The effect of wetting and drying on carbon availability in switchgrass soils

Matthew A. Belanger[1], Carmella Vizza[2], Jabarius A. Jones[3], G. Philip Robertson[1], and Sarah S. Roley[2]
[1] W.K. Kellogg Biological Station, Michigan State University, Hickory Corners, MI; [2] School of the Environment, Washington State University, Richland, WA; [3] Dept. of Animal Science, North Carolina A&T, Greensboro, NC

Introduction

- Nitrogen (N) fertilizer enhances crop production, but it also increases waterway and greenhouse gas pollution.
- To make agriculture more sustainable, we need to better understand how to boost natural sources of N.
- N fixation, the conversion of N_2 to ammonium, is performed naturally by soil microbes, but it is an energetically costly process[1].
- Soil organic carbon (SOC) is a potential energy source for N fixation, which can be assessed by the mineralization of SOC to CO_2[2].
- Frequent re-wetting of dry soil has shown to boost microbial activity, including carbon (C) mineralization[3].
- Our goal was to examine the effects of rainfall frequency on soil C availability in switchgrass (*Panicum virgatum* L.), a potential biofuel crop.

Methods

- Three rainfall frequency treatments were applied to four unfertilized switchgrass plots using rainout shelters and sprinklers. (Fig. 1).

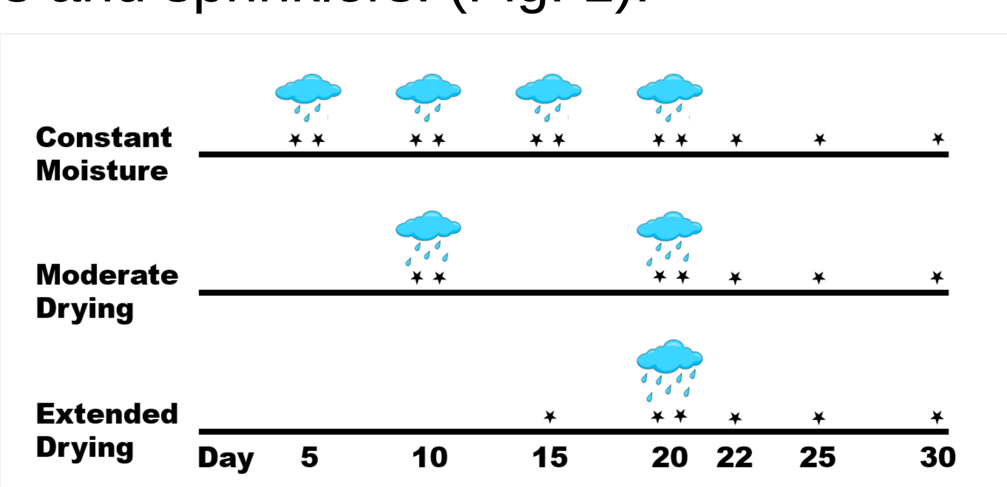

Fig. 1: All treatments received ~60 mm of water over 20 days. Wetting and sampling events are depicted with rain clouds and stars, respectively.

- During each sampling event, soil was collected at the appropriate plots with a push probe, sieved (4-mm mesh), split into triplicates, weighed, air-dried, and re-weighed to determine gravimetric soil moisture.
- 10 g of dry soil per triplicate was re-wet to 50% water-filled porespace and sealed in a mason jar[2].
- The jar headspace was sampled at 5 intervals (0, 2, 4, 8, and 24 hours) and stored in vacuumed exetainers.
- CO_2 production rates were determined with a LI-COR LI-820 and used as a proxy for C availability.

Data analysis

- Using a repeated-measures analysis of variance (ANOVA), we tested for the effect of rainfall frequency (i.e., constant moisture, moderate drying, and extended drying), sampling period (i.e., before and after wetting), and their interaction on Day 20 C availability.
- We also examined the effect of rainfall frequency, time after the final wetting (i.e., Days 20, 22, 25, and 30), their interaction, and soil moisture on C availability.

Results

- Soil from the constant moisture treatment had the most consistent moisture content, while the extended drying treatment experienced the greatest loss in soil moisture until re-wetting on Day 20 (Fig. 2).
- Soil moisture across treatments was roughly the same after the final wetting event on Day 20, followed by the gradual drying of all treatments through Day 30 (Fig. 2).

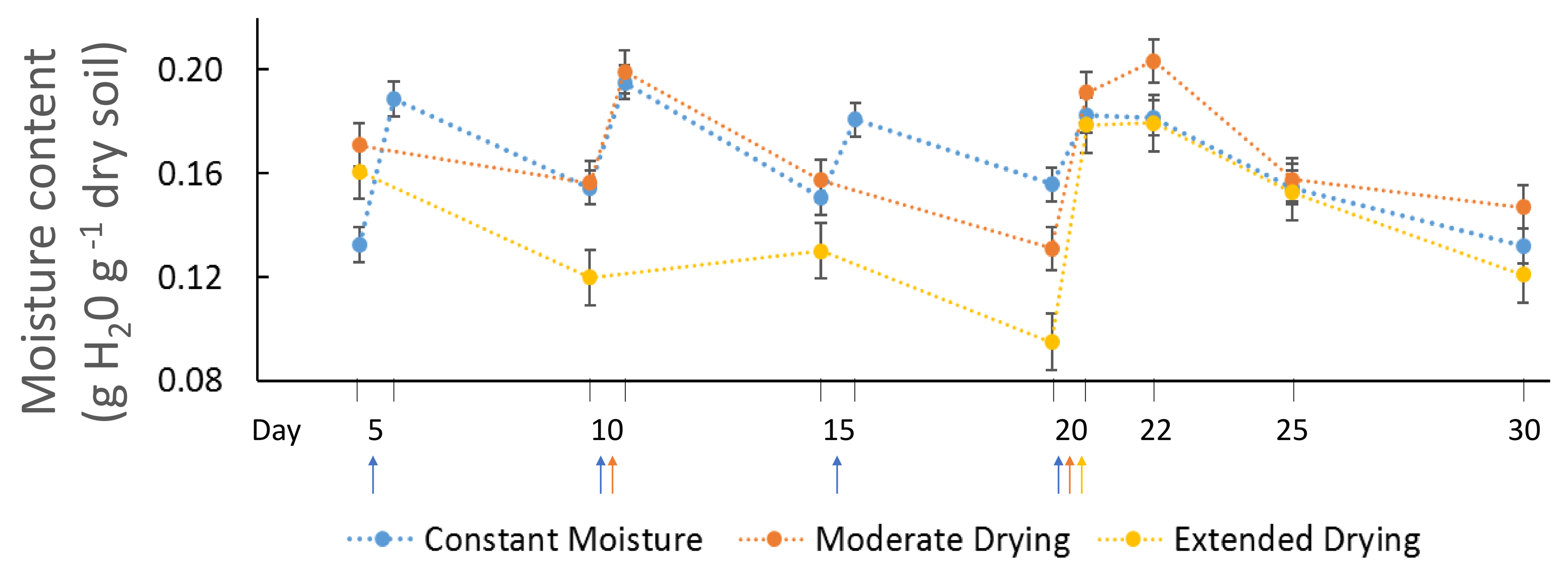

Fig. 2: Soil moisture (± standard error) over the 30-day experiment. Wetting events are marked with arrow colored corresponding to rainfall frequency treatment. Sampling events that occurred before/after wetting are depicted with tick marks.

- C availability decreased immediately after the wetting event on Day 20 ($P = 0.05$, Fig. 3).
- Rainfall frequency treatment, however, did not significantly affect Day 20 C availability ($P = 0.34$), and there was no significant interaction between the two factors ($P = 0.19$, Fig. 3).

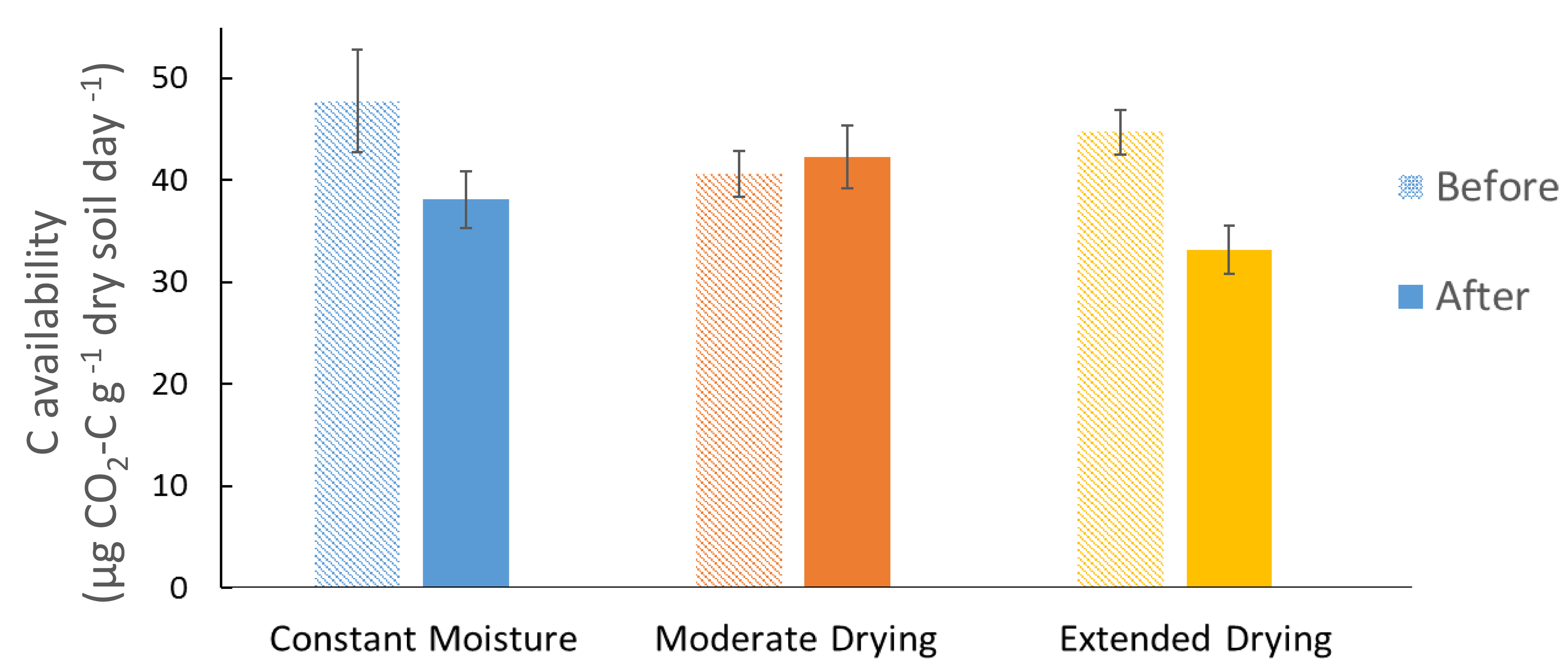

Fig. 3: Carbon availability (± standard error) on Day 20 in the three rainfall frequency treatments. Sampling events before wetting are denoted with patterned bars, while post-wetting events are represented by solid bars.

Results (continued)

- C availability on Day 20 – 30 tended to vary across rainfall frequencies ($P = 0.06$, Fig. 4), while time after wetting ($P = 0.64$) and their interaction had no significant effect ($P = 0.13$).
- Drier soils had lower C availability ($P < 0.001$).

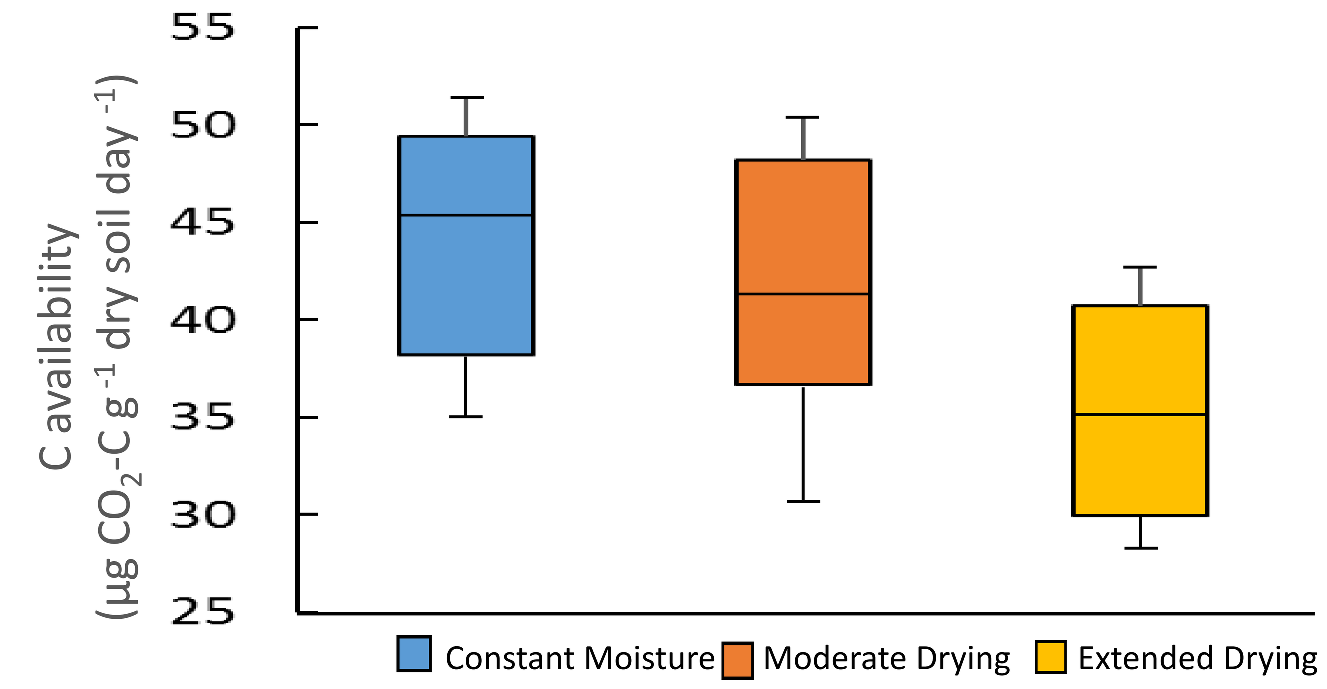

Fig. 4: Box plots depicting carbon availability after the final wetting event on Day 20 along with Days 22, 25, and 30. The lowest boundary of the box indicates the 25th percentile, the line within the box marks the median, and the top boundary represents the 75th percentile. Error bars below and above indicate the 10th and 90th percentile, respectively.

Discussion

- The decrease in C availability on Day 20 between sampling events indicates C consumption immediately after wetting and before soil was dried and then re-wet in the laboratory.
- Greater C consumption in the soil immediately after rainfall could help explain N fixation patterns if N-fixers are using SOC as their energy source.
- Our next step is to determine the appropriate timescale for measuring C availability to better predict variation in N fixation.
- Investigating how to manage crops to enhance N fixation will make agricultural and biofuel production more sustainable.

Acknowledgements

We would like to thank Sean Murphy for his help collecting samples. Kevin Kahmark designed and helped to construct the rainout shelters and sprinkler system. Funding for this project was provided by the National Science Foundation and Michigan State University. We would also like to acknowledge the LTER and GLBRC for their support.

References

[1] Smercina, D. N. et al., (2019). *Appl. Environ. Microbiol.*, *85*(6), https://doi.org/10.1128/AEM.02546-18
[2] Franzluebbers, A. J. et al., (2000). *Soil Science Society of America Journal*, 64(2), 613-623.
[3] Birch, H. F. (1958). *Plant and soil*, 10(1), 9-31.