Slow and controlled release and stabilised fertilizers

Update on existing and new technologies

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Enhancing the efficiency of fertilizers

Slow or controlled release fertilizers

Delays the availability of a nutrient for plant uptake or extends its availability to the plant longer than 'rapidly available nutrient fertilizers'

- Slow release – nutrient release pattern is fully dependant on soil and climatic conditions and cannot be predicted
- Controlled release – release pattern, quantity and time can be predicted within certain limits

Slow and Controlled Release Fertilizers

Type	Description	Examples
Organic-N low solubility compounds	Condensation products of urea-aldehydes (slow-release)	Urea-formaldehyde (UF) Isobutylidene-diurea (IBDU) Cyclo-diurea/ Crotonylidene diurea (CDU)
Physical barrier - coated/encapsulated	Organic polymer coatings (thermoplastic or resins) Inorganic coatings Matrices can be hydrophobic (e.g. polyolefines, rubber etc) or hydrophilic (hydrogels)	Polymer coated sulphur-coated urea (PSCU) Polymer coated urea (PCU) Sulphur-coated urea (SCU) Polyolefin coated urea (e.g. Meister®) and coated NPK(+) compounds (e.g. Nutricote®)
Inorganic low-solubility compounds	Slow release	Eg. Metal ammonium phosphates (struvites), partially acidulated phosphate rock

Slow and Controlled Release Fertilizers

Advantages	Disadvantages
• N release rate matches crop demand • Increases nitrogen use efficiency • Reduces N loss to the environment • Reduces number of applications/rates/ labour saving	• Synchronizing nutrient release to plant need • High cost per unit N compared to conventional fertilizers • 'Burst', damaged granules • Residues of synthetic material in soil

Use

- Limited use < 0.20 – 0.47% of total world fertilizer consumption (Trenkel, 2010)
- High cost compared to conventional fertilizers has limited their use to niche non-agricultural markets
- They are cost-effective for high-value crops
- Recent increase in use due to increased production capacity for SCU in China, and development of new PCU fertilisers (e.g. Environmentally Smart Nitrogen by Agrium) for agricultural crops in USA (profitable in field crops like maize, rice, wheat & potatoes)

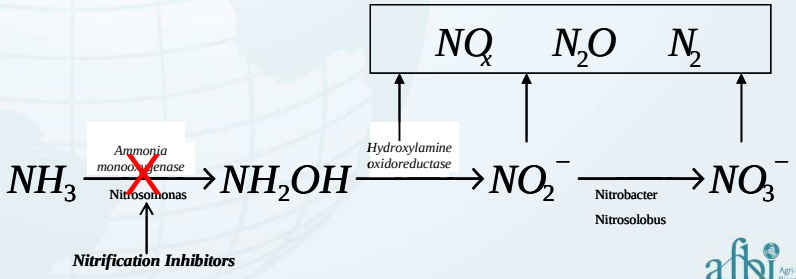
Stabilised N fertilizers

Extends the time the N component of the fertilizer remains in the soil in the urea or ammoniacal form

- Urease inhibitors (inhibit hydrolytic action of urease enzyme on urea)

$$CO(NH_2)_2 + H^+ + 2H_2O \xrightarrow{\text{urease}} 2NH_4^+ + HCO_3^-$$

- Nitrification inhibitors (inhibit the biological oxidation of NH_4^+-N to NO_3^--N



Requirements for successful inhibitors

- Non toxic
- Stable during production, storage and use
- Effective at low concentrations
- Inexpensive
- Compatible with urea or ammoniacal N

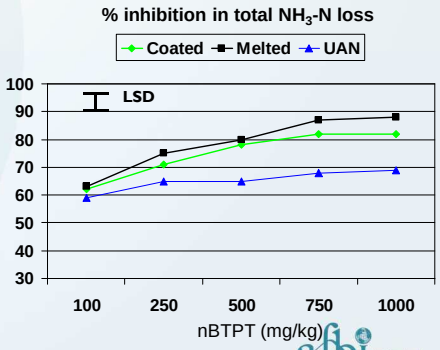
Many compounds have been tested but few meet these requirements and are commercially available

nBTPT is the most widely used commercially available urease inhibitor

- Tradename is AGROTAIN®
- Supplied in liquid form (green solvent containing 20 - 25% nBTPT) or as a powder (60% nBTPT) .

This can be :-

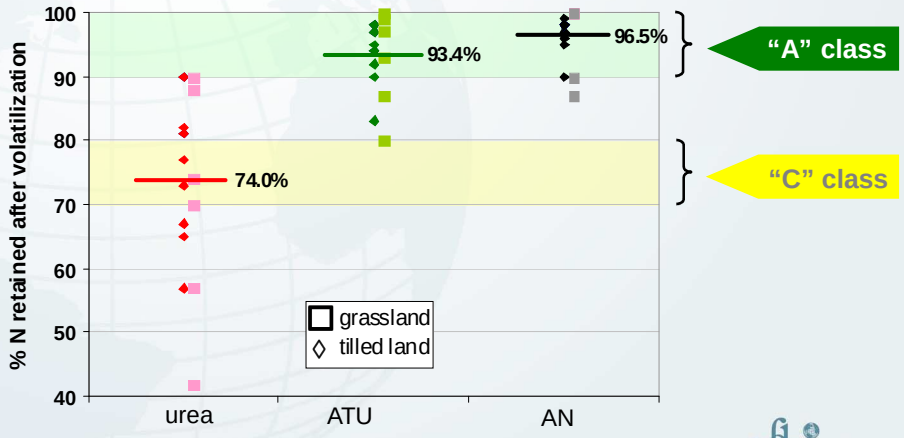
- Used to coat urea granules
- Added to the urea melt during manufacture
- Added to UAN solutions prior to surface spreading in the field



Watson et al. 2008

Amended urea and AN in same category for retained N

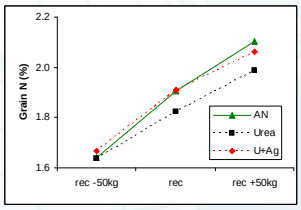
NT2605: 16 field sites over the UK

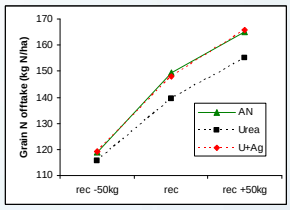


DEFRA 2006

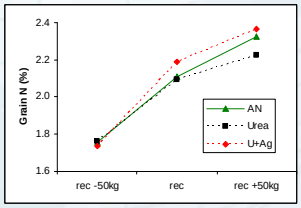
Grain N (%) and grain N offtake (kg N/ha) of winter and spring cereals in UK

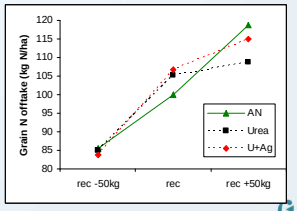
Winter cereals (mean of 7 sites)





Spring cereals (mean of 6 sites)

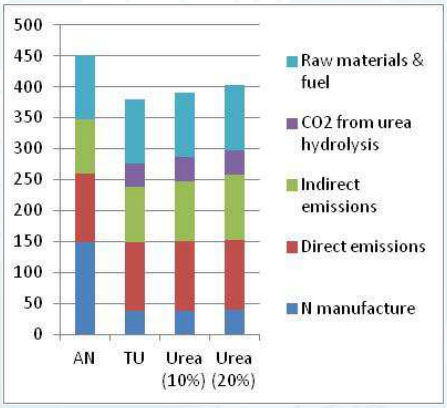




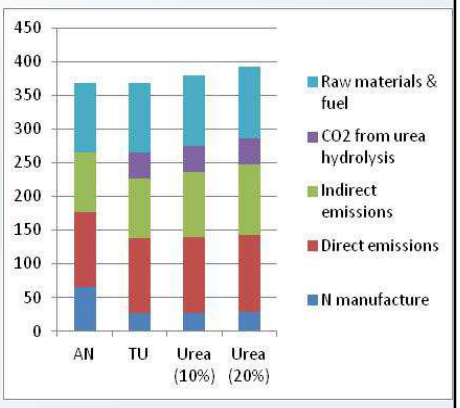
DEFRA 2006

GHG intensities of wheat grown with AN, urea or treated urea (kg CO_2eq / tonne grain)

Average European Technology



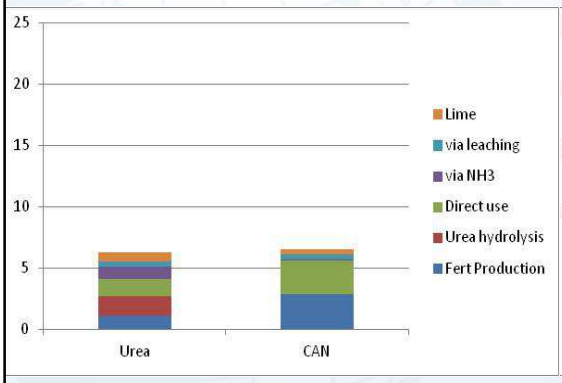
Best Available Technology



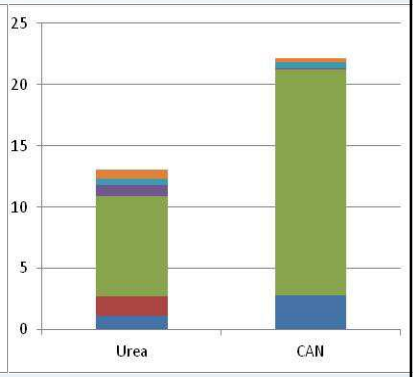
Sylvester-Bradley et al., 2012

GHG emissions from urea and CAN fertilizer production (using BAT) and use (kg CO_2eq/kg N)

Dry year



Wet year

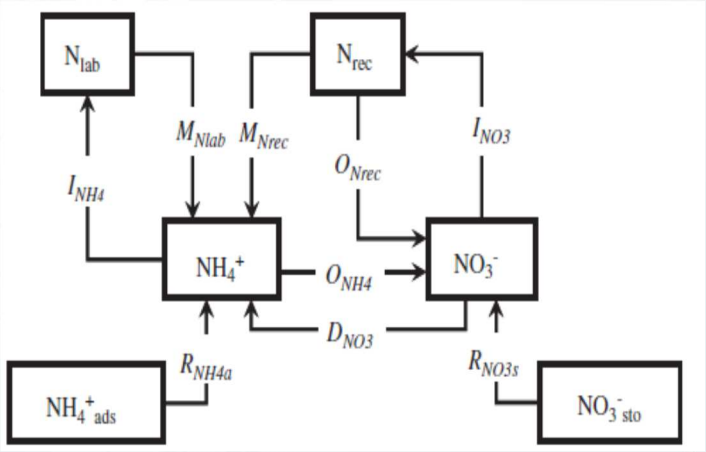


Commercially available nitrification inhibitors

Inhibitor	Rate	Relative volatility	Solubility in water	Mode of application
Nitrapyrin/ N-serve	1-2 mg/kg	High (Corrosive)	Low	Suitable with anhydrous ammonia with injection into soil
DCD	20 mg/kg (10 kg/ha)	Low	High	Use in solid, liquid fertilisers & slurry
DMPP	0.5–1.5 kg/ha	Low	Low	Use in solid, liquid fertilisers & slurry

Gross soil N transformations

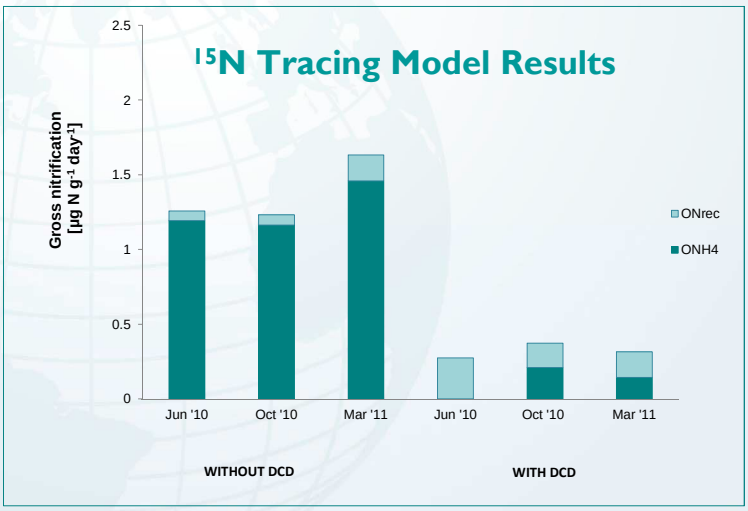
Quantified with a ^{15}N tracing model which considers six nitrogen pools and 12 nitrogen transformations



^{15}N tracing model (Müller et al., 2007)

Reduction in gross nitrification rates

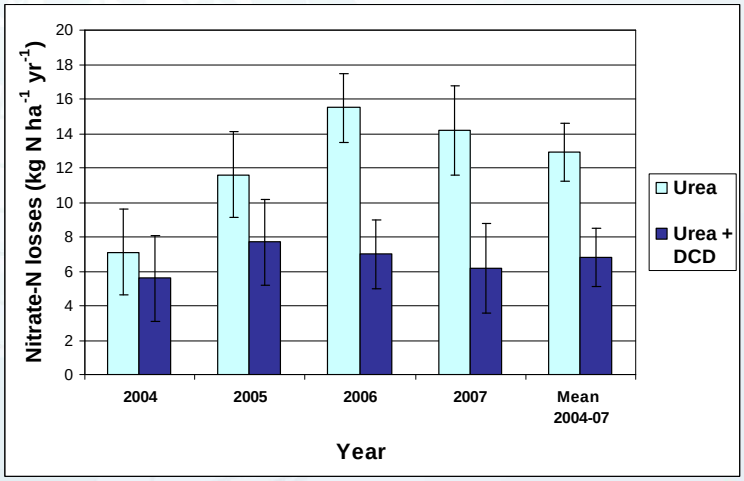
DCD applied to cattle slurry



McGeough et al., 2012

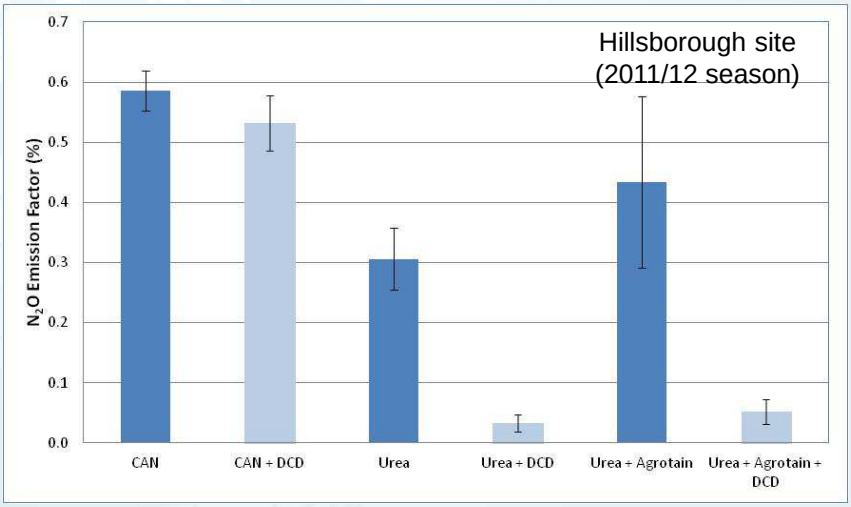
Reduction in nitrate leaching

Hydrologically isolated grazed dairy pastures in New Zealand



Source: Monaghan et al., 2009

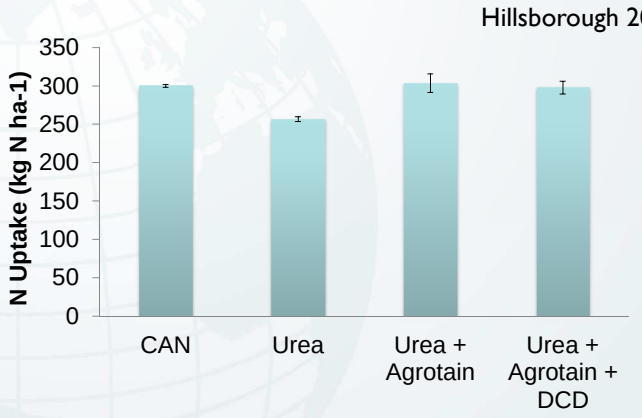
Reduction in N_2O emission factors



Research funded by DEFRA and DARD as part of AC0116

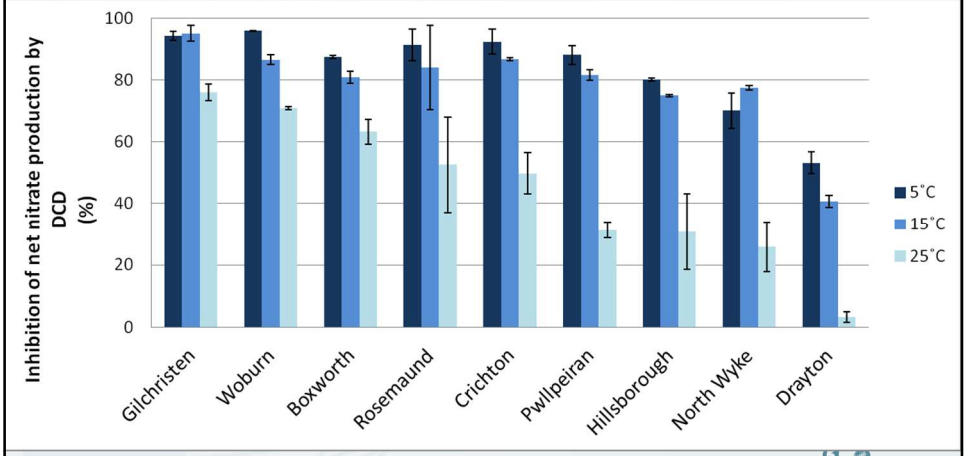
McGeough et al., 2012

Increased N uptake of grass



Urea is significantly lower ($P<0.01$, $LSD=26$ kg N ha^{-1})

% Inhibition in rate of nitrate production



Economics of Agrotain amended urea vs CAN

Additional cost of amending urea is US$50 per t

Current price differential between urea and AN/CAN in UK makes amended urea cost effective, if DM yields are comparable

Koch Fertiliser Ltd are the main distributors of Agrotain treated urea

Amended urea is a viable alternative to AN/CAN

Economics of nitrification inhibitors

A cost benefit analysis is difficult due to fluctuations in the price of standard fertilizers, the target crops and the marketing strategies of national/local sales departments (e.g. high volume or high market share)

Subbarao et al. (2006) estimated the cost of nitrapyrin or DCD to be ~ US$ 25-35/ha. DCD including spreading costs in NZ = €120 /ha

To be economic the long-term average losses must exceed 40-50 kg N/ha

To be more widely accepted for use with agricultural crops, they will need to be priced competitively

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Conclusions

- SRF/CRFs and stabilised fertilizers can increase plant growth, reduce N losses and reduce GHG intensities
- Variable effects are due to crop, soil properties, climatic and management factors
- Urease inhibitors are likely to be most beneficial on soils where loss of NH_3 from urea fertiliser is high. Amended urea could be an alternative to AN/CAN under wet conditions
- Nitrification inhibitors likely to have greatest benefit on soils where N losses (leaching or N_2O emissions) are large
- The development and commercialisation of new, effective, low cost and non toxic fertilizer formulations is a time-consuming process
- For SRF/CRFs and stabilised fertilizers to be more widely accepted for use in agriculture they need to be cost effective

As producers begin to understand the multiple benefits of SRF/CRF and stabilised fertilizers in crop production (yield increases, improved crop quality, management flexibility and reduced environmental losses) there should be increased interest in their use, particularly if C credits for reduced GHGs can be used to offset costs

Thank you for listening