SF-1581

Nitrogen Extenders and Additives

FOR FIELD CROPS

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Nitrogen management continues to be difficult due to transformations of nitrogen fertilizers that are possible when applied to soil and the uncertainties of weather (Cabrera et al., 2008). Nitrogen (N) fertilizer in the form of urea is subject to ammonia volatilization through the activity of the urease enzyme found ubiquitously in soil (Kissel et al., 2008). Nitrate fertilizer is subject to leaching (Randall et al., 2008) or denitrification (Coyne, 2008), depending on the water content of the soil and water movement through the soil. Ammonium forms of N can be fixed (Kissel et al., 2008) or transformed to nitrate through the activities of specific soil bacteria (Norton, 2008). Because of these and other processes, nitrogen use efficiency is low.

Nitrogen often is applied to crops in the north-central region of the U.S. before planting. During the first four to six weeks after planting, corn will require only about 5 percent of the N applied. The following two to four weeks of growth require a large proportion of the total seasonal N requirement.

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In winter wheat, very low levels of N are required for overwintering. However, once wheat breaks dormancy, a large proportion of N is required during the next few weeks. In spring wheat, a small of amount of N is required to establish the crop during the first two to four weeks after seeding; however, most of the remaining N is required during the next 30 days.

To address some of the delayed N requirement issues of winter wheat, much of the crop is top-dressed in the spring. In corn, some growers use side-dress applications; however, spring preplant application is most common, with fall application preferred by growers in some Northern states. In spring wheat in the northern Plains, some post-N applications are made.

Because of the lack of rain during the growing season in many years, post-N applications as a source of most of the N requirement are discouraged except under irrigation. To increase nitrogen use efficiency and thereby increase yields or decrease N rates, a number of products have been developed to delay an N transformation process so that the period of time in which the N source is available for uptake is closer to the time the crop needs the available N. These products can be classified into the following groups: nitrification inhibitors, urease inhibitor additives, and nitrification and urease inhibitors.

Nitrification Inhibitors

Nitrapyrin

N-Serve, or nitrapyrin (2-chloro-6-[trichloromethyl] pyridine) has been studied and commercially used since the late-1960s. Work by Janssen (1969), summarized by Hergert and Wiese (1980), showed that nitrapyrin was active as a nitrification inhibitor and that the degree of nitrification was influenced by the nitrapyrin rate as a ratio of nitrapyrin to anhydrous ammonia. Greater N recovery with nitrapyrin than anhydrous ammonia alone was measured in April (190 days after application), June (230 days) and July (280 days) when anhydrous ammonia was applied from late October to early November.

Illinois studies in the mid-1970s showed that when injected into anhydrous ammonia or applied with urea, the rate of nitrification decreased (Figures 1 and 2) (Touchton et al., 1978a, 1978b; Touchton et al., 1979a); however, rainfall during the years of the experiments did not result in consistent increases in corn N uptake or corn yield in Illinois (Touchton et al., 1979b). Lack of yield response from the use of nitrapyrin also was reported in Iowa by Blackmer and Sanchez (1988); however, Stehouwer and Johnson (1990) reported higher corn yield from fall-applied N, with nitrapyrin related to higher N availability later in the season.

Higher corn yield with nitrapyrin in fall-applied N also was reported by Randall et al. (2003) and Randall and Vetsch (2005) in Minnesota; however, spring-applied N was highest yielding with greatest N-use efficiency. N-Serve is labeled for immediate incorporation or injection and not as a surface-applied product. Yield increases during the seven Minnesota study years were 15 bushels per acre more for fall anhydrous ammonia + N-Serve versus fall anhydrous ammonia alone, and 27 bushels per acre more for spring anhydrous ammonia compared with fall anhydrous ammonia (Randall et al., 2008).

A Wisconsin study (Hendrickson et al.,1978) found that on May 6, 1976, following an

Oct. 6, 1975, application of anhydrous ammonia, 53 percent of the recoverable N was ammonium-N with nitrapyrin (0.5 pound/acre active ingredient) compared with 11 percent ammonium-N without nitrapyrin. Nitrapyrin also increased the ammonium-N concentration in Minnesota research (Malzer, 1977) through June 8 of the following spring. In North Dakota (Moraghan and Albus, 1979), greater ammonium-N following fall anhydrous ammonia application was present through July 5 of the following spring.

Grain yield increases with the use of a nitrification inhibitor have been inconsistent due to the variability of rainfall necessary to lead to nitrate leaching in sandier soils or denitrification in high-clay soils. Malzer et al. (1979) recorded a corn yield increase with the optimum N rate in fall anhydrous ammonia application with nitrapyrin, but a split application of N resulted in similar yield with nitrapyrin as without it. Hergert et al. (1978) showed that the benefit of nitrapyrin use under irrigated sands increased as the irrigation water as a percent of evapotranspiration increased.

Instinct is an encapsulated nitrapyrin formulation that can be applied to fertilizer left on the soil surface for up to 10 days for delay of ammonium fertilizer nitrification. It received its label in 2009. Research is ongoing at a number of universities. University of Nebraska studies in 2008 and 2009 (Ferguson et al., 2008, 2009) showed no yield benefits to the use of nitrapyrin (GF-2017, Instinct); however, the plots were hampered by heavy rainfall in June (2008) and spatial variability (2009).

In Wisconsin, two years of work with Instinct resulted in corn yield increases in 2008 but not in 2009 (Laboski, unpublished data). In Illinois, yield did not increase due to the use of Instinct with urea ammonium nitrate (UAN) during six site-years (Fernandez, 2010). Iowa (Killorn, unpublished data) and Minnesota (Randall, unpublished data) research also showed no yield increase with Instinct compared with N fertilizer alone.

Field and laboratory studies show that nitrapyrin effectively reduces the rate of nitrification. However, these same studies show an inconsistency in yield increases due to the use of the product. The inconsistency is related to rainfall patterns within the experiment. Predicting the profitability of the use of nitrapyrin is therefore very difficult. The use of nitrapyrin to reduce N losses "needs to be considered at the scale of a sensitive region, such as a watershed, over a prolonged period of use as well as within the context of overall goals for abatement of N losses from the agroecosystem to the environment." (Wolt, 2004).

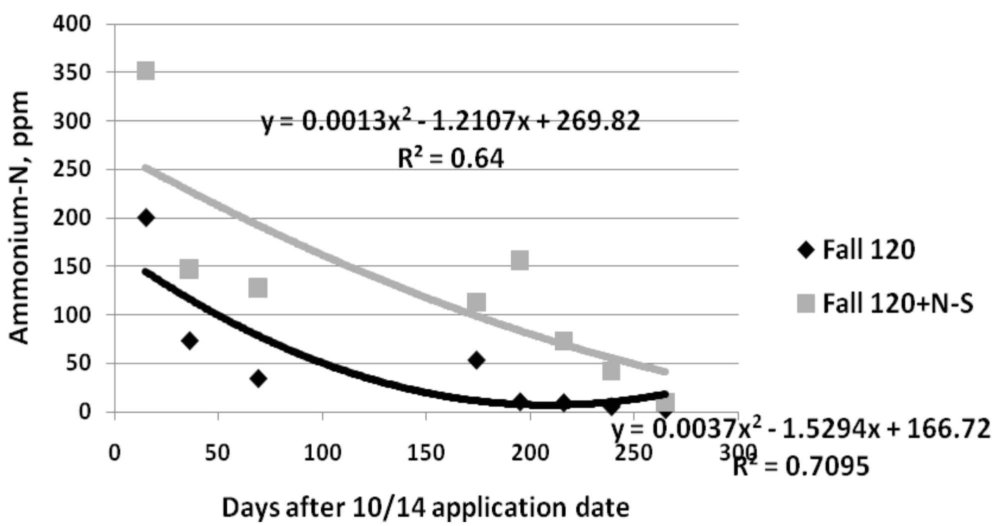
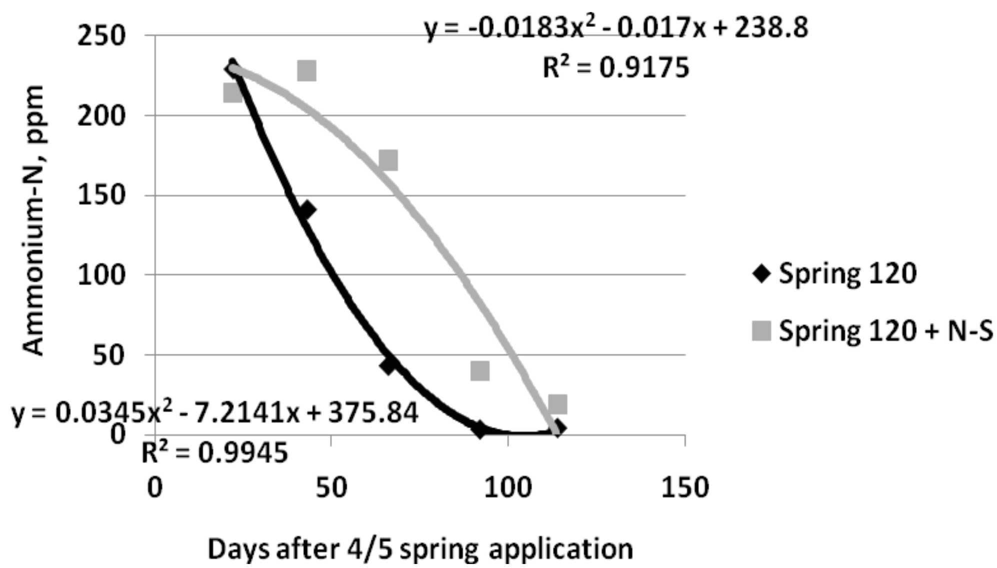


Figure 1.

Ammonium-N concentration in soil after 120 pounds/acre of N as anhydrous ammonia was applied Oct. 14, 1975, with and without 1 pound/acre of active ingredient (two times labeled rate) N-Serve®/nitrapyrin (N-S). Differences between treatments were significant at all sampling dates through day 239 (Touchton et al., 1978).

Figure 2.

Ammonium-N concentration in soil after 120 pounds/acre of N as anhydrous ammonia was applied April 5, 1976, with and without 1 pound/acre of active ingredient (two times labeled rate) N-Serve®/nitrapyrin (N-S). Differences between treatments were significant at all sampling dates through day 114 (Touchton et al., 1978).



Research on DCD (dicyandiamide or cyanoguanidine) has shown that it can be used as a nitrification inhibitor, although research generally has shown that its activity is shorter than nitrapyrin (Bronson et al., 1989). Products that contain DCD in the U.S. include Super-U (IMC Phosphate Co., licensed exclusively to Agrotain International LLC) and Guardian fertilizer additive (Conklin Co. Inc.). DCD contains about 67 percent N and was examined as an N source early in the last century (Reeves and Touchton, 1986). It was found to decrease crop yield when rates exceeded about 36 pounds/acre (Cowie, 1918). The Guardian label recommends a 2 percent addition to fertilizer. The content of DCD in Super-U is not stated. Growers likely would not overapply either product to the point of crop phytotoxicity.

A review of north-central states' research on DCD was published by Malzer et al. (1989). The review concluded that DCD was similar to nitrapyrin in its nitrification inhibition. Yield differences between fertilizer treated with DCD and fertilizer alone were inconsistent and limited to those soils and conditions where nitrate was lost through leaching or denitrification. The greatest value of either nitrification inhibitor would be in soils where nitrate loss through leaching or denitrification is more likely. A summary by Malzer et al. (1989) is reproduced in Table 1.

In contrast to the relatively low frequency of corn responses in the Midwest, potato responses were more consistently positive (Table 2).

The ammonium-N remaining in the soil following ammonia application with both nitrapyrin and DCD treatments was explored at four Illinois locations by Sawyer (1985). Within 30 days of a fall application, no differences were found between the control and the DCD and nitrapyrin treatments in the percentage of remaining ammonium-N. In the spring, the DCD and nitrapyrin treatments provided a greater percentage of remaining ammonium-N compared with the control at three of four locations. The differences are presented in Figure 3 for the Urbana and Dekalb locations. Spring application of DCD and nitrapyrin were even more effective at some sites (Figure 4).

The use of nitrification inhibitors with liquid manure applications has generated considerable interest. In response to reports of poor corn growth due to injected liquid manure in Illinois, placement studies with and without nitrapyrin were conducted on similar soils. The results of one study showed that the use of nitrapyrin increased corn plant and grain N concentrations but did not translate into a yield increase (Sawyer et al., 1991). In another study, the use of nitrapyrin was useful in lowering soil nitrite levels in the liquid manure band, which was one reason why poor corn growth was observed in the banded liquid manure fields (Sawyer et al., 1990).

Table 1. Summary of corn grain yield responses to DCD and nitrapyrin at N rates equal to or less than optimum for fine-textured Midwest soils. *(From Malzer et al., 1989.)*

	DCD			Nitrapyrin		
	No. of comparisons			No. of comparisons		
	Total	With significant advantage	Average response	Total	With significant advantage	Average response
			%			%
Timing						
Fall	4	1	+1.6	2	0	-0.2
Spring	15	3	+3.4	7	1	-0.4
Sidedress	3	1	+1.4	3	2	+8.1
N Source						
Ammonium sulfate	2	0	-1.0	0	0	-
Anhydrous ammonia	6	1	+3.6	6	1	-1.8
Urea	4	4	+2.2	6	2	+1.1

Table 2. Relative effect of dicyandiamide (DCD) used with three nitrogen sources on potato yield, % Grade A US1A tubers, and apparent N recovery in tubers at Hancock, Wis., 1984-1986. *(From Malzer et al., 1989.)*

		Number of positive significant responses			Average relative response to DCD		
N Source	Number of comparisons	Yield	% Grade A	Tuber N Recovery	Yield	% Grade A	Tuber N Recovery
Ammonium nitrate	9	3	1	4	+2.0	-3.6	+6.5
Urea-ammonium sulfate	6	3	0	4	+5.1	-10.8	+23.7
Urea-ammonium nitrate solution	9	2	2	6	+4.0	-5.1	+27.6

Urease Inhibitors

The compound that most consistently has decreased urea volatilization when mixed with urea or urea-ammonium nitrate solutions is NBPT (N-(n-butyl) thiophosphoric acid triamide). NBPT is marketed as Agrotain (Agrotain International LLC). The mechanism for NBPT is to lock onto the urease enzyme-binding sites, preventing the enzyme from reacting to the urease (Manunza et al., 1999). Agrotain has at least two possible uses in crop production: One is to protect against seed injury for growers, especially in the northern Plains, who apply urea with small-grain seed at planting. Use of Agrotain has increased the rate of urea that can be applied safely with small-grain seed in some studies (Table 3).

Agrotain also decreases the rate of ammonia volatilization from urea applied to the surface as dry urea or urea-ammonium nitrate solutions (Brouder, 1996, Table 4). Ammonia volatilization losses from urea at Brandon, Manitoba, decreased from 40 milligrams (mg) to 2 mg and from 88 mg to 12 mg with Agrotain in two separate studies for a seven-day period after application (Grant, 2004).

In a recent Kansas study (Weber and Mengel, 2009), urea was applied in three site-years to the soil surface after corn emergence using a number of nitrogen-extending additives, including Agrotain. The Agrotain treatment was superior to urea alone by 25 bushels per acre in one of the three site-years. The two locations that received significant rainfall immediately

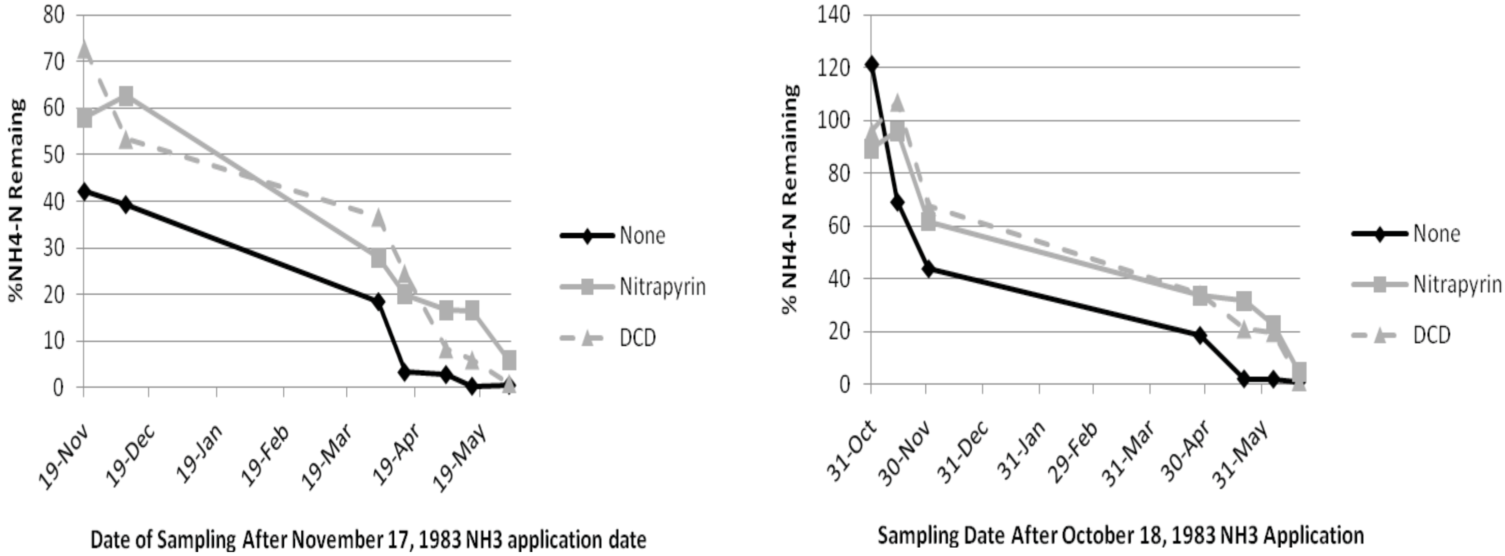


Figure 3. Percent NH4-N remaining after fall NH3 application at Urbana (left) and Dekalb (right). From Sawyer, 1985.

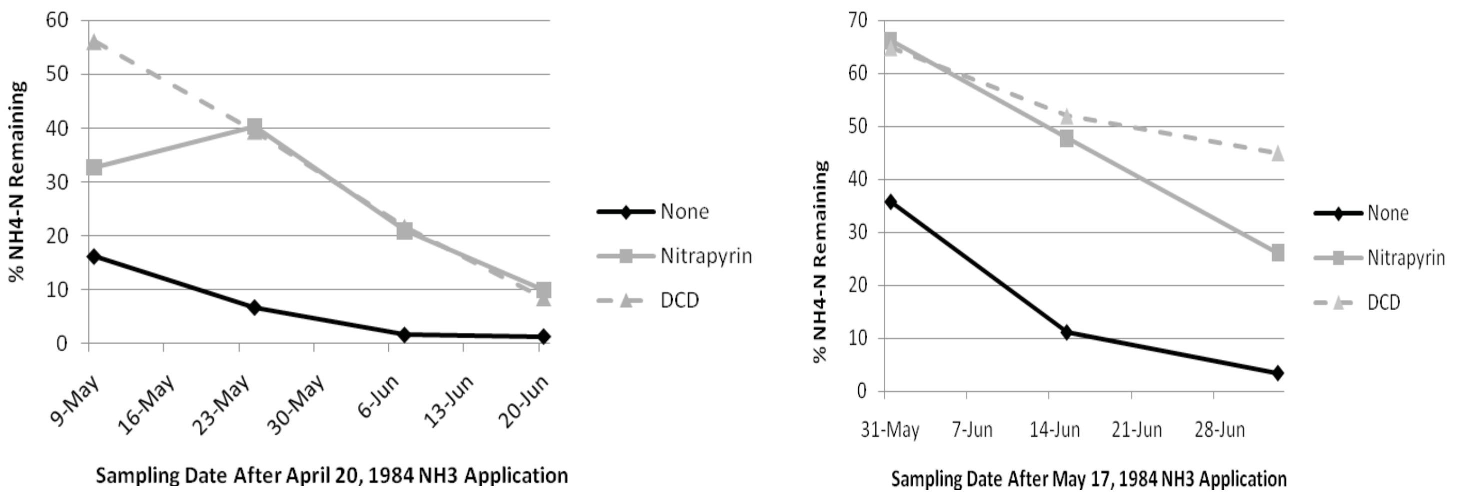


Figure 4. Percent NH4-N remaining after spring NH3 application at Monmouth (left) and Brownstown (right). From Sawyer, 1985.

following applications did not receive a yield benefit from the Agrotain treatment. In sorghum, urea + Agrotain and urea + SuperU were 11 and 12 bushels per acre, respectively, greater in yield than with urea broadcast alone (Weber et al., 2009a). At two drier locations, no yield differences occurred between urea + Agrotain and urea alone.

A 14-year study in southern Illinois (Ebelhar et al., 2010) showed a 3-bushel corn yield advantage of urea + Agrotain compared with urea broadcast in conventional till surface and incorporated during 12 years of treatments. In no-till, urea + Agrotain held an 11 bushel/acre advantage over urea surface applied during four years of treatments. Similar results were demonstration by Varsa etal 1995 (Table 5).

In Kentucky, 50 pounds of N/acre was applied preplant to all corn plots (Schwab and Murdock, 2009). Side-dress applications of urea and UAN with several additives or formulations were applied to the soil surface at the six-leaf stage. Higher yields than urea alone were achieved with urea + Agrotain and SuperU. Higher yields than UAN alone were achieved with UAN + Agrotain and UAN + Agrotain Plus (combination of NBPT and DCD formulated for use with UAN) (Table 6). Also notable: The ammonium nitrate treatment was the highest yielding treatment, suggesting that some loss of N was realized with the Agrotain treatments.

Nitrification and Urease Inhibitors

Ammonium thiosulfate (ATS) and several additional commercial thiosulfates have nitrification- (Goos, 1985; Janzen and Bettany, 1986) and soil urease-inhibiting properties (Goos, 1985). In the process of identification of thiosulfates as nitrification and soil urease inhibitors, researchers noted that the compounds would not be expected to perform as well as some other alternative nitrification and urease inhibitors due to the shorter decomposition period for ATS compared with nitrapyrin (Goos, 1985).

One study was unable to duplicate urease inhibition results, but it used different methods than originally presented at

Table 3. Effect of seed-placed urea with and without Agrotain on stand density and grain yield of barley on a fine sandy loam soil, 1994-96. *(From Grant, 2004.)*

	Stand, plants/foot		Yield, bu/acre	
N rate	No Agrotain	Agrotain	No Agrotain	Agrotain
lb/acre				
0	7.6	7.6	50	50
18	7.9	8.2	55	52
36	7.3	7.7	53	62
54	6.0	7.1	59	57
72	5.7	7.1	63	61
89	4.7	7.1	57	65

Table 4. Mean corn yield from Purdue Agronomy Farm, SEPAC, Pinney Purdue and Kosciusko locations with urea and UAN alone and treated with NBPT. *(From Brouder, 1996, citing work by Phillips, Mengel and Walker, 1989, unpublished work, Purdue University.)*

Fertilizer treatment	Yield, bu/acre
Control (20 lb N/acre in starter only)	99
Urea broadcast, surface	130
Urea + NBPT broadcast, surface	143
UAN broadcast, surface	135
UAN + NBPT broadcast, surface	140
UAN dribbled, surface	139
UAN spoke injected	142
UAN coulter injected	147
UAN knife injected	145

Table 5. No-till corn yield as affected by N fertilizer sources, Agrotain and placement in Illinois. *(From Varsa et al., 1999.)*

Treatment	Belleville	Dixon Springs		
	Yield, bu/acre			
Control (0N)	34	53	62	73
Urea	106	120	98	100
Urea + Agrotain	134	143	112	112
UAN, surface	123	137	103	107
UAN + Agrotain, surface	128	145	107	114
UAN, dribble	139	137	108	112
UAN + Agrotain, dribble	143	152	110	120
UAN injected	172	176	123	121
Anhydrous ammonia	158	166	122	130

Table 6. Yield for side-dressed no-till corn in Hardin County, Ky. *(From Schwab and Murdock, 2009.)*

Treatment	Yield, bushels per acre
Check (50 lb N/acre preplant N only)	117d*
Urea	158c
Urea + Agrotain	201b
SuperU	201b
UAN	150c
UAN + Agrotain	179bc
UAN + Agrotain Plus	175bc
Ammonium nitrate	239a

* Numbers followed by the same letter are not significantly different (5%)

rates of ATS from 3.3 to 33 times the rates of Goos, 1985 (McCarty et al., 1990). Thiosulfate activity is regulated by its concentration (effective at S rates of 25 mg kg^{-1}, Goos and Johnson, 2001).

Thiosulfate readily breaks down rapidly in temperatures of 15 C. In a laboratory study at 15 C, ATS essentially was mineralized in about a week. Under cooler temperatures, however, significant thiosulfate remained after two weeks in two of three soils, with mineralization complete in all soils by week three. When thiosulfate was placed in a band with aqua ammonia in the fall in North Dakota (Oct. 3, 1996), thiosulfate resulted in similar spring (May 12, 1997) ammonium and nitrate levels as aqua ammonia treated with nitrapyrin (Goos and Johnson, 1999). Spring wheat yields of aqua ammonia treated with thiosulfate and nitrapyrin were similar, and both were greater than aqua ammonia alone.

Janzen and Bettany (1986) expressed cautions on high rates of banded ATS (in excess of 100 parts per million, or ppm) due to nitrite accumulation from ATS inhibition of not only the ammonium to nitrite process, but the nitrite to nitrate process.

The rate used by Goos (1985) was about 43 ppm if expressed as a band with a radius of 2 inches, which did not accumulate nitrite in the Janzen/Bettany (1986) study.

Recently, the use of thiosulfate has been re-examined. In Kansas, the application in the spring of a 5 and 10 percent calcium thiosulfate by volume solution with UAN had similar yield as urea broadcast in no-till (Tucker and Mengel, 2007).

Nutrisphere-N is a product marketed by SFP (Specialty Fertilizer Products) LLC, Leawood, Kan. The formulation for dry fertilizer is a 30 to 60 percent maleic itaconic co-polymer calcium salt. The pH of the dry formulation is between 2.5 and 5, according to the label. The rate of use is 0.5 gallon per ton of urea/ammonium sulfate. The formulation for liquid fertilizer is a 40 percent minimum maleic-itaconic co-polymer. The pH of the liquid product is between 1 and 2, according to the label. The rate of mixing with liquid N products is 0.5 gallon Nutrisphere-N per 99.5 gallons of fertilizer solution. A gallon of Nutrisphere-N liquid or dry formulation weighs 9.6 pounds per gallon.

Nutrisphere-N is marketed as both a urease inhibitor and a nitrification inhibitor. Marketing literature explains that the activity of Nutrisphere-N on nitrification is related to its binding to copper ions necessary for the nitrification process in soil bacteria. The activity of the product on urease is based on its binding to nickel ions necessary for the formation and function of the enzyme. Also, the product Avail, which is marketed as a phosphate-enhancing product by SFP, contains the same active ingredient as Nutrisphere-N.

The Avail activity is attributed to binding of calcium or iron ions in the soil that normally might bind phosphate. Based on the mode of action of the active ingredient of Nutrisphere-N/Avail, the compound is highly negatively charged and would tend to bind with any compound with a positive charge, not distinguishing one ion from another.

The most consistent yield increases and crop uptake of N from the use of Nutrisphere-N has been through work by Gordon (2008). In two years of corn at Scandia, Kan., and two years of grain sorghum at Belleville, Kan., yield increases from the use of Nutrisphere-N were similar to those achieved with urea-Agrotain and ESN (Environmentally Smart Nitrogen, Agrium Inc.) (Tables 7 and 8).

The consistent results from Gordon (2008) are very curious, considering that careful laboratory experiments by Goos (2008) and Norman (Franzen et al., 2011) have shown that Nutrisphere-N has no nitrification or urease inhibitor ability (Figures 5 and 6, Table 9).

Laboratory experiments clearly show that no nitrification inhibition or urease inhibition occurs by Nutrisphere when used at label rates. Goos has observed some small nitrification inhibition when the Nutrisphere for liquid fertilizer is applied in a concentrated band. He attributes this to the strong acidity of the liquid formulation and not to the Nutrisphere itself (Goos, personal communication, 2010). Acid conditions are known to inhibit nitrification bacteria (Schmidt, 1982).

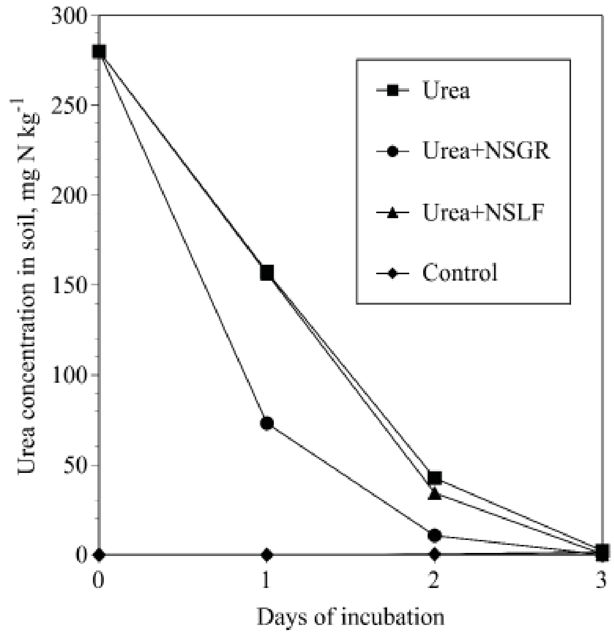


Figure 5.

Urea remaining in an Overly soil, as influenced by time of incubation, and application of urea, urea plus Nutrisphere-N for granular fertilizers (NSGR) and urea plus Nutrisphere-N for liquid fertilizers (NSLF).

Experiment by R.J. Goos in Franzen et al., 2011.

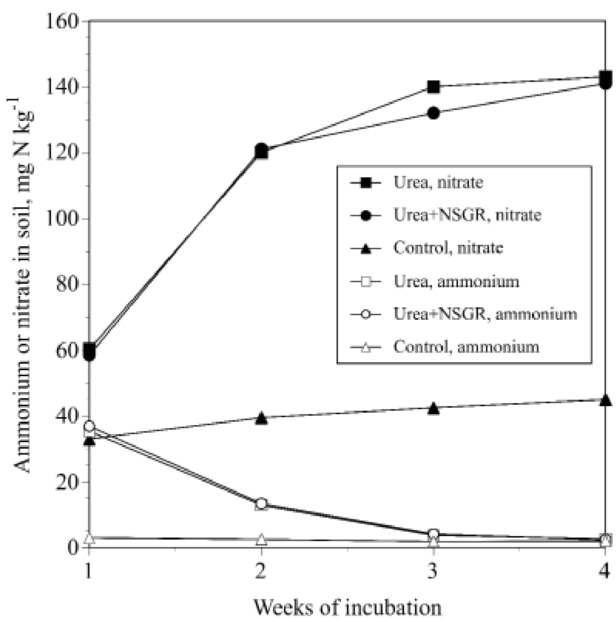


Figure 6.

Ammonium and nitrate in a Renshaw soil as influenced by length of incubation and application of urea granules, and urea granules treated with Nutrisphere-N for granular fertilizers (NSGR).

Experiment by R.J. Goos, in Franzen et al., 2011.

Table 7. Effects of N additive, averaged over source (UAN and urea) and N rate on corn grain yield, earleaf-N and grain-N, Scandia, Kan. (2-year average). *(From Gordon, 2008.)*

Treatment	Yield	Earleaf N	Grain N
	bu/acre	%	%
Check	152	1.72	1.13
Urea/UAN	168	2.57	1.26
ESN	185	2.96	1.33
Nutrisphere-N	183	2.96	1.35
Agrotain	183	2.98	1.36
LSD 5%	6	0.09	0.04

Table 8. Effects of N source and rate on grain sorghum yield, Belleville (2-year average). *(From Gordon, 2008.)*

Treatment	N-Rate	Yield
	lb/acre	bu/acre
Check	0	71
Urea	40	108
	80	122
	120	128
ESN	40	120
	80	130
	120	132
Urea + Agrotain	40	116
	80	129
	120	133
Urea+ Nutrisphere	40	120
	80	133
	120	132
LSD 5%		5

Table 9. Cumulative ammonia volatilization losses for urea, ammonium sulfate, urea + NBPT and urea + 0.25% Nutrisphere (NSN) from a Dewitt silt loam soil during a 15-day laboratory incubation at 25 C. Norman data, University of Arkansas, Fayetteville. *(From Franzen et al., 2011.)*

	Days after N source application			
	3	7	11	15
N sources	Cumulative NH3 loss, % of N applied			
Urea	14.5	35.9	51.8	56.9
Ammonium sulfate	0.1	0.2	0.5	0.6
Urea + NBPT†	0.006	2.7	12.9	18.3
Urea + 0.25% NSN	17.6	42.2	57.8	62.7
LSD(0.05)‡	12.2			
LSD(0.05)§	9.6			

† NBPT= N-(n-butyl) thiophosphoric triamide
‡ LSD to compare means between N sources within the same sampling time.
§ LSD to compare means between sampling time within the same N source.

In the field, consistently finding yield or quality responses to the use of Nutrisphere at the labeled rate is uncommon. In North Dakota studies on spring wheat at eight locations, no yield increases or grain N uptake increases were found with Nutrisphere compared with urea (Franzen et al., 2011). In Kansas (Tucker and Mengel, 2008), no increases occurred due to Nutrisphere with UAN versus UAN surface banded or injected in grain sorghum in 2007.

In two years of corn in Kansas, no yield increases were found from the use of Nutrisphere-N UAN compared with surface-applied UAN at three total sites (Weber and Mengel, 2009). In 2009, no response was found to Nutrisphere + UAN broadcast on grain sorghum compared with broadcast UAN alone in Kansas at three locations (Weber and Mengel, 2010).

One sorghum yield increase occurred with surface-banded Nutrisphere + UAN compared with UAN surface banded alone, and two sites were nonresponsive. The yield increase with surface band but not broadcast suggests that perhaps the acidity of the Nutrisphere may have delayed nitrification at this site (Schmidt, 1982).

At Waseca, Minn., in 2009, no corn yield difference was found between urea and urea with Nutrisphere applied in the fall (Randall and Vetsch, 2009). Grain and stover N between urea and urea with Nutrisphere were similar. In Illinois at two locations in 2008, Nutrisphere-urea was lower in yield than urea and similar in yield at the two locations with UAN and Nutrisphere-UAN (Ebelhar and Hart, 2009). At Dixon Springs in 2009, Nutrisphere urea, UAN and ammonium sulfate treatments did not result in higher corn yield than the N sources with Nutrisphere-N (Ebelhar and Hart, 2010), although the main effects for Nutrisphere-N on corn yield were significant.

In Arkansas and Mississippi, Nutrisphere-N had no effect on rice yields in three field studies compared with urea (Franzen et al., 2011). In South Dakota, Nutrisphere-N did not result in higher corn yield in 2007 (Bly and Woodard, 2007), 2008 (Bly et al., 2008) or 2009 at two sites (Bly et al., 2009).

In Idaho, no spring wheat yield increases were found with Nutrisphere during two years (Jeffrey Stark, personal communication, Aug. 23, 2010). In barley, however, yield increases occurred in 2008 and 2009 with Nutrisphere, but no increase occurred in grain protein versus similar rates of urea. Plant N uptake with Nutrisphere was similar to urea without Nutrisphere, suggesting that the yield increase in barley came from some response other than enhanced N nutrition (Stark, 2008; 2009).

Laboratory studies with Nutrisphere-N show no effect on nitrification or urease activity. Therefore, the findings that the great majority of studies with Nutrisphere show no yield effects are not surprising. What is surprising is that some studies show yield effects, but not from increased N nutrition. The results from Gordon (2008) suggest that under some conditions, Nutrisphere may have some effect on plant growth and development, and even N nutrition not related directly to urease inhibition or nitrification. However, the company may need to re-examine its label as a nitrification inhibitor and urease inhibitor.

Summary

Certain nitrogen additives provide growers with options for extended activity of nitrogen nutrition for their crops. Their economics depends on rainfall following application, application methods, timing and soil characteristics, especially soil texture. Nitrapyrin has been effective in delaying nitrification. Dicyandiamide also has been shown to be effective in delaying nitrification. Thiosulfates have been shown to delay nitrification, but the body of literature to support their use is much smaller than that of nitrapyrin. NBPT (Agrotain) is an effective urease inhibitor. Thiosulfates have shown some urease inhibition characteristics, but again, the body of literature that supports their use is small.

Nutrisphere has been shown to be ineffective as both a nitrification and urease inhibitor. The data that support the use of Nutrisphere is small in comparison with the data that does not support its use. If one accepts that the laboratory studies, conducted in a similar manner to those used to evaluate products such as Agrotain, show that Nutrisphere is not a nitrification or a urease inhibitor, then the small number the field studies that show a yield benefit to the use of the product, and in some circumstances even show an accumulation of N, must have other explanations. The very acidic nature of the liquid formulation of Nutrisphere suggests that in banded applications, the nitrification delay may be associated with the acidity of the solution more than the Nutrisphere itself.

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