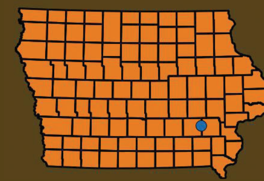

Manure Additives Comparison in Corn Production

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In a Nutshell

- Applying manure or fertilizer with a nitrogen stabilizer has been identified as a practice farmers can use to reduce the potential for nonpoint source pollution of surface waters.
- Farmer-cooperator Tim Sieren assessed the effect on corn yields of liquid swine manure and anhydrous ammonia applied with commercially available nitrogen stabilizers.

Key findings

- Corn yields were the same with and without a nitrogen stabilizer.
- The amount spent on N per bushel of corn produced was significantly greater when a nitrogen stabilizer was used.

Project Timeline:
2013-2014

Farmer-cooperator Tim Sieren of Green Iron Farms.

Background

The Iowa Nutrient Reduction Strategy, released in 2012, outlined several practices farmers can implement to reduce non-point source pollution (Iowa Department of Agriculture and Land Stewardship et al., 2012). One such practice is the use of a nitrogen stabilizer when applying manure to crop ground in the fall. A nitrogen stabilizer works by slowing the conversion of nitrogen in the manure to nitrate by soil microbes. Nitrate is a water soluble, inorganic form of nitrogen that is readily plant-available but is also prone to leaching from the soil with rainfall and drainage (Dinnes et al., 2000). A nitrogen stabilizer has the potential to better align the availability of manure-borne nitrate in the soil with the period of rapid uptake in the corn lifecycle. This in turn would reduce the potential for nitrogen losses from crop production systems that result in the pollution of rivers, lakes and streams. While the use of nitrogen stabilizers with manure might be a good crop management practice in theory, practices like this are in need of "ground-truthing" on commercial farms for agronomic and economic feasibility.

The objective of this research project was to quantify the agronomic and economic effect on corn yields of applying liquid swine manure with commercially available N stabilizers. Comparisons are made to corn yields following manure applied with liquid P and K fertilizer, untreated manure, and anhydrous ammonia applied with liquid P and K fertilizer.

Method

This research project was conducted by Tim Sieren of Green Iron Farms near Keota in Washington County in southeast Iowa. Green Iron Farms is a small, diversified row crop-livestock family farm.

Treatments included liquid swine manure applied with vertical disc injectors in the fall with one of three commercially available nitrogen stabilizers (Instinct®, AGROTAIN® Plus, and More Than Manure™), manure applied with 4-10-10 liquid starter fertilizer (manure + starter), manure with no additives (manure), and anhydrous ammonia applied in the spring with N-Serve® and 25 gal/ac, 4-10-10 liquid starter fertilizer (anhydrous ammonia + N-Serve® + starter) (**Table 1**). The liquid starter fertilizer was applied to appropriate strips at the time of corn planting. The design of the project was a randomized complete block with each of the six treatments replicated three times in strips the length of the field (**Figure 1**). Strips measured 20 ft wide and ranged from 875-950 ft long.

The field was planted to soybeans in 2013 with an average yield of 40 bu/ac. Following harvest, Tim strip tilled the field on November 12, 2013.

Table 1

Treatments applied at Green Iron Farms

Treatment	Manure applied (gal/ac)	N-P-K applied (lb/ac)	Nitrogen stabilizer application rate per acre[a]	Application date
Manure + Instinct®	3,250	117-61-72	35 oz	November 2013
Manure + AGROTAIN® Plus	3,250	117-61-72	52 oz	November 2013
Manure + More Than Manure™	3,250	117-61-72	21 oz	November 2013
Manure + starter	3,250	122-74-85	--	November 2013; April 2014
Manure	3,250	117-61-72	--	November 2013
Anhydrous ammonia + N-Serve® + starter	--	137-26-26	1 qt	April 2014

[a] Instinct® applied at 10.4 oz/1,000 gal manure, AGROTAIN® Plus applied at 1 lb/1,000 gal manure; More Than Manure™ applied at 6.4 oz/1,000 gal manure.

All five manure treatments were applied in the till strips to assigned plots on November 13, 2013 at a rate of 3,250 gal/ac. The manure contained 36 lb N, 19 lb P, and 22 lb K/1,000 gal. Liquid starter fertilizer was applied at a rate of 13 gal/ac (5 lb N, 13 lb P, 13 lb K/ac) at corn planting in April 2014 in the manure + starter treatment. Liquid starter fertilizer was applied at a rate of 25 gal/ac (10 lb N, 26 lb P, 26 lb K/ac) at corn planting in April 2014 in the anhydrous ammonia + N-Serve® + starter treatment.

In mid-April 2014, corn (cv. Pioneer 1498) was planted to all plots. UAN (32%) was side-dress applied to corn in all plots at a rate of 77 lb N/ac on June 11, 2014.

Soil nitrate concentration was determined to a depth of 12 in. by collecting soil samples according to protocols for the late-spring soil nitrate test (LSNT) when corn was six to eight inches tall on June 2, 2014 after Blackmer et al. (1997).

Stalk samples were collected for nitrate concentration analysis (Blackmer and Mallarino, 1996) on September 24, 2014.

Corn was harvested from all strips on November 5, 2014 and corrected for 15.5% moisture.

Data were analyzed using JMP Pro 10 (SAS Institute Inc., Cary, NC) and yield comparisons employ least squares means for accuracy. Statistical significance is determined at $P \leq 0.05$ level and means separations are reported using Tukey's Least Significant Difference (LSD).

Results and Discussion

Total rainfall during the period of April 1-September 30, 2014 at Green Iron Farms was 33.8 in. compared to the 120-year average of 23.1 in. at Washington, Iowa (12 miles from Green Iron Farms) (Iowa Environmental Mesonet, 2014).

Soil nitrate concentrations when corn was six to eight inches tall are provided in **Table 2**. This stage of development in the corn lifecycle marks the beginning of the period of rapid N uptake from the soil (Blackmer et al., 1997). Soil nitrogen in the nitrate form is readily available for plant uptake. The anhydrous ammonia, manure, and Instinct® treatments all resulted in the greatest amount of soil nitrate in the soil at this point in the growing season. From these results, one might be inclined to suggest that the AGROTAIN® Plus and More Than Manure™ nitrogen stabilizers were preventing soil N availability, and the potential for leaching, more so than the Instinct® or N-Serve® additives. However, the manure + starter treatment, which included no stabilizer, resulted in a soil nitrate concentration that was no different than the concentration in the AGROTAIN® Plus and More Than Manure™ treatments.

Stalk nitrate concentrations just after the corn had reached physiological maturity ("black layer") are shown in **Table 3**.

Most treatments result in stalk nitrate concentrations being in the optimal or marginal categories. This signifies that the corn in those treatments had enough N throughout the growing season to ensure maximum yield potential. The anhydrous ammonia treatment resulted in stalk nitrate concentration being in the excess category which suggests that the corn was never lacking in N and that the total amount of N applied in that treatment could have been reduced without affecting yield potential (Blackmer and Mallarino, 1996). This is not entirely surprising as the soil nitrate concentration when the corn was six to eight inches tall in the anhydrous ammonia treatment was quite high, signaling that the corn in that treatment likely did not require any side-dress N applied as recommended by the results of the LSNT (**Table 2**).

Corn yields are provided in **Figure 2**. There was no difference in corn yields among

Figure 1

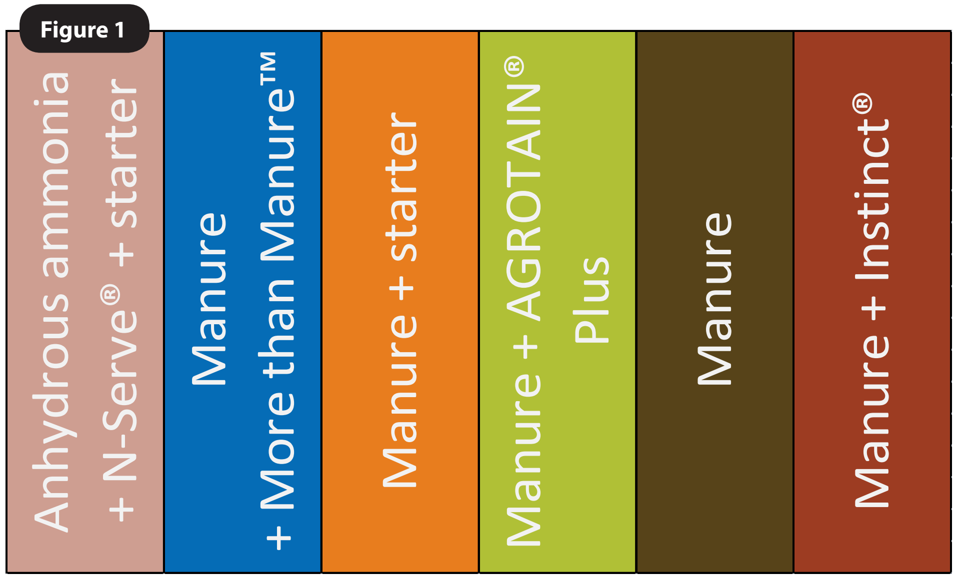

Figure 1. Strip layout in Rep Two comparing nitrogen stabilizers at Tim Sieren's Green Iron Farms.

the treatments. The mean yield across all treatments was 209 bu/ac and the 10-year corn yield average for Washington County is 163 bu/ac (USDA-NASS, 2014).

Economic considerations

Tim provided the costs associated with the N applied and the additives used (**Table 4**). The total cost of the N applied + additive used for each treatment is presented as well as the amount spent on N + additive per bushel of corn produced. Tim spent the most per bushel in the anhydrous ammonia + N-Serve® + starter treatment and the least in both manure treatments that did not involve a nitrogen stabilizer: manure and manure + starter. Tim spent $0.12 more on N per bushel of corn produced in the anhydrous ammonia + N-Serve® + starter treatment compared to the manure and manure + starter treatments, yet yields were not significantly different (**Figure 2**). Tim spent roughly $0.10 more on N per bushel of corn produced when he applied manure with a nitrogen stabilizer compared to when he applied manure with no stabilizer. The two nitrogen stabilizers that resulted in lower soil nitrate concentrations in June, AGROTAIN® Plus and More Than Manure™ (**Table 2**), turned out to be more expensive than Instinct®.

Conclusion and Next Steps

Tim Sieren assessed the effect on corn yields of manure and anhydrous ammonia applied with commercially available nitrogen stabilizers. The manure was applied in the fall prior and anhydrous ammonia was applied just before planting corn. All treatments received 77 lb N/ac as UAN (32%) in a side-dress application in June 2014.

Soil nitrate concentrations in June 2014 were least in the AGROTAIN® Plus and More Than Manure™ treatments that might suggest that, among the nitrogen stabilizers used, these two stabilizers were most effective in delaying soil N availability and reducing the potential for N leaching. Given that corn yields among the treatments were equivalent and stalk nitrate concentrations were generally at levels that would support maximum corn yield potential, it is safe to say that the lower soil nitrate concentrations in June 2014 in the AGROTAIN® Plus and More Than Manure™ treatments were not a detriment to yield. Also, keep in mind that the amount side-dressed in June (77 lb N/ac) was less than what the results of the LSNT recommended (90 lb N/ac; **Table 2**).

Table 2 **Soil nitrate concentrations at the 12 in. depth and soil N contents as affected by treatment on June 2, 2014**

Treatment	Soil nitrate concentration (ppm)[a]	Soil N content (lb N/ac)[b]	LSNT recommendation for side-dress N rate (lb N/ac)[b]
Manure + Instinct®	19.7 a	157.6	0
Manure + AGROTAIN® Plus	5.7 b	45.6	90
Manure + More Than Manure™	4.3 b	34.4	90
Manure + starter	3.7 b	29.6	90
Manure	22.0 a	176.0	0
Anhydrous ammonia + N-Serve® + starter	36.7 a	293.6	0

[a] For soil nitrate concentration, values followed by the same letter are not significantly different at $P \leq 0.05$.
[b] After Blackmer et al. (1997).

Table 3 **Stalk nitrate concentrations in corn just after physiologicalmaturity. Stalk samples were collected on September 24, 2014**

Treatment	Stalk nitrate concentration (ppm)[a]	Interpretation[b]
Manure + Instinct®	740 b	Optimal
Manure + AGROTAIN® Plus	790 b	Optimal
Manure + More Than Manure™	470 b	Marginal
Manure + starter	325 b	Marginal
Manure	316 b	Marginal
Anhydrous ammonia + N-Serve® + starter	3977 a	Excess

[a] Values followed by the same letter are not significantly different at $P \leq 0.05$.
[b] After Blackmer et al. (1996).

Figure 2

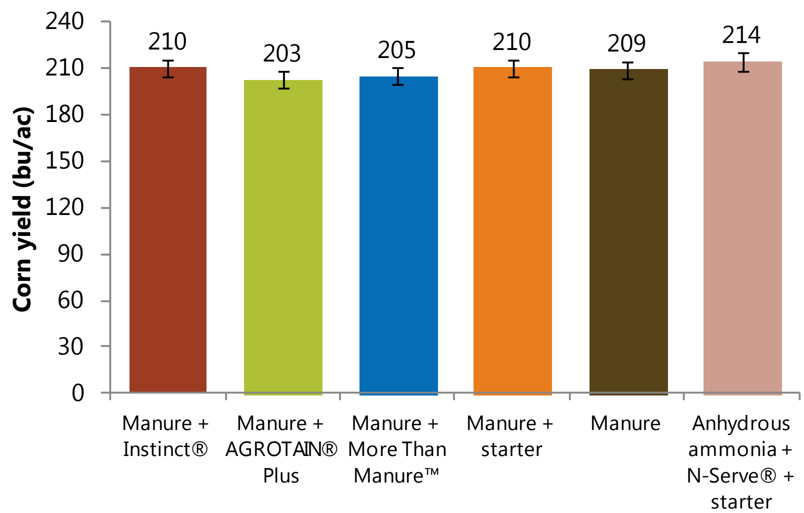

Figure 2. Mean corn yields from strips harvested on November 5, 2014. Black bars about the means represent the LSD (12 bu/ac).

Including a nitrogen stabilizer with the manure or with the anhydrous ammonia proved to be more expensive in terms of total money spent on N per bushel of corn produced. This ranged between $0.02-$0.10/bu in additional expense compared to when no stabilizer was used. The total amount of N applied in the anhydrous ammonia + N-Serve® + starter treatment probably could have been reduced as evidenced by the soil nitrate concentration in June and stalk nitrate concentration at physiological maturity, thus reducing expenses for that treatment.

Tim's results show that including a commercially available nitrogen stabilizer when applying manure or anhydrous ammonia can increase expenses but did not have a negative effect on corn yield. This should alleviate concerns about N tie-up and too low availability of soil N as a result of using nitrogen stabilizers, which ultimately seek to maintain or improve crop yields while preventing mass loss of N from the soil profile through leaching.

Table 4

Costs associated with the treatments

Treatment	Cost of N applied[a] ($/ac)	Cost of additive[b] ($/ac)	Cost of side-dress N[c] ($/ac)	Total cost of N[d]	Average N expense per bu corn ($/bu)[e]
Manure + Instinct®	$16.09	$10.85	$43.72	$70.66	$0.34 c
Manure + AGROTAIN® Plus	$16.09	$16.64	$43.72	$76.45	$0.38 b
Manure + More Than Manure™	$16.09	$19.17	$43.72	$78.98	$0.39 b
Manure + starter	$16.09	$1.21	$43.72	$61.02	$0.29 d
Manure	$16.09	--	$43.72	$59.81	$0.29 d
Anhydrous ammonia + N-Serve® + starter	$29.52	$15.32	$43.72	$88.56	$0.41 a

[a] Local custom rate to apply manure is $0.015/gal x 3,250 gal/ac applied = $48.75/ac. Cost of N in manure is calculated as 33% of the cost to apply the manure as N was considered 1/3 of the intended nutrients applied with the manure. Anhydrous ammonia was quoted at $660/ton.
[b] Additive refers to nitrogen stabilizer and/or starter fertilizer applied. Instinct® quoted at $0.31/oz; AGROTAIN® Plus quoted at $0.32/oz; More Than Manure™ quoted at $0.91/oz; N-Serve® quoted at $13.00/qt; Liquid starter was quoted at $410.04/ton which amounted to $0.21/lb N.
[c] 22 gal/ac of UAN (32%), which is 77 lb N/ac. UAN (32%) was quoted at $350/ton.
[d] Includes the cost of the additive.
[e] Calculated as the total cost of N divided by the corn grain yield from each strip for each treatment. Values followed by the same lower-case letter are not significantly different (LSD = $0.02).

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