Comparing Organic Vegetable Production and Weed Management Outcomes Among Reduced Tillage Practices in the Midwest U.S.

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Introduction

Emerging reduced tillage practices, including occultation with tarps, are gaining popularity in organic vegetable production systems for cover crop termination, weed management and soil preparation. Despite growing interest, there is limited research supporting the effectiveness of reduced tillage methods for organic vegetables. Our multi-year study aimed to evaluate the outcomes of several common tillage and reduced tillage approaches in terms of cover crop termination, weed control and crop productivity in a spring seeded pea–oat cover crop followed by beet, broccoli and cabbage cash crops.

Methods

Two vegetable farms using organic practices participated in the study including Michigan State University's Upper Peninsula Research and Extension Center (MSU-UPREC) North Farm (NF) in Chatham, MI, and Full Plate Farm (FPF) in Skandia, MI. NF historically uses conventional tillage practices, whereas FPF implemented reduced tillage practices about 5 years ago.

A fully randomized block design containing four replicates of the following five treatments was used at each farm: i) mow-till, ii) strip-till, iii) roll-crimp, iv) woven-tarp, and v) poly-tarp (Figure 1, n=8). A pea (100 lbs. ac^{-1}) and oat (128 lbs. ac^{-1}) cover crop was broadcast seeded in spring, then terminated by our treatments on July 8th, 2024 and June 25th, 2025. Tarps were in-place for approximately 3 weeks before single rows of beet and cabbage (2024), or broccoli and cabbage (2025) were transplanted into each plot.

Cover crop (pea & oat) and weed (broadleaf & grass) above-ground biomass (T ac^{-1}) samples (n=16) were clipped within two 0.5-1 ft^2 quadrats per plot immediately pre- and post-treatment. Critical weed-free period (CWFP) biomass (T ac^{-1}) and timed hand weeding occurred approximately four weeks after transplanting. The count (n) and weight (lb) of marketable and unmarketable beet, broccoli and cabbage plants was recorded at the time of harvest.

Linear and non-parametric models were used to estimate mean weed and crop metrics, where Kruskal-Wallis and Tukey post-hoc mean test were used to compare treatments (α = 0.05) in R.

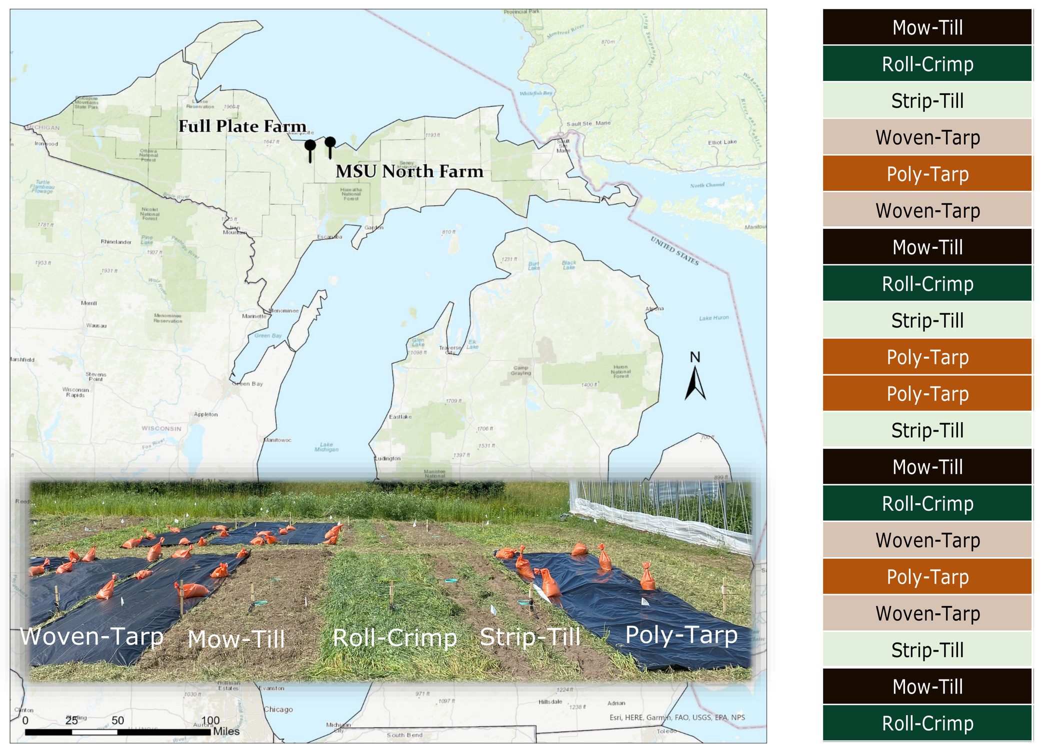

Figure 1. MSU-UPREC North Farm and Full Plate Farm study area locations, treatment types, and fully-randomized block experimental study design.

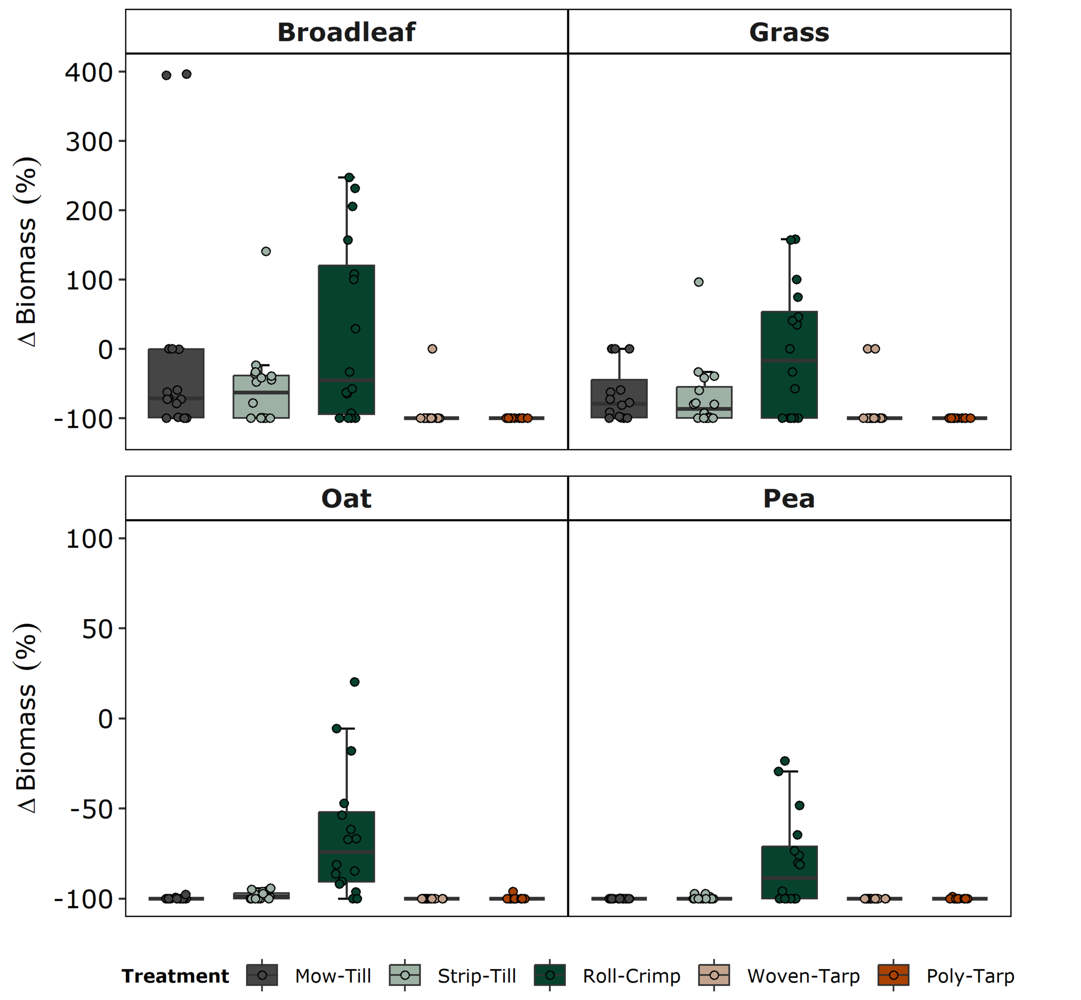

Figure 2. Change in biomass (Δ; %) observations (points) between pre- and post-treatment periods for broadleaf and grass weeds, oat and pea cover crop among treatments across farms and years. Boxplot lines represent median, 25% and 75% quartiles, and whiskers represent ± 1.5× the interquartile range.

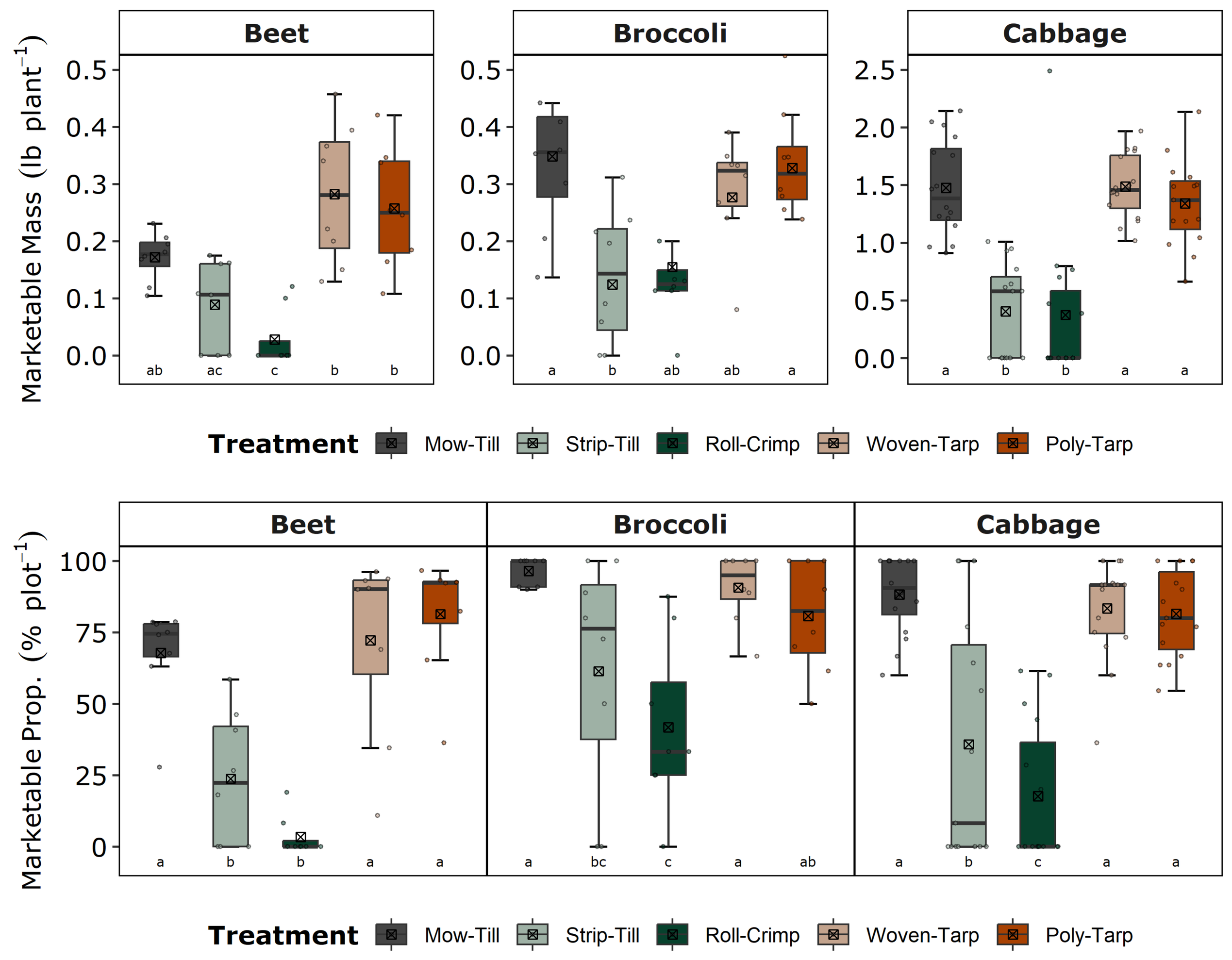

Figure 3. Marketable mass (top; lb $plant^{-1}$) and marketable proportion (bottom; % $plot^{-1}$) of beet, broccoli and cabbage observations (points), post-hoc mean estimates (⊠), and mean comparisons among treatments ($p<0.05$). Boxplot lines represent median, 25% and 75% quartiles, and whiskers represent ± 1.5× the interquartile range.

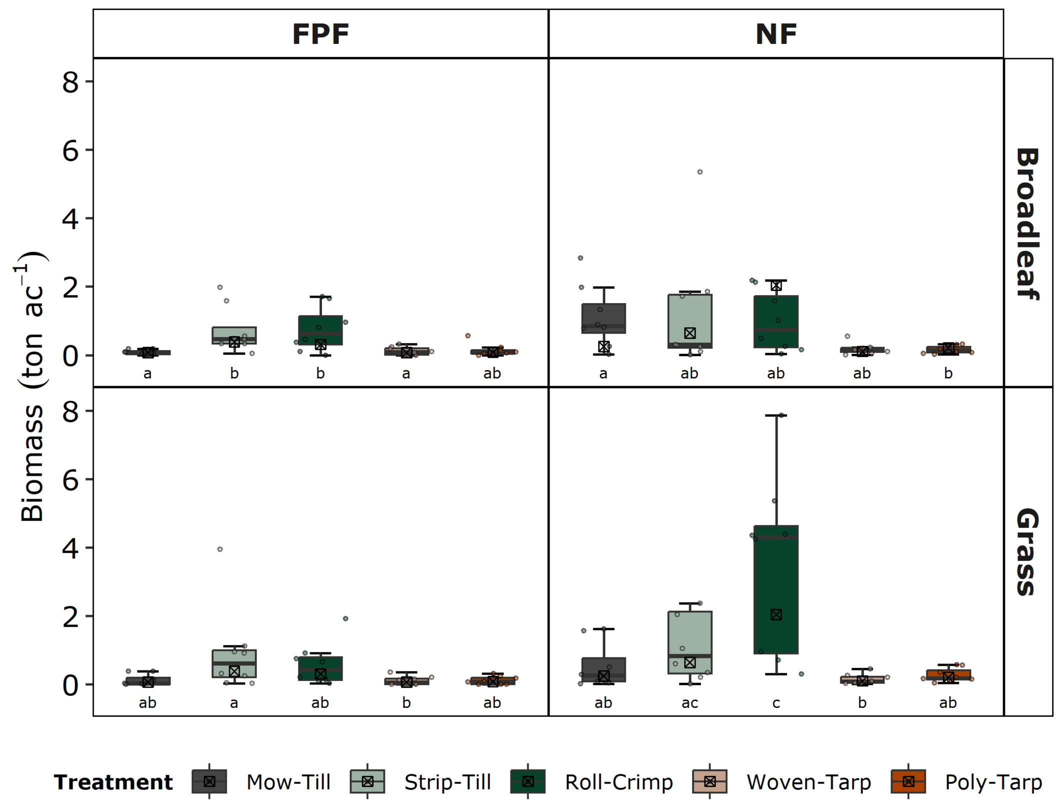

Figure 4. Critical weed free period biomass (T ac^{-1}) observations (points) for broadleaf and grass weeds at Full Plate Farm (FPF) and North Farm (NF) for each treatment. Boxplot lines represent median, 25% and 75% quartiles, and whiskers represent ± 1.5× the interquartile range.

Table 1. Summary statistics including number of observations (n), mean change in cover crop biomass (T ac^{-1}, ±SE) and mean change in the weed biomass (T ac^{-1}, ±SE) between pre- and post-treatment study periods, mean critical weed free period (CWFP) biomass (T ac^{-1}, ±SE), and post-hoc mean comparison tests (MT; $p<0.05$) among treatments across farms and years.

Treatment	n	ΔCovCrop Biomass (T ac^{-1})	MT	n	ΔWeed Biomass (T ac^{-1})	MT	n	CWFP Weed Biomass (T ac^{-1})	MT
Mow-Till	16	-10.2 (±0.6)	a	16	-0.3 (±0.11)	ab	16	0.4 (±0.1)	ab
Strip-Till	16	-9.4 (±0.6)	a	16	-0.4 (±0.18)	ac	16	1.2 (±0.3)	ac
Roll-Crimp	16	-6.4 (±0.6)	b	16	-0.1 (±0.02)	b	16	1.8 (±0.5)	c
Woven-Tarp	16	-9.7 (±0.6)	a	16	-0.5 (±0.23)	ac	16	0.2 (±0.1)	b
Poly-Tarp	16	-9.2 (±0.6)	a	16	-0.9 (±0.40)	c	16	0.3 (±0.7)	b

Plant	Treatment	n	Marketable Mass (lb $plant^{-1}$)	MT	n	Percent Marketable (% $plot^{-1}$)	MT
Beet	Mow-Till	8	0.2 (±0.3)	ab	8	67.9 (±6.1)	a
	Strip-Till	8	0.1 (±0.3)	ac	8	23.8 (±8.2)	b
	Roll-Crimp	8	0.03 (±0.3)	c	8	3.4 (±2.5)	b
	Woven-Tarp	8	0.3 (±0.3)	b	8	72.3 (±11.4)	a
	Poly-Tarp	8	0.3 (±0.3)	b	8	81.5 (±7.4)	a
Broccoli	Mow-Till	8	0.3 (±0.08)	a	8	96.5 (±1.7)	a
	Strip-Till	8	0.1 (±0.03)	b	8	61.5 (±14.6)	bc
	Roll-Crimp	8	0.2 (±0.03)	ab	8	41.8 (±10.4)	c
	Woven-Tarp	8	0.3 (±0.06)	ab	8	90.7 (±4.3)	a
	Poly-Tarp	8	0.3 (±0.07)	a	8	80.8 (±6.9)	ab
Cabbage*	Mow-Till	16	1.5 (±0.1)	a	16	88.3 (±3.4)	a
	Strip-Till	15	0.4 (±0.1)	b	15	35.8 (±10.9)	b
	Roll-Crimp	15	0.4 (±0.1)	b	15	17.6 (±6.3)	c
	Woven-Tarp	16	1.5 (±0.07)	a	16	83.5 (±4.3)	a
	Poly-Tarp	15	1.3 (±0.1)	a	15	81.5 (±4.0)	a

Table 2. Summary statistics including number of observations (n), mean marketable mass (lb. $plant^{-1}$), mean percent of marketable plants (% $plot^{-1}$), and post-hoc mean comparison tests (MT; $p<0.05$) among treatments for beets, broccoli, and cabbage across farms and years. * Three cabbage plots were lost in 2025 due to transplanting errors (i.e. n=15).

Figure 5. 2025 pre-termination biomass sampling at Full Plate Farm (left) and 2025 cabbage harvest at MSU-UPREC North Farm.

Results

Cover crop establishment was generally successful with plant densities similar across farms and years. The broadleaf weed community, largely consisting of pigweed, lambs-quarter and clover, was similar at both locations, with somewhat higher densities at NF. Grass weed density, consisting of quack-grass and large crabgrass, was considerably higher at NF (Fig. 4).

The change in cover crop biomass (Δ , T ac-1) from pre- to post-treatment (Fig. 2 & Table 1) was significantly greater (-Δ) in all treatments as compared to roll-crimp. Mean Δ weed biomass (T ac-1) in poly-tarp (-0.9) was statistically similar to woven-tarp (-0.5) and strip-till (-0.4) but significantly greater than both mow-till (-0.3) and roll-crimp (-0.1) where weeds flushed or persisted post treatment. When compared to roll-crimp (1.8), mean CWFP weed biomass (T ac-1) was significantly lower in mow-till (0.4), woven-tarp (0.2), and poly-tarp (0.3; Table 1).

Marketable proportion of all crops harvested in mow-till, woven-tarp and poly-tarp was significantly greater than strip-till and roll-crimp, except for broccoli where poly-tarp and strip-till performed similarly. Marketable mass of crop plants was statistically similar across the mow-till, woven-tarp and poly-tarp treatments, which generally yielded more than the strip-till and roll-crimp treatments (Fig. 3; Table 2).

Discussion

Cover crop termination, weed control, and crop performance were enhanced under tarps in comparison to the tillage and roll-crimp treatments. This suggests that organic vegetable growers can capture the multiple benefits of reduced tillage with tarps while maintaining crop performance.

Although tarping has apparent benefits, such as efficient cover crop termination & weed control, increased soil nitrogen mineralization and opportunities for strategic soil moisture management, negative effects like increased greenhouse gas emissions and plastic waste / microplastics may be problematic. Tarping may also increase labor costs and could be impractical for large scale farms.

Variability in soil, cover crop, and weed community responses to these practices is anticipated across environmental and climatic gradients. Consequently, the applicability of these results is strongest within the North Central Region and on sandy loam soils. A notable limitation was the lack of efficacy for roll-crimp in spring-planted oats and peas at our study sites, where this treatment failed to terminate the cover crop and control weeds. Furthermore, the potential persistence of perennial weeds under tarping treatments warrants consideration.

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