# Effects of crop rotation and grazing in an ICLS on greenhouse gas emissions in the Northern Great Plains

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## INTRODUCTION

- Integrated crop-livestock system (ICLS) can reduce soil greenhouse gas (GHG) emissions that majorly includes carbon dioxide ($CO_2$), Nitrous oxide ($N_2O$), and Methane ($CH_4$).
- Little is known about the impacts of the crop rotation and grazing on GHG fluxes in Northern Great Plains in the United States.

## OBJECTIVES

- To evaluate the impacts of cattle grazing and different crop rotations on soil $CO_2$, $N_2O$, and $CH_4$ fluxes in the Northern Great Plains, USA.

## MATERIALS AND METHODS

- The experiment was a randomized complete block design with 3 replications at Dickinson Research Extension Center, near Dickinson, North Dakota, USA. The treatments were described in Table 1.
- Gas samples were taken once a week from June to October 2016 at 0, 20 and 40 minutes' intervals. Samples were collected using 10-ml syringe via a chamber and transferred to a 10-ml vacuumed vial (Fig. 1).
- Gas chromatography (GC) machine was used to measure concentrations of $CO_2$, $CH_4$, and $N_2O$ for each gas sample (Fig. 2).

**Table 1**. Treatments of crop rotation and grazing.

| TRT | Description |
|---|---|
| C | Continuous Spring Wheat (Control) |
| S1 | Sunflower-Spring Wheat-Cover crop-Corn-Pea |
| S2 | Spring Wheat-Cover crop-Corn-Pea-Sunflower |
| S3 | Cover crop-Corn-Pea-Sunflower-Spring Wheat |
| S4 | Corn-Pea-Sunflower-Spring Wheat-Cover crop |
| S5 | Pea-Sunflower-Spring Wheat-Cover crop-Corn |
| G | Grazed by yearling steers |
| U | Ungrazed |

Fig. 1.Chambers for collecting GHG samples.

Fig. 2. GC for measuring concentrations of GHG.

## RESULTS

**Table 2.** Means of $N_2O$, $CO_2$, and $CH_4$ fluxes under different crop rotation sequences in 2016 at Dickinson, North Dakota, USA.

| Treatment | $N_2O$ Fluxes (g ha$^{-1}$ d$^{-1}$) | $CO_2$ Fluxes (kg ha$^{-1}$ d$^{-1}$) | $CH_4$ Fluxes (g ha$^{-1}$ d$^{-1}$) |
|---|---|---|---|
| *Rotation* | | | |
| C | 4.75$^{a†}$ | 11.7$^a$ | 1.46$^a$ |
| S1 | 2.74$^a$ | 9.80$^a$ | 4.57$^a$ |
| S2 | 4.26$^a$ | 11.1$^a$ | 3.00$^a$ |
| S3 | 3.45$^a$ | 13.1$^a$ | 3.52$^a$ |
| S4 | 3.43$^a$ | 9.07$^a$ | 3.49$^a$ |
| S5 | 4.16$^a$ | 11.7$^a$ | 1.21$^a$ |
| | Type 3 Tests of Fixed Effects ($P>F$) | | |
| *Rotation* | 0.18 | 0.46 | 0.56 |
| *Time* | 0.003 | <.0001 | 0.06 |
| *Rotation×Time* | 0.051 | 0.59 | 0.65 |

†Means within the same column followed by different small letters are significantly different at P<0.05 for treatments.

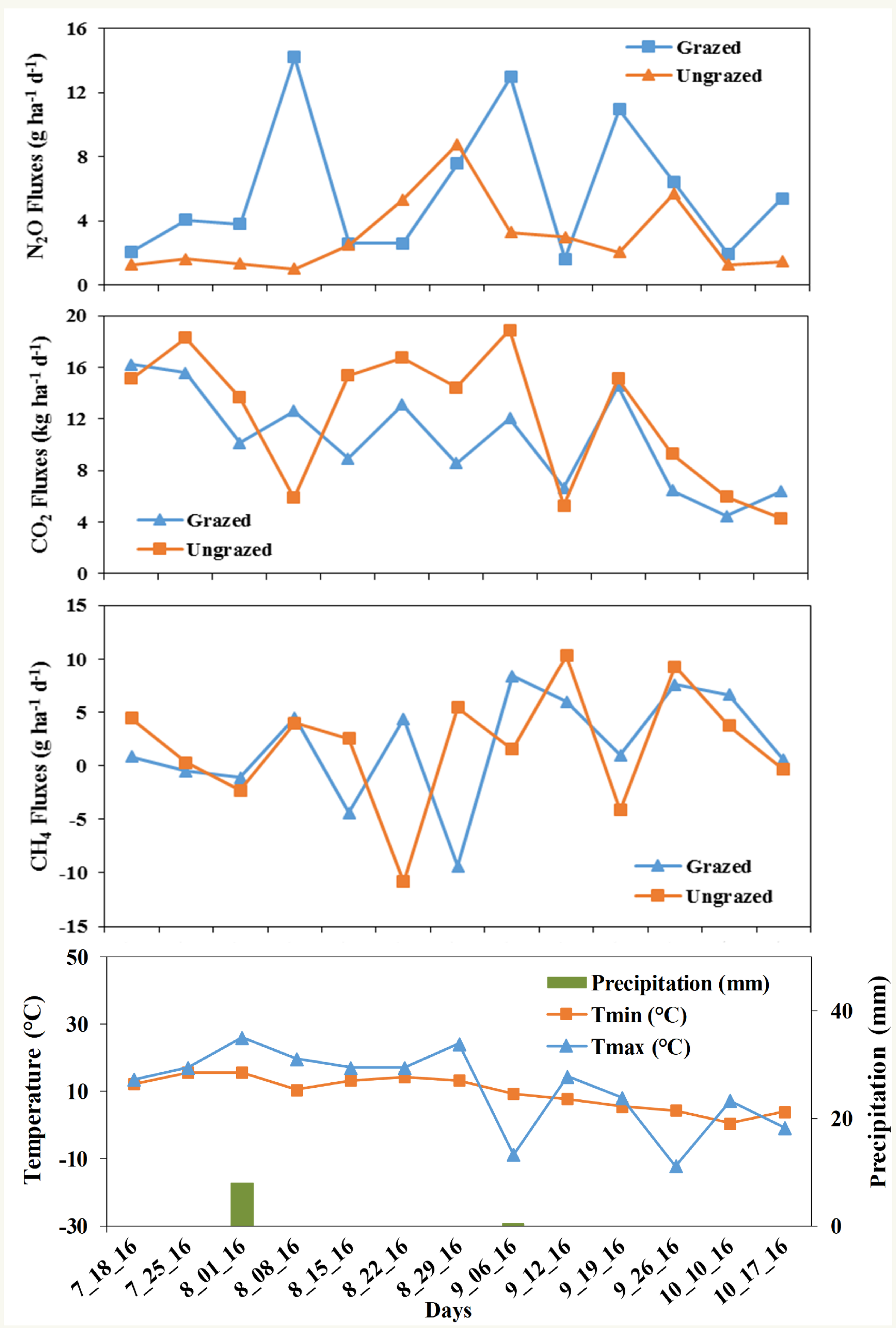


Fig. 3. Trends of $N_2O$, $CO_2$, and $CH_4$ fluxes under grazing and un-grazing, and maximum and minimum temperature and precipitation over time in 2016 at Dickinson, North Dakota, USA.

**Table 3.** Means of $N_2O$, $CO_2$, and $CH_4$ fluxes under rotation sequence 2, 4, and 5, and grazing and un-grazing in 2016.

| Treatments | $N_2O$ Fluxes (g ha$^{-1}$ d$^{-1}$) | $CO_2$ Fluxes (kg ha$^{-1}$ d$^{-1}$) | $CH_4$ Fluxes (g ha$^{-1}$ d$^{-1}$) |
|---|---|---|---|
| *Rotation* | | | |
| S2 | 4.26$^{a†}$ | 11.1$^a$ | 3.00$^a$ |
| S4 | 3.43$^a$ | 9.07$^a$ | 3.49$^a$ |
| S5 | 4.16$^a$ | 11.7$^a$ | 1.21$^a$ |
| *Grazing* | | | |
| G | 5.73$^a$ | 10.4$^a$ | 1.88$^a$ |
| U | 2.98$^b$ | 12.2$^a$ | 1.84$^a$ |
| | Type 3 Tests of Fixed Effects ($P>F$) | | |
| *Rotation* | 0.07 | 0.06 | 0.79 |
| *Grazing* | 0.003 | 0.52 | 0.86 |
| *Rotation× Grazing* | 0.36 | 0.62 | 0.68 |

†Means within the same column followed by different small letters are significantly different at P<0.05 for treatments.

- $N_2O$, $CO_2$, and $CH_4$ fluxes among the rotation sequences were not significantly different (Table 2 and 3).
- Mean $N_2O$ fluxes under the grazing was significantly higher than that for the un-grazing but $CO_2$ and $CH_4$ fluxes were not significantly different between the grazing and un-grazing (Table 3 and Fig. 3).
- Time significantly impacted $N_2O$ and $CO_2$ fluxes but not $CH_4$ fluxes (Table 2).
- Trends of $N_2O$ and $CO_2$ fluxes followed the temperature trend over the observed days, but $CH_4$ flux trend was not (Fig. 3).

## CONCLUSIONS

- Crop rotation sequence did not impact the greenhouse gas fluxes significantly.
- Grazing significantly increased $N_2O$ fluxes.
- Time had a significant effect on $N_2O$ and $CO_2$ fluxes but not on $CH_4$.

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