USE OF NITROGEN MANAGEMENT PRODUCTS AND PRACTICES TO ENHANCE YIELD AND NITROGEN USE EFFICIENCY IN NO-TILL CORN

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Abstract

Long- term research has shown that nitrogen (N) fertilizer is usually needed to optimize corn production in Kansas. Research has also shown differences in the response to various N fertilizers, products, and practices, particularly in the eastern portion of the state, where soil and climatic conditions regularly can lead to N loss. A project was initiated in 2008 and continued in 2009 to quantify how a number of currently marketed products and commonly utilized management practices performed at supplying N to no-till corn. Conditions in 2008 and 2009 at these locations were conducive for N loss from ammonia volatilization, immobilization and denitrification. A significant response to N fertilizer as well as a significant difference in performance among N fertilizers, enhancement products, and application practices was observed. Using currently available tools to protect N from volatilization, immobilization and/or denitrification loss significantly increased yields in these experiments.

Introduction

The purpose of this study was to evaluate the performance of different N fertilizer products, fertilizer additives, and application practices used in Kansas and determine whether specific combinations did improve yield and N use efficiency of no-till corn. The long-term goal of the study was to quantify some of these relationships to assist farmers in selecting specific combinations of fertilizer products, additives and application techniques that could enhance yield and profitability on their farm. In this study, four types of tools for preventing N loss were examined: fertilizer placement, or putting N below surface residue to reduce ammonia volatilization and/or immobilization; use of a urease inhibitor (NBPT) to block the urease hydrolysis reaction that converts urea to ammonia and potentially could reduce ammonia volatilization; the use of a additive that contains both a nitrification inhibitor (DCD) and a urease inhibitor to slow the rate of ammonium conversion to nitrate and subsequent denitrification or leaching loss; and the use of a polyurethane plastic-coated urea to delay release of urea fertilizer until the crop can use it more effectively. The ultimate goal of using these practices or products is to increase N uptake by the plant and enhance yield.

Materials and Methods

In 2008 the study was initiated at the K-State Agronomy North Farm near Manhattan, KS. The study was continued in 2009 at the Agronomy North Farm and the East Central Kansas Experiment Field near Ottawa, KS. Plots were arranged in the field in a randomized complete block design with four replications. Starter fertilizer was applied to all treatments, including the no N control, at a rate of 20 lb/a N as UAN. At the Manhattan location starter N was applied using a 2x2 placement, at Ottawa it was applied as a surface band. In 2008, 11 treatments were used consisting of broadcast granular urea; broadcast granular urea treated with Agrotain (NBPT, N-butyl-thiophosphoric triamide) a urease inhibitor; broadcast granular urea treated with Super U, a combination of NBPT and DCD (dicyandiamide) a nitrification inhibitor; broadcast-sprayed UAN; broadcast sprayed UAN plus Super U; broadcast granular ESN urea (urea coated with polyurethane); a 50/50 ESN/urea blend; surface band treatments of UAN and UAN plus Super U; and Coulter-banded UAN. Coulter banded treatments were placed approximately 2 in. below the soil surface in the row middles on 30-in. centers. A check plot with starter N was also included. All treatments were applied at the V-2 growth stage, at a rate of 80 lbs N per acre, for a total N application with starter of 100 pounds N/acre. Applications were delayed in hopes of maximizing volatilization loss potential.

In 2009 at both the Manhattan and Ottawa locations, the same 11 treatments used in 2009 were applied at planting, with additional treatments of broadcast sprayed UAN+Nutrisphere-N, and surface banded UAN+Nutrisphere-N, applied at planting and broadcast applications of urea and ESN applied in early February. Broadcast urea treatments of 90, 120, and 150 lbs N/ac were also applied at both sites to determine the shape of the N response curve. Important facts concerning the studies, including soils, planting dates and hybrids used are summarized in Table 1.

Table 1. Important factors in conducting the experiments.

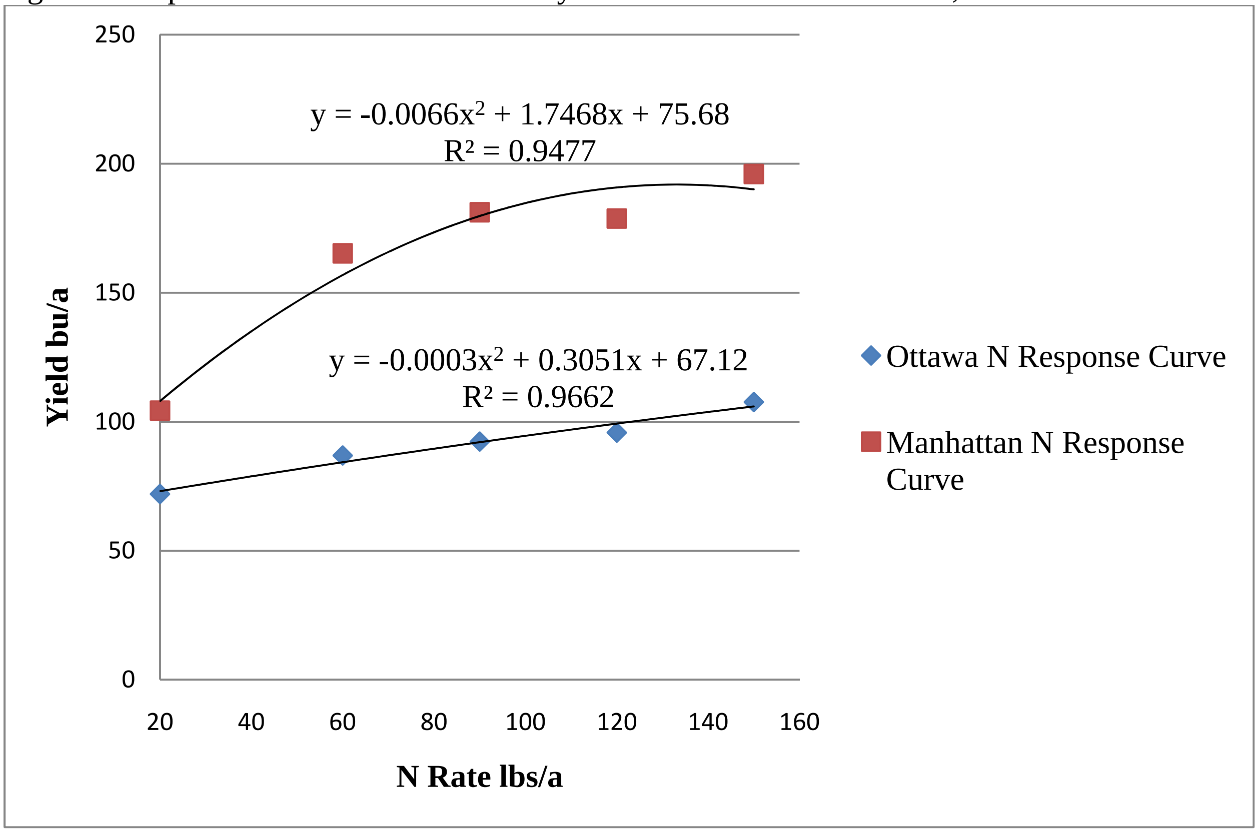
Location and year	Manhattan, 2008	Manhattan, 2009	Ottawa. 2009
Soil Type	Ivan/ Kennebec silt loam	Smolan silt loam	Woodson silt loam
Previous crop	Grain Sorghum	Double crop soybeans after canola	Double crop soybeans after wheat
Corn hybrid	RX785VT3	DKC52-59VT3	DKC52-59-VT3
Planted population	27,000	23,500	26,000
Planting date	23-Apr	23-Apr	20-May
Winter applications	N/A	4-Feb	6-Feb
Total N Rate	100 lbs/a	80 lbs/a	80 lbs/a
Spring application	16-May	18-May	20-May
Green leaves counted	24-Jul	24-Jul	22-Jul
Whole plant sampling	26-Aug	24-Aug	1-Sep
Harvest	22-Sep	14-Sep	7-Oct

A number of measurements were made to document the relative effectiveness of each treatment. Ear leaves were collected at silking to determine plant N content. Firing ratings (number of green leaves remaining below the ear) were made to evaluate N stress to the plants approximately 10-20 days after pollination. Whole plant samples were taken to measure plant/stover N content at physiological maturity. Ten plants were selected at random from the plot and cut off at ground level. Ears were removed, and the remaining vegetative portions of the plants were weighed and chopped, and a subsample was collected to determine N and dry matter content. In 2008 and 2009 in Manhattan plots were hand harvested, corn was shelled, and samples were collected for grain moisture and grain N content. The Ottawa location corn was mechanically harvested, and grain samples were again collected. Yield was adjusted to 15.5% moisture.

Results and Discussion

Results from these experiments are summarized in Table 2. A significant response to N was obtained in this study in 2008 and in 2009 as shown in Figure 1.

Figure 1. Impact of N fertilization on corn yield at Ottawa and Manhattan, 2009.



Relatively low levels of N in the ear leaf, less than 2.7% N, the critical N level, suggest that the 100 lb/a and 80 lb/a N application was not adequate at this site (Table 1). This sub-optimal N rate was selected to ensure that differences in efficiencies between products were not masked out by over application of N.

The potential for N loss through ammonia volatilization or immobilization loss of surface-applied N was high at all three sites because of moist soil at the time of application, good drying conditions, and a large amount of crop residue on the soil surface. This is typical of the conditions found in eastern Kansas most years, especially where corn is grown in rotations that include wheat.

In 2008, surface application of granular urea and broadcast liquid UAN were significantly less effective at supplying N to the corn than other practices (Table 1). In this study conditions for ammonia volatilization were high for the 10 day period immediately after fertilizer application, with high levels of surface residue, moist soil surfaces, high temperatures and ET, and no significant rainfall. The UAN was particularly affected, likely because it would have been prone to loss of N from both volatilization and immobilization when surface applied. Addition of the urease inhibitor NBPT as Agrotain or Super U significantly improved performance of both products at this site, though less with UAN than urea. This is likely because the primary N loss from granular urea would have been due to volatilization, while broadcast UAN contains only 50% urea, would have been impacted by both immobilization and volatilization. Surface banding, which would have limited immobilization by reducing residue-fertilizer contact, increased performance of UAN. Addition of Super U to the surface-banded UAN further improved performance, likely through urease inihibition and reducing ammonia volatilization. Coulter banding also provided good performance. The polyurethane-coated ESN urea product provided excellent performance, particularly when used in combination with some immediately available urea. The combination of some starter followed by a blend of urea and ESN broadcast after planting is a simple application system that could provide some protection from leaching, denitrification, and volatilization. The all ESN treatment was less effective than the urea/ESN blend, likely a result of too slow release of N from the coated granule, re-enforcing that adequate available N must be present early in the season.

In 2009 at Manhattan, the broadcast treatment of urea applied at planting performed significantly better than when applied in winter, but was less effective than some of the alternative products such as ESN applied at planting (Table 1). The use of urease inhibitors with urea or UAN did not improve performance in 2009, likely because a 3.00 inch rain, which occurred three days after fertilizer application, effectively incorporating any un-hydrolyzed urea. Granular urea was more effective than broadcast UAN at this site in both 2008 and 2009, likely due to the high level of surface residue capable of immobilizing the uniformly applied UAN. Surface banding did not improve UAN performance in 2009, though coulter banding did. The broadcast urea/ESN blend and the urea +Super U treatments were the highest yielding at this location in both 2008 and 2009. In both years high intensity rainfall events 30 to 40 days after fertilizer application occurred, which would have created conditions for denitrification loss. Winter applications of ESN were not as effective as planting time applications of ESN or a ESN/urea blend. Nutrisphere N was not seen to be of benefit at this location in 2009 when added to broadcast or surface banded UAN.

Results from the Ottawa location in 2009 are also summarized in Table 1. Yields were lower than found at Manhattan, likely a result of delayed planting due to heavy spring rains, and significant green snap of plants which occurred with a thunderstorm shortly after tasseling. Approximately 30% of the plants were lost due stalk breakage across all plots. Potential N loss due to ammonia volatilization, immobilization and denitrification was also high. Ear leaf N content was low at this location, well below the 2.7% suggested critical level. Ammonia volatilization was likely high at this site as indicated by the excellent performance of the ammonium nitrate application (non-volatile N source). Conditions were excellent for N loss from volatilization and denitrification as well as immobilization following N applications. Soil conditions at the time of N application were moist, followed by a 5 day period of no rainfall when temperatures were high. In the three weeks following fertilization, there were several rainfall events (<1.0 in) followed by a period of heavy rainfall (> 4 in) which gave a potential for denitrification. In general UAN applications of nitrogen seemed to be less effective than urea applications, regardless of additive products used. The use of additives to fertilizer increased yields only slightly at this site this year. This was likely due to the high denitrification loss potential over an extended period, and the reduced effective plant stand due to greensnap.

Summary

Most fertilizer products, additives and application practices tested in this project did prove to have some benefit, particularly at the Manhattan location in both 2008 and 2009. The relative performance of these management tools varied though as loss potential from mechanisms such as ammonia volatilization, immobilization and denitrification varied from site to site. This indicates a need for growers to match potential loss mechanisms with the particular management practice to maximize N response and crop yield.

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Table 2. Effect of nitrogen product and method of application on corn yields

	Manhattan 2008			Manhattan 2009			Ottawa 2009		
Treatment	Yield	Earleaf N	GL	Yield	Earleaf N	GL	Yield	Earleaf N	GL
	bu/a	%		bu/ac	%		bu/ac	%	
Control	78	1.57	1.75	104	2.10	3.15	72	1.40	3.35
Broadcast urea in winter	N/A	N/A	N/A	138	2.32	4	76	1.60	4.25
Broadcast ESN in winter	N/A	N/A	N/A	154	2.36	4.1	84	1.62	5.25
Urea	133	1.98	2.7	165	2.53	5.15	87	1.56	5.3
Broadcast Urea+Agrotain	158	2.09	2.8	169	2.56	5.75	89	1.61	4.95
Broadcast Urea+Super U	164	1.9	3.45	173	2.38	4.8	91	1.81	5.4
Broadcast ESN-coated urea	147	1.98	3.1	167	2.36	5.55	88	1.71	5.85
Broadcast 50% urea+ 50% ESN-coated urea	164	1.94	2.95	174	2.40	5.2	82	1.80	5.3
Broadcast UAN	116	1.78	2.2	148	2.37	4.3	81	1.49	3.8
Broadcast UAN+ Super U	133	1.82	2.35	142	2.36	4.5	79	1.55	4.35
Broadcast UAN+Nutrisphere-N	N/A	N/A	N/A	149	2.34	3.65	71	1.50	4.05
Surface Band UAN	135	2.13	2.6	148	2.28	4.3	79	1.59	4.1
Surface Band UAN +Super U	158	2.11	3.45	157	2.44	5.05	78	1.69	4.5
Surface Band UAN+Nutrisphere-N	N/A	N/A	N/A	148	2.39	4.15	80	1.64	4.3
Coulter band UAN	151	2.23	3.2	162	2.35	5.35	N/A	N/A	N/A
Broadcast ammonium nitrate	N/A	N/A	N/A	N/A	N/A	N/A	106	1.82	5.8
Broadcast Urea, 90 lbs N/a	N/A	N/A	N/A	181		5.45	92	1.66	5.1
Broadcast Urea, 120 lbs N/a	N/A	N/A	N/A	179	2.61	6.1	96	1.76	5.8
Broadcast Urea, 150 lbs N/a	N/A	N/A	N/A	196	2.62	60	108	1.78	6.2
LSD (.10)	15	0.2	0.48	19	0.16	0.81	10	0.25	0.62

GL= Green leaves below the ear leaf

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