Hog and Cattle Manure Additions in the Black Soil Zone of Saskatchewan: Agronomic Considerations

J. J. Schoenau [1], J. Charles [1], G. Went, P. Qian [1], G. Hultgreen [2]

[1] Dept. of Soil Science, University of Saskatchewan, Saskatoon, S7N 5A8
[2] Prairie Agricultural Machinery Institute, Humboldt, Sk, SOK 2A0

Abstract

Experiments were conducted in 1997 at two sites (Burr and Dixon) in the Black soil zone, east - central Saskatchewan, to examine the effects of different rates and methods of application of swine and cattle manure applied to previously unmanured soils. Liquid hog manure and solid feedlot cattle manure were land applied at nitrogen rates ranging from 74 kg / ha to 790 kg / ha and the effects on soil fertility and canola yield were assessed.

There was considerable spatial and temporal variability in the nutrient concentrations within the hog and cattle manure used in the study. Land application of hog manure had a greater effect than cattle manure on increasing soil available nutrients and crop yield in the year of application. However, residual effects of the 1997 applications of cattle manure became apparent in 1998 in the form of higher yields than the control plots. Soil nitrate levels increased with increasing hog manure and urea application rates at both sites and this was mainly restricted to the top 30 cm. Appreciable amounts of residual inorganic N (~450 kg N / ha) remained in the soil after harvest at the high hog manure rate (~20000 gallons/acre) at the Burr site. Although extractable soil inorganic P and K levels were not significantly affected by manure additions, crop P and K uptake and straw concentrations increased with application rate. The soil pH and soluble salt levels were unaffected by hog and cattle manure additions at both sites in the first year of application. Grain and straw yields significantly increased following hog and cattle manure additions at Dixon, but these increases were not statistically significant at Burr due to high variability in soil properties across the plot area. The yield responses to application of manure are mainly attributed to their effect on soil nitrogen availability. The low (-6000 gallons / ac) hog manure application injected using a 30 cm spacing resulted in the highest yields at Burr, while the medium rate at Dixon (-7000 gallons / ac) was most effective.

Introduction

In 1996, the revenue generated from the sale of hogs and cattle in Saskatchewan represented about 15% of total farm cash receipts (Saskatchewan Agriculture and Food, 1996). As livestock production in Western Canada expands, there are concerns surrounding the land application of the manures produced. Land application of animal manure can benefit crop production as a source of nutrients in the short and longer term, as well as contribute to improvements in soil tilth. Increases in soil organic matter content arising from applications of solid manures have been well documented (Chang et al., 1991). However, improper application of animal manure can potentially result in crop injury and soil problems such as salinization, nutrient imbalances and excessive nutrient losses. As new intensive livestock operations are proposed and manure management plans are developed for application of manures to surrounding agricultural lands, there is a need for information on how soils and crops are likely to respond to the manure additions.

This paper reports on a study initiated in 1997 in east-central Saskatchewan in the Black soil zone near Humboldt. The study examines the soil and crop response to application of liquid hog manure and solid feedlot cattle manure at different rates and methods of application over a four year period at two sites with no previous history of manure application. The research results covered in this paper deal mainly with year one of the study. Objectives of the study include evaluation of nutrient forms and amounts in hog and cattle manure and the effect of rate and method of application on soil fertility, nutrient utilization and crop yield. As the study progresses, it will be possible to evaluate residual effects of manure applications made in previous years.

Methodology

Sites

Two field sites were selected in the fall of 1996 in the Black soil zone near Humboldt, Saskatchewan. One site (Dixon) is located on a farm field with soil classified as belonging to the Cudworth Association (Black Chemozem with loamy surface texture on very gently sloping land). The other site (Burr) is on a farm field containing soil classified as Meota Association (Black Chemozem with sandy loam texture) and is underlain by a gravel lens of variable depth with significant sub-surface salinity. The two sites therefore offer a contrast in production capability, with the Burr site limited by low water holding capacity and salinity. The plot area is much more variable at the Burr site.

Experimental Design

The trials for each of the hog and cattle manure experiments consisted of manure and urea fertilizer treatments applied in four blocks with randomized treatments in each block The trial layout was the same at the Burr and Dixon sites.

Treatments in the hog manure trials include a check, three rates of injected liquid hog manure at 30 cm spacing & 10 cm depth, low rate of injected manure at 60 cm spacing, low rate of surface broadcast and incorporated manure, and three rates of banded urea (10 cm depth). The hog effluent was obtained from a single cell earthen storage unit located about 5 km away. Applications of liquid hog manure were made using a heavy duty cultivator applicator (30 cm sweep-type openers) attached to a nurse tank At the Burr site, the hog manure was applied in October of 1996 and the urea in May of 1997 before seeding. The Dixon site received both the hog manure and urea treatments in May of 1997 before seeding. The low, medium and high rates of hog manure application at Burr were 6200, 12000 and 23900 gallons per acre. At Dixon the low, medium and high rates were 3400, 6800, and 13600 gallons per acre. More hog manure was added at Burr than at Dixon because the initial calibration was done without the manifold sweeper device on. In operation, the manifold sweeper acted as a pump so that the actual measured flow rates were much higher than anticipated

Treatments in the cattle manure trials included the check, three rates of broadcast and incorporated, low rate of broadcast and 24 hour delayed incorporation, and three rates of banded urea as in the hog manure trials. Cattle manure approximately one year in age was obtained from the Poundmaker feedlot and mixed with a rototiller in the back of a truck to homogenize the material as much as possible before application. Treatments were manually spread followed by incorporation with a rotary tiller. Cattle manure treatments at both Burr and Dixon sites were applied in May, 1997 before seeding. The low, medium and high rates of cattle manure applied at Burr were 18, 37 and 73 tonnes/ha and at Dixon 10, 20 and 39 tonnes/ha.

In late May, 1997 the plots were seeded to canola (B. napus) using a plot drill with spoon openers at 20 cm spacing and the plots were harvested in late August.

Hog manure samples were taken from the earthen storage unit before application for initial determination of nitrogen content to enable the applicator to be set in the desired range. During application to the plots, seven ten litre samples of liquid hog manure effluent were collected between the tank and the manifold These samples were analyzed for total and available forms of plant nutrients. For the cattle manure samples, several samples were taken at random from the mixed manure before application in the field These samples were also analyzed for total and available forms of nutrient.

Soil cores (0-30cm, 30-60cm) were taken from each plot in early June, 1997 and again in late September, 1997 after harvest The soil cores were analyzed for total and available amounts of plant nutrients, pH, E.C. and SAR Additionally, at the Dixon site, the check and low and high mte hog manure and urea treatments were cored to a 120 cm depth to investigate possible deep leaching of nitrates. At the end of June, in-field nutrient supply rates over a two week period were measured in the hog and cattle manure plots using anion exchange membrane PRS™ probes.

Yield measurements were made on the plots at the end of August, 1997 by taking square meter quadrats from each plot. Grain and straw yields of the canola were measured and samples retained for analysis of macro and micronutrient concentrations in the grain and straw.

Results and Discussion

Manure Composition

The nutrient composition of the hog and cattle manure used in the field studies is shown in Table 1. Hog manure concentrations are reported on a wet basis while cattle manure concentrations are expressed on a dry matter basis. The liquid hog manure contained approximately 1.8% dry matter while the solid cattle manure contained about 54% dry matter as collected. There is considerable variability in nutrient content of the manure from batch to batch collected in the field during application as shown by the high standard deviations, especially for phosphorus and the microelements. This is likely a consequence of spatial variations in nutrient content in the storage unit and the applicator tank, mainly associated with differences in solids content (Schoenau, 1998). As well, the difference in composition between the hog manure applied at Burr in the fall and Dixon in the spring from the same earthen storage unit suggests there may be significant temporal variations in nutrient content.

No detectable amounts of nitrate were found in either the hog or cattle manure applied at both sites, and this is consistent with observations of several researchers (Paul and Beauchamp, 1993). For the liquid hog manure, about 40% of the fall applied hog manure was plant available ammonium while 75% of the spring applied hog manure was ammonium, with the rest of the N present in organic forms. Controlled environment studies with the same manure suggests that about 20% of the organic N in the liquid hog effluent would become available through mineralization over a growing season. In the case of the cattle manure, only about 15% of the total nitrogen was comprised of inorganic ammonium. Furthermore, in the cattle manure the carbon to nitrogen ratio was in the vicinity of 20: 1 while the C:N in the hog manure ranged from 5: 1 to 10: 1. Narrower C:N ratios of hog manure suggest net N mineralization of the organic N upon land application. However, net immobilization of inorganic N is expected with the field application of the cattle manure since Beauchamp (1986) and Sommerfelt and Mackay (1987) observed net immobilization of inorganic N in cattle manure with C:N ratios of 15.4 and 16.5 respectively.

Table 1. Nutrient composition of manures used in study in 1997.

Nutrient	Burr hog manure (µg/g)	Dixon bog manure (µg/g)
Total N	2941 (583)	1931 (28.6)
organic N	1787	484
NH_4-N	1153 (52)	1447 (195)
Total P	829 (696)	175 (18.4)
Resin P	190 (179)	81.9 (15.8)
Total K	1393 (82)	1006 (10.5)
Resin SO_4-S	14.1 (4.1)	430.4 (10.8)
Total Mg	615 (527)	163.5 (12.2)
Total Ca	1230 (611)	407.3 (9.7)
Total Cu	23 (13)	4.3 (0.2)
Total Mn	13.8 (12)	2.4 (0.5)
Total Zn	42 (27)	6.1 (0.5)
Total Fe	172 (128)	20.4 (2.0)
Total B	-	1.9 (1.0)
pH	8.5 (0.1)	

Nutrient	Burr and Dixon cattle manure (µg/g)
Total N	12460.5 (2693)
Organic N	10727.9
W - N	1732.6 (286.2)
Total P	4044.9 (862.1)
Resin P	211.7 (95.2)
Total K	129524 (2815.8)
Total S	7758.3 (2251.0)
Resin SO_4-S	1365.5 (210.8)
Tod Mg	107828 (2964.7)
Total Ca	30791.9 (7325.1)
Total Cu	87.1 (6.9)
Total Mn	265.0 (73.1)
Total Zn	155.4 (41.2)
Total Fe	4486.7 (1328.3)
Total B	44.7 (12.9)

Reported values are means (n = 5) with standard deviations in parentheses

The amounts of manure phosphorus in readily soluble inorganic forms (resin extractable phosphate) ranged from 22% in the fail applied hog manure to 47% in the spring applied. However, in the cattle manure, only about 5% was in a readily soluble inorganic form. Readily soluble inorganic sulfate concentrations were higher in the spring applied hog manure than the fall applied The low concentrations of sulfate in the fall applied manure (14 µg SO_4-S / g of manure) are consistent with results of Eriksen (1997) who reported concentrations of plant available S in hog slurry to be only 20 µg / g (5% of total S). The cattle manure had higher concentrations of sulfur with a total S concentration of about 8000 µg S / g and about 18% of this present as sulfate. Total potassium concentrations of about 1000 µg K / g found in the liquid hog manure and 10000 µg K / g found in the cattle manure are similar to results reported by other researchers (Dormer, 1997; Daniel et al., 1994). Copper and zinc concentrations in the liquid hog manure were similar to that reported by Dormer (1997). The copper content of the cattle manure was higher than that reported by McCalla (1974), while the zinc levels were within the reported range of Zn concentrations for fresh animal manure. The boron concentrations in the spring-applied hog manure were lower than the range of values reported by McCalla while the cattle manure had boron concentrations close to the upper range of reported values (52 µg I g). Variability in total micronutrient content among samples is likely associated with variability in the solids content of the manure while discrepancies among published results may also reflect differences in composition of feeds, feed additives and manure handling practices.

Nitrogen:

Many researchers have reported increased soil inorganic N levels following land application of animal manures. At both the Burr and Dixon sites, there were significant increases in soil nitrate and ammonium concentrations in spring *O-30 cm* samples with increasing application rates of hog manure and urea fertilizer. No significant differences in either nitrate or ammonium were observed at the 30 - 60 cm depth. The 1997 growing season was a dry one and as such there may not have been enough precipitation to move the inorganic N down to the 30-60 cm depth. At the Burr site, about 30 to 50% of the fall applied hog manure N was detectable as inorganic N in the soil profile at the time of sampling in the spring. This is similar to results of Beauchamp (1983) who suggested that about 48% of manure N becomes available following land application. Spring soil inorganic N levels of the broadcast and incorporated manure treatments were lower than the injected treatments at similar application rates, suggesting that additional N losses may have occurred from the broadcast and incorporated application.

Table 2. Simple N balance for hog manure trials.

Burr Site

Treatments	Plant available N after treatment application (kg ha^{-1} 0-60 cm)	Plant N uptake (seed and straw) (kg ha^{-1})	Plant available N after harvest (kg ha^{-1} 0-60 cm)
Check with injector pass @ 30 cm spacing	57	24	31
204 kg N/ha manure @ 30 cm spacing	156	93	42
395 Kg N/ha manure @ 30 cm spacing	262	122	86
790 kg N/ha manure @ 30 cm spacing	361	97	463
204 kg N/ha manure broadcast & incorporated	124	57	35
236 Kg N/ha manure @ 60 cm spacing	184	73	104
50 kg N/ha urea banded	176	51	57
100 kg N/ha urea banded	158	78	69
200 kg N/ha urea banded	338	71	235
LSD (0.10)	79	45	136

Dixon Site

Treatments	Plant availabk N after treatment application (kg ha^{-1} 0-60 an)	Plant N uptake (seed and straw) (kg ha”)	Plant available N after harvest (kg ha” 0-60 cm)
check with injector pass @ 30 cm spacing	60	22	23
74 kg N/ha manure @ 30 cm spacing	95	54	26
147 kg N/ha manure @ 30 cm spacing	163	92	26
295 kg N/ha manure @ 30 cm spacing	252	118	68
74 kg N/ha manure broadcast & incorporated	90	47	17
74 kg N/ha manure @ 60 cm spacing	80	50	23
50 kg N/ha urea banded	156	54	20
100 kg N/ha urea banded	138	75	22
200 kg N/ha urea banded	207	133	97
LSD (0.10)	41	23	31

Table 2 shows a simple nitrogen balance constructed for the hog manure trials at Burr and Dixon. Hog manure and urea fertilizer addition increased soil profile inorganic N levels in the spring and increased plant nitrogen uptake. At Burr, where application rates of manure nitrogen were much higher, crop nitrogen uptake decreased at the highest application rates and this is attributed to the seedling damage and crop stand reduction which occurred at this site at the high application rates. At the high application rate of hog manure at Burr (790 kg N / ha), there was a large amount of inorganic nitrogen present in the soil profile after harvest, in fact more than that present in the spring before seeding. This indicates that there must have been significant mineralization of manure organic nitrogen over the growing season and into the fall. Crop N uptake was lower in broadcast and incorporated versus injected manure treatments, again suggesting that there were greater losses from surface applied manure (Sutton, 1993). Overall, recovery of the applied nitrogen in the crop decreased with increasing application rate of manure and fertilizer at both sites and recoveries were lower with hog manure than urea fertilizer. The lowest recovery was encountered in the high rate (790 kg N / ha) of hog manure applied at the Burr site, with only about 9% of the applied nitrogen recovered in the crop. At the low rates of applied hog manure nitrogen, recoveries of nitrogen in the crop were in the range of 30 to 40%.

At both Burr and Dixon, the addition of cattle manure did not significantly increase the soil inorganic nitrogen levels in the spring after application. This can be attributed to the low proportion of cattle manure N that is comprised of ammonium as well as potential immobilization of inorganic nitrogen because of the high C:N ratio. The 24 hour delay in incorporation of the cattle manure did not significantly inorganic N levels in the soil as compared to incorporation immediately after application.

The medium and high rates of cattle manure addition resulted in increased plant nitrogen uptake over the control at both sites. As only a small proportion (-10%) of the cattle manure N was plant available two weeks after application, enough organic nitrogen must have mineralized over the growing season to significantly increase plant nitrogen uptake. Overall, plant recovery of nitrogen in the year of application was much lower for cattle manure than for hog manure or urea, with crop recoveries of cattle manure nitrogen typically only around 5%. Culley et al. (1981) also observed lower recovery in manure amended plots compared to fertilizer amended plots. The lower availability of cattle manure N as compared to hog manure and urea in the year of application was also reflected in significant increases in mid-season soil nitrate supply rate with increasing rates of hog manure and urea but not for cattle manure.

Soil cores taken from the 60-90 cm and 90 - 120 cm depths in the Dixon plots after harvest revealed no significant difference among treatments. This infers that there was no deep leaching of nitrates in the first year of manure application at the Dixon site. This is not surprising since the effect of the hog manure and fertilizer treatments on available N was mainly restricted to the top 0 - 30 cm. As well, the 1997 growing season was dry and there probably was limited deep percolation of water.

Phosphorus, Potassium, Sulfur and Micronutrients:

The addition of manure had little or no impact on extractable inorganic phosphorus levels in the soil following application. The largest increase was observed at the Burr site where the high rate of hog manure phosphorus addition (220 kg P / ha) increased the Kelowna extractable P from 19 kg P / ha (control) to 30 kg P / ha in the 0-30cm depth. However, this increase was not significant at $p < 0.10$. All other manure treatments resulted in little or no difference in extractable inorganic phosphorus. Campbell et al (1986) have reported increases in extractable inorganic P when animal manure was repeatedly applied in large quantities over long periods of time (several years), but in the current study we are dealing with only the first year of application. There was an increase in phosphorus concentration and uptake by the canola with increasing rates of manure phosphorus which was most evident for the hog manure. This implies that there was increased availability of phosphorus subsequent to the land application of the manures due to mineralization of organic phosphorus (Dubetz et al.

1975) which would not be accounted for in a measurement of extractable inorganic P in the spring. Higher percentage recoveries of manure P in the crop were observed at the Dixon site than at Burr, consistent with lower amounts of manure added and a higher proportion of manure P present in soluble inorganic forms at the Dixon site.

Canola potassium concentrations and uptake were increased by hog and cattle manure additions. As well, mid-season soil K supply rates to the resin membrane probes were higher in manured treatments. However, the exchangeable K concentrations in the controls at the two sites were close to 1000 kg K / ha 0-30cm so that limited response to added manure K is expected.

Hog and cattle manure had no significant effect on soil sulfate concentrations or sulfur concentration and uptake by canola at the two sites. This is attributed to the low sulfate content of manure and the high and variable indigenous soil sulfate contents at both sites. There was in excess of 1000 kg SO4-S / ha in the soil profile detected in the control plots due to the natural presence of sub-soil sulfate salts. As the sites used in this study had inherently high soil sulfur availability, the low sulfur content of the hog manure was not an issue in canola production at these sites. However, on sulfur deficient soils, one should pay attention to the amounts of sulfur added as manure relative to nitrogen to ensure that a N:S imbalance does not arise. The availability of manure sulfur, especially organic S mineralization, deserves further attention.

The effects of manure addition on micronutrient availability were assessed through analysis of micronutrient concentrations in the canola straw. Overall, plant micronutrient concentrations were not greatly affected by additions of either cattle or hog manure. At the high rate of hog manure addition at the Burr site there was a significant increase in concentration of manganese. In the majority of instances, manure additions had no significant effect on concentrations of micronutrients in the plant tissue. Straw lead and cadmium concentrations were also measured and there were no significant differences between treatments. This was expected since the lead and cadmium levels in the hog and cattle manure applied at these sites were generally below the detection limits of the plasma emission spectroscopy instrumentation.

pH, Electrical Conductivity and SAR:

There were no significant differences in spring soil pH electrical conductivity and sodium adsorption ratio between any of the treatments at the two sites. Several researchers (Chang et al., 1990, 1991) have reported increases in electrical conductivity and sodium adsorption ratio when animal manure was applied at high rates over several years. However, the current study deals with effects of a single application in which the amount of soluble salts does not appear to be high enough to cause a significant change. Over several years on poorly drained soils, the cumulative effect of the salts could become a factor.

Effects of Manure Additions on Canola Yield

At the Burr and Dixon sites, the addition of hog manure at low rates resulted in increased canola yields over the control (Table 3). However, at the Burr site, the differences in yield among treatments were not significantly different. Crop response to applied nutrients was lower at Burr than at the Dixon site, presumably due to lower soil moisture storage and greater sub-soil salinity at Burr. At the Burr site, canola grain and straw yields decreased with increasing hog manure application rate, with the the low rate (204 kg N / ha) giving the best yield. The decrease in yield at the medium and high manure application rates at Burr may have been due to ammonium toxicity since considerable seedling damage and stand reduction were observed in the plots with the high hog manure rate. This damage potential would be aggravated at Burr by the sandier texture and saline nature of the sub-soil. Similarly, the high fertilizer rate treatment at Burr had low grain and straw yield that may have been due to ammonium toxicity. Generally, the hog manure treatments showed slightly greater yield when compared to fertilizer treatments with similar nitrogen rates which may be due to the fact that several other plant nutrients are applied with the hog manure that could contribute to a response. Overall, the similarity between manure and urea responses suggests that the main factor responsible for crop yield response to added hog manure is the nitrogen component. The 30 cm injection spacing appears to be superior to the 60 cm spacing as evidenced by lower yields at the wider injection spacing. Broadcast and incorporated hog manure treatments also yielded lower than the injected treatments, which may be related to lower nutrient losses and greater root accessibility to nutrients in the injected treatments. At the Dixon site, the medium hog manure rate of 6800 gallons per acre (147 kg N / ha) with 30 cm injection produced the highest yield. With this application rate and method, grain yield was maximized and residual soil levels of nitrate were not significantly different from the control. At the high rate (295 kg N/ ha) of hog manure at Dixon in 1997, there was sufficient residual N to produce significantly higher yield of wheat than the control in 1998 (Fig. 1).

Table 3. Canola grain and straw yields in the 1997 hog manure trials.

Gram and straw yield for Burr hog manure trial.

Treatments	Grain Yield (kg/ha)	Straw Yield (kglha)
Check with injector pass @ 30 cm spacing	**408 (7)**	1535
204 kg N/ha manure@ 30 cm spacing	1271 (23)	3937
395kgN/ha manure @ 3Ocm spacing	1133 (20)	3822
790 kg N/ha manure @ 30 cm spacing	587 (10)	2556
204 kg N/ha manure broadcast & incorporated	837 (15)	2628
236 kg N/ha manure @ 60 cm spacing	749 (13)	2659
50 kg N/ha urea banded	412 (7)	1891
100 kg N/ha urea bandcd	600 (11)	2820
200 kg N/ha urea banded	432 (8)	1825
LSD (0.10)	ns	**ns**

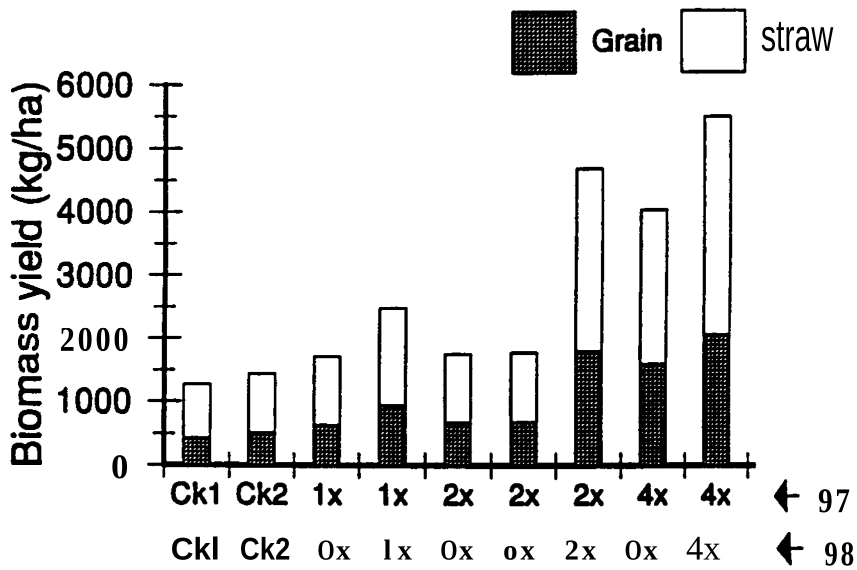
† Canola gram yield in bu/ac in parentheses

Grain and straw yield for Dixon hog manure trial.

Treatments	Grain Yield (kg/ha)	Straw Yield (kg/ha)
Check with injector pass @ 30 cm spacing	**564** (10)	1559
74 kg N/ha manure @ 30 cm spacing	1319 (23)	3706
147 kg N/ha manure @ 30 cm spacing	1743 (31)	4427
295 kg N/ha manure @ 30 cm spacing	1605 (29)	4150
74 kg N/ha manure @ 60 cm spacing	1190 (21)	3245
74 kg N/ha manure broadcast & incorporated	1206 (21)	3201
50 kg N/ha urea banded	1272 (23)	3693
100 kg N/ha urea banded	1437 (26)	4013
200 kg N/ha urea banded	1668 (30)	4189
LSD (0.10)	400	952

† **Canola grain** yield in **bu/ac** in parentheses

Figure l.Wheat grain and straw yields in 1998 at the Dixon site under two year hog manure management. lx, 2x and 4x refers to low, medium and high rates of injected hog manure. Treatments are listed for 1997 and 1998.



The cattle manure was much less effective in inducing a yield response in the year of application than the hog manure (Table 4). However, the treatments which received cattle manure in 1997 show a yield benefit in spring wheat grown on the plots in 1998 (Fig. 2). At both Burr and Dixon sites in 1997, gram yields were increased by cattle manure addition but the increases were only significantly greater than the control at the medium and high rates of application at Dixon. The large percentage of constituent nutrients in the organic form in the cattle manure as well as the higher C:N ratio as compared to hog manure would have reduced nitrogen availability. Beauchamp (1986) observed net immobilization following the application of solid cattle manure with a C:N ratio of about 15: 1. The yield of the delayed incorporation treatment was not significantly different from the immediately incorporated cattle manure treatments at both Burr and Dixon sites.

Table 4. Canola grain and straw yields in the 1997 cattle manure trials.

Grain and straw yield for Burr cattle manure trial

Treatments	Grain Yield (kg/ha)	Straw Yield (kg/ha)
Check with incorporation	644 (11)	**1817**
228 kg N/ha with incorporation	838 (15)	**2735**
456 kg N/ha with incorporation	920 (16)	**2617**
912 kg N/ha with incorporation	955 (17)	**2715**
228 kg N/ha with delayed incorporation	1023 (18)	**2959**
50 kg N/ha urea banded	795 (14)	**2641**
100 kg N/ha urea banded	675 (12)	**2338**
200 kg N/ha urea banded	542 (10)	**2407**
LSD **(0.10)**	ns	ns

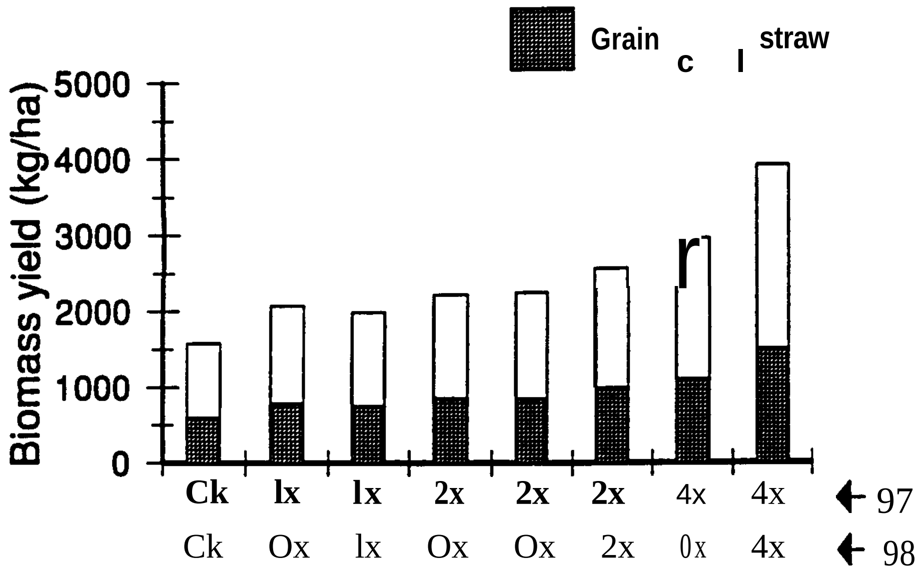
t Canola grain yield in bu/ac in parentheses

Grain and straw yield for Dixon cattle manure trial.

Treatments	Grain Yield (kg/ha)	Straw Yield (kg/ha)
Check with incorporation	713 (13)	**2388**
121 kg N/ha with incorporation	798 (14)	2592
242 kg N/ha with incorporation	1015 (18)	**2772**
484 kg N/ha with incorporation	1019 (18)	**3178**
121 kg N/ha with delayed incorporation	637 (11)	1998
50 **kg N/ha ma banded**	1240 (22)	3590
100 kg N/ha urea banded	1264 (22)	3811
200 kg N/ha urea banded	1292 (23)	3611
LSD (0.10)	**269**	643

† **Canola grain** yield in bu/ac in parentheses

Figure 2.Wheat grain and straw yields in 1998 at the Dixon site under two year *cattle* manure management. lx, 2x and 4x refers to low, medium and high rates of broadcast and incorporated cattle manure. Treatments are listed for 1997 and 1998.



Conclusion

There is potential for considerable spatial and temporal variability in the constituent nutrients of manure which makes precise and uniform land application challenging. Both hog and cattle manure contain elements important in plant nutrition. However, a proportion of certain nutrients such as N, P and S are in organic forms and are not likely to be completely converted to plant available inorganic forms in the first year of application. In solid 1 yr old cattle manure, a much higher proportion of these nutrients were found to be in slowly available organic forms as compared to hog effluent In hog manure effluent, all of the ammonium present may be considered readily available as in commercial fertilizer, but perhaps only 20% to 30% of the organic nitrogen will become available through mineralization in the year of application. Therefore, it is important to know what amounts of manure nutrient are in immediately available inorganic forms and in slowly available organic forms when making application rate decisions.

Application of hog manure had the greatest effect on increasing soil inorganic N levels in the spring and lesser effect on available concentrations of other soil macronutrients. Generally the cattle manure additions had less impact than hog manure on available soil nutrient levels in the first year of application. Nitrate levels increased with hog manure application rate at both sites, with the increase mainly restricted to the top 30 cm. Large amounts of residual inorganic N remaining in the soil profile after harvest at the high hog manure (-20,000 gpa) rates at Burr suggest that these rates are inappropriate under 1997 growing season conditions. As well, crop injury was observed at Burr at the highest rates of hog manure and fertilizer additions. The low and medium hog manure application rates injected using a 3Ocm spacing appeared to be the most effective rates and method of application at Burr in terms of crop yield response and acceptable residual nutrient levels in the year of application. The medium rate of hog manure addition (6800 gpa) injected using a 30 cm spacing appeared to be the best rate and method of application for the Dixon site as it represented an amount of manure that produced maximum yield with low (<20 kg NO_3-N / ha 0-6Ocm) residual levels of nitrate in the soil after harvest. The high rate of cattle manure resulted in the highest yields at both sites owing to the lower availability of nitrogen in cattle manure. Carryover effects into following years of nitrogen and other nutrients applied as manure also need to be considered. Proper credits should be given for residual inorganic nutrients and increases in soil mineralization rates when recommending application rates for hog and cattle manure on soils that have received manure in previous years.

Acknowledgements

The authors gratefully acknowledge the financial support of the Canada- Saskatchewan Agri-Food Innovation Fund and Saskatchewan Agriculture Development Fund.

References

Beauchamp, E.G. 1983. Response of corn to nitrogen in preplant and sidedress applications of liquid dairy manure. Can. J. Soil Sci. 63: 377-386.

Beauchamp,E.G. 1986. Availability of nitrogen from three manures to corn in the field. Can, J. Soil Sci. 66: 713-720.

Campbell, C.A., M. Schnitzer, J.W.B. Stewart, V.O. Biederbeck and F. Selles 1986. Effect of manure and P fertilizer on properties of a black Chemozem in southern Saskatchewan. Can. J. Soil Sci. 66: 601-613.

Chang, C., T.G. Sommerfeldt and T. Entz. 1990. Rates of soil chemical change with eleven annual applications of cattle feedlot manure. Can. J. Soil Sci. 70: 673681.

Chang,C., T.G. Sommerfeldt and T. Entz. 1991. Soil chemistry after eleven annual applications of feedlot manure. J. Environ. Qual. 20: 475480.

Culley, J.L.B., P.A. Phillips, F.R. Hore and N.K. Patni.1981. Soil chemical properties and removal of nutrients by corn resulting from different rates and timing of liquid dairy manure applications. Can. J. Soil Sci. 61: 35-46.

Daniel, T.C., A. Sharpley, D.R. Edwards, R. Wedepohl, and J.L. Lemunyon. 1994. Minimizing surface water eutrophication from agriculture by phosphorus management. J. Soil Water Conserv. 49: 30-38.

Dormer, S.G. 1997. The effects of elemental sulfur and hog manure on a solonetzic soil. M.Sc. thesis. University of Saskatchewan, Saskatoon, Sk.

Dubetz, S., G.C. Kozub and J.F. Dormaar. 1975. Effects of fertilizer, barnyard manure and crop residues on irrigated crop yields and soil chemical properties. Can. J. Soil Sci. 55: 481-490.

Eriksen, J. 1997. Animal manure as S fertilizer. In: Sulfur in Agriculture, Vol. 20, pp 27-30.

McCalla T.M. 1974. Use of animal manure wastes as a soil amendment. J. Soil Water Conserv. 29: 213-216.

Paul, J.W. and E.G. Beauchamp. 1994. Short-term nitrogen dynamics in soil amended with fresh and composted cattle manures. Can. J. Soil Sci. 74: 147-155.

Saskatchewan Agriculture and Food. 1997. Agricultural Statistics 1996 Handbook

Schoenau,J.J. 1998. Swine manure as a plant nutrient source. In: Proceedings of 19th Western Nutrition Conference'98 Univ. of Sask. Extension Press, pp 121-125.

Sommerfeldt, T.G. and D.C. Mackay. 1987. Utilization of cattle manure containing wood shavings: effect on soil and crop. Can. J. Soil Sci. 67: 309-316.

Sutton, A.L. 1994. Proper animal manure utilization. J. Soil Water Conserv. 49: 65-70.