MM11: Avoiding using N in Excess by using a Fertiliser Recommendation System

Category

Cropland and grassland management: nutrient management

Overview

Nitrogen, a key limiting nutrient in plant production, needs to be added externally (or via biological fixation) in order to achieve the yields sustaining our food system. Plants react to additional synthetic and organic N by an increase in yield (and protein content), given no other major limitations are present. This yield response is sharply increasing at low fertilisation rates, but as fertilisation rate increases the additional gain in yield diminishes. At the economic optimum the cost of the additional N fertiliser results in the same amount of additional income from the sales of the product (AHDB 2019). The yield response to additional N depends on a mixture of factors. Crop type and variety, climatic conditions, the plant-available N content of the fertiliser used (particularly for organic fertilisers), soil quality, soil pH, soil N content (which depends on the rotation and fertilisation history) and other nutrients in the soil can be estimated, even though information is not readily available about all these factors. There are also less predictable factors, like actual growth conditions during the season (rainfall, drought), pests and diseases and actual relative price of the crop and the fertiliser.

Most farmers use decision rules to optimise their fertiliser use (Defra 2018a) – it is one of the requirements in Nitrate Vulnerable Zones[1]. Farmers can rely on a variety of tools, including software based decision support tools (e.g. PLANET, Muddy Boots) as well as paper based calculations (Beegle *et al.* 2000). Nevertheless farmers might keep an over-application margin as a protection from potential yield penalties which could happen with better than expected growing conditions. Equally, underfertilisation might also happen, resulting in suboptimal utilisation of land – however, this measure considers only overfertilisation.

Mitigation summary

Table 1 Effects on emissions

GHG categories	Effect*	Notes
Enteric $_{CH4}$		
Manure $_{CH4}$		
Manure N_2O		
Soil N_2O: applied N	-	
Soil N_2O: grazing		
Energy CO_2: fieldwork		
Energy CO_2: other		
CO_2 liming and urea		

[1] https://www.gov.uk/guidance/rules-for-farmers-and-land-managers-to-prevent-water-pollution

GHG categories	Effect*	Notes
CO_2 sequestration below ground		
CO_2 sequestration above ground		
Pre-farm emissions	-	Production of fertiliser
Post-farm emissions		
Substitution of higher C products		
Production increases by more than the emissions		
	Rating	
Confidence in mitigation effect	High	
Cost-effectiveness**	Low	
Confidence in cost-effectiveness	Medium	

* ”-“ GHG reduction, “+”: GHG increase, “ ”: no significant effect
** low: =< £0/tCO_2e, moderate: £0/tCO_2e< >SCC, high: >SCC

Related measures and potential synergies

This measure is closely related to many other mitigation measures targeting crop production, particularly nitrogen use and fertilisation (e.g. Keeping pH at an optimum for plant growth (e.g. liming), Analyse manure prior to application). Any change in this aspect of farming needs to be considered in planning and managing nitrogen for crop growth.

1.1.1 Inclusion in other marginal abatement cost curves

Table 2 Past assessment of the measure

UK 2008	UK 2010	UK 2015	Ireland 2012	France 2013	France 2019
Yes	Yes	Yes	Yes	Yes	?

What does the measure entail?

This measure is based on the assumption that using a nutrient (including manure) management plan and keeping to its recommendations eliminates most of the excess N use. Though eliminating N excess can be done in a combination of different ways, this measure requires farmers planning their fertiliser needs based on a recommendation system, considering field and crop characteristics. This can be achieved by creating and using a nutrient management plan, using a combination of published recommendation tables, software tools, with or without the help of farm advisors or other professionals.

Abatement rate

The abatement arises from the reduced synthetic N application, combining savings both in organic and synthetic N use (if organic N is used more efficiently the synthetic N applied to the same field can be reduced).

Though in reality the relationship between N rate and N_2O emissions is not linear (Cardenas *et al.* 2019), meaning that the more N applied the higher proportion of it gets converted to

N_2O, in the calculations here a linear relationship is used, based on the EFs used in the Smart Inventory.

The reduction in the N use was estimated to be 10% of the applied synthetic N, based on the studies in Table 3.

Table 3 Data from literature on abatement

Abatement	Value	Country	Reference
N use	-10 kg N ha^{-1} across tillage land and grasslands; 7.6% of the average field application rate of 132 kg N ha^{-1} in 2015 (Defra 2016)	UK	(Eory *et al.* 2015)
N use	-19.7 kg N ha^{-1} for arable crops; assuming 150 kg N ha^{-1} average fertilisation rate on these crops it is 13%	France	(Pellerin *et al.* 2013)
N use	-5%	UK	(ADAS 2017, Newell-Price *et al.* 2011)
N use	-10%	UK	(MacLeod *et al.* 2010)
N use	-10%	UK	(Moran *et al.* 2008)

Cost

The cost of the measure is estimated as the cost of creating a nutrient and manure management plan and updating it annually. Establishing a nutrient management plan is approximately £800 for a medium sized farm (80 ha), while the annual update is around £100. Soil sampling, which is required to the plan, is £14 per sample, on average one to be taken from every 4 ha (SAC 2014) in every 5 years (Soil Associaton 2018). Additionally, the savings in N costs are also included in the calculations.

Applicability

The measure is applicable in all areas where synthetic and/or organic fertilisers are used. Across Great Britain 89% and 16% of tillage land receives synthetic N and manure N, respectively. For grassland the relevant values are 48% and 8%, respectively (Defra 2018b).

Current uptake and maximum additional future uptake

Direct evidence on the overfertilisation in the UK does not exist to the knowledge of the authors. The average fertilisation rates in the UK have slightly increased since 2010 for most of the major crops and for temporary grassland (Figure 1), with some increase in yields too (Figure 2).

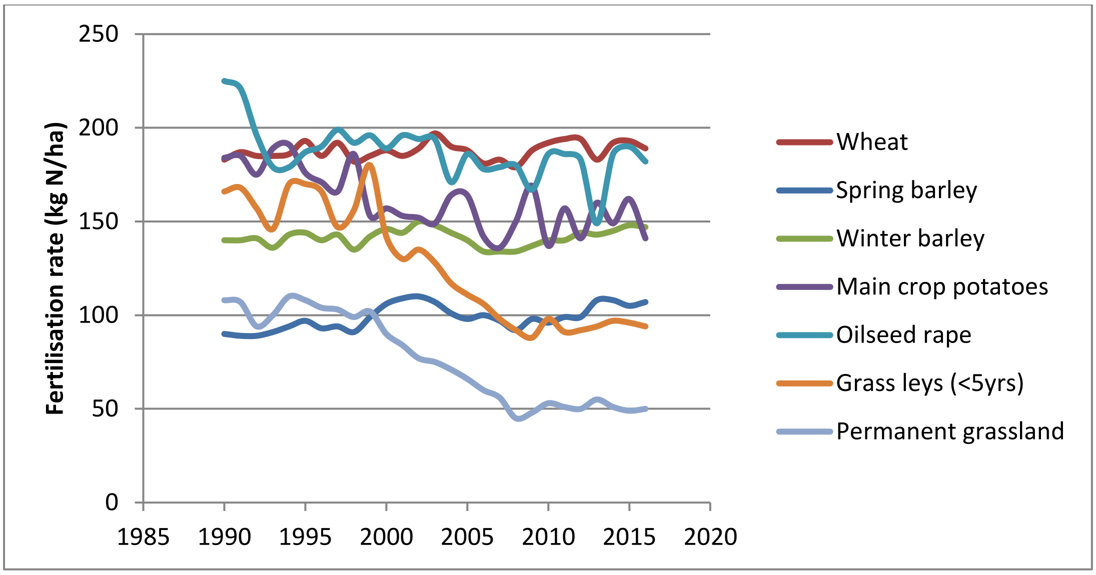

Figure 1 Fertilisation rate in the UK (Brown et al. 2018)

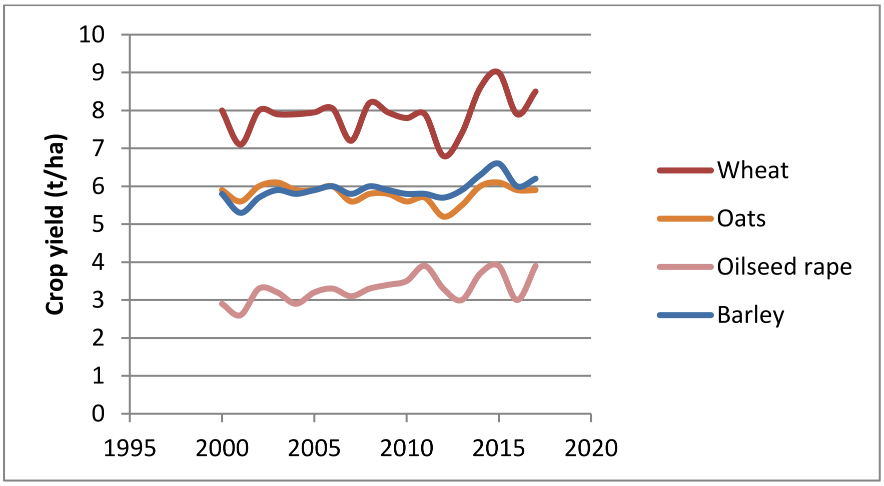

Figure 2 Crop yield in the UK (Defra 2017)

A sample of field level N fertiliser use rates is available in the British Survey of Fertiliser Practice (Defra 2018b), but the reported values are not contrasted to the recommended levels. Comparing the distribution of these rates with the Nutrient Management Guide (RB209) (AHDB 2019) does not suggests that crops are, on average, given more or less N fertiliser than is required. However, without field level information the existence of over- and under-application cannot be derived from these data.

Given the lack of other information the uptake of the measure is approximated by the existence and use of nutrient management plans and manure management plans as reported for England and Wales (Defra 2018a). 78% of the farm area has nutrient management plans and 78% has manure management plans in England and Wales across farm types (where it is applicable). Of those having a nutrient management plan 5% never uses it, so the current uptake can be estimated as 73%. The future uptake could, in theory, reach 100%, therefore the maximum additional uptake is 26%.

Assumptions used in the MACC

Parameter	Change in value	Notes
N application rate	-10%	
Nutrient management plan establishment	£10 ha^{-1} for every 15 years	
Nutrient management plan update	£1.25 ha^{-1} y^{-1}	
Soil sampling	£3.5 ha^{-1} for every 5 years	

Wider effects

Table 4 Wider effects of the measure

Aspect	Effect	Reference
Positive effects		
Off-farm GHG	Reduced GHG emissions from synthetic fertiliser production	
Production		
Adaptation		
Environment	Reduced energy use and NH_3, NO_x emissions and N leaching from synthetic fertiliser use and production	
Negative effects		
Off-farm GHG		
Production		
Adaptation		
Environment		

Identified implementation challenges and barriers

Table 5 Potential barriers of the measure

Barrier to uptake	Reference
Other key risks/uncertainties	**Reference**

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Prepared by Vera Eory, SRUC