N_2O EMISSIONS FROM A PULSE CROP IN A LONG-TERM CROP ROTATION STUDY IN THE DARK BROWN SOIL ZONE.

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INTRODUCTION

Best management practices often include pulse crops in rotation with direct seeding management in order to help achieve a more sustainable cropping system. Pulses in rotation can provide many advantages such as a break in disease and weed cycles. Pulses can also contribute nitrogen to the fertility cycle in the crop year and the subsequent year. The nitrogen that pulse crops contribute to the soil can also affect greenhouse gas emissions from the soil in the form of nitrous oxide (N_2O). It is important to assess the contribution of pulses to N_2O emissions from cropping systems.

OBJECTIVE

The main objective in this project was to quantify the N_2O emissions from a crop rotation that included peas and compare it to continuous wheat and a wheat-fallow rotation. Another objective was to measure the interaction of cropping systems and tillage management. The information presented is a preliminary assessment of four years of data collected from the long-term Sustainable Cropping Systems Research Study located in the Dark Brown soil zone at Three Hills, Alberta.

METHODS

A long-term plot study was established in 1991 on a Solonetzic Black Chernozem soil (clay loam over clay parent material) located adjacent to the airport at Three Hills, Alberta. From 2000 to 2004 N_2O emissions were measured on selected treatments of the long-term study.

Treatments

- The long-term study has nine different crop rotations and two tillage management systems with every phase of each rotation expressed each year. The selected rotations used in this N_2O emissions study are:
  - 1. Continuous Wheat (CW)
  - 2. Canola-Barley-Peas-Wheat (CBPW)
  - 3. Wheat-Fallow (WF)
- Both the pea and wheat crop phase of the CBPW rotation were measured and both the wheat and fallow phase of the WF rotation were measured.
- Since the fall of 1994 each main plot was split by two tillage treatments:
  - Conventionally Seeded – spring and fall tillage (CS)
  - Direct Seeded – zero tillage system (DS)
- N_2O chambers were placed in both tillage treatments. This makes for five main treatments split for two tillage systems.
- The DS treatments fallow plots were chemically fallowed while the CS fallow plots were tilled 3 to 4 times.

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Fertilizer

- The wheat plots received a banded application of urea (46-0-0) fertilizer at 67 kg ha^{-1} of N. The pea and fallow plots did not receive any banded N fertilizer.
- Ammonium phosphate (12-51-0) fertilizer was placed with the wheat seed at 33 kg ha^{-1} of P_2O_5 and with the pea seed at 20 kg ha^{-1} of P_2O_5.

N2O Sampling and Processing

- Sampling occurred post fertilizing and seeding in May until freeze up in December and again on the same stubble plots the following spring thaw in March to pre fertilizing and reseeding in May.
- Samples were taken at midday and twice a week around emission events (spring thaw, rain, fertilization) and once a week or less at other times for an average of 29 sample points per year.
- Samples were collected using vented plexiglass soil chambers (0.1 m^2 surface area) designed to fit between crop rows. Gas samples were taken after 30 minutes and the concentration of N_2O was determined in the lab by a gas chromatograph equipped with an electron capture detector.
- The difference between the mean ambient N_2O concentration and the headspace N_2O concentration after 30 minutes gave the change in N_2O concentration for a specific point in time.
- Cumulative estimates of N_2O fluxes over the sample period were determined by assuming a constant 24 hour flux and interpolating between sample points. The measured and interpolated flux values were summed across sample periods to give a cumulative loss of N_2O-N for the growing season (post seeding to freeze up) and for the spring thaw season (snow melt to pre seeding). Combining these two seasons gives the annual loss of N_2O-N measured in g ha^{-1}.
- The N_2O data was processed to compare the effects of rotation-phase and tillage on the seasonal and annual loss of N_2O. The data was statistically analyzed for analysis of variance as a split plot design using PROC GLM and LSMEANS (SAS®) at $p<0.1$.

RESULTS

Seasonal Precipitation

- Precipitation was variable and less than normal for much of the study (**Figure 1**). For 2001 and 2004 the spring thaw period was dryer than normal while for 2003 the spring thaw period was much wetter than normal. The growing seasons of 2000, 2001, and 2002 had slightly lower precipitation than normal but the 2003 growing season was much drier than normal.

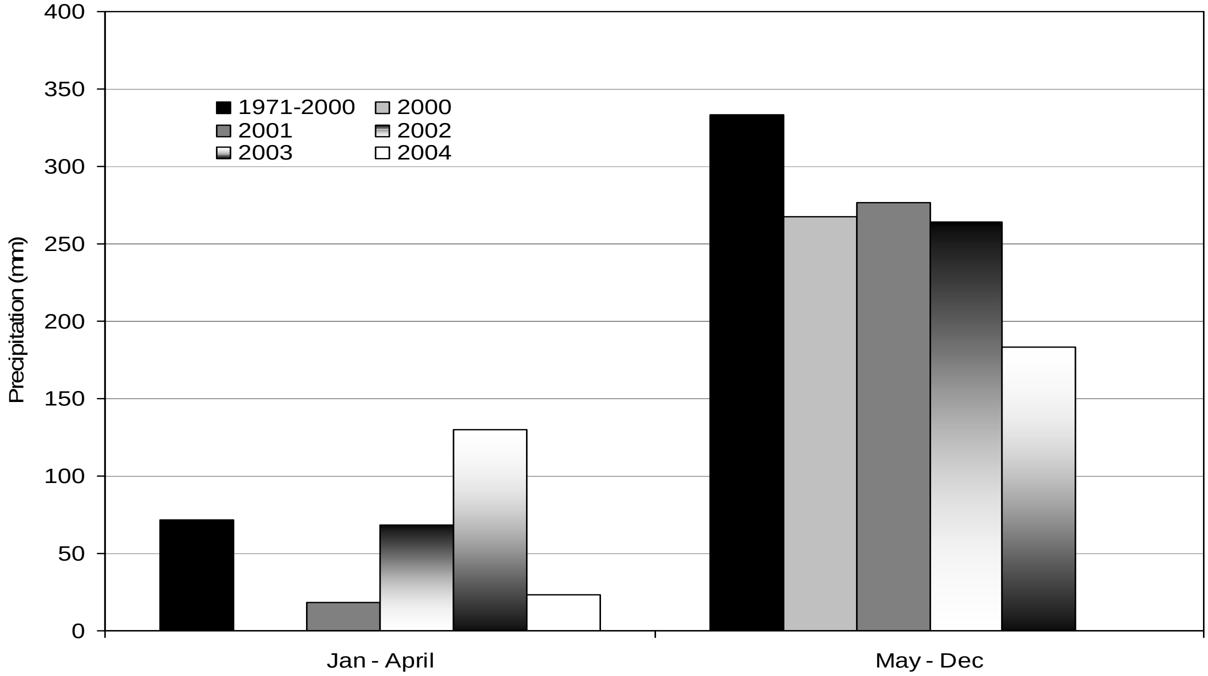

Figure 1. Seasonal precipitation at the Three Hills long-term plots from May 2000 to May 2004.

Seasonal N_2O emissions

- The seasonal N_2O emissions (**Figure 2**) showed similar trends as precipitation with much higher emissions in the wet spring thaw season of 2003 than in the drier spring thaw season of 2001. The very dry growing season of 2003 had the lowest N_2O emissions.
- For 2000-2001 and 2001-2002 annual crop year the loss of N_2O was much higher during the growing season than the following spring thaw season. This trend was reversed for the 2002-2003 and 2003-2004 annual crop year with the higher loss of N_2O in the spring thaw season.
- When seasonal precipitation and N_2O emissions are low there is less noticeable differences in the amount of emissions between treatments. When emissions are high there were more differences between treatments but also larger variability between replicates.

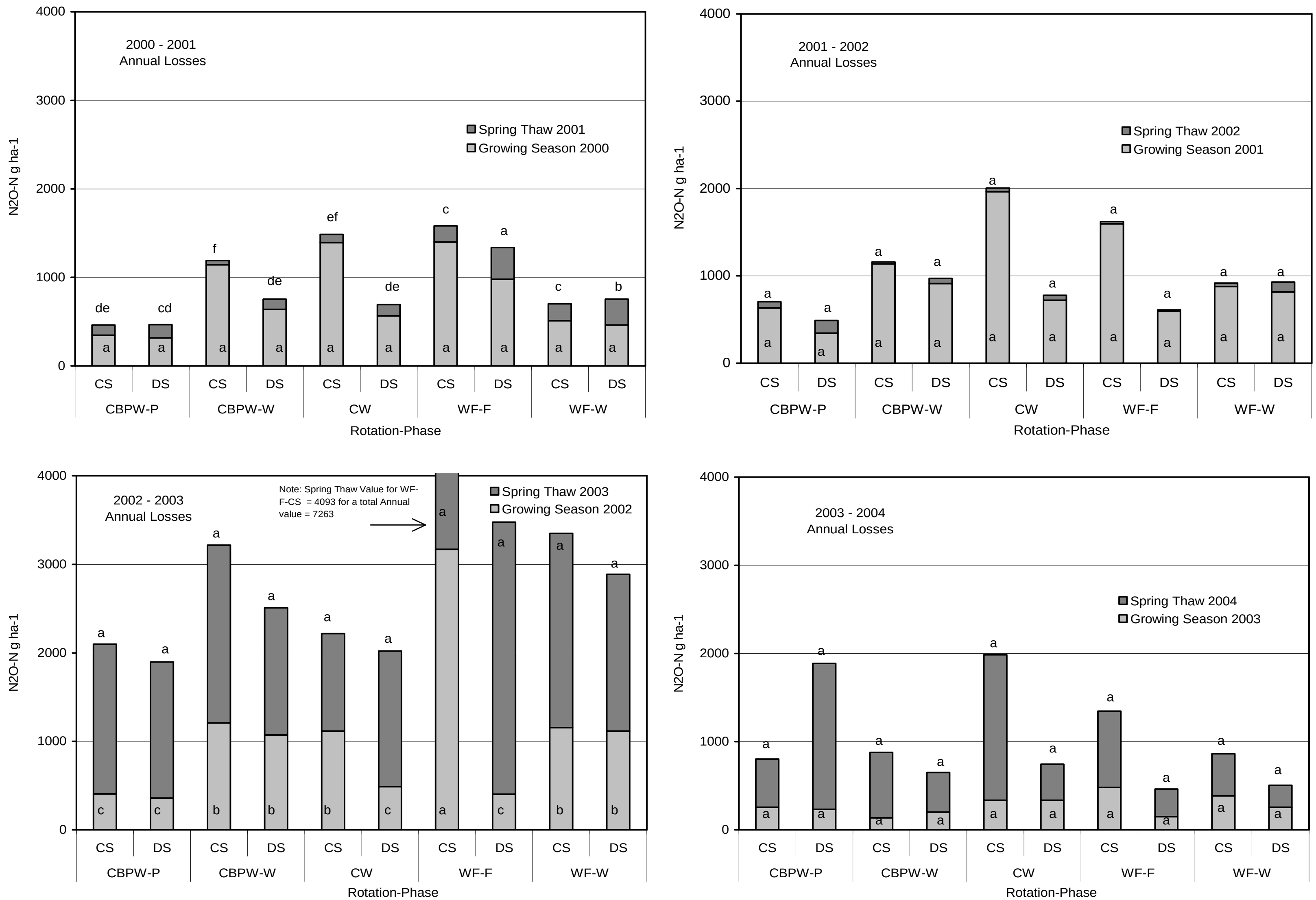

Figure 2. Seasonal and annual N_2O-N losses from selected treatments at the Three Hills long-term plots for each of the four years of the study. Treatments with the same letter within a season category are not statistically different ($p<0.1$).

Annual N_2O emissions

- The treatments that often had higher annual N_2O emissions (**Figure 2**) were the CS continuous wheat and fallow plots. For three of the four years the lowest annual N_2O emissions were on the DS pea plots.
- Averaging across tillage treatments showed that the pea plots had lower N_2O emissions than the other treatments in each year except in the 2003-2004 annual crop year.
- The annual N_2O emissions averaged across the four years of the study (**Figure 3**) showed only small differences in emissions between all the DS treatments. There is more of a difference on the CS treatments, the CBPW-P treatment had the lowest and the WF-F treatment had the highest emissions. The wheat grown on pea stubble had slightly higher emissions than the pea plots. This might be expected as the wheat plots received banded nitrogen as well as the carry over of fixed nitrogen from the previous pea crop.

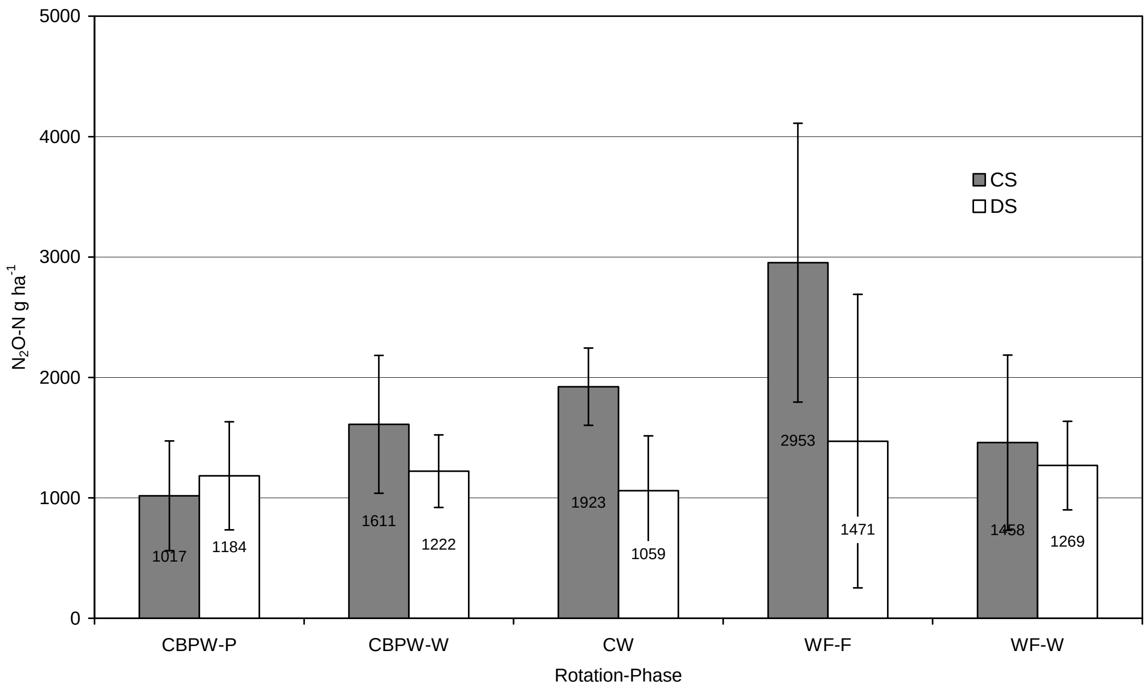

Figure 3. Annual N_2O-N losses from selected treatments at the Three Hills long-term plots averaged over the four years of the study.

- N_2O emissions averaged across tillage treatments showed that the CBPW-P treatment had 25% less emissions than the CW treatment and 50% less than the WF-F treatment.
- Averaging N_2O emissions across the rotation-phase treatments showed 30% higher emissions on the CS treatments than the DS treatments.
- N_2O emissions averaged across the crop phases for each rotation (**Table 1**) showed that annual N_2O emissions were highest for the WF rotation on both the CS and DS treatments.
- The average annual N_2O emissions for the pea and wheat phases of the CBPW rotation were lower than for the CW rotation on the CS treatments but somewhat higher on the DS treatments.

Table 1. Average annual loss of N_2O-N (g ha^{-1}) from selected rotations at the Three Hills plots. Data was averaged across the crop phases of each rotation and across the four years of the study.

Rotation	CS	DS	Mean [y]
CBPW *	1314a	1203a	1258a
CW	1923a	1059a	1491a
WF	2206a	1370a	1788a
Mean [z]	1814a	1210b	

*Only the pea and wheat phases of the CBPW rotation were measured
[y] Mean for rotation averaged across tillage systems
[z] Mean for tillage system averaged across rotation
Values followed by the same letter are not statistically different ($p<0.1$)

CONCLUSIONS

- Precipitation directly affected N_2O emissions where the driest growing season produced the lowest emissions and the wettest spring thaw season produced the highest emissions.
- The tillage system interaction with rotation-phase was often significant with DS treatments on average producing significantly less N_2O emissions than on CS treatments.
- The wheat grown on pea stubble in three of the four years had higher emissions than the pea crop.
- Averaged across the four years and tillage systems the annual N_2O-N emissions for each rotation-phase is ranked from lowest to highest to show the trends in emissions, however there is no statistical difference between treatments:

Rotation-Phase	g N_2O-N ha^{-1} y^{-1}
CBPW-P	1101
WF-W	1364
CBPW-W	1416
CW	1491
WF-F	2212

- The results of this study show that pulses can be an important part of a sustainable cropping system without contributing significantly more N_2O emissions than that of less desirable rotations.

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