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Factors affecting the effectiveness of NBPT in Brazilian soils

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Outline

- Field response to NBPT: annual crops and green sugarcane
- NBPT and fertilizer storage time
- NBPT and soil pH
- Combination of NBPT & DCD
- Concluding remarks

Brazil: situations in which incorporation of N fertilizer is not always feasible: no-till, perennial crops, green cane

NH_3 volatilization losses are high in Brazil

- Urea: 60% of solid N fertilizer
- Many conditions in which incorporation is difficult or costly
- Soils with high T and moisture

Alternative: urease inhibitor

$$CO(NH_2)_2 + 2H_2O \xrightarrow{\text{urease}} 2\,NH_3 + CO_2$$

- **NBPT [N-(n-butyl) thiophosphoric triamide]**
- **Commercial product since 1996 (20 to 25% NBPT)**
- **Inhibitory effect : 3 to 10 days then gradually decreases**
  - **Temperature, soil moisture**

NH_3 losses (Brazil: maize, pasture)

Crop/Location	NH_3 volatilization (Percentage reduction compared to urea)	
	UR	UR-NBPT
	-------- % of applied N -----	
Corn Mococa	45	24 (47)
Corn Rib. Preto	37	5 (85)
Corn Mococa	64	22 (65)
Corn Pindorama	48	34 (29)
Pasture 1	18	6 (69)
Pasture 2	51	22 (56)
Pasture 3	18	3 (83)
Pasture 4	18	2 (89)
Average	*37*	*15 (60)*

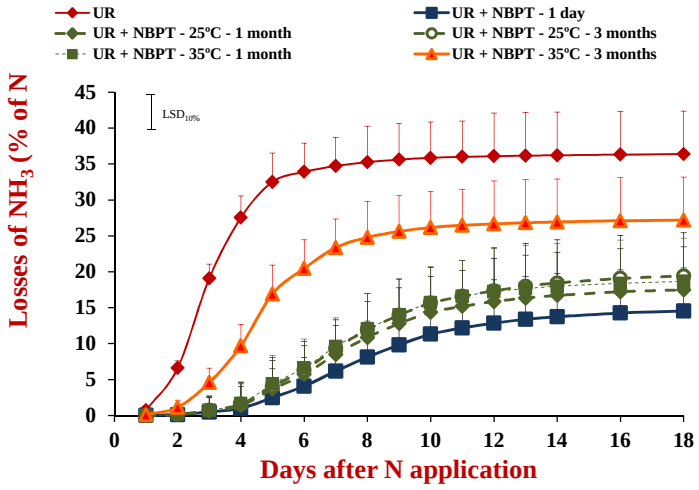
Cantarella, 2005

NBPT and Fertilizer Storage Time

- NBPT stability decreases with storage time
- Experiment
  - UR vs UR+NBPT (1060 mg kg^{-1})
  - Stored in plastic bags at controlled T (25 or 35℃)
  - Storage times: 0, 1, 3, 6, and 9 months
- Soil: Surface layer of Red Latosol

pH-$CaCl_2$	MO	CEC	V%	Clay	Sand	Urease activity
	g dm^{-3}	$mmol_c$ dm^{-3}	%	— g kg^{-1} —		mg kg^{-1} h^{-1}
5.9	24	93	76	403	503	24

NH_3 losses up to 3-month storage



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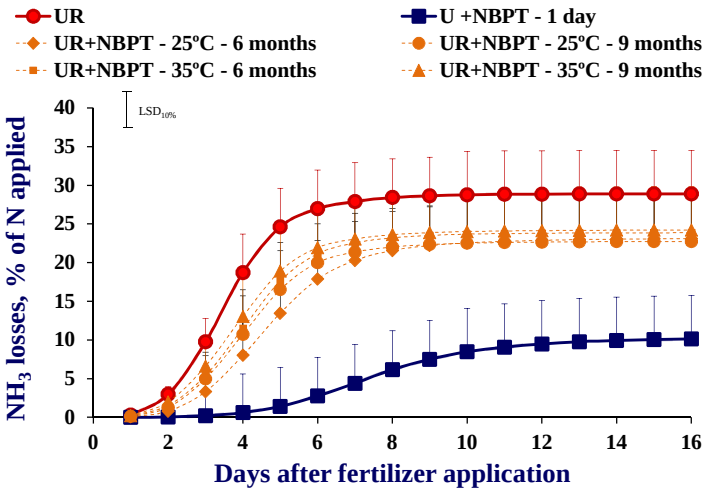
Soares & Cantarella, 2012

NH_3 losses up to 9-month storage



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Soares & Cantarella, 2012

Residual NBPT in urea after storage

Up to 3 months	NBPT content	6 to 9 months	NBPT content
	mg kg^{-1}		mg kg^{-1}
UR	-[a]	UR	-
UR+NBPT - 1 day	890	UR+NBPT - 1 day	930
UR+NBPT - 25°C - 1 m	720	UR+NBPT - 25°C - 6 m	8
UR+NBPT - 25°C - 3 m	530	UR+NBPT - 25°C - 9 m	5
UR+NBPT - 35°C - 1 m	470	UR+NBPT - 35°C - 6 m	-
UR+NBPT - 35°C - 3 m	< 100	UR+NBPT - 35°C - 9 m	-

Storage gradually causes NBPT degradation. Higher at high T
Storage up to 3 month at 25°C did not significantly affect NBPT efficiency

NBPT degradation products may still have some urease inhibitory effect (?)

Soares & Cantarella, 2012

Soil pH and NH_3 losses

Soils originally very acid; pH adjusted by liming
A) Red-Yellow Latosol (359 g/kg clay; 561 g/kg sand)
B) Red Latosol (525 g/kg clay; 391 g/kg sand)

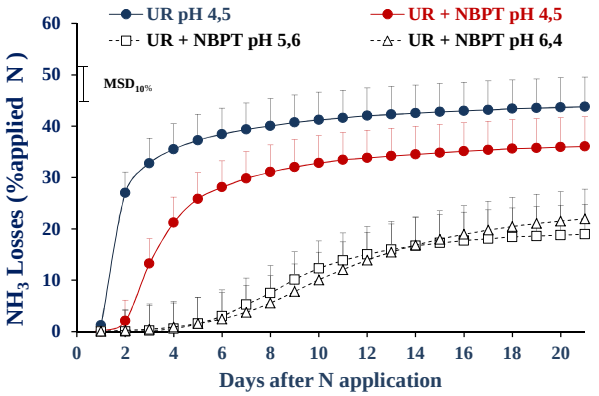
Fertilizer	Cumulative NH_3 losses at soil pH (A)		
	pH 4.5	pH 5.6	pH 6.4
	% of applied N		
UR	44 Aab	40 Ab	47 Aa
UR + NBPT	36 Ba	19 Bb	22 Bb
Loss reduction due to NBPT (%)	18	52	53

Fertilizer	Cumulative NH_3 losses at soil pH (B)		
	pH 4.5	pH 5.4	pH 6.1
	% of applied N		
UR	26 Ab	26 Ab	32 Aa
UR + NBPT	21 Ba	18 Bb	19 Bab
Loss reduction due to NBPT (%)	19	31	41

The efficiency of NBPT to reduce NH_3 volatilization decreases under soil acidic conditions

Soares 2011

Soil pH, NBPT & NH_3 losses



At low soil pH NBPT effectiveness decreased fast

(Red-Yellow Latosol, clay 359 g/kg)

Soares, 2011

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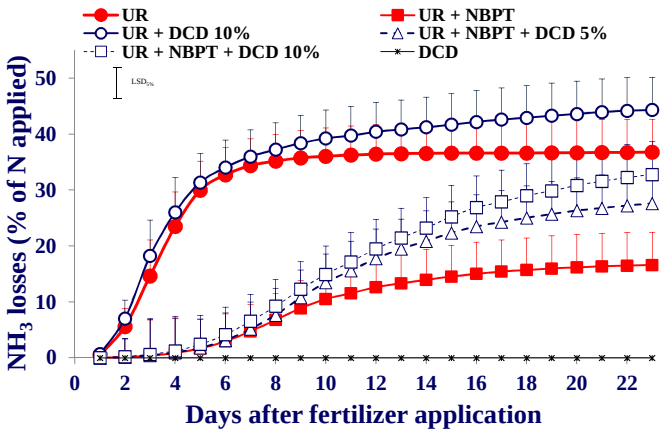
Urease and Nitrification Inhibitors Added to Urea



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Source: Soares et al. Soil Biol Biochem (2012)

Soil properties after 23 days

Treatment	pH	N concentration		$N\text{-}NH_3$ volatilized	Total N recovery
		$N\text{-}NH_4^+$	$N\text{-}NO_3^-$		
	$CaCl_2$	mg kg^{-1} in 0-2 cm depth		% of N applied	
UR	5.5 c	177 c	252 a	37 c	80
UR+DCD 10%	6.8 a	305 b	53 b	44 d	80
UR +NBPT	5.7 b	237 c	287 a	17 a	70
UR +NBPT+DCD 5%	6.8 a	369 ab	93 b	28 b	74
UR +NBPT+DCD 10%	6.8 a	370 a	70 b	33 bc	77
DCD	5.9	6	0	0	

DCD: higher soil pH, higher NH_4^+-N, higher NH_3 losses

Source: Soares et al. Soil Biol Biochem (2012)

Urease & Nitrification Inhibitors: effect on NH_3 losses

Fertilizer	Cumulative ammonia volatilization		
	At 7th day	At 14th day	Total (23 days)
	% of applied N		
Urea	34 b	37 c	37 b
Urea + DCD	36 b	41 c	44 c
Urea + NBPT	5 a	14 a	17 a
Urea + NBPT + DCD	7 a	23 b	33 b

DCD maintained high soil pH (urea hydrolysis) thus maintained NH_3 volatilization for a longer period.

Source: Soares et al. Soil Biol Biochem (2012)

Concluding Remarks

NBPT is a proven additive to reduce NH_3 volatilization losses from surface-applied urea but caution is needed to obtain the desired benefits:

1. **Proper time and temperature of storage is important to guarantee NBPT effectiveness**
   - **Very little change up to 3 months at 25℃**
     - **New formulations may increase shelf-life**
2. **NBPT performance decreases under acidic conditions**
   - **Lime to raise soil pH**
3. **The combination of NBPT and DCD must be done with care: DCD may cause increased NH_3 losses**

Thank you

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