RESPONSE OF NO-TILL CORN TO UREASE INHIBITORS AND PLACEMENT OF N SOURCES[1]

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ABSTRACT

N(n-butyl)thiophosphoric triamide (NBPT) and ammonium thiosulfate (ATS) were investigated as urease inhibitors when added to urea and urea-containing N sources and applied to no-till corn. Significant yield increases, some in excess of 20 bu ac^{-1}, were observed with NBPT treatment of the N fertilizers. Lack of a yield response from NBPT, when it occurred, was usually associated with a rain event of major proportions soon after fertilizer application. ATS showed considerably less promise as a urease inhibitor, in that, in only 1 of 4 experiments did a significant yield response result from its employment. The urease inhibiting action of ATS has been suggested to be indirect in nature and may be influenced by the density of residue cover. In these studies there was no clear evidence that placement (broadcasting compared to dribbling) of the inhibitor-treated fertilizers had a any appreciable influence on crop N uptake or yields.

INTRODUCTION

Substantial N losses are observed from surface applications of urea and urea-containing fertilizer sources. The primary loss mechanism is through hydrolysis of urea and the subsequent formation of ammonia (NH_3) which is not completely adsorbed by the soil. Urea hydrolysis is catalyzed by the urease enzyme which is ubiquitous in soils and is especially prevalent in living and decaying plant debris. Consequently, urease levels are high in no-till environments where residues are abundant and microbial populations are active.

Numerous factors are known to be involved in the loss of urea-N as NH_3 in no-till systems. The soil moisture, amount of residue as cover, time following N application before significant rainfall, wind and relative humidity, and the soil properties of texture, organic matter content, acidity, and cation exchange capacity are all suggested by researchers as playing a role in influencing loss.

As the availability and use of urea as a N source in crop production has increased, so has efforts to identify and develop a urease inhibitor for practical field application. Recently, research has focused on three compounds for their potential as a urease inhibitor to reduce ammonia volatization losses under field conditions. They are phenylphosphorodiamidate (PPDA), N-(n-butyl)thiophosphoric triamide

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(NBPT), and ammonium thiosulfate (ATS). Both PPDA and NBPT are substituted phosphoroamides while ATS is an inorganic compound having reducing properties and which is currently being produced and marketed in the fertilizer trade. ATS as a fertilizer has an analysis of 12-0-0-26S.

OBJECTIVE

It is the objective of this report to share results obtained with NBPT and ATS inclusion with urea and urea-containing fertilizers on the yield and N composition response of no-till corn in southern Illinois.

MATERIALS AND METHODS

Field evaluations of NBPT were conducted in 1985 at Belleville and in 1987 and 1988 at Belleville and Carbondale. Studies with ATS were conducted in 1987 and 1988 at both Belleville and Carbondale. Soils at the Belleville site were primarily Iva silt loam (fine-silty, mixed, mesic Aeric Ochraqualfs) having a pH of 6.6 and an organic matter content of 1.4 percent. At Carbondale studies were conducted on a Stoy silt loam (fine-silty, mixed, mesic, Aquic Hapludalfs) having a pH of 6.4 and an organic matter content of 1.6 percent. For all three years at Belleville the experimental corn crop was planted into residues of a previous corn crop. At Carbondale the previous crop residues in 1987 were wheat stubble that was double-cropped to no-till grain sorghum following wheat harvest. In 1988 the previous crop residues were no-till corn.

In all experiments placement of the fertilizer treatments was either by broadcasting on the surface or sidebanding (dribbling) near the corn rows. Several studies included companion treatment comparisons where the N sources were injected into the soil using Nutri-Blast® 2000 or a plot scale point injector system. Urea-N sources evaluated were granular urea, urea solution (US, 15-0-0), and 28% N urea-ammonium nitrate solution (UAN). Urea coated or cogranulated with NBPT, and product for inclusion with solution N sources, were obtained from EniChem Americas, Incorporated, and ATS was obtained from the Arcadian Corporation.

A preplant application of ammonium sulfate to provide 10 pounds of sulfur per acre was broadcast over all experiments to reduce the potential for a sulfur response in all experiments that involved ATS. All experimental treatments were applied after corn emergence at the 2 to 4 leaf stage of development.

RESULTS AND DISCUSSION

A significant response to NBPT coating on urea was observed at Belleville in 1985 (Table 1). Yield increases in excess of 20 bu ac^{-1} were observed from the use of the chemical compared to non-treated urea. This response was observed with both broadcast and sideband placement of the fertilizer and was nearly the same at either 75 or 150 lbs N ac^{-1}. Generally, yields from non-treated UAN sources were intermediate between those of conventional urea and the NBPT-treated urea. Ear leaf N concentrations generally followed the observed yield patterns.

In 1987 and 1988 studies on the effects of different concentrations of NBPT cogranulated with urea were conducted at a fixed N rate at Belleville and Carbondale (Table 2 and 3). In 1987 a significant grain yield response was obtained at Carbondale with 0.25 percent NBPT compared to non-treated urea, but at Belleville a concentration of 0.50 percent was necessary to obtain a significant yield increase. Higher yields from dribble placement were observed compared to broadcasting at Belleville but yields were not different as a function of placement at Carbondale. NBPT inclusion had no effect on ear leaf N concentration at Belleville but resulted in higher levels of leaf N at Carbondale.

Yields in 1988 were affected by drought but NBPT treatment of urea again enhanced grain yields at both locations (Table 3). As was observed in 1987, a concentration of only 0.25 percent was necessary to obtain a significant yield increase at Carbondale, but urea treated with 0.50 percent NBPT resulted in a higher yield than the urea treatment with 0.25 NBPT. Placement of the treated fertilizers had no influence on yields at Belleville but broadcast treatments were superior to dribbling at Carbondale, especially at the lower and zero NBPT rates. NBPT treatment of urea significantly increased leaf N concentrations at both locations in 1988.

Experiments that included ATS and NBPT as a urease inhibitors were conducted at Belleville and Carbondale in both 1987 and 1988 and the results are given in Table 4. In these experiments N sources were either urea solution (US) or urea-ammonium nitrate (UAN) solution that was amended with different rates of the two inhibitors. At Carbondale in 1987, no significant treatment effects were observed because a three-inch rain was received less than 48 hours after treatment application. This probably nullified any possible manifestation of a treatment effect. In 1987 at Belleville yield enhancements from urease inhibitor inclusion with US, but not UAN, were observed. ATS applied at 5 percent of the treatment N rate (~10% by volume) significantly increased corn yields over non-treated US when dribble placed. This increase was about 11 bu ac^{-1}. However, NBPT inclusion with US that was dribble placed resulted in an additional 11 bu ac^{-1} increase in yield over the 5 percent ATS treatment. The addition of ammonium polyphosphate (APP, 10-34-0) to ATS treatment of US that was broadcast approached significance in the enhancement of yields. This suggested that the acidifying properties of APP may have played a role in decreasing ammonia volatilization. It was generally observed that injection of the N sources (especially US) with Nutri-Blast was not as effective as broadcast or dribble placement of US. These effects were observed at both Belleville and Carbondale.

In 1988 ATS at 2.5 or 5.0 percent (~ 5 and 10% by volume, respectively) did not have any direct effect on yields when added to either US or UAN. Evidence of some enhancement of yield was observed when APP was included with ATS and added to US, which was subsequently dribble placed. Significant yield increases were again observed with NBPT addition to urea solutions that were either broadcast or dribble placed. NBPT additions to UAN at either location had no significant effect on yields. The highest yields at Carbondale were those that resulted from point injection of the N fertilizer sources and were clearly higher than any of the broadcast or dribbled treatments.

CONCLUSIONS

Three years of field studies with NBPT as a urease inhibitor have demonstrated its strong potential to increase N use efficiency and corn yields under no-till production conditions in southern Illinois. In six of seven experiments in which NBPT was part of the treatments investigated, significant grain yields were observed with its employment.

ATS demonstrated much less promise as a urease inhibitor. In only 1 of 4 experiments in which it was studied as an additive to liquid N sources did a significant yield result from its employment. Research at North Dakota State University has suggested that ATS does not serve directly as urease inhibitor but as a reducing agent in the soil to form soluble metal ions which in turn deactivate the urease enzyme. In generally, no clear cut evidence was shown to indicate that urease inhibitor performance was strongly influenced by placement method on the soil surface.

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Table 1. Effect of nitrogen placement, sources, and NBPT on no-till corn yields and leaf N composition for N applied at 75 and 150 pounds of N per acre at Belleville in 1985.

N Source/Placement	Yield 75	Yield 150	Yield MEAN	Ear Leaf N 75	Ear Leaf N 150	Ear Leaf N MEAN
	------bu ac^{-1}------			---------%---------		
Broadcast						
Urea	68	104	86	1.41	2.02	1.72
Urea + NBPT[1]	83	130	107	1.84	2.40	2.12
UAN	79	118	99	1.56	2.35	1.95
Sideband						
Urea	71	110	91	1.52	2.01	1.76
Urea + NBPT	94	130	112	1.68	2.44	2.06
UAN	85	131	108	1.66	2.45	2.05
Inject[2]						
UAN	88	131	110	1.97	2.66	2.32
Anhy NH_3	88	122	105	1.91	2.39	2.15
Mean	82	122		1.69	2.34	
Control (0-N)		33			1.31	
Statistical Significance and (LSD .05):						
N Rate (1)		**(3.0)			**	
N Source/Placement (2)		**(7.5)			**	
Interaction (1) x (2)		NS			**(0.18)	

[1]NBPT, [N-(n-butyl)thiophosphoric triamide], applied as a 0.92% coating on urea.

[2]UAN inject-applied using Nutri-Blast® 2000.

Table 2. Effect of N-(n-butyl)thiophosphoric triamide (NBPT) treated urea applied at 120 pounds of N per acre on no-till corn using two placements at Belleville and Carbondale in 1987.

NBPT Coating Treatment	Grain Yield B'Cast	Grain Yield Dribble	Grain Yield Mean	Ear Leaf N B'Cast	Ear Leaf N Dribble	Ear Leaf N Mean
----%----		----------bu ac^{-1}--------			--------------%------------	
Belleville						
0	95	93	94	2.70	2.72	2.71
0.25	94	105	100	2.69	3.76	2.72
0.50	99	112	106	2.70	2.80	2.75
Mean	96	103	100	2.70	2.76	2.73
Control (0-N)		(14)			(1.26)	
Stat. Sign.[1] and (LSD .05):						
NBPT (1)		**(6.8)			NS	
Placement (2)		*(5.5)			NS	
Interaction (1)x(2)		NS			NS	
Carbondale						
0	83	88	85	2.44	2.33	2.38
0.25	103	102	102	2.46	2.66	2.56
0.50	110	104	107	2.69	2.79	2.74
Mean	99	98	98	2.53	2.59	2.56
Control (0-N)		(56)			(1.65)	
Stat. Sign.[1] and (LSD .05):						
NBPT (1)		**(7.7)			**(0.21)	
Placement (2)		NS			NS	
Interaction (1)x(2)		NS			NS	

[1]NS = Not significant at the 5 percent level. *,** = Significant at the 5 and 1 percent levels, respectively.

Table 3. The effect of N-(n-butyl)thiophosphoric triamide (NBPT) treated urea applied at 120 pounds of N per acre on no-till corn using two placements at Belleville and Carbondale in 1988.

NBPT Coating Treatment	Grain Yield B'Cast	Grain Yield Dribble	Grain Yield Mean	Ear Leaf N B'Cast	Ear Leaf N Dribble	Ear Leaf N Mean
----%----		----------bu ac^{-1}--------			---------------%------------	
Belleville						
0	83	75	79	2.37	2.34	2.36
0.25	92	93	93	2.68	2.67	2.68
0.50	101	99	100	2.52	2.65	2.59
Mean	92	89	91	2.52	2.55	2.54
Control (0-N)		(47)			(1.51)	
Stat. Sign.[1] and (LSD .05):						
NBPT (1)		**(7.0)			**(0.11)	
Placement (2)		NS			NS	
Interaction (1)x(2)		NS			NS	
Carbondale						
0	81	75	78	2.22	2.18	2.20
0.25	98	90	94	2.38	2.36	2.37
0.50	93	94	94	2.37	2.34	2.35
Mean	91	86	89	2.32	2.31	2.31
Control (0-N)		(26)			(1.40)	
Stat. Sign.[1] and (LSD .05):						
NBPT (1)		**(3.3)			**(0.09)	
Placement (2)		**(2.7)			NS	
Interaction (1)x(2)		*(4.7)			NS	

[1]NS = Not significant at the 5 percent level. *,** = Significant at the 5 and 1 percent levels, respectively.

Table 4. The effect of urease inhibitor inclusion with urea and urea-ammonium nitrate solutions on no-till corn yields at Belleville and Carbondale in 1987 and 1988.

	1987				1988			
	Belleville		Carbondale		Belleville		Carbondale	
Treatment[1]	Urea Solution	UAN	Urea Solution	UAN	Urea Solution	UAN	Urea Solution	UAN
	------------bu ac^{-1}------------				------------bu ac^{-1}------------			
Broadcast								
0	87	96	96	99	93	107	109	112
2.5% ATS	87	101	96	94	94	110	109	118
5.0% ATS	91	100	87	93	92	111	105	117
2.5% ATS + 20% APP	96	90	80	93	101	106	112	119
2.0 lbs NBPT ac^{-1}	93	100	96	94	103	111	123	114
Dribble								
0	89	106	92	94	90	107	102	115
2.5% ATS	90	104	95	99	91	112	102	119
5.0% ATS	100	104	95	97	88	106	103	124
2.5% ATS + 20% APP	90	106	92	102	91	108	109	118
2.0 lbs NBPT ac^{-1}	111	107	92	94	104	114	114	120
Inject	86	106	84	92	120	128	123	118
LSD .05	10		NS		10		12	
Control (0-N)	15		62		47		34	

[1]Total N application was 120 lbs N ac^{-1} in all treatments. ATS (ammonium thiosulfate, 12-0-0-26%S) N applied as the indicated percentages of the total treatment N. APP (ammonium polyphosphate, 10-34-0) applied as the indicated percentage of the total solution volume. NBPT [N-(n-butyl) thiophosphoric triamide] is a urease inhibitor from EniChem Americas, Inc.

Injection in 1987 was by Nutri-Blast® 2000. In 1988 injection was by means of a modified point injector.

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