North Wyke Farm Platform

Case study no. 22

Measuring nitrous oxide emissions for life cycle assessment of pasture-based beef production systems

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The conventional method of life cycle assessment (LCA), a research tool to compare environmental performance of multiple farming systems, uses data from "representative farms", or virtual farms created from either national-level herd statistics or farm surveys. As these data are already aggregated at the time of inventory analysis, this approach implicitly assumes that the rate of on-farm greenhouse gas (GHG) emissions is homogenous, both temporally and spatially. Recent research has demonstrated, however, that estimates of global warming potential for pasture-based livestock production systems are extremely sensitive to the assumptions laid out for each model. This finding suggests that even a small difference in "universal" emission factors could drastically alter the study's conclusion, casting a serious doubt on the meaningfulness of point estimates provided by LCA models run under the representative farm approach.

The research setup at the North Wyke Farm Platform (NWFP) allows us to overcome this issue through extensive collection of primary data. The NWFP is comprised of three hydrologically isolated "farmlets" with different pasture-based livestock systems: the "green" system based on a permanent pasture; the "red" system based on high sugar perennial ryegrass monoculture; and the "blue" system based on a legume (white clover) / high sugar perennial ryegrass mix. Every year, 30 Charolais / Hereford-Friesian and Stabiliser calves enter each system after weaning. We evaluate the environmental performance of each animal, and by extension each farmlet, by calculating the carbon footprint required for the animal to achieve 1kg of bodyweight gain.

Chambers to trap nitrous oxide

Thrice-weekly gas sampling

Since April 2017, the research team has been testing a novel, data-driven approach of life cycle impact assessment that complements the traditional LCA methodology. Nitrous oxide (N_2O) emissions are being measured using static chambers at high spatial and temporal resolutions on each farmlet, enabling a detailed analysis of hotspots that require further attention to make livestock production more eco-friendly. Collected information will further be processed to obtain intra-farm, inter-animal differences in economic and environmental performance indicators, offering an alternative method to the standard uncertainty analysis whereby these variables are assumed to follow arbitrary distributions. Results will also be utilised to evaluate the data quality of automated N_2O measurements, which are also being carried out at the NWFP. These tests are crucial for the environment, as our recent research has indicated that N_2O is responsible for 37% of the NWFP's on-farm GHG emissions, second only to methanogenic (methane) emissions.

Going forward, the internationally unique set of primary data across the NWFP will further be integrated into our LCA framework to enhance accuracy. For example, snip samples of pastures (in summer) and "grab" samples of silages made from them (in winter) are collected on a regular interval, with forage quality parameters such as the modified acid detergent fibre content analysed for all samples. The use of this information will allow more reliable estimation of energy intake by each animal, and thus the resource use efficiency of the farmlet. In addition, the meat produced from each farmlet will be analysed for their nutrient compositions, physical characteristics and consumer preference, in order to account for the difference in product quality attributable to farming strategies. These data will contribute to an unprecedentedly comprehensive assessment of beef production systems, through which we hope to contribute to sustainable intensification of UK agriculture.