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Effects of nitrogen fertiliser use on N2O intensities of arable crop products

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Nitrogen (N) availability remains one of the key drivers of crop productivity from arable farms of Northern Europe. Most crops receive significant amounts of inorganic N fertilisers but these are also associated with significant losses of the greenhouse gas (GHG) nitrous oxide (N_2O). National GHG inventories and current commercial GHG accounting procedures assume a direct proportionality between N fertiliser use and N_2O emissions from land, as agreed internationally by IPCC (2006). This assumption implies that drastic reductions in N fertiliser use and crop productivity are required to minimise N_2O intensities of crop products (kg N_2O-N per kg product). However, direct proportionality seems unlikely because some N_2O emissions occur after crop N uptake, hence these may relate to the balance between N supply and N uptake, not directly to N supply. If N_2O emissions were entirely N-balance related, N amounts that minimise N_2O intensities would be similar to current use, and crop productivity would be maintained.

A study in the UK has been designed to test relationships between N_2O emissions, N fertiliser applications and crop yields, as affected by crop species under different soil and climatic conditions. Experiments have been set up at sites in i) Cambridgeshire (clay loam), ii) Norfolk (silt loam), iii) Nottinghamshire (loamy sand) and iv) East Lothian (sandy loam) on cereals (winter wheat, winter barley, spring barley), winter oilseed rape and sugar beet, with at least five levels of ammonium nitrate fertiliser, each with a single nitrogen level in previous years (as required by IPCC). Nitrogen fertiliser treatments ranged from nil to $\sim$160% of recommended N. Three replicated plots per treatment were established in a completely randomised design. Intensive measurements were made over the 12 months from just before fertiliser application in spring at all N levels, including crop yields, crop N uptakes, and direct N_2O emissions (five static chambers per plot) and soil moisture, density, nitrate and ammonium N, and temperature.

Example data from East Lothian in 2010 show that spring barley grain yield increased from 1 t ha^{-1} at 0 kg N ha^{-1} to 6.0 t ha^{-1} at the economic optimum fertiliser rate of 215 kg N ha^{-1}. Soil nitrate and ammonium N concentrations increased immediately after fertiliser applications, in proportion to the N rate, and diminished thereafter. N_2O emissions did not always respond immediately to fertiliser application. Cumulative N_2O flux per hectare increased with N applied, but per unit yield (g N_2O per t grain) decreased with increasing fertiliser application at low levels of fertiliser application. Thus, in this example, the fertiliser application rate (kg N ha^1) giving minimum N_2O intensity (g N_2O per t grain) was 144 kg N ha^1, about 70 kg N ha^1 and 0.9 t grain ha^1 less than the economic optimum. Further results will indicate whether use of fertiliser N should be modified generally, to minimise N_2O intensities of arable products.

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