
Soil and Crop Response to Injected Liquid Swine Manure on Two Gray Luvisols

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Introduction

Intensive livestock production is increasing in western Canada, and so is the need to dispose of the manure produced. In the last six years or so, the Saskatchewan Centre for Soil Research at the University of Saskatchewan in conjunction with researchers at Prairie Agricultural Machinery Institute (PAMI) and Agriculture and Agri-Food Canada (AAFC) have carried out studies in various areas of manure management. The overall aim of these studies is to determine the viability and sustainability of manure application to agricultural land. The impact of livestock manure application to land is influenced by various factors, among them: soil characteristics, climatic conditions, cropping systems, manure handling and application techniques. Thus, manure management is bound to be site-specific. In order to come up with viable site-specific manure management recommendations, studies have to be conducted in various regions representing the diverse agricultural zones of the province. Although there are various aspects of the impact of manure application to agricultural land, both long-term and short-term, the immediate impact of manure application is typically exhibited in enhanced availability of N in the soil, crop yield and plant N concentration. This is more so with swine manure which has a relatively high concentration of inorganic N. Hence, the objective of this study was to determine the effects of rate and frequency of swine manure application on crop performance and soil available N in the Gray and Dark Gray soil zones of Saskatchewan.

Materials and methods

The experiment was initiated in 1999 at Melfort (SW26 Tp44 R18 W2) and Loon Lake (SW32 Tp58 R21 W3). Although soils around Melfort are typically described as Thick Black Chernozems, there are pockets under wooded areas falling into other descriptions. The Melfort site was located on a field with soil classified as Dark Gray Luvisol (Kamsack Association) of clay loam texture. The Loon Lake site was situated on a Gray Luvisol (Loon River Association) of loam texture. Liquid swine manure was injected into the soil using the PAMI manure tanker truck fitted with low disturbance coulter injection system in the fall prior to each cropping season. Four rates of manure application (none, low, medium and high) were used. The low rate was applied at 3000 gallons per acre. The medium and high rates were double and triple multiples of the low rate, respectively. The low rate was applied annually. The medium rate was applied in the first and the third year, while the high rate was applied only in the first year. A fifth treatment of urea at soil-test recommended rate was included and applied annually at the time of seeding. Thus, the five treatments were coded as **000**, **111**, **202**, **300** and **uuu**, respectively. At the time of manure application, manure samples were taken for the determination of nutrient content later in the

laboratory. Table 1 gives the actual rates of inorganic N (mainly ammonium-N) applied per year at each location in the three years of the study.

The treatments were arranged in a RCBD with four replications at each site. However, at Loon Lake, three crops were seeded across the main treatments each year, thus changing the experiment to a split-plot design. Hence, statistical analysis was conducted separately based on the two experimental designs. At Melfort, wheat, canola and oats were seeded in 2000, 2001 and 2002, respectively. At Loon Lake, canola, pea and barley were seeded in rotation during the three years of the study. Flax was seeded in place of canola in 2001. Soil samples were taken in the spring prior to seeding and in the fall after harvesting. The soil samples were analyzed for various variables including inorganic N. Crop samples were taken for the determination of grain yield and N concentration.

Table 1. Inorganic N concentration in the liquid swine manure applied at Melfort and Loon Lake for the growing seasons 2000, 2001 and 2002

Manure Application Rates			
Regime	2000	2001	2002
Melfort - - - - (Av. N kg/ha) - - - -			
1	0	0	0
2	54	73	80
3	108	0	160
4	162	0	0
5	80	80	80
Loon Lake			
1	0	0	0
2	61	30	84
3	122	0	168
4	183	0	0
5	80	80	80

Results and discussion

Injection of liquid swine manure significantly increased pre-seeding available soil N at Melfort in 2000 (Fig. 1). At Loon Lake, pre-seeding available soil N was not significantly different from that in the control treatment except at the high rate of application. The urea treatment at both locations exhibited pre-seeding available soil N similar to those in the control plots because the urea was applied after sampling. The low enhancement of pre-seeding available soil N at Loon Lake may be due to immobilization of N in the manure. Similarly, in 2001, pre-seeding available soil N was significantly higher than the control at Melfort but not at Loon Lake. Treatments **202** and **300** at Loon Lake, exhibited higher pre-seeding available soil N although these treatments did not receive manure applications for that growing season. This could be attributed to the release of the N that was immobilized in the first year as well as carry-over of residual inorganic N. At Melfort, treatments **202** and **300** showed no significant difference in available soil N than that observed in the control, suggesting low residual effect of higher rates of manure application in these soils. In 2002, swine manure application enhanced pre-seeding available N in both the **111** and **202** treatments, but only the latter showed a significant enhancement in pre-seeding

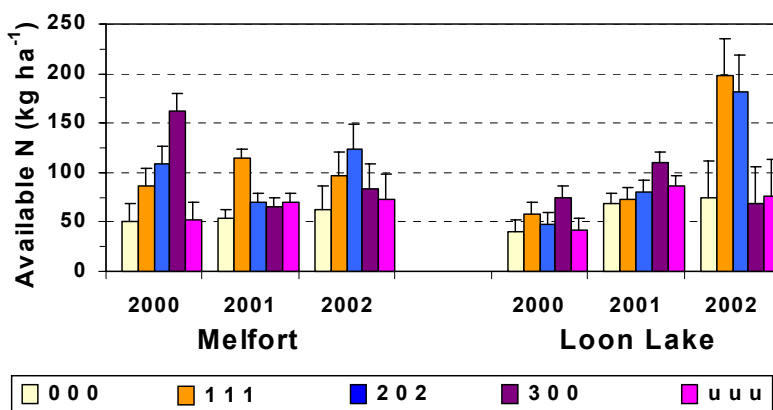


Fig. 1. Effect of liquid swine manure application rate and frequency on pre-seeding available soil N at Melfort and Loon Lake.

available soil N over the control. At Loon Lake, both treatments **111** and **202** significantly enhanced pre-seeding available soil N as compared to the control. No significant residual effect of high rate of swine manure application was observed at both locations by the third year following application.

At Melfort, post-harvest available soil N was generally low (Fig. 2). In 2000, only at the high application rate of swine manure was a significant elevation in post-harvest available soil N observed. In 2001, post-harvest available soil N in all manure treated plots was not different from that in the control. However, treatments treated with urea exhibited a significant post-harvest available soil N. This could be attributed to poor utilization of the urea by the canola crop, which showed significant effects of sulfur deficiency (Schoenau et al. 2003). In 2002, only treatment **202** exhibited a significant elevation in post-harvest available soil N compared to the control.

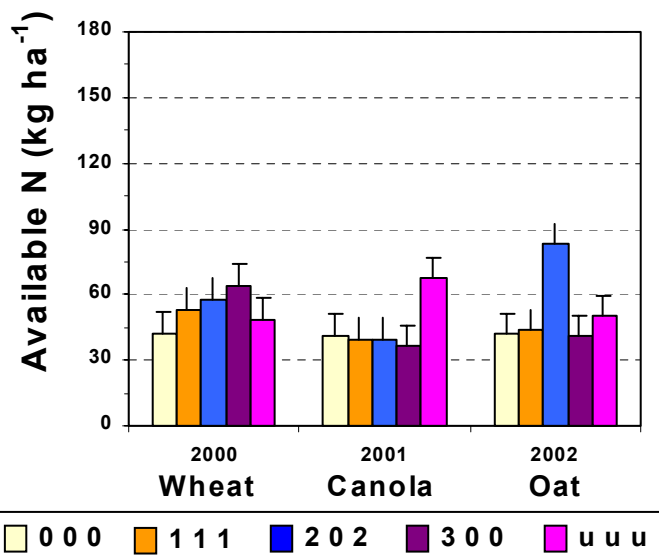


Fig. 2. Effect of liquid swine manure and urea application rate and frequency on post-harvest available soil N at Melfort.

At Loon Lake, no significant elevation in post-harvest available soil N was observed in all treatments in 2000 (Fig. 3). In 2001, significant elevation in post-harvest available soil N was observed, particularly in treatment **202**. It is not clear as to why treatment **202** exhibited significantly higher post-harvest available soil N than treatment **300**, both of which received no manure application for the 2001 season, with the latter having received a higher rate of swine manure

application. As no plausible explanation can be given for the elevated post-harvest available soil N in treatment **202**, it can generally be noted that manure and urea application did not significantly enhance post-harvest available soil N.

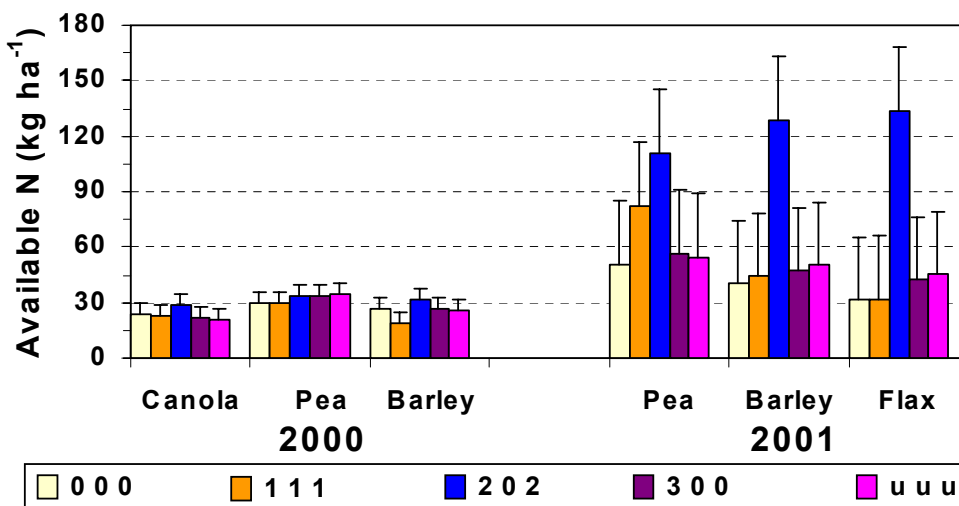


Fig. 3. Effect of liquid swine manure and urea application rate and frequency on post-harvest available soil N at Loon Lake in 2000 and 2001.

At Melfort, application of swine manure and urea significantly increased grain yield of wheat in 2000 (Fig. 4). No significant differences in wheat grain yields were observed in manure treated plots beyond that observed at the low rate of application. Wheat grain yields in manure treated

plots were comparable to those receiving urea. In 2001, swine manure application at the low rate produced significantly higher than that of any other treatment. Treatments **202** and **300**, which received no manure in 2001, resulted in low canola grain yields, comparable to the control plots. Urea application at 80 kg ha⁻¹ resulted in the lowest canola grain yield. Plots receiving urea only exhibited severe symptoms of sulfur deficiency (Schoenau, et al. 2003). In 2002, grain yield of oats was significantly elevated by both swine manure and urea application. No significant response to rate was observed, probably due to the dry conditions. However, since similar lack of response to rate was observed in the first year with relatively sufficient moisture, the results suggest that applying manure at rates higher than 3000 gpa in these soils may result in no added grain yield benefit. The comparative increase in grain yield of oats in the urea treated plots also show that cereal crops are not as sensitive to the low S levels in these soils.

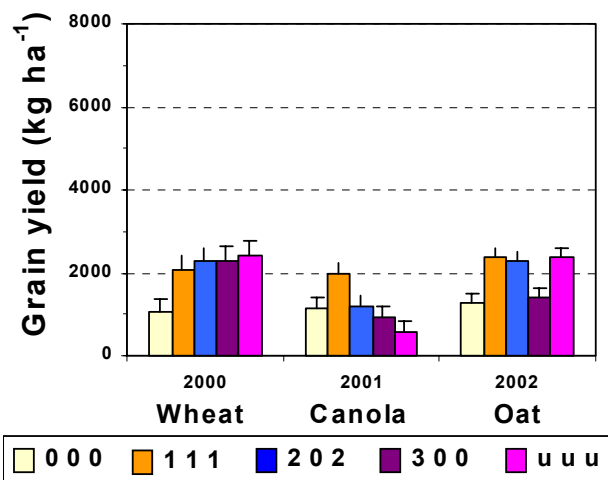


Fig. 4. Effect of liquid swine manure and urea application rate and frequency on grain yield of wheat, canola and oats in 2000, 2001 and 2002, respectively, at Melfort.

At Loon Lake, swine manure and urea application significantly increased canola and barley grain yield in 2000 (Fig. 5). A significant response to the rate of manure application was also observed in these crops. The effect of urea application on grain yield of canola and barley was comparable to that of the low rate of swine manure. Grain yield of pea was high and no difference was observed between manure treated plots and the control. However, pea grain yield was suppressed by urea application.

In 2001, no significant grain yield differences were observed in pea and flax crops. On the other hand, barley grain yields in the swine manure and urea treated plots were significantly higher than that in the control. The lack of response to the rate of manure application or urea application was attributed to the drought of that year. The pea and flax crops were more affected by the drought due to the openness of their canopies which under such situations render them poor competitors with weeds for scarce moisture, or lose more moisture through evaporation.

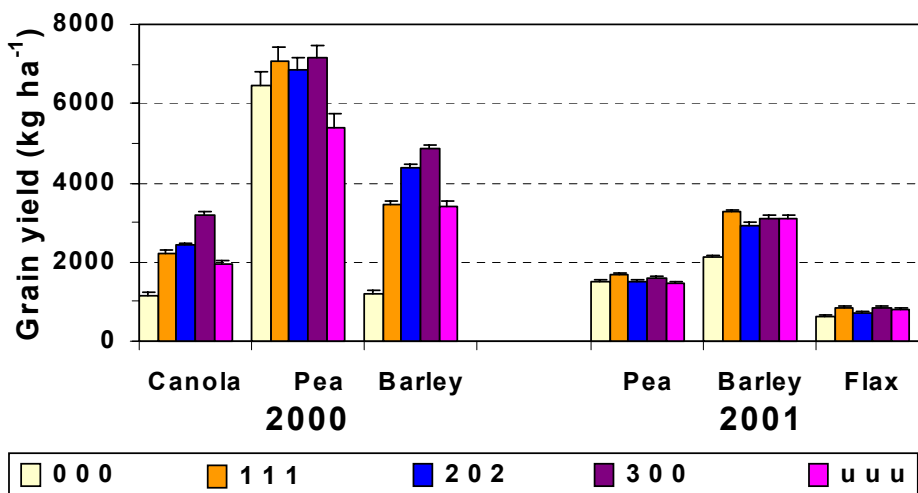


Fig. 5. Effect of liquid swine manure and urea application rate and frequency on grain yield of canola, pea and barley in 2000, and pea, barley and flax in 2001 at Loon Lake.

At Melfort in 2000, grain protein of wheat was significantly enhanced by swine manure application at the high rate and by urea application (Fig. 6). In 2001, canola grain protein concentration was highest in the urea treated plots, which also yielded the lowest. Treatments **111** and **300** also resulted in significantly higher protein concentration compared to the control. No difference in canola grain protein was observed between treatment **202** and the control. Grain protein concentration of oats seeded in 2002 showed less response to swine manure application. Only treatment **202** and **uuu** showed small but a significant increase in grain protein compared to the control.

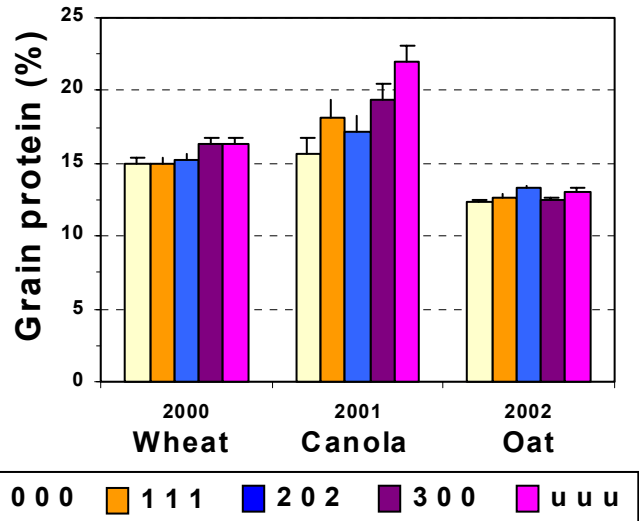


Fig. 6. Effect of liquid swine manure and urea application rate and frequency on grain protein of wheat, canola and oats in 2000, 2001 and 2002, respectively, at Melfort.

At Loon Lake in 2000, both canola and barley showed significant increase in grain protein concentration over the control, with the highest values observed at the high rate of swine manure (Fig. 7). In peas, no significant difference in grain protein was observed between manure treated plots and the control. However, urea treated plots exhibited higher pea grain protein concentration than high manure rate treated plots. In 2001 at Loon Lake, pea grain protein concentration in urea treated plots was higher than in any other treatment. Manure treated plots were not different from the control. A significant grain protein concentration response to rate of manure application was observed in barley and flax. In barley, no significant difference in grain protein concentration was observed among the **111**, **300** and **uuu** treatments. However, in both barley and flax, the **uuu** treatment resulted in the highest grain protein concentration.

The elevation of pre-seeding available soil N following swine manure application have been observed in other soil zones (Pastl et al. 2000; Mooleki et al. 2002; Grevers 2002). Under ideal conditions, this results

in enhanced crop yield in non-leguminous crops as observed at Melfort and Loon Lake in the first year. Grain protein concentration may also increase. The effect of swine manure application on available soil N and crop performance is comparable to that of chemical N fertilizer. This is attributed to the high (60 – 80%)

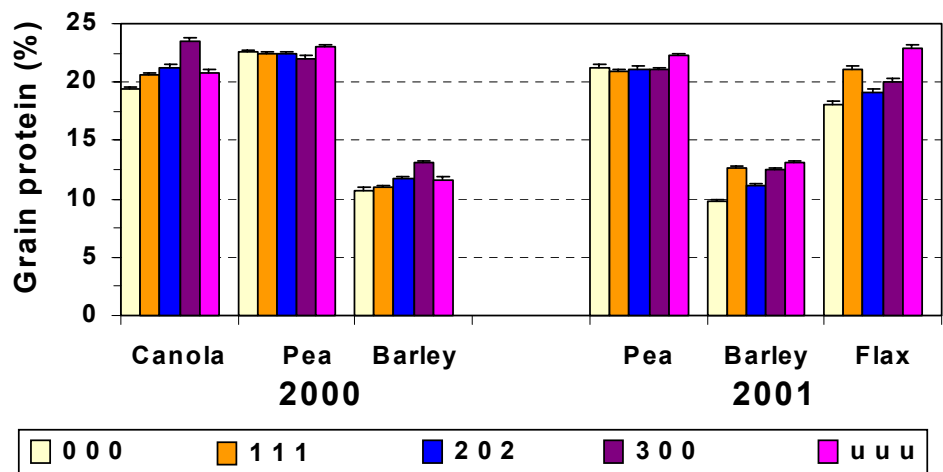


Fig. 7. Effect of liquid swine manure and urea application rate and frequency on grain protein of canola, pea and barley in 2000, and pea, barley and flax in 2001 at Loon Lake.

inorganic N available in the manure or becoming available over the growing season (Qian and Schoenau 2000). Like chemical N fertilizers, the advantages of manure application are suppressed under droughty situations as observed at both Melfort and Loon Lake in 2001 and 2002. Unlike chemical N fertilizers, swine manure supplies other nutrients, which may help offset nutrient deficiencies in sensitive crops – e.g. S deficiency in canola as observed in 2001 at Melfort (Fig. 4). These results also show that swine manure application in excess of 3000 gpa (approx. 80 kg N ha⁻¹) may not result in increased grain yield in the year of application. Unlike in the Black, Dark Brown and Brown soil zones (Mooleki et al. 2002; Grevers 2002) where the residual N from high rates of manure lasted at least two years, the residual effect of high rate of swine manure in the Gray soils seems to be shorter. This can also be seen from the low post-harvest available soil N. Given the more moist conditions of these environments, the low residual effect of high rates of swine manure application may be attributed to leaching or gaseous losses, or immobilization in the soil organic matter.

Conclusions

Liquid swine manure application in the Gray soils is a sustainable practice. The residual effect of high manure application and the low increase in grain yield above that obtained from the low rate of manure application indicate that annual application at low rates would be a better practice.

Acknowledgements

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