Effect of Solid Cattle Manure Injection on Oat Crop Production in East-Central Saskatchewan

Tom King[1], Jeff J. Schoenau[1] and Hubert Landry[2]

[1]Department of Soil Science, University of Saskatchewan, Saskatoon, SK S7N-5A8
[2]Prairie Agricultural Machinery Institute (PAMI), Humboldt, SK S0A-2A0

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Introduction

Beef cattle operations have traditionally removed solid cattle manure (SCM) from feeding/holding pens and broadcast the manure on pasture and cultivated fields. The main distribution method has been to broadcast (pasture), and broadcast and eventual incorporation (cultivated fields). Some Saskatchewan cattle producers/feedlot operations have shifted to winter feeding systems that include feeding strategies such as bale grazing, swath grazing and straw/chaff pile grazing. This method maximizes the economical method of manure distribution by not having to use machinery, fuel and time to distribute the manure in the field (Jungnitsch et al., 2005). In intensive hog operations, liquid hog manure (LHM) is applied via a direct injection system. The agronomical and environmental advantages of LHM direct injection are well documented (Mooleki et al., 2002).

Similar to LHM injection, SCM can now be applied using a direct injection system that utilizes a coulter opener and is "injected" into a furrow that is then closed behind the injection unit. SCM Injection will aid in reducing foul odors associated with broadcast and/or broadcast and incorporation operations. It is possible that injection of SCM will also decrease volatilization losses of N and P losses resulting from run-off. The objectives of this study were to evaluate the effect of injecting solid beef cattle manure on oat crop yield, nutrient uptake, and residual soil nutrients.

Materials and Methods

This study was conducted at Dixon, SK (legal location NW21-37-23-W2). The soils at this site belong to the Cudworth Association: a Black Chernozem formed in calcareous silty, lacustrine parent materials and having a loam surface texture (Saskatchewan Soil Survey 1989).

The SCM injection trials at the Dixon site consisted of 15 treatments that were replicated in four blocks, arranged in a north to south direction. The SCM was applied using 4 application methods: 1) broadcast (B) ; 2) broadcast and incorporated (B&I); 3) surface injection(SCM Inj) and 4) surface injection with added urea (SCM Inj+U); and at 3 application rates: 1) 9 t ha^{-1} (low); 2) 18 t ha^{-1} (medium) and 3) 27 t ha^{-1} (high).

Plant samples were collected from the plots just prior to the producer swathing the oat crop. Duplicate $1m^2$ plant samples were cut from each trial plot. Plant samples were dried, weighed (total biomass weight was recorded), thrashed and cleaned (separated into grain and straw components). The grain & straw samples were digested to determine total nitrogen (N) and phosphorus (P).

Soil samples were collected from the site in the fall of 2007 following harvesting operations. Soil samples were obtained from each plot in the study. Soil samples were obtained using a truck mounted mechanical soil coring unit. All samples were taken to a 0-15 cm depth and analyzed for soil extractable nitrate-nitrogen (NO_3-N), ammonium-N (NH_4-N), phosphorus (P) and potassium (K). Basic soil properties such as pH, electrical conductivity (E.C.) and organic carbon (O.C.) were also measured.

Results and Discussion

There was a significant yield response of the oat crop to addition of SCM. An average increase of 1000 kg ha^{-1} was obtained in the B, B&I and SCM Inj treatments compared to the unfertilized, un-manured control (Figure 1). The broadcast 3X rate achieved the highest overall oat grain yield at 5356 kg ha^{-1}, possibly due to higher surface organic matter (OM) helping to reduce evaporation during the period of above normal temperatures in late June and July 2007. The injected SCM yields were not significantly different from B and B&I yields at equivalent rates of manure addition (Figure 1).

The SCM Injection at the 1X rate + urea produced a good crop yield of 5103 kg ha^{-1}. Oat straw yields were also increased by manure addition (Figure 2), but there was no significant effect of application method.

The grain N increased with increasing rate of B & I application, but not for the B treatment. Grain N increased from 13.3 mg g^{-1} in the low rate treatment to 14.4 mg g^{-1} in the high treatment (Figure 3). The lower N concentration in the B treatments indicates lower N recovery from broadcast application. Injected SCM grain N concentrations were slightly elevated compared to the B&I treatments, and were higher than the B treatments (Figure 3).

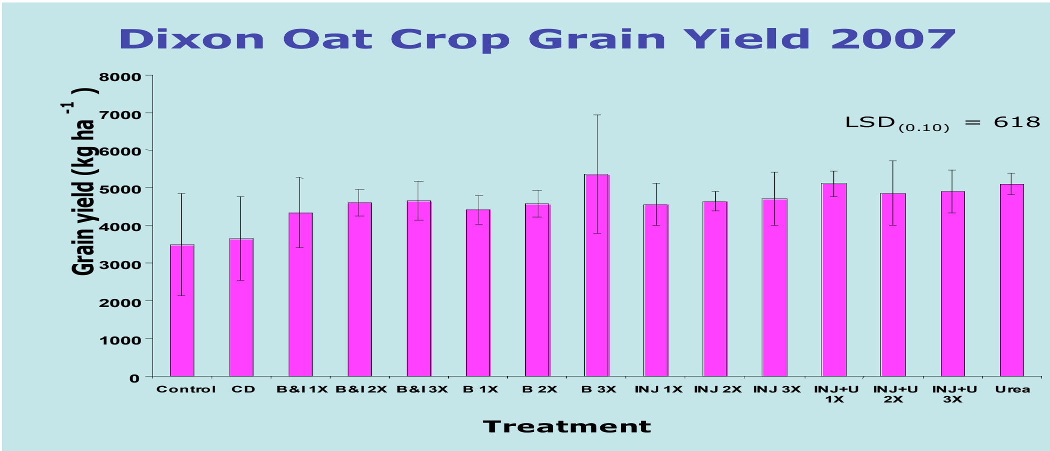

Figure 1. Oat crop grain yield at Dixon, SK in fall 2007.

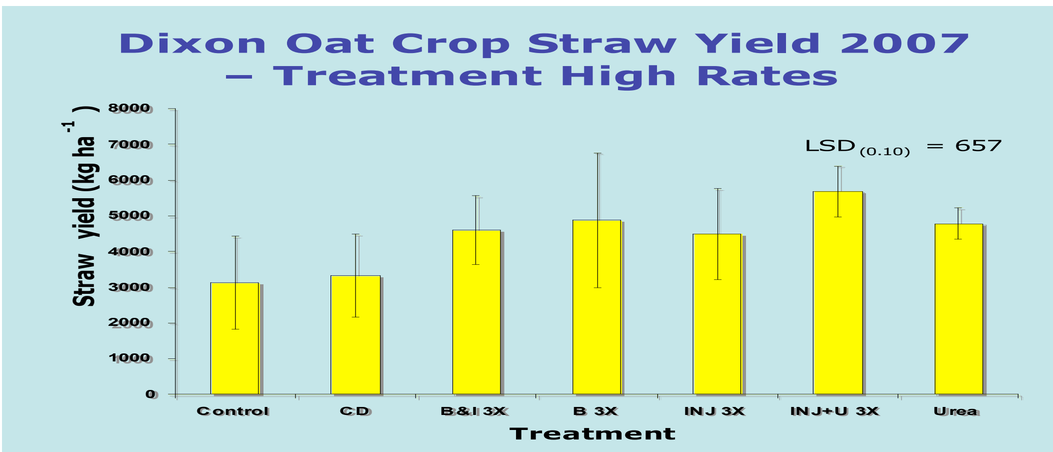

Figure 2. Oat crop straw yield for treatment high rates at Dixon, SK in fall 2007.

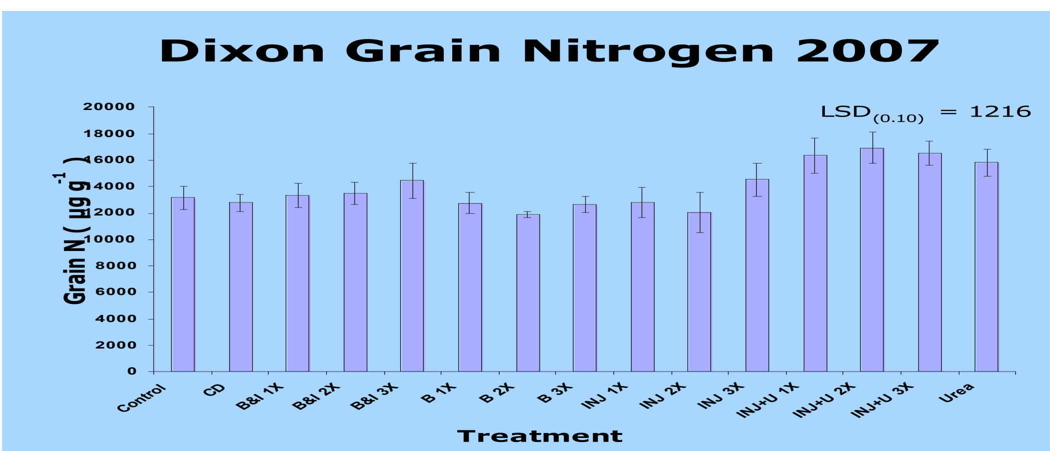

Figure 3. Oat crop grain nitrogen concentration at Dixon, SK in fall 2007.

Grain and straw N concentrations (Figure 4) were significantly higher in the solid cattle manure + urea (SCM Inj+U treatments) than other treatments, reflecting the enhancement in soil N availability resulting from the added urea.

Oat crop grain P levels (approximately 4 mg g^{-1}) were virtually the same across all application strategies and rates, with the exception of the urea only treatment which had the lowest grain P content of 3.3 mg g^{-1} (Figure 5).

Straw P concentrations increased with rate of manure, with the exception of the B&I medium and high rates. However, no differences in straw P content were found among the application methods (Figure 6).

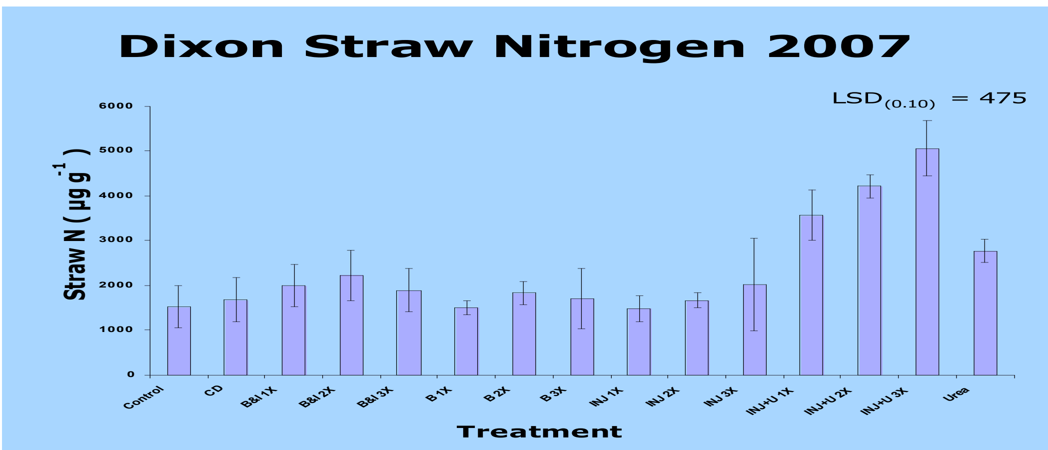

Figure 4. Oat crop straw nitrogen concentration at Dixon, SK in fall 2007.

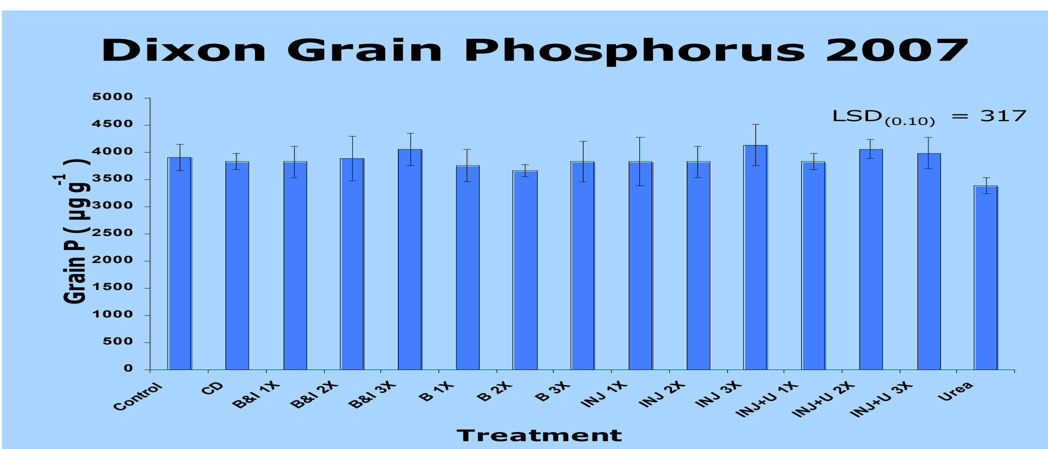

Figure 5. Oat crop grain phosphorus concentration at Dixon, SK in fall 2007.

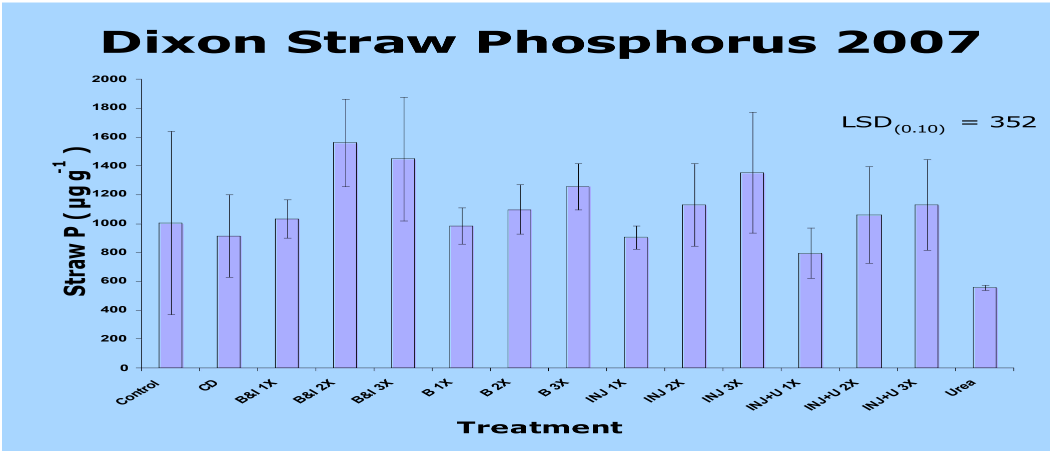

Figure 6. Oat crop straw phosphorus concentration at Dixon, SK in fall 2007.

Manure application rate and method did not have any significant effects on soil pH, with pH ~ 7.1. Addition of SCM, whether broadcast, broadcast and incorporated or injected did not significantly affect soil salinity as indicated by electrical conductivity (E.C.) measurement. Mean organic carbon (O.C.) concentration values (0-15cm) were increased by about 0.4-0.5 % units from the control to the 3X rate, but there was no significant effect on O.C. values associated with application method or rate of application.

Soil sample analysis revealed that residual soil NO_3-N levels were all low (between 8-10 kg ha^{-1}) for the B and B&I treatments (Figure 7). There were no significant differences between the B and B&I treatments and the low and medium SCM Inj rates and the control. The high rate of SCM Inj+U had elevated levels of soil extractable NO_3-N (17 kg ha^{-1}) in 0-15 cm depth compared to all other treatments (Figure 7). The high rate SCM Inj and medium rate SCM Inj+U also show slightly elevated levels of NO_3-N versus the B and B&I treatments (Figure 7). Soil extractable ammonium levels were highest (over 7 kg ha^{-1}) in the medium and high rate SCM Inj+U and urea alone treatments, but otherwise no significant differences were found between the B, B&I and SCM Inj treatments (Figure 8).

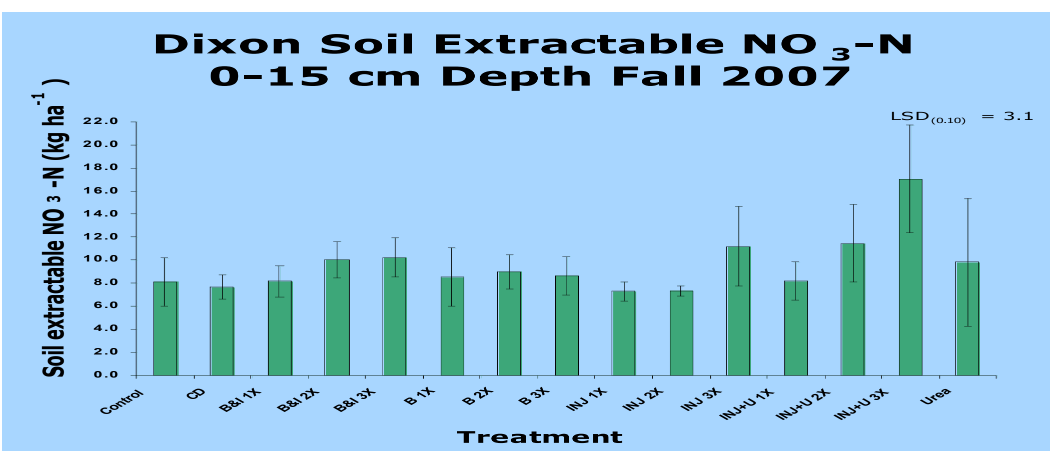

Figure 7. Soil extractable nitrate-nitrogen in the 0-15 cm depth at Dixon, SK in fall 2007.

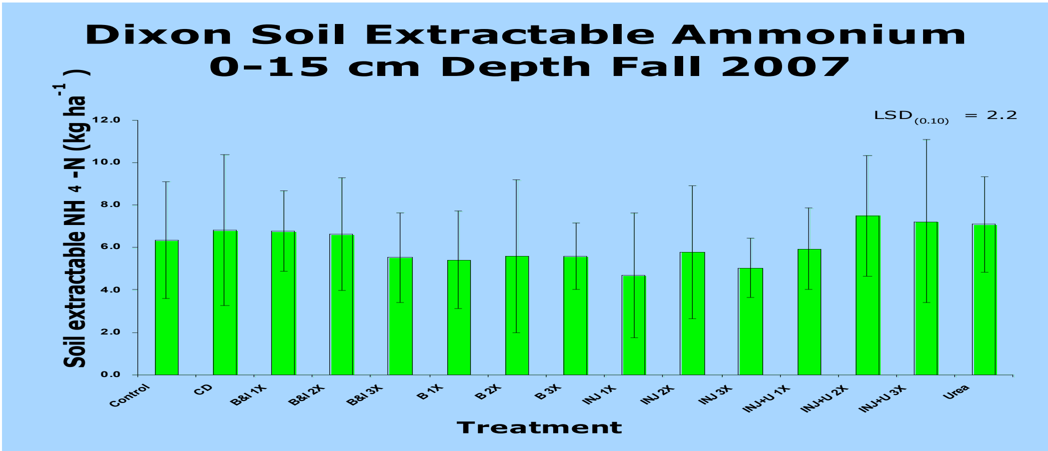

Figure 8. Soil extractable ammonium in the 0-15 cm depth at Dixon, SK in fall 2007.

Kelowna extractable P (0-15 cm depth) was found to significantly increase with rate of application for all four application treatments. For example, Kelowna extractable P increased from 17 to 48 to 117 kg ha^{-1} in the low, medium and high rates of SCM Inj treatments, respectively (Figure 9). Kelowna extractable P increased from 21 to 26 to 85 kg ha^{-1} in the low, medium and high rate SCM Inj+U treatments, respectively (Figure 9). Both the high rate SCM Inj and SCM Inj+U soil P levels were considerably elevated versus the high rate B (64 kg ha^{-1}) and B&I (60 kg ha^{-1}) treatments (Figure 9).
The elevated soil P levels in the high rate SCM Inj and SCM Inj+U treatments suggests better retention of P under a high SCM rate injected treatment as opposed to broadcast treatments.

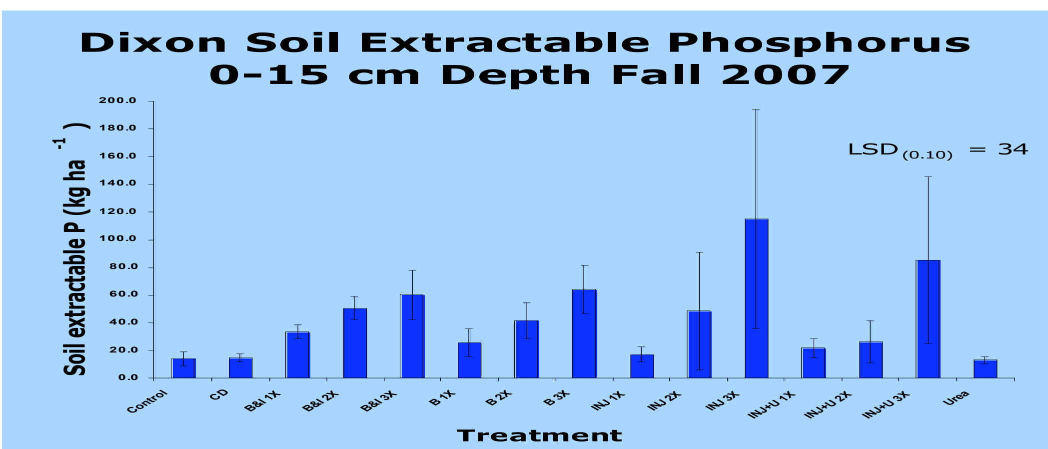

Figure 9. Soil extractable phosphorus in the 0-15 cm depth at Dixon, SK in fall 2007.

Soil extractable K was highest at 1189 kg ha^{-1} under the high rate SCM Inj treatment. Elevated levels of K were also found at the low rate SCM Inj (806 kg ha^{-1}) and at the medium rate SCM Inj +U (877 kg ha^{-1}) (Figure 10). The B&I treatments had lower extractable soil K levels, ranging from 630-760 kg ha^{-1} (low and high rate , respectively), compared to the low and high rate SCM Inj treatment and medium rate SCM Inj+U treatment (Figure 10).

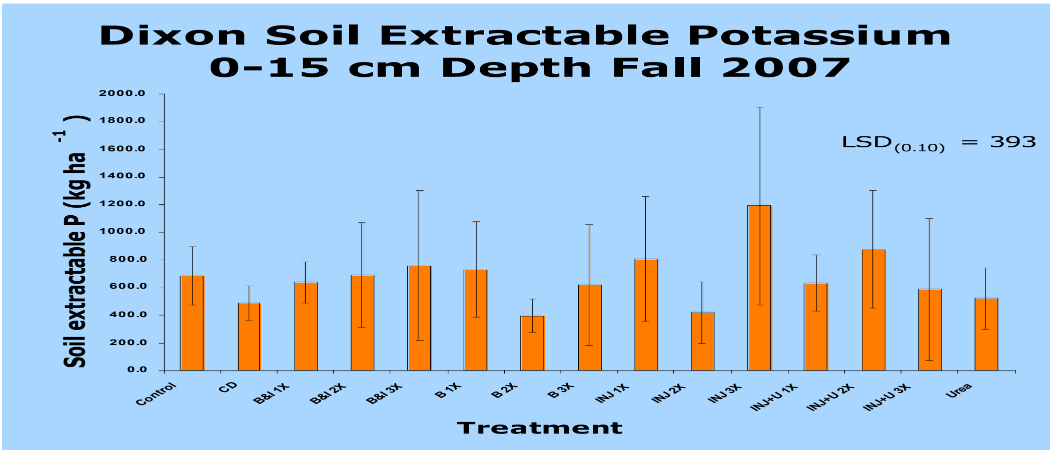

Figure 10. Soil extractable potassium in the 0-15 cm depth at Dixon, SK in fall 2007.

Conclusions

Response of the oat crop yield to the injection of solid cattle manure was similar to broadcast only and broadcast and incorporated applications of cattle manure. The high application rate of the broadcast treatment may have produced higher yields than other treatments as a result of a surface mat of organic residue that helped to preserve moisture and reduce evaporation under conditions of the summer drought of 2007. Grain and straw N levels increased under SCM Inj+U treatments. Higher SCM Injection rates resulted in higher soil extractable NO_3-N and NH_4-N. Injection of solid cattle manure at high rates significantly increased soil extractable P compared to other methods of application. Future research will be focused on a more detailed assessment of soil N and P forms, distribution and movement as affected by application rate and method.

Acknowledgements

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