CORN RESPONSE TO ANHYDROUS AMMONIA RATE, TIMING, AND INHIBITOR USE: A REVISITATION

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Abstract

Field experiments were conducted from 2001 through 2003 at three southern Illinois locations to obtain more current data on the effects of anhydrous ammonia rates, application timing, and nitrapyrin (N-Serve) use on corn. Nitrogen rates of 0, 60, 120, and 180 lbs N/ac were evaluated at three times of application (fall, spring pre-plant, and sidedress) with and without nitrapyrin. Corn yield results suggest that fall anhydrous ammonia application is inferior to spring application even if nitrapyrin is added to the fall N. Yields obtained from sidedress-applied treatments were only slightly greater than spring pre-plant treatments and the benefit of nitrapyrin was usually less than 2 bu/ac. Nitrapyrin inclusion to fall-applied ammonia resulted in greater yield increases (about 8 bu/ac) compared to its non addition to ammonia applied at the same timing. However, yields averaged about 7 bu/ac less with fall applications of anhydrous (that included nitrapyrin) compared to spring applications that did not include nitrapyrin. The value of the yield loss (about $14/ac) with fall ammonia applications plus the cost of the nitrapyrin addition (about $8/ac) would mean a net profit reduction of about $22/ac if a producer chose to fall-apply ammonia that included the inhibitor. The loss would be about $32/ac if the producer chose to fall apply the ammonia that did not include nitrapyrin. The results obtained suggest that the current Illinois Agronomy Handbook recommendation remain unchanged. That is, fall nitrogen applications to southern Illinois soils for corn not be made even if an inhibitor is used.

Introduction

The practice of fall anhydrous ammonia application for corn has been rather commonplace in northern and central Illinois, and across wide areas of the northern Corn Belt, where soils remain in a more permanent "deep freeze" during the winter months. In the 1970's, commercialization of nitrapyrin (N-Serve) as a nitrification inhibitor additive to anhydrous ammonia extended the geographic area and feasibility for fall nitrogen (N) application. However, research in Illinois by Touchton et al. (1979) showed that nitrapyrin added to fall-applied anhydrous ammonia degraded more rapidly in southern than northern Illinois soils. This eventually led to the recommendation that fall N applications to corn not be made to soils south of Illinois State Route 16, or roughly the southern one-third of Illinois, regardless of inhibitor use (Illinois Agronomy Handbook, 2003-2004). In recent years, due to a variety of factors, fall anhydrous ammonia applications have increased in southern Illinois and more current data is needed to either substantiate or refute the practice given the numerous crop management and hybrid changes that have occurred over the years.

Previous Research

Extensive research with anhydrous ammonia on corn has been conducted since the introduction of the fertilizer into Midwestern agriculture during the late 1950's and early 1960's. Early works showed that crop N use efficiency, as measured by yield, for fall N was only 80-90% of that obtained from spring applications (Stevenson and Baldwin, 1969; Welch et al., 1971). Detailed studies conducted in Iowa, using ^{15}N-labeled ammonia, suggested that losses ranging from 25-49% of the applied N could occur between the fall and spring seasons (Sanchez and Blackmer, 1988). Inclusion of nitrapyrin with fall applied ammonia was found to enhance soil N recovered as ammonium in the following spring as compared to its non addition (Blackmer and Sanchez, 1988). In Illinois studies, Touchton et al. (1978a) found that nitrapyrin's effectiveness in reducing nitrification was greater in the darker soils of northern Illinois compared to the low organic matter soils of southern Illinois. Elevated rates of degradation of nitrapyrin were also shown to be related to warmer soil temperatures (Touchton et al., 1978b; Gomes and Loynachan, 1984) which may explain its reduced effectiveness in southern Illinois. Corn yield results from fall versus spring applied ammonia, with and without nitrapyrin, have been varied. On a Putnam silt loam in Missouri, similar to soils in southern Illinois, Hanson et al. (1987) reported that, from a fall ammonia application, equivalent yields could be obtained with 15-18% less N if the ammonia were amended with nitrapyrin. Its inclusion with spring applied ammonia results in only three to five percent less N being required for equivalent yields. Averaged across three rates of N as ammonia, they found corn yields as follows: fall applied = 144 bu/ac, fall applied + nitrapyrin = 147 bu/ac, and spring applied = 153 bu/ac. Comparable recent data is largely non-existent for southern Illinois.

Objectives

1. To evaluate nitrogen rates, application timing, and nitrapyrin on corn ear leaf N composition and grain yield.
2. To determine the impact of nitrapyrin on soil ammonium and nitrate levels following fall N application.

Approach

A three-year study was conducted at three locations in southern Illinois from 2001 through 2003 to evaluate corn response to N rate, application timing, and nitrapyrin addition to anhydrous ammonia. Locations of these studies were the Southern Illinois University Belleville Research Center and the Dixon Springs and Brownstown Agricultural Research Centers of the University of Illinois. The studies were conducted on soils typical of those of the region and were all on soils of the Alfisol order. Nitrogen rates were 60, 120, and 180 lbs N/ac and nitrapyrin was included at 0 and 0.5 lb a.i./ac. These six treatments were applied: (a) in the fall (usually November), (b) prior to corn planting (spring), and (c) as a side dressing at the four to six leaf stage of crop development. A 0-N check was included to give a total of 19 treatments. A randomized complete block design with six replications was used at each location.

Soil samples for ammonium and nitrate N were collected from the ammonia shank slots of selected fall application treatments (120 and 180 lbs N/ac without and with nitrapyrin) and the 0-

N check plots at the time of the spring applications. Analyses of the soil samples was performed by Brookside Laboratories, Inc., New Knoxville, Ohio. Ear leaf samples were collected at the tasseling stage and were analyzed for total N composition by the same laboratory as used to determine the ammonium and nitrate in soils. The corn hybrid used in all three years of the study and at all locations was Pioneer 33P67. Additional experimental details are given in Table 1.

Results and Discussion

Ear Leaf Nitrogen Composition and Grain Yield as Influenced by Treatments.

Seasonal growing conditions during this three-year study had a major impact on the corn response at the various locations. Because of drought effects, only the 2001 and 2003 data will be presented for Dixon Springs and only the 2003 data will be presented from Brownstown. All three years of data (2001-2003) will be presented from the Belleville location.

Ear leaf N composition results for the locations and years cited in the above paragraph are shown in Figures 1-6. Tissue N composition, as influenced by N rates, was relatively unaffected by the timing of N application in 2001 at Belleville and Dixon Springs (Figures 1 and 4). However, in 2002 and 2003 leaf N composition was much higher for the spring and sidedress treatments than the fall-applied N treatments (Figures 2, 3, 5, and 6). Nitrapyrin addition to the ammonia did improve leaf N composition for the fall N treatments (increase of 0.14% N) but had little effect on the N composition from the spring or sidedress applications (increase of 0.05% N for both). Over winter losses of some of the fall applied N, especially when not treated with nitrapyrin, probably accounted for the lower leaf N composition results observed with the fall N treatments in the 2002 and 2003 experiments.

Corn yield data for the six site-years is summarized in Table 2-4 and presented graphically by location and year in Figures 7-12. Averaged over all experiments, the yield from sidedressed N exceeded those from spring pre-plant N applications (156 bu/ac versus 151 bu/ac). However, the yield from fall applied N treatments was considerably less at 138 bu/ac. Nitrapyrin addition to fall-applied ammonia was effective in improving corn yield. However, in only one of the before-mentioned six site-year experiments (Figure 7) did the inclusion of nitrapyrin with fall-applied ammonia result in a yield that was equal to the spring-applied treatment without nitrapyrin. Averaged over all six site-years, there was a 7 bu/ac greater yield obtained from spring-applied ammonia without nitrapyrin compared to fall-applied ammonia that included nitrapyrin. Clearly some loss of fall-applied N occurred even with nitrapyrin addition to the ammonia fertilizer that resulted in the lower grain yield compared to spring applied ammonia.

Effects of Nitrapyrin (N-Serve) on Soil Ammonium and Nitrate.

Exchangeable ammonium and nitrate levels found in the ammonia bands of fall-applied N at Belleville and Dixon Springs are given in Figures 13 and 14. The data presented shows the mineral N present in the bands some six months after application in those treatments receiving 120 and 180 lb N/ac without and with nitrapyrin. The mineral N present varied significantly from year to year and from location to location reflecting the impact of overwinter rainfall, temperature and soil variations. The largest contrast was between the 2001 and 2003 winter seasons. In all cases nitrapyrin addition to fall-applied ammonia led to greater amounts of ammonium being present in the bands although the differences were not always significant. The higher ammonium plus nitrate levels found in the ammonia bands, when nitrapyrin was employed, probably accounted for the greater corn yields usually observed compared to when no nitrapyrin was added to the ammonia.

Conclusion

Results of this research continue to support the recommendation in the Illinois Agronomy Handbook that fall nitrogen for corn not be applied to southern Illinois soils regardless if nitrapyrin is added to the fertilizer. Economic as well as environmental concerns renders the practice a "non-BMP".

Acknowledgements

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Table 1. Selected details and conditions of the field research experiments.

	Belleville	**Dixon Springs**	**Brownstown**
Soil Type	Herrick silt loam	Grantsburg silt loam	Cisne silt loam
Tillage	Reduced till	No till	Reduced till
Previous Crop	Soybean	Soybean	Soybean
2001			
Fall Application	October 28, 2000	November 18, 2000	November 2, 2000
Spring Application	April 26, 2001	May 1, 2001	May 3, 2001
Side-Dress Application	June 12, 2001	June 6, 2001	June 13, 2001
Planting Date	April 30, 2001	May 2, 2001	May 3, 2001
2002			
Fall Application	November 1, 2001	November 6, 2001	October 31, 2001
Spring Application	May 28, 2002	May 30, 2002	May 23, 2002
Side-Dress Application	June 25, 2002	June 24, 2002	June 27, 2002
Planting Date	May 31, 2002	May 30, 2002	May 23, 2002
2003			
Fall Application	November 9, 2002	November 19, 2002	November 8, 2002
Spring Application	May 16, 2003	May 28, 2003	May 19, 2003
Side-Dress Application	July 1, 2003	June 20, 2003	June 18, 2003
Planting Date	June 5, 2003	May 28, 2003	May 19, 2003

Table 2. Corn grain yield (bu/ac) as affected by N rate without and with nitrapyrin addition (-/+ NS). Belleville Research Center, 3-year average (2001-2003).

Check (0-N) = 87

	Fall			Spring			Sidedress	
N Rate	- NS	+NS		- NS	+NS		- NS	+NS
60	120	129		136	138		146	153
120	152	163		175	175		178	179
180	168	180		188	187		187	186

Table 3. Corn grain yield (bu/ac) as affected by N rate without and with nitrapyrin addition (-/+ NS). Dixon Springs Agricultural Center, 2-year average (2001 and 2003).

Check (0-N) = 64

	Fall			Spring			Sidedress	
N Rate	- NS	+NS		- NS	+NS		- NS	+NS
60	97	107		112	112		119	120
120	117	126		137	136		142	138
180	130	138		138	138		143	147

Table 4. Corn grain yield (bu/ac) as affected by N rate without and with nitrapyrin addition (-/+ NS). Brownstown Agronomy Research Center, 1-year 2003.

Check (0-N) = 100

	Fall			Spring			Sidedress	
N Rate	- NS	+NS		- NS	+NS		- NS	+NS
60	132	130		132	136		137	152
120	124	133		150	159		159	158
180	146	155		156	157		162	156

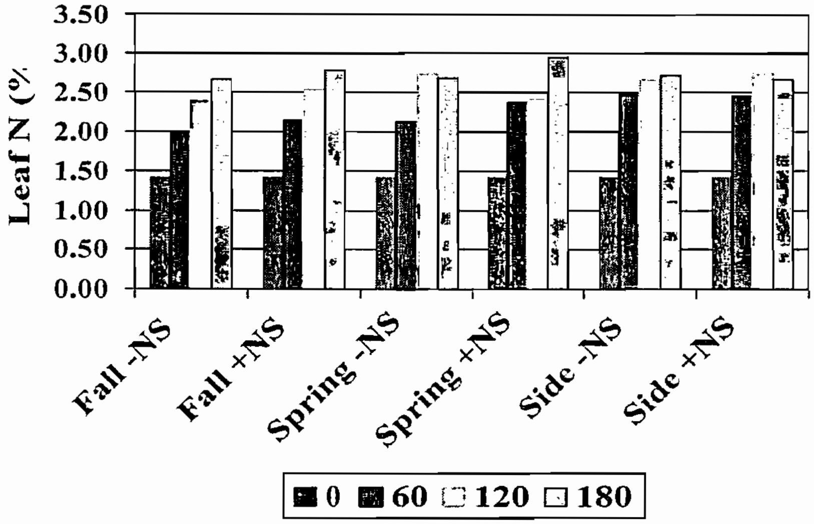

Figure 1. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn ear leaf tissue nitrogen composition. Belleville Research Center, 2001.

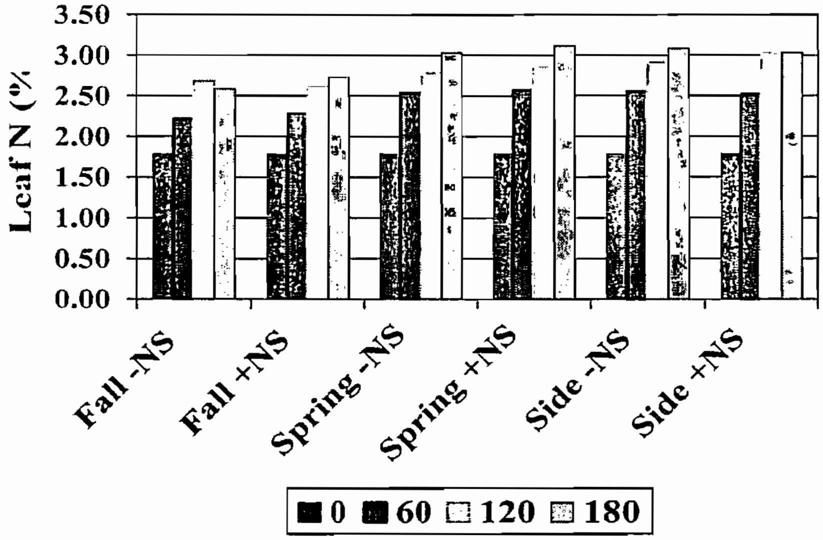

Figure 2. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn ear leaf tissue nitrogen composition. Belleville Research Center, 2002.

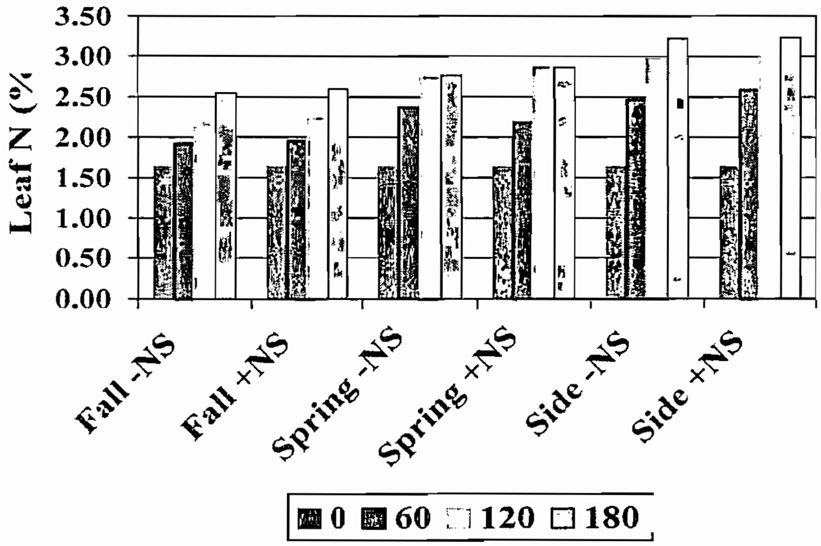

Figure 3. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn ear leaf tissue nitrogen composition. Belleville Research Center, 2003.

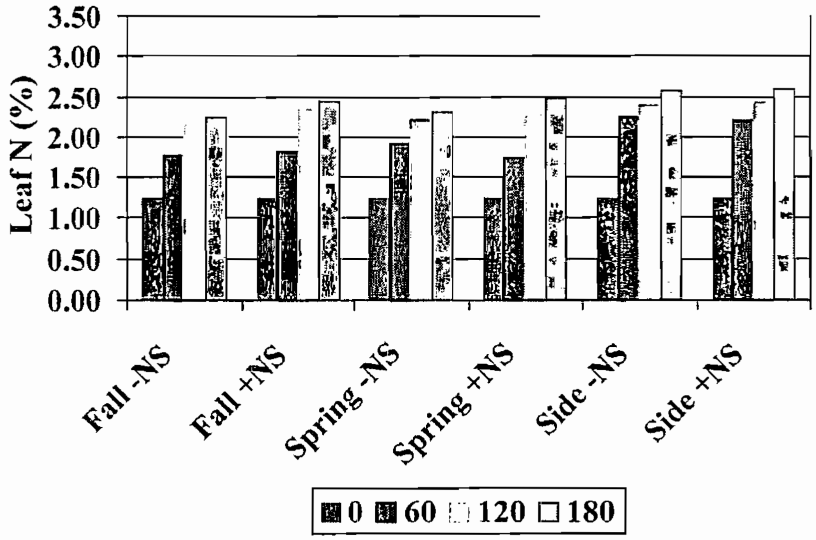

Figure 4. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn ear leaf tissue nitrogen composition. Dixon Springs Agricultural Center, 2001.

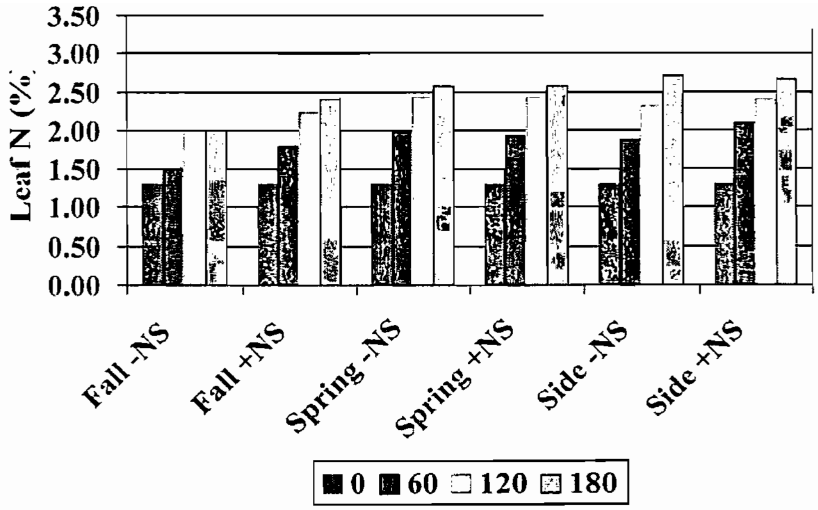

Figure 5. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn ear leaf tissue nitrogen composition. Dixon Springs Agricultural Center, 2003.

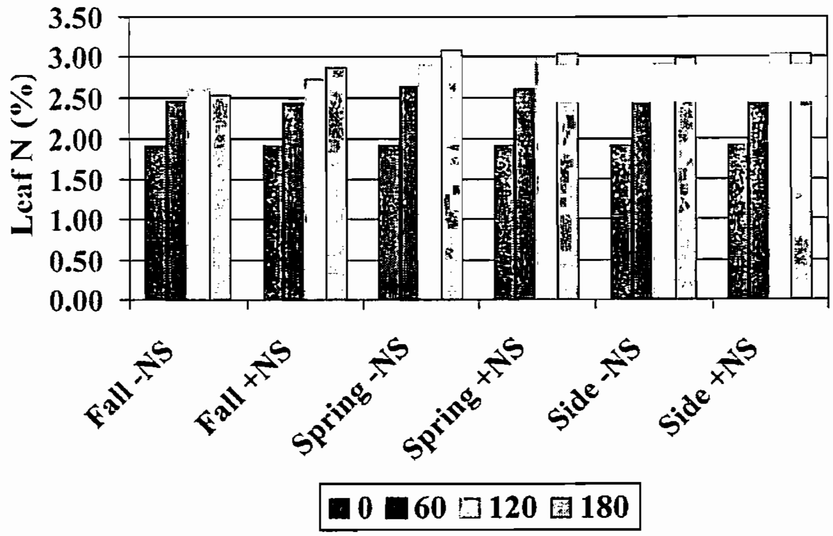

Figure 6. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn ear leaf tissue nitrogen composition. Brownstown Agronomy Research Center, 2003.

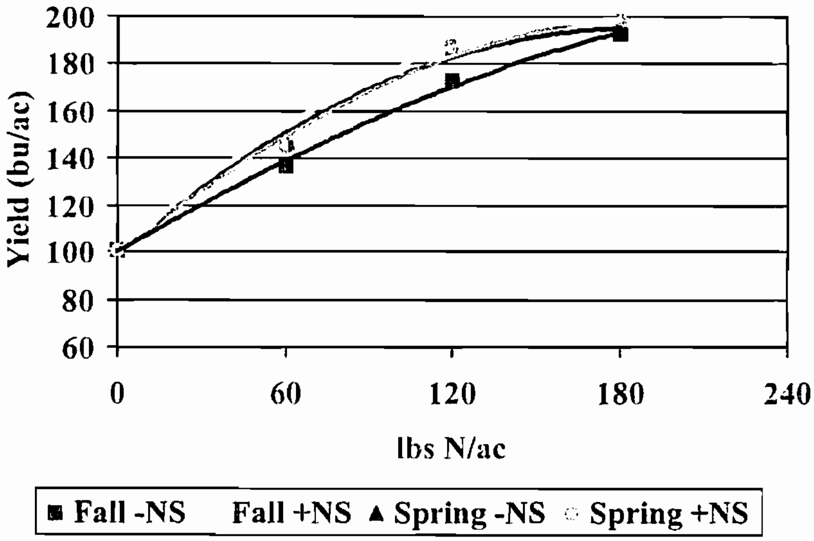

Figure 7. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn grain yield. Belleville Research Center, 2001.

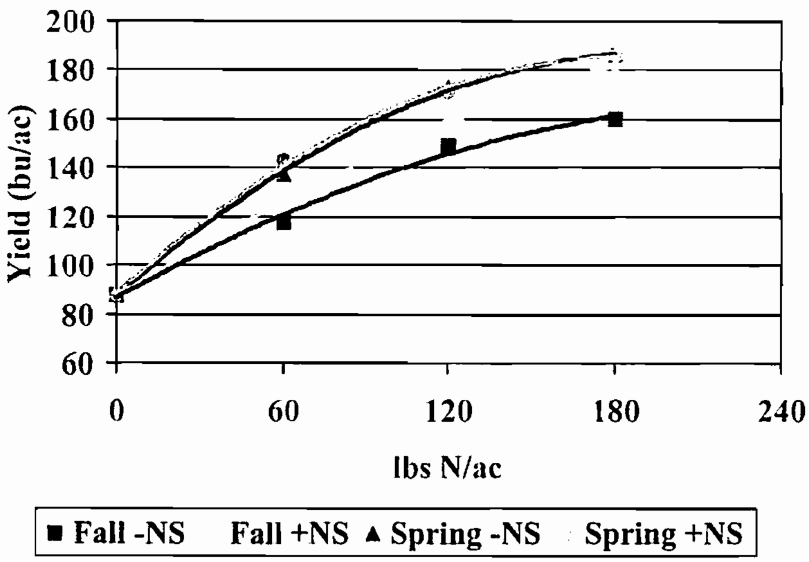

Figure 8. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn grain yield. Belleville Research Center, 2002.

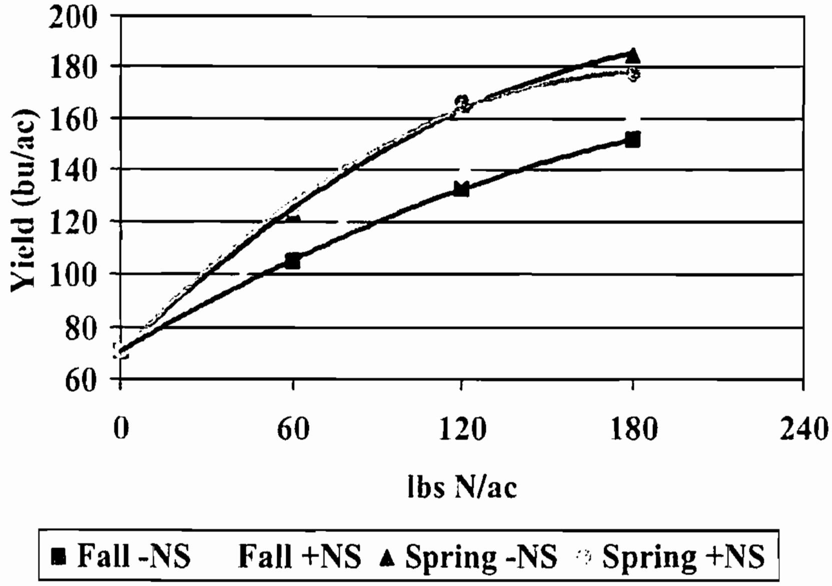

Figure 9. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn grain yield. Belleville Research Center, 2003.

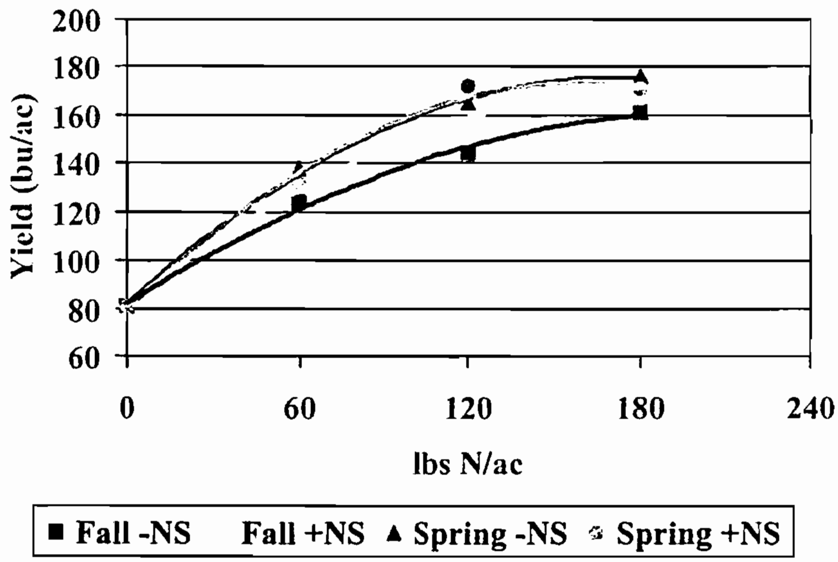

Figure 10. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn grain yield. Dixon Springs Agricultural Center, 2001.

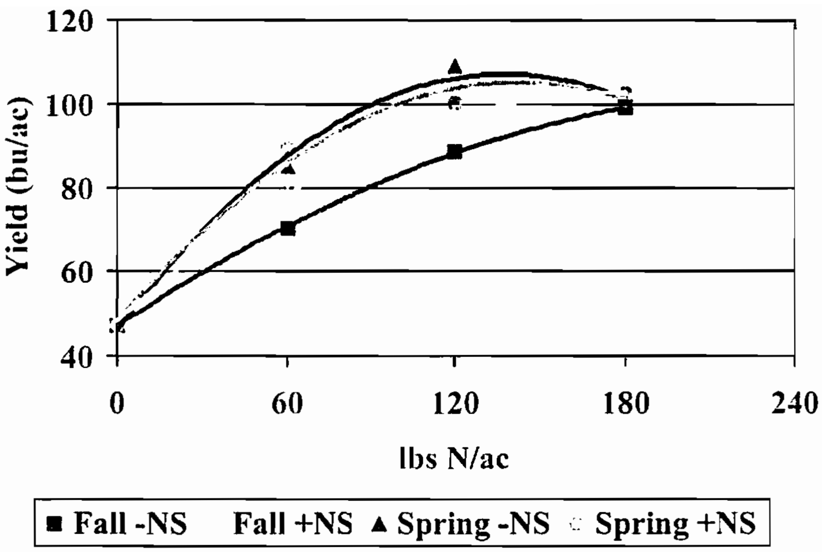

Figure 11. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn grain yield. Dixon Springs Agricultural Center, 2003.

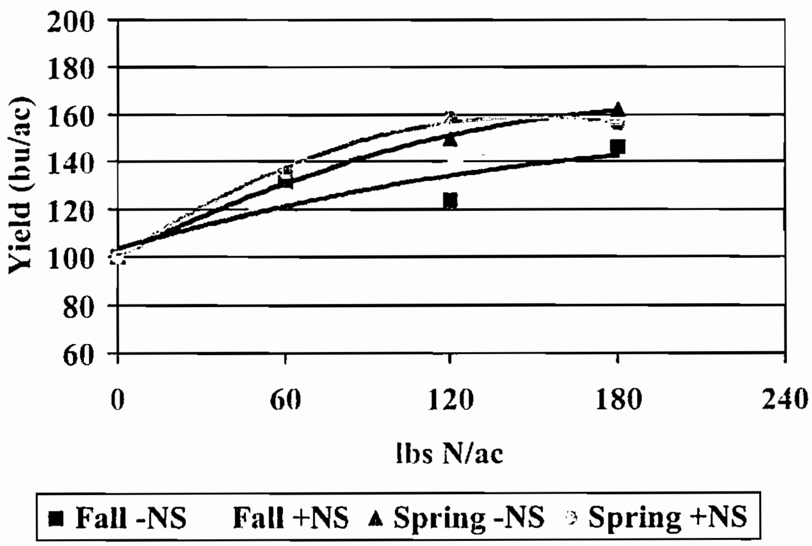

Figure 12. Influence of anhydrous ammonia rate, timing, and nitrapyrin (N-Serve) on corn grain yield. Brownstown Agronomy Research Center, 2003.

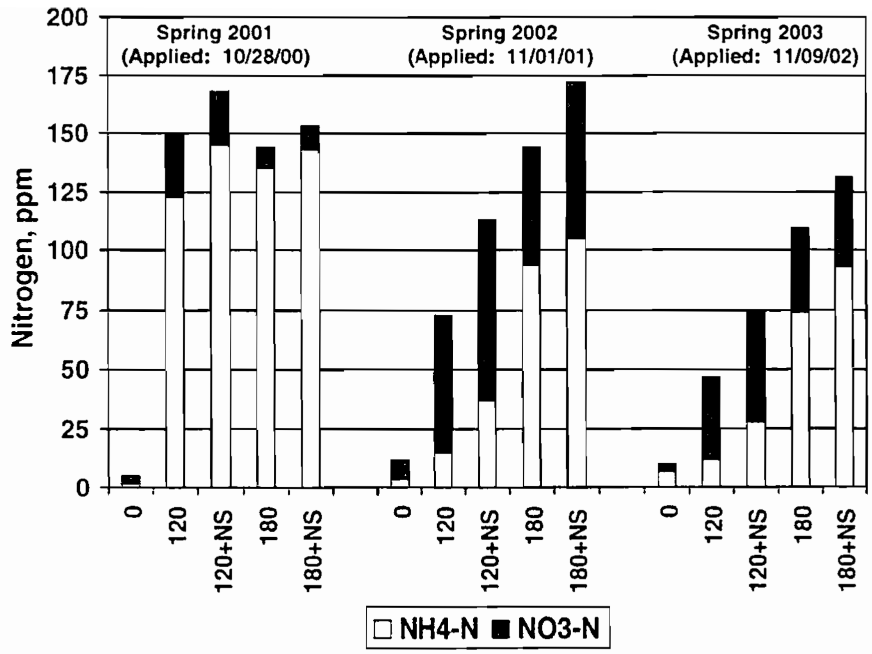

Figure 13. Ammonium and nitrate in the ammonia band, Belleville Research Center, 2001-2003.

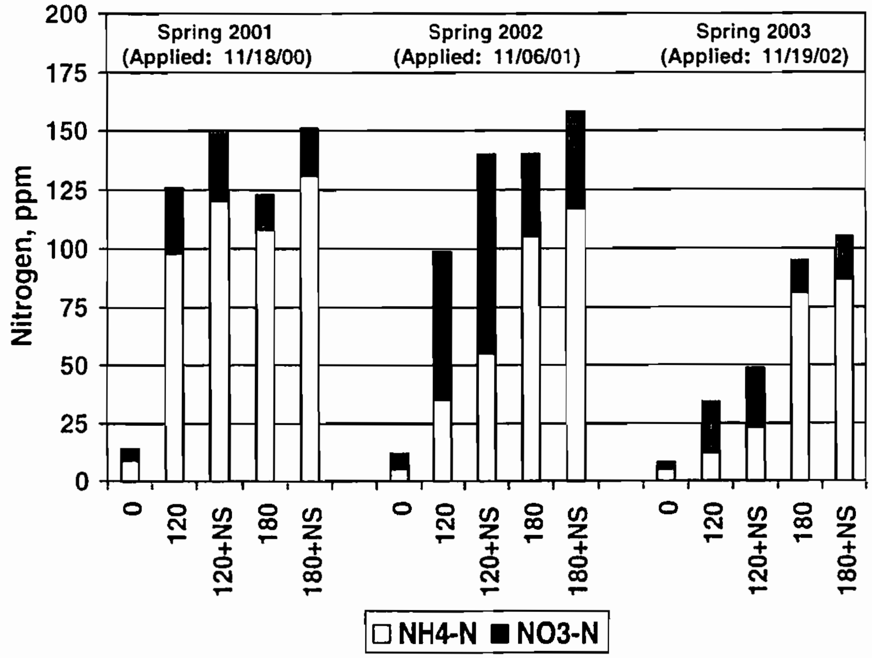

Figure 14. Ammonium and nitrate in the ammonia band, Dixon Springs Agricultural Center, 2001-2003.

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