Potential Impact of Global Warming on Forage Yield in South-Central Alberta

S.S. Malhi[1], J.T. Harapiak[2], N.A. Flore[2] and Z.H. Wang[1,3]

[1]*Agriculture and Agri-Food Canada, Research Farm, P.O. Box 1240, Melfort, Saskatchewan S0E 1A0 (Fax: 306-752-4911; E-mail; malhis@agr.gc.ca)*

[2]*Western Co-operative Fertilizers Limited, P.O. Box 2500, Calgary, Alberta T2P 2N1*

[3]*College of Resources and Environmental Sciences, Northwestern Sci-Tec University of Agriculture and Forestry, Yangling, Shaanxi 712100, P. R. China*

ABSTRACT

A long-term bromegrass (*Bromus inermis* Leyss) experiment was initiated in 1968 on a thin Black Chernozemic (Typic Boroll) soil at Crossfield, Alberta, Canada. Data was collected on dry matter yield (DMY), total precipitation (TP) and mean maximum daily temperature (MMDT) over 23 years. The results showed that TP and MMDT for May, June and July fluctuated in the range of 116.0-258.2 mm and 18.4-21.8°C from 1968 to 1990. The DMY during this period ranged from 0.54 to 2.80 Mg ha^{-1} in the zero-N treatment, and from 2.93 to 10.06 Mg ha^{-1} with application of 112 kg N ha^{-1}. The regression analysis of data indicated that DMY increased with increase in precipitation, and decreased with rise in temperature. Application of N intensified response of DMY to the changes in precipitation and temperature during the growing season.

INTRODUCTION

In Alberta and other Prairie Provinces, nitrogen (N) is the major limitation to grass forage production. Forage yields are also affected by precipitation and temperature. Our objective was to summarize information for a long-term bromegrass (*Bromus inermis* Leyss) experiment to determine the relationship of forage yield to precipitation and temperature during growing season.

MATERIALS AND METHODS

The field experiment was initiated in 1968 on a thin Black Chernozemic (Typic Boroll) soil with pH 7.0 and a loam texture at Crossfield, Alberta, Canada. The mean annual precipitation of the area is about 480 mm. The treatments were 0, 56, 112, 168, 224 and 336 kg N ha^{-1} rates from ammonium nitrate, surface-broadcast annually in the second half of April on a smooth bromegrass (*Bromus inermis* Leyss) stand grown for hay (harvested once or twice in each growing season). A randomized complete block design with six replications was used to arrange the 3 m x 3 m plots. The data on dry matter yield (DMY), precipitation and mean maximum daily temperature (MMDT) were collected from 1968 to 1990. For this report, DMY only in the zero-N control and 112 kg N ha^{-1} treatments was used.

RESULTS AND DISCUSSION

Total Precipitation, MMDT and DMY

During the period of 1968 to 1990, total precipitation (TP) for May, June and July ranged between 116.0 to 258.2 mm (Figure 1). Mean maximum daily temperature (MMDT) for the same months ranged between 18.4 to 21.8°C (Figure 2). The DMY during this period ranged from 0.54 to 2.80 Mg ha^{-1} when no N was applied, and ranged from 2.93 to 10.06 Mg ha^{-1} when 112 kg N ha^{-1} was applied (Figure 3).

If the entire period was subdivided into two parts, the mean of TP was 187.8 mm for the years from 1968 to 1978, and was 187.4 mm for the years from 1979 to 1990. The corresponding means were 20.2 and 20.4°C for MMDT, 1.3 and 1.1 Mg ha^{-1} for DMY with no N applied, and 5.4 and 5.1 Mg ha^{-1} for the DMY with application of 112 kg N ha^{-1}. The results suggest that the increase in TP would increase DMY, while the increase of MMDT would decrease DMY.

Regression relationship between TP or MMDT and DMY

The regression analysis of data indicated that DMY with and without N fertilizer increased with increase in precipitation (Figure 4), but it decreased with rise in temperature (Figure 5). Based on the

regression equations, the DMY increased from 4.31 to 6.87 Mg ha^{-1} in the 112 kg N ha^{-1} treatment, and from 0.86 to 1.38 Mg ha^{-1} in the no N treatment when precipitation during the growing season was increased from 116 to 258 mm. The corresponding values for DMY decreased from 7.18 to 4.73 Mg ha^{-1} and from 1.65 to 0.98 Mg ha^{-1}, respectively, in the two N treatments when the MMDT was increased from 18.5 to 21.5°C. This implied that DMY of bromegrass was very sensitive to changes in precipitation and temperature during the growing seasons. That is, a slight decrease in temperature and/or a slight increase in precipitation would promote grass growth and increase dry matter accumulation.

Interaction of TP and MMDT with N

In the zero-N treatment when MMDT rose from 18.5 to 21.5°C, the DMY decreased from 1.24 to 0.78 Mg ha^{-1} at 116 mm precipitation, and from 1.65 to 1.19 Mg ha^{-1} at 258 mm precipitation (Figure 6). In the 112 kg N ha^{-1} treatment, the DMY decreased from 5.39 to 4.07 Mg ha^{-1} at 116 mm precipitation, and from 7.26 to 5.94 Mg ha^{-1} at 258 mm precipitation (Figure 7). This indicated that application of N increased the response of DMY to the changes in precipitation and temperature during the growing seasons. For example, when MMDT increased from 18.5 to 21.5°C at 116 mm precipitation, the DMY decreased by 0.46 Mg ha^{-1} for the zero-N treatment and 1.32 for the 112 kg N ha^{-1} treatment. When precipitation increased from 116 to 258 mm at 18.5°C, the DMY increased by 0.41 and 0.87 Mg ha^{-1} for without N and with N application, respectively.

SUMMARY AND CONCLUSIONS

Total precipitation and mean maximum daily temperature for May, June and July fluctuated in the range of 116.0 to 258.2 mm and 18.4 to 21.8°C from 1968 to 1990. The DMY during this period ranged from 0.54 to 2.80 Mg ha^{-1} in the zero-N treatment, and from 2.93 to 10.06 Mg ha^{-1} with application of 112 kg N ha^{-1}. The regression analysis of data indicated that DMY increased with increase in precipitation, and decreased with rise in temperature. Application of N intensified the response of DMY to the changes in precipitation and temperature during the growing season. By implication, if temperatures were increased by only a few degrees, which may occur through global warming effect, without a corresponding increase in precipitation, there would be a marked reduction in forage production in south-central Alberta and similar areas elsewhere.

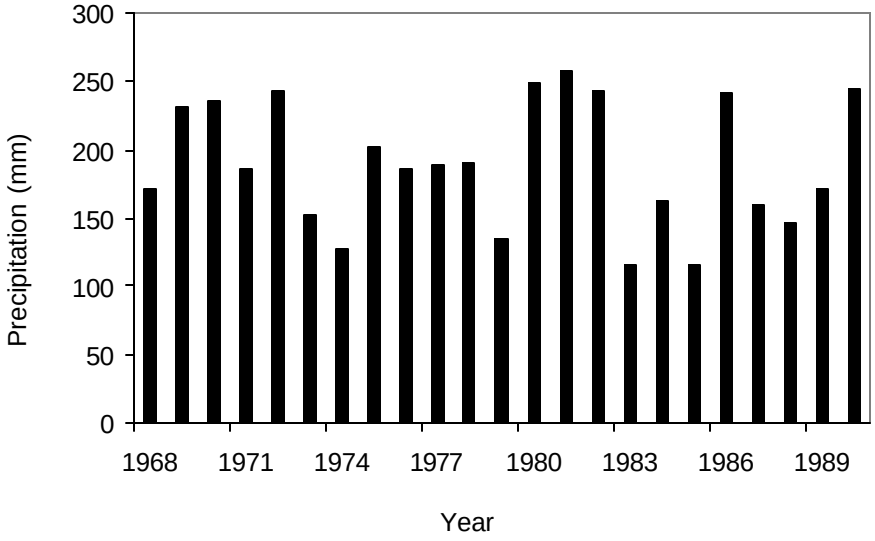

Figure 1. Total precipitation for the months of May, June and July from 1968 to 1990.

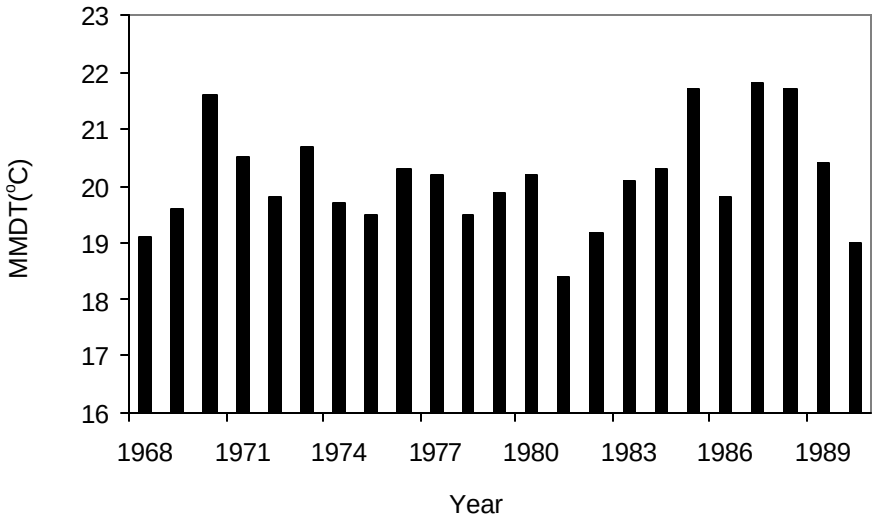

Figure 2. Mean maximum daily temperatures (MMDT) for the months of May, June and July from 1968 to 1990.

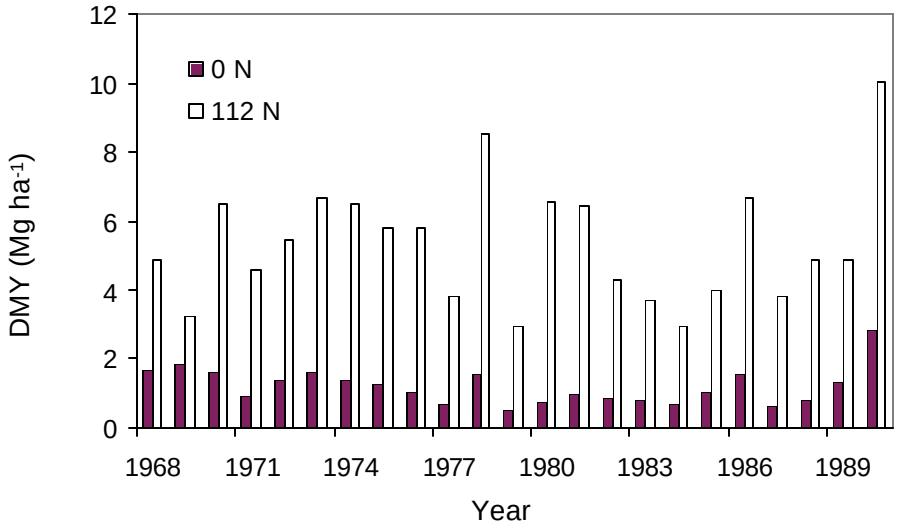

Figure 3. Dry matter yield (DMY) with 0 and 112 kg N ha^{-1} rates from 1968 to 1990.

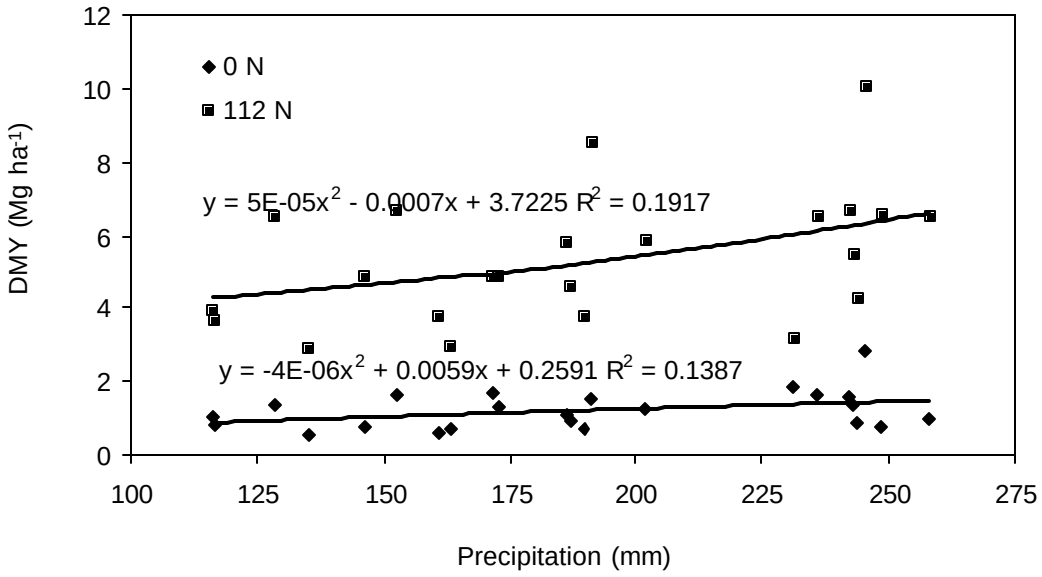

Figure 4. Relationship between dry matter yield (DMY) of bromegrass with 0 and 112 kg N ha^{-1} rates and precipitation during May, June and July from 1968 to 1990.

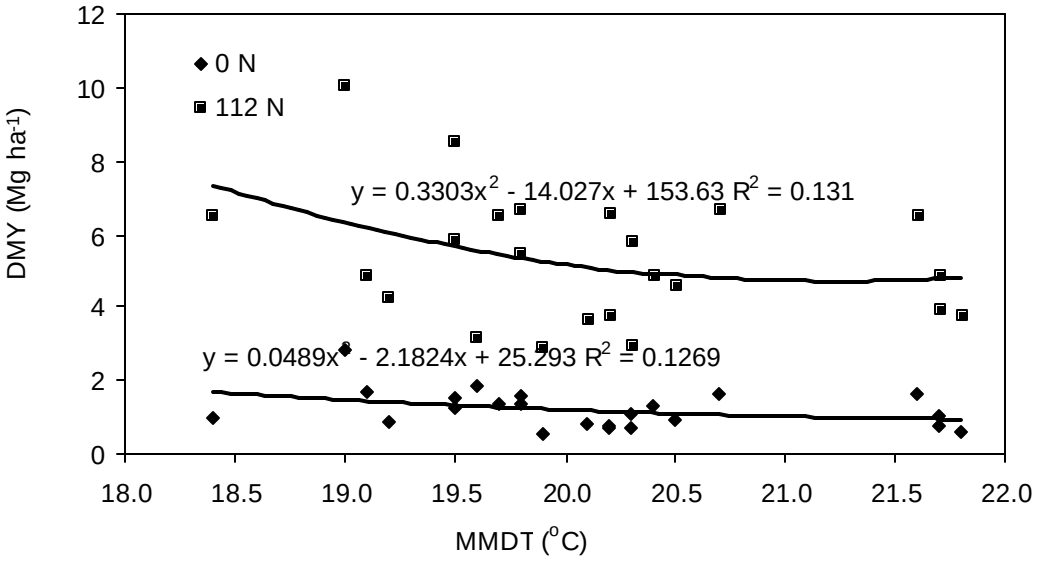

Figure 5. Relationship between dry matter yield (DMY) of bromegrass with 0 and 112 kg N ha^{-1} rates and mean maximum daily temperature (MMDT) during May, June and July from 1968 to 1990.

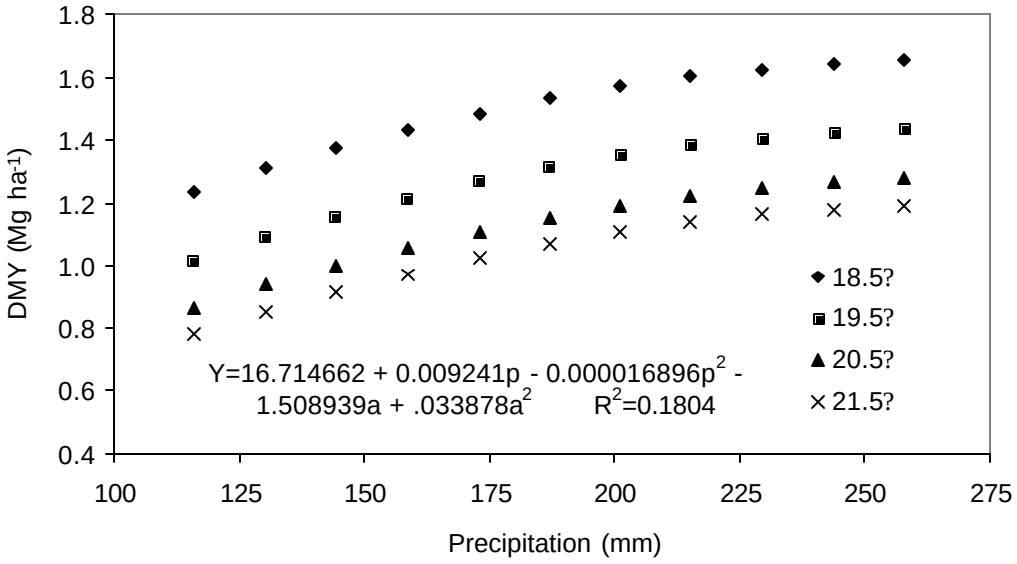

Figure 6. Dry matter yield (DMY) of bromegrass in the zero-N treatment related to total precipitation and mean maximum daily temperature (°C) for May, June and July from 1968 to 1990 (in the regression, p refers to precipitation in mm, and a refers to temperature in °C).

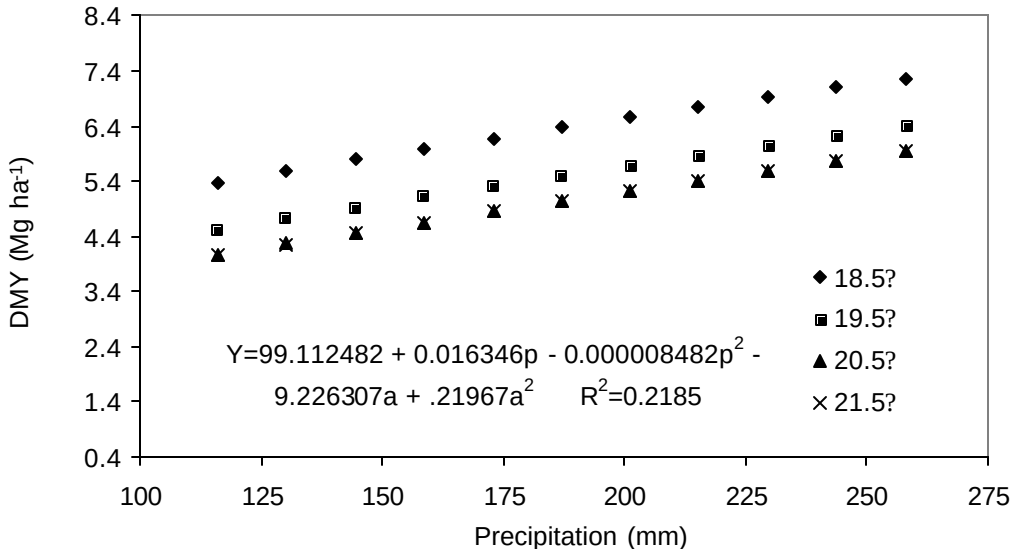

Figure 7. Dry matter yield (DMY) of bromegrass in the 112 kg N ha^{-1} treatment related to total precipitation and mean maximum daily temperature (^{o}C) for May, June and July from 1968 to 1990 (in the regression, p refers to precipitation in mm, and a refers to temperature in ^{o}C).