Plastic, Fabric, and Marsh Hay Mulch with No-Till Organic Tomatoes

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Key Findings

- Tomato yields were the same for all the no-till mulches and the conventionally tilled and plastic mulched control.
- Given that there was no yield penalty, it is worth experimenting with no-till tomatoes, especially when wet soils prevent or delay tillage.
- Soil temperature under the marsh hay was significantly lower than the other two treatments and the control.
- Tomato harvest from the marsh hay plots was equal to, but peaked later than, the other treatments, likely due to the lower soil temperature.
- Labor in each no-till system was different, with the marsh hay requiring the least time and the plastic requiring the most. The control required less time than any of the no-till systems.
- Weed control under all the no-till mulches was excellent, even through they were applied directly on top of sprouted weeds.

Project Timeline:
2016—2017

Background

Using cover crops to create an in situ mulch is one way that organic farmers can explore no-till techniques. While there has been some success with organic no-till row crops, organic no-till vegetables remain a conundrum. Inadequate weed control, narrow cover crop termination windows, and planting delays related to termination are all challenges. This project was originally designed to look at the use of season-long managed fallow concluding with high-residue, winter-killed cover crops to create weed-free mulch that does not need exact timing or special equipment for termination. The primary cover crop was sorghum sudangrass, which is known for producing large amounts of biomass. Tomatoes were to be no-till planted into the residue in year 2 of the project.

Before tomato planting, it was clear that the sorghum sudangrass residue would not provide adequate weed control for the cropping year. (See "Sorghum Sudangrass Residue as Mulch for No-Till Organic Tomatoes") The project then pivoted to look at three supplemental mulch materials used to exclude weeds in the no-till tomatoes.

Methods

Three diversified vegetable farms in Dane County, Wisconsin participated in this project. All the farms are certified organic. Each farm had three replicates of three no-till mulch treatments applied over the sorghum sudangrass residue: (1) green or black plastic, (2) black landscape fabric, and (3) marsh hay. The control was managed with conventional tillage and green or black plastic mulch. All plots were irrigated with drip tape under the mulch. The tomato variety was Monica, which is a determinate paste tomato.

Year 1 – Cover crops reduce weeds and create an in situ mulch for no-till

- 4/26: Seeded oats (80 lbs/acre) and chickling vetch (50 lbs/acre); tilled to kill weeds and work in seed.
- 6/20: Mowed oats and chickling vetch; seeded buckwheat (80 lb/acre); tilled to kill oats/vetch and work in buckwheat seed.
- 7/13: Seeded sorghum sudangrass (80 lb/acre), sunn hemp (80 lb/acre), and cow peas (80 lb/acre) into standing buckwheat according to randomized treatment plot map; tilled to kill buckwheat and work in seed.
- 7/27: Reseeded Blue Moon and Crossroads where sorghum sudangrass did not germinate well.
- 10/4: Rolled cover crops with a disengaged rotovator just before frost to knock over and align biomass into an even mulch mat.

Year 2 – Tomatoes were planted into sorghum sudangrass residue

- week of 5/23: Prepared control with tractor drawn tiller and plastic mulch layer; hand-laid 4' wide plastic mulch and landscape fabric treatments directly over live weeds; planted tomatoes in single rows, 7' on center, 18" between plants; laid 4' wide marsh hay mulch treatment directly over live weeds.
- 6/1: Weeded all aisles.
- 6/13: Weeded all aisles; broadcast seeded annual ryegrass (25 lb/acre) and Dutch white clover (14 lb/acre) as a living aisle; weeded all aisles a second time to work in seed.
- 6/21: Installed posts and strung first line of basket weave trellis.
- July: Mowed aisles, sprayed for disease, and trellised as needed.
- 7/26 to 9/26: Harvested tomatoes weekly.

Labor time, soil temperature, plant survivorship, and vegetable yield were recorded. An analysis of variance (ANOVA) was conducted using the R package lme4 (Bates et al 2015). Means were compared with the R package lsmeans (Lenth 2016). A confidence level of 90% was used, meaning that for each comparison that is statistically significant, we are 90% confident that the difference is due to the treatments and not to chance variation.

No-till trial at Blue Moon Community Farm 6/13/17. From left to right: no-till marsh hay, no-till landscape fabric, no-till plastic, control.

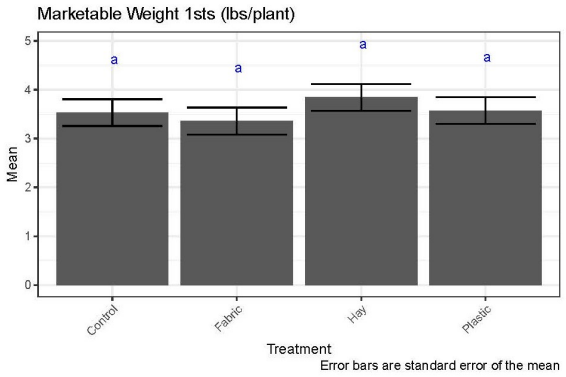
Results

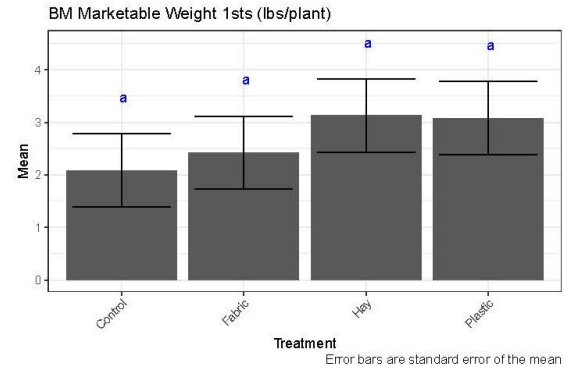
Tomato Yield

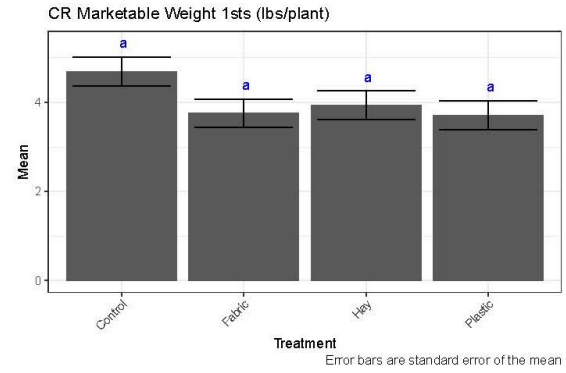
Marketable tomatoes were harvested weekly and sorted into first and second quality fruits. Non-marketable fruits were left in the field. First quality fruits were mostly blemish free, with one small green shoulder or small healed scar allowed. Second quality fruits were small in size or had larger healed blemishes (many caused by multiple hail events). In some cases second quality fruits were beginning to show signs of disease. Non-marketable fruits were very small, diseased, or had open wounds.

First quality yield is the most important measure because those tomatoes will fetch the highest price. There was no difference in first quality yield between the no-till or the control. Nor was there a difference among the three no-till treatments. First quality yield averaged 3.58 pounds per plant. (Figure 1.)

First quality (left) and second quality (right) tomatoes. Wounds on the right caused by hail. Equinox Community Farm 8/15/17 & Crossroads Community Farm 8/16/17.







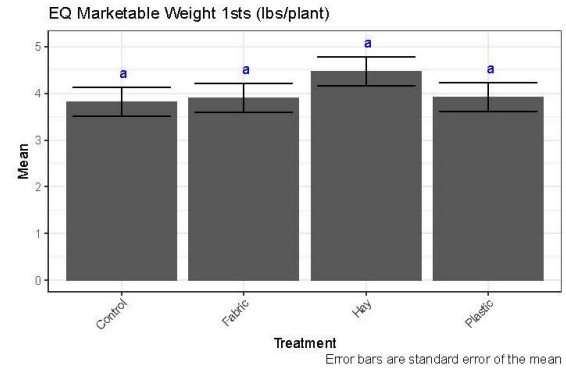


Figure 1: First quality yield for each treatment overall (top) and for each individual farm (bottom) measured in lbs. per plant. Error bars represent the standard error of the mean. Means with the same letter are not significantly different from each other at the 90% confidence level. BM = Blue Moon Community Farm, CR = Crossroads Community Farm, EQ = Equinox Community Farm.

Because there were several hail events at each of the farms right after fruit set, many tomatoes were classified as seconds that would otherwise have been firsts. Thus, it is useful to also consider total yield. Total yield followed the same pattern as the first quality yield and averaged 6.31 pounds per plant. (Figure 2.)

Soil Temperature

Soil temperature was recorded 6 times between June 27th and September 28th. As expected, the soil under the light colored marsh hay was lower than the plastic or landscape fabric by 3-4 degrees, which was a significant difference. (Figure 3.)

Though there was no statistical difference in the first quality yield or total yield from the marsh hay mulch, the harvest from those plots came on slower and caught up with the other treatments about six weeks into the harvest. (Figure 4.)

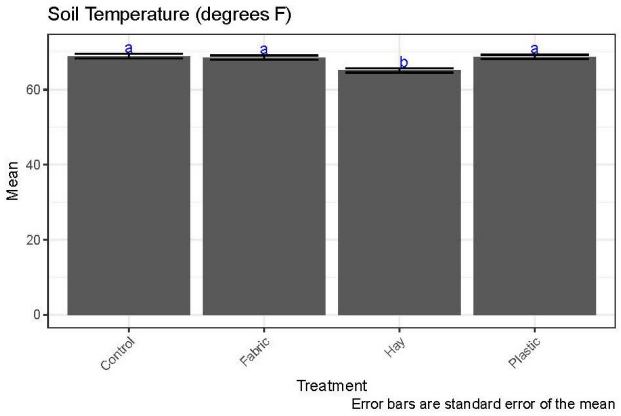


Figure 3: Soil temperature per treatment, measured in degrees Fahrenheit. Error bars represent the standard error of the mean. Means with the same letter are not significantly different from each other at the 90% confidence level.

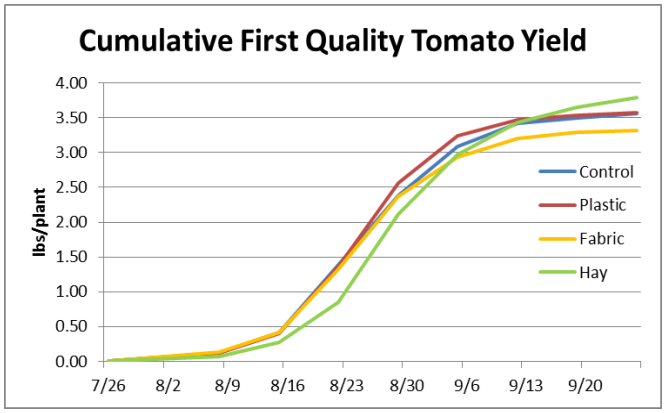


Figure 4: Cumulative first quality tomato yield by treatment, measured in pounds per plant.

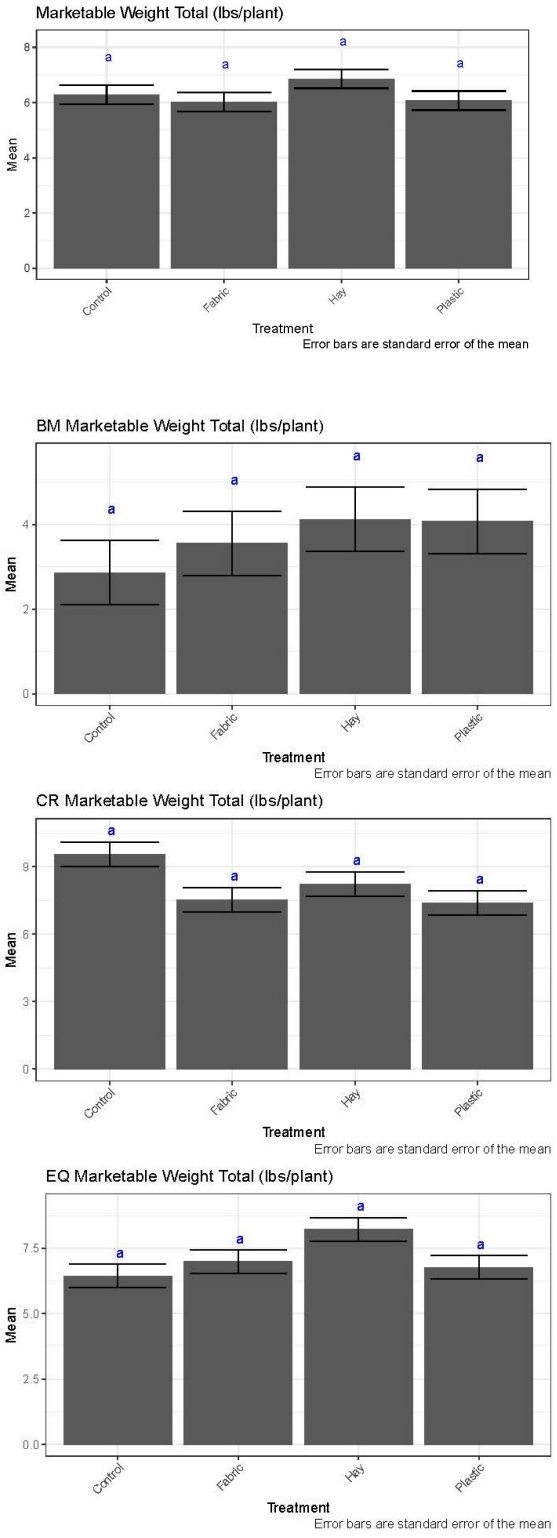


Figure 2: Total yield for each treatment overall (top) and for each individual farm (bottom) measured in lbs. per plant. Error bars represent the standard error of the mean. Means with the same letter are not significantly different from each other at the 90% confidence level. BM = Blue Moon Community Farm, CR = Crossroads Community Farm, EQ = Equinox Community Farm.

Labor

Management time for each treatment was tracked in minutes. Laying mulch, planting, weeding, trellising, and removing mulch and trellis materials were all tracked. Because harvest labor is primarily dependent on yield and is not affected by the mulch treatment, it was not tracked and is not included in the labor totals. Labor time did vary for each no-till treatment and the control, with the control requiring the least time and the no-till plastic mulch requiring the most. (Figure 5.)

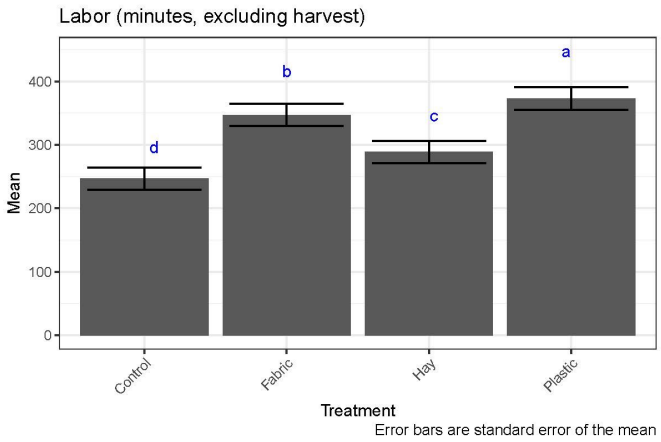


Figure 5: Labor per treatment measured in minutes per 100'bed. Error bars represent the standard error of the mean. Means with the same letter are not significantly different from each other at the 90% confidence level.

Laying plastic by hand over untilled ground meant digging a shallow trench around the stretched plastic and burying the edges with shovels. The process was not only time consuming, but also difficult. A narrow trowel was used to create a small planting hole in the plastic. That same process was used in the tilled, plastic mulch control, but was much more difficult in the untilled ground. Removing the plastic at the end of the season did require some caution in both the treatment and the control in order to ensure that none was left buried in the soil.

No-till planting through sorghum sudangrass residue at Blue Moon Community Farm 5/25/17.

Laying the landscape fabric was quick, in comparison. Sod staples pressed easily through the fabric and held securely in the firm ground. Planting into the landscape fabric was the most difficult and time consuming of any of the treatments. A sharp-edged trowel was used to cut a slit in the fabric and to create a small planting hole. Because the fabric did not puncture or tear easily, it was difficult to maneuver the plant into the untilled ground through the inflexible hole. Removing the fabric at the end of the season was more difficult than expected, as the sod staples were firmly embedded in the soil.

A narrow shovel was used to plant tomatoes into the untilled ground before the marsh hay treatment was applied. This planting process was by far the easiest because there was no mulch material in the way. At the end of the season, the drip line was easily removed and the marsh hay was left in place to decompose.

Aisles were weeded with a wheel hoe fitted with a wide stirrup blade. The durability of the landscape fabric allowed the blade to cut right up against it without causing damage, and made weeding easy. Greater caution was needed against the plastic so as not to snag and tear it. As a result, some hand-weeding was required on the plastic edges. It was also difficult to avoid snagging and moving the marsh hay with the wheel hoe, so some hand weeding was needed in that treatment as well. The planting holes in both the control and no-till plastic did allow weeds through, which required hand weeding. Planting holes in the landscape fabric did not allow weeds to grow, because the thin planting slit closed back over the soil completely. Similarly, weeds did not grow around the tomatoes in the marsh hay, because the mulch did not leave any exposed soil around the plant.

The chart on the right shows the degree of difficulty of each task as compared to the tractor tilled and plastic mulched control, as judged by the research crew.

Difficulty of No-Till Tasks as Compared to the Tilled Control

	No-Till Fabric	No-Till Hay	No-Till Plastic
Laying mulch	Harder	Harder	Much Harder
Planting (by hand)	Much Harder	Easier	Harder
Weeding	Easier	Same	Same
Trellising	Same	Same	Same
Harvesting	Same	Same	Same
Field Clean Up	Easier	Much Easier	Same

Weed Control

Though numerous weeds had sprouted throughout the trial area prior to laying mulch materials, only the weeds in the control were terminated (though tillage) prior to planting. In each of the no-till treatments, the mulch materials were applied directly over the living weeds. With the exception of weeds that grew in the plastic mulch planting holes, no weeds survived under any of the properly laid mulch materials. (Green plastic mulch must be stretched tight against the soil to prevent weeds.)

Material and Labor Costs

Given that there is no yield difference among the no-till treatments or the control, differences among the input and labor costs are core to this comparison. The chart below shows input and labor costs for a 100' bed. Constant factors such as trellis materials and harvest time are not included. Though the control is clearly the most cost effective, benefits to the soil through reduced tillage and the addition of marsh hay are not quantified. These benefits could translate into decreased fertility costs or higher yields in the future.

Material and Labor Costs per 100' Bed of Tomatoes (Excluding Constants)

	Control Plastic[1]	No-Till Fabric[2]	No-Till Marsh Hay[3]	No-Till Plastic[1]
Mulch Materials	$4.01	$2.77	$25.50	$4.01
Labor Time	248 minutes	347 minutes	289 minutes	373 minutes
Wage	$10/hour	$10/hour	$10/hour	$10/hour
Labor Cost	$41.33	$57.83	$48.16	$62.17
Total Materials & Labor	$44.84	$60.60	$73.66	$65.68

Discussion

One of the most common criticisms of organic agriculture is that it relies too heavily on tillage. Tillage is known to have a negative effect on soil structure and leads to loss of organic matter and beneficial soil organisms. While organic vegetable farmers already grow cover crops, practice crop rotation, and incorporate other techniques to counteract the negative effects of tillage, the results of this trial provide additional ideas on how to include some no-till tomato practices.

Given that yield was the same across the tilled control and the no-till treatments, other cost and management considerations can come to the fore while trying to capture the benefits of no-till:

- No-Till Plastic: The relative labor cost and difficulty of laying plastic by hand, as is currently required in a no-till system, makes this the least practical option.

[1]Green Plastic Mulch: Nolt's Midwest Produce Supplies, 2018 prices, 4' by 4000' roll is $140.50 plus $20.00 shipping from Iowa to Madison, WI. Product is not reusable and must be removed from the field.
[2]Black Landscape Fabric: Nolt's Midwest Produce Supplies, 2018 prices, 4' by 300' roll is $56.00, 1000 6" staples are $27.50, plus $25.00 shipping from Iowa to Madison, WI. Used 24 staples per 100' bed. Total cost spread over the expected minimum life of the product, 10 years.
[3]Marsh Hay Mulch: Local supplier, $4.25 per bale, 6 bales to cover 4' by 100'. Product is not reusable and is left on the field to decompose.

- No-Till Landscape Fabric: The labor cost of this treatment was higher in part because of the time consumed creating and planting into the fabric holes. This time could be reduced by laying two lengths of fabric side by side with a slight overlap, leaving a bed-length seam down the middle. Parting and planting into the seam would have been quicker and easier than the hole method we used, thus reducing the cost. In this system, the untilled ground was a benefit to laying the tarps because the staples held more firmly then they do in tilled soil. Weed control under the fabric was excellent, even though weeds were not killed before laying the material. As more farms experiment with landscape fabric for weed control, doing so in a no-till system is well worth exploring.
- No-Till Marsh Hay: Though the labor time in this system is significantly less than the other two no-till systems, the material costs are higher. That additional cost may be offset by improved soil structure and increased soil organic matter in the long-term, but it was not possible to quantify those benefits during the term of this trial. Also, though overall yield was the same in the end, the harvest in this system was delayed. This method might be valuable in conjunction with one of the other systems as a way to extend the tomato harvest season.

The spring of 2017 was wet. When it came time to plant this trial, it was difficult to find a dry spell long enough for tillage. As a result, two of the farms were tilled when soil conditions were wetter than they should have been. In the no-till plots, however, planting was unaffected by the wet conditions. In a year when planting may be delayed by wet soils, the no-till landscape fabric and no-till marsh hay systems become even more attractive as options to keep planting on schedule and avoid soil damage caused by tilling wet soils.

Tomato beds and annual rye/Dutch white clover aisles after mulch removal. From left to right: control, no-till plastic, no-till landscape fabric, no-till marsh hay (marsh hay still in place) Crossroads Community Farm 9/28/17.

Recommendations for Farmers

1. Given that yield was the same between the tilled and no-till plots, it is worth experimenting with no-till organic tomatoes as a way to reduce tillage on organic farms.
2. When wet soils prevent or delay tillage, the no-till landscape fabric and no-till marsh hay systems can keep tomato planting on schedule, avoid soil damage, and result in yields equal to the typical tilled and plastic mulched system. Cooperator Kristen Kordet of Blue Moon Community Farm is considering the benefits of this approach for her heavy clay soils.

3. Areas where cover crops have winter-killed are great for trying out these systems. Tomatoes can be planted directly into, and mulch laid directly over, the cover crop residue with no weeding or tilling required. Weeds that sprout through the residue before tomato planting will die under the mulch materials.

4. Using landscape fabric with a single row crop like tomatoes can be simplified by punch planting into cover crop residue and then laying a sheet of fabric on either side of the plants. Trellis posts can then be easily placed in the same seam, with no damage to the fabric. This method is used by farmer cooperator John Binkley at Equinox Community Farm and is faster and more protective of the mulch material than creating holes in the fabric and then planting into those, as we did in this trial.

White tipped t-post (back left) and lighter, shorter u-post (front right). Blue Moon Community Farm 6/22/17.

5. Tomato harvest in the no-till marsh hay system was equal to the other systems, but peaked later. It could be valuable to plant some tomatoes with marsh hay even if the bulk of the planting uses another mulch, thus extending the harvest season without using succession planting or multiple varieties. Cooperator Mike Noltnerwayss of Crossroads Community Farm is considering using marsh hay mulch alongside his usual tilled, plastic mulched system as a season extension technique.

6. Though not a part of this trial, circumstances allowed the team to informally compare the taller, heavier t-posts to shorter and lighter u-posts in the tomato trellis. The u-posts were much faster and easier to install, less expensive, and just as effective for these determinate roma tomatoes.

References

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Lenth, Russell V. (2016). Least-Squares Means: The R Package lsmeans. Journal of Statistical Software, 69(1), 1-33. doi:10.18637/jss.v069.i01