The role of nitrogen fertilisers in Irish GHG and NH_3 abatement

Dublin, 31st May 2017

Response to Concerns

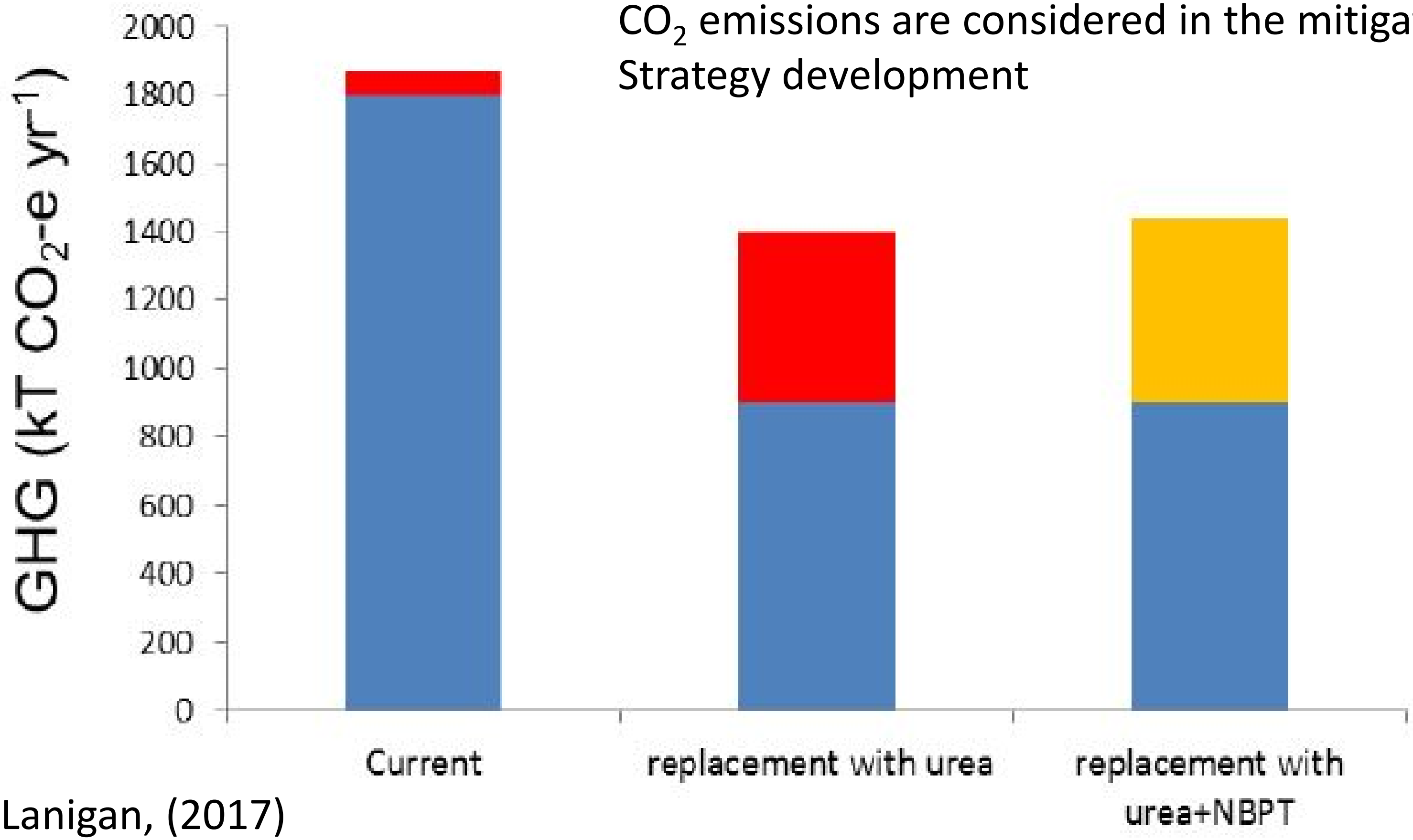
Teagasc & AFBI

Teagasc
Agriculture and Food Development Authority

afbi
Agri-Food and Biosciences Institute

1. CO_2 emissions from urea have not been considered

CO_2 emissions are considered in the mitigation Strategy development



Lanigan, (2017)

Figure 2: Impact of replacing 50% CAN with urea on GHG emissions and 50% CAN+ all untreated urea with urea+NBPT

Teagasc
Agriculture and Food Development Authority

1. CO_2 emissions from urea have not been considered

- AFBI have calculated overall GHG emissions from both the use and production of mineral fertilisers in Ireland using mineral fertiliser carbon footprint reference values for European production technology (Fertilizers Europe 2011)

  1) Default IPCC N_2O EFs (i.e. 1%)

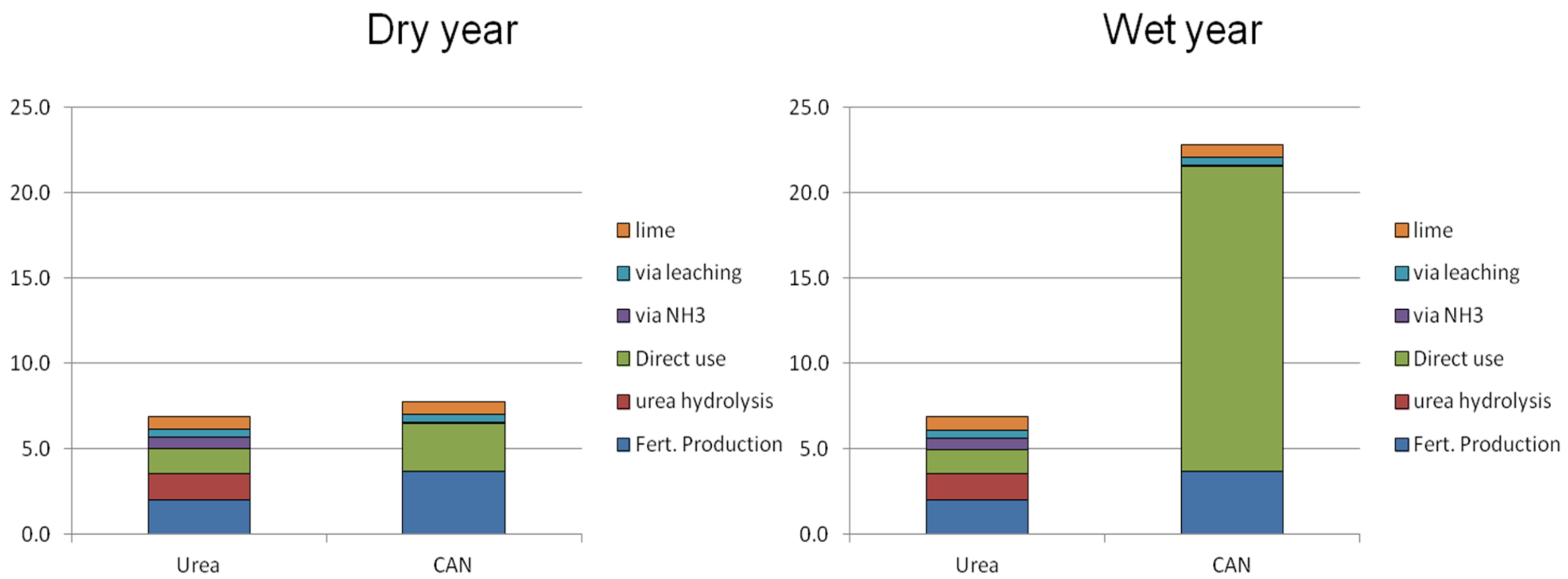
  2) Regional N_2O EFs

- **Scenario 1:** Using default IPCC values AFBI have found that total GHG emissions from fertiliser production and use are slightly higher for urea (10.13 kg CO_2-eq/kg N), than for CAN (9.65 kg CO_2-eq/kg N)

afbi Agri-Food and Biosciences Institute

1. CO_2 emissions from urea have not been considered

- **Scenario 2:** AFBI have measured annual N_2O EFs at Hillsborough for four consecutive years. Annual EFs for CAN range from 0.44% in a dry year to 3.81% in a wet year



Carbon footprint (units, kg CO_2-equivalents/kg N) associated with the manufacture and use of urea and CAN in a dry year at Hillsborough (LHS) and wet year (RHS), at the same site (Higgins *et al*., 2013).

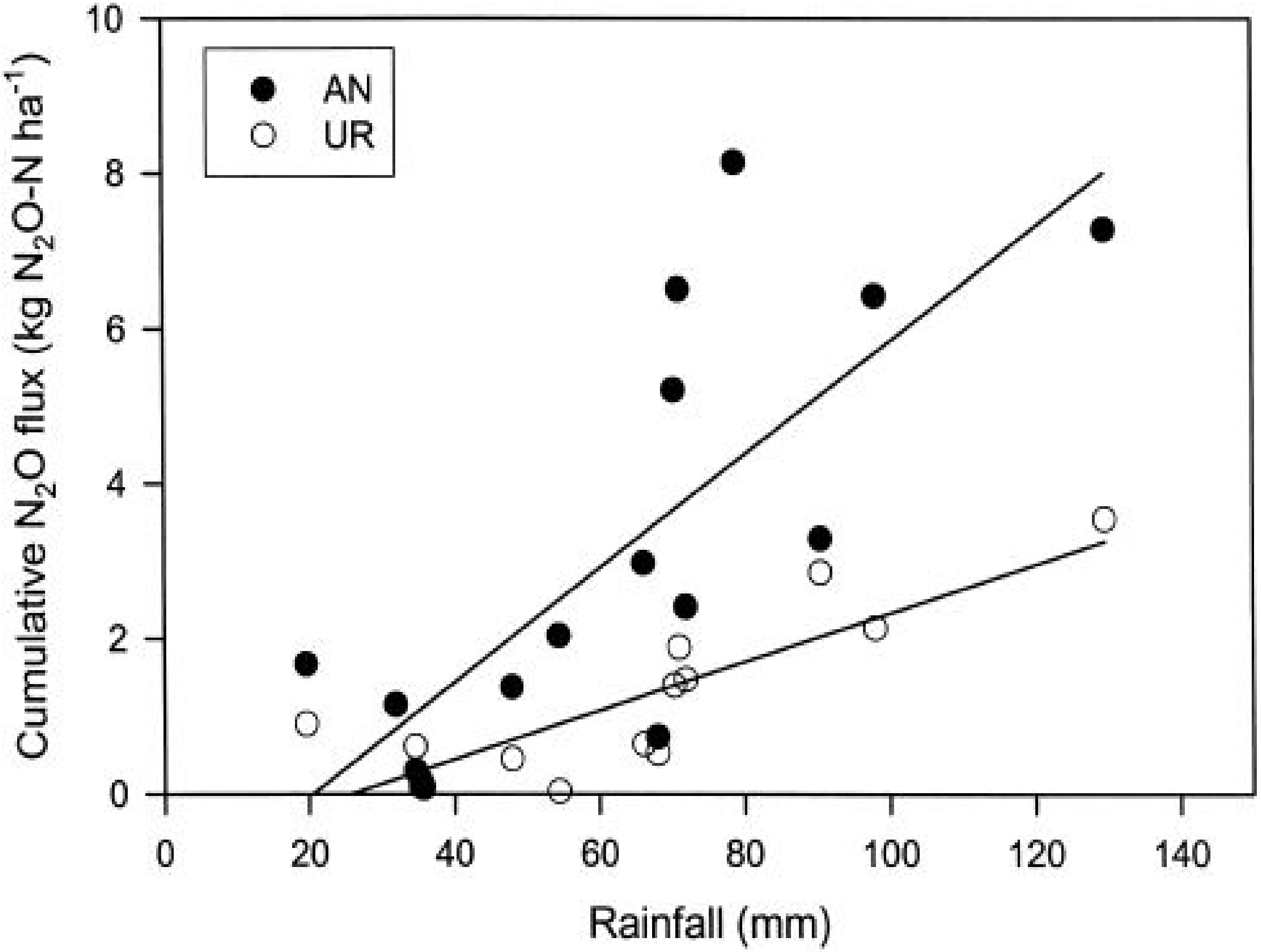
2. Recommendation based on limited data set

- Results of higher N_2O emission factors for CAN are supported by other work in Ireland & the UK

Study		Land use	CAN	urea	urea+ NBPT
Harty et al. 2016	Ireland	Grassland	0.58-3.81	0.1-0.49	0.21-0.69
Krol et al. (2017)	Ireland	Grassland	2.39	0.25	0.17
Higgins et al (In Prep)	Ireland	Grassland	0.44-3.81	0.3-0.49	0.25-0.43
Hyde et al (2016)	Ireland	Grassland	2.15		
Dobbie and Smith (2003)	Scotland	Grassland	2.75	2.12	
Jones et al 2007	Scotland	Grassland	0.1-1.4	0.1-0.4	
Clayton et al 1997	Scotland	Grassland	0.4-1.2	0.8-1.4	

Agriculture and Food Development Authority

2. Recommendation based on limited data set



Dobbie and Smith (2003) Figure 6
Relationship between the cumulative flux in the four weeks after N fertilizer application and the amount of rainfall over the period from one week before to three weeks after N application.

Agriculture and Food Development Authority

2. Recommendation based on limited dataset

- Work builds on substantial research by AFBI, which has been carrying out research on fertiliser formulation, including Urea+NBPT, since the late 1980s*

- Study results supported by numerous studies in Ireland and UK, that show higher emissions from CAN/AN than urea**

- Smith *et al*. (2012), in their analysis of N_2O results from 12 DEFRA funded trials from 2003-2005, compared AN/CAN, urea and Urea+NBPT and found that emissions from Urea+NBPT were generally lower than from other N forms

***** Watson *et al*., 1990a; Watson *et al*., 1990b; Watson *et al*., 1994; Watson *et al*., 2008; Watson *et al*., 2009; Higgins *et al*, 2013; Forrestal *et al*., 2015, Harty *et al*., 2016, Higgins *et al*, in prep, Carolan *et al*, in prep.

****** Harrison and Webb, 2001; Dobbie and Smith, 2003; Jones *et al*., 2007; Watson *et al.* 2009, Smith *et al*., 2011, Higgins *et al*, in prep, Carolan *et al*, in prep.

2. Recommendation based on limited dataset

- We see a similar trend over the four consecutive years of research at Hillsborough

Fertiliser Form	Direct N_2O EF				
Year	2011	2012	2013	2014	*Average EF*
CAN	0.44	3.48	3.81	1.67	*2.35*
Urea	0.31	0.44	0.30	0.49	*0.39*
Urea + NBPT	0.43	0.25	0.36	0.38	*0.36*

Year	N Rate
2011	320
2012	240
2013	200
2014	200

NB. 2011 was a 'dry' year, 2012 and 2013 'wet', and 2014 'dry' relative to the 30 year average at HB, which highlights the variability of CAN emissions

The Hillsborough site(s) is classed as a SWG on shale till, Hydrology Of Soil Type (HOST) class 24 soil, which is representative of approximately 54% of Northern Irish soils

3. Reducing greenhouse gases but increasing ammonia emissions

- The UN ECE Guidance document on preventing and abating ammonia emissions from agricultural sources (2014) no preference for substitution of urea with ammonium nitrate vs inhibitor usage.

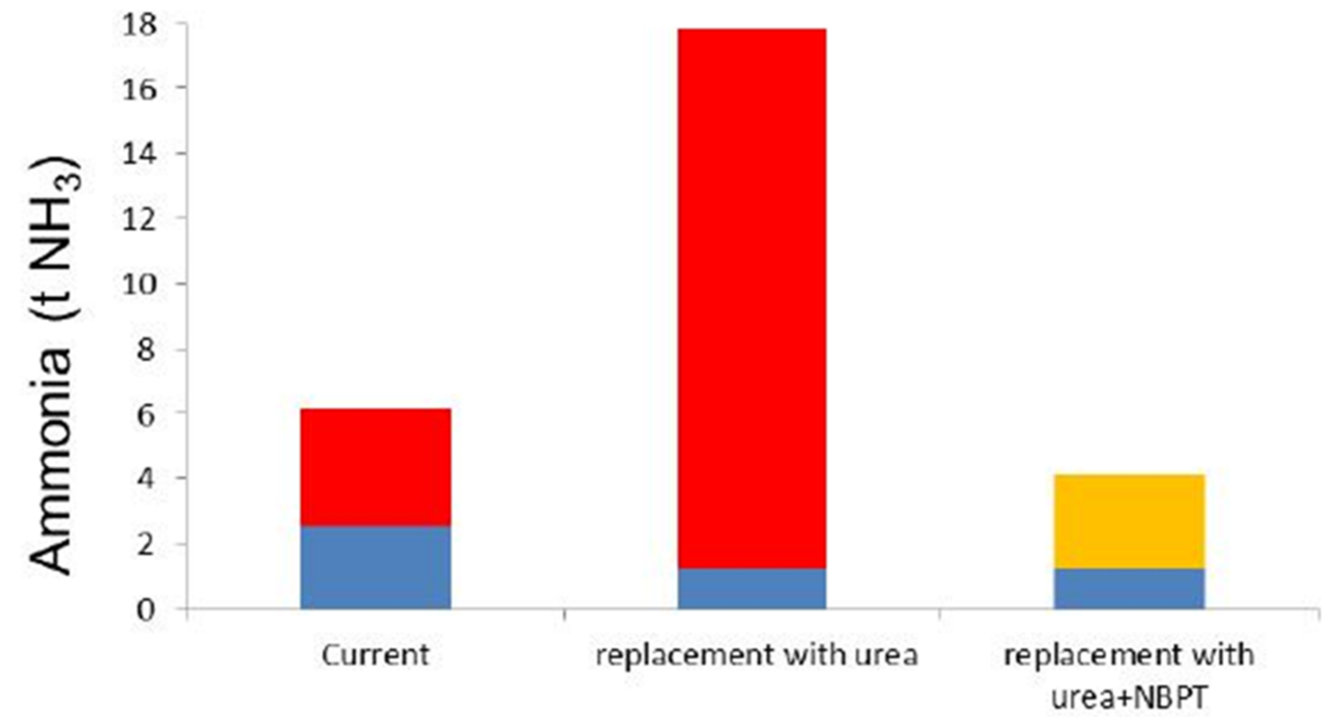


Figure 3: Current fertiliser-based ammonia emissions (CAN =blue, urea = red), theoretical ammonia loss based on 50% replacement of CAN and AN compounds (blue) with untreated urea (red) and theoretical ammonia emissions where 50% CAN replacement and 100% untreated urea is replaced with urea+NBPT (orange). Data derived from Lanigan et al. 2017 (in press)

3. Reducing greenhouse gases but increasing ammonia emissions

- Forrestal *et al.* (2016) reduction in NH_3 from Urea+NBPT supported by other studies (Chambers & Dampney, 2009; Watson *et al.* 2008)

- NH_3 emissions from urea+NBPT were marginally higher than for CAN, though <u>not significantly higher</u> (Forrestal *et al.*, 2016)

- This research project found that replacing CAN with Urea+NBPT did not have a significant effect on NH_3 emissions and maintained grass production whilst simultaneously delivering significant reductions in N_2O emissions

afbi Agri-Food and Biosciences Institute

4. Inhibitors yet again introducing another chemical in agriculture

Parallels with New Zealand?

Inhibitor	DCD	NBPT
Process inhibited	Nitrification	Urea hydrolysis
Application method	(NZ) sprayed onto grass	On fertiliser granule
Half-life	37 days	< 1 day
Inhibitor application rate (kg ha^{-1})	(NZ) 20 kg/ha/yr	287 g /ha/yr @ 200 kg N/ha/yr

teagasc

Agriculture and Food Development Authority

Teagasc grass uptake study

In 2015 Teagasc conducted a grass uptake study

- Urea + NBPT was applied to grass at 40 kg N/ha 4 replicate plots
- 57 g NBPT/ha
- Grass was cut at 2, 5 and 20 days
- Residue testing by AFBI

No detections > MRL (0.01 ppm)

No detections > the lowest calibration standard i.e. 0.005 ppm

One detection @ 0.001 ppm in 1 of 4 samples 2 days after application

Teagasc
Agriculture and Food Development Authority

4. Inhibitors yet again introducing another chemical in agriculture

- Residues found in powdered milk in New Zealand refer to the nitrification inhibitor DCD, not the urease inhibitor NBPT
- NBPT passed extensive toxicological and environmental tests in the USA; commercially available in Europe
- Short half-life: 0.59 day at pH 6.1 (Engel *et al.*, 2015) *versus* DCD: 37 days at 15°C (McGeough *et al.*, 2016)
- Loading rate of NBPT equates to only 287g NBPT/ha/yr @200 kg N/ha/yr

afbi Agri-Food and Biosciences Institute

4. Inhibitors yet again introducing another chemical in agriculture

- Even if a cow *was* to ingest grass containing 0.001ppm NBPT two days after fertiliser application, the risk of NBPT entering milk is highly unlikely

- NBPT is highly sensitive to pH (Engel *et al.*, 2015) and temperature (Watson et al., 2009); meaning that, to our current knowledge, it would be unlikely to survive:

  1) the acidic conditions in the cow rumen

  2) the milk pasteurisation process

afbi Agri-Food and Biosciences Institute

4. Inhibitors yet again introducing another chemical in agriculture

- Watson and Miller (1996) observed short-term leaf scorch but new leaves were unaffected
- Concentration of NBPT used by Watson and Miller (1996): **0.1 & 0.5%** vs. **~0.06%** in SUDEN/AGRI-I work
- AFBI have not observed leaf tip scorch at NBPT concentrations of **~0.06%** in any recent trials
- Watson and Miller (1996):

  "the benefit of nBTPT in reducing NH_3 volatilization of urea would appear to far outweigh any of the observed short-term effects, as dry-matter production of ryegrass is increased"

afbi Agri-Food and Biosciences Institute

Conclusions: Teagasc and AFBI

1. In Irish grasslands Urea+NBPT has lower and less variable N_2O emissions than CAN
2. Several studies in Irish and UK grasslands have shown lower N_2O emissions from urea+NBPT
3. Treatment of all unprotected urea with an effective urease inhibitor (e.g. NBPT) is a key measure for reducing NH_3 emissions
4. Based on the evidence presented, the risk of NBPT residues in milk appears to be negligible
5. Changing fertiliser type is a low cost mitigation option for meeting Irish GHG and NH_3 mitigation commitments

Teagasc
Agriculture and Food Development Authority

afbi
Agri-Food and Biosciences Institute

Thank you for your attention

Funding gratefully acknowledged from:

Department of Agriculture, Food and the Marine

(Grants: RSF 10-/RD/SC/716, 'AGRI-I' & RSF 11S138, 'SUDEN')

&

Department of Agriculture, Environment and Rural Affairs

(DAERA E&I, Project 13/4/06)

afbi Agri-Food and Biosciences Institute

Department of Agriculture, Environment and Rural Affairs www.daera-ni.gov.uk

Department of Agriculture, Food and the Marine An Roinn Talmhaíochta, Bia agus Mara

teagasc Agriculture and Food Development Authority