Fertiliser formulation for the reduction of gaseous emissions

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Fertiliser nitrogen (N) affects gaseous N emissions

Greenhouse gas (GHG)

Nitrous oxide (N$_2$O)
  1. How much are we losing?
  2. What can we do about it?

Gaseous N air pollutant

Ammonia (NH$_3$)
  1. How much are we losing?
  2. What can we do about it?
1. How much are we losing?
2. What can we do about it?
3. What is the impact on yield and efficiency?

**Grassland**
6 site-years
Annual N rates 0 – 500 kg/ha
Suite of fertiliser N formulations

**Spring barley**
8 site-years
Annual N rates 0 – 200 kg/ha
Suite of fertiliser N formulations
1. How much are we losing?

The main N formulations currently used:

- **Urea fertiliser**: 100%
- **Ammonium fertiliser**: 50:50
- **Nitrate fertiliser**
Nitrate links to loss of the GHG N$_2$O

Soil NO$_3$-N (mg kg$^{-1}$)

N$_2$O-N (g ha$^{-1}$ d$^{-1}$)

05/03/2013  05/04/2013  05/05/2013  05/06/2013  05/07/2013  05/08/2013  05/09/2013  05/10/2013
Stabilising fertiliser N

**Urease inhibition:**
Moderates the rate of urea hydrolysis reducing loss of the gaseous air pollutant NH$_3$.

**Nitrification inhibition:**
Moderates the rate of NH$_4^+$ nitrification reducing NO$_3^-$ related losses such as the greenhouse gas N$_2$O.
Urease inhibition

*N-(n-butyl) thiophosphoric triamide (NBPT)*

- Most widely used globally (Chien *et al.*, 2009)
- Active ingredient is off patent
- Koch hold patents on AGROTAIN® formulation
- Urea + AGROTAIN® is marketed in Ireland as Koch advanced Nitrogen (KaN) 660 ppm NBPT
- It is this formulation of NBPT which was tested in the current work

AFBI and Teagasc’s use of a commercial product in this research does not imply any endorsement or warranty of any quality for any specific purpose, of such a product.
NBPT

- Ammonia loss is a relatively fast process => activity needed for a relatively short period
- Short half-life: 0.59 day at pH 6.1 (Engel et al., 2015)
- Low loading to environment @ 200 kg N/ha/yr = 287 g NBPT/ha/yr
- Targeted delivery on fertiliser granule
- Research on NBPT in Ireland going back to the 1980’s (e.g. Watson et al., 1990)
Nitrification inhibition
Dicyandiamide (DCD)

- Nitrification is occurring continually => longer action needed
- DCD average half-life of 37 days at 15 °C (McGeough et al., 2016)
- @ 200 kg N/ha/yr = 7 kg DCD/ha/yr
- Targeted delivery incorporated into the fertiliser granule
- Not commercially available in Ireland
- Been around for many years:
  - Fox and Bandel (1989) evaluated yield response throughout 1980’s in Maryland and Pennsylvania
Fertiliser formulations tested and presented today

- CAN
- Urea
- Urea + NBPT
- Urea + NBPT + DCD
- Urea + DCD
Forrestal, P.J. 2016
Are there Ammonia gas loss differences between fertilisers?

- Yes: urea > CAN
- Urea + NBPT ≈ CAN

![Graph showing ammonia gas loss differences between fertilisers.](image)

Based in Misselbrook et al., 2004; Forrestal et al., 2016; Kim et al., 2012
The percentage of N fertiliser lost as N\textsubscript{2}O is known as the emission factor (EF).
Grassland: Urea + NBPT reduces direct $\text{N}_2\text{O}$ compared to CAN

On average a 73% reduction in direct $\text{N}_2\text{O}$ EF using urea+NBPT

Adapted from Harty et al. (2016)
Spring barley: direct $\text{N}_2\text{O}$ losses lower than the default

Adapted from Roche et al. (in review)
Forrestal, P.J. 2016
**Grassland:** CAN N₂O loss is more than previously thought urea + NBPT reduces fertiliser N₂O loss

IPCC default 1%

- CAN: c.71% reduction
- Urea + NBPT: c.83% reduction
- Urea + DCD: c.90% reduction

Adapted from Harty et al. (2016)
Spring barley: CAN $\text{N}_2\text{O}$ loss is less than previously thought further reductions possible with urea + NBPT

Adapted from Roche et al. (in review)
Key messages

**Ammonia (NH$_3$)**
- NBPT is highly effective in reducing ammonia loss from urea:
  \[ \text{Urea} + \text{NBPT} \approx \text{CAN} \] with very low ammonia loss

**The GHG Nitrous oxide (N$_2$O)**
- **Grassland**: the CAN N$_2$O EF is c. 50% higher than the default
- Urea + NBPT reduces the N$_2$O EF by c. 71% compared to CAN
- Up to c. 90% EF reduction possible with urea+NBPT+DCD
- **Spring barley**: the CAN EF is lower than the default
- Urea + NBPT gives further reductions
Thank you for your attention

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References


