Soil Health: Reduced Tillage Strategies for Organic Farmers

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NORTHERN MICHIGAN UNIVERSITY
EARTH, ENVIRONMENTAL AND GEOGRAPHICAL SCIENCES

With financial support from: MICHIGAN STATE UNIVERSITY | AgBioResearch
Doug and Maria Bayer New Initiatives Fund for Sustainable Agriculture

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Presentation Outline

- Problem Statement & Need
- Goals and Objectives of the Project
- Summary of Methodology
- Results & Discussion
- Collaborator Posters
- Questions

Problem Statement & Need

Emerging reduced tillage practices are becoming increasingly popular in organic crop production systems. However, a limited amount of research has been conducted to support their implementation.

"*Applying reusable tarps for weeks to months is an increasingly common no- till and low-labor way to prepare a bed before planting.*"

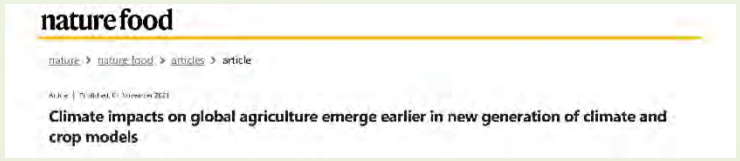
"***Even as tarping is gaining in popularity, there is very limited Midwest-specific research to inform producers about the best ways to employ tarps***."

https://practicalfarmers.b-cdn.net/wp-content/uploads/2023/08/23.H.TarpingCCTermination.pdf

https://climate.nasa.gov/news/3124/global-climate-change-impact-on-crops-expected-within-10-years-nasa-study-finds/

"Climate change presents new challenges; finding strategies to adapt to these changes can help farmers remain productive and profitable."

https://www.climatehubs.usda.gov/sites/default/files/NIACS-NRCS%20CROPLAND%20Booklet_Midwest.pdf



https://doi.org/10.1038/s43016-021-00400-y

"*One criticism of organic farming is based on the hypothesis that tillage and cultivation required for weed control degrades soil health and negates the benefits of cover cropping and other soil-building practices.*"

"***Additional research leading to practical tools and guidelines that can help organic producers reduce tillage is clearly warranted. Uneven results with organic rotational no-till indicate a need for more work to develop improved tools and method…***"

"Approaches to organic conservation tillage must also be regionally adapted…"

https://www.nrcs.usda.gov/sites/default/files/2024-03/Soil%20health.pdf

Qualitative observations…

Cover cropping

Tarping (occultation)

Interplanting

Interplanting

Permanent, minimum/no-till beds

Deep compost mulch

“Ideally, quantitative assessment of observed changes in soil health and crop vigor will guide future action”

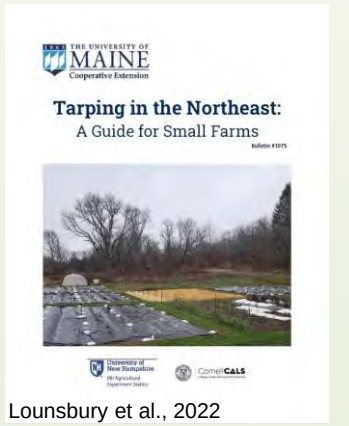
Goals and Objectives of MSU-NMU Project

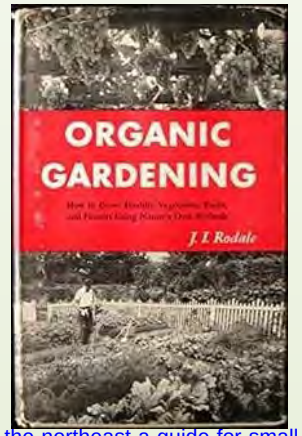
A multi-year cooperative on-farm research project where MSU-UPREC, NMU Applied Biogeosciences Lab and Full Plate Farm collaborate to:

- Evaluate the influence of cover crop termination methods, including conventional tillage, strip- tillage, rolling & crimping, and occultation (tarping) on *i*) soil health & fertility, *ii*) GHG emissions, *iii*) climate resiliency, *iv*) weed occurrence, and *v*) organic vegetable crop production & quality.

- Generate quantifiable and meaningful results to directly inform and support organic vegetable growers and crop advisors.

  ***Results may be applicable to some conventional agriculture and/or field crop systems.**





Lounsbury et al., 2022
https://www.sare.org/resources/tarping-in-the-northeast-a-guide-for-small-farms/

Summary of Methodology

A pea (100 lbs ac^{-1}) & oat (128 lbs ac^{-1}) cover crop was broadcast seeded in mid-May and terminated by our treatments in late-June or early-July. Tarps were in-place for ~3 weeks before tillage was repeated, beets/broccoli and cabbage were transplanted. Crops were harvested at maturity.

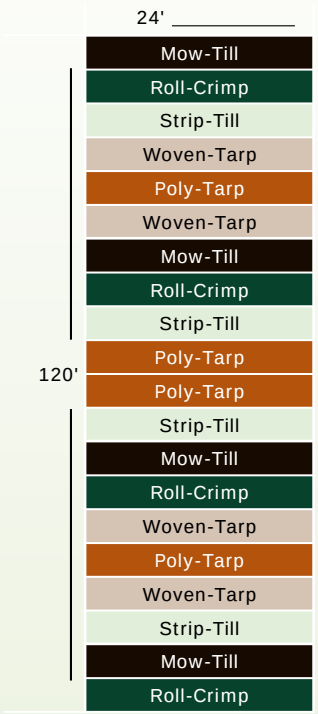


Figure 1. MSU-UPREC North Farm and Full Plate Farm study area locations, treatment types, and fully-randomized block experimental study design.

Fully randomized block design w/ 4 reps at 2 farms

- 2024 & 2025 growing seasons

Above-ground biomass pre, post-termination & CWFP

- Pea, oat, broadleaf & grass weeds 1 ft.2 (n=16)
- 12-18” in-row band hand weeded (timed)

Soil temperature, moisture, fertility and health

- Data loggers in each plot for temp and moisture
- Soil samples pre and post-termination

Soil GHG flux pre-termination through crop harvest

- CO_2 and N_2O with LICOR 7810 & 7820

Beet/broccoli and cabbage harvest (n=8)

- Marketable and unmarketable (size, deer) count and weight

LMM analysis with treatment as fixed and block as random

- Tukey for all pair-wise mean comparisons ($p < 0.05$) in R

Results: Stand Density

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- Cover crops were broadcast over tilled soil and incorporated.
  - Rolled at NF & tilled at FPF
- Cover crop establishment was successful with densities similar across farm locations.
- Broadleaf weed community & density was similar across locations.
  - Pigweed, lambsquarter, clover
- Grass weed density was significantly higher at North Farm.
  - Quackgrass, large crabgrass

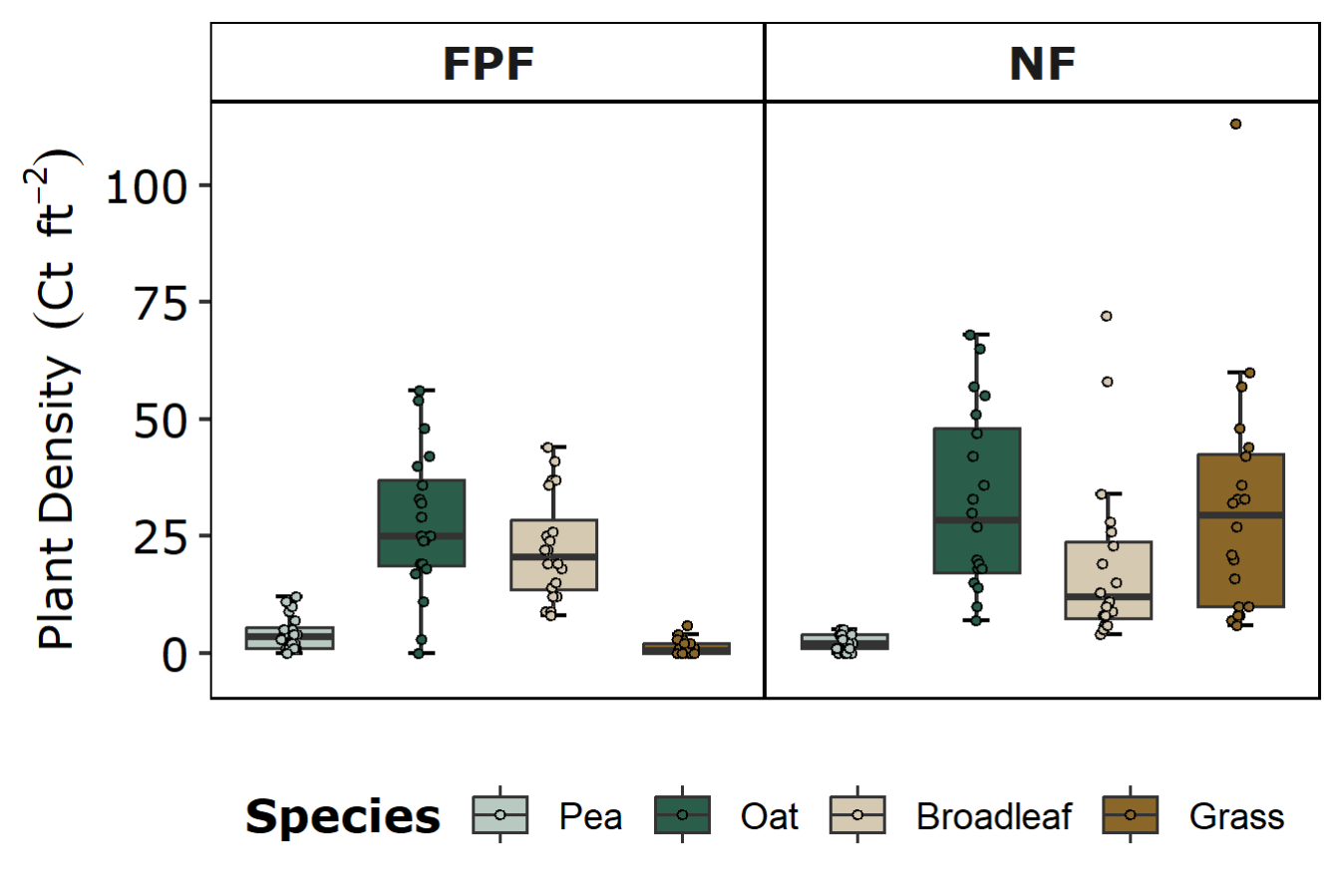

Figure 2. Initial stand density by species and location

Results: Termination Efficacy

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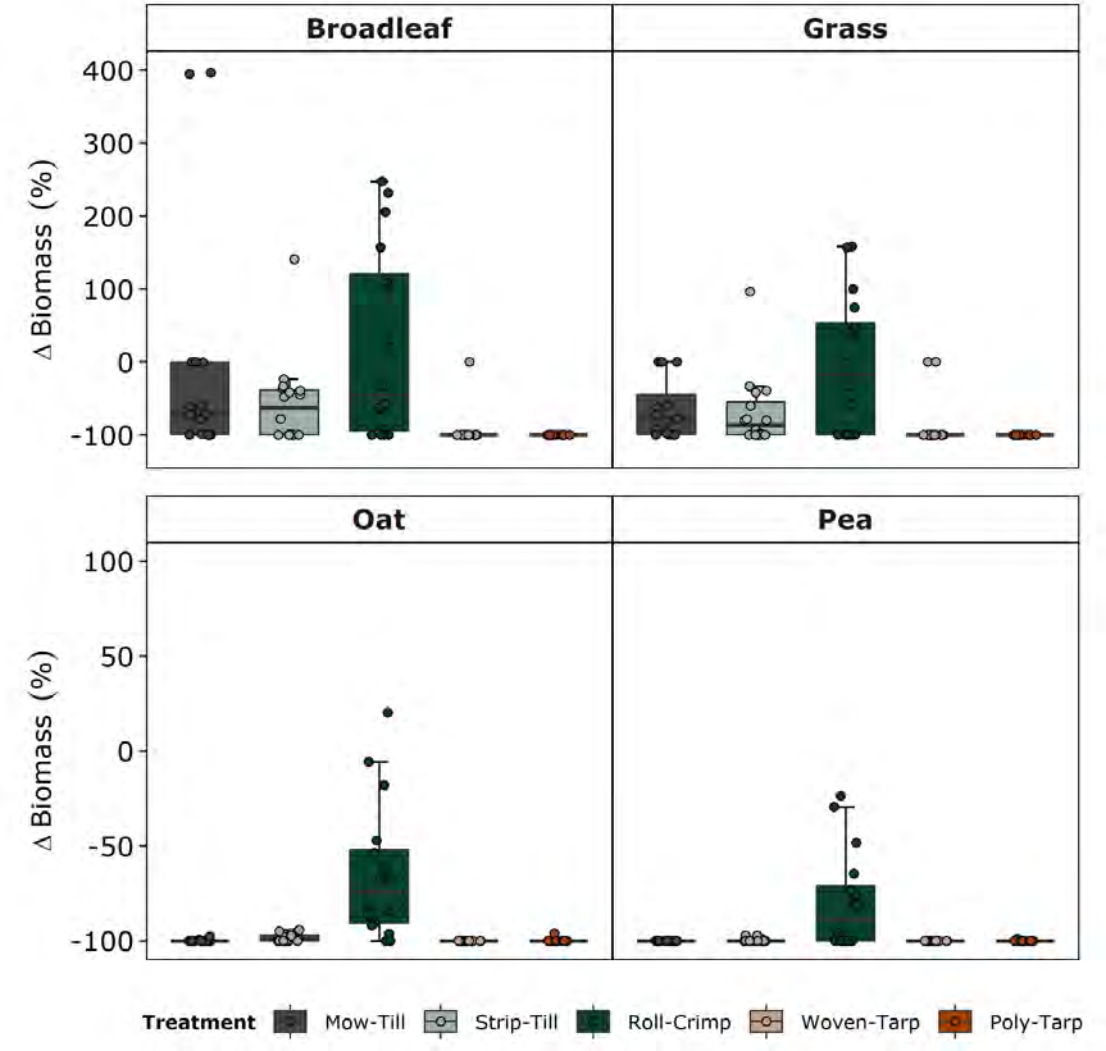

Figure 3. Change in biomass pre-post treatment by species

- All treatments, except roll-crimp, successfully terminated the cover crop and weeds.
- Weeds flushed following tillage (full and strip), especially at North Farm.

Table 1. Summary statistics including number of observations (n), mean change pre-post (Δ, ± standard error), and Tukey tests ($p<0.05$) for total cover crop and weed biomass (T ac^{-1})

Treatment	n	ΔCC Biomass	Mean Test	n	ΔWeed Biomass	Mean Test
Mow-Till	16	-10.2 (± 0.60)	a	16	-0.3 (± 0.11)	ab
Strip-Till	16	-9.4 (± 0.60)	a	16	-0.4 (± 0.18)	ac
Roll-Crimp	16	-6.4 (± 0.60)	b	16	-0.1 (± 0.02)	b
Woven-Tarp	16	-9.7 (± 0.60)	a	16	-0.5 (± 0.23)	ac
Poly-Tarp	16	-9.2 (± 0.60)	a	16	-0.9 (± 0.40)	c

Results: Soil Temperature and Moisture

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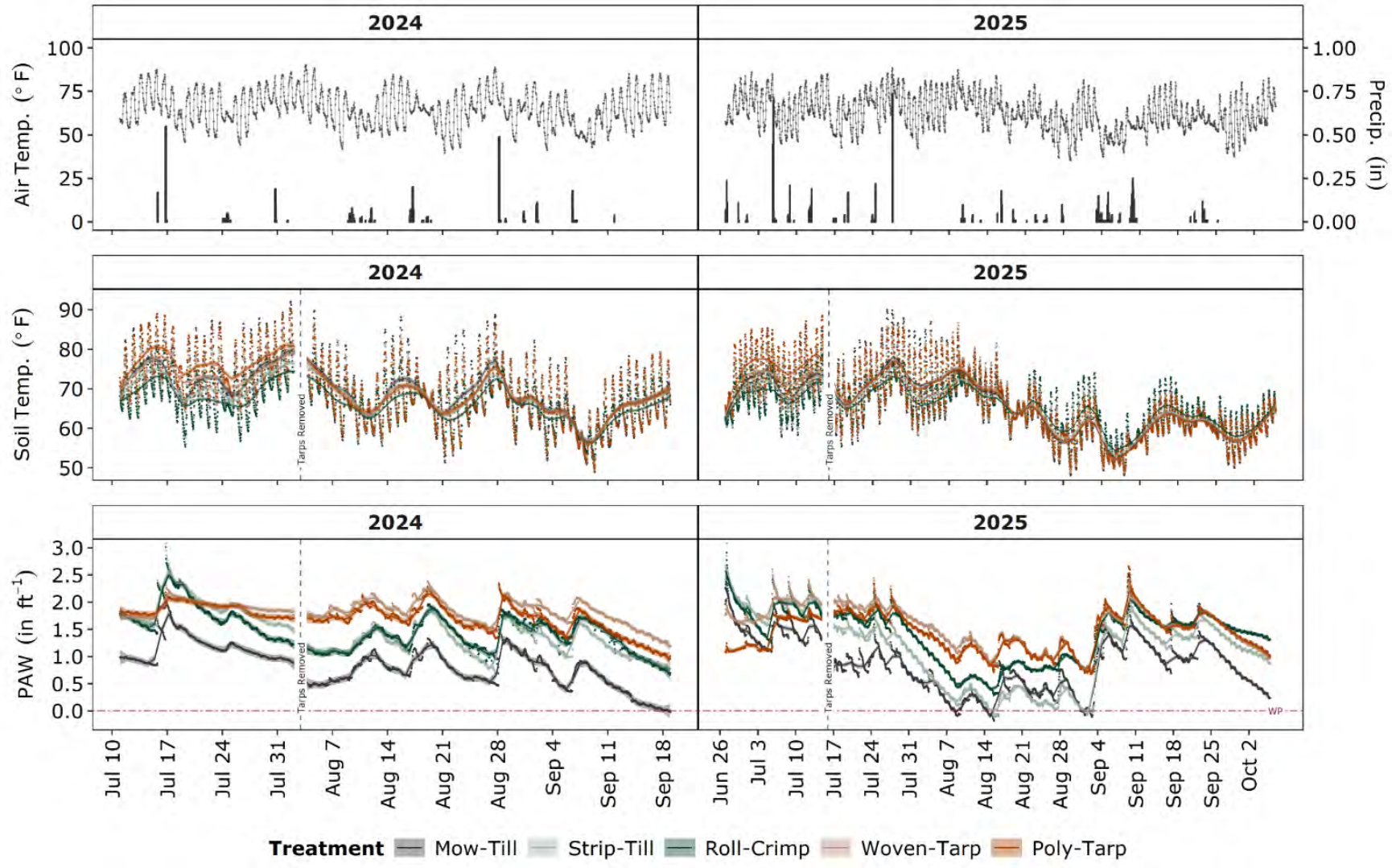

- Mean daily soil temp under poly-tarps was 3.8 and 2.8 °F warmer than mow-till and woven-tarp, respectively, during termination.
- Tarps and mow-till were significantly warmer than roll-crimp during cropping.
- PAW in mow-till was significantly lower than all other treatments throughout.
- PAW under tarps was significantly higher when compared to all other treatments during cropping.

Figure 5. Air and soil temperature, plant available water (PAW) recorded at 1-hr intervals

Results: Soil Health and Fertility

Results: Soil Health and Fertility

- ΔIN of mow-till and tarps was similar and significantly greater than roll-crimp, while strip-till was intermediate.
- ΔK of mow-till was significantly greater than roll-crimp, but similar to the other treatments.
- ΔActiveC under poly-tarp and mow-till was considerably larger (more than 7x) when compared to other treatments, but not significantly different.
- MEA levels increased following all treatments, but treatments did not differ.

Table 3. Summary statistics including number of observations (n) and mean change pre-post (Δ, ± standard error) for inorganic nitrogen (IN), phosphorous (P), potassium (K), soil organic carbon (SOC), active carbon (active C) and soil microbial enzyme activity levels (MEA).

Treatment	df	Soil Temp. (°F)	MT	n	ΔIN mg kg^{-1}	MT	ΔP mg kg^{-1}	MT	ΔK mg kg^{-1}	MT	ΔSOC %	MT	ΔAct. C mg C kg^{-1}	MT	ΔMEA nmol hr^{-1} g^{-1}	MT
Mow-Till	9.1	72.1 (±0.5)	a	16	21.0 (±3.7)	a	5.8 (±10.7)	a	34.1 (±5.9)	a	0.07 (±0.02)	a	16.2 (±14.8)	a	107.0 (±98.7)	a
Strip-Till	9.1	70.5 (±0.5)	b	16	13.7 (±2.4)	b	13.6 (±10.7)	a	19.2 (±5.9)	ab	0.17 (±0.04)	a	1.8 (±14.8)	a	112.7 (±127.4)	a
Roll-Crimp	9.3	68.8 (±0.5)	c	16	5.1 (±0.9)	c	10.1 (±10.7)	a	0.8 (±5.9)	b	0.19 (±0.04)	a	2.3 (±14.8)	a	104.8 (±96.7)	a
Woven-Tarp	9.5	73.0 (±0.5)	d	16	20.8 (±3.7)	ab	-5.2 (±10.7)	a	13.0 (±5.9)	ab	0.14 (±0.03)	a	2.1 (±14.8)	a	103.5 (±95.5)	a
Poly-Tarp	9.3	75.8 (±0.5)	e	16	22.7 (±4.0)	a	0.5 (±10.7)	a	12.7 (±5.9)	ab	0.18 (±0.04)	a	20.8 (±14.8)	a	66.7 (±61.6)	a

Results: Critical Weed Free Period (CWFP)

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- Weed biomass was significantly greater in roll-crimp than mow-till and tarps during the CWFP.
- Weeds in strip-till were intermediate as a hybrid of other treatments.

Table 2. Summary statistics including number of observations (n), mean (± standard error), and Tukey tests ($p<0.05$) for total weed biomass (T ac^{-1})

Treatment	n	Weed Biomass	Mean Test
Mow-Till	16	0.4 (± 0.1)	ab
Strip-Till	16	1.2 (± 0.3)	ac
Roll-Crimp	16	1.8 (± 0.5)	c
Woven-Tarp	16	0.2 (± 0.1)	b
Poly-Tarp	16	0.3 (± 0.7)	b

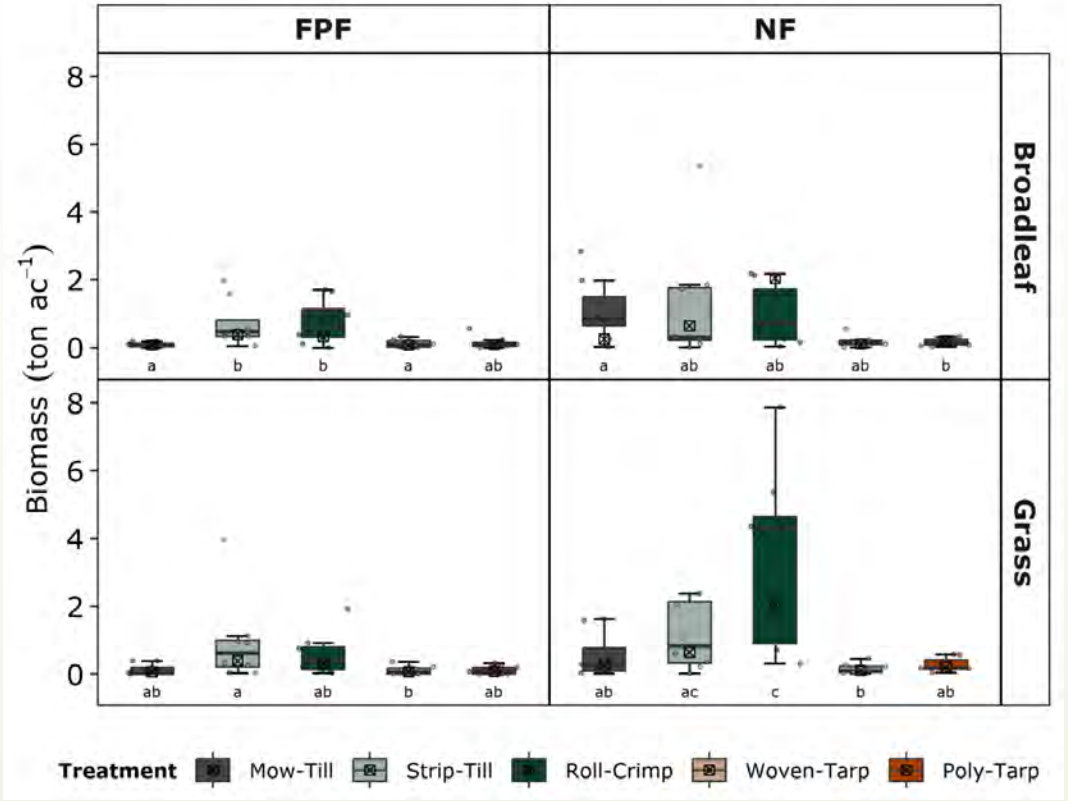

Figure 4. CWFP biomass at Full Plate Farm (FPF) and North Farm (NF)

Results: Greenhouse Gas Emissions

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- CO2 flux under poly-tarps was significantly larger when compared to other treatments during the termination period.
- Poly-tarp and woven-tarp CO2 fluxes were significantly lower when compared to all other treatments during the post-termination period.
- N2O fluxes in mow-till and tarps were not significantly different, while strip-till and roll-crimp had elevated N2O fluxes during the post-termination period.
- Lifecycle GHG emissions will depend on many factors.

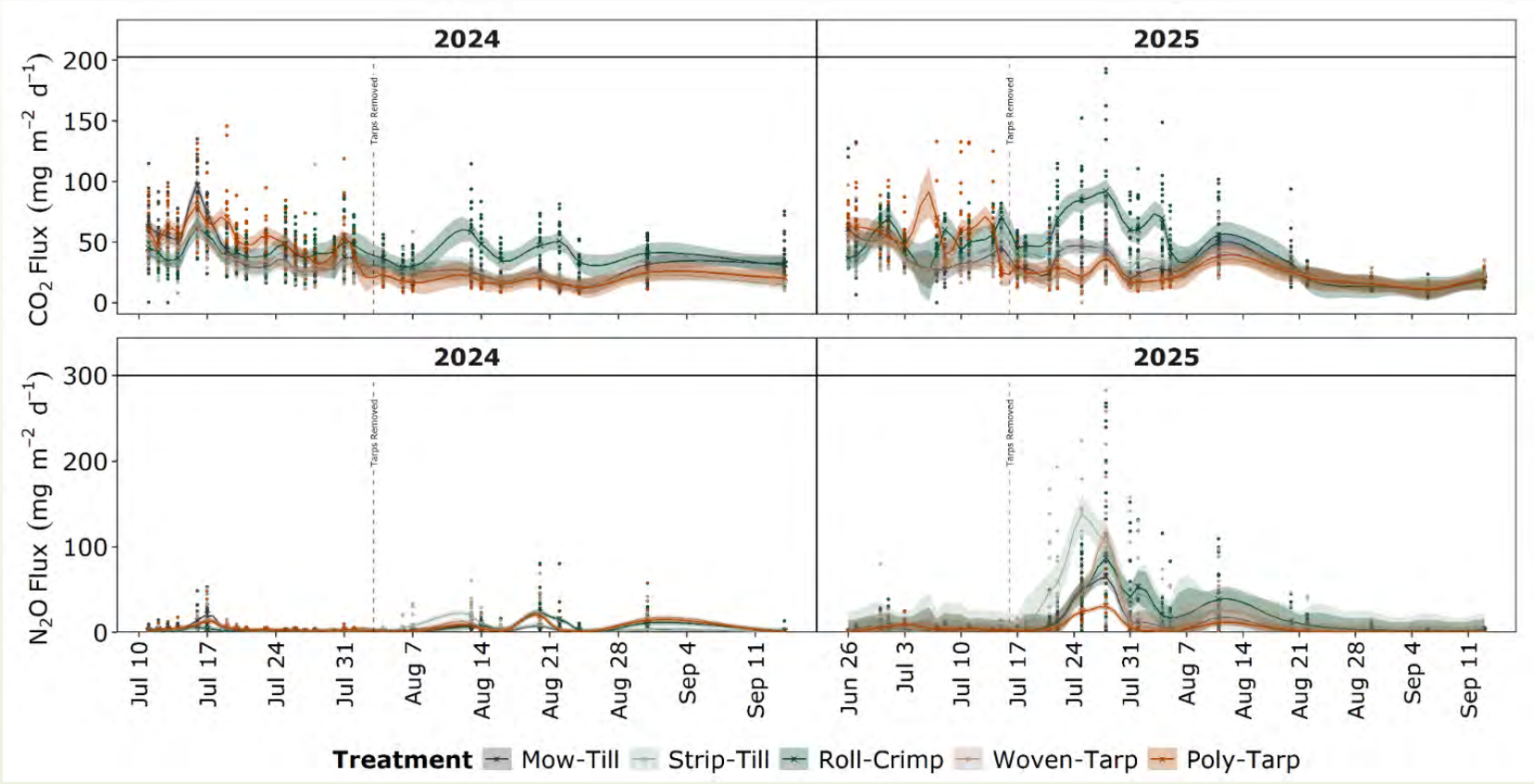

Figure 6. Daily mean soil CO2 flux (top) and soil N2O flux (bottom)

Results: Crop Yield & Quality

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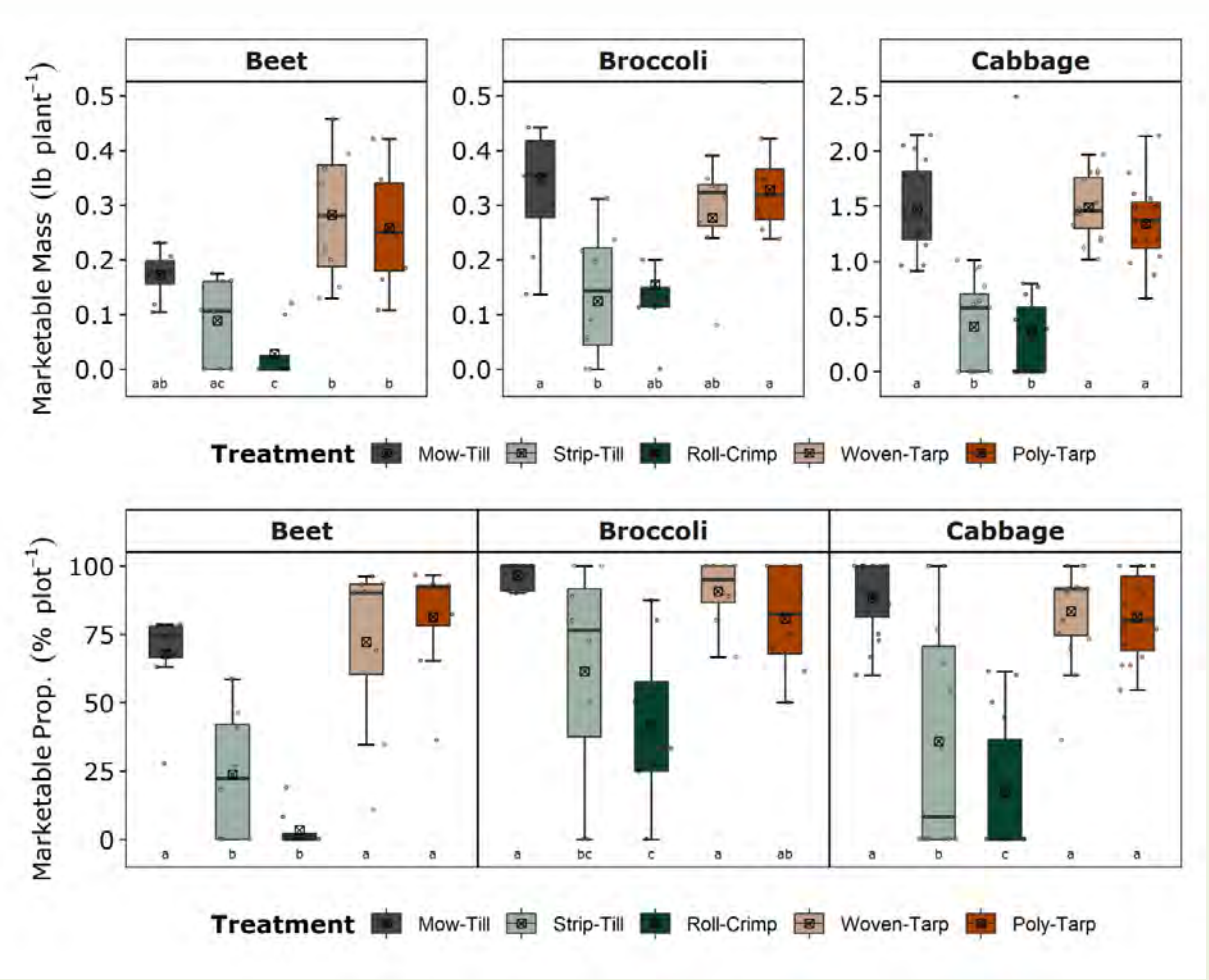

Figure 7. Marketable mass and proportion of beet, broccoli and cabbage

- Yield & quality of crops was similar in mow till and tarps, but beets performed better under tarps.
- Beets and cabbage suffered more than broccoli under heavy weed pressure in roll-crimp and strip-till.
- Soil temp, moisture and nutrient availability differences were also observed.

Discussion

Cover crop termination, weed control, and crop performance were enhanced under tarps, equivalent to or even better than conventional tillage.

- Growers can capture many benefits of reduced tillage and maintain or improve crop performance (PAW, nutrient cycling) using tarps.
- Tarping takes time, and is not readily applicable to larger fields/farms.
- Tarps may bring other challenges like increased GHG emissions and plastic waste.

Every environment (soil, climate, cover crop, weed community) will respond somewhat differently to these practices.

- Spring oats and peas did not respond well to rolling & crimping, whereas cereal rye or other cover crops may perform better.
- Soil temperature increases under tarps and tillage may be a benefit or risk.
- Perennial weeds can persist under tarps.

Discussion

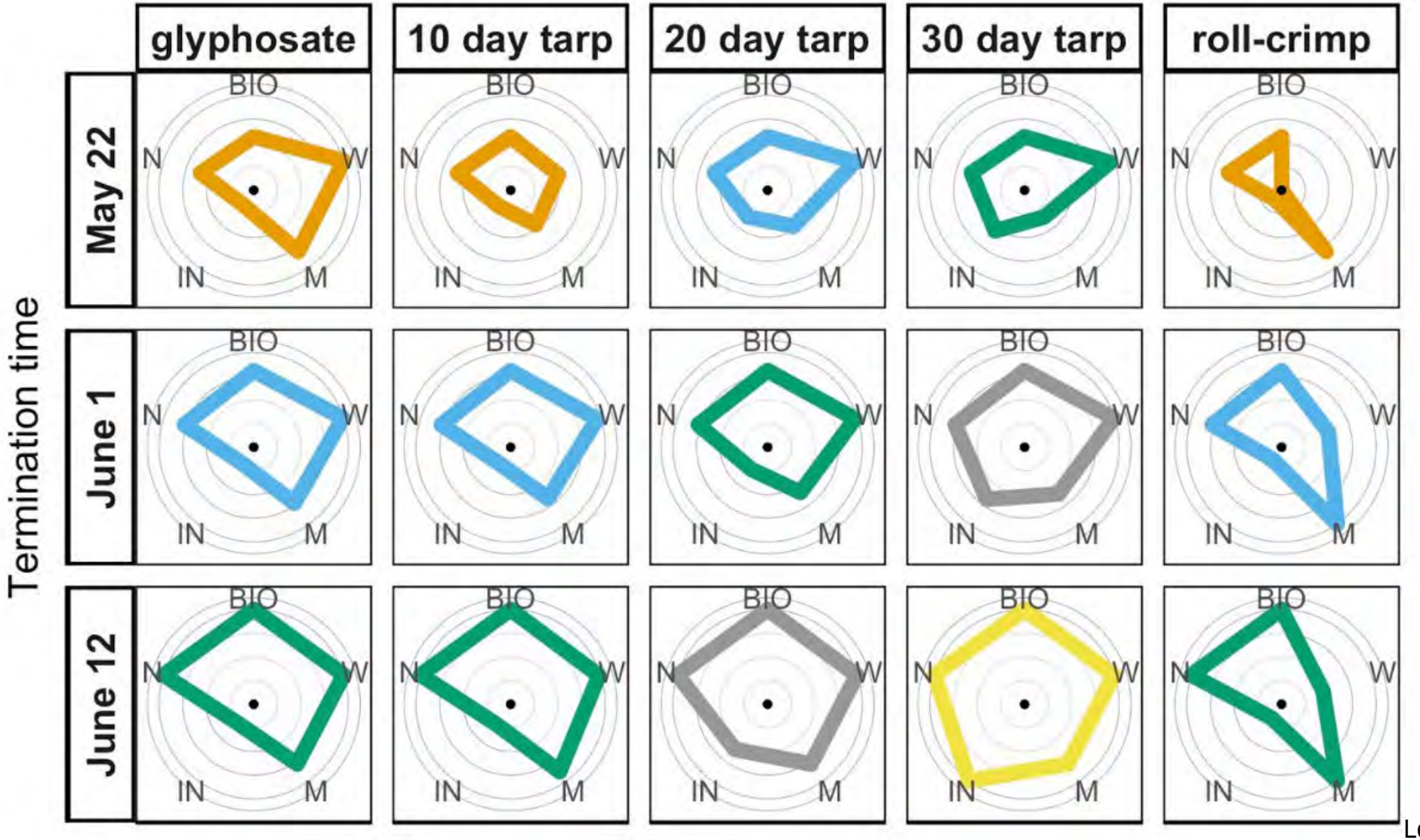

Figure 5: Spider plots depicting tradeoffs of cover crop termination date and method at University of New Hampshire. BIO= cover crop biomass; W=weed suppression; M= mulch; IN=inorganic soil nitrogen; N=cover crop biomass. Values are relativized with "greater" values farthest from the center.

Crop 'planting date'

- June 1
- June 12
- June 21
- July 1
- July 12

Lounsbury, Warren and Smith, 2022

Discussion

Questions?