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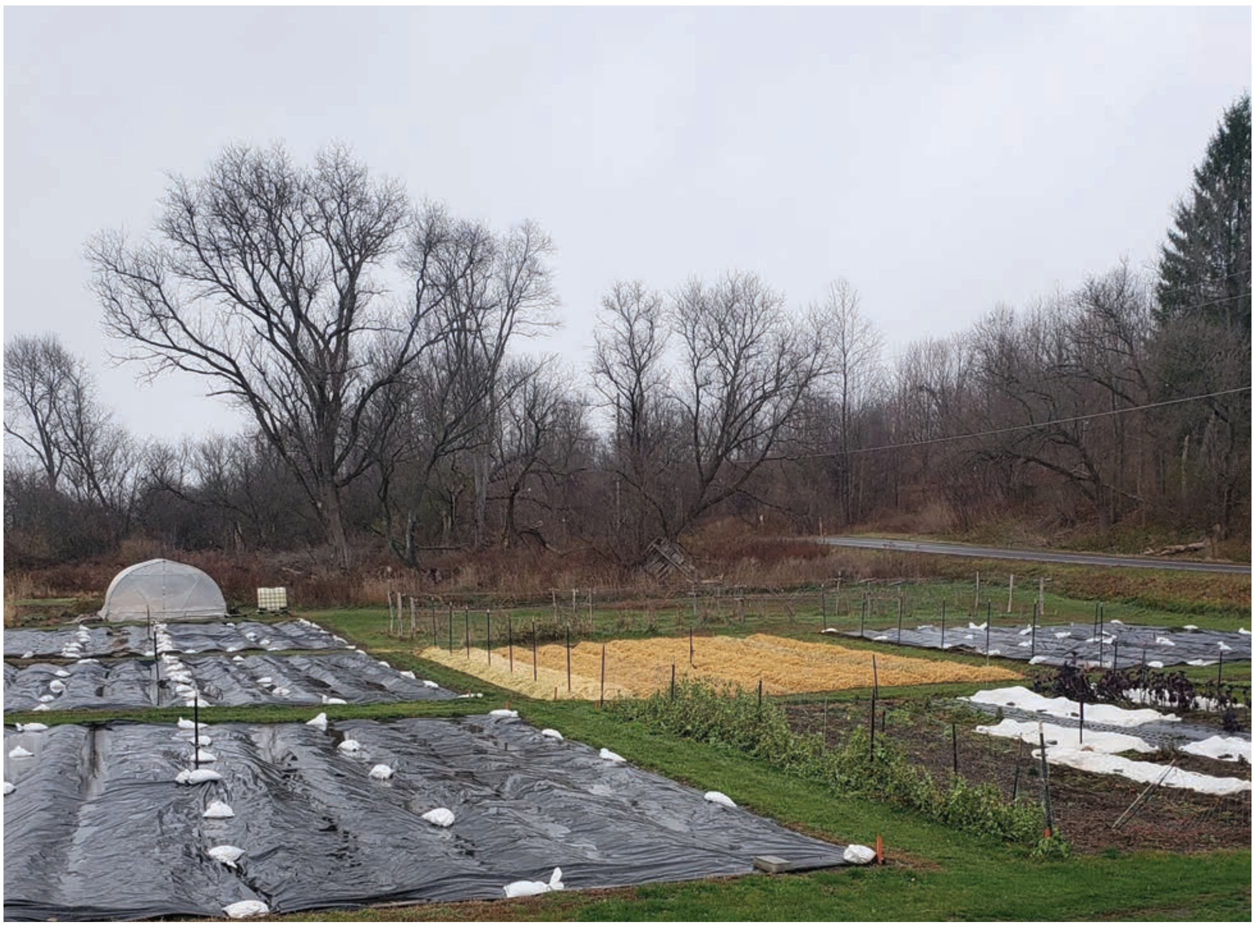
Tarping in the Northeast:
A Guide for Small Farms



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Tarping in the Northeast:
A Guide for Small Farms

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The authors would like to thank Maeve Wivell, Molly Shea, and Sue Ishaq, for research and writing contributions to this guide as well as the farmers who graciously shared information about their operations for the Case Studies, including Dave McDaniel and Heather Selin, Molly Comstock, Ben Stein and Alicia Brown, Ryan and Kara Fitzbeauchamp, Daniel Mays, and John Hayden. Additionally, we would like to thank Becky Maden, Anu Rangarajan, Peyton Ginakes, and Johnny Sanchez for helpful reviews.

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Introduction

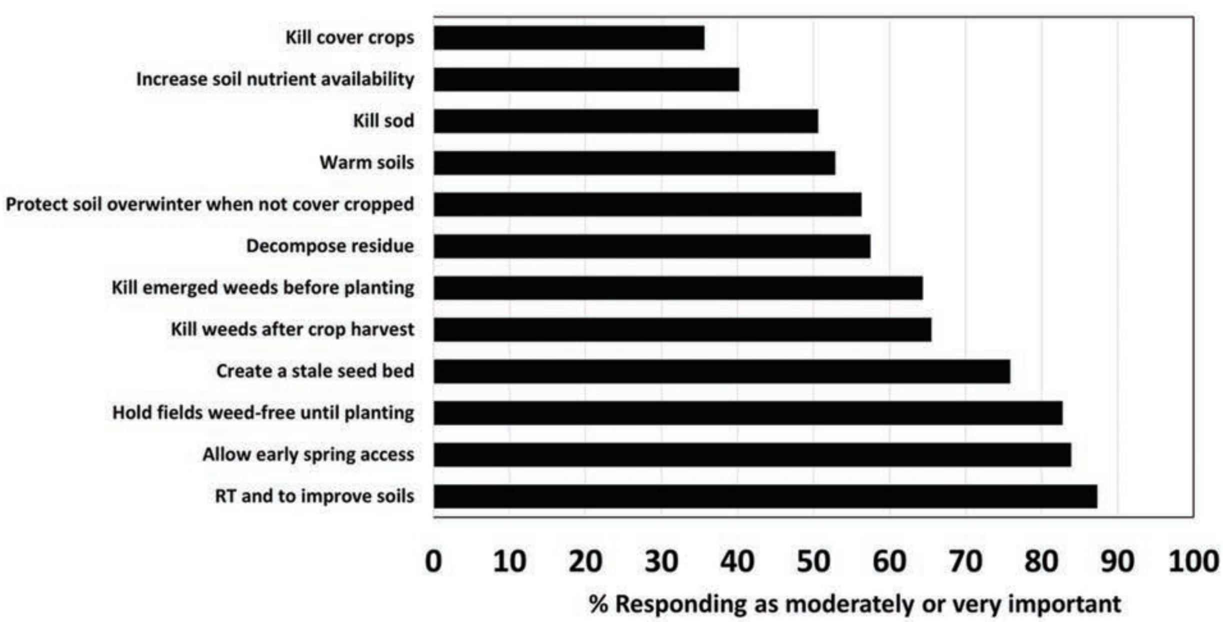
Reusable tarps, including black plastic (silage tarps), clear plastic, and landscape fabric, are multi-functional, accessible tools that are increasingly popular on small farms. The use of opaque materials that block light is frequently called "**occultation**" while the use of clear tarps is called "**solarization**." We treat "**tarping**" as a general term to include both. Regardless of the material used, tarps are applied to the soil surface between crops and then removed prior to planting. In cool climates like that of the Northeastern US, tarping has emerged as an important way to manage weeds, crop residue, soil moisture, and nutrients. Tarps can be versatile tools left in place for days to months at a time depending on context. They are commonly seen as 'placeholders,' covering soils to keep them weed-free and to retain moisture and nutrients until planting time. Many farmers use tarps to reduce the intensity of tillage or the number of tillage passes, while other farmers have moved to rotational no-till or even continuous no-till with tarps. Tarps have also been deployed as a way to transition new fields into production.

Solarization: The practice of using clear tarps to capture solar energy and heat the soil surface. The effects of solarization on pests (weeds and pathogens) and beneficial organisms are highly dependent on weather conditions.

Occultation: The practice of using opaque (typically black) tarps to block light and therefore prevent photosynthesis. The word has Latin origins, meaning "to block." The effects of occultation are less dependent on, but nonetheless affected by, weather conditions.

Farms using tarps are generally small (<5 acres) and employ organic practices, however, the reasons farmers use tarps are diverse. A recent survey of farmers in the Northeast (Rangarajan 2019) showed that there are many different goals with tarping.

Despite the advantages of using tarps, there are tradeoffs to this practice and many



Percent of farmer survey participants who ranked various goals of tarping as moderately or very important on their farm. (Rangarajan 2019) unknowns. Farmers cite the logistics associated with handling tarps, including moving, securing, and storing them, as especially challenging. Because of these challenges, tarping is currently scale-limited. Tarping is a powerful weed management tool, but some weed species can become problematic when tarping is deployed without additional or alternative weed management techniques. Occupying valuable field space during the growing season with a tarp on land that would otherwise be planted to cash or cover crops represents an opportunity cost, and the benefits of tarping must outweigh the time required to implement the practice effectively. While tarps are reusable, they are made of plastic; manufacturing, disposal, and plastic contamination during their use are concerns.

This guide is intended for those who are interested in or currently using tarps and would like to know more. The individual practice sections (see page 13) for Tarping Practices section) and farmer case studies (see page 29) serve as standalone resources. Research results and farmer experiences from multiple states in the Northeast have been combined to provide a thorough and up-to-date picture on the state of tarping knowledge including logistics, science, and economics.

Types of Tarps and How They Work

Tarp types

Tarps come in different materials, sizes, and thicknesses and vary in permeability, cost, and longevity (see Table 1 on page 10). For occultation, polyethylene silage tarps—made for excluding light and water from silage bunkers—or "ag plastic" are most commonly used because they are cost-effective, durable, and allowable under National Organic Program (NOP) rules. Landscape fabrics including woven polypropylene ground

Tarps come in many different materials, sizes, and thickness. Photo: Ryan Maher.

cover, which are often marketed as "permeable" are also popular. However, the permeability of these woven fabrics is limited and semi-permeable is a more accurate descriptor; water will still run off them. Black plastic billboard tarps have been favored in the past by producers because of their thickness (11-15mil), weight, and stiffness, but their use is disallowed under NOP standards because they are made of polyvinyl chloride (PVC). Woven blue poly tarps are easily accessible, but their utility is limited for field applications. For solarization, salvaged greenhouse plastic can be used and may be preferable to new clear tarps for both cost and efficacy (Avissar et al., 1986). Double layers of clear plastic, or clear on top of black, can further increase efficacy in some applications when more heat is needed (Mahrer and Shilo, 2012). If you have questions about using tarps in certified organic production, please discuss them with your certifier.

How tarps work

Occultation and solarization change light, temperature, and moisture dynamics at the soil surface. Effects on these conditions, in turn, affect biological processes such as photosynthesis, weed germination, and insect and microbial activity, which regulate the availability of nutrients like nitrogen. Understanding the mechanisms through which tarps work can help inform which type of tarp to use and how long to deploy it in a given context.

Light

The word occultation means to hide or block light, and black and other opaque tarps do just that. Occultation prevents photosynthesis and plant growth. How long plants can persist without light for photosynthesis depends on the temperature, species, maturity of the plant, and whether the plant has belowground vegetative propagules like rhizomes or tubers. Solarization, on the other hand, allows light through and relies on changes in temperature, discussed below, to kill plants.

Soil moisture

Managing soil moisture is central to successful tarping. Available soil water is an important factor that regulates biological processes, such as weed seed germination and microbial activity. These processes are generally greatest when soils are moist but not saturated. Moisture also increases heat conductance in soil, resulting in greater temperatures, which also influence germination and microbial activity. The effects of tarping are therefore strongly dependent on soil moisture at the time of tarp application. In some cases, it may be beneficial to irrigate prior to tarping.

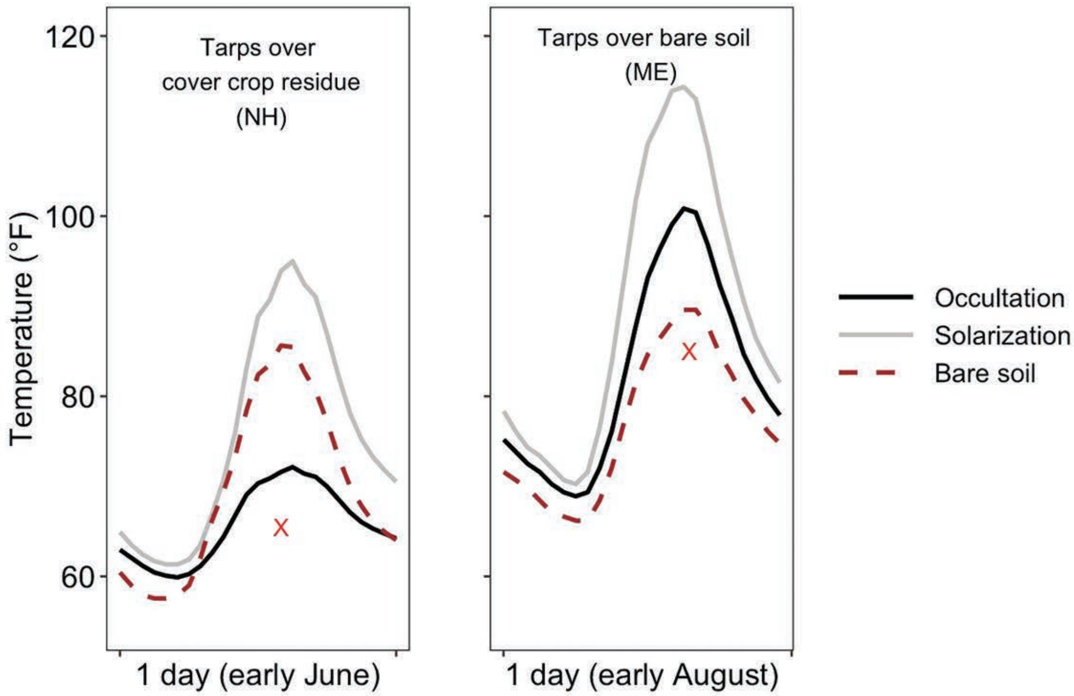
Once applied, impermeable tarps generally "hold" moisture and maintain it at a relatively constant level for the duration of the tarping period. The exception to this is if edges are not sealed during solarization, which can lead to soil moisture losses from condensation. Holding soil moisture with a tarp can be advantageous because it helps ensure that there is adequate—but not excessive—water for the following crop. Woven landscape fabric also reduces evaporation from soils, but allows for some rainfall to infiltrate. When there is little or no precipitation, soil under landscape fabric will likely lose moisture over time.

By excluding precipitation, impermeable tarps can serve as a water management tool. For example, if applied over winter or prior to wet periods, tarps can improve field access in early spring. This can be especially valuable in soils that are not well drained. Excluding precipitation also reduces leaching losses, meaning tarps help retain mobile nutrients, like nitrate, in the soil (Lounsbury, 2021; Rylander et al., 2020a). This keeps nutrients out of waterways, instead of keeping them on the farm and available for future crops. However, when deployed for an extended time period and over a large area, tarps may prevent important soil water recharge from precipitation events.

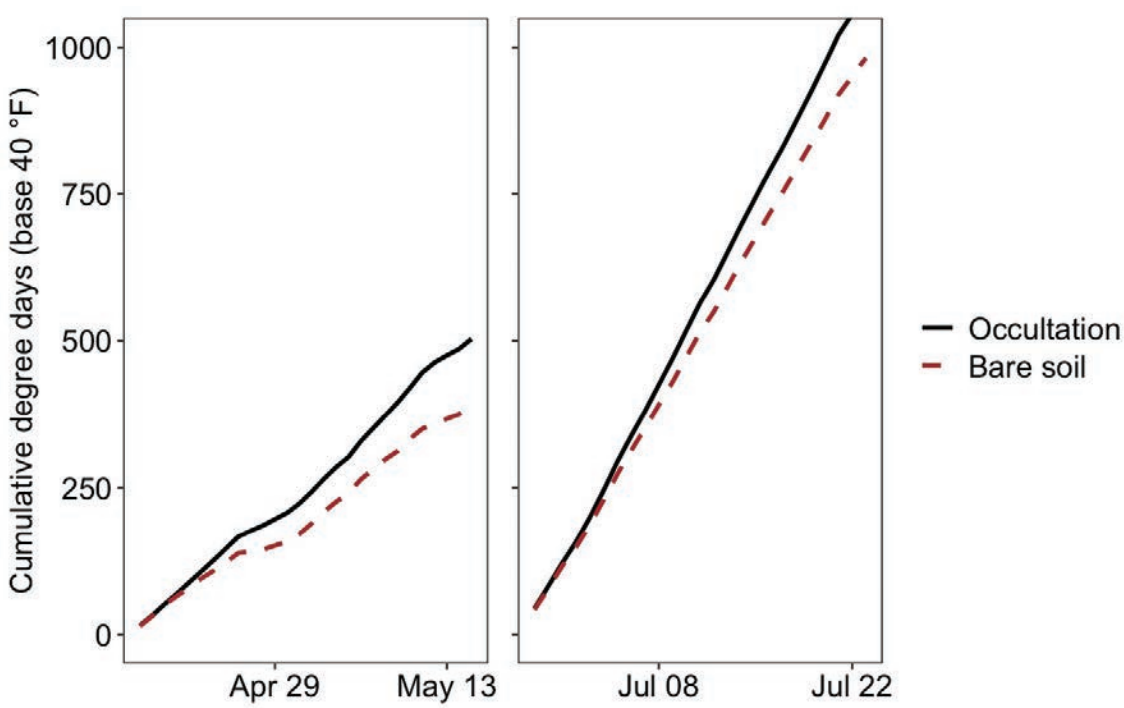
Soil temperature

Occultation and solarization both affect soil temperature but in different ways. Solarization traps heat from solar radiation and creates conditions inhospitable to plant growth. The time required for solarization is a function of solar radiation, air temperature, wind speed, and moisture. In the Northeast, less than two weeks of solarization can be effective during average weather around the time of the summer solstice. If temperatures are not high enough, however, plants can thrive in a mini greenhouse created by the tarp. Burying tarp edges during solarization is critical to its efficacy by trapping heat and retaining moisture.

Because the absence of light is already inhospitable to plant growth, occultation can be effective across a wider range of ambient air temperatures, levels of solar radiation, and with a variety of edge securement methods. Black tarps transfer heat via conduction or



Soil surface temperatures under occultation, solarization, and bare soil in early June and early August. Note the combination of cover crop mulch and occultation has the effect of lowering the temperature compared to bare soil or solarization. Without cover crop mulch, occultation raises the surface soil temperature compared to bare soil, but not as much as solarization. The red x marks the daily maximum air temperature. Data from Lounsbury et al, 2020 and Birthisel 2019.



Cumulative degree days in New York over a four-week period in spring vs. summer. In spring, the soil warming provided by occultation is greater than it is in summer. Data from Maher unpublished.

direct contact. To raise soil temperatures with occultation, there must be tarp-soil contact. If there is something creating an air gap, such as cover crop mulch in a rotational no-till practice (see page 20), a black tarp can lower maximum soil temperatures compared to no tarp at all, as illustrated below.

he cumulative effects of occultation on soil temperature are shown in the figure below. The difference in cumulative "degree days" between occultation and bare soil is much greater in spring than it is in mid-summer. These temperature effects in spring are likely to have a larger effect on biological processes like soil nitrogen mineralization and weed seed germination.

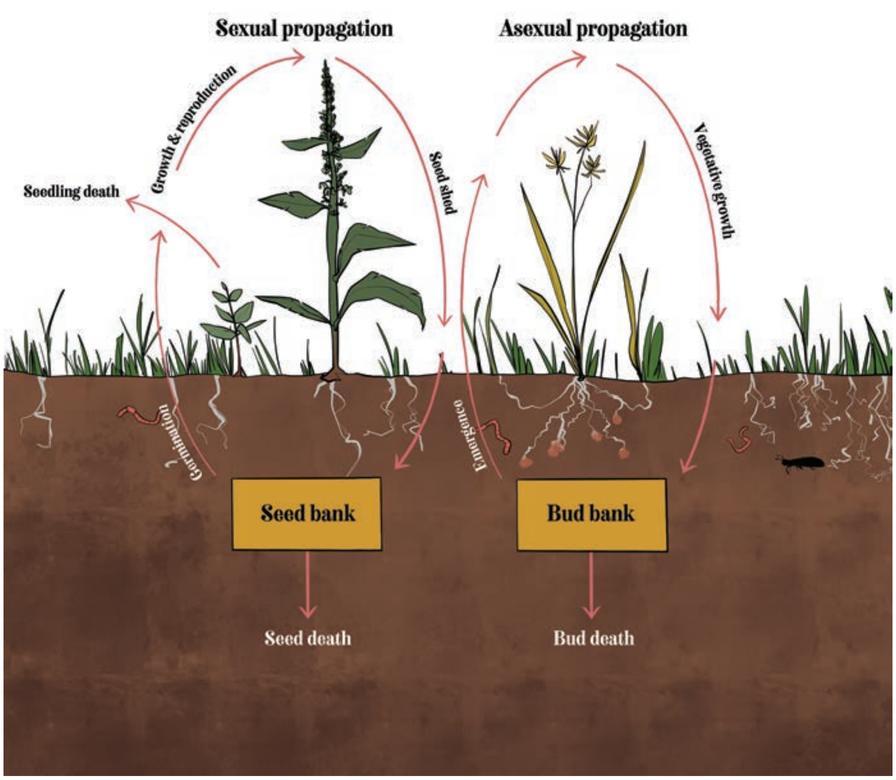
Weeds

Because tarping can alter light, moisture, and temperature conditions at different points in the weed life cycle, tarping practices offer ways to manage both living and lurking weeds. Living weeds are actively growing annual and perennial species. Lurking weeds include seeds in the seed bank and the belowground storage organs of perennials in the bud bank that will germinate and emerge, respectively, when they have the right conditions.

The shift to tarping as a primary weed management strategy may alter the weed communities present, creating problematic dominant species that are resistant to tarping. Nearly 10% of farmers using tarps reported that some weeds had become bigger problems since they began tarping (Rangarajan 2019). For many of these farmers, the shift to tarping

Seed bank: Weed seeds in the soil that will germinate when they have the right combination of germination cues. These seeds can be of annual or perennial weed species.

Bud bank: Belowground storage organs of perennial weeds including roots, rhizomes, tubers, and bulbs. New plants can emerge from these storage organs, and some types of organs (e.g. rhizomes) can help species spread.



Visual depiction of the weed life cycle. Both annual and perennial weeds have seeds and can reproduce sexually contributing to the seed bank, while perennial weeds can also reproduce vegetatively, contributing to the bank. Illustration: Sydney Smith.

was likely accompanied by a reduction in tillage, which is known to shift weed communities toward perennial species. Even though tarping can be a highly effective weed management tactic, relying on a single strategy can be problematic, and it is important to integrate tarping with other weed management practices including crop rotation, cover crops, mulching, and in some cases tillage. Understanding how different tarping practices affect weeds and at what stage in their life cycle is critical to integrating this powerful tool effectively into an overall weed management strategy.

Killing living weeds

Terminating growing weeds with a tarp after crop harvest or before planting another crop is a popular practice because it eliminates at least one tillage pass. Most annual weeds are effectively terminated with less than one week of tarping in the peak of summer but may take up to three weeks in cooler seasons. Fully killing perennial weeds poses a challenge because of the lurking bud bank, however.

Managing perennial bud banks

The underground storage organs of perennial weeds store enough energy reserves to survive winters and other difficult conditions. This translates to resilience in the face of tarping. Perennial weeds tend to be most vulnerable to weed management tactics like tarping when they are just emerging in the spring, with only a few leaves sprouted, as they have already drawn on stored sugar reserves to survive the winter and must further exhaust these reserves to form spring shoots. However, once shoots emerge and start photosynthesizing at full capacity, perennials can quickly replenish reserves.

While there is much research needed to understand the relationships between tarping and perennial weeds, there is currently enough evidence to say that some common perennial species on farms in the Northeast are not well controlled with tarping, and can even become worse. The tubers, or "nutlets," and rhizomes of nutsedges (*Cyperus* spp.) are especially resistant to occultation. They are somewhat susceptible to solarization, however, when combined with tillage in the peak summer months (Johnson III et al., 2007). Other common perennials including quackgrass (*Elymus repens (L.) Gould*), field bindweed (*Convolvulus arvensis L.*), and Canada thistle (*Cirsium arvense (L.) Scop.*), which all spread via rhizomes, may be knocked back but not eliminated by short or mid-term (<6 weeks) periods of solarization and/or occultation. The lack of data specific to perennial weed control with tarps in the

> If perennial weeds are present in fields, farmers should be aware that tarping alone may not be sufficient to avoid problematic levels of these species. Using multiple tactics to deplete the storage organs of challenging perennial weeds may be necessary before relying on short-duration tarping.

Yellow nutsedge growing in an area of previously tarped sod. Tarps had been applied for five weeks. Photo: Bonnie Lounsbury.

Northeast makes it challenging to offer management recommendations. This is further complicated since most studies investigating solarization for perennial weed control have used thin (e.g. 1-2 mil) new, clear plastic, which creates different thermal conditions than thicker (4-6 mil) reusable tarps (Elmore et al., 1993).

Research on whether long tarping periods can deplete the bud bank has not been conducted in this region. If perennial weeds are present in fields, farmers should be aware that tarping alone may not be sufficient to avoid problematic levels of these species. Using multiple tactics to deplete the storage organs of challenging perennial weeds may be necessary before relying on short-duration tarping. Plowing a field with perennial weeds to pull up the storage structures and letting them dry in the sun weakens plants, and alternating this practice with tarping throughout a season may help control pernicious perennials. However, care should be taken not to inadvertently spread perennial weeds to new locations through this practice.

Managing weed seed banks

Weed seeds must receive signals, or cues, to germinate. These cues can include moisture, light, temperature, nutrients, and gases. Solarization and occultation regulate these cues differently, but both can encourage so-called fatal germination or death of a newly germinated seed. Dead white thread stage weeds that have apparently succumbed to intense heat (solarization) and/or a lack of light (occultation) after germinating are commonly observed following these practices. By increasing fatal germination, tarping can deplete the weed seed bank, killing many of the weeds that would have emerged during early crop growth. This gives crops a competitive advantage in the important early period of their growth. It is believed that this is the primary mechanism for weed suppression observed from tarping in the Northeast, and while research is limited, tarping durations beyond three weeks have not been shown to significantly increase fatal germination(Rylander et al., 2020b).

Some annual species, including purslane (*Portulaca oleracea L.*) appear unsusceptible to fatal germination induced by tarping and solarizing. Crabgrasses (*Digitaria* spp.) have shown condition-dependent results, with some farmers reporting increased abundance after tarping. In the absence of other weed competitors, these weed species can become dominant following tarping.

In warmer climates, thermal destruction (seed death) of some weed seeds as a result of very high temperatures under solarization has been documented. Evidence from Maine suggests that this occurs to a limited extent in the field, and to a greater degree in hoophouses (see" stale seedbedding" section page 13). However, it is not believed to be a major pathway of weed seed loss under occultation because of lower temperatures. Other pathways for weed seed death, or loss of seed viability, include microbial decay and seed predation by invertebrates, rodents, and birds. It is unclear how or if tarping affects these pathways of seed loss. Researchers in New York found that more seeds of Powell Amaranth (*Amaranthus powellii S. Wats*), which is a kind of pigweed, remained viable under tarping than in bare, untarped soil. This suggests that the pathways for seed death are indeed affected by tarping, but the mechanisms are unclear and may be species-specific (Rylander et al., 2020a).

Practices like cover crop based rotational no-till (see page 20), imported straw mulch, or deep compost mulch (see page 24), which are often combined with tarping, manage lurking weed seeds by the opposite of fatal germination. By reducing germination cues like light, these practices prevent weed seeds from germinating altogether, keeping weed seeds in the seed bank. In other words, these practices do not deplete the weed seed bank, but, to different degrees, bury it. By reducing the number of weed seeds that germinate, these practices also reduce the number of weeds that can potentially go to seed. Preventing seed inputs is another important way to manage the weed seedbank.

Soil organisms

Because tarping modifies the soil environment, it can affect soil biological activity (i.e. how active organisms are) and the community (i.e. who is present). Many farmers have questions about these effects, but very little research has been conducted in climates like the Northeast and with occultation, which results in significantly lower temperatures than solarization. Warmer, wetter temperatures can increase microbial activity, but very high temperatures (e.g. >110°F) achieved during solarization can decrease microbial activity and kill non-heat tolerant microbes. However, research conducted in warmer climates suggests that beneficial soil microbes persisting deeper in the soil profile can re-colonize upper layers of soil quickly following solarization treatment (DeVay and Katan, 1991). Research investigating the effects of solarization on mycorrhizal fungi found that solarization for >50 days did not reduce the viability and presence of mycorrhizae, but that prolonged periods (>8 months) of bare soil without weeds following solarization did (Schreiner et al., 2001).

The effects of these practices on soil-dwelling arthropods have received little consideration to date, though early results from an ongoing study in Vermont found that diversity and abundance of aboveground arthropods were reduced during both occultation and solarization. These populations rebounded within three weeks compared to a cultivated control, however. The effects on belowground arthropods were inconclusive but showed a trend toward decreased abundance and diversity following tarping. It has been noted by many farmers that occultation seems to increase earthworm abundance compared to tilled areas, and this phenomenon has been validated in field research (Vallotton, 2018).

Anaerobic soil disinfestation (ASD), which also uses tarps, is a process for pathogen control in which organic materials are added to the soil, the soil is irrigated to saturation, and the tarps are applied and sealed. Microbes quickly use up the oxygen present, creating anaerobic conditions that have been shown to reduce pathogens and increase beneficial microbes. There is currently research underway in the Northeast on this practice, but it falls outside the definition of tarping that we use in this guide and is therefore not covered here. ASD is, however, another use for tarps on the farm.

Soilborne Pathogens

We are aware of no published studies evaluating tarping for control of soilborne pathogens in our region. Previous research in other regions suggests that tarping does not result in hot enough soil temperatures to be consistently effective in cool northern climates like ours (Walters and Pinkerton, 2012). Nonetheless, it is likely that pathogens could be reduced under ideal conditions, or through some more creative applications of the practice. For example, theoretical work based on field studies in Maine suggested that the use of tightly-secured clear plastic tarps within a closed hoophouse achieved temperatures hot enough for control of several important pathogens including late blight (*Phytophthora infestans*), *Alternaria* leaf blight, and *Verticillium* wilt (Birthisel et al., 2019).

Based on studies conducted outside our region, at soil temperatures between 99°F and 122°F, thermal death and population reduction of many pathogenic organisms takes between two and five weeks. The effect is greatest, and lasts the longest, in the upper layers of the soil. In instances where temperatures are not high enough to kill pathogenic microbes outright, studies using clear tarps suggest that their application may still result in some benefits to the crop due to delayed propagule germination and reduced pathogen growth rates.

As with using tarps to manage weeds, moisture is important for pathogen control because pathogens are typically more susceptible to thermal killing when wet than dry, and moisture helps conduct heat deeper into the soil profile. The addition of organic amendments like manure may create conditions in which oxygen is limiting, also reducing the populations of plant pathogens. This can be done in a controlled manner using anaerobic soil disinfestation (see inset), but may also occur to some degree under more typical applications of black or clear tarps with high levels of organic matter additions. It should be noted that low oxygen conditions are likely to also create conditions for denitrification, lowering soil nitrate content over time.

Soil Nitrogen

Tarping practices can have significant effects on soil nutrients, especially inorganic nitrogen, which is available for plant uptake. This occurs through changes to biological activity and water dynamics already discussed. An accumulation of nitrate under tarps has been observed in multiple research studies and on-farm samples. Because nitrogen mineralization—the transformation of organic nitrogen to inorganic forms—is a biological process, accumulation is minimal with very short duration tarping. However, high levels (i.e. >30 mg kg-1 nitrate-N) can be reached after three weeks, especially in the peak of summer when soils are warm and microbes are very active, and when there is high soil organic matter. Higher nitrate levels after tarp removal likely reduce the need for fertilizer applications. Predictive tools such as the pre-sidedress nitrate test (PSNT) were not designed for cropping systems using tarps, but may provide an indication of whether to delay or even eliminate fertilizer application. PSNT samples are easy for a farmer to take (similar to a regular soil sample) and analysis is affordable with quick turnaround results through most labs.

With higher levels of nitrate present and somewhat limited gas exchange under impermeable tarps, there have been questions about the potential for denitrification (the biological conversion of nitrate to gaseous nitrogen, which occurs under limited oxygen conditions). This has not been studied. The fact that substantial accumulation of nitrate occurs under typical tarping conditions suggests that the extent of denitrification is limited. However, certain conditions such as high organic matter inputs may lead to the creation of anaerobic or limited oxygen conditions and some denitrification may occur. It is possible to inadvertently create the conditions that are intentionally created for anaerobic soil disinfestation (i.e. sealed edges, high organic matter inputs, wet soil, and warm temperatures) with tarping, and this is likely to lead to some denitrification.

General Logistics of Tarp Management

Tarp Size and Thickness

The typical size tarp for occultation and solarization ranges between 16-50′ wide and 50-100′ long. Weight and bulk is often the limiting factor to size selection. For example, a 50′ x 100′ 5 mil silage tarp weighs 150 lb when clean and dry. In addition to handling considerations, bed width and layout typically determine the desired dimensions of tarps. Areas with raised beds require larger tarp sizes to account for the depression of the walkways. Silage tarps are available in a wide range of sizes, making them easily customizable. They can be cut to the desired length or width based on bed size and number of beds. Landscape fabric is typically available in long, narrow rolls (up to 16′ wide).

It is possible to purchase tarps less than 4 mil thick, but they often do not last longer than a single season. While 5-6 mil tarps contain more plastic, they typically last multiple seasons (see Table 1 for best estimates). Landscape fabric is sold by weight or tensile strength, rather than thickness.

Price Comparisons

The following chart compares the cost to cover a 32′ x 100′ area with the various tarp types.

Table 1

Tarp Type	Material	Years Use	Thickness	Range of Prices to Cover 32′x100′ (New)	Estimated price per Year	Permeability	Notes
Silage or Ag Plastic	Polyethylene	3-5	5-6 mil	$130-$202	$26-$67	Impermeable	One side black, one side white or black on black.
Landscape / Woven Fabric	Polypropylene	5-7	2.2 – 4 oz	$184-224	$26-$45	Semi-permeable	Usually available in narrow rolls (7-16′ wide)
Clear Plastic	Polyethylene	3-5	6 mil	$253-$535	$51-$178	Impermeable	Can use old greenhouse plastic; edges must be buried to avoid moisture and heat loss.
Billboard	Polyvinyl Chloride (PVC)	6-10	11 mil	$448-$540	$45-$90	Impermeable	Typically only available in smaller dimensions; *not allowable under NOP Rules.*
Blue Tarp	Polyethylene	2-4	4-5 mil	$90-$112	$23-56	Semi-permeable	Not as effective for field tarping purposes.

*Longevity is based on best estimates from experienced farmers using good storage conditions
**Prices do not include shipping costs

Sourcing tarps through local suppliers (e.g. farm supply and equipment dealers) can avoid substantial shipping costs.

Securing Tarps

Tarps that blow in the wind can be dangerous to people, infrastructure, and livestock in the area—not to mention ineffective and unsightly. The majority of farmers using tarps secure them with sandbags. Once filled, sandbags are easy to move and store. Sandbags (10-15lbs) should be set close to the edges of the tarps, approximately every 5′ down the edges and less frequently across the middle of the tarp (10′). Placing them down each bed walkway works well to prevent air from entering under the tarp and lifting it. More sandbags are recommended on exposed, windy sites and when tarping for long durations or over winter. It is better to put on extra sandbags than to return to windblown tarps that need to be readjusted. Lighter tarps need to be secured more tightly than heavier ones.

Other options include 1 ft3 cinder blocks. The edges of cinder blocks grab the tarp well, but more care needs to be taken to prevent damaging the tarp. Blocks can be easily stacked on pallets for storage; with a pallet fork on a tractor, this process is much easier. For woven landscape fabric, steel garden staples work well and tools exist that make it possible to insert them quickly while standing. Burying the edges of tarps with soil works especially well for clear tarps, for which it is important to seal edges more tightly to create the hot conditions needed to solarize. The case studies illustrate some farmers' preferences for different edge securement methods and their reasons.

Labor Requirements

The hand labor requirements to apply and remove tarps vary by tarp size, securement method, and field conditions. It takes two people approximately 20 minutes to apply a 24′ x 100′ tarp if sandbags are ready to go and close by. It takes a similar amount of time, about 25 minutes, to remove a tarp and sandbags from a field. This includes the time needed to fold them when putting them away for storage. Wind can severely hamper tarping operations, as can ponding on tarps. Having more than two people may be necessary and desired under some conditions. Tarps may need adjustment, especially after days with high winds. In addition to applying and removing tarps, moving them among fields can be time-consuming and challenging. One way to reduce this labor is by planning the rotation to keep tarped beds in close proximity. Some farmers have a dedicated set of beds for tarping. If the planning and timing in the rotation are right, tarps can be peeled back one or several beds at a time for succession plantings or removed by sliding them over adjacent beds. Once tarping systems are more established, another labor-saving strategy is to acquire more tarps and dedicate them to specific fields or areas on the farm.

In research from New York, a no-till tarp system required equal or more labor for production compared to conventional tillage, but this labor was significantly shifted. Equipment and hand weeding labor can be reduced with significant labor added for tarp application and removal. However, all labor is not equal and adding tarping labor in early

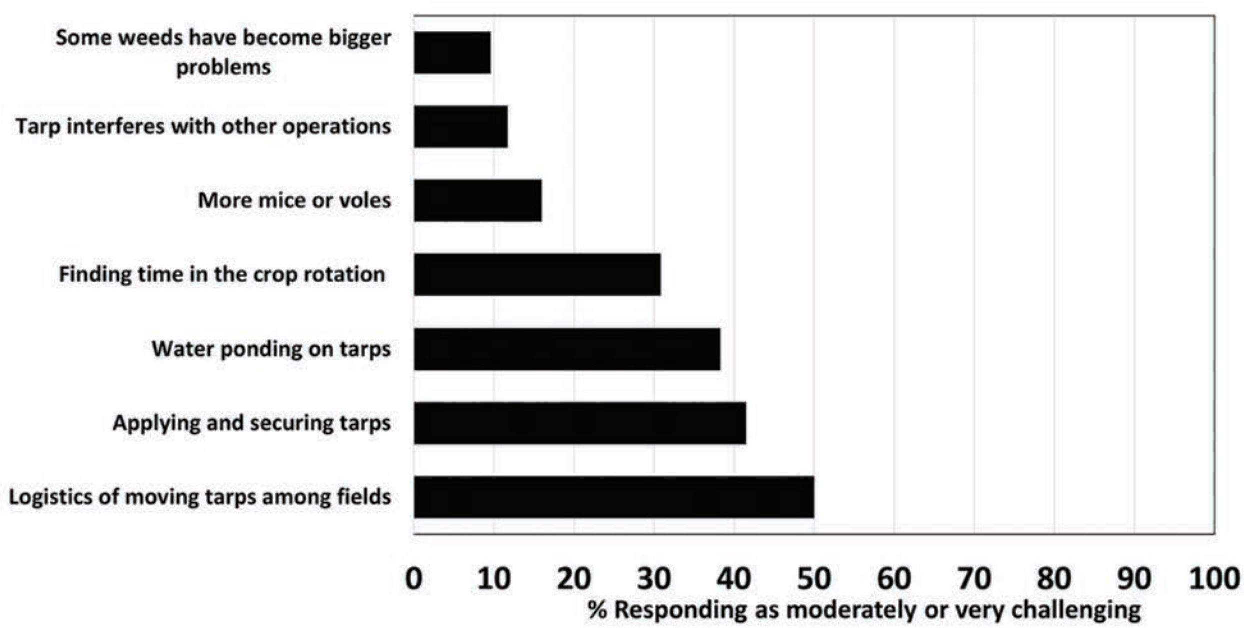
All labor is not equal and adding tarping labor in early spring or late fall when wet field conditions limit field access, or when other farm demands are not at their peak, can have clear advantages.

spring or late fall when wet field conditions limit field access, or when other farm demands are not at their peak, can have clear advantages.

Longevity and Storage

Breakdown of tarps is typically a result of both in-field damage and storage conditions. Silage tarps, greenhouse plastic, and landscape fabric are all UV stabilized, lasting many years even in direct sunlight. However, damage occurs in the field from deer and other animal traffic, crop stubble, and blocks or garden staples creating large tears. Landscape fabric is less likely to be damaged by these factors. In storage, rodent damage can be significant. Preventing these sources of damage can maximize tarp longevity and efficacy. Minimizing soil and plant debris sticking to the tarps when folding them and storing them outdoors can help to deter rodents. If outdoors, it is recommended to store them off the ground (e.g. on a pallet). The average lifespan of tarps varies by type from 2-10 years, with some common choices for more durable tarps listed in Table 1 on page 10.

Impermeable tarps pond rainfall that can weigh them down and keep them secure but make them messy and difficult to move. Cornell Thompson Vegetable Research Farm in Freeville, NY. Photo: Ryan Maher.



Percent of farmer survey participants who ranked various tarp-related problems as moderately or very challenging on their farm. (Rangarajan 2019)

Drawbacks and Considerations

Farmers who use tarps cite the logistics of moving them among fields as the biggest management challenge (Rangarajan 2019). Ponding on impermeable tarps is also challenging under wet conditions, and runoff from tarps can end up in a neighboring bed or another part of the field. Water can make tarp removal difficult and messy. If possible, directing water to sod alleys when removing tarps can help mitigate some of this problem. The use of tarps can lead to increased habitat for rodents and—partially as a consequence—snakes. Caution should be taken if a crop that is susceptible to rodent damage is grown near a tarped field, as this may have food safety implications. It is also possible that moving tarps between fields could introduce soil-borne diseases into previously uninfected fields. If soil-borne disease is a major concern, tarps dedicated to specific fields may be advisable unless tarps can be cleaned and sanitized. Operating equipment along the edges of tarps can be difficult, and sandbags can get in the way when managing neighboring untarped beds.

Tarping Practices

"Stale seedbedding" with tillage and tarps

Introduction

Stale seedbedding is a practice that encourages the germination of weed seeds, then kills emerged weeds before crop planting in order to minimize weed competition with the crop. The practice reduces in-season weed competition and can also deplete the weed seed bank, leading to reduced weed pressure in subsequent seasons (Gallandt, 2006). Tarps can be used for enhanced stale seedbedding.

Typically, stale seedbedding is done over a period of several weeks in the spring or early summer. Fields are prepared for planting with primary and secondary tillage, and raised beds may be made before applying this practice. These early-season soil disturbances help stimulate a "flush" of weed seeds to germinate. In traditional stale seedbedding, emerged white thread or cotyledon-stage weeds are killed with flaming, cultivation, or herbicide. When tarps are used for stale seedbedding, they are applied soon after field preparation, and kept in place for two or more weeks to allow time for weed seeds to germinate and be killed (Marenco and Lustosa, 2000).

Both occultation and solarization can enhance the flush of weeds by altering the soil's thermal and temperature regime. Emerged weeds are killed either from the absence of light (occultation) or extreme heat (solarization). Because it targets the seed bank, stale seedbedding is typically more effective for annual weeds than perennials. After tarp removal, crops should be seeded or transplanted into the prepared field with little additional soil disturbance – and certainly without further deep tillage or heavy cultivation – since disturbing soil can bring more deeply buried weed seeds to the soil surface, reducing the in-season benefit of the practice.

Farmers and researchers in the Northeast have had success with occultation and solarization for stale seedbedding in both fields and hoophouses (Birthisel et al., 2019; Fortier and Bilodeau, 2014). A key benefit to this practice is reducing the number of hand weeding, cultivation, or flaming passes needed by at least one. This results in less field traffic and fuel use. Under good conditions, solarizing can also create a better (less weedy) stale seedbed than is possible with other stale seedbedding techniques, potentially saving time and money on cultivation and hand weeding throughout the growing season while retaining valuable nitrate in the soil (Birthisel and Gallandt, 2019).

Logistics

Stale seedbedding with tarps can occur anytime during the growing season, especially in hoophouses. When applied in open fields, it is most commonly done in the springtime. For solarization, effectiveness is greatest near the summer solstice when solar energy gain is at a maximum.

Two weeks is a minimum time frame needed to establish a stale seedbed with tarping. This is based on the time required for many weed seeds to germinate and subsequently be killed. Farmer experience suggests that shorter treatment times may be effective in some circumstances. Research conducted in Maine found that four-six weeks does not typically lead to greater weed suppression than two (Birthisel and Gallandt, 2019).

Amendments that need to be incorporated into soils should be applied before tarping, so that field operations that could unearth buried weed seeds are not needed after tarp removal. Incorporating organic amendments before tarping may also improve the effectiveness of this practice by increasing microbial activity and microbial seed decay.

Research and experience in the Northeast have shown that solarization is a higher risk, higher reward method for stale seedbedding, while occultation is slightly less effective but also less likely to fail and cause a weedy mess that must be cleaned up through subsequent flaming or cultivation. Photo: Liam Kenefic.

There are key tradeoffs when considering occultation vs. solarization for stale seedbedding. Solarization is a higher-risk, higher-reward scenario. Under ideal conditions and when correctly applied (i.e. when plastic is applied over moist soils with edges tightly secured) and the weather is hot and sunny, solarization results in higher soil temperatures, more weed seed bank depletion, and better subsequent weed control than occultation (Birthisel et al., 2018). However, because light can penetrate clear plastic tarps, solarization is more likely to 'fail' if conditions are not ideal, calling for subsequent occultation, tillage, or other practice to control weeds. Occultation is, by comparison, a lower-risk, lower-reward strategy: it is unlikely to fail in ways that cause a 'mess' that must be cleaned up through subsequent flaming or cultivation, but maximum effectiveness for depleting the seed bank is lower.

Effects and outcomes from stale seedbedding with tarps

Stale seedbedding with tarps has proven effective at reducing weed density across a range of summer annual weeds including hairy galinsoga (*Galinsoga quadriradiata Cav.*), redroot pigweed (*Amaranthus retroflexus L.*), lambsquarters (*Chenopodium album L.*), and crabgrass species (*Digitaria* spp.). Solarization decreased subsequent weed density by 78% in Maine in comparison to a stale seedbed created with flaming, demonstrating that this application can be very effective when correctly applied.

Data from experiments in Maine suggest that solarization may indeed thermally kill some weed seeds at shallow soil depths. However, not all species are susceptible – neither solarization nor occultation have proven reliably effective against purslane in our region. This application of tarping also has minimal utility for controlling perennial weeds.

The substantial weed control achieved through stale seedbedding with tarps can contribute to improved yields. For example, a study in Brazil found that a stale seedbed created with 3 weeks of solarization decreased weed pressure and doubled carrot yield as compared with untreated controls (Marenco and Lustosa, 2000). Yield impacts are likely also a result of increased nutrient availability. As with other tarping applications, available nitrogen accumulates in the soil during stale seedbed periods and can be significantly higher under tarps compared to bare soil controls (Birthisel et al., 2019). Tarps may improve yields for direct seeded crops, especially in dry periods, by leaving a firm, moist seedbed that can lead to more favorable germination; on the other hand, added compaction can be a challenge for root crop development, depending on soil conditions.

Soil biological activity and abundance of beneficial soil microbes can be somewhat reduced during and for a period of days to weeks after tarping for stale seedbed establishment, with greater impacts seen for solarization than occultation. It is likely that reduced weed pressure contributes to this, as beneficial rhizosphere-associated bacteria may be less abundant where there are fewer plant (weed) roots with which to associate. Dead invertebrates including carabid beetles under tarps at the end of a stale seedbed period have been observed, and more research to evaluate the impact of tarping on these organisms would be beneficial.

Drawbacks

Key considerations when stale seedbedding with tarps include the time, or opportunity cost, and labor required. When creating a stale seedbed using flaming, it is common practice to plant slow-germinating direct-seeded crops like carrots during the waiting period and flame directly before crop emergence; with tarps, this is not possible. Another drawback is the time and effort required for tarp application — particularly for solarization, which requires tighter edge securement than occultation. Because stale seedbed preparation using tarps can be both time and labor-intensive, reserving this

A cautionary tale — purslane seedlings successfully established after stale seedbedding with clear plastic during the summer in Maine.
Photo: Sonja Birthisel.

Lettuce at planting in a conventional tillage system (left) and a continuous no-till system using tarps (right) at the Cornell Thompson Vegetable Research Farm in Freeville, NY. Repeated tillage events were used in spring to prepare tilled beds for planting while tarps were applied for several weeks, removed, and beds transplanted without soil disturbance.
Photo: Ryan Maher.

practice for high-value crops, particularly those that are slow-growing, highly susceptible to weed competition, or for which weeds are likely to interfere with harvest and cleaning (e.g., salad mix) is advisable.

Several drawbacks to the use of solarizing are worth reiterating. If temperatures under the tarp are sub-lethal, it can actually create a 'greenhouse' that encourages weed growth. This is likely to occur if plastic edges are not tightly secured, and when the practice is applied too late in the season and there is insufficient sunlight to achieve killing temperatures. Solarizing can also fail in low-lying portions of fields where water pools, creating a cool microclimate. Finally, not all species are susceptible to stale seedbedding with tarps; purslane germination even appeared to be stimulated by solarization (Birthisel and Gallandt, 2019). By contrast, black tarps may fail to result in substantial seed bank depletion if applied under suboptimal conditions but are unlikely to fail so abjectly.

Read more about stale seed bedding with tarps and tillage on Earth Dharma Farm, ME, in Farm Case Studies (see page 29).

Minimizing tillage with tarps

Introduction

Vegetable farmers in the Northeast increasingly use tarps to prepare beds with minimal or no tillage between crops. The keys to successfully using tarps in this capacity is that tarps must: 1) terminate any living plants (cash crop, cover crop, or emerged weeds), 2) help create a planting bed that is suitable for the following crop, and 3) provide adequate weed suppression in the early period of cash crop growth, if not longer. When applied in this way, tarps provide some or all of the bed preparation services typically provided by tillage. Tarps can help fill a niche for farmers using minimal tillage by creating weed-free planting conditions for the following crop without relying on heavy applications of organic mulches (e.g., hay, straw, leaves, or compost), materials that are not appropriate for short season or direct seeded crops, and can be difficult to source and labor intensive to apply.

There is a range of different applications for this practice, ahead of both direct and transplanted crops, and for multiple planting windows across the season. Farmers frequently put tarps directly over harvested crop residues between plantings or on overwintering cover crops (such as cereal rye) before they have accumulated much biomass in spring. As has been discussed elsewhere, the efficacy of occultation vs. solarization for this purpose depends on the conditions; most farmers in the Northeast use occultation because it is a lower risk strategy, but in summer months some farmers find solarization highly effective.

Sequences that farmers and researchers have employed include*:*

1. **Fall** cash crop → overwintering or early spring tarp → spring or summer cash crop
2 **Spring** cash crop → summer tarp → fall cash crop
3. **Winter**-killed or overwintering cover crop early spring tarp → spring or summer cash crop

Tarping with minimal tillage between plantings effectively reduces the intensity of tillage used in a rotation and fits into long-term soil health goals like protecting soil organic matter and building soil structure. It can also eliminate field passes – which can be especially valuable in early spring or other rainy periods when soils are otherwise too wet to work and operating equipment may cause lasting damage. Even when cash crop and cover crop residues are minimal, leaving soils undisturbed with some intact roots can help to improve water infiltration and reduce the potential for soil erosion and surface runoff.

Logistics

It is essential to identify and plan for the tarping period in the crop rotation, as tarping takes time. Tarping for three weeks or more is common, though some farmers use much shorter durations (<1 week) when conditions are warmer, like mid-summer or in high tunnels.

Residue management and seedbed quality are the two main considerations in this system: it is important to consider the conditions the tarped crop will leave behind as well as the conditions that are required for establishing the following crop. For many direct seeded crops, especially those with small seeds, having low amounts of surface residue and a level seedbed is important for establishment and growth. These issues are less of a concern for transplanted crops, making them good candidates for first trialing this practice.

Tarp effects on residue and decomposer organisms are not well documented. Many farmers have observed that tarps appear to expedite residue decomposition and increase activity of some organisms, like earthworms. However, research in New York and Maine found that tarping did not accelerate decomposition of an oat cover crop left on the soil surface, regardless of the tarping duration (3 or 6 weeks in spring or 10+ weeks over winter) (Rylander et al., 2020a). Tarping may sometimes accelerate decomposition but the effectiveness likely depends on several factors including: the history of field management, the soil and weather conditions, the quality of residue (i.e., C:N ratio), and if or how it is incorporated into the soil. Even when heavy residues remain after tarp removal, tarps can make it easier to manage.

It is recommended to combine tarping with other strategies to limit residue interference for no-till crop establishment, including selecting appropriate crops, modifying available planting tools, and physically removing plants. For example, tarping low-residue cash crops (e.g. leafy greens) or crops that will be largely removed by harvesting (e.g. root crops) can minimize interference with planting the next crop after tarp removal. When tarping after higher biomass

No-till tarped beds planted to lettuce in spring after tarping directly over winter annual weeds and residue (winter squash) from the previous fall. Cornell Thompson Vegetable Research Farm in Freeville, NY. Photo: Ryan Maher.

Flail mowed oat cover crop residue after tarping over different durations where tarps killed winter annual weeds while having no effect on residue cover; plots with darker residue had overwintering tarps. Cornell Thompson Vegetable Research Farm in Freeville, NY. Photo: Ryan Maher.

and stalky crops (e.g. Brassicas) that can lead to excess residue, farmers have cut and removed whole plants at the soil surface prior to tarping, or raked crop residue into pathways — mechanically or with hand tools — after tarping. Flail mowing the previous crop also can be used to finely chop and evenly distribute cash crop or cover crop biomass prior to tarping, though crop stems can persist and may still need to be pulled by hand to avoid poking holes in tarps.

Soil physical conditions are another important consideration before implementing no-till production with tarps. Establishing a system of permanent or semi-permanent beds can help preserve the soil's structure by limiting field traffic and compaction to between-bed pathways. Even in permanent beds, planting can be more difficult without a tilled, uniform, and friable seedbed. Dry, compacted soil can be especially hard to plant into, whether by hand or mechanically, highlighting another reason to ensure there is adequate soil moisture before tarping. When surface compaction or crusting is a problem, it is common for farmers to use available tools to work the soil surface shallowly (<1") after tarping to improve the seedbed without bringing up new weed seeds (e.g. power harrow, tine/basket weeder, hand rake). Some farmers have overcome compaction and soil tilth issues in no-till systems by using compost at high rates (>1" annually), though there are other management implications to consider in adopting this approach, including compost availability and cost, application logistics, and potential nutrient loading (see tarping in deep compost). When applying compost and other amendments to meet specific crop nutrient requirements, they can be top-dressed either before or after tarp removal, though applying compost before tarping is advantageous if the compost contains any weed seeds.

Tarps suppress living annual weeds in no-till beds (left) in comparison to conventionally tilled and untarped beds (right). Cornell Thompson Vegetable Research Farm in Freeville, NY." Photo: Ryan Maher.

Effects and outcomes from minimizing tillage with tarps

Killing established annual weeds: In research where black tarps were left in place for three weeks, they killed all or more than 95% of emerged winter annual and summer annual weeds for no-till planting. This result was consistent when tarps were placed in early (mid-April to May) and late spring (mid-May to June) (Rylander et al., 2020b). Similar results have been found in more recent trials when tarps were used for three weeks in mid-summer (July), after a spring lettuce crop and prior to fall broccoli. Whether applied over harvested cash crops or cover crops, tarps make it possible to suppress established annual weeds without needing to manage or disturb crop residues. If tarps are well timed to kill weed escapes, before they go to seed, they can also indirectly help to manage the weed seed bank. In trials that have documented the labor associated with tarping in continuous no-till (Maher et al., 2017), the ability to kill established weeds prior to planting has been shown to provide significant labor savings, reducing labor for no-till systems by 40%.

Weed emergence and competition in the following crop: Although fatal germination of weed seeds has been observed with tarping in no-till systems, it is likely less effective at drawing down the weed seed bank than stale seedbedding with tillage and tarps because there are fewer germination cues. Research that looked at weed emergence after no-till planting found that tarp durations in excess of 3 weeks did not provide additional benefits (Rylander 2019a). Other research in a continuous no-till tarped system has shown that tarps can reduce annual weed emergence when compared to conventional tillage over multiple years (Maher et al., 2017). This is likely the combined result of tarps: 1) increasing fatal germination, 2) suppressing weeds between crops that would otherwise produce seed, and 3) eliminating soil disturbance and the introduction of weed seeds from greater soil depths. It is likely that some additional in-season weed management tactics will be necessary in these applications, especially for long season crops and to suppress perennials, unless significant previous efforts have drawn down the weed seed bank or a weed suppressive crop is grown.

Beets prior to harvest in conventionally tilled beds (left) next to continuous no-till beds managed with tarps (right) at the Cornell Thompson Vegetable Research Farm in Freeville, NY. Photo: Ryan Maher.

Retain and increase soil inorganic nitrogen for the following crop: No-till soils often show lower soil N availability compared to conventionally tilled soils. However, after tarping, crops can inherit a large amount of plant-available soil nitrogen in the form of nitrate. Longer tarp durations typically increase soil N availability, helping farmers overcome one of the previous limitations of no-till production.

Crop establishment and yields: Across several trials in New York and Maine, a no-till system with tarping has produced equivalent crop yields to conventional tillage (Maher et al., 2017; Rylander et al., 2020b). When trialing direct-seeded beets, tarped no-till beds led to equivalent or better crop stands when compared to untarped and conventionally tilled beds. These results are likely due to the combined effects that have previously been discussed: weed-free planting beds, conserved soil moisture, and elevated soil nitrate at planting. Similarly, in a 4-year continuous no-till system using tarps, crop yields of cabbage and winter squash were equivalent to conventional tillage, though a no-till tarp system did require 25% more labor due to the time needed to manage tarps.

Killing cover crops: Tarps can be an effective no-till termination strategy for winter hardy cover crops (e.g., cereal rye) prior to spring cash crop planting. Rather than growing the cover crop to produce a weed suppressive mulch, farmers are killing cereal rye in spring (early to mid-May) when earlier cash crop plantings and lower residue conditions are desired. Cover crop benefits in this application include protecting soil with living ground cover over winter, which can reduce soil erosion and retain mobile nutrients. In NY, tarps have been shown to terminate cereal rye within three weeks between late April and mid-May with similar results using black plastic, woven landscape fabric, and clear tarps with the edges sealed.

Drawbacks

There are some unique challenges to consider when trialing tarps in no-till applications. Primarily, rough, uneven planting conditions and surface soil compaction can become a bigger issue when using no-till over multiple years. This can be especially challenging in heavy or rocky soils. It may be necessary to complement tarping with a shallow tillage pass (<1″), plan for additional planting labor, or modify the planting approach – either by modifying tools or transplanting rather than direct seeding – to improve crop establishment under these conditions. Research and farmer experiences have also shown that tarping without supplemental weed management tactics in a no-till system does not provide reliable season-long weed suppression for the following crop, especially in soils where the weed seed bank is high. Just as incorporating multiple weed management strategies is necessary to avoid problematic weed species, incorporating additional soil health-building practices are recommended to complement tarping practices to improve soil tilth and increase overall soil health.

Read more about minimizing tillage with tarps on Colfax Farm, MA, in Farm Case Studies (see page 33).

Read more about minimizing tillage with tarps on Edible Uprising Farm, NY, in Farm Case Studies (see page35).

Cover crop-based rotational no-till with tarps

Introduction

Cover crop-based organic rotational no-till was originally developed as a system in which high biomass cover crops like rye and vetch are terminated mechanically with a roller-crimper. A subsequent cash crop is planted into the residue without additional tillage. Despite myriad benefits, this system as it was originally conceived has several limitations for small-scale growers in cooler regions like the Northeast. A roller-crimper is a specialized piece of equipment that is only effective at specific cover crop growth stages. Furthermore, the biomass required to provide season-long weed suppression (>7000 lb/acre) is often hard to achieve with long winters in the north. Integrating tarps has helped overcome these challenges and made this system accessible because it eliminates the need for specialized machinery and provides flexibility in the timing of cover crop termination. Tarping also augments the weed suppression provided by cover crop residue, allowing successful implementation even with lower levels of cover crop biomass.

Transplanted Brassica crops growing through tarped rye cover crop mulch at Frith Farm in Scarborough, ME. Photo: Jason Lilley.

Leaving cover crop residue on the soil surface as a mulch for the cash crop has important benefits: the residue suppresses weeds, conserves moisture, and protects soil from intense precipitation events. In this system, it is possible to let the cover crops grow very large without worrying about the equipment needed to incorporate biomass. Cover crop-based organic rotational no-till includes three of the most important management practices for improving soil health—growing high biomass cover crops, leaving a mulch on the soil surface, and reducing tillage. Furthermore, when a legume cover crop is included, it adds valuable nitrogen and reduces fertilizer requirements for the cash crop.

This system requires that farmers commit the time and space needed to grow and terminate high biomass cover crops, but it reduces the need for purchasing additional external inputs such as straw mulch and fertilizer, and can reduce irrigation requirements. Most farmers practice "rotational" no-till—not continuous— with cover crops, often relying on tillage prior to cover crop establishment. However, some farmers using the deep compost continuous no-till method (see page 24) with tarping have started using high biomass cover crops more often, with the goals of reducing the amount of compost they apply and reaping the benefits of a mulch grown in place.

Rolling a rye-vetch cover crop with a riding mower and water-filled lawn roller attachment, prior to tarping. Photo: Bonnie Lounsbury.

Logistics

Resources, tools, equipment, supplies

Establishing cover crops: In addition to a tarp, this system requires an even cover crop stand with high biomass, a way to lay down or roll the cover crop, and a method to plant through the cover crop residue. To establish an even cover crop stand without bare patches, it is critical to get uniform seed distribution and good seed-soil contact. On a small scale, this is possible either by broadcasting or "drilling" using a push seeder like an Earthway. Timing with soil moisture and forecasted rain or irrigation in mind is always advised.

Rolling cover crops: Rolling the cover crop prior to tarp application is the best way to lay it down. In addition to creating stubble that can poke holes in tarps, mowing often chops up residue, leaving it unevenly distributed on the soil surface. Rolling lays all residue in one direction, making transplanting easier. Tools that work for rolling include a lawn roller, which can be pulled by a riding mower or manually, a disengaged rototiller or flail mower, and one or two people with a board on strings.

Upright tree dibbling tools allow for creating holes relatively easily for transplanting through heavy cover crop residue. Photo: Natalie Lounsbury.

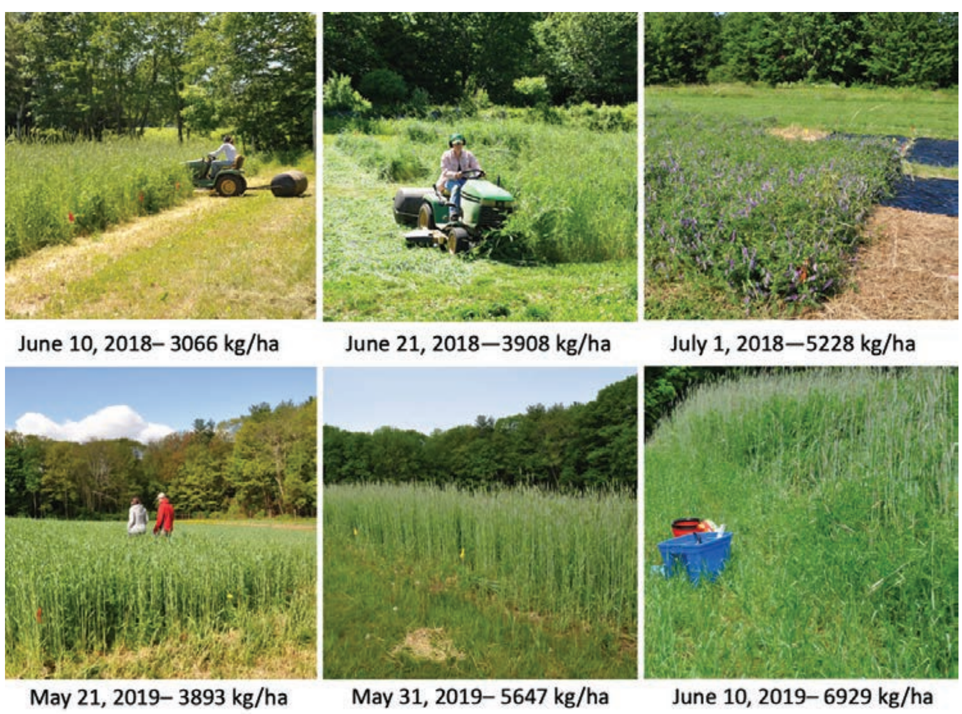
Transplanting: Transplanting through the cover crop residue usually requires a special tool unless the soil has been amended with very large amounts of compost. Some farmers have made tractor-mounted transplanters, but on a small scale something like a tree dibbler can be effective to create a hole in the soil, into which the transplant is placed. As with other operations, soil moisture plays a large role in the ease of creating holes. For this and other reasons discussed throughout the guide, applying the tarp when soil moisture is optimal and only removing it when the field is ready to be planted ensures that this process will not be hindered by dry soil and that transplants will have adequate moisture.

Timing and duration

This system requires significant planning in advance. The period of cover crop growth, date, and duration of tarping, and date of cash crop planting must all align. For the purposes of this guide, this section focuses on winter hardy cover crops like rye and vetch that are planted in fall and terminated in summer. This timing does not work for early planted cash crops, but it does for later planted cash crops like fall broccoli and other Brassicas (see case studies). Other sequences that differ in timing and crops (e.g. a spring/summer cover crop followed by a fall cash crop) but still follow the cover crop — tarp — no-till cash crop pattern could be effective.

Each location and season is different, but there are some general considerations when planning the critical steps in this system:

- **Fall cover crop planting:** Although there are some advantages to planting rye and vetch as early as August, a September planting is often most feasible in the Northeast. If planted later, like the beginning of October, higher seeding rates



Rye-vetch cover crop biomass in Turner, ME (2018) and Durham, NH (2019). Delaying cover crop termination until peak biomass leads to greater weed-suppressive mulch and, in the case of hairy vetch, much more N accumulation. Photos: Bonnie Lounsbury.

(>180 lb/acre) can compensate for some of the lost early growth and tillering. Vetches run the risk of not surviving winter if planted too late, and it is typically recommended that they be seeded >30 days before the first killing frost.

- **Spring/summer tarp application date:** Growth in spring is much more important than fall growth for biomass and nitrogen accumulation; in the mid-Atlantic, it takes two months of extra growth in fall to equal 10 days of extra growth in spring (Mirsky et al., 2011). Data from two years in New Hampshire and Maine illustrate the rapid growth that occurs in spring, first for rye and then for vetch. Allowing cover crops to grow to peak biomass (in full flower, but before seed set) before applying a tarp has many benefits including the greatest production of mulch leading to the highest weed suppression, and the greatest nitrogen fixation from the vetch. As with all tarping applications, soil moisture must be adequate when tarps are applied. In a dry season, it is possible that the growing cover crop will deplete soil moisture and irrigation may be necessary, but in a wet season this system increases flexibility because fields are accessible and no spring tillage is required.
- **Tarping duration:** The primary goals of tarping in this system are to terminate cover crops and suppress weeds. A secondary goal is to manipulate nitrogen availability. The duration of tarping required to meet these goals is tied to the time of tarp application and the amount of biomass produced and nitrogen fixed. In other words, earlier tarp application dates may require longer durations (>10 days) to terminate cover crops effectively and provide adequate weed suppression, while later termination dates require less time (<10 days). This is because cover crop termination is easier when air temperatures are higher and cover crops have reached anthesis, and weed suppression is increased with greater cover crop biomass—thus the system relies less on the effects of tarping itself to suppress weeds. Some farmers have reported applying tarps on very high biomass cover crops for 2-3 days in summer resulting in complete termination. As with other tarping applications, longer durations do lead to higher soil nitrate levels.

Effects and outcomes from cover crop-based rotational no-till with tarps

Weed suppression: This system has the potential to be highly weed suppressive, offering nearly season-long weed suppression and therefore eliminating or dramatically reducing the need for weeding during crop production. When cover crop biomass levels are low, however, additional in-season weeding is required unless density of the weed seed bank and bud bank are already very low.

Nitrogen: When incorporated, some cover crops with high C:N ratios like winter rye

The effect of mulch on weed suppression is illustrated by the weeds that emerged where mulch was removed (within white square) and where mulch was left in place. Photo: Natalie Lounsbury.

have been known to immobilize N, leading to greater fertilizer requirements. Leaving mulch on the soil surface, rather than incorporating the residue, changes nutrient cycling dynamics. Although research has not investigated the N dynamics of tarping winter rye alone, data have shown that tarping winter rye and hairy vetch bicultures leads to high levels of available nitrate (e.g. >20 mg kg-1) 20-30 days after tarp application.

Purslane emerging through rye residue in transplanted cabbage. The combination of low cover crop residue and the fact that purslane emergence appears to increase following tarping led to high purslane levels. However, purslane has been shown not to compete significantly with crops and can even be a living mulch. Photo: Natalie Lounsbury.

Drawbacks

Soil quality, the evenness and quantity of the cover crop stand, and the weed seed bank present are all important to consider before trying this system. Poor soil quality, especially on compacted high clay soils, can limit growth of the no-till planted cash crop. A sparse, uneven, or poorly growing cover crop will not provide adequate mulch and weed suppression throughout the growing season, even if weeds are terminated by the tarp. If there is a known soil quality or weed seed bank problem, it may be advisable to work to ameliorate these problems before attempting to implement a cover crop-based no-till system with tarps.

One of the drawbacks of this system is that if weed suppression is insufficient, mechanical cultivation is not possible because of the mulch present. Hand weeding can be—although it isn't always—more time consuming than in a tilled system, depending on the species present and moisture content. Because mulch increases soil moisture, weeds are often easy to pull by hand.

Some soils require additional soil-health building practices as well as drawdown of the weed seed bank and bud bank before implementing no-till practices, even when using tarps. Photo: Jason Lilley.

Compost applied at mulching rates helps bury weeds seeds in native soils. Cornell Thompson Vegetable Research Farm, Freeville, NY. Photo: Ryan Maher.

Read more about stale seed bedding with tarps and tillage on Earth Dharma Farm, ME, in Farm Case Studies (see page 29).

Continuous no-till with deep compost mulch and tarps

Introduction

A growing number of farmers are combining tarping with deep compost application, sometimes termed compost mulching, to help transition to a high-yielding continuous no-till vegetable production (Mefferd, 2019). Compost is a valuable soil amendment with many well-known benefits for soil health that provides a slow-release organic nutrient source for crops. Deep compost can quickly transform the native soil and form a layer of surface mulch that suppresses weeds and alters the soil's physical, biological, and chemical characteristics.

When used as a soil amendment to account for specific crop nutrient needs, typical compost application recommendations range from 10-20 cubic yards per acre annually, or approximately 1/10 inch. The deep compost no-till method uses compost in much higher quantities—often more than twenty times this rate— which can result in excessive nutrient levels that pose a pollution risk.

Tarping can provide several complementary benefits to a deep compost system. For example, tarping can create weed-free conditions for compost application and provide supplemental weed suppression to control weed escapes that emerge through the mulch. In this way, tarping may help advance this system by enabling farmers to use lower compost rates or reduce compost use over time. Given the nutrient-rich conditions, impermeable tarps can also help retain mobile soil nutrients that are at risk for leaching in the absence of a cover crop, especially in an overwinter application. Tarps can also facilitate high biomass cover crop adoption in this system, which some no-till farmers have been cautious to introduce without an effective termination strategy.

Weed escapes are still a problem in no-till compost mulch compared to beds where tarps have been applied over winter or in early spring ahead of planting. Cornell Thompson Vegetable Research Farm, Freeville, NY. Photo: Ryan Maher.

Effects and outcomes from tarping in deep compost mulch

Deep compost mulch can be used to bury weed seeds and reduce weed emergence though the effectiveness is likely dependent on compost application rates and the weed species present. Researcher and farmer experience in this system has shown that some weeds can persist, especially perennials, and that new weed seeds can also be introduced through the compost. When comparing a no-till compost mulch with and without tarping, research has shown that tarps significantly increase the effectiveness of this method by providing supplemental weed suppression for these weed escapes and saving hand weeding labor, primarily by killing living weeds prior to planting. Light, fine textured compost on the surface impacts soil tilth in ways that change the efficiency of hand labor tasks: some weeds are easier to pull and remove, and hand hoeing can be faster. Farmers have found that no-till transplanting by hand is easier in these systems, eliminating some planting constraints associated with surface compaction in no-till systems.

Compost applied annually at >1″ rate creates a new soil layer, quickly raising organic matter content and elevating soil nutrients beyond crop needs. Cornell Thompson Vegetable Research Farm, Freeville, NY. Photo: Ryan Maher.

Research from New York quantifying weeding labor costs, labor to handle and apply compost, and crop yields over four years, showed that including tarping with a deep compost no-till system can increase profitability. Importantly, tarping without the addition of deep compost also provided weed-free planting beds using equivalent labor, which suggests that tarping can reduce the quantity of compost needed for effective weed control. Applying manure-based compost at mulching rates (1.5″ annually) raised organic matter content in the surface soil (0-8″) at an average rate of 1% per year in New York and Maine, and increased no-till crop yields by as much as 25%.

Drawbacks

There are several constraints to farmer adoption of this system that center on heavy compost use. These include concerns over the high potential for nutrient loading, high compost cost and limited availability, and the time and labor associated with application. Nutrients are often imported at levels that far exceed crop demands, especially phosphorus and nitrogen with manure-based compost. Soil tests from farms using these systems have revealed phosphorus levels well above the optimum range. In research trials spanning four years, application of 1.5″ of compost annually increased soil test P levels eightfold—from below optimal to four times the upper optimal limit. High quality purchased compost can be prohibitively expensive and with growing demand, many farmers have reported difficulty procuring enough compost to meet their needs. Applying compost can also be challenging or highly labor-intensive for farmers that have limited labor or lack equipment for compost application. Read more about continuous no-till with deep compost mulch and tarps on Frith Farm, ME, in Farm Case Studies (see page 42).

Bringing sod into production

About half of farmers surveyed who already use tarps have used them to bring sod into production (Rangarajan, 2019). Details on the most efficient and effective methods are lacking and are likely highly site-specific, based on soil type, soil health, the living plants present, and the weed seed and bud banks. It is possible to transition some soils that have good tilth and organic matter straight into production without tillage, by terminating sod with tarps. However, compacted soils with low organic matter and poor tilth may require amendments like compost, some tillage, and soil building cover crops before making this transition. In the absence of perennial weed problems and a robust bud bank, it may be possible to terminate sod and weeds within 4-6 weeks. However, some farmers have found that nearly a full season (i.e. four months) of tarping is necessary. In any case, it is advisable to monitor weeds closely following sod termination to address any problems that emerge. The ongoing use of woven landscape fabric tarps when transitioning sod to perennial production is a related application that can help successfully control perennial weeds. Read more about bringing sod into production on The Farm Between, VT, in Farm Case Studies (see page 46).

Read more about bringing sod into production on Colfax Farm, MA, in Farm Case Studies (see page 33).

Overwintering for early season production

When tarping over winter, beds are prepared in late summer or fall and covered in preparation for planting the following spring. By excluding snowfall and spring rains, impermeable tarps can keep soils from waterlogging, increase soil temperatures by a few degrees, allow for early field access in spring, and retain leachable soil nitrate. Many farmers consider this as a major benefit, where these tarped beds serve as some of their first beds for spring planting. This can be especially valuable on fields with heavy, poorly drained soils. Overwintered tarps can also provide soil cover on bare ground after late fall crops when cover crop planting windows have passed. Tarping over winter suppresses winter annual weeds like chickweed that germinate in late fall and early spring, and gives spring greens and other early cash crops a head start. Despite these benefits, overwintered tarps can create headaches if not secured well or located on windy sites. They require a set of eyes on the field and will likely require adjusting in the absence of good snow cover and after periods of heavy wind.

Read more about overwintering for early season production on Edible Uprising Farm, NY, in Farm Case Studies (see page 35).

Read more about overwintering for early season production on Earth Dharma Farm, ME, in Farm Case Studies (see page 29).

Concerns with Plastic Use

Many farmers are rightfully concerned about the extensive use of plastic in agriculture. Farmers must determine for themselves whether the benefits currently outweigh the risks. Plastic manufacturing, use, and disposal all present environmental and health risks, some of which we are only beginning to understand. One of the best ways to reduce the environmental impacts of plastic tarps is to maximize their longevity and reduce plastic contamination in the field by storing tarps properly and minimizing holes and tears.

Low density polyethylene (LDPE), including silage tarps and greenhouse plastic, are recyclable, but polypropylene landscape fabric is not. Several states in the Northeast have implemented pilot programs for limited agricultural plastic recycling, but there is currently no widespread recycling program for these materials. For recycling success, plastic must be clean and uncontaminated with other materials (e.g. bailing twine). A successful recycling program in Minnesota takes agricultural plastic, including silage bunker covers as well as boat wrap covers. A similar model in Northeastern states may be possible in the future as LDPE recycling capacity increases. It is likely that very soiled tarps will never be acceptable for recycling programs, but many tarps used in the applications outlined in this guide remain relatively clean.

Unfortunately, there is very little information about some of the concerns farmers have expressed related to the potential for leaching from tarps. The toxic nature of PVC is one of the reasons billboard tarps have been disallowed in organic standards, while polyethylene and polypropylene products are allowed.

Conclusions

Tarping encompasses several valuable management techniques for different cropping niches on small farms. These techniques complement—but are not substitutes for—other soil health-building and weed management tactics. Increasingly important, tarping can help farmers adapt to climate change by regulating moisture dynamics and facilitating reduced tillage with or without high levels of residue. While the use of plastic in agriculture has drawbacks, tarping can provide some environmental benefits; specifically, retaining mobile nutrients like nitrate reduces nutrient pollution and reduces the need for fertilizer, and overwintering tarps can protect vulnerable soil from erosion when it is impossible to seed a cover crop.

Many questions remain regarding how different tarping practices and materials affect weeds, soil organisms, nutrient cycling, and labor and economics on the farm. Further work could refine best management practices that minimize the opportunity cost of tarping, while achieving specific weed, soil, or cropping system goals during our relatively short growing season in the Northeast. Additional research could further illuminate temperature, time, and light thresholds for seed mortality, fatal germination, and bud mortality of individual weed species, as well as the effects of tarp permeability (i.e. different tarp types), edge securement, and organic amendments on soil biological activity (including pathogens), gas exchange (i.e. oxygen levels), and nutrient cycling. Despite many remaining questions, there is ample evidence—both from farmer experience and research trials—that tarping holds promise for multiple applications on small farms in the Northeast.

Farmer Case Studies

- **Earth Dharma Farm ME —** Stale Seedbedding with Tillage and Tarps
- **Colfax Farm MA —** Breaking Ground: Bringing Sod into Production and No-till Bed Management with Tarps
- **Edible Uprising Farm NY —** Overwintering Tarps: Cover Crop Based Tarping with Minimum Till
- **Evening Song Farm VT —** Cover Crop-based Rotational No-till with Tarps
- **Frith Farm ME —** High Input No-Till Permanent Raised Beds
- **The Farm Between VT —** Breaking Sod and Weed Management in Perennial Fruit Crops with Tarps

Earth Dharma Farm ME — Stale Seedbedding with Tillage and Tarps

Farm Information

- **Farmers:** *Dave McDaniel and Heather Selin*
- **Farm Name:** Earth Dharma Farm
- **Location:** Jackson, M.
- **Total Acres and Crops Produced:** On their 182-acre farm, there are 160 acres of managed woodlot, 7.5 acres of hay, 2 acres of vineyard, 1.5 acres of mixed vegetables. The primarily marketed vegetable crops include spinach, tomatoes, peppers, eggplants, and garlic.
- **Soil Type and Water Dynamics:** Very well-drained, sandy loam. However, previous to Dave and Heather purchasing the land, much of the topsoil was removed during stump removal.
- **General Equipment Use:** 32 HP Kubota for breaking sod, primary (subsoiler, disk harrow), and secondary tillage (Kuhn 5′ tiller).

Earth Dharma Farm owners Dave McDaniel and Heather Selin in a high tunnel pepper crop.
Photo: D. McDaniel, Earth Dharma Farm

- **Field Layout:** Earth Dharma Farm is set up with permanent beds where possible. However, there is ledge that makes it tough to make long contiguous stretches. Plots are 50′ x 100′ long (1/10 acre) for most fields. Beds are 5′ on center with 42″ bed tops.

Tarping Goals and System

- **Goals of Tarping:** In 2015, Dave attended various workshops and lectures by Brian O'Hara, Ray Archuleta, and Mark Hutton that all pointed him in the direction of using tarping to reduce tillage and control weeds. The weed seedbank on the farm was so bad that they were ready to abandon certain crops such as spinach. Dave looks at tarping as an integral tool to reduce soil disturbance, therefore building soil organic matter, and leaving weed seeds buried. It has also been critical to reduce the weed pressure and allow for successful production of spinach and garlic crops.

One piece was cut too short, leaving 8 bed feet untarped. Despite flame weeding that untarped section 3 times, the tarped section was significantly less weedy. The next year Dave went all in.

- **Early Uses of Tarps:** Their early goal with tarping was to fully eliminate tillage. In the first season, Dave picked up two odd-shaped bunker tarps. He cut a few to 32′ x 100′ then cut others for individual beds. One piece was cut too short, leaving 8 bed feet untarped. Despite flame weeding that untarped section 3 times, the tarped section was significantly less weedy. The next year Dave went all in.
- **Current Crops and Systems:** When Earth Dharma Farm started transitioning to using tarps, they were highly diversified. So much so that Dave was concerned about the profitability of many of their enterprises. While transitioning to fitting tarps into the rotation, it was an ideal time to scale back and focus on fewer crops. Now Dave preps beds in the fall, tarps overwinter, then direct seeds spinach into those tarped plots. Tarps are also used to prepare beds for garlic with minimum tillage.

Tarp Details and Management

- **Years Tarping:** 5 (Started tarping in 2016).
- **Source of the Tarps and Lifespan:** Paris Farmers Union. Two of their tarps are 5 years old, two are 4 years old, and two are 3 years old. If tarps are kept in full pieces and mice, deer, and goshawks are managed, Dave believes that you could easily get 6-10 years out of these tarps. (While Dave appreciates the goshawks controlling rodents, their talons did a number on one of his tarps one season).
- **Tarp Material:** 6 mil white on black silage tarp. Tarps are used black side up.
- **Tarp Size:** Tarps are kept in 50′ x 100′ sheets.
- **Securing Method:** Dave started using sandbags, but didn't like the additional use of plastic. Now they utilize 16″ x 8″ x 8″ cinder blocks every 6′ and have t-posts along the entire edge. They don't put anything in the middle of the tarps.
- **Storage:** Throughout the season, the tarps are folded down the field a few beds at a time. By the end of the season, the tarps are rolled up, parallel to the bed at the bottom of the field. They will usually leave them there in a "sausage roll." Occasionally they would fold it a few times but they have found that when the tarps are less folded, they've had reduced rodent presence and damage.

Specific Applications and Management

- **Fitting Tarps into the Rotation:** Dave uses tarps to prepare spinach throughout the season and for garlic beds. They also use them for the mixed veg homestead use plot. He aims to get the tarps down at least 1 month prior to seeding. In early seeding plots, the tarps go on as soon as the snow is off.
- **Pre-tarping Practices:** For garlic beds, Dave mows the summer cover crop, spreads compost that they make on the farm, shallowly tills to incorporate the amendments and form beds, then tarps for at least 4 weeks. For early spring spinach plantings, they prepare and amend those beds in the fall with compost additions, then Dave puts down the tarps either overwinter or as soon as the snow is off of the fields in the spring.
- **Timing and Duration:** Summer crops and garlic plots are tarped for at least 3 weeks but ideally 4. In the early spring, tarps are applied when the last snow is off the field. At this point in the season, 6 weeks is the minimum that Dave would leave the tarps on due to the short days and cool temperatures. In his system of slowly rolling the tarps back, bed by bed with every 10-day succession planting, he sees significantly better weed control with his second, and especially his third and onward successions.
- **Post-Tarp Crop Establishment and Management:** Dave rolls back the tarps a few beds at a time. For early spinach, he transplants early plantings, but primarily uses a Jang Seeder to direct seed into the tarped plots. Garlic seed is also placed by hand into the tarped soil with no other tools.
- **Amendments Critical to the System:** They use 20,000 to 40,000 lb of farm-made compost per year over the 1.5 acres. This roughly equates to 15-25 yards per acre.
- **Labor Demands of the System:** The biggest savings with this system is in the reduced labor spent weeding. After

Field of spinach that has been uncovered bed by bed throughout the season. Note the "tarp sausage roll" on the left, leaving one bed to be uncovered for the next succession planting.
Photo: D. McDaniel, Earth Dharma Farm

A tarp under the late winter snow. This overwintered tarp will allow for additional tarp time prior to the first spring crop. Photo:
Photo: D. McDaniel, Earth Dharma Farm

tarping, they only make one quick pass with a hoe. Prior to tarping, they were still losing some crops to weeds after flame weeding and hand weeding several times.

- **Material and Equipment Modifications:** Prior to tarping, Dave and Heather started transplants for most plantings in an attempt to beat the weeds. After seeing the weed control from tarping, they invested in a Jang seeder and significantly cut back on transplanting.

He has effectively controlled “12 of his 14 weed species” with tarps. That means that he still has issues with crabgrass and lambsquarters. So, while tarping has significantly reduced weeding labor needs, and helped improve soil health, it isn’t a complete silver bullet. It requires a different level of management.

Takeaways, Mistakes, and Big Wins

- **Failures, Unintended Consequences, and Adjustments:** Dave gives the practice of tarping a solid ‘B’ rating. It’s a solid tool that fits in well with commercial vegetable rotations, especially with our cold New England spring soils. He has effectively controlled “12 of his 14 weed species” with tarps. That means that he still has issues with crabgrass and lambsquarters. So, while tarping has significantly reduced weeding labor needs, and helped improve soil health, it isn’t a complete silver bullet. It requires a different level of management.
- **Measures of Success:** The reduced weed pressure has allowed Dave to continue and expand his spinach market, which he was ready to walk away from prior to tarping. Being able to direct seed has greatly reduced labor and inputs, resulting in increased profitability of that enterprise. Dave has also seen improved soil health due to the reduction in tillage.
- **Future Experimentation and Adjustments:** Dave and Heather are planning to try some different approaches to manage crabgrass. Potentially tarping for 2 or 3 weeks, removing the tarp for 5 days, then reapplying. They may also try removing the tarp 2 weeks prior to seeding the crop and flaming the bed prior to seeding.
- **Lessons Learned:** Tarps need to be taken care of to be effective. Prevent deer from walking over the tarp and tearing it, and use rodent deterrents.
- **Advice for New Tarpers:** Don’t cut your tarps too small. Working with larger sheets is more efficient, easier to hold down, and holds heat better. Start small and see what works for your system.

Dave and Heather are planning to try some different approaches to manage crabgrass. Potentially tarping for 2 or 3 weeks, removing the tarp for 5 days, then reapplying. They may also try removing the tarp 2 weeks prior to seeding the crop and flaming the bed prior to seeding.

Colfax Farm MA — Breaking Ground: Bringing Sod into Production and No-till Bed Management with Tarps

Farm Information

- **Farmer:** *Molly Comstock*
- **Farm Name:** Colfax Farm
- **Location:** Alford, M.
- **Total Acres and Crops Produced:** Three acres in mixed veg production and expanding.
- **Soil Type and Water Dynamics:** Well drained river valley silt loam.
- **General Equipment Use:** The tractor is used only for breaking ground by moldboard plowing then rototilling. After the initial opening of the sod, all management is done with hand tools: Broadfork, Jang, and Earthway.
- **Field Layout**: Each field section contains 12 to 15 beds each with 30" wide bed tops x 100' long. It takes 3 tarps to cover 1 section.

Tarping Goals and System

- **Goals of Tarping:** At the farmland, Molly was on before her current location, she used conventional tillage (plowing, discing, rototilling beds) and lots of plastic mulch. Weeds were out of control and they were concerned about the farm's productivity, degrading soils, and sustainability. Molly sees tarps as a bed saver and weed suppressor and has used them to help move the farm towards practically zero tillage. Tarps hold beds between crops, help residue decay, and also cover beds that have gotten real weedy that they can't deal with at the time.
- **Early Uses of Tarps:** When opening new ground at the new farm in 2017, Molly used a moldboard plow, followed by the tractor-mounted rototiller to incorporate and break up the sod. After tilling the crew would apply the tarp to help break down the sod and flush weeds out of that newly opened ground.
- **Current Crops and Systems:** Since that time, tarping has become more of a bed preparation tool to kill crops and decompose residue over a 3 to 4 week tarped window before planting the following crop. They have also recently tried breaking new ground with only tarps, and no tillage. This involves applying the tarp over old hay ground, leaving it for an entire year, and then no-till planting a cover crop (cereal rye) directly through the tarped zone in the late fall.

Tarps hold beds between crops, help residue decay, and also cover beds that have gotten real weedy that they can't deal with at the time.

Tarp Details and Management

- **Years Tarping:** 4 seasons — since 2017.
- **Source of the Tarps and Lifespan:** Ground cover tarps from Rainflow have held up since initially purchasing them in 2017.
- **Tarp Material:** Woven (polypropylene) fabric.
- **Tarp Size:** 12' x 100' long.
- **Securing Method:** 11" ground staples.
- **Storage:** Tarps are folded, and stored in the field. They have not had any rodent problems from this approach.

Specific Applications and Management

- **Fitting Tarps into the Rotation:** Tarps are used throughout the growing season. All direct seeded crop beds get tarped prior to seeding (carrots, beets, salad greens, etc.) For most transplants, tarps have, or get holes burnt into them for planting into and they are left in place throughout the growing season. Molly incorporates the time needed for tarping into her planning, especially for crops that can have the biggest weed issues.
- **Pre-tarping Practices:** Tarps are typically applied directly over crop residue from the previous crops without tillage. For example, in Mid-June prior to Fall Carrots, tarps go directly over crop residue of the April-planted mustard greens, radish, and turnip crops. If larger, stalky brassicas were there prior to tarping, the stalks are cut below the soil surface.
- **Timing and Duration:** Tarps are typically left on the field for 1 month between crops.
- **Post-Tarp Crop Establishment and Management:** After removing the tarp in July, the crew will rake the beds to remove residue, if needed, broadfork, add amendments (Krehers or compost, see below), and often just rake to smooth. They then plant carrots. After the carrot harvest, they often reapply tarps overwinter, and plant greens (e.g. spinach) in spring.
- **Amendments Critical to the System:** Molly and the farm crew apply ten 5-gallon buckets of compost per 2.5′ wide by 100′ long bed. That's about 15-20 tons per acre per year.
- **Labor Demands of the System:** Molly prefers woven fabric tarps to silage tarps because she finds them easier to move and secure. Molly and members of the crew can do it themselves if they need to, and it's really easy with two people. It takes 20 minutes to move tarps and staples from one spot to the next. The crew is moving tarps all the time, 2-3 per week. If weeds get out of control and "beds are going to be a nightmare" they just tarp it and hold it. They are always moving tarps across the farm. This system "adds flexibility, saves beds."
- **Material and Equipment Modifications:** Molly is still looking for the right tool for very shallow tillage when they need it. A tilther hand tool worked at first but didn't hold up with the residue and soil conditions. They are currently sticking with a landscape rake, which gets the job done.

In fields that have been tarped the longest (three years) they are finding that broadforking is not necessary as things are loosening up. They note that the "soil is a pleasure to work in" and less physically challenging to work.

Takeaways, Mistakes, and Big Wins

- **Failures, Unintended Consequences, and Adjustments:** Colfax Farm still has some problem weeds, primarily nutsedge, in both beds and pathways. They also have a lot of rodent activity under the tarps, and are hoping for predators! When nutsedge was really bad after spring brassicas, they just tarped that plot and kept it on for the season, choosing to not plant until the following year.
- **Measures of Success:** Soils: In fields that have been tarped the longest (3 years) they are finding that broadforking is not necessary as things are loosening up. They note that the "soil is a pleasure to work in" and less physically challenging to work. They are avoiding compaction from

tractors and the lack of tractors in the system allows for just " humans in the space," where the field feels like a natural space to be. Pests: They have significantly less weed pressure. Nutsedge and galinsoga are still big problems; however, the overall weed pressure is significantly reduced due to the tarping. Labor: Molly appreciates the flexibility that tarps offer, knowing beds are covered, and not feeling the pressure to deal with weedy beds before they set seed — just tarp it.

- **Future Experimentation and Adjustments:** Molly would like to trial different approaches and adjustments to get better control of weeds that are surviving the tarping. Potentially watering before tarping, flaming, or other ways to get on the weeds.
- **Advice for New Tarpers:** "Staple it to keep it down! Don't think you're not going to have weeds. It's not magic, but it is magic! Sometimes the soil is so nice."

Edible Uprising Farm NY — Overwintering Tarps: Cover Crop Based Tarping with Minimum Till

Farm Information

- **Farmers:** *Ben Stein and Alicia Brown*
- **Farm Name:** Edible Uprising Farm
- **Location:** Troy, NY
- **Total Acres and Crops Produced:** Edible Uprising Farm intensively manages 1 acre to produce mixed vegetables, herbs, and cut flowers.
- **Soil Type and Water Dynamics:** Very General Equipment Use: Ben and Alicia utilize a BCS rotary plow for paths and building beds, a BCS precision depth roller set shallow, and a 40 HP Kubota with bucket.
- **Field Layout:** 12 plots that are 60ft wide x 50ft long. Each plot is made up of 15 permanent beds, which are 4′ on center with 30″ bed tops.

Tarping Goals and System

- **Goals of Tarping:** Ben and Alicia's main goal on the farm is to keep the ground covered and use tarps along with mulch and cover crops to do that. Their objectives with tarping are to:
  1. Terminate cover crops, like winter rye in the spring, prior to anthesis.
  2. Regulate soil moisture to optimize planting windows (protect from storms). For example, fall prep beds and tarp overwinter for early spring planting.
  3. Protect soil when mulching or cover cropping is not an option.
  4. Break ground with minimal tillage.
  5. Reduce weeds with minimal labor input (only two full-time crew).

Farmer Ben Stein inspecting the recently untarped beds of cover crop residue. Photo: Alicia Brown.

- **Early Uses of Tarps:** Edible Uprising Farm broke ground in their first year without access to a tractor or equipment. Instead, they used tarps to break down perennial cover. The land was a hayfield prior to them jumping in that spring. They mowed the field, laid out blocks, rotary plowed, tarped for 3 weeks, rotary plowed again, tarped, then formed beds. They made the decision to get into the land quickly and had mixed results, mostly due to the tarps needing to be on longer. That year was a "weeding nightmare," except where they tarped for 4 months before fall planting, where it worked beautifully.
- **Current Crops and Systems:** Some of the systems that tarps accommodate are killing overwintered cereal rye and preparing for no-till direct seeding cucurbit and tomatoes. Also, terminating successions of greens, and preparing beds for early small seeded crops.

Tarp Details and Management

- **Years Tarping:** 3 years — started in 2018.
- **Source of the Tarps and Lifespan:** 3 years so far, still using original tarps acquired in 2018.
- **Tarp Material:** 5 mil polyethylene silage tarps.
- **Tarp Size:** Various sizes are used to fit different applications. They started with three 32′ x 100′ tarps and one very large tarp (400′ x 60′), acquired from a neighboring dairy farm, that was cut down to size. Now they have one 50′ x 60′ sheet to cover whole plots, two ½ block pieces that are 50′ x 30′ each, and two 10′ x 50′ pieces to cover two beds at a time and make them more flexible. All tarps are and need to be a couple of feet wider than the bed width.
- **Securing Method:** Ben and Alicia secure tarps with sandbags and t-posts to create as strong of a seal as possible. On 10′ x 50′

Fall time preparation of the beds. These beds have just been seeded with winter rye, the seed was incorporated with a precision depth roller, and leaves are added to the paths. Photo: Alicia Brown.

Various blocks and sizes of tarps across Edible Uprising Farm. Photo: Alicia Brown.

tarps they place sandbags every 10′ along the sides with t-posts in between. On larger pieces, they place sandbags every 4′ to 5′ on windy spots of the farm, and every 8′ to 10′ around protected plots.

- **Storage:** Large tarps are on the fields overwinter. All of the tarps are folded the same way, with the dimensions clearly labeled for easy selection.

- ## Specific Applications and Management

- **Fitting Tarps into the Rotation:** Tarps are left on the plots overwinter for the earliest planted crops like onions and greens. Beds seeded to cereal rye get tarped in spring prior to planting cucurbits and tomatoes, which serves to terminate the cereal rye cover crop. Tarps are also used by the farm to hold beds after summer cover crops, like buckwheat, until seeding fall crops or cover crops.

> The main reason Edible Uprising does bed prep and tarps in the fall is to relieve the spring workload. Prepping beds in the spring was a huge workload and doing as much as possible in the fall helps.

- **Pre-tarping Practices:** Between mid-September and mid-November, Ben and Alicia shape beds and amend with the annual application of compost (see ‘Amendments’ below). Rye is then broadcasted by hand on the bed tops only, at a rate of about 4 gallons of seed per 50′ x 60′ block), followed by a pass with the precision depth roller. The paths are mulched with leaves. In the spring, they mow the rye when it’s knee high although this may not be needed.

Cucurbit seedings emergening through the tarped winter rye residue with leaf mulch in the aisles. Photo: Alicia Brown.

- **Amendments Critical to the System:** Ben and Alicia get their compost from a dairy farm; applied at a rate of 50 yards per acre. They use leaf mulch for pathways sourced from a local landscaper. Krehers chicken pellets are surface applied and additional fertility is added through fertigation (Natures Source). They would like to use more leaf-based compost. Their driver for using compost is mostly for organic matter addition, for water retention and soil biology, to improve the health of their sandy soils.

- **Timing and Duration:** Tarps are applied in late April for at least 3 to 4 weeks. If the following crop can wait and go in in June, they will wait to tarp to maximize the amount of rye biomass, still leaving the tarp on for 3 to 4 weeks.

- **Post-Tarp Crop Establishment and Management:** After removing the tarp, Ben and Alicia transplant into the soil. If needed, they will make a furrow with a hoe first. However, the tilth of the soil is good enough that they often do not need to work the soil to facilitate transplanting. They also lay drip tape on the soil surface when transplanting. For their early spring plantings, they have to plan out what plots will be utilized for those crops the fall before, and apply tarps in fall to hold those beds. For onions, Ben and Alicia apply compost and krehers to the beds and leaves in the path in the fall. They then use a precision depth roller to incorporate that material into the top couple inches, and tarp. In the spring they pull back the tarp, broadfork if needed as there can be compaction, rake it out, and plant.

- **Labor Demands of the System:** When they first started, Ben and Alicia came in with a mentality from larger farms. Initially, they did transplants all on plastic laid by hand, including the drip tape. The work and the waste were too much. It has been much easier to move the tarps than to lay that mulch, not to mention the weeding labor savings. They also make the extra effort to remove weeds going to seed, which helps keep weed pressure low.

> Standardized sizes are really important, making sure that tarps fit your blocks and beds. Make sure to always include a little extra length to account for the raised beds and overhang for sandbags and securing.

Takeaways, Mistakes, and Big Wins

- **Failures, Unintended Consequences, and Adjustments:** While minimal, Ben and Alicia have found some compaction in the overwintered beds. This is easily counteracted by broadforking if needed. They have never needed to broadfork the rye planted plots. With the high amount of dairy-based compost additions, their phosphorus levels are very high. They are trying to adjust their compost source to get more leaf-based compost and rethink the overall fertility program. Tarps slipping out of the sandbags in the winter is another hurdle; they are planning to just add more sandbags for future overwintered applications. In a colder spring, they took the tarps off of the rye to find it still alive despite the transplants being ready to go into the ground. Finally, rodents and grub populations are very high and are attributed to the use of tarps. Hopefully Yuki the farm dog can keep the voles in check.
- **Measures of Success:** Adjusting the time crunch — due to this being the only system used at this property, it is hard to compare what the land could produce without tarps. However, weed management, particularly after a cereal rye cover crop, has been great. They typically just need one quick pass with the colinear or stirrup hoe per crop. The main reason Edible Uprising does bed prep and tarps in the fall is to relieve the spring workload. Prepping beds in the spring was a huge workload and doing as much as possible in the fall helps.
- **Future Experimentation and Adjustments:** Last spring Edible Uprising decided to plant a couple beds to peas/oats. They let that grow until mid-May, then weed whacked the plot, and tarped two 10′ x 50′ beds for 3 weeks. They are still tweaking this variation on the full winter cereal rye system.
- **Lessons Learned:** Most of the failures and runaway problems that they expressed were due to not leaving the tarps on for long enough. They are also improving how they seal tarp edges to keep the tarp down. This is particularly important with small tarps. Standardized sizes are really important, making sure that tarps fit your

blocks and beds. Make sure to always include a little extra length to account for the raised beds and overhang for sandbags and securing.

- **Advice for New Tarpers:** "Recognize your goals and follow through. Don't be afraid to try tarping winter rye even if the rye is not at full size. We've seen benefits from rye even if planted late. One part of the problem is not getting the rye seeded early enough in fall, like October into early Nov. Our goal is not to maximize productivity (on each square foot of land). If it was then we wouldn't do it this way."

Evening Song Farm VT — Cover Crop-based Rotational No-till with Tarps

Farm Information

- **Farmers:** *Ryan and Kara Fitzbeauchamp*
- **Farm Name:** Evening Song Farm
- **Location:** Shrewsbury, VT
- **Total Acres and Crops Produced:** 4 acres of mixed vegetables with 3 High Tunnels.
- **Soil Type and Water Dynamics:** Somewhat poorly drained, rocky silty loam with a hardpan about 18" down. Much of the farm is on a 4 to 8% slope. They have installed swales every 40′ down the slope to slow and divert water.
- **General Equipment Use:** 45 HP tractor for field operations and a BCS with power harrow which is mostly just for use in the high tunnels.
- **Field Layout:** Most of the plots on the farm are 40′ x 120′ long. Beds are semi-permanent. Since each field is limited to 40′ wide, wheel tracks remain consistent from one year to the next. Bed tops are 4′ wide.

Tarping Goals and System

- **Goals of Tarping:** Tarps allow them to achieve complete kill of seed setting weeds that mowing or tilling doesn't completely kill. The new layout of their plots to accommodate tarping also allows for better water management. Tarping has allowed them to reduce tillage, ultimately improving soil structure. A goal of the no-till rolled rye-vetch plots is to grow N to reduce imported nutrients, however, they are still working on making that goal a reality.
- **Early Uses of Tarps:** Early uses of the tarps involved putting tarps down to prepare the first planting of greens and again between successions of greens. At that point, they were growing in permanent beds with permanent sod pathways which complicated tarp placement and use.
- **Current Crops and Systems:** In addition to the greens successions, late season crops like cucurbits and fall brassicas have worked well in the high residue cover crop no-till tarped system.

Tarp Details and Management

- **Years Tarping:** 4 years — since 2017.
- **Source of the Tarps and Lifespan:** They are still using their initial tarps from Nolts Greenhouse Supplies
- **Tarp Material:** Black Ultraweb polypropylene tarps (landscape fabric, however it is lighter weight than traditional landscape fabric).
- **Tarp Size:** 40′ x 120′ long
- **Securing Method:** Sandbags are used. The spacing depends on the season and windiness. During the main season bags are placed every 8′ on the edges, and every 15′ in the middle. More are used for overwinter and spring (windy season) applications.

- **Storage:** Tarps are stored rolled up into tubes. Ryan has noticed that rodents are really attracted to this roll, but hasn't figured out a good way to deter them. Some tarps have gotten holes chewed through, but these small holes don't easily get ripped larger and the tarps still work effectively with some holes.

Specific Applications and Management

- **Fitting Tarps into the Rotation:** Ryan and Kara's high residue cover crop tarping system requires more planning, for tarping in the rotation. Traditionally, they would mow and incorporate a cereal rye cover crop between mid-May to mid-June, followed by multiple passes of a chisel plow and rototiller to sufficiently incorporate the residue. With tarping, the cover crop may be rolled and tarped as early as June 1, with two weeks of tarping necessary to sufficiently terminate the cover crop. Planting occurs from June 15 through early August.
- **Pre-tarping Practices:** After planting a cereal rye / hairy vetch mix in September of the year before, they use a tractor bucket floating on the ground to flatten the cover crop in early to mid-June of the following spring. At that point in the year there is substantial growth of the cover crop, so getting that knocked down and in closer contact with the soil is key. The tarp is pulled over the cover crop immediately after knocking it down.
- **Timing and Duration:** In year one of trialing managing cover crop residue with tarps, they used a clear plastic tarp for the first week. This killed the cover crop, but not the germinating summer annual grass weeds. They swapped that out for the black woven tarp for another week and a half and got excellent control of the weeds. Ten days of tarping with a woven black tarp is sufficient to kill the cover crop, but longer tarp applications tend to correlate with better weed suppression.
- **Post-Tarp Crop Establishment and Management**: After removing the tarps from the high residue system in July, Ryan will broadcast pelletized fertilizer over the surface of the residue and soil. Three 20" wavy coulters are pulled through the residue to mark rows and loosen a slot to plant, and fall brassica and cucurbit transplants are put in. They attempted to plant directly into the soil, but the compaction created very slow transplanting conditions.
- **Amendments Critical to the System:** 18 yards of compost over one 40' x 120' zone used experimentally (about 2" thick).
- **Labor Demands of the System:** In their early trials with this practice they have almost completely controlled annual weeds in the system, and can usually achieve excellent weed control with a single quick hand weeding. While transplanting was somewhat slower than transplanting through a tilled bed, the development of a tractor-mounted coulter system has improved transplanting speed dramatically.
- **Material and Equipment Modifications:** Evening Song Farm has almost completely adjusted the layout of the farm fields to accommodate their tarp sizes, while simultaneously creating better water runoff management. The uniform dimensions of their plots allow for easier

Three 20" wavy coulters are pulled through the residue to mark rows and loosen a slot to plant, and fall brassica and cucurbit transplants are put in.

rotation and eliminate the need to sift through different sized tarps. They have utilized their tractor bucket in a unique way, which did not require any modifications. In order to better facilitate transplanting, they have experimented and developed a tool bar with two rows of 20” fluted coulters. In its first season, it has worked well. .

Takeaways, Mistakes, and Big Wins

- **Failures, Unintended Consequences, and Adjustments:** Ryan and Kara are working on figuring out nitrogen and fertility issues related to the compost source they are using. Where fertilizer is not incorporated in the high residue system, they are interested to see how that affects availability. These systems also affect the ease and speed of transplanting. Due to transplanting being slowed so much in the first year of the system, crew morale was low. If the plot was any bigger it would have worn on spirits. The implementation of the coulter strip-tiller has sped up the process to be comparable in ease to a fully tilled system.

The uniform dimensions of their plots allow for easier rotation and eliminate the need to sift through different sized tarps.

- **Measures of Success:** They have seen big improvements to soil structure from their amendment additions as well as the big reduction in tillage. On sloping soil, it is highly advantageous to have a cropping system that reduces tillage and can accommodate very high levels of residue on the soil surface. The reduction in labor spent on weed management, paired with equal or higher crop yields show a real potential for elevated profitability with this system. Ryan and Kara also use tarps in a minimum till system for greens succession plots and have found the best weed control is achieved by preparing beds at least three weeks in advance of planting, tarping for about two weeks, uncovering the tarp, leaving the soil for 10 days, and flame weeding immediately before seeding.

The coolest toolbar in the Northeast with 3 wavy coulters trailed by repurposed injector knives. This implement is pulled through tarped winter rye residue to improve transplanting of fall brassicas and cucurbit crops. Photo: Ryan Fitzbeauchamp.

- **Future Experimentation and Adjustments:** Ryan and Kara are thinking about planting sudangrass in the late summer to facilitate early spring tarping and no-till planting for earlier season crops. They are also considering mounting a drop spreader on the coulter toolbar to apply fertilizer directly in the row, rather than broadcast over the field.
- **Lessons Learned:** While these systems can make good progress at addressing production problems associated with excessive tillage on small-acreage systems it still has some drawbacks. Perennial weeds need particular attention in

reduced tillage systems. They can become particularly problematic if they are not controlled before seeding the rye-vetch cover crop. The benefits of the high-residue no-till system may be diminished with high weed seedbanks, as mechanical cultivation is not an option. Having straw mulch ready to spread if weeds are germinating has proved to be effective. They have also had to adjust and get creative to overcome transplanting concerns due to compaction. Their creativity and adaptability have allowed them to make these simple adjustments to make the system work.

- **Advice for New Tarpers:** "Just try on a 1/10 acre and see how it goes. Start small and give it a shot. Grow some rye, tarp, and throw in some fall brassicas."

Frith Farm ME — High Input No-Till Permanent Raised Beds

Farm Information

- **Farmer:** *Daniel May*
- **Farm Name:** Frith Farm
- **Location***:* Scarborough, ME
- **Total Acres and Crops Produced:** 3 acres of mostly mixed organic vegetables with some herbs, flowers, and fruit.
- **Soil Type and Water Dynamics:** Very flat, loamy sand with a seasonal high water table. Wet in the spring, droughty mid-season. After many seasons of intensive purchased compost, leaf mulch, and cover crop applications, they are mostly utilizing built soil over the native soil.
- **General Equipment Use**: Mostly human power. A 35 hp tractor with a loader, primarily only used to load wheelbarrows and to pull a subsoiler and a bush hog for field edges. A BCS is the primary tool for growing areas with a flail mower and rotary plow for opening fields and making raised beds. They also use a weed wacker, riding lawn mower, and many hand tools.
- **Field Layout:** The farm is divided into 16 plots, each one being 12 permanent beds that are 5′ on center x 100′ long. One-third of the farm is cover cropped each year for some duration. Depending on the plot that may just be for the fall or spring.

> They have seen big improvements to soil structure from their amendment additions as well as the big reduction in tillage. On sloping soil, it is highly advantageous to have a cropping system that reduces tillage and can accommodate very high levels of residue on the soil surface.

Tarping Goals and System

- **Goals of Tarping:** Daniel uses tarps primarily as a termination strategy for crops, cover crops, and weeds. He appreciates the efficacy of tarps as a tool for managing beds without tilling and tillage equipment. The tarps function as a reset or pause button as opposed to constantly chasing after weeds. They also function as a placeholder; when the beds are not being cropped, tarps hold nutrients and suppress weeds. After significant additions of amendments to build soil since the inception of the farm, the farm has mostly buried their weed seed bank. This, in combination with tarping, creates a very clean environment. What weeds do show up are easily pulled by hand.

- **Early Uses of Tarps:** Early on, tarping on Frith Farm was used as an emergency response, pausing weed growth. It was less a part of the full crop plan and just plugged in where weeds were getting out of control. They were not connected to cover crop management at all.
- **Current Crops and Systems:** Tarps are now used as a central component of the soil health plan on the farm. Tarps are utilized between plantings of salad greens to disrupt weed and crop growth, as well as to terminate cover crops, without disturbing soil. The current system goes far beyond the early approach of just trying to maintain a semblance of control.

Tarp Details and Management

- **Years Tarping:** 7 years – since 2014.
- **Tarp Material:** Initially, the farm had invested in 11-millimeter (mil) used billboard tarps. After the National Organic Program (NOP) disallowed the use of polyvinyl chloride (PVC) materials, the material used to make billboard tarps, Daniel switched to 6 mil polyethylene silage tarps, black side up.

Palletized "tarp kits." On each pallet the crew stack the 30 concrete blocks followed by the folded 24′ x 100′ tarp. These kits are left next to the field where they will be deployed next.
Photo: courtesy of Frith Farm.

Tarps are now used as a central component of the soil health plan on the farm. Tarps are utilized between plantings of salad greens to disrupt weed and crop growth, as well as to terminate cover crops, without disturbing soil.

- **Source of the Tarps and Lifespan:** He sources these new tarps from Johnny's Selected Seeds. He has used both styles of tarps for 3 years each and neither has begun to break down. Crop stubble can be a concern, particularly if you walk over the tarp. There are some small holes appearing, mostly from rodent damage during storage.
- **Tarp Size:** 24′ x 100′ sheets cover four 5′ wide beds at a time. The raised beds and excess on either edge for securing the tarps requires a few extra feet.
- **Securing Method:** Each tarp section gets 30 8″ x 8″ x 8″ concrete blocks. They stack well in storage, grab the tarp well, and last forever. Daniel is not a fan of sandbags due to how annoying the filling process is, how the plastic degrades, and the fact that they don't stack easily.
- **Tarp Storage:** Daniel has a system of palletized tarp "kits". On each pallet, they stack the 30 concrete blocks followed by the folded 24′ x 100′ tarp. Those pallets are stored outside.

Specific Applications and Management

- **Fitting Tarps into the Rotation:** There are two distinct ways that the farm uses tarps. The first is between successions of salad greens. The tarp is added to the field for between one day (during hot long days) to a week to kill crop residue and weeds, and to prepare the bed for the next succession without tillage. Successions are planted every week for greens. Having plots next to each other allows the crew to just drag the tarp sideways to the next set of beds. Tarps are also used to terminate overwintered cover crops, usually cereal rye in late May or early June. Two to three weeks of tarping leaves a nice mulch to transplant through. The tarp durations are scheduled into the crop rotation plan.
- **Pre-tarping Practices:** After a light spring application of fertilizer for salad greens, future successions are not fertilized. That early fertilizer is broadcasted and raked in, or buried with an inch or two of bark mulch. Bed prep for the overwintered cover crop fields involves raising the beds as needed prior to planting rye, however that is usually only done every 4-5 years. Fertilizer is applied before seeding fall cover crops.

High amounts of compost, bark mulch and other organic ammendments have been added to the fields. This high organic matter system in combination with tarping significanly reduces weed pressure. Photo: Jason Lilley.

- **Amendments Critical to the System:** Early on, compost was critical. Now that nutrient levels (specifically phosphorus) are elevated, sifted bark mulch is used as a mulch that can be seeded into directly. Other mulches used include leaves, straw, peat moss, and wood chips. Organic fertilizer is also applied according to a soil test.
- **Tarping Process Details:** The crew uses the tractor with forks to drive the "tarping kit" pallet to the field. The crew drags the tarp out and places blocks every 8 feet with a few blocks in the middle. The pallet is left there so it's ready after the tarping process. The wind needs to be pretty intense to cancel application. These 6 mil tarps are heavier and easier to apply in wind compared to row cover.
- **Timing and Duration:** The amount of time that the tarp stays on the field depends on what's growing there. After arugula, tarps are left for just a week in early fall. If there are established weeds, they might leave it for 2 to 3 weeks. Mid-season salad greens successions may only get tarped for 1 day to a week depending on the time of year (warmer and longer days = less tarping time). The farm does not have a perennial weed problem, which would require longer tarping durations. Longer durations (one month^{+}) are only used when opening new plots.
- **Post-Tarp Crop Establishment and Management:** Daniel is both transplanting and direct seeding in this system. When transplanting, they remove

the tarps and plant through remaining residue. If fertility is needed, it is added in each planting hole at transplanting. Even with the very high organic matter levels and soil friability, transplanting through the rye can be tough and slower than bare soils. They use a broadfork as a dibbler, inserting it parallel to the beds in the planting rows to make transplanting easier and faster. Direct seeding is done with an Earthway Seeder. If there is minimal residue, they will seed right into it. If they're going into a high residue bed, the crew will rake the residue out of rows and into the walkways. In higher residue beds they will increase the seeding rate of the next crop to get the desired germination.

- **Labor Demands of the System:** The use of tarps on Frith Farm has resulted in big labor savings. Particularly when managing cereal rye for termination. The time that it takes to install and secure tarps, and move them from plot to plot is definitely offset by the reduction in time spent controlling weeds and terminating cover crops.
- **Material and Equipment Modifications:** Prior to tarping cover crops, Daniel prefers to knock down the cover crop to get the tarp closer to the soil. To accomplish this, he has developed a human-powered "walker crimper" by tying ropes to either end of a t-post. Two crew members hold either rope, with the t-post perpendicular to the bed, hanging by their feet. As either person walks down the opposite side of the bed, they step on the post in unison with each step, in effect knocking and crimping the cover crop.

A field of tarped winter rye with recently transplanted brassica seedlings. These seedlings were planted by hand, which is feasible due to the high organic matter levels in the soil. Photo: Jason Lilley.

Daniel prefers to knock down the cover crop to get the tarp closer to the soil. To accomplish this, he has developed a human powered "walker crimper" by tying ropes to either end of a t-post…." The crew "step(s) on the post in unison with each step, in effect knocking and crimping the cover crop.

Takeaways, Mistakes, and Big Wins

- **Failures, Unintended Consequences, and Adjustments:** The primary issue has been dealing with rainwater on the tarp when moving or folding the tarps. In order to remove the water and move the tarps, space is needed on at least one side of the plot. They have found that flipping the tarp the 100′ length is longer to walk but results in less water weight being moved at once and better drainage into the pathways instead of over beds. Nutrient loading has also become apparent with the high level of amendments. Daniel is cutting back on compost and fertility additions, and keeping a close eye on phosphorus and pH levels moving forward.
- **Measures of Success:** Soils are a primary indicator of success with this system. Daniel does soil tests annually, carefully watching organic matter levels in particular. He has also seen tactile

improvements in the feel of the soil, and ease of operations such as pulling root crops. Pests are another key factor. They do not leave tarps in the field overwinter, primarily to avoid creating rodent habitat. Despite the low weed populations on the farm, they have noticed that certain weed species such as sheep sorrel and most perennial weeds are not effectively controlled with tarping. Based on the reduced labor needs, reduced weed populations, improved management and utilization of intensive cover cropping, and increased yields, Frith Farm directly attributes an increased profitability to their use of tarps.

- **Future Experimentation and Adjustments**: The current system is working and Daniel feels as if they have worked out most of the kinks with their system. They may go back to trialing overwintered tarps to improve their earliest spring plantings.
- **Lessons Learned:** The farm has zeroed in on the minimum time needed to be effective and get adequate termination or weed control. Their primary goal has been identifying optimal duration of tarp based on soil, weather, and weed factors.
- Advice for New Tarpers: Try small first. Don't look at it as a silver bullet to build soil health, or build the farm, but it can be a tool to help achieve those goals.

The Farm Between VT — Breaking Sod and Weed Management in Perennial Fruit Crops with Tarps

Farm Information

- **Farmer:** *John Hayde*
- **Farm Name:** The Farm Between
- **Location:** Jeffersonville, VT
- **Total Acres and Crops Produced:** 5 acres of mostly perennial berries and orchard.
- **Soil Type and Water Dynamics:** Variable soils, some sandy loams with a few clay wet spots. Interesting hilly topography, overall well-drained.
- **General Equipment Use:** Changed over the decades. Started out mostly by hand with livestock and vegetables, then went to draft horses, and in the transition to more perennial systems, got a tractor with a front-end loader.

Lanscape fabric used to directly transition sod to elderberry production with no tillage required. Photo: John Hayden.

Tarping Goals and System

- **Goals of Tarping:** John has now sold The Farm Between, but prior to doing so he successfully used landscape fabric tarps for no-till establishment of perennial crops into sod or fields previously used for annual production. For fruits like elderberry, they'd dig a hole and plant directly into the sod or un-tilled field, then take two pieces of landscape fabric and lay them on either side of the crop row with the edges meeting alongside the planted perennials. This allowed for several (typically 3 feet) of weed control on either side of the row, with the ability to easily remove tarps to apply amendments. After a few years of the excellent weed control enabled by the fabric, they'd transition to natural mulch (cardboard and woodchips). Periodically when the quackgrass crept back in, they'd re-apply the landscape fabric as needed to maintain weed control.
- **Early Uses of Tarps:** Before they started doing this, the weed pressure in their perennials plantings was unbearable. They would hand weed every season, and weed competition still consistently harmed their crops. They saw immediate benefits from this use of landscape fabric.
- **Current Crops and Systems:** During the years they used this practice it allowed the farm to become more profitable, reduced their labor costs, and made life a lot easier.

Tarp Details and Management

- **Years Tarping:** 10 years.
- **Tarp Material:** Woven landscape fabric.
- **Source of the Tarps and Lifespan:** John sourced new landscape fabric from Gemplers, and used the fabric for many years – it would typically last for at least seven years of use.

> [With landscape fabric] it's important to know that you can't just cut this stuff with a knife or scissors, it becomes confetti — you need to melt it.

- **Tarp Size:** They would purchase 6' wide fabric and create two 3' wide lengths by "cutting" it with a propane torch; John said, "it's important to know that you can't just cut this stuff with a knife or scissors, it becomes confetti — you need to melt it."
- **Securing Method**: 5 or 7-inch metal staples.
- **Tarp Storage:** For many crops including Aronia, elderberry, raspberries, and blueberries they would leave the fabric out in the field over the winter. When fabric would start to get weedy from being in one place too long they'd rip it up, flip it over, or move it around. An exception was in crops susceptible to vole damage like young apples. Voles love it under landscape fabric, so in susceptible crops, they would fold up the fabric and store it for the winter. They would not bother cleaning it and would leave the staples in so it was easy to roll back out and re-secure next year.

Specific Applications and Management

- **Fitting Tarps into the Rotation:** This application is used in the transition to perennial crops. Here John gives an example of transitioning a field to blueberry production.
- **Pre-tarping Practices**: If they were going to start a new blueberry field, they would first soil test and adjust pH as necessary. If the field had previously been in annual production, they'd put in a nitrogen-fixing

cover crop and then kill it, and direct-plant into the residue.

- **Amendments Critical to the System:** A benefit of this system is the way the fabric meets along the crop rows, which allows the farmer to lift it up, put compost in, and put the edges back together as needed. Other folks cutting holes in fabric to plant into don't have the same access to apply amendments.
- **Tarping Process Details:** For blueberries, John would sometimes use just 2' strips on either side of the row rather than the 3' strips used for some of their other crops. It took some trial and error to figure out how big the strips needed to be and how long to keep them in place for different crops.
- **Timing and Duration:** For blueberries, they would keep the fabric in place for about two years, and then flip the fabric outward and put natural mulch in the weed-free zone next to the blueberries. They might do this twice over a 6 year period, until they had a sizable weed-free zone they could take care of with just natural mulch.

Landscape fabric placed on either side of a perennial crop row is easily removed and replaced to allow for addition of compost. Photo: John Hayden.

- **Post-Tarp Crop Establishment and Management:** The crops benefited from this system, as it freed up the farmers' time; they were able to spend less time weeding and more time getting other things right.
- **Labor Demands of the System:** John estimated that this system cut their weed management time at least in half. There was some time involved in laying the fabric out, stapling it down, and flipping it periodically, but given that they were leaving the tarps in place for years at a time, the investment in materials and labor paid for itself quickly in reduced weed management costs.
- **Material and Equipment Modifications:** They always managed things by hand in a low-tech way. At larger scales, John thinks developing something for rolling or unrolling would be interesting.

Takeaways, Mistakes, and Big Wins

- **Failures, Unintended Consequences, and Adjustments:** One major failure was trying to mulch over the landscape fabric. They attempted this because they didn't like the aesthetics of the plastic, but it just invited the quackgrass to move in and "created a mess."
- **Measures of Success:** In addition to labor savings, improved weed management, and retention of soil moisture so that irrigation was not needed in their perennials, they saw improvements to soil health and biological activity. In comparison to the "beating" their soils experienced when in annual production with tillage, John saw switching to perennials and no-till practices as a game changer for soil health.

- **Future Experimentation and Adjustments:** They made their own compost from horse manure, woodchips, and food scraps from local schools and businesses. John really liked ramial woodchips as a mulch as well.
- **Lessons Learned:** The biggest lesson learned was don't mulch over the fabric. Other key lessons: burn the fabric rather than cutting it with scissors, and in susceptible crops, "don't leave it out all winter for the voles to have a party."
- **Advice for New Tarpers:** "Try it out!" In the long run, taking time to experiment with things that might be able to improve your system can be really helpful.

One major failure was trying to mulch over the landscape fabric. They attempted this because they didn't like the aesthetics of the plastic, but it just invited the quackgrass to move in and created a mess.

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This publication was funded in part by the through Grant #2018-70006-28882 from the National Institute of Food and Agriculture (NIFA), Crop Protection and Pest Management, Regional Coordination Program. Additional funding was provided through Northeast SARE Project LNE18-371, Northeast SARE project LNE19-382, USDA NIFA OREI 2014-51300-22244, USDA NIFA Agriculture and Food Research Initiative (Niles, 2018-68006-28098), USDA NIFA Hatch Projects 100682, 1004501 and 1013971, and the New Hampshire Agricultural Experiment Station.