Hannah Dairy Research Foundation

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Research Paper Summary

The impacts of precision livestock farming tools on the greenhouse gas emissions of an average Scottish dairy farm

Short title: Reducing dairy emissions with technology

Key words: carbon footprint, dairy, emissions, PLF

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Practical point

Precision livestock farming (PLF) tools (e.g., fertility collars) are increasingly used in daily herd management to improve health, welfare, and overall production. While not intended to reduce greenhouse gas (GHG) emissions, PLF tools can do so by improving overall farm efficiency, reducing emissions per unit of product. This work modelled effects of commercially available PLF tools (oestrus and health) on whole enterprise and product emissions of two average Scottish dairy farms.

Background

Globally, the number of dairy farmers using PLF tools in daily management of their enterprises is increasing, for example oestrus/fertility detection, lameness detection, in-line milk quality sensors, and more. The number of users globally is unknown, with many farmers not regarding themselves as PLF users, despite using technology daily.

When used fully, PLF tools can help improve animal management, health, welfare and production. They can also help monitor or reduce GHG emissions, improve farm environmental efficiency, improve traceability and provide more focused use of available labour. Tools are not meant to replace evaluation of stock by a trained stockperson, or the routine information they gather, but to support them. PLF tech can allow collection of detailed information in quicker, more accurate ways, with reduced animal handling and associated stresses.

Although not intended to reduce emissions, PLF technologies can do so indirectly by improving animal efficiency and therefore enterprise efficiency. The more efficient an animal is, the lower the emissions per unit of product, e.g., milk. Improved animal production efficiency through adoption of technologies could maximise the profitability of dairy farms and therefore improves environmental and economic sustainability of the sector. For example, PLF technology such as an oestrus detection tool could reduce GHG emissions through more accurate detection of oestrus, leading to more successfully timed artificial insemination (AI). More successful AI reduces days left open, reducing the number of days cows are non-productive – i.e., producing emissions with no product.

Work undertaken

This research aimed to demonstrate the impact of the adoption of PLF tools intended to improve fertility or health on the emissions of a high and low input Scottish dairy farm, based on currently commercially available animal-mounted systems.

Data for Scotland from the Cattle Tracing System (CTS) and the Farm Advisory Service (FAS) Farm Management Handbook were used in this study. Average values were used to create a baseline dairy farm, typical of those seen in Scotland; *225 cows calving all year-round (AYR), with access to pasture and producing 8,000L/cow/annum*. Using data from the Langhill Research herd and the Farm Management Handbook, a second baseline dairy farm was created; *225 cow, AYR calving, fully housed herd producing 10,000L/cow/annum*.

Diets were formulated to create representative Scottish dairy total mixed rations (TMR), along with typical grazing periods. Diets were formulated to provide 17% crude protein at 70% digestibility, comprising predominantly of grass silage plus wholecrop cereal, barley, barley straw, concentrate pellets and minerals. Grazing cows were assumed to be grazed for 152 days of a 305-d lactation. For all herds/scenarios, dry cows were expected to be grazed (60d dry period). Youngstock were expected to graze for 340d, and be fed concentrate in late season when grass is poorer quality and less available, at a rate of 1.5kg/head/day.

Carbon footprints for baseline farms and PLF technology adoption scenarios were modelled using the Agrecalc carbon footprinting tool. Estimated impacts of technologies were modelled based on assumptions from validated technologies, expert opinion (SAC Consulting), and direct experience of similar tools on similar Scottish farms.

Scenarios modelled included:

- (S1) adoption of an accelerometer-based sensor for fertility (OESTRUS TECH)
- (S2) adoption of an accelerometer-based sensor for fertility and associated yield improvements (OESTRUS TECH + YIELD)
- (S3) adoption of an accelerometer-based sensor for health detection (HEALTH TECH).

Parameters expected to be affected by introduction of technology (e.g., calving interval, replacement rate, mortality, yield) and associated feed, bedding and land requirement changes were modelled. Modelling was split into 3 groups with each scenario (S1-3) applied within each group:

- Group 1 – Modelling PLF technology on a baseline average Scottish dairy farm with 225 cows calving AYR, having access to pasture and producing **8,000L/cow/annum, with no management changes** applied, i.e., no change in % use sexed semen.
- Group 2 – Modelling PLF technology use on a baseline average Scottish dairy farm with 225 cows calving AYR, having access to pasture and producing **8,000L/cow/annum, with management changes** applied, i.e., changes in % use sexed semen with improved fertility.
- Group 3 – Modelling PLF technology use on a baseline 225 cow, AYR calving, fully housed herd producing **10,000L/cow/annum, with management changes** applied, i.e., changes in % use sexed semen with improved fertility.

Baseline emissions were higher for the 8,000L grazing herd with and without management changes (groups 1 and 2), in comparison to group 3, the 10,000L housed herd. For each scenario, emissions intensities were also lower for group 3.

The most consistent reductions achieved, though not numerically largest, were observed for S1 OESTRUS TECH; introduction of a technology intended to improve fertility, across all groups. In all but one case across groups 1–3, there was an increase in total emissions from farming with S2 OESTRUS TECH + YIELD and S3 HEALTH TECH. This is likely because of increased stock numbers due to improved fertility and reduced mortality and increased feed and electricity consumption associated with increased yields and herd sizes. However, when considered on a per product basis (kg CO2e/ kg fat and protein corrected milk (FPCM)), S2 and S3 resulted in the greatest reduction in emissions for all groups.

The difference between the percentage reduction in total emissions from milk and per kg FPCM between groups 1 (no change in % sexed semen) and 2 (changes in % sexed semen with improved fertility) highlights effects other factors can have on enterprise emissions and impacts of technology introduction. Differences in management means that effects of technology introduction on emissions will vary greatly between farms. For example, a farm with poorer fertility that would benefit greatly from technology would be expected to show a greater reduction in emissions.

Results from S3, improvement in health, showed a reduction in emissions intensity across all scenarios (per kg product) and agreed with previous work showing cows retained in a herd longer had reduced emissions intensity. A cow with 5-8 lactations could have emissions intensity 40% lower than those leaving the herd after their first lactation. Therefore, monitoring health via PLF could not only improve animal health/welfare and improve production (reduction in sub-clinical/clinical diseases which limit production), which reduces emissions, but would also further reduce emissions intensities through reduced culling.

Differences between total emissions from the whole farm – increase for some scenarios – and emissions per kg FPCM shows that the most efficient farms (in terms of product emissions) are not always the lowest emitters (in terms of total emissions). Improved fertility and health could lead to more animals with higher liveweights, so although there is more output for emissions to be divided over, total emissions would still be increased. If production efficiency was increased, farmers would also likely increase stock numbers. Therefore, efficiency gains should be made sustainably to avoid an unintended increase in total emissions, i.e., increasing livestock numbers across the sector.

Conclusions

This study found that application of technologies intended to improve fertility and health, to both lower and higher yielding housed Scottish dairy systems, resulted in realistic reductions in emissions across some scenarios. However, dependent on individual farm and management aspects there may be variation in the time taken to achieve these changes on real farms. This additional benefit (decreased emissions) of PLF tools on farm could further improve farmer uptake of technology.

Reference

H.J. Ferguson, J.M. Bowen, L.C McNicol, J. Bell, C-A Duthie and, R.J. Dewhurst 2024. **The impacts of precision livestock farming tools on the greenhouse gas emissions of an average Scottish dairy farm**. Frontiers in Sustainable Food systems, Volume 8: https://doi.org/10.3389/fsufs.2024.1385672