Influence of Long-Term Applications of N and S Fertilizers (1980-2005) on Dry Matter Yield of Grass and Soil Properties in a Dark Gray Chernozem in North-Central Saskatchewan

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Background

❖ In the Prairie Provinces of Canada, most soils are deficient in plant-available N.
❖ In the Parkland region, many soils also contain insufficient amounts of plant-available S for high crop yields.
❖ When soils are lacking in one or more nutrients, plant growth is reduced, resulting in low crop yields. So, application of fertilizers is essential to obtain high sustainable yield.
❖ Application of N, S and other fertilizers to soils lacking in these nutrients can increase forage dry matter yield and improve soil quality.

Objective

To determine the effects of long-term annual applications of N, S and K fertilizers to grass from 1980 to 2005 on forage dry matter yield (DMY), and soil pH, total organic C (TOC), total N (TN), light fraction organic C (LFOC) and light fraction organic N (LFN).

Materials and Methods

• Field experiment was conducted on a Dark Gray Chernozem (Boralfic Haploboroll) loam soil at Canwood in north-central Saskatchewan (mean annual precipitation 425 mm).
• The site had been cultivated for several years in 1920’s or early 1930’s, and then allowed to revert to grassland.
• The dominant grasses on the experimental site were bromegrass (Bromus inermis Leyss), Kentucky bluegrass (Poa pratensis L.) and rough hair grass (Agrostis scabra Wild).
• Experiment was established in 1980 with annual applications of:
  o no fertilizer (Nil);
  o Ammonium nitrate at 112 kg N ha⁻¹ (N);
  o 112 kg N + sodium sulphate to supply 11 kg S ha⁻¹ (NS); and
  o 112 kg N + 11 kg S + potassium chloride to supply 40 kg K ha⁻¹ (NSK).
• Fertilizers were broadcast on the surface every year in May from 1980 to 2005.
• There was one strip (0.91 m wide x 62 m long) for each treatment, and each strip was divided into 10 replications (6.2 m long x 0.91 m wide).
• The strips were separated by 1 m wide x 62 m long pathways.
• Grass was usually harvested once in each growing season for DMY.
• Soil samples in Nil, N, NS and NSK treatments were obtained from the 0-5, 5-10 and 10-15 cm depths in spring 2007.
• Soil samples after air-drying and grinding were analyzed for pH, TOC, TN, LFOC and LFN.
• In 1994, grass species composition in cut 1 and cut 2, and ground cover were estimated.

Summary of Results
• There was no increase in DMY with N alone application compared to the unfertilized control. Forage DMY increased considerably when both N and S fertilizers were applied together (i.e., NS treatment), and DMY further improved when K fertilizer was also applied in combination with NS (i.e., NSK treatment).
• Composition of plant species changed markedly in various treatments after long-term fertilization. In Nil treatment, land was covered with bromegrass, fine grasses and herbs (dogwood). In N only treatment, there was virtually no bromegrass in the stands. In treatments with combined applications of NS or NSK, vegetation was predominantly bromegrass, which is a high yielding grass species.
• Root mass (0-15 cm) usually maximized when N, S or K fertilizers were applied together. Root mass in the Nil, N, NS and NSK treatments was 19.5, 17.6, 32.8 and 41.2 Mg ha\(^{-1}\), respectively.
• Soil pH declined with annual applications of N and S fertilizers mainly in the 0-5 cm and 5-10 layers.
• TOC and N increased with NS application mainly in the 0-5 cm soil layer, while LFOC and LFN also increased in the 5-10 cm soil layer.
• There is a close relationship between DMY improvement and increase in C sequestration in soil from proper fertilization.

Conclusion
• The findings suggest that application of balanced fertilization by alleviating all nutrient deficiencies is an appropriate strategy for sustaining high forage yield, while also improving soil quality by increasing organic C and N storage in soil.

Acknowledgements
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Figure 1. Effect of long-term applications of N, S and K fertilizers (from 1980 to 2005 - 26 annual applications) to grass on dry matter yield (DMY - averaged over 26 years) on a Dark Gray Chernozem soil at Canwood, Saskatchewan (Experiment 1).

Figure 2. Effect of long-term applications of N, S and K fertilizers (from 1980 to 2005 - 26 annual applications) to grass on soil pH in a Dark Gray Chernozem soil at Canwood, Saskatchewan (Experiment 1).
Figure 3. Effect of long-term applications of N, S and K fertilizers (from 1980 to 2005 - 26 annual applications) to grass on soil total organic C (TOC) and total N (TN) in a Dark Gray Chernozem soil at Canwood, Saskatchewan, Canada (Experiment 1).

Figure 4. Effect of long-term applications of N, S and K fertilizers (from 1980 to 2005 - 26 annual applications) to grass on soil light fraction organic C (LFOC) and N (LFN) in a Dark Gray Chernozem soil at Canwood, Saskatchewan, Canada (Experiment 1).
Table 1. Effect of long-term annual applications of N, S and K fertilizers on vegetation composition in cut 1 and cut 2 in 1994, and estimated ground cover of various grass species on a Dark Gray Chernozem soil at Canwood, Saskatchewan, unlimed plots (Experiment 1 – established in 1980)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nil</th>
<th>N</th>
<th>NS</th>
<th>NSK</th>
<th>^aLSD&lt;sub&gt;0.05&lt;/sub&gt;</th>
</tr>
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<tr>
<td>Vegetation composition in cut 1 (%)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Bromegrass</td>
<td>29</td>
<td>2</td>
<td>92</td>
<td>92</td>
<td>11***</td>
</tr>
<tr>
<td>Vetch</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2**</td>
</tr>
<tr>
<td>Fine grasses</td>
<td>12</td>
<td>70</td>
<td>7</td>
<td>6</td>
<td>10***</td>
</tr>
<tr>
<td>Herbs</td>
<td>57</td>
<td>28</td>
<td>1</td>
<td>2</td>
<td>13***</td>
</tr>
<tr>
<td>Vegetation composition in cut 2 (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromegrass</td>
<td>43</td>
<td>5</td>
<td>83</td>
<td>89</td>
<td>15***</td>
</tr>
<tr>
<td>Vetch</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fine grasses</td>
<td>19</td>
<td>88</td>
<td>16</td>
<td>7</td>
<td>12***</td>
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<tr>
<td>Herbs</td>
<td>38</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>11***</td>
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<tr>
<td>Estimated ground cover (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bromegrass</td>
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<td>2</td>
<td>72</td>
<td>75</td>
<td>10***</td>
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<tr>
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<td>4</td>
<td>5</td>
<td>3</td>
<td>4***</td>
</tr>
<tr>
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<td>12</td>
<td>15</td>
<td>11***</td>
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<tr>
<td>Herbs</td>
<td>22</td>
<td>23</td>
<td>11</td>
<td>7</td>
<td>6***</td>
</tr>
<tr>
<td>Bluegrass</td>
<td>12</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>3***</td>
</tr>
</tbody>
</table>

<sup>a</sup>ns indicates that the difference between the treatments is not significant; **, and *** indicate that the difference is significant at P ≤ 0.01 and P ≤ 0.001, respectively.