Practical guidance for reducing agricultural greenhouse gas emissions and soil carbon losses

The environmental effects of greenhouse gas (GHG) emissions and the loss of soil carbon are receiving increased attention as public concern over global warming grows.

Agriculture and land use contribute to around a quarter of Scotland's annual GHG emissions. *Government targets of an 80% reduction in emissions of GHGs by 2050 will require agriculture to further reduce current GHG emissions.* Sequestration of carbon in agricultural soils is an important strategy in the effort to mitigate carbon dioxide (CO_2) emissions to meet obligations under climate change agreements.

Background

GHGs (nitrous oxide, methane and carbon dioxide)

Emissions of nitrous oxide (N_2O) in the UK, contribute ~ 8% of overall GHG emissions. Nitrogen from fertilisers can be lost as N_2O gas produced by soil microorganisms. In addition to fertiliser application, soil structure, soil water content and temperature influence N_2O emissions. Poorly drained or fine-textured soils, prone to wetness or compaction problems, are likely to produce most N_2O and methane (CH_4).

In comparison with arable cultivation, grassland GHG emissions are generally higher due to soil compaction. The major sources contributing to grassland CH_4 emissions are livestock enteric emissions and excreta emissions (post-deposition and storage). Production of CH_4 from grassland soils is highly variable but generally increases immediately after excreta returns and organic applications. Organic soils are more likely to act as a source rather than a sink of CH_4.

For arable crops, potatoes and vegetables give larger emissions than cereals, mainly because nitrogen-fertilisers are applied later in the growing season when temperatures are higher. Similarly, incorporation of crop residues can release nitrogen leading to N_2O emissions later in the season, if not taken up by plants.

Soil microbes store carbon in the soil, preventing it from reaching the atmosphere as CO_2.

Soil carbon

Carbon Sequestration *is the capture and storage of carbon from the atmosphere in carbon sinks (such as oceans, forests or soils) through physical or biological processes (e.g. photosynthesis).*

Soil contains around twice as much carbon as the air, and over half of that is found in the topsoil. Soil carbon levels are determined by the balance of net carbon inputs (e.g. vegetation, crop residues, organic amendments) and net carbon losses through organic matter decomposition (i.e. oxidation by microbes) and soil erosion losses.

Long-term use of ploughing and other cultivations that expose soil organic matter to oxygen (thus causing it to break down to CO_2) can lead to carbon losses.

Erosion of bare soils from the action of wind, water and tillage drives large carbon losses.

Here are some actions that can help reduce GHG emissions and soil carbon loss:

Minimising N_2O emissions

- **Grow appropriate crops**

Locate intensively grazed grass or crops with high nitrogen requirements on the driest soils

- **Match fertiliser to crop**

Ensure that nitrogen fertiliser applications correspond to the requirements of the crop and split applications wherever possible

• **Fertiliser type**
Consider options for optimising fertiliser types for crop needs and local soil and climate conditions.
• **Spread fertiliser when it is dry and cool**
Avoid spreading fertiliser or slurry 1-2 days before or after heavy rain
• **Alleviate compaction and maintain artificial drainage systems**
Well-drained soils have correspondingly low N_2O emissions
• **Avoid cloddy seedbeds and sub-surface compaction**
Cultivate the soil when friable rather than when too wet or too dry
• **Minimise the number of tillage operations and group operations together**
Reducing the frequency of tillage decreases the stimulation gas producing microbial activity
• **Maintain pH levels**
Keeping soil pH at the optimum level for crop growth (pH 5.8 for grassland and pH 6.3 for arable) will help minimise N_2O emissions
• **Use of nitrification inhibitors**
The use of nitrification inhibitors with applied fertiliser nitrogen can reduce N_2O emissions from high emitting crop systems (e.g. grassland and potatoes)

Minimising CH_4 emissions

• Good timing of fertiliser and manure applications
• Maintaining field drainage
• Reducing stocking rates to reduce excreta returns and avoidance of animal trampling
• Optimising soil health through application of no-tillage practices if conditions are appropriate

Minimising loss of carbon from agricultural soils

• Reduced and no-tillage practices reduce soil disturbance and carbon losses but are not suitable for all farms. Farm-specific soil and climate conditions need consideration before switching to reduced or no-tillage
• Growing cover crops on otherwise bare ground and maintaining a rough surface on sloping ground will minimise soil erosion
• Nutrient management using long term manure applications boosts soil carbon whilst making good use of resources
• Where straw is required for bedding, returning it later as manure helps to maintain soil carbon
• Incorporating crop residues after harvest returns carbon and nutrients to the soil
• Crop rotations that include grass and clover leys will build soil organic matter and fertility (when designing a rotation consider nitrogen fixing crops, varying rooting depths and maintaining soil cover)

• Afforesting highly degraded or marginal soils will significantly reduce soil erosion and actively sequester carbon

"Key management practices for minimising GHG emissions are good choice and timing of fertiliser and manure applications, maintaining field drainage, avoiding compaction and animal trampling of wet soils, localisation of machinery wheelings and increasing structural stability by applying amendments of organic matter. These options will be easier to satisfy on coarser textured, well-drained soils. The combination of visual evaluation of soil structure (VESS) with a target Sq 3 or less and good soil/field drainage are key indicators of the effectiveness of any mitigation option involving soil management. Adaptation by choice of crops that require less mineral N fertiliser and less machinery movement in wet conditions may be considered if gross margins can be maintained."

Further reading:
Farming for a Better Climate
https://www.farmingforabetterclimate.org/
Valuing your soils
https://www.farmingandwaterscotland.org/soil-nutrients/valuing-your-soils/

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