Tarps to Terminate Cover Crops Before No-Till Organic Vegetables

Staff

Claire Strader, Dane County Extension and FairShare

Caitin Hartnett, FairShare

Julie Dawson, Horticulture, University of WI—Madison

Cooperators

Bethanee Wright, Winterfell Acres

Chris McGuire, Two Onion Farm

John Binkley, Equinox Community Farm

John Schlitz, Forest Run Farm

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Key Findings

- Silage tarps and landscape fabric terminated the rye/vetch cover crop fully in three weeks.
- Brussels sprout yields were the same for all the no-till treatments and the conventionally tilled control.
- A good stand of rye is critical for creating a weed-smothering mulch layer.
- Labor was significantly higher for the tarped no-till treatments in this trial because of the hand-labor required for planting and because of insufficient cover crop biomass to prevent weeds.

Project Timeline:
2017—2018

Background

A common criticism of organic agriculture is that it relies too heavily on tillage. While there has been some success with cover crop based reduced tillage in organic no-till row crops like soybeans, no-till systems for organic vegetables are still a conundrum. Inadequate weed control, narrow cover crop termination windows, planting delays related to cover crop termination, and the need for specialized equipment are all challenges. This project was designed to address these issues by using tarps to terminate a high-residue winter-hardy mix of rye and vetch thus creating an *in situ* mulch suitable for no-till planting of organic vegetables. While a rye/vetch mix can provide a balance of hardy residue for mulch (rye) and nitrogen for vegetable development (vetch), successful termination of this combination can be tricky using organic methods. Successful roller crimping or mowing require that the covers are in flower, but rye and vetch are not often in sync when it comes to flowering and thus one or both can grow back after crimping or mowing. Additionally, waiting for the optimal termination window can delay vegetable planting. In this trial, tarps were used to terminate the cover crop, thus removing the need for a roller crimper, allowing for flexibility in timing, and creating a stale planting bed through occultation. Brussels sprouts were then no-till planted into the residue.

Methods

Four diversified vegetable farms in Wisconsin participated in this project. All the farms are certified organic. The trial was conducted as a randomized complete block design (RCBD) at each location. Each farm had three replicates of a conventional tillage control and three tarp treatments applied over a rye/vetch cover crop to terminate the cover: (1) 5 ml black/white silage film, (2) 6 ml black/white bunker cover, and (3) black landscape fabric. The Brussels sprout variety was Gustus. All plots were irrigated with drip tape and sprayed with Bt to control cabbage worms as needed and at the discretion of the farmers.

Year 1 – Rye/vetch were established to reduce weeds and create an *in-situ* mulch for no-till

- 7/25: Broadcast seeded winter rye (180 lbs/acre) and hairy vetch (40 lb/acre) at Equinox and Two Onion; tilled to kill weeds and work in seed.
- 8/9: Broadcast seeded winter rye (180 lbs/acre) and hairy vetch (40 lb/acre) at Forest Run and Winterfell; tilled to kill weeds and work in seed.
- 8/17: Overseeded additional rye at Equinox (100 lbs/acre) and Two Onion (50 lbs/acre) to fill in thin areas.
- 8/24: Overseeded additional rye at Forest Run (180 lbs/acre) and Winterfell (90 lbs/acre) to fill in thin areas.

Year 2 – Rye/vetch was terminated and Brussels sprouts were planted into resulting residue

- 5/8 and 5/10: Applied tarps black side up to terminate rye/vetch through occultation; used 8 inch sod staples to secure tarp edges at all farms; added bricks or sandbags at two farms where winds were more extreme.
- Week of 5/18: Mowed and tilled rye/vetch in control plots.
- 5/29 and 5/31: Removed tarps and hand-dug planting holes in no-till plots; tilled control plots; planted Brussels sprouts in single rows, 7 ft on center, 18 inches between plants with 1 pint of compost in each planting hole; covered Brussels sprouts with row cover on all farms except Two Onion where the farmer does not normally use row cover in late May.
- 6/11: Removed row cover at Equinox and Forest Run.
- 6/19: Removed row cover at Winterfell.
- 6/11 through 8/6: Used tarps to “weed” the treatment plots with occultation as needed; used a stirrup blade on a wheel hoe and a hand hoe to weed the control as needed.
- 8/21: Topped all Brussels sprouts.
- 8/28 and 8/30: Harvested mature Brussels sprouts.
- 9/11 and 9/13: Harvested mature Brussels sprouts.
- 9/25 and 9/27: Final Brussels sprout harvest.

Cover crop and weed densities and biomass, percent residue cover, plant survivorship, labor time, and vegetable yield were recorded. Cover crop densities were counted and used three weeks after planting to determine if more seed was needed to ensure an adequate stand. Cover crop biomass was collected at the end of year 1 and before tarping in year 2. Weed densities were recoded regularly before weeding the control and before tarps were applied to “weed” the treatment plots. An estimate of the percent of ground covered by residue was taken four times, the first at planting and the last after the final “weeding,” using the line transect method. Brussels sprouts

Terminating winter rye and hairy vetch at Winterfell Acres. Top to bottom: (1) Before tarps are applied over approximately 3000 lbs. of dry biomass per acre on 5/10/18. (2) After tarps are applied on 5/10/18. (3) Before tarps are picked up on 5/29/18. (4) Terminated cover crops immediately after tarp removal. Note the cover crop was not rolled/aligned before tarp application resulting in a haphazard residue pattern.

were harvested three times. Mature, marketable sprouts were snapped from the stalk and weighed at each harvest. Non-marketable sprouts were removed from the plants and left in the field. Plant survivorship was counted at each harvest. Labor time was recorded for all vegetable crop planting and maintenance activities, excluding harvest.

An analysis of variance (ANOVA) was conducted using the R package lme4 (Bates et al. 2015). Means were compared with the R package emmeans (Lenth 2018). A confidence level of 90% was used for pairwise comparisons among treatments, 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.

Results and Discussion

Cover crop biomass

The function of the winter rye in this cover crop based no-till system is to smother weeds. In the cover crop establishment year it should crowd them out as it grows, and in the following vegetable cropping year it should smother them as a dead *in situ* mulch. The function of the hairy vetch is to provide some nitrogen to the system as the rye tends to tie up nitrogen as it decays in the vegetable cropping year. In both cases, the greater the biomass the more likely the cover crop is to fulfill its function.

Biomass samples were taken in the fall at the end of the cover crop growing season and again the following spring, the same day that tarps were applied to terminate the cover. As planned, rye accounted for most of the cover crop biomass on each farm (figure 1). It was a surprise, however, to see that on three of the farms spring biomass was less than fall biomass. This result is the opposite of what was expected and likely indicates that the late July planting date was too early and that the rye was too mature in the fall to survive the winter. The one farm where biomass was greater in the spring was planted a bit later, in early August. Rye is more commonly planted in September or October in southern Wisconsin, with earlier planting dates generally correlating to greater biomass in the fall and spring (Bastidas et al. 2017). Biomass results from this trial seem to indicate that there is a limit to how early winter rye can be planted when the goal is high spring biomass.

As a follow up to this question, cover crops were planted again at the same rates on the same farms in 2018, but planting dates were delayed by two weeks to 8/14 on three of the farms and by three weeks to 8/30 at Winterfell. Biomass samples were taken in the fall at the end of the cover crop

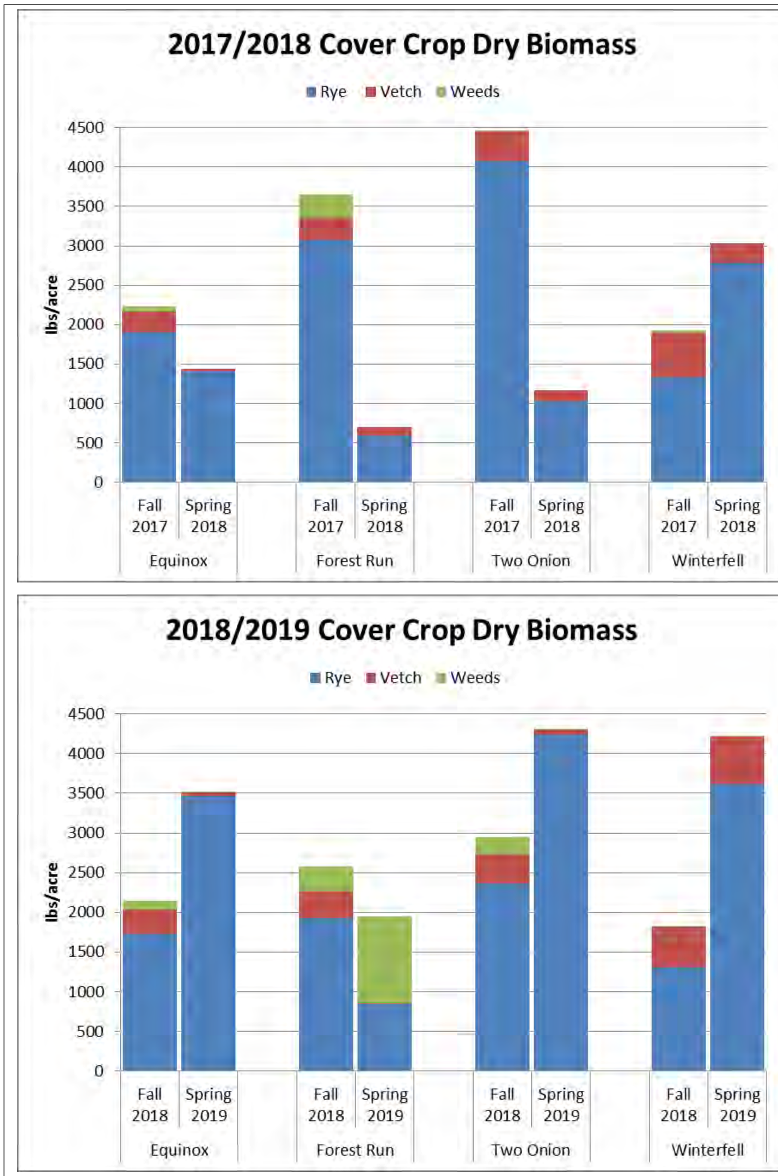

Figure 1: 2017/2018 (top) and 2018/2019 (bottom) comparison of cover crop biomass from fall of the cover crop establishment year to spring of the vegetable planting year.

growing season and again the following spring, as before. Temperatures and rainfall were very similar in both years, but in the second year with later planting dates, all but one farm had greater biomass in the spring as compared to fall (figure 1). The one farm that had less biomass in the spring had a significant population of foxtail which may have been mistaken for rye in the fall data collection when both were alive, but was clearly identified as a weed in the spring when it lay dead among the living rye plants. Though this trial was not designed to look at optimal winter rye seeding dates, this information seems to support the idea that a July planting date for winter rye is too early and that a mid or late August planting date can work.

Digging small trowel holes for planting at Forest Run Farm with about 35% residue coverage (top) and Winterfell Acres with about 90% residue coverage (bottom).

Cover crop termination

All three tarp treatments used occultation (blocking sunlight from reaching the crop) as the method for terminating the cover crops. All three tarps effectively terminated the rye/vetch cover crop in no more than 21 days. No cover crop regrew after any of the tarp treatments were removed. The only difference among the treatments at the time the tarps were removed was that the rye under the landscape fabric appeared to be somewhat greener.

Percent residue coverage

Given that all three tarp materials terminated the cover crop effectively, it is useful to ask if any of them did a better job of preserving the cover crop biomass and keeping the ground covered with residue. Only one farm had enough spring biomass to provide any data on this question, Winterfell Acres.

When the tarps were removed, there was no difference in the percent of residue coverage under any of them, and none of them had enough residue to fully cover the ground and smother weeds through Brussels sprout harvest. In order to preserve the no-till nature of the plots, the appropriate tarp was reapplied over weeds as a way to "weed" through occultation without disturbing the soil. Each plot at Winterfell was covered a total of two times to weed in this manner, with the tarps left in place just one week each time in order to minimize decomposition of cover crop residue under each tarp. There was no difference in how much residue was preserved under any of the three tarp materials (figure 2.)

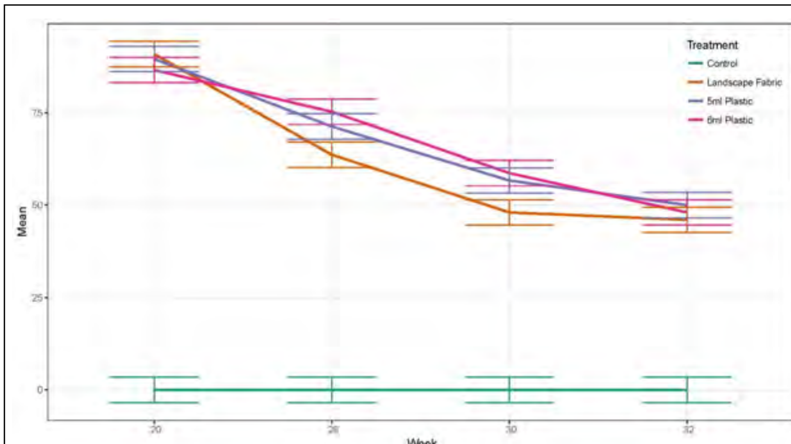

Figure 2: Cover crop residue by treatment (percent cover) at Winterfell Acres. There is no significant difference among tarp treatments within dates at the 90% confidence level. Control is significantly different than all tarp treatments. Error bars represent the standard error of the mean.

Weed control

Weed population counts in the fall of the cover crop establishment year showed that weeds were well controlled. Of the 48 total samples counted (12 at each of the 4 farms) only 18 had any weeds at all. Only the weediest farm had more than 2 weeds in any of the samples and even that farm dropped from an average of 56 weeds per square foot after cover crop emergence on 8/24/17 to an average of 2 weeds per square foot on 10/31/17.

Tarps were used to kill weeds that germinated in aisles through the cover crop residue. The foreground shows weeds and cover crop reside after one week of tarping. The background shows weeds that have not yet been tarped. Winterfell Acres 6/26/18.

Because the spring cover crop biomass was not sufficient to fully cover the ground at any of the farms, weeds were not well controlled in the spring and continued to germinate through the residue in the tarp treatments as well as in the tilled, residue-free control.

Ideally a thick layer of rye residue would have prevented weeds in the tarped no-till treatments. Instead, in order to preserve the no-till nature of the treatment plots, weeds were re-covered with the appropriate tarp twice during the growing season. In most cases, one week was enough to terminate the weeds, though in a few cases where the weeds were larger, it took two weeks of tarping to kill them.

The only difference between the tarps in this supplemental "weeding" was that the two types of plastic tarps seemed to do a better job of killing perennial weeds like dandelions. Though weeds were counted many times over the season, the data did not distinguish between annual and perennial weeds. So, this observation is anecdotal. It could be that perennial weeds survived better under the landscape fabric because rain is able to penetrate the woven fabric and sustain plant roots in a way in cannot through the solid plastic tarps.

Brussels sprout yield

Though overall yield was lower than expected, there was no difference in Brussels sprout yield between any of the no-till treatments nor between the no-till treatments and the tilled control on any of the four farms (figure 3). There was a significant effect of location (farm) but no significant effect due to treatment or treatment by location interactions.

There is no visible difference in Brussels sprouts among any of the treatments. The cover crop residue is gone at Two Onion Farm on 8/14/18 two weeks before the first harvest.

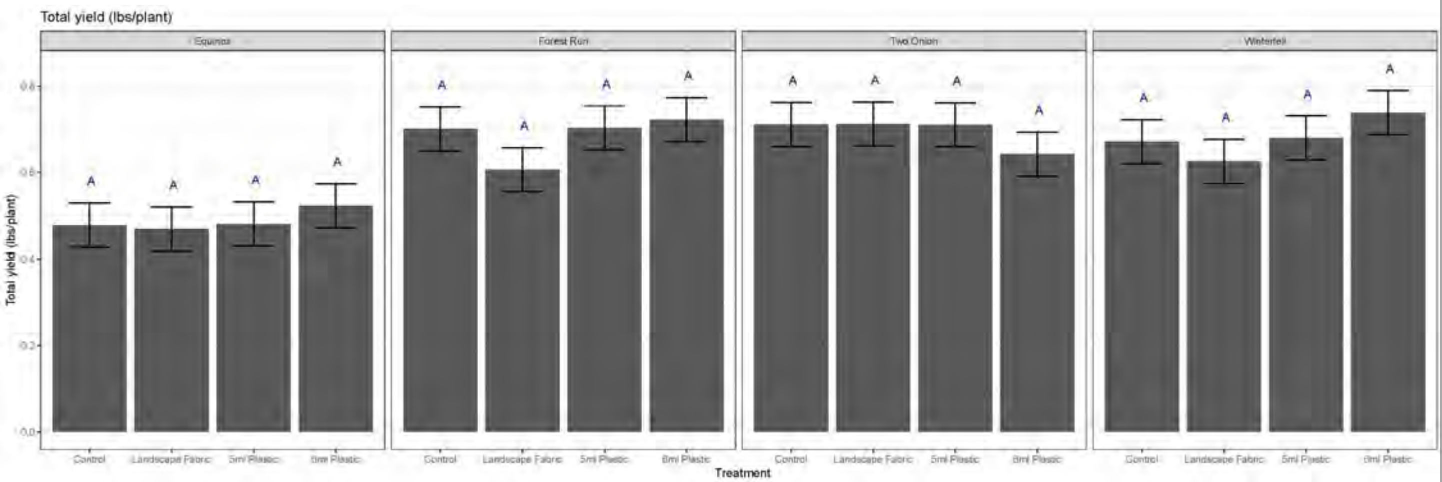

Figure 3: Total yield in pounds per plant (lb/plant). Error bars represent the standard error of the mean. Means with the same letter are not significantly different from each other at the 90% confidence level. There was a significant effect of location (farm) but no significant effect due to treatment or treatment by location interactions.

2018 was not a good year for Brussels sprouts is southern Wisconsin. The average yield per plant in this trial was only .64 lbs. As a comparison, we used the same variety of Brussels sprouts (Gustus) for a trial looking at living aisles in 2015 and 2016 (SARE ONC15-011) and recorded an average yield per plant of 1.47 lbs in 2015 and 1.63 lbs in 2016 across the four participating farms. This difference is likely due to the above average rainfall in 2018 as compared to 1981-2010 normals (Young 2018). These wetter conditions from June through September likely promoted more disease and a lower marketable yield.

*Labo*r

Management time for each treatment was tracked in minutes for planting and weeding. Because harvest labor is primarily dependent on yield and is not affected by the treatment, it was not tracked and is not included in the labor totals. There was no difference in labor time for any of the tarp treatments, but all of those treatments required more time than the tilled control (Table 1).

Table 1. Material and labor cost per 100-ft bed of Brussels spouts (excluding constants)

	Tilled Control	No-till 5ml silage plastic[1]	No-till 6ml bunker cover[2]	No-till landscape fabric[3]
Tarp materials		\$7.77	\$5.91	\$3.27
Sod staples[4]		\$0.45	\$0.45	\$0.45
Labor time	120 min	160 min	160 min	160 min
Wage	\$10/hour	\$10/hour	\$10/hour	\$10/hour
Labor cost	\$20.00	\$26.67	\$26.67	\$26.67
Total materials & labor	\$20.00	\$34.89	\$33.03	\$30.39

[1] 5ml silage plastic: FarmTek, 2018 prices, 32-ft by 100-ft piece is \$246.95 plus \$24.95 shipping from Iowa to Wisconsin. Total cost is spread over the expected minimum life of the product, 7 years.
[2] 6ml bunker cover: Farm Plastic Supply, 2018 prices, 32-ft by 100-ft piece is \$159.99 plus \$46.96 shipping from Illinois to Wisconsin. Total cost is spread over the expected minimum life of the product, 7 years.
[3] Landscape fabric: Nolt's Greenhouse Supplies, 2018 prices, 6-ft by 300-ft roll is \$84.00 plus \$14.00 shipping from Iowa to Wisconsin. Total cost is spread over the expected minimum life of the product, 10 years.
[4] Steel Sod Staples: Nolt's Greenhouse Supplies, 2018 prices, 500 8-guage/8-inch staples are \$33.00 plus \$14.00 shipping from Iowa to Wisconsin. Used 24 stapes per 100-ft bed. Total cost spread over the expected minimum life of the product, 5 years.

Planting took longer in the no-till treatments because each plant was set in a small hand-dug hole in order to minimize soil disturbance. Labor required to create those holes was greater than mechanical tillage in the control. Weeding the no-till plots with the occultation tarps also required more time than weeding the control with a wheel hoe. Much of that difference is likely attributable to the extra time it took to move the tarps around the randomized plots. If a farmer used one type of tarp to weed an entire bed, application and removal of the tarp would certainly be faster than it was in this trial and might be more comparable to wheel hoe weeding.

Cover crop residue is gone and weeds are emerging again after two rounds of tarping on the day harvest begins at Winterfell Acres on 8/28/19.

Material and labor costs

Given that there is no yield difference among the tarped no-till treatments or the control, differences among the input and labor costs are core to this comparison. Table 1 shows input and labor costs for a 100-ft bed of Brussels sprouts. Constant factors such as cost of cover crop seed and harvest time are not included.

The control is clearly the most cost effective in this trial. Costs for the no-till treatments could be reduced in a few ways:

- Having a good stand of rye in the spring will mean a thicker mulch layer and less time weeding, no matter the weeding method.
- Labor for the no-till plots in this trial included time to move tarps among the randomized plots for weeding through occultation. Farmers can easily reduce that time by using only one type of tarp and cutting it to fit 1/4 or 1/3 the length of the aisle. That one tarp can then easily be moved down the aisle every week to cover the full length of the aisle over 3 or 4 weeks and avoiding the difficulty of moving tarps from one aisle to another without damaging vegetable plants
- Labor might be able to be further reduced by switching from occultation to wheel hoeing when remaining cover crop residue permits.
- Materials for this trial were purchased new. Costs for silage plastic could be reduced by sourcing used tarps from dairy farms, though additional labor might be required to clean salvaged tarps before use.
- Benefits to the soil through reduced tillage are not quantified in this trial. These benefits could translate into either decreased fertility costs or higher yields in the future.

Brussels sprout harvest.

Recommendations for farmers

1. Plant winter rye in mid-August through early-September to maximize spring biomass for use as an *in situ* mulch.
2. When using tarps to cover and terminate winter rye through occultation, it is beneficial to first knock over and align the rye all in one direction by rolling a disengaged rotovator over the cover crop. If rye is not flowering, it will rebound, but even knocking it over temporarily will make it easier to apply the tarp.
3. The black side of 5ml or 6ml silage plastic or woven landscape fabric all work to kill winter rye in about three weeks. Use whichever you have on hand or can source cheaply. If perennial weeds are an issue, silage plastic may work better than landscape fabric to reduce them.
4. This project was not designed to look at the minimum amount of time needed to terminate the cover crop with each tarp material. It is possible one of the materials could be faster than another, and that question would be worth exploring. If the tarping time can be reduced, either the vegetables could be planted earlier OR the cover crop could be left to stand longer to produce more biomass.
5. Using sod staples to anchor the edges of smaller tarps is effective in low winds. Where winds are more severe or tarps are larger, additional weight on top of the tarps in the form of sandbags will likely be required.
6. If terminated cover crop residue is not sufficient to cover the soil, weeds will germinate. Tarps can also be used to kill weeds in the aisles through occultation. A tarp cut to 1/4 or 1/3 of the aisle length will be easy to move down the aisle weekly and cover the full length of the aisle in 3 or 4 weeks. Ideally the vegetable crop canopy will prevent weeds after one or two rounds of occultation in the aisles.
7. Given that there was no yield penalty in the no-till plots as compared to the tilled control, it is worth experimenting with and increasing efficiency for cover crop based reduced tillage systems on organic vegetable farms.

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