Swine Manure Application Timing in Southern Minnesota

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ABSTRACT

This poster describes the results of 12 site-years of research on-farm (9 trials) and on-station (3 trials) in Southern Minnesota. The goal of the experiments was to determine the best time to apply liquid swine manure to corn to maximize crop yields and minimize nitrogen (N) losses.

The small-plot experiment station results indicate that N from fall applied swine manure, which has a high proportion of N in the inorganic, ammonium form, is rapidly converted to nitrate. The earlier the application, the higher the proportion of ammonium that is converted and available for leaching. The total N remaining in the top three feet of the soil profile by June of the cropping year was less for the earlier manure applications than for the later applications in 2008 but not as clear in 2009.

In the on-farm strip trials over two years the contrast of early compared with late manure applications showed that the yields from the September (early) manure application were significantly lower than yields from the later (October-November average) application and lower than from the late urea application. The combined analysis clearly shows a significant loss in yield when manure was applied in September relative to later months.

All of these nitrogen processes are controlled by soil type and rainfall patterns. But in general early application of manure increases the risk for leaching and denitrification losses, since there is no crop present for nitrogen uptake. Liquid swine manure, with a high inorganic N content, should be managed much like inorganic fertilizer N sources with either late fall or spring application to delay conversion of ammonium to nitrate and subsequent loss by leaching and denitrification.

PROJECT GOAL

The goal of the experiments was to determine the best time to apply liquid swine manure to corn to maximize crop yields and minimize N losses.

METHODOLOGY

Small-Plot Studies

Three small-plot trials were performed in 2007-2008, 2008-2009 and 2010-2011 at the SROC on a clay loam soil. Target dates for the manure applications were 1 August, 1 September, 1 October, and 15 April, but actual dates depended on soil conditions. Available manure-N averaged 150 lb/acre across the four application times for the 2007-2008 trial, but varied widely for the 2008-2009 trial due to an inconsistent manure supply. Urea was broadcast in the spring using a calibrated air-flow fertilizer research-plot applicator. Each manure/fertilizer nitrogen treatment was replicated four times in the first two trials and three times in the third in a randomized complete-block design. Plot dimensions were 50 feet long by 10 feet wide in the first two trials, and 80 feet by 15 feet in the third, with four and six 30-inch rows respectively. The fields were tilled and managed using procedures typical of south central Minnesota. Treatments, manure application dates, and available N applied are listed in Table 1.

Table 1. Swine liquid manure (SLM) and fertilizer application timing, and applied nitrogen rates for the small-plot trials.

Source	Manure Application Timing			Rate†		
				lb N/A		
	2008	2009	2011	2008	2009‡	2011
SLM	02-Aug-07	8-Aug-08		150	120	
SLM	01-Sep-07	2-Sep-08	30-Sep-10	150	90	120
SLM	12-Oct-07	1-Oct-08	14-Oct-10	150	145	120
SLM	01-Nov-07	31-Oct-08	1-Nov-10	150	80	120
SLM	17-Apr-08	14-Apr-09		150	150	
None	None	None		0	0	0
Urea	30-Apr-08	17-Apr-09	6-May-11	40	40	120
Urea	30-Apr-08	17-Apr-09		80	80	
Urea	30-Apr-08	17-Apr-09		120	120	
Urea	30-Apr-08	17-Apr-09		160	160	

† N rate, based on 80% of total N in manure.

‡ Available manure nitrogen varied due to inconsistent manure supply.

Field-Size Strip Studies

Nine on-farm strip trials of corn response to timing of manure were carried out, three in 2009-2010 and six in 2010-2011. Sites without a recent manure history were chosen by the farmer or their crop advisor. All sites were corn after soybean. Swine finishing manure from the host farm or a local hog producer was sweep-injected. The target available nitrogen rate was 120 lb/acre. All sites contained soil types that represented typical drained soils derived from loamy glacial tills or glacial moraines in the flat landscapes of South Central Minnesota.

Participant farmers managed their fields according to their typical practices except for nitrogen applications. Nitrogen was applied as manure or fertilizer to long strips across each field. Strip width was dependent upon the width of the manure applicator and combine header. Strip lengths varied between 300 and 850 feet. Fertilizer treatments were applied either in the fall in the form of injected anhydrous ammonia or in the spring as broadcast urea. Each manure/fertilizer nitrogen treatment was replicated three times in a randomized complete-block design.

Initially the target dates for the manure applications were August 1, September 1, October 1, and November 1. The August manure application was not possible due to the lack of available harvested fields in August. The other applications were applied at the farmers' availability. Table 2 shows the actual application dates for the manure and fertilizer treatments. October 2010 was extremely wet and farmers were not able to apply manure.

Table 2. Manure and fertilizer application timing for the 2010 and 2011 on-farm trials.

Trials by Year	Manure Application Dates (Fall)			Fertilizer Application Dates
2010	September	October	November	
1	2-3	31		15-Apr-10
2	9		2-5	20-Apr-10
3	10		2-5	3-Nov-09
2011	September	October	November	
4	13-15	15	9	12-Nov-10
5	15-17	11	15	6-Nov-10
6	17	21-23	15-18	3-Nov-10
7	16	15	10	4-Nov-10
8	9	11	11-13	10-Nov-10
9	14	11-13	12	7-Nov-10

RESULTS

Small-Plot Studies

Corn yields (Tables 3, 4, 5) were excellent in all three trials/years. Yields ranged from 190 to 226 bu/acre in the fertilized (manure and urea) treatments. All fertilized treatments yielded significantly more than the control (zero N) treatment. However, no significant differences were found among the fertilized treatments within a given trial/year. The lack of yield differences among manure application timings (late summer to early spring) can be explained by the data. Control plot yields ranged from 158 to179 bu/acre. These high control plot yields suggest significant soil N contributions in these trials. All three sites were corn following small grain. It's likely a combination of carryover nitrogen from the small grain crop and mineralization of N from the organic matter in these high organic matter soils provided much of the N the crop needed. This hypothesis is also supported by the fact that in two of the three trials 40 lb N/acre as urea was enough N to maximize corn yield. In the absence of yield differences, we will look at the distribution of N in the soil profile at different times during the growing season to help explain the effect of manure application timing.

Table 3. Corn yields for the small-plot experiment harvested in 2008.

N management / Treatment			Grain Yield	Tukey HSD Group‡
Source	Timing	Rate†		
		lb N/A	bu/A	
SLM	02-Aug-07	150	207	ab
SLM	01-Sep-07	150	213	ab
SLM	12-Oct-07	150	223	a
SLM	01-Nov-07	150	213	ab
SLM	17-Apr-08	150	223	a
None	30-Apr-08	0	179	b
Urea	30-Apr-08	40	223	a
Urea	30-Apr-08	80	217	a
Urea	30-Apr-08	120	226	a
Urea	30-Apr-08	160	223	a

Table 4. Corn yields for the small plot experiment harvested in 2009.

N management / Treatment			Grain Yield	Tukey HSD Group‡
Source	Timing	Rate†		
		lb N/A	bu/A	
SLM	8-Aug-08	120	211	a
SLM	2-Sep-08	90	212	a
SLM	1-Oct-08	145	223	a
SLM	31-Oct-08	80	202	a
SLM	14-Apr-09	150	219	a
None	None	0	158	b
Urea	17-Apr-09	40	208	a
Urea	17-Apr-09	80	210	a
Urea	17-Apr-09	120	214	a
Urea	17-Apr-09	160	222	a

Table 5. Corn yields for the small plot experiment harvested in 2011.

N management / Treatment			Grain Yield‡
Source	Timing	Rate†	
		lb N/A	bu/A
SLM	30-Sep-10	120	190
SLM	14-Oct-10	120	199
SLM	1-Nov-10	120	198
Urea	6-May-11	120	205
None		0	167

Field-Size Strip Studies

Results of the two years of on-farm trials are shown in Tables 6, 7 and 8. An analysis of variance for each year separately indicated no significant site by treatment interaction in either year. Treatments were not significantly different ($P<0.05$) in the first year trials. For the second year, 2011, treatments were significant. The September manure application showed a significantly lower corn yield compared to the two other manure application times and the fertilizer application, when using a pre-planned contrast in the analysis. With the Tukey HSD for unplanned comparisons some individual sites showed significant differences among treatments.

In order to combine the two years of data for analysis, it was necessary to average the October and November manure application yield data in each replication of the second year sites to form one treatment. The number of treatments in the second year then matched the number of treatments (three) in the first year, i.e. "early manure", "late manure", and "late urea". This is appropriate because the late treatment in the first year was at the end of October or beginning of November, while the corresponding treatments in the second year were mid-October and mid-November. The nine-site analysis of variance of corn yields was significant for treatments and insignificant for the treatment by site interaction. The contrast of early with late manure application showed that the yields from the September (early) manure application were significantly lower than yields from the late (October-November average) application and lower than from the late urea application (Table 8) The contrast of yields from late manure application compared to late urea was also significant at $P<0.05$ (pooled error term), but not with the more conservative Tukey HSD comparison at $P<0.05$. The combined analysis clearly shows a significant loss in yield when manure was applied in September relative to later months.

Table 6, 7 & 8. Corn yields for the field-size strip trials .

Trial	Source†	Manure Application Timing		Grain Yield	Tukey HSD Group‡
		Month	Day	bu/A	
2010-1	SLM	Sep	2-3	187	a
	SLM	Oct	31	186	a
	Urea	Apr	15	195	a
2010-2	SLM	Sep	9	201	a
	SLM	Nov	2-5	215	a
	Urea	Apr	10	207	a
2010-3	SLM	Sep	10	189	a
	SLM	Nov	2-5	197	a
	AA	Nov	3	203	a

Trial	Source†	Manure Application Timing		Grain Yield	Tukey HSD Group‡
		Month	Day	bu/A	
2011-4	SLM	September	13-15	186	a
	SLM	October	15	197	a
	SLM	November	9	199	a
	AA	November	12	203	a
2011-5	SLM	September	15-17	178	b
	SLM	October	11	201	a
	SLM	November	15	196	a
	AA	November	6	198	a
2011-6	SLM	September	17	196	a
	SLM	October	21-23	199	a
	SLM	November	15-18	205	a
	AA	November	3	211	a
2011-7	SLM	September	16	195	a
	SLM	October	15	206	a
	SLM	November	10	203	a
	AA	November	4	205	a
2011-8	SLM	September	9	188	b
	SLM	October	11	196	b
	SLM	November	11-13	201	b
	AA	November	10	222	a
2011-9	SLM	September	14	191	a
	SLM	October	11-13	198	a
	SLM	November	12	195	a
	AA	November	7	195	a

Treat.	Month(s)	Grain Yield	Tukey HSD Group†
		bu/A	
Early manure	Sep.	190	a
Late manure	Oct &/or Nov	200	b
Late urea	Nov or Apr	205	b