Field-based comparison of soil-derived greenhouse gas emissions from irrigated and rain-fed shelterbelts in the semi-arid Canadian Prairie

UNIVERSITY OF SASKATCHEWAN

C. Amadi[1], R. Farrell[1] & K. Van Rees[1]

[1]Department of Soil Science, University of Saskatchewan, Saskatoon, SK. Canada

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

INTRODUCTION

- Soil moisture is known to be a major control of GHG emissions from agricultural soils.
- However, there is little data regarding GHG exchange from the organic matter-rich soils characteristic of shelterbelts—especially under elevated soil moisture conditions.
- Shelterbelts, an agroforestry system that consists of one or more rows of trees planted across cropped fields, have been shown to increase C sequestration and mitigate GHG emissions in arable soils (Amadi et al., 2016)
- Elevated soil moisture coupled with warm temperatures favour soil microbial activity, which in turn, may alter the dynamics of soil GHG emissions from shelterbelts (Smith *et al*., 2003)

OBJECTIVES

- To measure and compare CO_2, CH_4 and N_2O fluxes from shelterbelts under elevated soil moisture (irrigated) and dry conditions (rain-fed)

MATERIALS AND METHODS

Study site

- The study site is located at the Canada Saskatchewan Irrigation Diversification Centre (CSIDC) in Outlook, SK (Fig. 1).

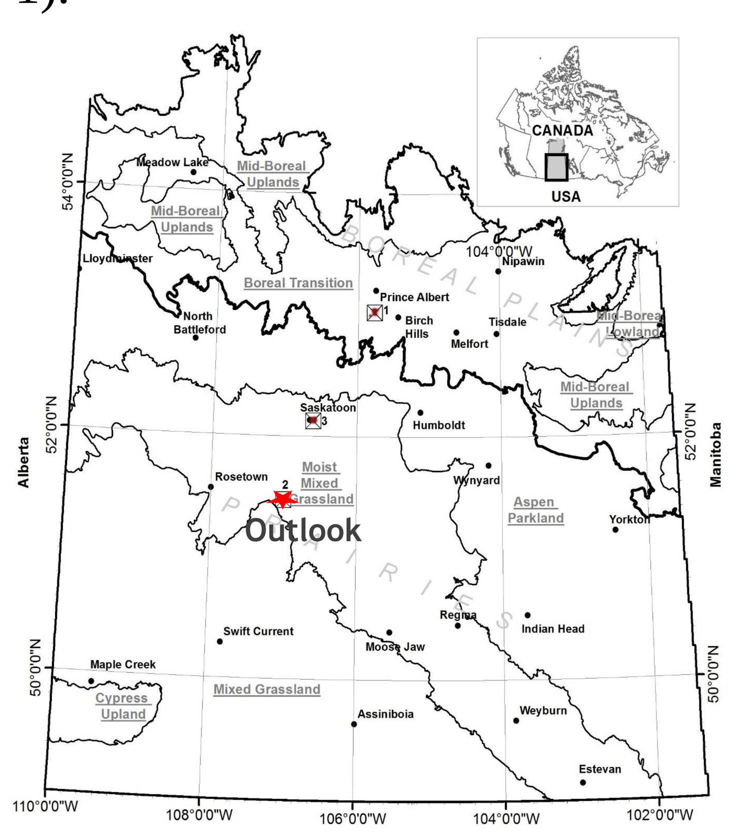

Fig. 1. Map of study site

Experimental layout

- Field measurements of CO_2, CH_4 and N_2O fluxes were carried out between the spring and fall of 2013 and 2014 using the static state, vented chamber method.
- Three single-row shelterbelts were selected for this study. Each shelterbelt was divided into irrigated and rain-fed sites (Fig. 2).
- Four chamber bases were installed in the irrigated and rain-fed shelterbelts and were used to monitor GHG emissions over two growing seasons.

Gas and soil sampling

- Gas samples from the chamber headspace were collected weekly and analyzed using a gas chromatograph (Bruker 450-GC)

Fig. 2. Irrigation increases soil moisture content in organic matter-rich soils under a Scots pine shelterbelt at CSIDC, Outlook

RESULTS AND DISCUSSION

Soil moisture

- Soil moisture in the irrigated shelterbelts was greater than the rain-fed shelterbelts by 28% in 2013 and by 23% in 2014 following irrigation activities (Fig. 3a)

Soil N_2O, CH_4 and CO_2 fluxes

- Soil N_2O emissions were greater in the irrigated shelterbelts than in the rain-fed sites—especially during the months when irrigation water was applied (Fig. 3b; 4a).
- Across the entire study period, the sink potential (i.e. CH_4 uptake) of the irrigated shelterbelts was lower ($P = 0.0342$) than the rain-fed shelterbelts sites (Fig. 4b).

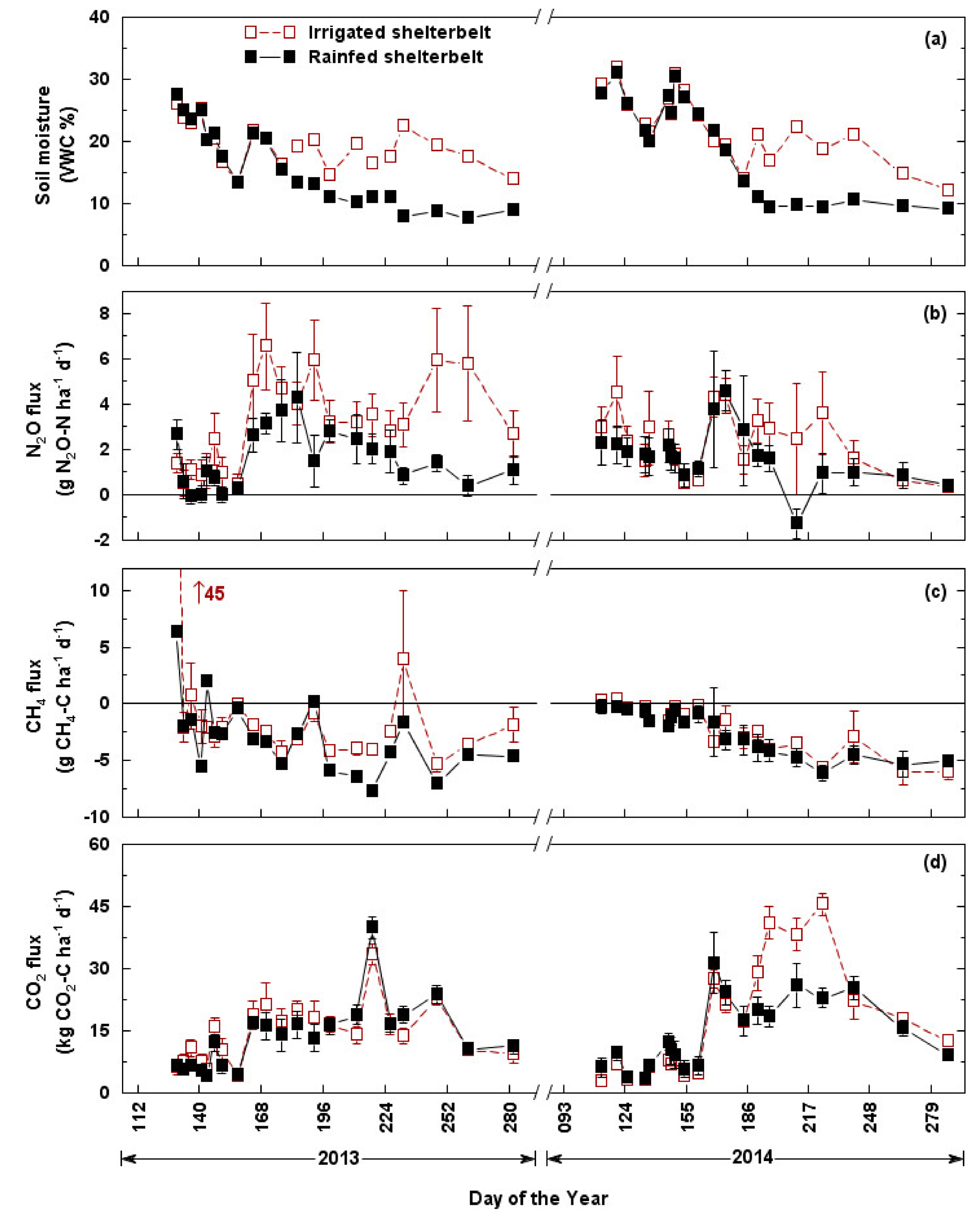

Fig. 3. Soil moisture (a); daily emissions N_2O (b), CH_4 (c), and CO_2 (d) from irrigated and rain-fed shelterbelt sites. Error bars represent standard deviation

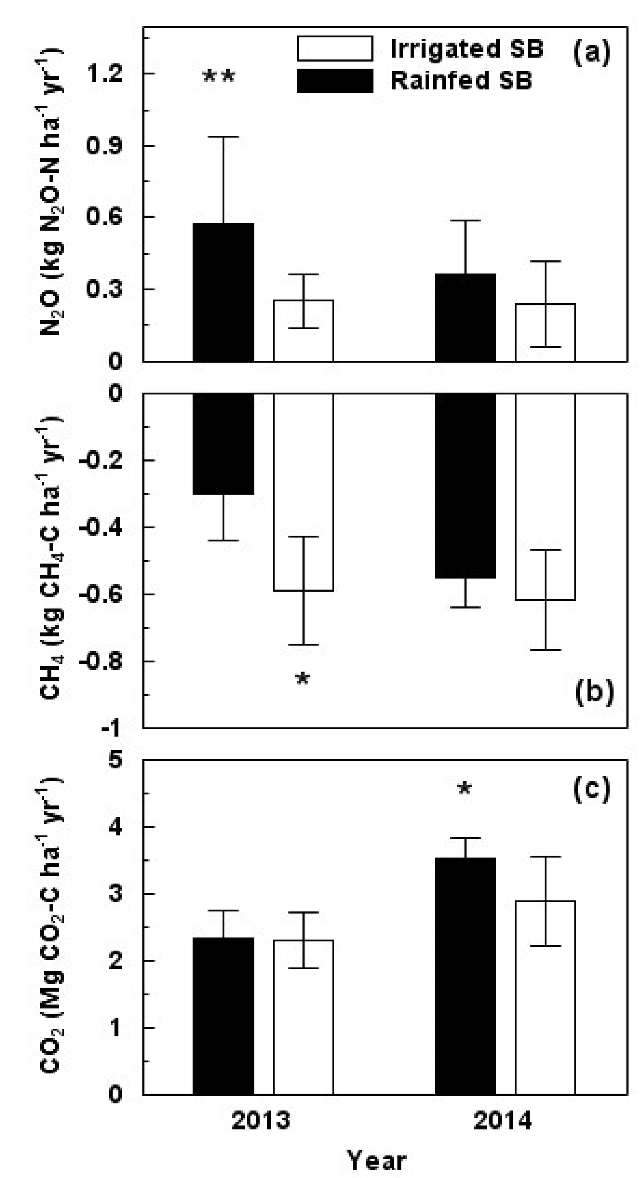

Fig. 4. Cumulative N_2O (a), CH_4 (b), and CO_2 (c) from irrigated and rain-fed shelterbelt sites. Error bars represent standard deviation

- Irrigation did not appear to stimulate CO_2 emissions in the irrigated sections in during the 2013 season (Fig. 3d). During 2014, however, cumulative CO_2 emissions were significantly greater in the irrigated shelterbelt than in the rain-fed sites (Fig. 4c).
- These findings are in agreement with Smith et al. (2003) and Suwanwaree & Robertson (2005) who showed increased N_2O fluxes, and reduced CH_4 oxidation under elevated soil moisture conditions, respectively.
- The increased CO_2 emissions from the irrigated shelterbelts in 2014 suggests increased microbial activity in response to elevated soil moisture..

CONCLUSION

- Not surprisingly, GHG dynamics in the shelterbelts were affected by elevated soil moisture conditions resulting from the application of irrigation water.
- Climate models have predicted increased alterations in precipitation under changing climate scenarios; therefore, the success of agroforestry systems will include an understanding of the impact of elevated soil moisture on GHG exchange in various agro-ecosystems—including shelterbelts.

REFERENCES

Amadi, C.C., K.C.J. Van Rees, R.E. Farrell. 2016. Soil – atmosphere exchange of carbon dioxide, methane and nitrous oxide in shelterbelts compared with adjacent cropped fields. Agric., Ecosyst. Environ. 223:123-134

Smith, K.A., T. Ball, F. Conen, K.E. Dobbie, J. Massheder and A. Rey. 2003. Exchange of greenhouse gases between soil and atmosphere: Interactions of soil physical factors and biological processes. Eur. J. Soil Sci. 54:779-791.

Suwanwaree, P. and G.P. Robertson. 2005. Methane oxidation in forest, successional, and no-till agricultural ecosystems. Soil Sci. Soc. Am. J. 69:1722-1729.

ACKNOWLEDGEMENT

The project was funded by Agriculture and Agri-Food Canada – Agricultural Greenhouse Gas Program

Contact: chukwudi.amadi@usask.ca