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Nitrapyrin (N-Serve) With Anhydrous Ammonia At/Near Corn Planting

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Introduction and Background

Higher prices for energy are driving corn fertilizer nitrogen (N) prices higher as well. This increases interest in alternative management practices and products that optimize corn's N nutrition, but maintain grower profit. Alternatives permitting fertilizer N rate reductions include: a) changes in N application timing and placement; b) using alternative sources of N (ex. poultry litter) to meet part of corn's N need; and c) using fertilizer N additives that improve N use efficiency by inhibiting one or more N loss processes in the soil N cycle (biological N transformations).

The *denitrification* process (conversion of nitrate-N into N_2 and N_2O gases) causes significant loss of N on imperfectly drained Kentucky corn soils (moderately-well, somewhat-poorly and poorly drained soils). These soils are prone to longer periods of wetness and low soil oxygen, which drives this biological process. Ammonium-N can not be lost from the soil in this way, regardless of how wet the soil might be. Slowing the conversion of ammonium-N to nitrate-N (*nitrification*) can reduce the possibility of denitrification by depriving soil microbes of needed nitrate-N. Therefore, *reducing denitrification* loss starts with *delaying nitrification*.

Nitrification causes substantial quantities of fertilizer ammonium-N to be converted to nitrate-N over a 3 to 6 week period following application (Schwab and Murdock, 2005). Chemical inhibitors can slow nitrification for several weeks in early spring, which often means that soils become both warmer and drier. Drier soils are less likely to become excessively wet and oxygen starved with later rainfall, and the chances of denitrification are reduced. Warm soil temperatures will also cause inhibitor effectiveness to decline (Murdock, 1985). So, a nitrification inhibitor will only be beneficial if the soil will become drier and the corn crop will soon start to take up fertilizer N. For these reasons, fall N fertilization, either with or without an inhibitor, is never recommended for Kentucky cornfields.

In Kentucky, most cornfields receive needed N fertilizer within an 80 to 90 day period, starting as early as 5-6 weeks before crop establishment and concluding as late as 5-6 weeks after corn planting. Earliest pre-plant corn N applications should be made to well-drained soils (where denitrification losses are not likely). On less than well-drained soils an inhibitor (or a higher N rate) is generally recommended (Anonymous, 2004). In general, most corn producers apply fertilizer N one week either side of corn planting, especially to soils with problematic drainage. When soil conditions are good, growers will complete several field operations (planting, fertilization, etc.) in a short period, for fear of future untimely rainfall. Delayed, side dress application of fertilizer N usually results in less denitrification loss. Therefore, nitrification inhibitors are not recommended for corn fertilizer N applied at this time (Anonymous, 2004; Schwab and Murdock, 2005).

Kentucky research done in the middle 1970's had found that nitrapyrin was beneficial when ammonium nitrate or urea were applied at-planting to the surface of imperfectly drained no-till corn soils (Frye et al., 1981), but only when the fertilizer N rate was clearly yield-limiting (from 75 to 125 lb N/acre). Information on the benefit of inhibiting nitrification when anhydrous ammonia is injected at or near corn planting, over a wide range of imperfectly drained western Kentucky corn soils, was needed. At the time this work was completed, fertilizer N prices were relatively low and the research results were "largely academic". That is no longer the case.

Experimental Methodology

The objective of this research was to evaluate the yield impact of the nitrification inhibitor, nitrapyrin (N-Serve®), applied with anhydrous ammonia at corn planting to imperfectly drained soils in the western Kentucky corn production region, over a range of producer-defined N application rates.

In 1993 and 1994, eighteen comparisons were established in eight different counties with eleven different cooperating growers (Table 1). Some counties were represented more than once, in a single season, because cooperators wanted to evaluate more than one fertilizer N rate, more than one corn variety, or more than one field/soil type. Corn followed soybean or wheat/double crop soybean at all locations. No-tillage soil management was used at three sites, but primary tillage (via disk or chisel plow) was performed at all others. Comparisons (without nitrapyrin versus with nitrapyrin) were established at or near (within 3 days) corn planting, either as single side-by-side blocks or as multiple side-by-side strips. Nitrapyrin was introduced into anhydrous ammonia at a rate of 1 quart N-Serve® 24 per acre. Grain yield was determined either by strip combine harvest into a weigh wagon, or hand harvest of four to six representative areas on either side of the line dividing the comparison blocks. Samples of grain were taken and analyzed for grain N concentration, an estimate of grain protein content.

Severe drought limited yield in two comparisons. The soil was well drained, not imperfectly drained, at one location. Two comparisons were removed from the data set due to confounding management issues. These five comparisons were removed, leaving thirteen comparisons for the final statistical analysis (Table 2). The thirteen comparisons were "pooled" as thirteen individual replicates in the larger experiment, comparing corn grain protein and yield in the absence/presence of nitrapyrin.

Table 1. Study sites used in the research

year of study	county location	cooperating grower	collaborating county agent
1993	Carlisle	Curtsinger	Wilson
1993	Fulton A	Moss	Crisel
1993	Fulton B	Moss	Crisel
1993	Hickman A	Rushing	Reber
1993	Hickman B	Rushing	Reber
1993	McLean	Nall	Henson
1994	Christian	Folz	Judy
1994	Hopkins A	Carr	Kelley
1994	Hopkins B	Stanley	Kelley
1994	McLean A	Baird	Henson
1994	McLean B	Baird	Henson
1994	Ballard	Denton	Perry
1994	Carlisle A	Curtsinger	Wilson
1994	Carlisle B	Sterman	Wilson
1994	Fulton	Moss	Crisel
1994	Graves A	Thompson	Green
1994	Graves B	Jones	Green
1994	Graves C	Jones	Green

Table 2. Fertilizer N rate and yield data for comparisons used in the analysis.

Comparison Number	fertilizer N rate	Grain Yield: Without Nitrapyrin	Grain Yield: With Nitrapyrin	Grain Yield Difference	Grain Yield Ratio
	lb N/acre	-----------------bu/acre-----------------			
1	200	176	189	13	1.07
2	178	139	174	34	1.24
3	165	134	142	8	1.06
4	175	182	189	7	1.04
5	164	160	191	31	1.19
6	200	213	213	1	1.00
7	160	137	138	1	1.01
8	160	119	111	-8	0.93
9	212	167	163	-4	0.97
10	160	168	185	17	1.10
11	190	204	214	10	1.05
12	130	99	129	30	1.30
13	130	113	133	20	1.17
average	171	155	167	12*	1.09

* Statistically significant difference at the 95% level of confidence.

Results and Discussion

Overall, use of nitrapyrin significantly (95% level of confidence) raised corn yield, from 155 to 167 bushels per acre. Corn grain protein concentration (data not shown) was not significantly (80% level of confidence) affected by use of nitrapyrin, averaging 8.3% (dry matter basis). These results, taken together, suggest that the greater N availability resulting from use of nitrapyrin tended to enhance yield of the corn crop, rather than increasing N in the grain.

Table 2 illustrates the wide range in crop yield response, whether expressed as the yield increment to use of nitrapyrin (-8 to +34 bushels/acre), or as the ratio of yields with/without nitrapyrin (0.93 to 1.30). This wide range in results was examined to see if the response to nitrapyrin was related to site yield potential. The yield increment to the use of nitrapyrin (Figure 1) and the with/without nitrapyrin yield ratio (Figure 2) were graphed against the yield observed when the inhibitor was not used. Figures 1 and 2 suggest that yield responses to nitrapyrin tended to be smaller, especially in relative terms, as site yield potential increased.

Also, did comparisons where the grower used a greater fertilizer N rate give a lower response to nitrapyrin? The yield increment to the use of nitrapyrin (Figure 3) and the with/without nitrapyrin yield ratio (Figure 4) were graphed against the fertilizer N rate used by the cooperating grower. Both figures show that the response to nitrapyrin tended to fade as the grower's fertilizer N rate rose. In Figure 4, where about 28% of the variation in relative response to nitrapyrin was explained by the grower's chosen N rate, the trend equation suggests that about 5% of the relative response was lost for each additional 20 lb N/acre (between 130 and 220 lb N/acre).

Figure 1. Yield Increment to Nitrapyrin as Related to the Yield Observed Without Nitrapyrin

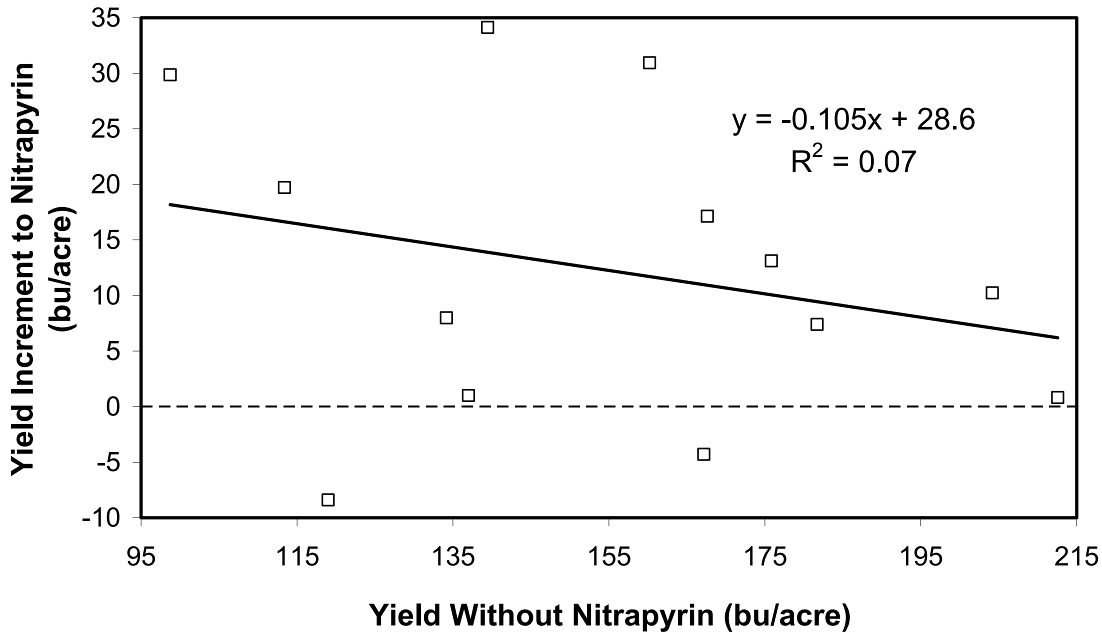


Figure 2. With/Without Nitrapyrin Yield Ratio as Related to the Yield Observed Without Nitrapyrin

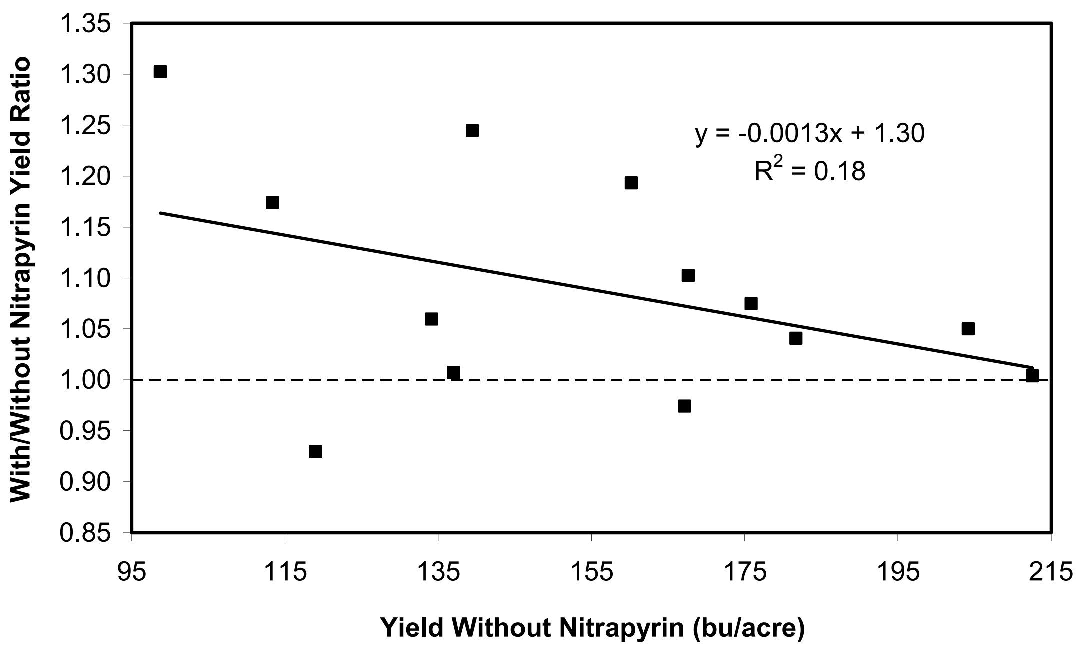


Figure 3. Yield Increment to Nitrapyrin as Related to the Rate of Fertilizer Nitrogen Used

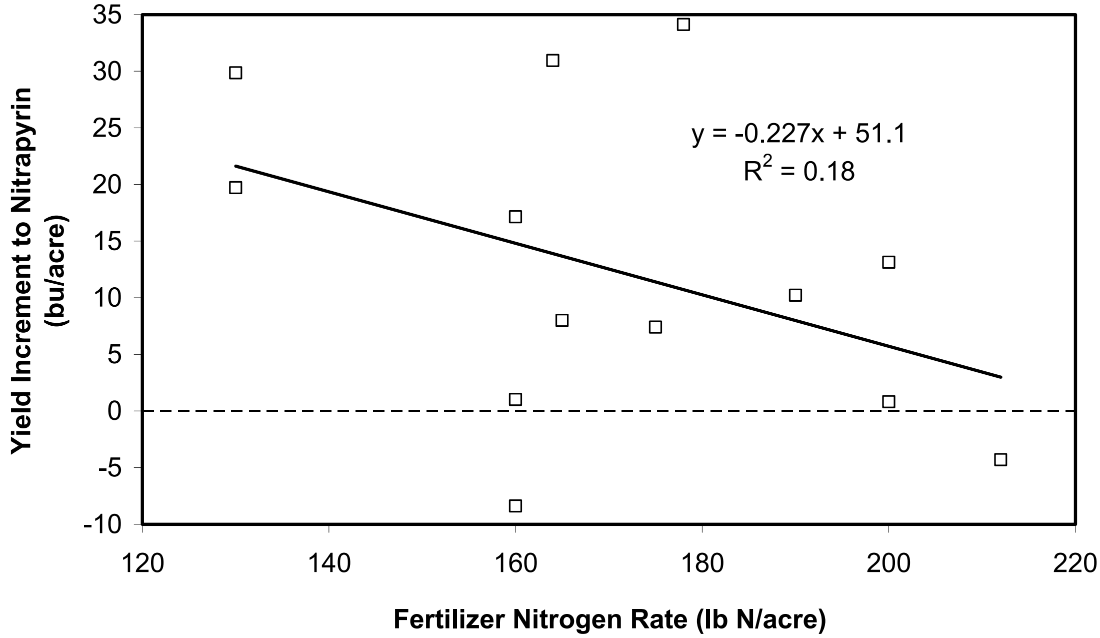
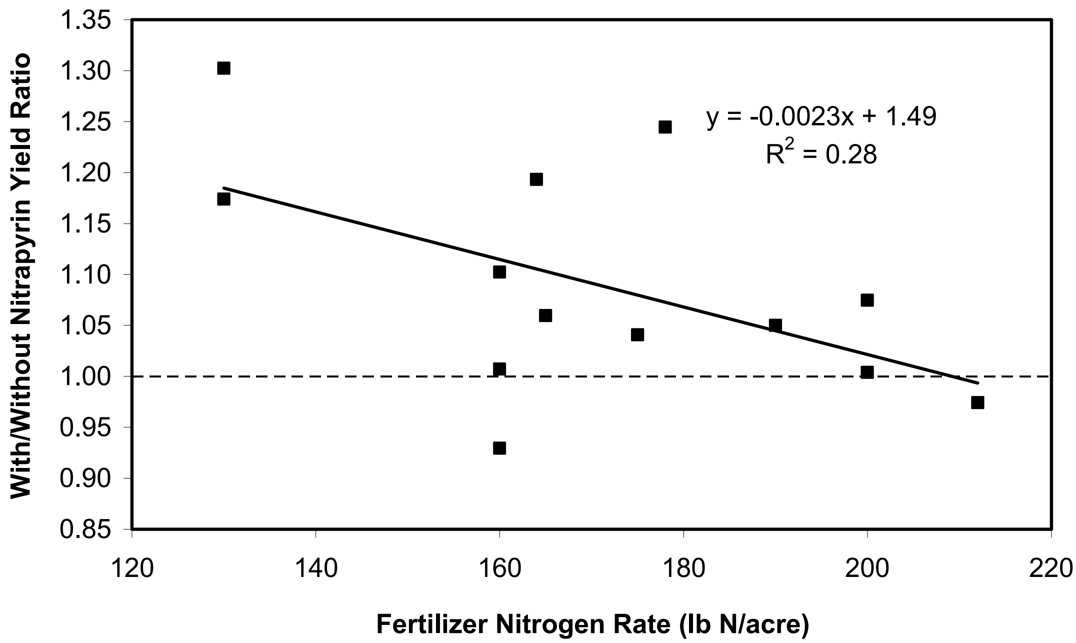


Figure 4. With/Without Nitrapyrin Yield Ratio as Related to the Rate of Fertilizer Nitrogen Used



Conclusions

Additives that inhibit nitrification (slowing both nitrate leaching and denitrification losses) are more economically attractive when N fertilizer prices are high because the corn producer does not have to reduce fertilizer N rates as much in order to recover the economic cost of the additive. Recently, the quoted price for one quart of N-Serve was $8.00. When fertilizer N prices were $0.10 to $0.20 per pound of N, there was more incentive to apply an additional 30 to 50 lb N/acre than to manage (fight with) an alternative N application system. Including inhibitors in the corn N management plan may now be more worthwhile.

In this work, nitrapyrin was generally beneficial (+12 bu/acre) when applied with anhydrous ammonia injected into imperfectly drained soils at or near corn planting. The yield benefit was not consistent, but this was due, in part, to differences in the rate of fertilizer N used. Depending upon the price of corn, 3 to 5 bushels of corn would pay for (breakeven) one quart of nitrapyrin. At 9 of the 13 experimental sites, the yield increment to added nitrapyrin was greater than the breakeven yield increment. Use of nitrapyrin will allow corn producers farming such soils to avoid “insurance” rates of N fertilization, rates greater than recommended (Anonymous, 2004).

Current UK recommendations indicate that fields under conservation tillage soil management should receive the minimum recommended rate of fertilizer N (165 lb N/acre) when a nitrification inhibitor is combined with at-planting anhydrous ammonia. This work does not contradict that recommendation. These results suggest that the recommendation should be applied to all imperfectly drained soils, regardless of the primary tillage system used, when fertilizer N is applied at or near planting.

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Trade Names

N-Serve® is a registered trade name of Dow AgroSciences.

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