Four Years of Hog and Cattle Manure Application in East-Central Saskatchewan: Impact on Soil and Crop Performance.

S.P. Mooleki, J.J. Schoenau, G. Wen, J.L. Charles, and G. Hultgreen

Introduction

- Interest in the use of livestock manure as a fertilizer has been rekindled by:
  - The expansion of the livestock industry
  - Need to utilize the manure in an environmentally friendly and economically viable manner
  - Desire to reduce fertilizer cost

Objectives

- This study was initiated in 1996 to:
  - Examine soil and crop response to application of liquid swine manure and solid feedlot cattle manure at different rates and methods of application
  - Evaluate nutrient forms and amounts in the manure and the effect of rate and method of manure application on soil fertility, nutrient utilization and crop yield.

- This paper summarises the results of crop response to annual application of the two types of manure compared to that of urea fertilizer observed over the past four years, 1997 to 2000.

Materials & Methods

Two sites were selected in the fall of 1996 in the Black soil zone near Humboldt, Saskatchewan. Various treatment combinations were used for both the swine and cattle manure experiments to cover a period of four years (Table 1). Quantities of manure-N application for the 1997 to 2000 growing seasons are given in Table 2. Both manure and urea fertilizer applications were made in the preceding fall of each growing season, respectively. Urea fertilizer application rates were 50, 100 and 200 kg N ha^{-1} for the low, medium and high treatment levels, respectively. Treatments for each experiment were arranged in a randomized complete block design with four replications at each location.

Table 1. Manure and Fertilizer Application Regimes for the 1997, 1998, 1999 and 2000 growing seasons at Burr and Dixon

Swine manure							Cattle manure						
Trt	'97	'98	'99	'00			Trt	'97	'98	'99	'00		
1	0	0	0	0	No injection		1	0	0	0	0	Check with incorporation	
2	0	0	0	0	Injection pass @ 12"		2	1	0	0	1	Cattle	Broadcast/incorporated
3	1	0	0	1	Swine	Injection @ 12"	3	1	1	1	1	Cattle	Broadcast/incorporated
4	1	1	1	1	Swine	Injection @ 12"	4	2	0	0	2	Cattle	Broadcast/incorporated
5	2	0	0	2	Swine	Injection @ 12"	5	2	0	2	2	Cattle	Broadcast/incorporated
6	2	0	2	2	Swine	Injection @ 12"	6	2	2	2	2	Cattle	Broadcast/incorporated
7	2	2	2	2	Swine	Injection @ 12"	7	4	0	0	4	Cattle	Broadcast/incorporated
8	4	0	0	4	Swine	Injection @ 12"	8	4	4	4	4	Cattle	Broadcast/incorporated
9	4	4	4	4	Swine	Injection @ 12"	9	1	1	1	1	Cattle	Broadcast/delayed-incorp.
10	1	1	1	1	Swine	Sweep @ 24"	10	1	1	1	1	Urea	Banded
11	1	1	1	1	Swine	Spiked & straight boot	11	2	2	2	2	Urea	Banded
12	1	1	1	1	Swine	Broadcast & incorporated	12	4	4	4	4	Urea	Banded
13	1	1	1	1	Urea	Banded							
14	2	2	2	2	Urea	Banded							
15	4	4	4	4	Urea	Banded							

Key: 1 Low; 2 Medium; 4 High

Table 2. Total N Applied in the Swine and Cattle Manure studies at the Low, Medium and High Application Rates in the 1997, 1998, 1999 and 2000 growing seasons at Burr and Dixon

		Swine manure								Cattle manure							
		1997		1998		1999		2000		1997		1998		1999		2000	
		Burr	Dixon	Burr	Dixon	Burr	Dixon	Burr	Dixon	Burr	Dixon	Burr	Dixon	Burr	Dixon	Burr	Dixon
		(kg N ha^{-1})								(kg N ha^{-1})							
	Code																
Check	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low	1	204	74	46	51	142	97	97	94	228	121	104	104	74	69	113	113
Medium	2	395	147	92	102	285	195	194	188	456	242	208	208	149	138	226	226
High	4	790	295	183	204	569	390	388	376	912	484	416	416	298	276	452	452

Results

- Pre-seeding available N in soil profile (0–60 cm) was elevated by increasing swine manure and urea rates applied the previous fall (Fig. 1). In contrast Cattle manure caused relatively less elevation of pre-seeding available N. Evidence of cumulative effect of repeated swine manure and urea application on pre-seeding available N was observed at Dixon at the high rate of application.
- Increasing rates of swine and cattle manure significantly enhanced crop N uptake in all the four crops (Fig. 2). However, only swine manure enhanced crop N uptake more than urea. At Burr, crop N uptake in cattle manure and urea treated plots were comparable.

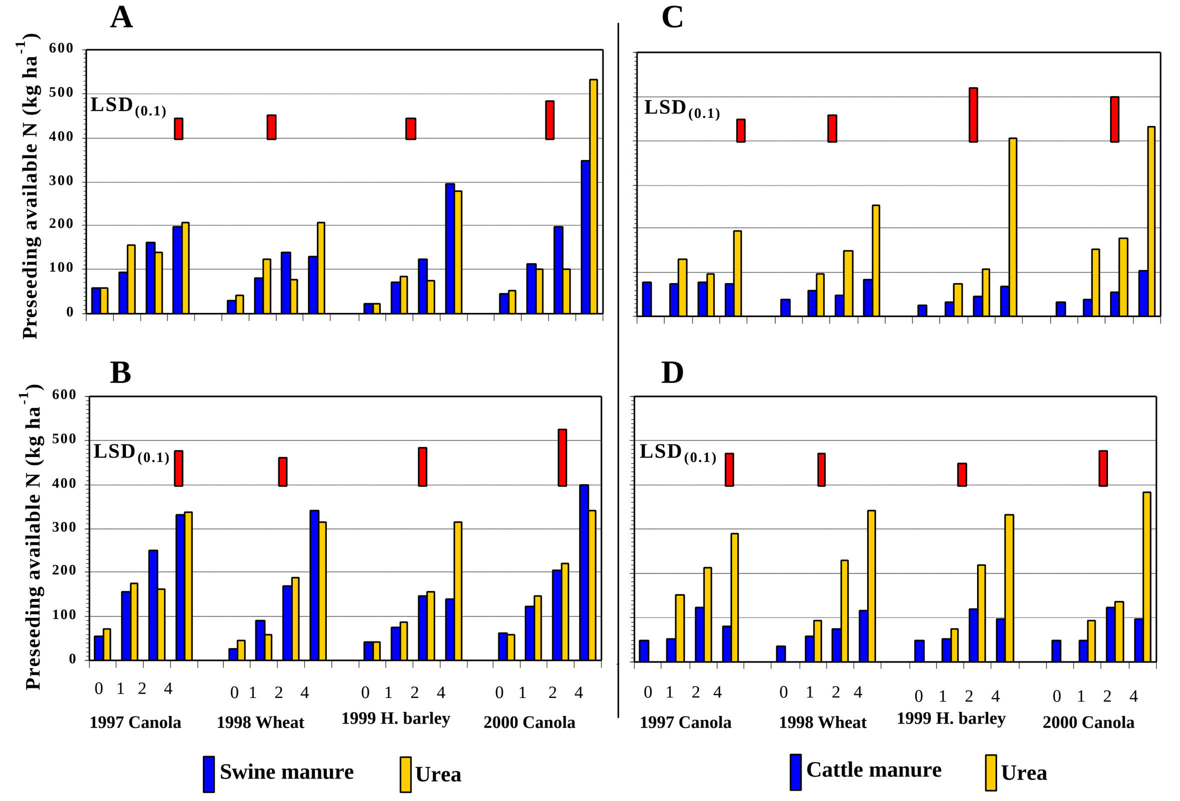

Fig. 1. Pre-seeding available N in 1997, 1998, 1999 and 2000, respectively, in the swine manure study at Dixon (A) and Burr (B), and in the cattle manure study at Dixon (C) and Burr (D).

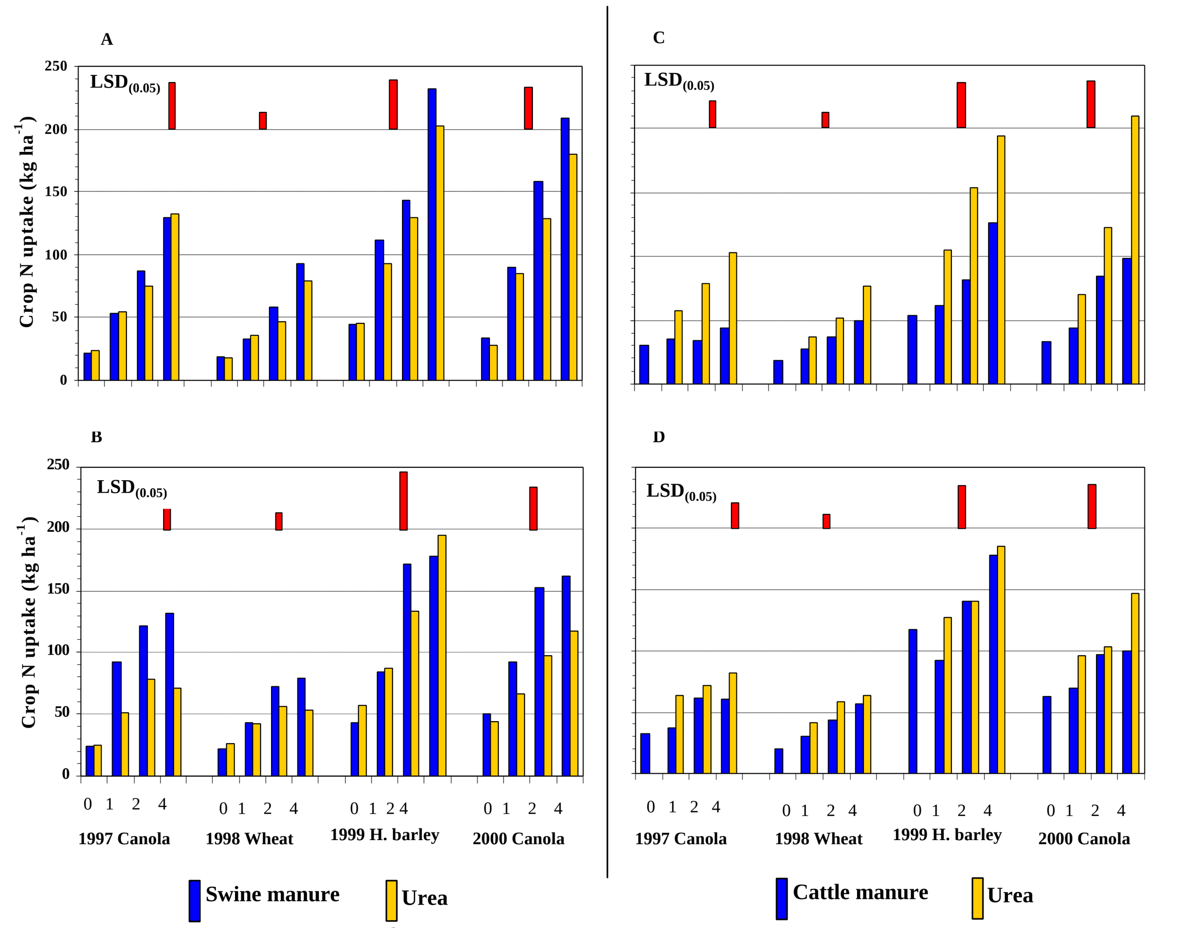

Fig. 2. Nitrogen uptake of canola, wheat, hulless barley and canola in 1997, 1998, 1999 and 2000, respectively, in the swine manure study at Dixon (A) and Burr (B), and in the cattle manure study at Dixon (C) and Burr (D).

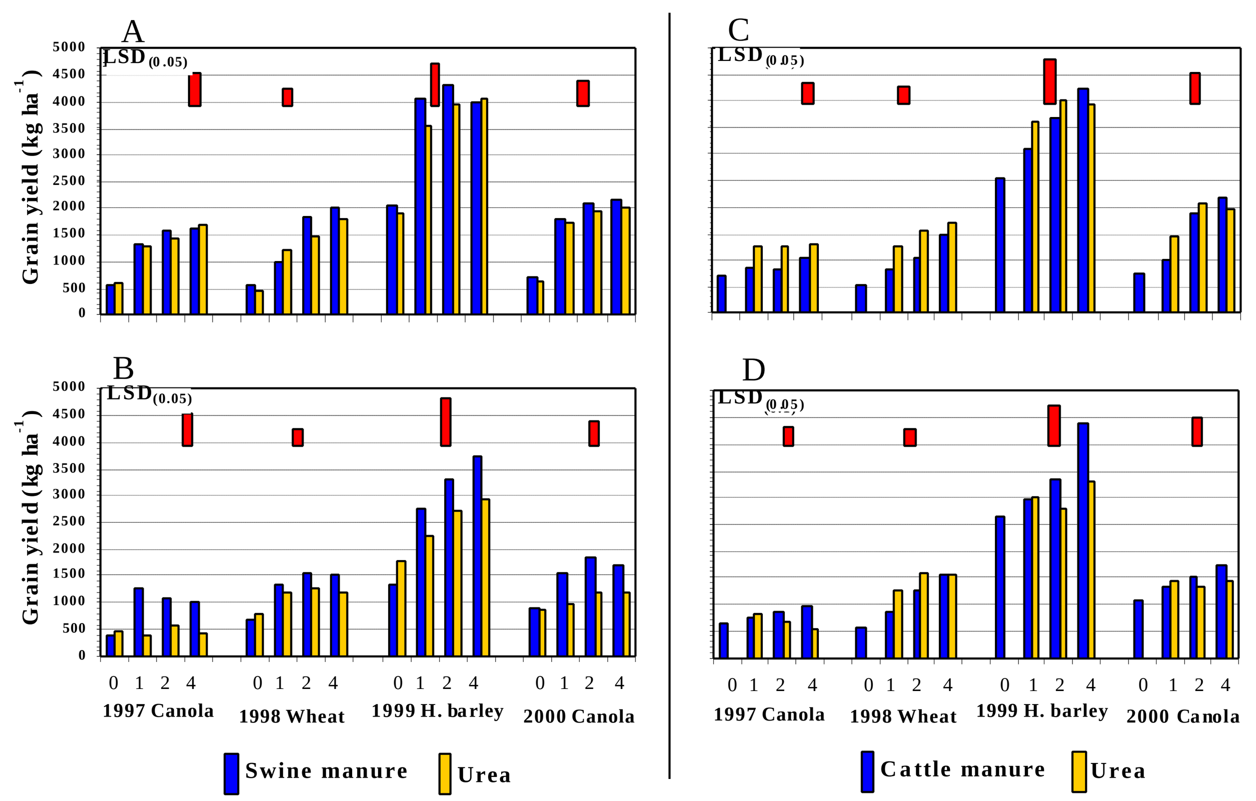

Fig. 3. Grain yield of canola, wheat, hulless barley and canola in 1997, 1998, 1999 and 2000, respectively, in the swine manure study at Dixon (A) and Burr (B), and in the cattle manure study at Dixon (C) and Burr (D).

Table 3. Grain protein of canola, wheat, hulless barley and canola in 1997, 1998, 1999 and 2000, respectively, in the swine manure study (A) and in the cattle manure study (B) at Burr and Dixon

A — GRAIN PROTEIN (%)

Trt	Source	Rate '97	Rate '98	Rate '99	Rate '00	1997 Canola Burr	1997 Canola Dixon	1998 Wheat Burr	1998 Wheat Dixon	1999 H.barley Burr	1999 H.barley Dixon	2000 Canola Burr	2000 Canola Dixon
2	Check	0	0	0	0	26.3 bc	19.6 c	14.7 c	16.2 b	10.5 d	8.9 d	24.7 b	22.1 d
4	Swine	1	1	1	1	30.7 a	20.4 c	14.8 c	15.2 bc	11.5 d	10.4 c	25.4 b	21.3 de
7	Swine	2	2	2	2	32.1 a	25.7 b	17.6 b	14.8 bc	14.6 bc	13.1 b	29.5 a	26.9 bc
9	Swine	4	4	4	4	33.0 a	29.5 a	19.6 a	18.3 a	15.1 ab	17.7 a	28.2 a	29.3 a
1	Check	0	0	0	0	24.9 c	18.6 c	15.4 c	16.2 b	11.2 d	8.8 d	23.6 b	19.7 e
13	Urea	1	1	1	1	29.5 ab	21.2 c	16.1 c	14.0 c	13.2 c	10.5 c	28.6 a	21.5 de
14	Urea	2	2	2	2	31.8 a	24.9 b	18.8 ab	15.0 bc	14.4 bc	12.9 b	28.5 a	25.9 c
15	Urea	4	4	4	4	32.3 a	28.3 ab	18.6 ab	18.7 a	16.6 a	16.5 a	28.4 a	28.8 ab

B — GRAIN PROTEIN (%)

Trt	Source	Rate '97	Rate '98	Rate '99	Rate '00	1997 Canola Burr	1997 Canola Dixon	1998 Wheat Burr	1998 Wheat Dixon	1999 H.barley Burr	1999 H.barley Dixon	2000 Canola Burr	2000 Canola Dixon
1	Check	0	0	0	0	23.6 c	19.5 c	17.1 bc	16.0 bc	12.0 cd	9.0 e	23.9 cd	20.0 c
3	Cattle	1	1	1	1	24.2 c	19.7 c	17.0 bc	16.4 bc	11.3 d	9.0 e	22.8 d	20.4 c
6	Cattle	2	2	2	2	28.2 b	19.9 c	17.0 bc	16.8 b	12.4 cd	9.9 de	26.3 b	20.5 c
8	Cattle	4	4	4	4	27.7 b	20.3 c	18.0 ab	16.8 b	13.0 bc	11.1 c	26.5 b	20.7 c
10	Urea	1	1	1	1	29.3 ab	23.5 b	16.1 c	14.6 d	12.6 c	10.2 cd	25.3 bc	20.4 c
11	Urea	2	2	2	2	29.2 ab	27.5 a	17.9 ab	15.3 cd	13.9 b	13.2 b	28.7 a	24.6 b
12	Urea	4	4	4	4	31.4 a	29.5 a	19.0 a	19.0 a	16.2 a	16.7 a	29.6 a	30.1 a

Means followed by the same letter are not different at 0.05 level of significance.

Table 4. Cumulative adjusted N use efficiency (NUE) of canola, wheat, hulless barley and canola in 1997, 1998, 1999 and 2000, respectively, in the swine manure study (A) and in the cattle manure study (B) at Burr and Dixon

A — Cumulative Adjusted %NUE

Trt	Source	Rate '97	Rate '98	Rate '99	Rate '00	1997 Canola Burr	1997 Canola Dixon	1998 Wheat Burr	1998 Wheat Dixon	1999 H.barley Burr	1999 H.barley Dixon	2000 Canola Burr	2000 Canola Dixon
4	Swine	1	1	1	1	33 b	43 ab	25 a	32 ab	18 ab	46 abc	23 a	43 bc
7	Swine	2	2	2	2	25 b	44 ab	17 ab	35 ab	19 ab	40 bc	21 ab	43 bc
9	Swine	4	4	4	4	14 b	36 b	9 b	27 b	10 b	33 c	11 b	29 d
13	Urea	1	1	1	1	53 a	64 a	20 ab	42 a	21 ab	58 a	22 a	62 a
14	Urea	2	2	2	2	54 a	53 ab	22 ab	33 ab	28 a	48 ab	25 a	53 ab
15	Urea	4	4	4	4	23 b	55 ab	9 b	30 ab	20 ab	43 bc	16 ab	41 c

B — Cumulative Adjusted %NUE

Trt	Source	Rate '97	Rate '98	Rate '99	Rate '00	1997 Canola Burr	1997 Canola Dixon	1998 Wheat Burr	1998 Wheat Dixon	1999 H.barley Burr	1999 H.barley Dixon	2000 Canola Burr	2000 Canola Dixon
3	Cattle	1	1	1	1	2 d	5 c	4 c	6 c	-3 c	7 c	5 c	7 b
6	Cattle	2	2	2	2	6 d	2 c	6 c	5 c	7 bc	8 c	8 c	11 b
8	Cattle	4	4	4	4	3 d	3 c	4 c	5 c	7 bc	9 c	6 c	9 b
10	Urea	1	1	1	1	63 a	55 a	34 a	40 a	26 a	60 a	37 a	49 a
11	Urea	2	2	2	2	39 b	49 ab	23 b	33 a	21 ab	53 a	23 b	49 a
12	Urea	4	4	4	4	24 c	37 b	12 c	24 b	17 ab	36 b	19 b	40 a

Means followed by the same letter are not different at 0.05 level of significance.

- Both swine and cattle manure increased grain yield to the same or greater extent as urea (Fig. 3), likely due to other nutrients added in the manure.
- Increasing swine (both locations) or cattle manure (at Burr) enhanced grain protein concentration similar to increasing rates of urea (Table 3).
- Cumulative N use efficiency (NUE) adjusted for straw N of the previous crop was lower in swine manure but still comparable to that of urea at the corresponding rates of N application (Table 4). NUE of cattle manure was lower than that of the corresponding rates of urea.

Conclusions

- Liquid swine manure elevated pre-seeding available N similar to that observed in treatments receiving urea fertilizer. This may be due to its low C:N ratio and high concentration of ammonium.
- Crop response to rate of swine manure was significant and similar to that caused by urea. In contrast, application of cattle manure did not cause an immediate elevation of available N, however, significant response to rates of cattle manure was observed in terms of N uptake and grain yield in all the four growing seasons.
- The relatively high C:N ratio of cattle manure may initially cause N immobilization of inorganic N. However, this N is potentially available to the crop during the growing season as N mineralization takes place. Furthermore, the slow release of N reduces the proportion of N that may be available for loss, thus, improving the N use efficiency over the long term.

Acknowledgements

This work was financially supported by:

Agri-Food Innovation Fund

SaskPork

mooleki@sask.usask.ca