Tarping for the Future: Evaluating Soil Temperature and Soil Greenhouse Gas Fluxes Among Cover Crop Termination Methods for Organic Vegetable Crop Production

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Introduction

Expected warmer and wetter conditions across the upper Midwestern U.S. place farmers in need of applied research identifying sustainable agriculture solutions that are resilient to our changing climate. The method of tarping has emerged as a no-till solution for terminating cover crops, but applied research on this method is lacking. We investigated the influence of cover crop termination methods, including i) mowing & tilling, ii) mowing & tarping, iii) rolling & crimping, and iv) an un-terminated control on weed occurrence, soil health, and greenhouse gas fluxes. Specific objectives of this research include assessing the influence of these cover crop termination methods on soil temperature and greenhouse gas emissions.

Methods

- The soil type in our study area was Ruse-Ensign-Nykanen complex fine sandy loam. Prior to implementation of the treatments, a previously uncultivated field was roto-tilled and a oat and pea cover crop was drilled across the entire study area in May 2023 (Figure 1).
- A fully-randomized block design containing four replicates of the following alternative cover crop termination methods was subsequently established on July 19, 2023: i) Mow-Tarp, ii) Mow-Till, iii) Roll-Crimp, and iv) No-Term. No-term plots were each 12 x 36 (ft) and all other plots were 12 x 52 (ft).
- Soil temperature loggers were used to continuously monitor soil temperature (hourly-intervals) and field-portable trace gas analyzers (LI-7810 and LI-7820; LI-COR Environmental, Lincoln, NE, USA) were used to collect 2 soil carbon dioxide (CO_2) and nitrous oxide (N_2O) gas fluxes observations from each plot on 17 sampling event days (n = 8 per treatment per event) between July – November 2023.

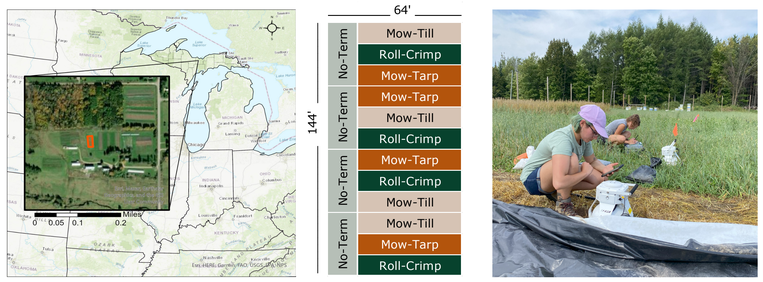

Figure 1. Michigan State University Upper Peninsula Research and Extension Center's MOSA Certified Organic North Farm is located in Chatham, MI (left), where an experimental study design was established (middle), and soil temperature, soil CO_2 flux and soil N_2O flux observations (right) were collected in each replicated treatment.

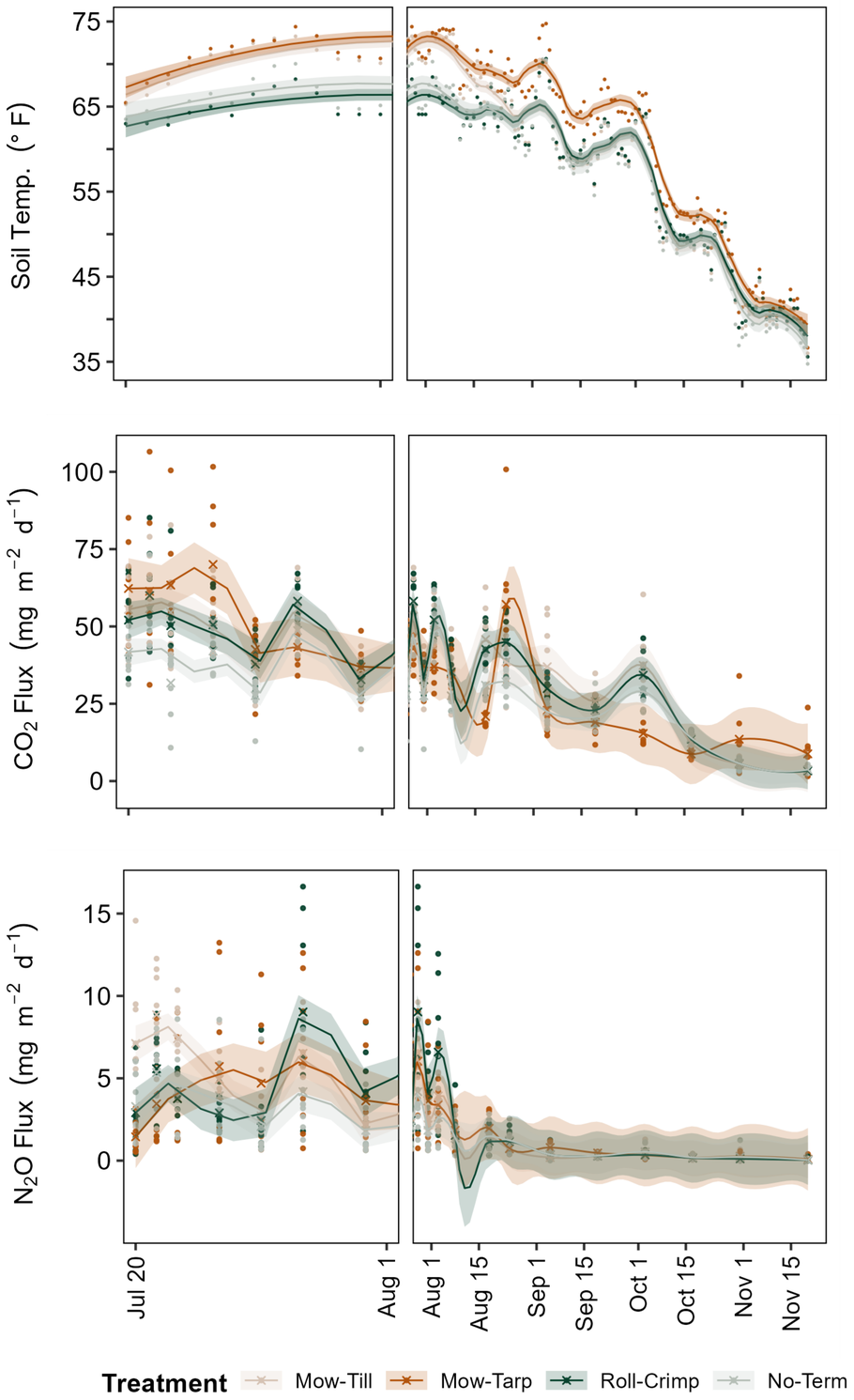

Figure 2. Daily mean soil temperature (top; °F), soil CO_2 flux (middle) and soil N_2O flux (bottom; mg m^{-2} d^{-1}) observations (points) collected in each treatment where lines and shaded ribbons were generated using local regression smoothing in R. The x-axis was expanded between Jul. 20 and Aug. 1 to improve interpretation during the first 12 days of the treatment period.

Table 1. Summary statistics including number of observations (n), mean (± standard error) for soil CO_2 fluxes (mg m^{-2} d^{-1}), soil N_2O fluxes (mg m^{-2} d^{-1}), and soil temperature (°F), and Kruskal-Wallis rank mean comparisons (Mean Test) for each treatment.

Treatment	n	CO_2	Mean Test	n	N_2O	Mean Test	n	Soil Temp.	Mean Test
Mow-Till	136	37.5 (± 1.7)	a	136	2.9 (± 0.3)	a	496	57.9 (± 0.5)	a
Mow-Tarp	136	42.2 (± 2.2)	a	136	4.3 (± 0.3)	a	496	60.7 (± 0.5)	b
Roll-Crimp	136	36.8 (± 1.6)	a	136	2.5 (± 0.3)	a	496	56.7 (± 0.4)	c
No-Term	136	30.0 (± 1.3)	b	136	2.0 (± 0.2)	a	372	56.3 (± 0.5)	c

Significant between-treatment mean differences are indicated by (a), (b) and (c) at $p<0.05$

Results

- Preliminary results show that the highest mean daily soil temperatures (60.7 ˚F) occurred in the Mow-Tarp treatment and were 2.7 and 3.9 (˚F) warmer when compared to Mow-Till and Roll-Crimp mean daily soil temperatures, respectively (Table 1).
- The cover crop termination practices had no significant impact on mean N_2O fluxes (mg m^{-2} d^{-1}) when comparing among all treatments, however the 4.3 (mg m^{-2} d^{-1}) mean N_2O flux in Mow-Tarp was the largest mean detected among treatments, and was 148% and 172% larger than the Mow-Till and Roll-Crimp mean fluxes, respectively (Table 1).
- The 30.0 (mg m^{-2} d^{-1}) mean CO_2 flux occurrence detected in the No-Term treatment was significantly lower ($p<0.05$) when compared to all other treatments, and the 42.2 (mg m^{-2} d^{-1}) mean CO_2 flux in Mow-Tarp was the largest observed among treatments. However, mean CO_2 fluxes detected in the Mow-Till, and Mow-Tarp and Roll-Crimp were not significantly different when compared to each other.

Discussion

The mean daily Mow-Tarp soil temperatures were statistically warmest among all treatments, at least 5 °F warmer than all other treatments for 55 of the 124 (44%) days. However, soil temperatures in the Mow-Till and Mow-Tarp treatments were statistically similar during the first 3 weeks of the study period (Figure 2).

When only the effective Mow-Till, Mow-Tarp and Roll-Crimp termination treatments were considered, there were no significant differences detected among treatments for soil CO_2 nor soil N_2O fluxes, indicating that reduction of soil GHG emissions may not be a justifiable reason for selecting among these cover crop termination methods. However, our study did not consider lifecycle emissions from fuel, plastic, or other cover crop management materials.