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Nitrification Inhibitors And Use In Minnesota

by

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NITRIFICATION INHIBITORS AND USE IN MINNESOTA

Nitrification inhibitors (NI), sometimes called nitrogen (N) stabilizers, have been around many years in Minnesota, yet they have never been used widely. Perhaps this is due to misunderstandings about the product and what its use can accomplish: increased efficiency of applied N fertilizer.

Situations exist in Minnesota where use of nitrogen (N) stabilizers can be agronomically, environmentally, and economically sound. This publication gives the background of NIs and explains their uses.

NITROGEN CYCLE

Nitrogen, whether newly applied or already existing in the soil is very dynamic—continually changing in form. Crop producers are most interested in two major forms of soil nitrogen: ammonium and nitrate. While both are available to crops, they are different in most other ways.

Ammonium N is a positively charged ion (cation) and is held in soil to the negatively charged clay and organic matter particles--resulting in very little movement. Ammonium N is also not lost to the atmosphere from waterlogged soils in the biological process called denitrification.

Nitrate N, conversely, is a negatively charged ion (anion) and not held by the soil particles. It is subject to leaching (movement of nitrate N below the crop's rooting zone) and denitrification, since nitrate is the form of N that microbes convert to gaseous N. **Figure 1** is a simplified sketch of how nitrate and ammonium play a role in the N cycle in the soil.

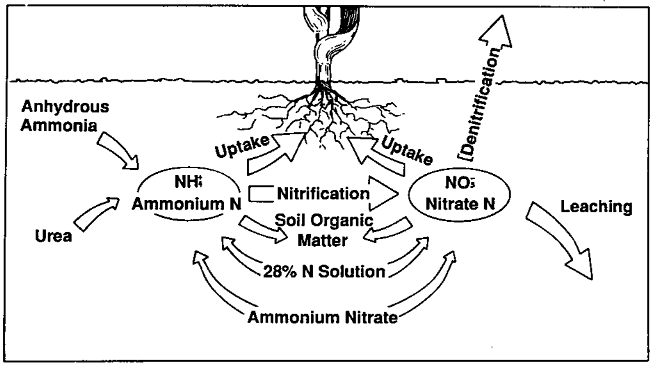

Figure 1. Changes that take place with nitrogen fertilizer in the soil.

While ammonium and nitrate appear to be independent in the soil, there is a definite relationship. Ammonium is either taken up by plants or converted to nitrate by a process called nitrification, carried out by specific microorganisms in the soil. Nitrification speeds up as soil temperatures warm and stops entirely when soil is frozen and there is no microbial activity. **Figure 2** shows how

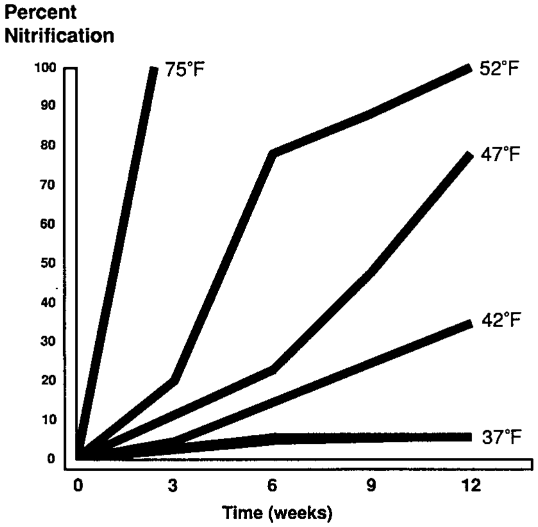

Figure 2. Nitrification at various soil temperatures. Source: *Western Fertilizer Handbook*, seventh edition, 1985, p. 58.

soil temperatures trigger ammonium conversion to nitrate.

It is advantageous to manage ammonium N since leaching and/or denitrification of nitrate N are potential loss mechanisms. Planning and managing a fertilizer program should consider forms of N, time of application, and, sometimes, the inclusion of a NI. Nitrification inhibitors halt or slow down the nitrification process: maintaining more ammonium N in the soil for a period of time.

POTENTIAL BENEFITS OF NITRIFICATION INHIBITORS

The ultimate goal of any NI is to increase the efficiency of the N fertilizer applied. To achieve this, either the amount of N applied can be reduced with stabilizer and the yields not decrease, or the amount of N applied can remain constant with the use of a stabilizer and the yields will increase.

Nitrate loss from denitrification and/or leaching generally occurs when high rainfall creates saturated soil conditions. On coarse-textured soils, leaching predominates, while on fine-textured soils, denitrification is more common. If N loss is sufficient, a yield increase due to a NI may be realized.

Reducing the leaching loss of nitrate from the soil N also has a benefit of reduced groundwater contamination. While a NI is often evaluated agronomically, environmental and social issues must be considered.

NITRIFICATION INHIBITORS AND FERTILIZER PRODUCTS

There are currently two NIs available to crop producers in Minnesota. The most familiar is nitrapyrin, sold as N-Serve by Dow Chemical Company. N-Serve effectively inhibits *Nitrosomonas* species, the primary bacteria that initiates the nitrification process. Nitrapyrin is a volatile liquid and should be injected or incorporated into the soil. Nitrapyrin is most commonly placed with anhydrous ammonia in the tanks and injected into the soil. N-Serve can also be added to UAN-28 and liquid manure, or impregnated onto urea; however, immediate incorporation is encouraged to reduce volatilization when applied in this way.

The other NI available in Minnesota is dicyandiamide, abbreviated as DCD. Fertilizers containing DCD are being marketed under various names. Similar to nitrapyrin, DCD inhibits the *Nitrosomonas sp.* bacteria. Unlike nitrapyrin, DCD is a solid, is not volatile, and is not soluble enough to be mixed with anhydrous ammonia. Urea should benefit most from DCD characteristics. The stabilizer can be impregnated onto the urea granule or incorporated into the granule at the time of manufacture.

STABILIZER USES AND RESEARCH RESULTS

Coarse-textured soils. Leaching of nitrates may be severe on these soils, especially if irrigation is being used. Research work done by the University of Minnesota has examined the effectiveness of NIs for several years.

N-Serve additions with several N sources resulted in significant yield increases when the N applications were all preplant **(table 1)**. The increases were greatest for UAN-28 solutions and least for anhydrous ammonia. These results are thought to be related to each N source's overall efficiency in the soil.

Table 1. Mean corn grain yields influenced by N source and N-Serve when applied pre-plant over a 3-year period at Becker, Minnesota

	Inhibitor	
N Source	None	N-Serve
	- - - - -bu/A- - - - -	
Anhydrous Ammonia	161	172
Urea	147	165
U.A.N.	145	163

Table 2. Three-year summary of corn grain yields influenced by time of N application and N-Serve at Becker, Minnesota

	N Rate (lbs N/A)						
	0	75		150		225	
Time of application		Inhibitor					
	-	None	N-Serve	None	N-Serve	None	N-Serve
	Grain yield (bu/A)						
Preplant	82	124	132	147	167	158	180
8-leaf		147	158	179	186	193	191
12-leaf		161	164	184	181	180	187
tassel		142	-	150	-	152	-
1/3 PP, 2/3 12lf*		153	155	167	182	187	190
2/3 PP, 1/3 12lf*		132	144	159	180	191	191
1/6 PP, 1/6 8lf*, 1/2 12lf*, 1/6 tassel		157	-	184	-	187	-

* *PP=preplant; 12lf=12-leaf stage of growth; 8lf=8-leaf stage of growth.*

Although N stabilizers appear to have a positive influence with different N sources applied preplant on coarse-textured soils, most N management programs take advantage of sidedress or split applications of N with the irrigation water. Data from table 2 show that proper split applications of N are generally superior to preplant applications. Time of N application is a key factor in N management for irrigated corn. At the lowest N rate (from **table 2**), N-Serve increased yields, as did delayed time of application. As N rate is increased, the yield increase due to a NI decreased. It is clear that an application of N either too early or too late decreases yields.

Table 3. Mean corn grain yields affected by time of N application and N-Serve over a 5-year period with anhydrous ammonia at Waseca, Minnesota

Time of application	Inhibitor None	N-Serve
	Grain yield (bu/A)	
Fall	163	168
Spring	165	166

Fine-textured soils. Denitrification is a major mechanism of N loss on fine-textured soils. The slow movement of water through fine-textured soils creates conditions conducive for the denitrification of nitrate N.

Fall applications of anhydrous ammonia and urea may be feasible on these soils. Due to the extended period of time the N from these sources will be in the soil and, thus, subject to loss by denitrification, NI could have a niche with fall applications in south-central Minnesota.

Research results from Waseca (**table 3**) show that N-Serve gives a slight yield increase with fall applications in some years. The earlier the fall N applications are made, the higher the probability of a response to a NI and fewer increases when used with spring applications. There is a much lower probability of getting a yield increase from the use of a NI when N is applied in the spring.

A 3-year project at Waseca examining N-Serve and DCD resulted in no significant yield advantages of either inhibitor (**table 4**). While the N-Serve treatments did not yield in a consistent manner relative to the treatments without a NI, the DCD treatments were almost always better yielding than treatments without a NI. The anhydrous ammonia N source was consistently superior to the urea throughout the study. While DCD was included with anhydrous ammonia in this study, this combination is not a practical option for Minnesota corn producers.

Table 4. Corn grain yields as influenced by nitrification inhibitors, N source, and time of N application on Webster soils at Waseca, Minnesota

Year	Application time	N Source	Optimum N-Rate	Inhibitor		
				None	DCD	N-Serve
				Grain yield (bu/A)[1]		
1981	Spring PP	Urea	188	174	179	-
1982	Fall	Urea	150	128	120	-
	Fall	A.A.	150	136	145	131
	Spring PP	Urea	150	137	145	-
	Spring PP	A.A.	150	150	151	144
1983	Spring PP	Urea	150	99	105	-
	Spring PP	A.A.	150	102	110	103

[1] *LSDs at the 95% level for 1981, 1982, and 1983 were 12.8, 17.5, and 14.4, respectively.*

ECONOMIC BENEFITS

Economics largely determine whether crop producers accept N stabilizers. While many people try to judge a NI only on a direct benefit (yield/cost) situation, there are some indirect situations where a NI may be economically beneficial.

Risk insurance. The primary function of a NI is to preserve N in the ammonium form, providing insurance against N loss of the fertilizer applied. There may not be a return every year for this type of insurance. The benefit of a NI depends on the environmental condition each year, and only in years of N loss will there be a potential for a return. The economic justification for using a NI should be based on several years.

Many growers apply "extra N" as risk insurance against N loss. This may not provide the same benefit as using a N stabilizer since N losses frequently occur as a percentage of the total N applied. The increased loss associated with higher rates for insurance also provides environmental concern.

Groundwater quality. The economics of preserving groundwater quality is impossible to quantify. Nitrate movement into the groundwater is a serious concern for people in several geographical locations in Minnesota. Since nitrate is the leachable form of N percolating in the soil, preservation of ammonium by a NI may have an indirect effect on groundwater quality. The price tag one is willing to pay for using a NI for this purpose is a highly personal issue.

MINNESOTA RECOMMENDATIONS

There are some situations where NIs do serve an agronomic and/or environmental purpose. Nitrification inhibitors are endorsed when N is being solely applied as a preplant application on sandy soils or if the sidedress N is applied before the 6th leaf growth stage. A NI is also suggested for fall--especially early fall--N applications for the regions of the state, such as the south-central, with poor drainage and higher rainfall.

Based on economical factors, NIs should not substitute for poor management. It is the combination of several environmental, management, and soil factors that determine the response to the use of a NI. Crop producers should evaluate whether conditions exist on their farms which could benefit from N stabilizer use.

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