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UREASE AND NITRIFICATION INHIBITORS FOR CROP PRODUCTION AND ENVIRONMENTAL QUALITY IN AUSTRALIA

Charlie WALKER

Incitec Pivot Ltd., Australia

International Fertilizer Industry Association

NEW AG INTERNATIONAL

Urease and nitrification inhibitors for crop production and environmental quality in Australia

Charlie Walker[1], Deli Chen[2] and Helen Suter[2]

[1]Incitec Pivot Limited
[2]School of Land and Environment, University of Melbourne
Australia

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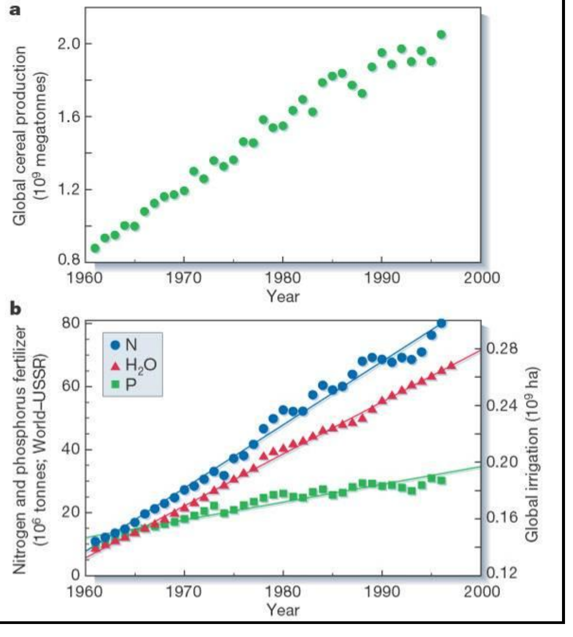
Fertiliser use (N and P) are essential for:

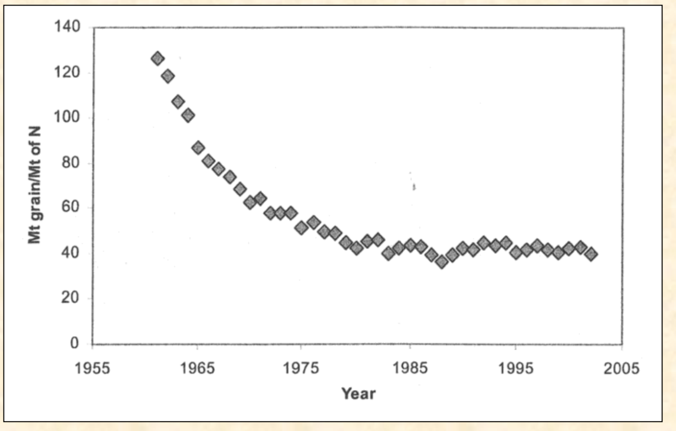
- Achieving high yields/profit (developed countries)
- Food security (developing countries)



[Source: Tilman et al, 2002. Nature]

- N fertiliser use efficiency (NUE) is low

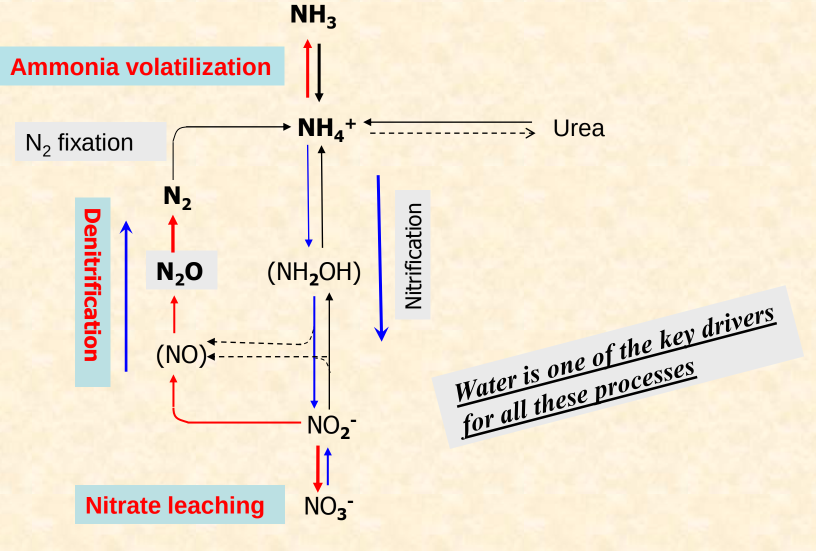
- In Australia: NUE 6-59%, average < 40% (Chen *et al.* 2008)



Metric tons of grain produced per metric ton of fertilizer N applied in the world (1961-2002)

[Source: Raun and Schepers, 2008, Nitrogen in Agricultural Systems]

Three main pathways of N losses in soil



Why use EEFs?

- Reduce environmental impact, eutrophication
- Mitigation of GHG (N_2O) and indirect GHG (NH_3) emissions
- Increasing cost of N fertiliser
- **Current driver in Australia is greater N efficiency**

Enhanced Efficiency Fertiliser (EEF) Research

- Controlled (slow) release fertilizers (limited studies)
  - lab incubations & NH_3 study
- Urease Inhibitors
  - lab incubations & NH_3 study
    - temperature, moisture and organic matter effect
  - field trials
    - production data
    - real time loss measurement
- Nitrification Inhibitors
  - lab incubations & N_2O study
    - temperature, moisture and system effect
  - field trials
    - production data
    - field N_2O loss measurements

Urease inhibitors

Urea hydrolysis

$$CO(NH_2)_2 + 2H_2O \xrightarrow{urease} 2NH_3/2NH_4^+ + CO_2 + H_20/2OH^-$$

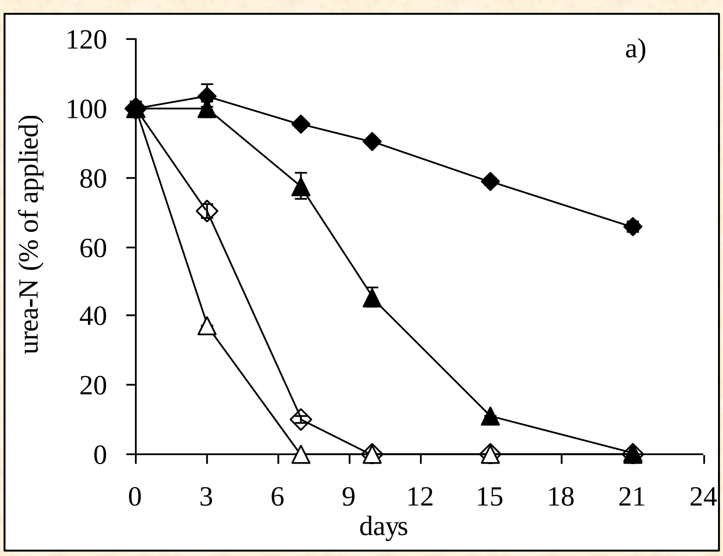
Urease inhibitor

pH
granule

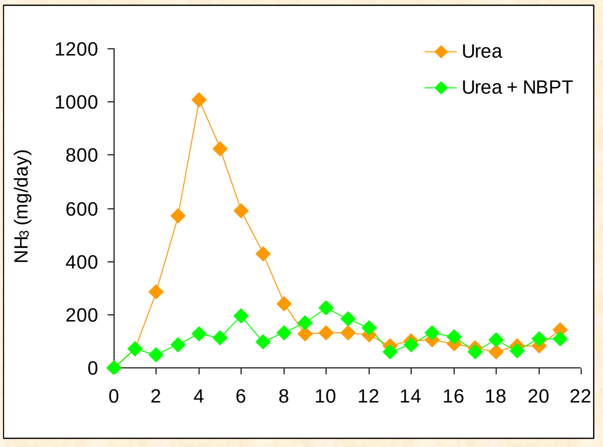
NH_3 reported losses
0 to >50% of applied N
e.g. pasture, Aus: 20 - 28%
[Prasertsak, et al. 2001, Eckard et al, 2003]

- Role: To
  - retain N in Urea form for longer
  - reduce NH_3 volatilisation

Effect of urease inhibitor (NBPT 0.1%) in wheat cropping soil, incubation exp:
◊ urea (15°C), △(25°C) ♦urea+NBPT(15°C), ▲ urea+NBPT (25°C)



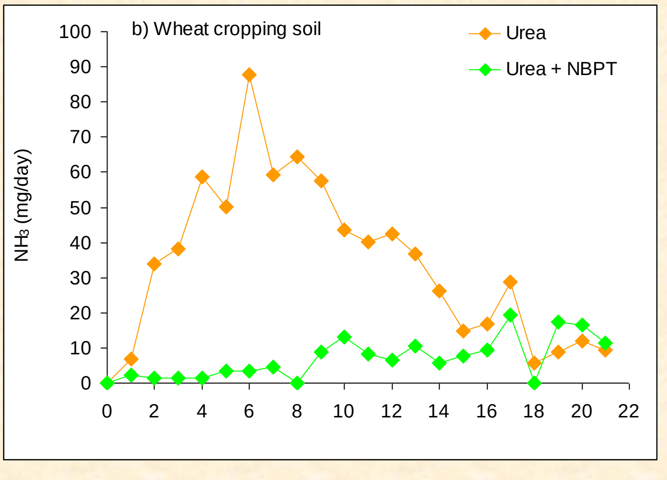
Reduction in NH_3 emissions from sugarcane trash blanket (incubation at 25 C)



Urea :
- 78% urea-^{15}N volatilised as NH_3 over 21 days

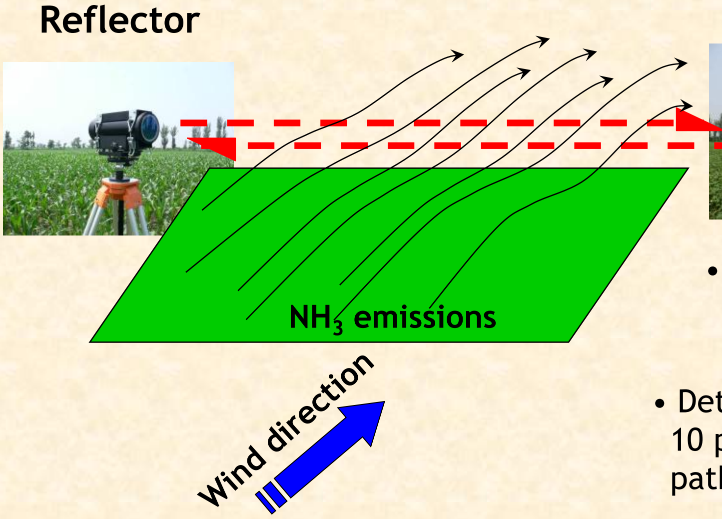
Urea + NBPT 0.1%:
- 54% reduction in NH_3 over 21 days (at 25ºC)

Reduction in NH_3 emissions from wheat cropping soil (incubation)

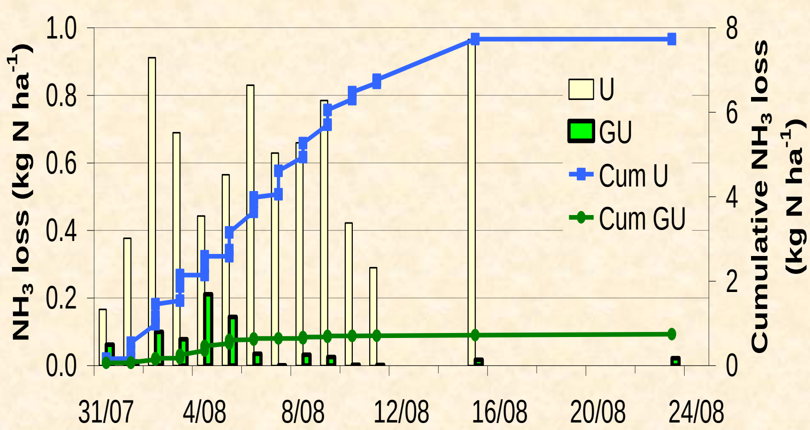


Urea + NBPT:
- 79% reduction in NH_3 over 21 days (clay loam, pH 7.8) (at 15ºC)

Open path laser/FTIR s to measure NH_3



- Measures line-average concentration
- Detection limit 10 ppb for 100 m path length
- Battery or mains powered



NH_3 losses measured in the field on a wheat soil from the Wimmera, western Victoria, using micrometeorological technique:

7.7 kg N ha^{-1} (9.7% of applied N) in urea
0.8 kg N ha^{-1} (1.0% applied N) for Green Urea (0.1% NBPT)

Improving the efficiency of urea in Australian agriculture using the urease inhibitor NBPT
- 5 ryegrass pasture case studies (*Lolium spp*)

Site	Number of harvests	kg dry matter / kg N		N fertiliser efficiency %	
		Urea	Urea + 0.1% NBPT	Urea	Urea + 0.1% NBPT
Birregurra	9	15.3	16.4	63	68
Tocal	2	16.4	20.4	61	88
Mt Gambier	12	17.1	16.8	58	67
Macalister	7	21.5	28.4	87	118
Drouin	7	10.1	10.6	36	45
MEAN		**16.1**	**18.5**	**61%**	**77%**

Improving the efficiency of urea in Australian agriculture using the urease inhibitor NBPT
- 15 wheat case studies (*Triticum aestivum*))

Treatment	Yield t/ha	Protein %	N fertiliser recovery in grain %	kg grain /kg N
Control	3.01	10.4		
Urea top-dressed @ GS31	3.26	11.6	25.9	5.1
Urea + 0.1% NBPT @ GS31	3.40	11.9	32.1	7.9
l.s.d.	0.090	0.21		
c.v.	7.7%	5.0%		

Nitrification inhibitors

Nitrification

Ammonium oxidising bacteria

$$NH_4^+ + 2O_2 \xrightarrow{eg.Nitrosomonas} NO_2^- + 2H_2O \xrightarrow{Nitrobacter} NO_3^- + 2H^+$$

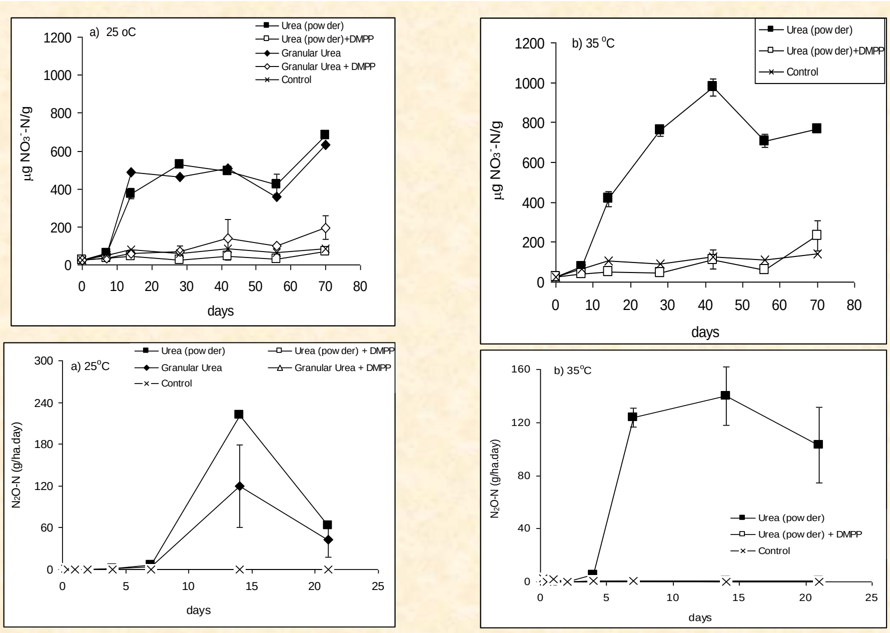
denitrification

N_2/N_2O

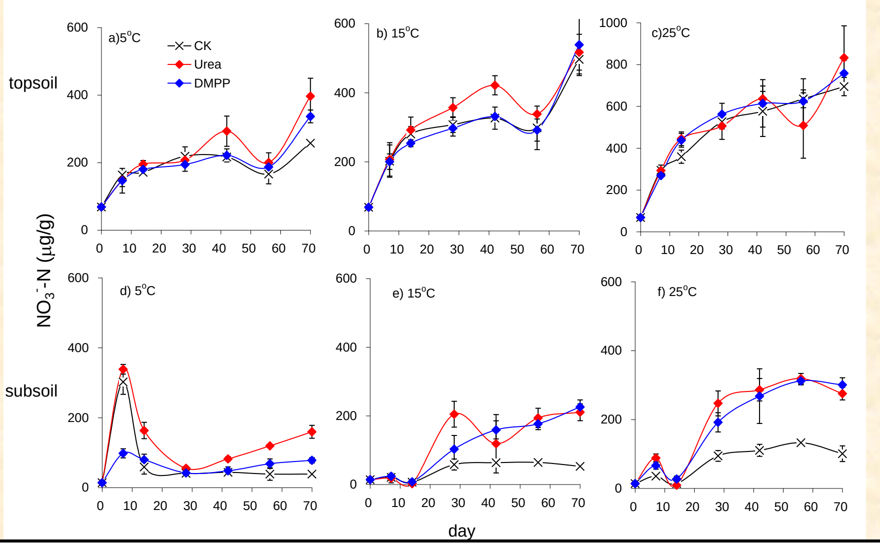
Nitrification inhibitor

- Role:
  - retain N in NH_4^+ form for longer
  - reduce NO_3^- leaching losses
  - reduce N_2O / N_2 emissions e.g. Grace (pers comms) reports up to38% of applied N lost in irrigated cotton

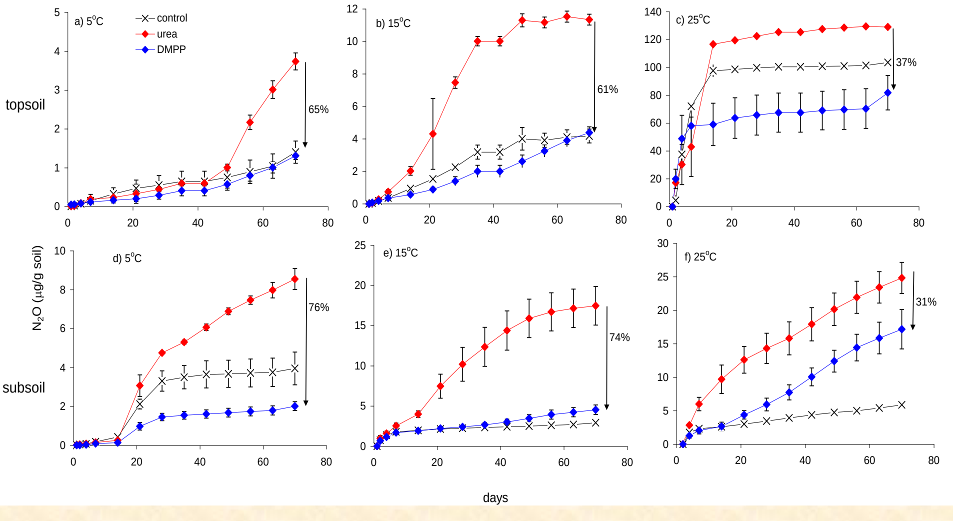
Effect of DMPP on NO_3^--N and N_2O production in a sugarcane soil in incubation exp, 25ºC (a) and 35ºC (b)



NO_3^- formation in pasture soils



Cumulative N_2O emissions dairy pasture soil



Improving the efficiency of urea in Australian agriculture using the nitrification inhibitor DMPP
- 26 wheat case studies (*Triticum aestivum)*)

Treatment	Yield t/ha	Protein %	N fertiliser recovery in grain %	kg grain /kg N
Control	3.40	10.5	-	
Urea banded at sowing	3.80	11.7	22.4	6.5
Urea with DMPP banded at sowing	3.90	11.7	28.4	8.3
l.s.d.	0.09	0.16		
c.v.	8.13	4.93		

Knowledge gaps/future directions on EEF

- Comprehensive system-based studies of the impact of EEFs on N cycling and plant growth and interactions of EEFs with other nutrients
- Process-based agroecosystem models to simulate EEF impact
- Decision support tool for fertilizer N management to incorporate EEF

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