Greenhouse gas emissions from soils of semi-arid pastures: Response to legume presence.

Paxton Hughes, Hannah Decker, Sanjit Deb, Lindsey Slaughter, and Charles West

Texas Tech University, Department of Plant and Soil Science

Introduction

Transitioning from continuous row-crop monocultures to grasslands can reduce water and nutrient inputs, increase resistance to wind and water erosion, and increase soil health indicators such as build-up of soil organic carbon and greater water retention in the semi-arid Texas Southern High Plains (SHP) (Cano et al., 2018).

Yet, because livestock production systems contribute a significant portion of global greenhouse gas (GHG) production through enteric CH_4 emissions, we do not know whether or to what degree these benefits entail a trade-off in terms of contribution to global climate change via GHG emissions.

Accounting for GHG production dynamics from both soil and cattle in pasture ecosystems can aide modeling and life cycle analysis efforts to assess potential climate change impacts of sustainable agriculture.

Objective: Quantify and compare soil emissions of CH_4 in pastures established with a warm-season perennial (Old World bluestem) grass either in monoculture or with legumes (alfalfa).

Materials and Methods

Experimental Design:

•Long-term sustainable field experiment at New Deal Research Farm, Texas Tech University

•Forage treatments: Pastures containing WW-B.Dahl, Old World bluestem grass (*Bothriochloa bladhii*) either alone **(OWB)** or in mix with alfalfa (*Medicago sativa*) **(OWB + Legume)**.

•Three blocks per treatment, split with grazing exclosures (ungrazed control) located inside each pasture.

Data collection:

•PVC collars (20 cm diameter) were installed in each whole pasture and within grazing exclosures on July 1, 2018.

•Gas samples were collected using static field chambers fitted on each collar at 0, 15, 30, and 45 minutes on July 3rd and 5th, 2018.

•CH_4 in gas samples was measured on a Shimadzu GC-2014 equipped with an FID.

Statistical Analysis: PROC Mixed in SAS 9.4.

Results

- Soil CH_4 emissions differed by forage treatment, but not by grazing.
- CH_4 emissions one day after a rain event were almost 10x higher than three days afterwards, but similar response patterns were observed between dates.

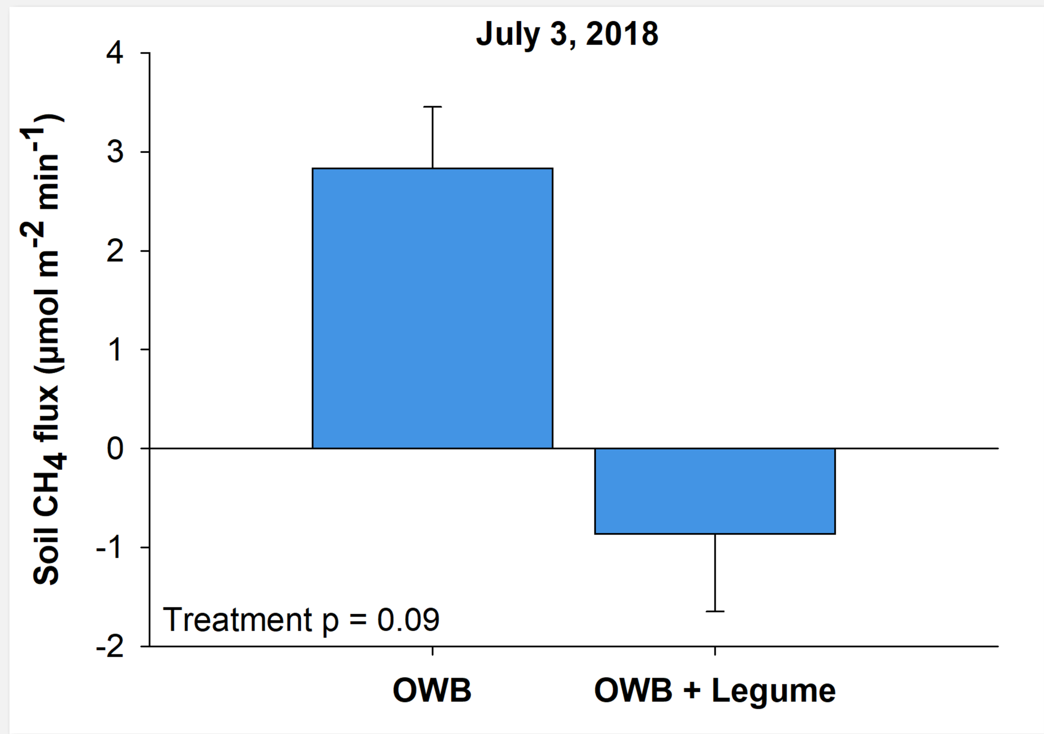

Figure 1: Effects of forage treatment on soil CH_4 flux collected on July 3, 2018.

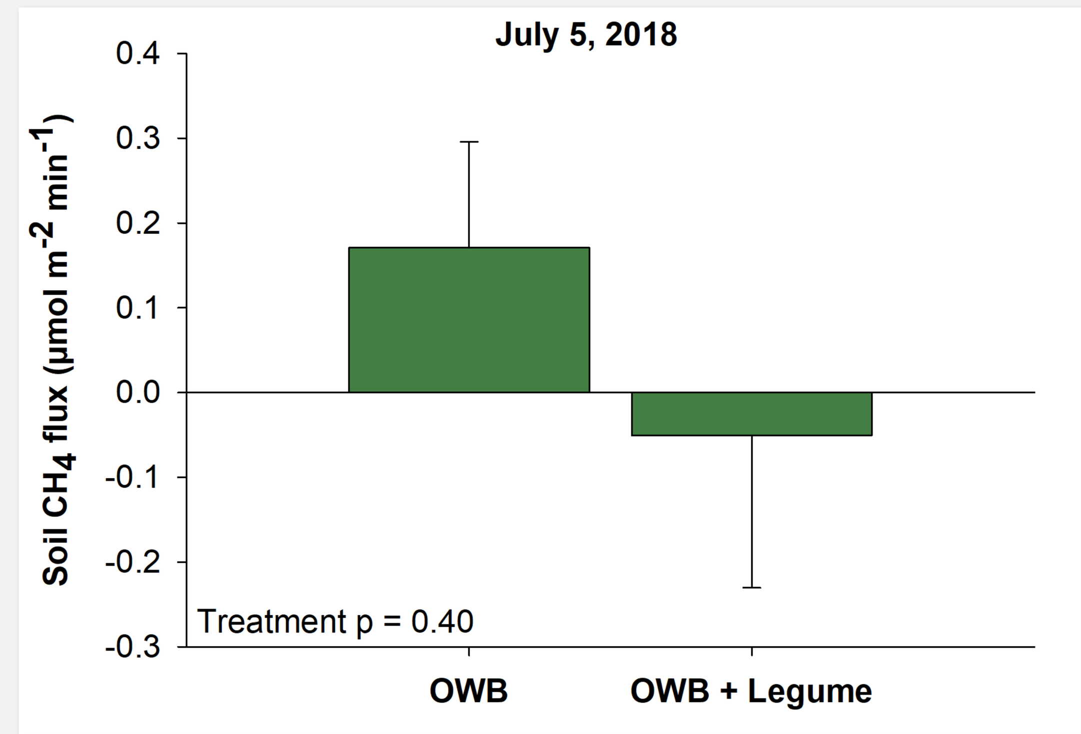

Figure 2: Effects of forage treatment on soil CH4 flux collected on July 5, 2018.

Table 1: ANOVA results for the main and interactive effects of forage treatment and grazing on measurements collected July 3, 2018. Values in unshaded rows are calculated means ± 1 standard error.

	CH_4 flux (µmol m-2 min-1)	Soil Temperature (°C)	Soil Moisture (% VWC)
Treatment	*p = 0.09*	*p = 0.17*	*p = 0.26*
OWB	2.8 (0.6)	24.1 (0.3)	32.8 (0.8)
OWB + Legume	-0.9 (0.8)	24.4 (0.4)	39.8 (2.8)
Grazing	*p = 0.28*	*p = 0.46*	*p = 0.19*
Grazed	1.4 (0.8)	24.2 (0.3)	37.1 (2.0)
Ungrazed	-0.3 (1.3)	24.3 (0.5)	35.0 (3.7)
Treatment x Grazing	*p = 0.90*	*p = 0.20*	*p = 0.57*
OWB, Grazed	3.1 (0.5)	24.1 (0.4)	33.3 (0.9)
OWB, Ungrazed	1.9 (2.4)	24.0 (0.3)	31.0 (0.5)
OWB + Legume, Grazed	-0.4 (1.1)	24.4 (0.4)	40.9 (3.3)
OWB + Legume, Ungrazed	-1.9 (0.8)	24.5 (0.9)	37.7 (6.0)

Table 2: ANOVA results for the main and interactive effects of forage treatment and grazing on measurements collected July 3, 2018. Values in unshaded rows are calculated means ± 1 standard error.

	CH_4 flux (µmol m-2 min-1)	Soil Temperature (°C)	Soil Moisture (% VWC)
Treatment	*p = 0.40*	*p = 0.48*	*p = 0.15*
OWB	0.2 (0.1)	24.3 (0.2)	20.9 (1.4)
OWB + Legume	-0.1 (0.2)	24.7 (0.3)	25.0 (1.5)
Grazing	*p = 0.40*	*p = 0.11*	*p = 0.17*
Grazed	0.1 (0.1)	24.7 (0.2)	24.0 (1.4)
Ungrazed	-0.1 (0.2)	24.3 (0.3)	21.0 (1.5)
Treatment x Grazing	*p = 0.68*	*p = 0.26*	*p = 0.48*
OWB, Grazed	0.2 (0.2)	24.6 (0.3)	22.4 (1.7)
OWB, Ungrazed	0.1 (0.2)	23.9 (0.1)	17.9 (0.8)
OWB + Legume, Grazed	0.1 (0.2)	24.8 (0.4)	25.5 (2.2)
OWB + Legume, Ungrazed	-0.3 (0.4)	24.6 (0.6)	24.0 (1.0)

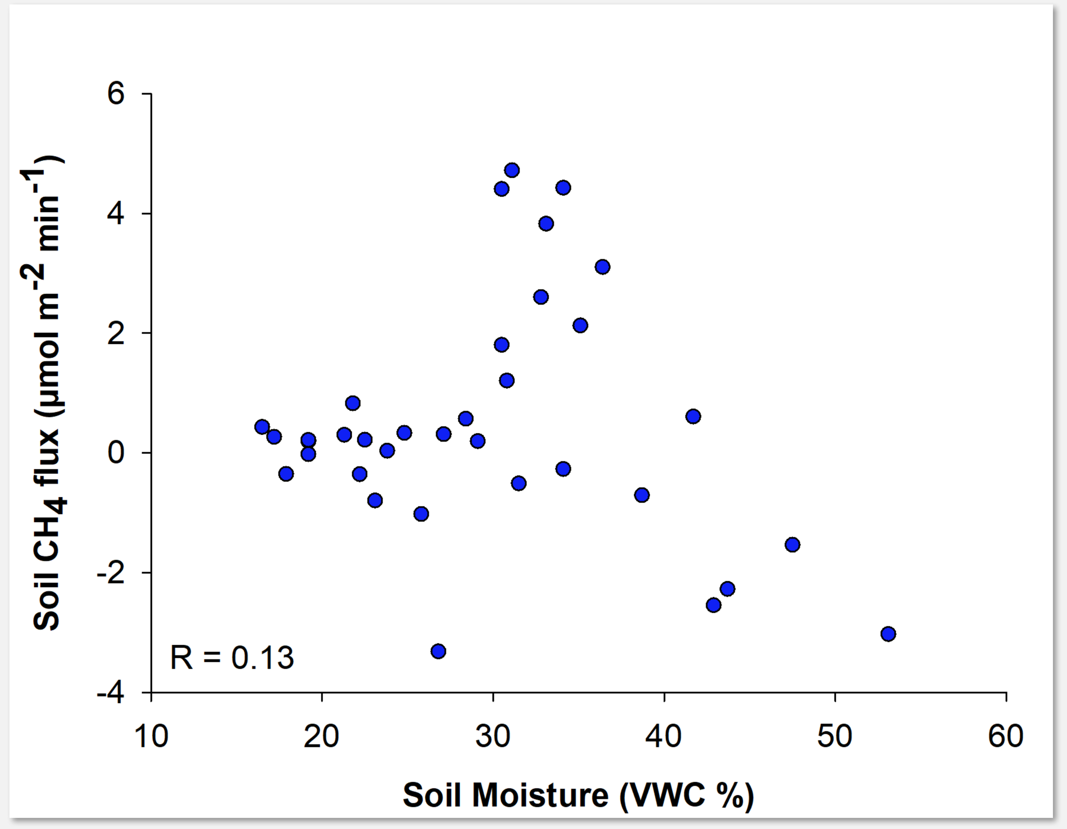

Figure 3: Response of soil CH_4 flux to mean soil moisture measured near each PVC collar July 3rd and 5th, 2018.

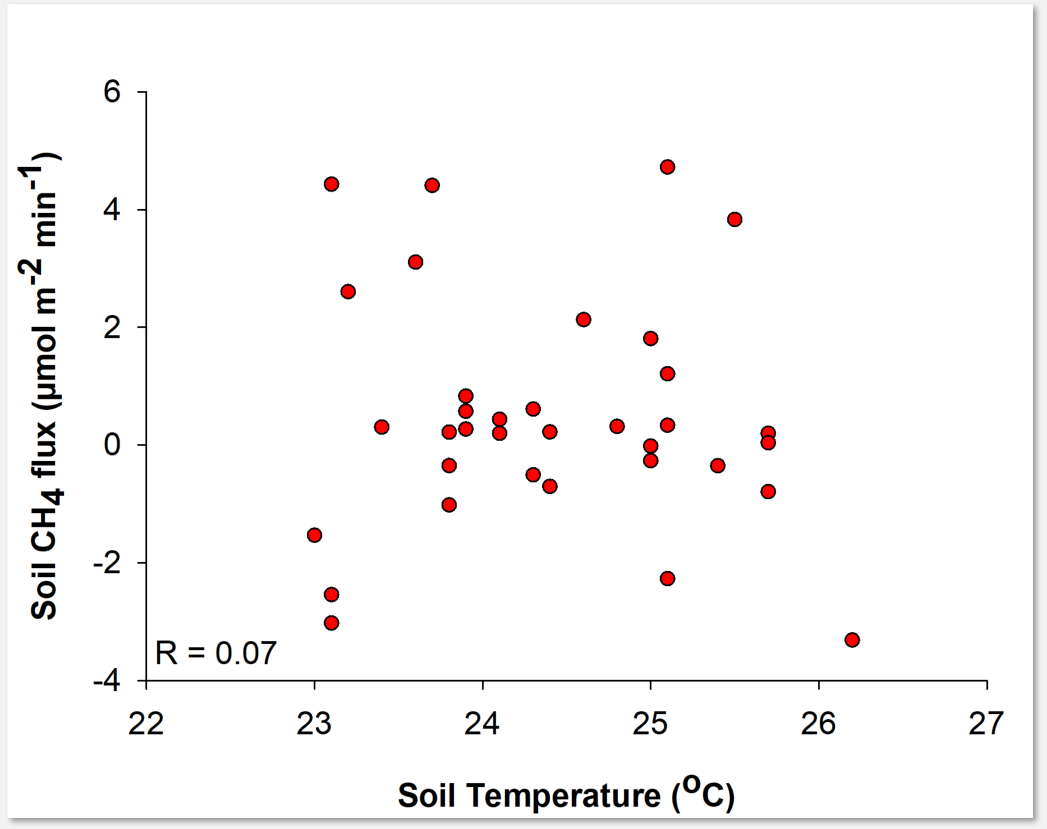

Figure 4: Response of soil CH_4 flux to mean soil temperature measured near each PVC collar July 3rd and 5th, 2018.

Discussion

- Pastures with OWB alone tended to result in a net CH_4 production from soil, while pastures with a mix of OWB and alfalfa tended to result in net CH_4 consumption in soil (Fig. 1,2).
- No differences between forage treatments occurred in enteric CH_4 emission from grazing cattle on these pastures (Henry et al., unpublished).
- Soil moisture and temperature did not correlate with CH_4 flux (Fig. 3,4). Yet, increased soil moisture on July 3 due to a rainfall event one day prior may have strengthened the effect of forage treatment compared to on July 5 (Table 1).
- Differences in CH_4 efflux/influx may be related to differential nitrogen availability between N-fertilized grass pastures and unfertilized legume mix (Mosier et al., 1991; Singh et al., 1997).

Conclusions

- In adjacent pastures, forage mix could influence whether soils represent a source or sink of CH_4.
- Adding alfalfa to improved perennial pastures may contribute to reduced soil CH_4 emissions in semi-arid production systems.
- If preliminary results hold up, they can change model inputs and life cycle analyses of livestock production through tradeoffs in cattle vs. soil CH_4 emissions.

References

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Acknowledgements

The authors sincerely thank Meagan Riley and Rael Otuya for their help with sample collection. We also thank L. Fultz (LSU AgCenter) for her help with GC methods and setup, and Philip Brown and Paul Green for field plot management and maintenance.

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2016-38640-25382 through the Southern Sustainable Agriculture Research and Education program, under subaward number LS17-286. USDA is an equal opportunity employer and service provider. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.