Effect of Winter Feeding Systems on Soil Nutrients

T.King[1], J.Schoenau[1], H.A. (Bart) Lardner[2,3] and Breeanna Kelln[3]

[1]Dept. of Soil Science, University of Saskatchewan, Saskatoon, SK S7N-5A8
[2]Western Beef Development Centre, Box 1900, Humboldt, SK S0A-2A0
[3]Dept. of Animal and Poultry Science, University of Saskatchewan, Saskatoon, SK S7N-5A8

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Introduction

Beef cattle producers in Western Canada compete at an economic disadvantage compared to other cattle producers in North America due to high feeding costs. Producers are constantly seeking methods to not only lower costs of production but more efficiently manage animal manure. By more effectively and economically managing manure and reducing handling costs, producers can more effectively manage soil nutrients. More producers are moving from traditional drylot confined pen feeding where manure is transported to fields for distribution to winter feeding on pasture and cropped land where nutrients may be more effectively conserved and manure handling costs are minimized.

Manure that is deposited in a drylot feeding pen can be subject to volatilization losses. If this loss could be minimized, there is the potential to improve soil N levels in cropped fields and increase plant biomass. Erickson and Klopfenstein (2001) reported that feedlot yearlings retain approximately 10 percent of nitrogen (N), excreting the remaining 90 percent, most of which is lost to volatilization. Previous research on forage grasses has shown that forages utilize nutrients throughout the growing season, however, most forage grasses used for pasture have lower than optimal plant growth due to shortages in one or more nutrients (Malhi et al., 2001). Griffin (1997, 1998) reported that forage yields on bale grazed pasture increased four times after two years of grazing and doubled after one year of grazing. Jungnitsch et al. (2005) reported that plant biomass was greater and quality was better later in the growing season when cattle were winter fed on a bale grazed and bale processed Russian wildrye forage pasture. Nutrient retention by the pasture was improved when compared to spreading the manure. Distribution of the nutrients after winter feeding was directly related to the feeding systems. Forage biomass response was greater in total from pasture winter feeding than when manure was hauled out of the yard and spread on the field (Jungnitsch et al., 2005). There is a lack of knowledge on the effect of winter feeding systems on cultivated crop land, therefore, the objective of this study was to determine what effect three different winter feeding systems had on soil nutrient distribution and soil cycling in a cultivated annually cropped soil.

Materials and Methods

This study was conducted at the Termuende Research Farm, Lanigan SK, over 2005-2006. The study site is situated on an Orthic Black Chernozemic soil (Saskatchewan Soil Survey, 1992). The cattle wintering site was broken into nine 4.0 ha replicate paddocks. One additional 4.0 ha paddock was selected for the randomized complete block design (RCBD) manure study. Animal access to feed was controlled using solar powered electric fencing. Portable wind shelters were used to provide protection from wind. Water was transported to the beef cattle in each paddock.

Replicate groups of Black Angus crossbred pregnant beef cows were randomly allocated to 1 of 3 replicated winter feeding systems. Feeding systems included: (1) replicate groups of cross bred cows wintered on 4 ha paddocks of cropped field for 75-100 days. Field bale grazed (BG) barley green feed bales fed *ad libitum* every 3 days; (2) replicate groups of cross bred cows wintered on 4 ha paddocks of swathed barley for 75-100 days. Field swath grazed (SG) with feed allocated *ad libitum* every 3 days; (3) replicate groups of cross bred cows wintered on 4 ha paddocks of barley chaff/straw for 75-100 days. Field straw-chaff (ST/CH) grazing with feed allocated *ad libitum* every 3days.

Soil samples were collected from the site in the spring of 2006 following winter feeding. Landscape directed soil sampling was conducted in all nine paddocks at the upper, mid and foot-slope positions. 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 nitrate-nitrogen (NO_3-N), ammonium-N (NH_4-N), phosphorus (P) and potassium (K). A manure study was also conducted at this site.

In one of each randomly selected winter feeding treatment, a 32 point grid (6.1m X 7.6m) was established. Anion plant root simulator (PRS™) probes were inserted in the soil at each grid point for 1 week in early May, 2006 to measure NO_3-N and P. The results from the spring of 2006 were used to create a map of soil nutrient distribution and availability on the winter fed paddocks using Surfer 8.0™ software.

In each of the nine paddocks, five one meter square plant samples were obtained from a randomly established transect prior to swathing (soft dough stage). A total of 45 plant samples were obtained from the nine paddocks. One-quarter meter square plant samples were obtained from each grid point for each of the three grid treatments just prior to swathing (soft dough stage). A total of 96 plant samples were obtained from the grids. All plant samples were dried and total biomass was measured.

Results and Discussion

Soil extractable NO_3 levels were about 40 kg N ha^{-1} in the SG with little landscape effect evident (Figure 1). The BG treatment NO_3 was about 60-65 kg N ha^{-1} in the high and low slope positions, but dropped to about 40 kg N ha^{-1} in the mid slope position. The ST/CH treatment had about 35 kg N ha^{-1} as NO_3-N in the high and low slope position and 60 kg N ha^{-1} in the mid slope position (Figure 1).

Soil extractable NH_4 levels ranged from 6.5-8 kg N ha^{-1} for all three winter feeding treatments (Figure 1). There were no discernable differences in NH_4 levels across the three landscape positions for all treatments.

A significant landscape effect on soil extractable P was observed in the ST/CH treatment. Soil P levels rose from 100 kg P ha^{-1} to 150 and 225 kg P ha^{-1} in the mid and low slope positions, respectively (Figure 1). This was the only treatment to show a landscape effect with soil P. SG soil P levels were about 150 kg P ha^{-1}. Soil P levels in the BG treatment ranged from 150 kg P ha^{-1} in the mid slope to over 200 kg P ha^{-1} in the low slope.

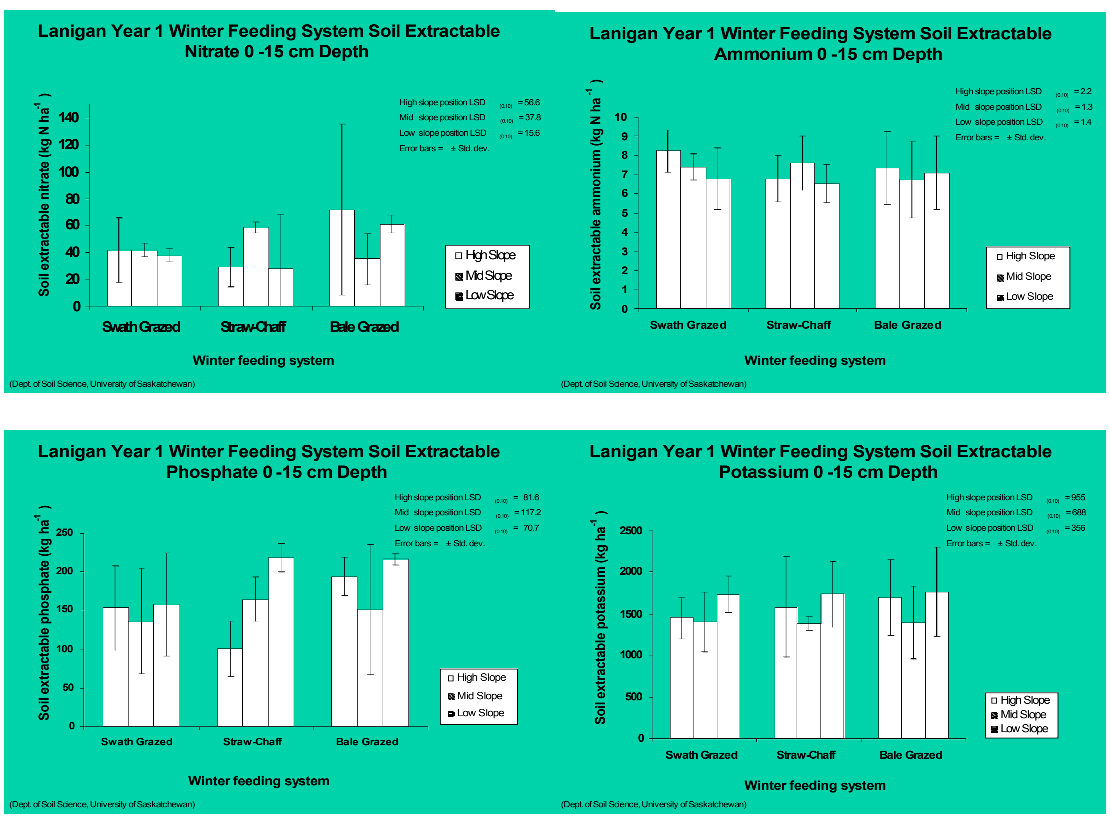

Figure 1. Soil extractable NO_3-N, NH_4-N, P and K in the 0- 15 cm depth for the three winter feeding systems.

Soil extractable K levels ranged from 1500-1700 kg K ha^{-1} for all three winter feeding treatments (Figure 1). There were no significant differences in K levels across the three landscape positions for all three winter feeding treatments. Across the landscape positions, extractable nitrate and phosphate tended to be higher in the BG treatment than the other treatments, while ammonium and potassium were similar.

Soil nutrient patterns from the detailed sampling grids showed highly variable soil nutrient levels where the cattle were fed amongst the three winter feeding systems. In the BG winter feeding system, the disposition of NO_3-N was greater in the areas surrounding the position of the round bales used for winter feeding (Figure 2). Nitrate supply rates ranged from 40 to 65 µg N cm^{-2} in the areas located adjacent to the round bale positions to under 25 µg N cm^{-2} where the bales were positioned. Plant biomass followed a similar trend to NO_3 supply rate levels in this grid. Greater amounts of biomass were located in the areas surrounding the bale positions (<8500 kg ha^{-1}), while biomass in the bale locations was <6500 kg ha^{-1} (Figure 2).

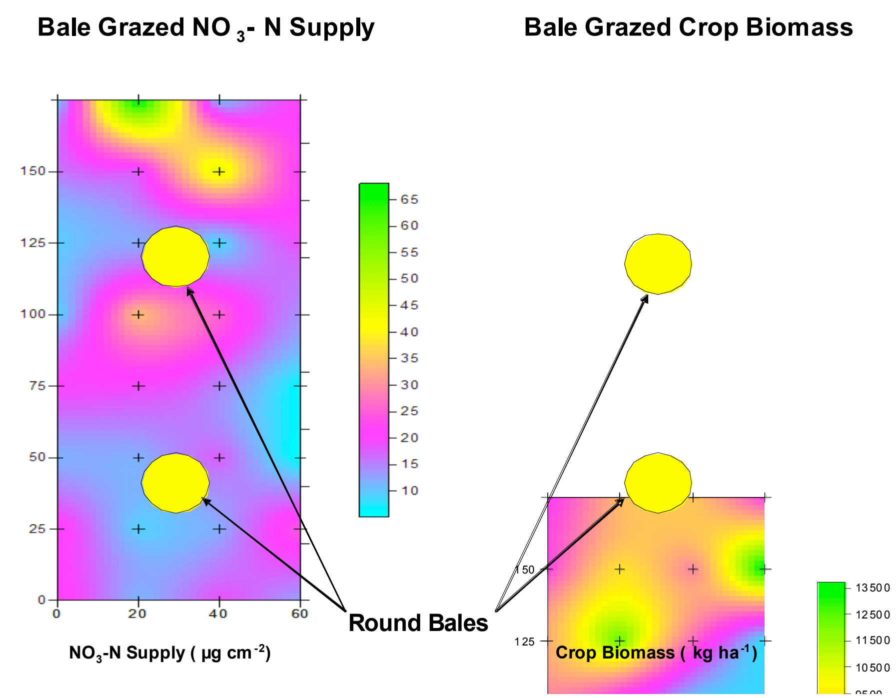

Figure 2. Bale grazed soil NO_3-N supply and crop biomass

The SG P supply was more closely linked to plant biomass response and soil N supply in this treatment (Figure 3). Where there was a higher level of soil N supply and plant biomass, the soil P supply was also higher, although not consistently seen in the entire grid. The SG plant biomass followed a consistent pattern with the soil N supply (Figure 4). Soil NO_3-N supply rates in the SG were not as high as the BG N supply rates, possibly reflecting the amount of time the cattle spent in one location, such as feeding on a round bale, versus grazing a swath and moving constantly, thus depositing manure over a wider pattern versus the BG treatment.

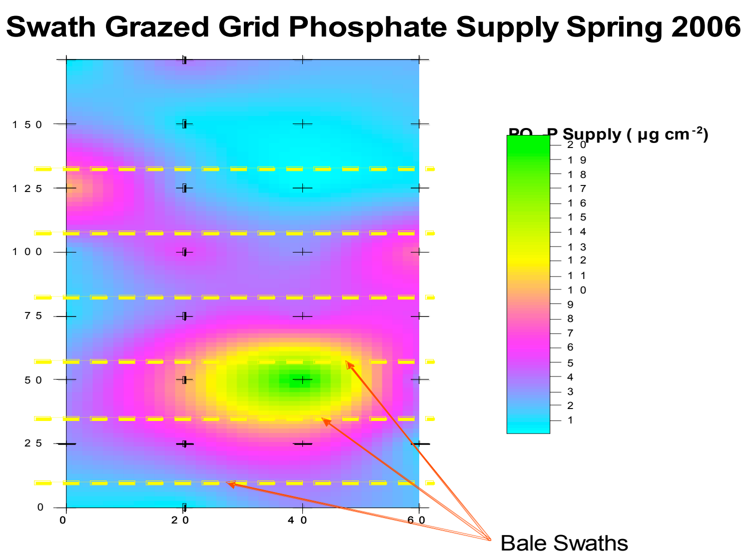

Figure 3. Swath grazed soil P supply.

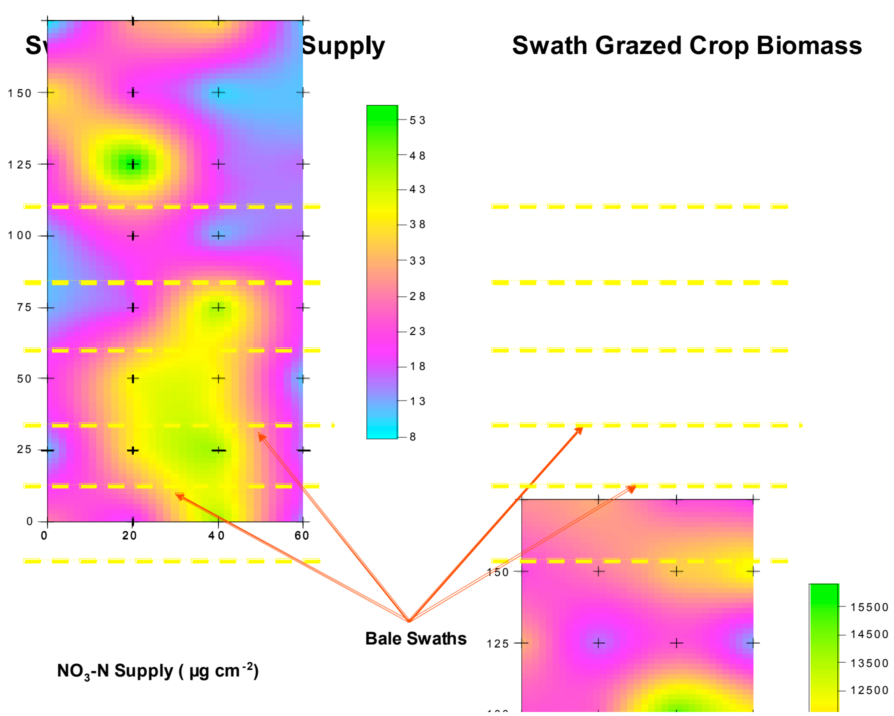

Figure 4. Swath grazed soil NO_3-N supply and crop biomass.

Soil P supply followed the plant biomass response in the ST/CH treatment, unlike the N supply (Figure 5). The ST/CH is low in N, which could explain the lack of a relationship with the plant biomass response. Although there are locations with higher plant biomass in the ST/CH as opposed to the SG and BG treatments, overall plant biomass levels were found to be significantly higher in the BG treatment (Figure 6), reflecting the capture of N nutrient from the urine deposits from this winter feeding pattern treatment and also possibly greater direct contribution to the soil from nutrients contained in the green bales themselves.

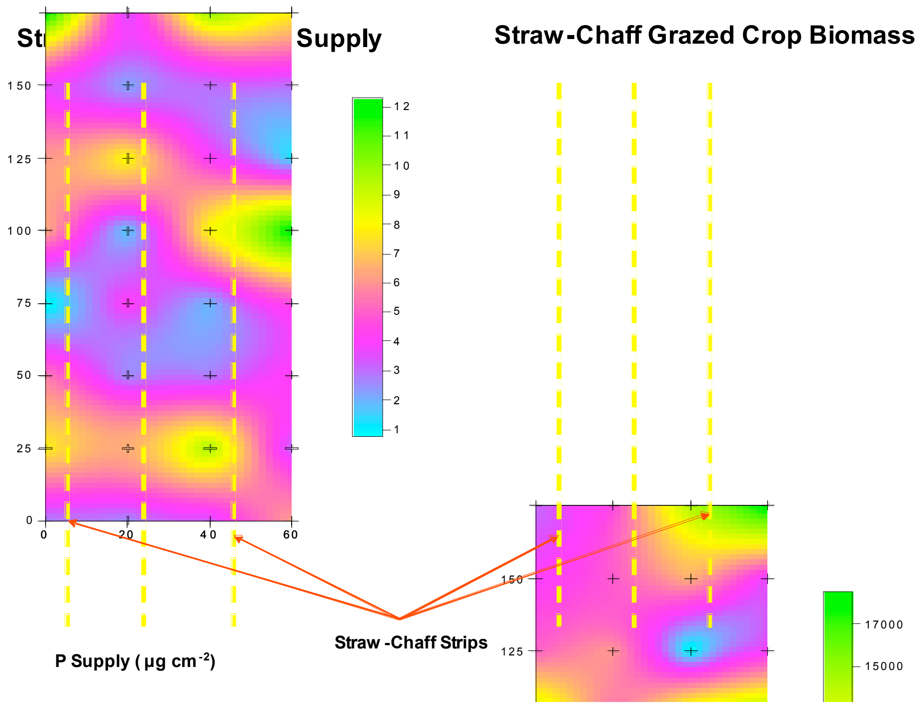

Figure 5. Straw-Chaff grazed soil P supply and crop biomass.

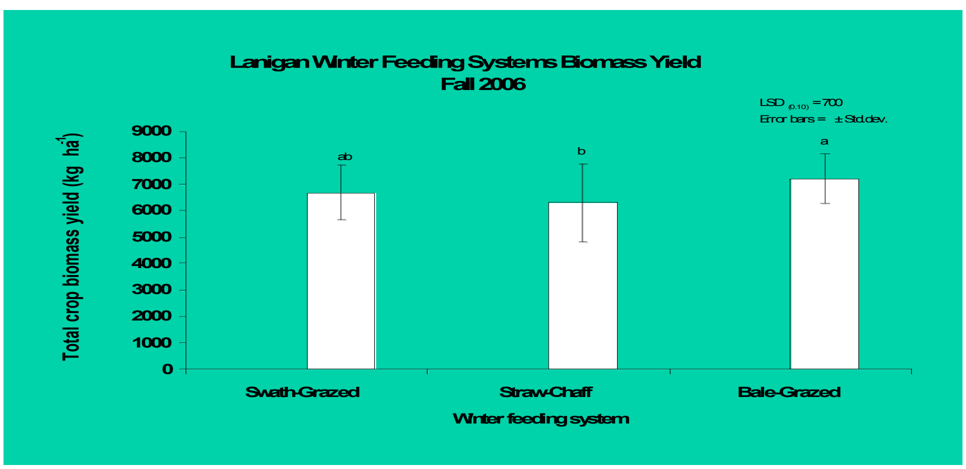

Figure 6. Winter feeding systems crop biomass.

Soil N supply was measured in early May, however the barley crop was not planted until late June. This site had significant moisture in 2006 resulting from the snow melt and late May, early June rains during the spring period. Between the N supply measurement and crop uptake of N beginning in early July, some of the N could have been moved downward in the soil profile. As well the straw and chaff could have induced some early season immobilization of available N. This could explain why there was not a closer relationship between N supply and plant biomass observed in the ST/CH treatments. The snow pack could have limited cattle access to some of the portions of swaths (SG treatment), which could explain why there was not as strong a relationship of soil N supply to plant biomass response. Snow pack levels can prevent cattle from accessing certain parts of a paddock thus influencing where the cattle deposited manure and impact the measured nutrient supply rates.

Conclusion

The BG treatment had greater crop biomass levels versus the SG and ST/CH grazed treatments. There appeared to be a greater contribution of N from the green bale residue as opposed to the low N in the ST/CH treatment. Compared to the study on feeding on Russian wildrye by Jungnitsch et al. (2005) there was less of a yield and soil nutrient response to the winter feeding treatments. The Russian wildrye forage response to the distributed manure from the winter feeding systems (bale grazed and bale processed) was greater and held its quality much later in the year (Jungnitsch et al., 2005). The annually cropped field in the current study had received manure applications in previous years so soil fertility was not a large constraint on production. This would explain reduced magnitude of response compared to the study with winter feeding on the Russian widlrye pasture which had not received any manure or fertilizer for a considerable period of time and was much more deficient in soil nutrients.

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