

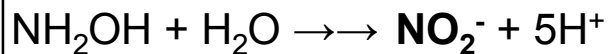
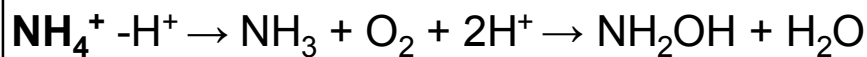
Nitrification Inhibition for Nitrogen Efficiency and Environment Protection

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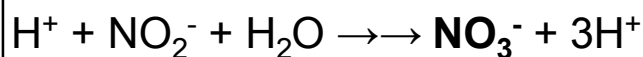
Nitrification Process

Autotrophic nitrification (energy from N oxidation)

Nitrosomonas

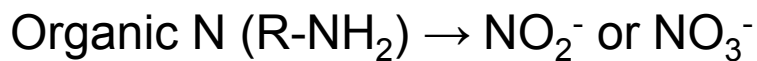


Nitrobacter



Nitrification Process cont'd

Heterotrophic nitrification—oxidation of organic N and NH_3 to NO_2^- or NO_3^- by chemoheterotrophic bacteria and fungi in acid soils. Energy from amino acids.



Importance of Nitrification

- Economic consequences
 - Makes N more vulnerable to losses
- $$\text{NH}_4^+ \rightarrow \text{NO}_3^- \text{ leaching and denitrification}$$
- Environmental consequences
 - NO_3^- pollutant in surface and groundwater
 - Eutrophication, hypoxia, and health risks
 - Greenhouse gases into the atmosphere
 - Nitrous oxide (N_2O)—global warming
 - Nitric oxide (NO)—destroys stratospheric O_3

Nitrogen Losses

- Conditions favoring NO_3^- leaching
 - Prolonged periods of rainfall
 - Soil with large pores, cracks, root channels, worm and insect holes
 - More prevalent in no-tillage (zero tillage)
 - Rapid movement to great depths
 - Coarse-textured (sandy) soil

Nitrogen Losses

- Conditions favoring denitrification
 - Poorly drained or somewhat poorly drained soil
 - Substantial denitrification can occur in well-drained soil
 - Periods of wet weather
 - Anaerobic conditions inside soil aggregates, especially with no-tillage (zero tillage)
 - Heavy residue cover

Effects of Nitrification Inhibitors (NI)

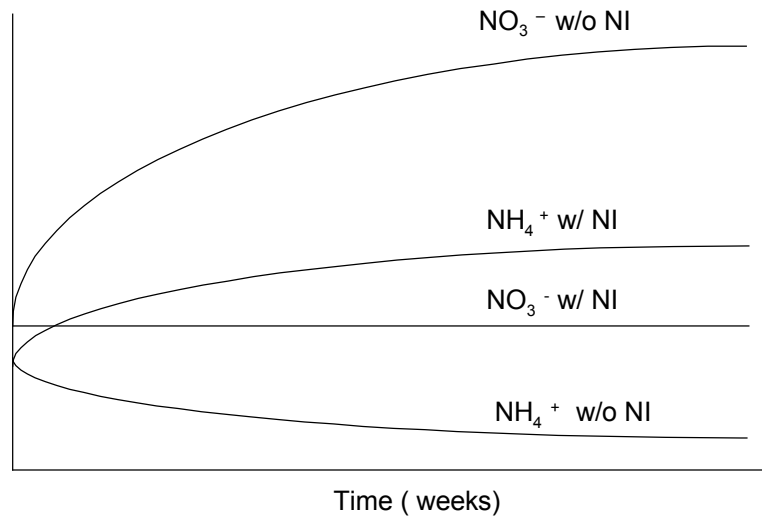


Table 1. Some patented nitrification inhibitors.

Chemical name	Common name	Inhibition by day 14
		%
2-chloro-6-(trichloromethyl)pyridine	Nitrapyrin	82
4-Amino-1,2,4-triazole-HCl	ATC	78
2,4-Diamino-6-trichloromethyltriazine	CL-1580	65
Dicyandiamide	DCD	53
Thiourea	TU	41
1-Mercapto-1,2,4-triazole	MT	32
2-Amino-4-chloro-6-methylpyrimidine	AM	31

Adapted from Paul and Clark (1989).

Nitrification Inhibitors

■ Nitrapyrin

- Advantages

- 82% inhibition by day 14
- Fairly reasonable cost ~ \$15+ ha⁻¹
- Proven performance

- Disadvantages

- Volatility— 2.8×10^{-3} mm Hg v.p.@ 23°C
- Must be incorporated into soil
- Petroleum-based—can't impregnate ammonium nitrate

Nitrification Inhibitors

■ DMPP (3,4-dimethylpyrazole phosphate)

-Advantages

- Highly effective
- Easily incorporated into granular fertilizers
- No environmental concerns

-Disadvantages

- No major disadvantages?

Yield Response to Inhibitor

- Effective inhibition but no yield effect—
What does it mean?
 - Optimum N rate, no N loss, no yield response to inhibitor
 - Excessive N rate, N loss, still optimum N, no yield response
 - Optimum N rate, N loss, yield response
 - Excessive N rate, excessive N loss, yield response

Table 2. Grain yield of no-tillage maize (*Zea mays* L.) as affected by nitrapyrin* in Kentucky.

N rate, kg ha ⁻¹	0	90	135	180
	----- Yield, Mg ha ⁻¹ -----			
Without nitrapyrin	3.41	5.96	5.13	7.45
With nitrapyrin	----	7.91	8.29	7.73

*Nitrapyrin sprayed directly onto granular ammonium nitrate at rate of 0.56 kg ha⁻¹ and surface-applied broadcast.



Deterrents to Use of Inhibitors

- Inexpensive N fertilizers—excessive rates
- Inconvenience of using nitrapyrin
- USEPA restrictions on DCD
- Other means of efficiency
 - Delayed application
 - Split application
 - Slow-release N for turf and specialty crops



Clarification Needed!

- Slow-release N—form that delays availability for plant uptake
- Stabilized N—N stabilizer added to fertilizer
- N stabilizer—extends time N is in urea or ammoniacal form in soil
 - Urease inhibitor
 - Nitrification inhibitor
- Enhanced Efficiency (EE)—includes slow-release and stabilized N

Conclusions

- Nitrification makes soil N more susceptible to leaching and dinitrification.
- Results are decreased N-use efficiency and environmental pollution.
- Nitrification inhibitors have been shown to slow nitrification.

Conclusions

- Slowing nitrification keeps N in more stable form (NH_4^+) longer:
 - Allows more time for plant uptake
 - More efficient use
 - Less loss to environment
 - Less environmental pollution



Future of Enhanced Efficiency Fertilizers

- Industry has focused on N for specialty uses, e.g., turf, nursery, high-value crops
- Recently turning attention to field crops
 - Good job with specialty products and uses
 - Greatest opportunities—economic and environmental—is in production agriculture, especially field crops