting the simple things right: improving soil fertility, growing more grass, achieving a longer grazing season, feeding less concentrates, improving the EBI of the herd and making efficient use of energy. These practices are also proven to increase farm profitability, which is a fundamental component of the sustainability of farms.

Main results:

The overall carbon footprint (CF) of milk production was 1.23 ± 0.04 kg of CO_2 Equivalents. This is relatively low by international standards. Internationally the carbon footprint of milk averages approximately 2.5 kg per kg milk ranging between 1 and 9 kg per kg milk according to a recent FAO report.
Mean N surplus was 175 kg/ha and mean NUE was 0·23, which represent a substantial improvement on levels recorded in similar Irish studies carried out before the introduction of the Nitrates Regulations in 2006.
Mean P surplus was 5·1 kg/ha and mean PUE was 0·70, which also represent a substantial improvement compared with levels prior to 2006.
Nitrogen and P balances and use efficiencies on farms compare favorably with other countries largely due to the low input pasture-based system in Ireland, with seasonal milk production (compact spring calving), low use of imported feeds and high use of grazed grass.

Opportunity / Benefit:

The sustainability of Irish dairy farms compared favorably with our European counterparts across a range of criteria. In general, higher resource use efficiency will result in a lower CF and a better economic outcome for the farmer. Resources include fertilizers, concentrates, electricity etc. Improving farm sustainability is typically about getting the simple things right: improving soil fertility, growing more grass, achieving a longer grazing season, feeding less concentrates, improving the EBI of the herd and making efficient use of energy. These practices are also proven to increase farm profitability, which is a fundamental component of the sustainability of farms.

Collaborating Institutions:

Waterford Institute of Technology, University College Dublin, Acorn Agricultural Research. Dairyman was a project co-funded INTERREG IVB program by the European Regional Development Fund. In Dairyman there were 14 partners in 10 regions of seven countries in the Northwest of Europe (NWE). For more information on the Dairyman project please follow the link: http://www.interregdairyman.eu/en/dairyman.htm

Contact James Humphreys Email: james.humphreys@teagasc.ie

Teagasc project team: Dr. James Humphreys Project leader/PI),
Mr Andrew Boland,
Dr. Elena Mihailescu,
Dr. John Upton.

External collaborators: Dr. Mingjia Yan, UCD,
Dr. Imelda Casey, WIT,
Dr. Paul Murphy, UCD,
Professor Nick Holden, UCD,
Mr Joe Kirk, Acorn Agricultural Research

1. Project background:

- Consumers and retailers are increasingly concerned that food is produced in a sustainable way.
- Life cycle assessment (LCA) is a method regulated by ISO that can be used to determine the environmental impact of milk production such as carbon footprint (CF) and efficiency of resource utilization. It is increasingly used to influence policy making.
- There is increasing concern about balancing agronomic and environmental gains from nitrogen (N) usage on dairy farms.
- Given the finite nature of global phosphorus (P) resources, there is an increasing concern about balancing agronomic and environmental impacts from P usage on dairy farms.
- Electricity consumption is an important part of the energy used for milk production.
- On-farm research has proven to be an effective means of improving exploitation of research output at farm level because it connects all relevant partners in the process. Furthermore, pilot farms can act as an effective platform for communication and dissemination.
- Such improvements will be necessary to achieve national targets of improved water quality and increased efficiency and sustainability of the dairy industry.

2. Questions addressed by the project:

- Quantify the carbon footprint of milk produced on dairy farms in the southwest of Ireland.
- Determine soil nutrient status on a field by field basis for each of the farms in this study.
- Quantify nutrient use efficiencies on farms and compare them with levels on farms prior to the introduction of the Nitrates Regulations in Ireland and to compare them with levels in other countries.
- Quantify electricity use per kilogram of milk sold and to identify strategies that reduce its overall use while maximizing its use in off-peak periods.
- Determine the economic implications of improving resource use efficiency on farms.

3. The experimental studies:

- In this study resource use efficiency and CF was determined for 21 commercial grass-based dairy farmers in Ireland based on data collected over a three-year period (2009 to 2011)
- The CF of milk production from the farms was determined using foreground data from a farm survey capturing management tactics and background data from the literature.
- Soil nutrient status was determined on a field by field basis for the farms in the study.
- Farm-gate N balances and N use efficiency (NUE) were assessed for the farms.
- Farm-gate P balances and P use efficiency (PUE) were assessed for the farms.
- Average daily and seasonal trends in electricity consumption on the farms were measured by detailed auditing of electricity-consuming processes. Total energy use of Irish milk, which is the sum of the direct (i.e., energy use on farm) and indirect energy use (i.e., energy needed to produce farm inputs) was assessed to determine the potential to save energy.
- The economic implications of improving resource use efficacy on farms were also assessed.

Contact James Humphreys Email: james.humphreys@teagasc.ie

4. Main results:

- Mean stocking rate (SR) was 2·06 livestock units per ha. There was large variation in farm attributes and management tactics; for example, up to a 1.5-fold difference in fertilizer nitrogen input was used to support the same stocking density, and up to a 3.5-fold difference in concentrate fed for similar milk output per cow.
- The overall CF of milk production was 1.23 ± 0.04 kg of CO_2 Equivalents. Improving the productivity of the dairy herd; by lowering the replacement rate, increasing the survival of cows in the herd and by increasing milk solids production per cow will lower methane production and the CF per litre of milk. Improving the EBI of the herd will lower the carbon footprint of milk produced. The second largest contributor to carbon footprint was fertilizer use, particularly fertilizer N use (23%). More efficient use of lime, fertilizers, slurry and clover will lower the carbon footprint of milk. The third and fourth largest contributors were greenhouse gasses generated by concentrates and silage fed and manure management. With a longer grazing season, there was less need for silage and concentrate supplementation and there is less manure to be managed because the livestock recycle the dung and urine directly onto the pastures. Hence, early turnout to grass and a long grazing season are a key component of lowering the carbon footprint of milk. The fifth largest contributor was fuel and electricity use. Efficient electricity and fuel use will lower the carbon footprint of milk.
- Mean N surplus was 175 kg/ha, or 0·28 kg/kg milk solids (MS), and mean NUE was 0·23. Nitrogen inputs were primarily as inorganic fertilizer (186 kg/ha) and concentrates (26·6 kg/ha), whereas outputs were milk (40·2 kg/ha) and livestock (12·8 kg/ha). Comparison with similar Irish studies carried out before the introduction of the Nitrates Regulations in 2006 suggest that N surpluses, both per ha and per kg MS, have decreased significantly (by 40 and 32%, respectively) and NUE has increased by 27%. These improvements are mostly attributable to decreased inorganic fertilizer N input and improvements in N management, with a notable shift towards spring application of organic manures and better timing of fertilizer N application.
- Mean P surplus was 5·1 kg/ha, or 0·004 kg P/kg milk solids (MS), and mean PUE was 0·70. Phosphorus imports were predominantly inorganic fertilizer (7·61 kg P/ha) and feeds (7·62 kg P/ha), while exports were mainly as milk (6·66 kg P/ha) and livestock (5·10 kg P/ha). Comparison to similar Irish studies carried out before the introduction of the Nitrates Regulations in 2006 indicated that P surpluses, both per ha and per kg MS, have decreased significantly (by 74 and 81%, respectively) and PUE has increased by 48%. These changes are mainly attributable to decreased use of inorganic fertilizer P on farms. Results suggest that optimizing fertilizer and feed P imports combined with improved on-farm P recycling are the most effective way to increase PUE. Equally, continued monitoring of soil test P (STP) is necessary to ensure that adequate soil P fertility is maintained.
- Mean net profit was not directly related to mean N and P balances or N and P use efficiencies. Eight farms exceeding the limit of 2 livestock units (LU)/ha, imposed through the Nitrates Directive, had 1.63 times higher net profit compared with the remainder, which justified the cost of compliance associated with being in derogation. The results of this study generally indicate that Irish dairy farms, as low-input production systems, have the potential to improve both economic (as indicated by net profit per hectare) and environmental (as indicated by N and P balances per hectare, N and P use efficiencies and N-eco-efficiency) sustainability.
- Mean N surplus was lower than the overall mean surplus (224 kg/ha) from six separate studies of dairy farms in northern and continental European countries, while mean NUE was similar. Mean P surplus was lower and PUE was much higher than the overall mean surplus (15·92 kg P/ha) and PUE (0·47) from three studies of continental and English dairy farms, largely due to the low input pasture-based system in Ireland, with seasonal milk production (compact spring calving), low use of imported feeds and high use of grazed grass.
- On average, a total of 31.73 MJ was required to produce 1 kg of milk solids, of which 20% was direct and 80% was indirect energy use. Electricity accounted for 60% of the direct energy use, and mainly resulted from milk cooling (31%), water heating (23%), and milking (20%). Analysis of trends in electricity consumption revealed that 62% of daily electricity was used at peak periods.

5. Opportunity/Benefit:

- Consumers and retailers are increasingly concerned that food is produced in a sustainable way. This study quantifies aspects of the sustainability of milk produced on Irish dairy farms and shows high environmental and economic performance compared other countries. The high standard of the sustainability of milk produced on typical Irish pasture-based dairy farms creates a unique selling proposition for Irish dairy products on international markets
- In general, higher resource use efficiency will result in a lower CF and a better economic outcome for the farmer. Resources include fertilizers, concentrates, electricity etc. Improving farm sustainability is typically

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about getting the simple things right: improving soil fertility, growing more grass, achieving a longer grazing season, feeding less concentrates, improving the EBI of the herd and making efficient use of energy. These practices are also proven to increase farm profitability, which is a fundamental component of the sustainability of farms.

6. Dissemination:

Main publications:

Mihailescu E., Murphy P. N. C., Ryan W., Casey I. A. and Humphreys J. (2014) Phosphorus balance and use efficiency on twenty-one intensive grass-based dairy farms in the South of Ireland. Journal of Agricultural Science (Cambridge), doi:10.1017/S0021859614000641

Mihailescu E., Murphy P. N. C., Ryan W., Casey I. A. and Humphreys J. (2014) Nitrogen balance and use efficiency on twenty-one intensive grass-based dairy farms in the South of Ireland. Journal of Agricultural Science (Cambridge), doi:10.1017/S0021859614000045

Mihailescu E., Ryan W., Murphy P. N. C., Casey I. A. and Humphreys J. (2014) Economic impacts of nitrogen and phosphorus use efficiency on nineteen intensive grass-based dairy farms in the South of Ireland. Agricultural Systems, 132, 121–132.

Popular publications:

Boland, A., Murphy, Paul, Upton, J., Mihailescu, E., Yan, M.J. and Humphreys, J. (2010). DAIRYMAN: a collaborative project to improve resource utilisation on dairy farms in northwest Europe. In: Agri-Environment Conference 2010, Solohead, Tipperary, 27-Aug 2010, P. 36-39.

Yan M., Humphreys J., Holden N.M. (2010) Methods and results of research on GHG emissions from dairy farms in Ireland. Invited speech at EGF (European Grassland Federation) pre-conference workshop 'Green effects of dairy farming', August 29, 2010, Kiel, Germany.

Yan, M-J., Humphreys, J. and Holden, M.N. (2010) Life cycle comparisons of greenhouse gas emissions from pasture-based dairy production of Ireland. Proceedings of VII International conference on Life Cycle Assessment in the agri-food sector Bari, September 2010, 22-24.

Mihailescu, E., Casey I. A., and Humphreys J. (2011) "Nitrogen and phosphorus use on dairy farms", In: Proceedings of the Agro-Environment conference, Athlone, Ireland, 10th November 2011, 29-30.

Yan M.-J., Humphreys J., Holden N. M. (2011) Life cycle comparisons of greenhouse gas emissions from pasture-based milk production of Ireland. Agriculture Research Forum. 14th-15th March 2011. Agricultural Research Forum, page 65. The Tullamore Court Hotel, 14-Mar-2011.

Mihailescu E., Casey I.A. and Humphreys J. (2012) Nitrogen use efficiency on commercial dairy farms. The Agricultural Research Forum. Tullamore, Ireland. 84.

Humphreys J., Boland A. and Upton J. (2012) European Farmers responding to the Sustainability Challenge. In: Proceedings of the Agri-Environment Conference 'Sustainable Pathways to Food Harvest 2020'. 13-18. Dublin, Ireland

Yan, M-J., Humphreys, J. and Holden, N.M. (2012) Carbon footprint of Irish milk production. In: Proceedings from 17th international Nitrogen Workshop, 26-29 June 2012, pages 404-405. (Oral presentation).

Mihailescu E., Murphy P., Casey I.A, and Humphreys J. (2012) "Nitrogen use efficiency on dairy farms". In: Proceedings of the 17th international nitrogen workshop (Eds. K. G. Richards, O. Fenton, C. J. Watson), 26-29th June 2012, Wexford, Ireland, 352-353.

Yan, M-J., Humphreys, J. and Holden, N.M (2012) Carbon footprint of Irish milk production. Oral presentation at the annual meeting of American Society of Agricultural and Biological Engineers (ASABE), Jul 29 - Aug 1st 2012, Texas, USA

Yan, M.-J, Humphreys, J. and Holden, N.M.(2012) Carbon footprint of Irish milk production. 8th International Conference on LCA in the Agri-Food Sector, Rennes, France, 2-4 October 2012 (in press).

Upton, J., M. Murphy, P. W. G. Groot Koerkamp, J. Humphreys, L. Shalloo, and I. J. M. De Boer. 2014. Strategies to reduce energy use in dairy milking facilities. ASABE annual meeting, Montreal, Quebec Canada July 13 – July 16, 2014.

Upton, J., Humphreys, J., Groot Koerkamp, P.W.G., French, P., Dillon, P.G. and De Boer, J.M. (2014). Life cycle assessment of energy use on Irish Dairy Farms. Agricultural Research Forum, Tullamore, Ireland, 48.

7. Compiled by: Dr James Humphreys

Contact James Humphreys Email: james.humphreys@teagasc.ie