Sample Grant Application: Vegetable Operation

Maryland's 2024 Healthy Soils Competitive Fund

Introduction

As a small, organic vegetable farm we are always experimenting with new techniques and equipment to better support our soils and our livelihoods. In this proposal, ***we are requesting funds to defray equipment and labor costs related to conducting new, important experimentation in the area of cover crop-based no-till and reduced-till organic vegetable production, focusing on hard squash, pumpkins, and summer solanaceous crops (tomatoes, etc)***. In the context of our farm business, we will trial and compare several systems–some new and some refined through our own experience and gleaned from other operations–to holistically evaluate these systems' performance. These practices address all four core soil health management principles, with the largest impacts on Maximizing Presence of Living Roots and Maximizing Soil Cover. Specifically we are seeking funding to:

1. Purchase equipment necessary to implement two new reduced/ conservation tillage cropping systems on our farm, including:
    a. A reduced tillage system that has significant carbon benefits and we expect will be easily adopted across our own and other regional farms ("System 1").
    b. A no-till system that holds greater carbon benefit potential, but is also more experimental and will require significant on-farm trials to successfully adopt ("System 2").
2. Use the above equipment to refine our current systems (reduce tillage and lengthen cover crop periods) and to function as a control in research trials.
3. Fund labor, production expenses, and educational materials related to conducting some of these educational research trials on public-facing property (where current rules prohibit farms from profiting off crops grown on the land). All or a portion of produce grown here will be donated to the Maryland Food Bank and other organizations.
    a. To purchase a trailer to move equipment and produce to and from the County's site during this work (and later to be used to transport some no-till equipment to share with other farms to experiment with).
    b. To lease additional County-owned equipment to conduct this research.

We particularly appreciate the flexibility offered by the Maryland Healthy Soils Competitive grant to allow us to flex our creative muscles as farmers and experiment with practices without immediate and binding deliverables like controlled trials. In Years 2 and 3 of this grant, we hope to use the preliminary data and experimentation from Year 1 as a springboard to pursue on-farm research trials that support ongoing development and trialing of related best management practices. In numerous recent overviews of organic no-till best practices, researchers have highlighted the need for practical, farmer-driven studies to determine best practices and facilitate wider adoption of these important regenerative practices.[1]

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[1] Beach, Heather M., Ken W. Laing, Morris Van De Walle, and Ralph C. Martin. 2018. "The Current State and Future Directions of Organic No-Till Farming with Cover Crops in Canada, with Case Study Support" *Sustainability* 10, no. 2: 373. https://doi.org/10.3390/su10020373

As a society, we must find new and better ways across industries to reduce and draw down atmospheric carbon. As mid-scale beginning farmers with limited working capital, we are specifically seeking funds that would cover equipment and labor to conduct on-farm research on carbon farming practices that *financially might not work as well as* their more standardized and carbon-intensive counterparts. We hope that as recipients, we will be able to comfortably experiment and refine these methods, contributing to important on-farm research and the broader education of Maryland farmers and the public, without having to worry that the capital expenses and potential reductions in yields would unduly harm our small business.

Challenges and Opportunities

We plan to adopt several cropping systems and holistically compare them as they address the following challenges:

- *Building soil organic matter (SOM):* In addition to SOM's importance to sequester atmospheric carbon in active agricultural soils, it is vital to the healthy function of soil ecosystems to support our crops. SOM aids nutrient and water retention and availability to support crop health and reduce input costs (both real and in net carbon contributions); bolsters aggregate stability to reduce damaging erosion in rain events; and is the cornerstone of a healthy soil ecosystem that supports crop health against a host of disease and pest pressures. Our operation has always prioritized scalable ways to build more SOM over time through "green manures" in our cover crop practices, reducing our reliance on expensive and time-consuming applications of imported material (eg, mushroom compost).

- *Maximizing cover crop biomass contributions:* Because we rely on these green manures to build SOM, we are always looking to increase the total biomass that our cover crops contribute to the soil. However, this can be a tricky balancing act because allowing cover crops to grow more mature before termination makes them significantly harder to incorporate, which can create cultural challenges for our cash crops. Also, the heavy tillage necessary to incorporate them can partially negate the SOM contribution by releasing stored soil carbon. For example, cereal rye, a biomass and weed suppression workhorse, can produce up to 10,000 lbs dry matter/ acre, "too much residue, depending on your tillage system" (SARE 2012, 99). However, mechanical termination requires either mowing it *after* it has grown full-size and started flowering and/or heavy tillage to plow it under (SARE 2012, 101). It also presents nutrient tie-up issues as its thick ligneous stems break down. In any case, we are rarely able to utilize rye as a cover before summer crops without resorting to heavy inversion tillage with a moldboard plow prior to planting. Likewise to achieve the maximum nitrogen contribution (~125 lbs/ acre) from crimson clover, it must be grown until stems are three or more feet high and seed heads are forming (SARE 2012, 130). To then incorporate it into the soil, we must mow it, then disk it one to three times to cut up and bury the stems, leave the ground bare and unplanted for 1-3 weeks, before finally tilling it with a reciprocating spader to a depth of 8 inches to complete sufficient ground prep for cash cropping.

- *Improving water retention:* Increasingly hot, dry summers are one of the most significant challenges we have faced over the last several seasons. Both heat waves and drought accelerate soil moisture losses to evapo-transpiration which stress plants and tax our farm's limited water resources. Beyond building SOM, techniques to decrease bare ground and reduce summer soil temperatures could improve yields by more efficiently using our existing and finite water resources.

- *Reducing weed pressure, especially regarding marketable yields and tillage:* As a mid-scale organic farm, we will always have to deal with weeds. As with most things in organic farming, this is a balancing act. With the exception of noxious and invasive weeds, we have varying levels of tolerance for the native pioneer species that thrive in fertile agricultural soils. Weeds must be managed to the extent that they harm yields, but because organic weed management often requires repeated tillage, we have to weigh (a) marginal near-term yield losses due to weeds against (b) the long-term harms of reduced SOM from tillage. The best practices are those that allow sufficient yields for profitability while reducing long-term weed pressure.

- *Our bottomline:* Finally, we have to holistically navigate these challenges within the context of our per crop net-income. As we look for scalable and shareable solutions that can inform other farm businesses, profitability is also a universal language. Existing research suggests that some level of yield losses is likely when switching to *no-till* organic systems when compared against traditional organic plasticulture,[2] especially in the short term. However, these practices can also substantially reduce labor, supply, fuel, and input costs to such an extent that they could be net-neutral when overall crop profitability is evaluated. as we experiment with the systems described below.

Although not our primary focus, several of the practices we trial and evaluate provide the ancillary benefits of increasing biodiversity in cropped fields and improving/ expanding habitat for pollinators and beneficial insects. These additional services are important to the overall health of our local environment and our farm business, but are significantly harder to quantify than the above.

Practices

As recipients of a healthy soils grant, we will implement and compare three different systems for growing organic hard squash, pumpkins, tomatoes, peppers, and eggplant. We have chosen these crops to start with because they are economically significant to our farm and to the region. They are also large and fast-growing, and thus best suited to overcome potential increased

[2] Beach, et al. "The Current State."

weed pressure related to these new practices. They are also widely grown across our farm–about four acres of squash and pumpkins annually and three acres of nightshades, so adopting them will have an extensive impact. Learning new tools and techniques always comes with a learning curve, and we believe they have the highest potential for initial success. We will adopt them on a limited basis at first (¼ or ½ acre in Year 1) and expand up to potentially 100% of the cropped area in Year 3. If we are able to profitably adapt the below practices for these crops, we will experiment with using them for other species we grow as well.

Collectively, these systems include–but take different approaches to–the following conservation practices: *cover crops, conservation tillage, conservation crop rotation, nutrient management, and soil carbon amendment.* In this section I will describe each of these systems, and note how they relate to the four core management goals for healthy soil (minimize disturbance, maximize soil cover, maximize presence of living roots, maximize biodiversity).

Control - Organic plasticulture with long season multispecies cover crops
This system is based on the most common cropping system in our region for the target crops, and is a modest improvement on our current practices. In that respect *it will function as a control in comparisons made*, but great care has been taken to ensure that it accurately reflects the best possible practices for tillage-based organic agriculture. Thus it is still a significant improvement over our current practices. *Although we will use equipment purchased in this grant to improve this system, none of it will be used* ***exclusively*** *for this system.*

Multispecies cover crop mixes will be seeded the previous summer or fall. In our case, if seeded before September 1, we like to use a mix of winter-killing daikon radish and oats to reduce compaction, take up excess nutrients, and smother weeds, along with one or several winter-hardy legumes like winter peas (if planted in summer), white clover, and/ or red clover. The radish and oats provide short-term weed suppression and "nurse" the legume crop, which then reaches full biomass potential the following spring, when it is mowed and tilled in before the main crop, adding a significant nitrogen contribution to the soil. For cover crops seeded after September 1, we use cereal rye with crimson clover or hairy vetch to a similar effect, but with the added step of mow-killing in late spring. In both cases, including a slow-growing mowable ground-cover like white and red clover in the mix allows us to keep the field in cover indefinitely without additional tillage requirements.

After terminating and partially incorporating the cover crop, we make one heavy non-inversion tillage pass with our reciprocating spader (8" depth), to fully incorporate remaining residues and any soil amendments. We follow that with one pass (4-5" depth) with a bed-shaping, raised bed plastic mulch layer using drip tape and biodegradable plastic mulch. Plastic mulch provides many benefits to our crops, including physical weed suppression without tillage, slowing water loss to evaporation, and warming soil to produce healthier and faster growing crops. Biodegradable mulch provides the additional advantage of a quick and easy transition to a new cover crop after termination, as all that's required is a single mowing, broadcast of seed, and disking of the field (2-3" depth), after which the drip tape can be removed and reused or disposed of.

Fertilizer application is targeted, as the initial dose of slow-release fertilizer is laid under the plastic mulch at prep (not in the walkways), and the crop is planted using a water wheel transplanter containing starter fertilizer in the hole/ furrow. Further fertility needs are provided as needed via fertigation through drip tape.

In this system, walkway weeds between mulched rows are managed with repeated light mechanical tillage. In our case, we use a lightweight, electric-converted Allis Chalmers Model G tractor with a gang of high crown cultivating shovels, and make 3-5 passes per season until the cash crop is too tall for the tractor clearance. To offset the SOM losses due to tillage we apply mushroom compost before planting to add organic matter back into the soil. The need to cultivate means this system, while still an improvement on standard plasticulture in our region, has the lowest potential for soil carbon sequestration, leaves the most bare ground exposed (~40% of a field during the growing season), involves the most soil disturbance, and allows for the least biodiversity and living roots. In terms of the challenges we are looking to address, it has proven to be the most effective at organically reducing weed pressure while managing soil moisture, but at the expense of significant input costs related to plastic mulch and labor costs related to the repeated and frequent tillage requirements.

New equipment/ practices used:

- *Seed drill* - We will use the seed drill to establish our mixes after cash cropping without having to broadcast and lightly disk (our current practices). This will reduce our annual tillage passes (<2”) on a given field by 1 and our total tractor passes over that field by 2. Higher germination rates due to better ground contact for seeds will also save money by reducing the necessary cover crop seeding rate.
- *Flail mower* - Currently we use our brush hog rotary mower to terminate cover crops, which leaves their stems primarily intact, facing the same direction, and on the surface. This then requires that the cover crop residue be disk-harrowed 1-3 times depending on the age and species of cover (eg, fewer for peas, more for rye) to break it into smaller pieces and partially bury them to facilitate decomposition. Purchasing a flail mower for cover crop termination will effectively mulch covers in place–including ligneous species like cereal rye–reducing the need for these secondary tractor passes to either one or zero and increasing the number of weeks that the soil is covered. The overall easier residue management will also allow us to delay termination until covers are closer to maturity. This will result in 1-3 more weeks of living roots, reduce imported nutrient needs by allowing for longer periods of N-fixation by legumes in the spring, and increase biodiversity where legumes are allowed to grow to flower serving as forage for beneficial insects.

System 1 - Organic plasticulture with living walkways

This system is one we have been experimenting with over the last several years and is similar to the above, but with changes to walkway management. With further tinkering and improvement, ***we are highly confident that it has the potential to supplant the Control system in all or nearly all transplanted plasticulture crops on our farm***, especially those crops like tomatoes, eggplants, and peppers that do not run and “fill in” the walkways between beds. Switching crops from the Control to the practices in this section is desirable because they holds greater potential for increasing SOM through green manures, improving soil moisture retention by protecting walkways from evaporation, and decreasing tillage both at cultivation and end-of-season termination. *Although they are not the focus of our on-farm research, these practices are also applicable to and will also be adopted for brassica crops like kale, collards, and cabbage, which make up nearly 40% of our cropping area each year.*

In this system, all steps are the same through cover crop termination and bed building/ plastic-laying. However at that point, prior to planting, we will (a) broadcast a cover crop mix over the field to germinate in the walkways and (b) perform *one* “stale seed bedding” cultivation pass with the Model G to incorporate cover crop seeds and knockback the first flush of germinated weeds. In the past we have used oats and white clover, but the specific cover crop mix is something we would like to experiment with. Different mixes will likely better suit different crops, but it will always contain a low-growing perennial legume (white or red clover) with a larger, faster growing weed suppressor. We would like to trial barley, ryegrass, buckwheat, and cover crop mustard among others. In all cases, the walkways will be allowed to grow freely until field access or crop air flow become a concern. Then they will be managed with repeated and regular mowing with a self-propelled brush cutter. This mowing is in lieu of cultivation and for many of the walkway cover crops will facilitate and encourage greater biomass production. At termination after the cash crop is finished producing, the living walkways will *not* need to be removed because of the inclusion of perennial clovers. Instead the cash crop will be flail-mowed and only the bed-top will be seeded with an additional cover-crop.

There are however, a few concerns we hope to evaluate and refine in a side-by-side comparison with the control system. Will increased walkway cover result in wetter fields and higher cull rates/ lower marketable yields? Which cover crop mixes are best for each crop from a management perspective (eg, will oats or barley in cabbage walkways grow too tall so as to impair crop growth and harvest)? Will greater in-field habitat lead to larger pest management issues with insects like squash bugs or small rodents like voles?

New equipment/ practices used:

- *Seed drill and flail mower - same as the Control system.* Also, these tools will allow for better and more precise seeding of the bed tops at the end of the season, without needing to disk.
- *Walk behind brush cutter* - In our experiments with this system, the greatest challenge to adopting it on a wider scale has been the labor requirements to manage the walkways to prevent the cover from impeding harvest or crop air flow. Regular walk-behind mowers can only be used while covers are quite short (<8”). This means we need to mow too frequently to allow widespread adoption, and it prevents us from using the full potential of the cover. They are also tiring on workers. Worse still, if we miss a mowing due to wet weather or other pressing concerns, we need to use a hand held brush trimmer which is even slower and more tiring. Adding a dedicated walkway mowing tool would be better for everyone involved, including the cover crops.

- *Living walkways in-season* - Mowed living walkways in season would supplant the need to cultivate in plasticulture crops. This would reduce in-season tillage events by 2-4 each season with ideally a minimal increase in short-term and annual weed pressure. Even better, it would increase ground cover and living roots in the field by 40% during the long growing season for summer crops, hopefully *reducing* perennial and noxious weed pressure by providing less bare ground for, eg, wind-blown thistle seeds to germinate. It would also contribute to SOM gains the following season. For example, in a mix of annual ryegrass and white clover, which both thrive when frequently mowed, a modest estimate of residues could be 6000-8000 lbs dry matter/ acre/ season. With 40% of the field covered during the growing season, this is 2400-3200 lbs/ acre, or a ~40% increase over just cover cropping in the winter season. Finally, living walkway plants improve biodiversity, creating excellent habitat for beneficial insects and pollinators.
- *Living walkways after crop removal* - Likewise, having nearly half the field already in cover at season's end causes a corresponding reduction in tillage needs to establish the winter cover. It potentially addresses a challenge for crops that grow into the cooler weeks after the solstice. How do we get a robust cover crop stand on crops like pumpkins that aren't harvested and terminated until the cooler dates after the solstice? Earlier establishment means more winter coverage and more total biomass, and we believe it would not be unreasonable that, in-season biomass contributions, this approach could offer an additional 10% increase in annual cover crop biomass produced.

System 2 - Cover crop-based organic no-till

We have wanted to experiment with this system for many years, but have been unable to acquire, rent, or borrow the necessary equipment without significant capital barriers. *(Note: at the end of the course of this grant, we intend to share this equipment with other farmers in our county so more farms are able to experiment with these techniques).* It has the greatest potential for net soil carbon sequestration and is the most intriguing for potential *long-term* benefits for reducing weed pressure and irrigation needs.[3] It is also the riskiest from a yield and profit perspective, which is why we have not yet explored it on our own. We believe squash and pumpkins are the best suited crops to trial this approach, and they are the most important and widest grown in our business. Accordingly, we will start with trials of those two crops and only later expand to tomatoes and eggplant whose upright, trellised growth habit could create additional management challenges to solve.

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[3] As described in a 2017 research study: "A decade of CCBRT research in the upper Midwestern US has demonstrated that CCBRT can provide a strong management tool for organic farmers aiming to improve their weed management practices while minimizing soil erosion risk, building soil organic matter, and incorporating further crop diversity into their rotations. Particularly in the face of climate change, where extreme weather events will occur with increasing frequency and the need for carbon mitigation tools becomes more imperative, CCBRT provides both management advantages and broader ecosystem services." Silva, Erin M., and Kathleen Delate. 2017. "A Decade of Progress in Organic Cover Crop-Based Reduced Tillage Practices in the Upper Midwestern USA" *Agriculture* 7, no. 5: 44. https://doi.org/10.3390/agriculture7050044

Cover crop-based organic no-till (as opposed to top-dressing or permanent-bed based organic no-till), is an *extensive* practice that uses strategically terminated, dense stands of cover crops as a weed-smothering mulch. Crops are then planted into this mulch using a no-till drill and will ideally grow to a large size capable of shading out and combating weeds before the weed-suppressing effects of the mulch break down. Despite over a decade of research, no-till vegetable practices lag far behind those of grain crops.[4]

Differing from the plasticulture systems above, past studies show this cropping system does best when preceded by a *single* species of cover crop to make termination easier and more complete.[5] It is also vital that the cover crop achieve a *very dense* and consistent stand, with biomass needs over 8000-9000 lbs/ acre to achieve maximal weed suppression.[6] Cereal rye and hairy vetch are the most widely researched options. With this stand established and before it goes to seed, farmers terminate the cover crop using a specially built, tractor drawn roller-crimper tool. This tool lays down all the stems in the same direction and snaps them at their base. After termination, we will follow behind with a no-till drill to plant.

However, this approach creates new potential issues. Researchers have suggested that both the allelopathic effects of rye and vetch residues and/or the major nitrogen tie-up in the decomposition process lead to worse growth and survivability in vegetable crops like squash.[7] Cooler soils than in plasticulture also certainly have an effect. Worse early growth leads to a less competitive crop when the mulch begins to allow weeds through in 4-6 weeks, which causes lower absolute and marketable yields at the end of the season. Finding new practices to improve early crop growth holds significant promise for the development of the technique.

We hope to address these concerns in two ways. First, we will plant squash and pumpkins as transplants, rather than as seeds. We will do so with a special no-till water wheel transplanter offered by a produce supply company in Pennsylvania. Traditionally, hard squash is direct-seeded rather than transplanted because rough transplanting conditions can damage fragile root structures and reduce yields. However, we have not found significant yield reductions in past trials on our farm when transplanting occurs carefully and in a timely manner. We hope that this approach will (a) offer a stronger head start for our crops versus direct seeding, (b) allow us to combat nutrient tie-up by applying necessary starter fertility directly to the roots with the water wheel, and (c) that using transplants will allow us to delay planting compared to seeds, negating some growth losses from cooler soils. Throughout the season, we will manage further fertility needs with fertigation through drip tape.

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[4]Beach, et al., “Current State.”

[5] Moyer, J. *Organic No-Till Farming*; Acres U.S.A.: Austin, TX, USA, 2011; ISBN 9781601730176. *In Beach, Heather M., Ken W. Laing, Morris Van De Walle, and Ralph C. Martin. 2018. "The Current State and Future Directions of Organic No-Till Farming with Cover Crops in Canada, with Case Study Support" Sustainability 10, no. 2: 373. https://doi.org/10.3390/su10020373*

[6] Smith, A.N.; Reberg-Horton, S.C.; Place, G.T.; Meijer, A.D.; Arellano, C.; Mueller, J.P. Rolled Rye Mulch for Weed Suppression in Organic No-Tillage Soybeans. *Weed Sci.* **2011**, *59*, 224–231. *In Beach, et al., “Current State.”*

[7] Testani, Elena, Corrado Ciaccia, Gabriele Campanelli, Fabrizio Leteo, Luca Salvati, and Stefano Canali. 2019. "Mulch-Based No-Tillage Effects on Weed Community and Management in an Organic Vegetable System" *Agronomy* 9, no. 10: 594. https://doi.org/10.3390/agronomy9100594

A significant challenge with no-till relative to plasticulture *and* bare-ground cultivation (which we do not practice) is that once the residue mulch is in place, traditional mechanical cultivation methods are no longer available to manage weed issues that arise. This is also what makes this technique intimidating to adopt. Speaking with farmers involved in other on-farm trials, they have identified these late appearing weeds as the primary driver of yield loss and making a “real mess” of the field. We will once again use the walk-behind brush mower as an emergency and/or stopgap management technique where we see weed issues arise that we believe will threaten the crops. The ability to mow weeds that emerge after the initial 4-6 week period, even in thick and brushy conditions, should allow at least an additional 2-3 weeks of unimpeded growth. In the case of most determinate hard squash varieties, this should be enough time to carry the crop through fruit-set (a crucial yield milestone) and to a time 4-6 weeks before harvest. Even if we don’t see yields equal to the systems above, we hope we will reach a point where:

Yield loss ($) = Cost of supplies + labor and fuel cost of cultivation

We estimate that this breakeven point corresponds to roughly an 8% loss in a yield, but we would tolerate at least a 15% yield loss with the expectation that longer term healthier soils could see higher yields in the future.

Benefits: If we are able to achieve or approach this point, the benefits of this system would be significant. We would be able to remove plastic mulch entirely from some of our cropping systems, reducing supply costs. Removing tillage from the system would reduce our total tillage passes per year from 4-6 in a living walkways system to zero. This reduced tillage would allow us to build more SOM, better supporting a healthy soil ecosystem to support our crops and hopefully supporting yield increases over time. Employing extremely high residue crops as mulch would result in an additional 2000-3000 lbs dry matter/ acre to build SOM. Higher SOM and increased ground cover (again, to nearly 100% coverage throughout the year) would reduce soil moisture loss, increasing irrigation water available for other crops around the farm. This heavy mat of terminated cover crops would also dramatically improve soil moisture retention during the season making our crops and business more resilient to dry-spells and droughts.[8]

Questions: As part of new and ongoing research, many questions remain regarding best practices. Among others, we will investigate if certain cover crops are more effective than others on our farm, the efficacy of fertigation rates and timing, cultivar selection (long-vine vs. short-vine varieties), and harvest timing and crop storage-life in wetter seasons.

Grant funds:

- *Seed drill* - to establish consistent and dense cover crop stands
- *No-till waterwheel transplanter -* to allow the experimental planting system above

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[8] Kornecki, T.S.; Kichler, C.M. Effectiveness of Cover Crop Termination Methods on No-Till Cantaloupe. *Agriculture* **2022**, *12*, 66. https://doi.org/10.3390/agriculture12010066

Walk behind brush cutter - handle and reduce weed pressure between crop rows farther into the season. To prevent noxious weeds that may appear from flowering and going to seed
Flail mower - to effectively terminate the crop and any weeds at the end of season
Trailer - to convey the above to and from County property; to facilitate harvest at County property
Labor - for the portion of the trials conducted on County property, where produce grown must be donated

Summary of Practices

	Control	**System 1**	**System 2**
Cover Crops	Three-season, multi-species; flail-mower killed	Three-season, multi-species; flail-mower killed	Single species, high biomass. Roller-crimped to kill
Heavy tillage	3-5 times/ year to incorporate cover crop, prep beds	2 times/ year to incorporate cover crop, then build beds	0-1 times/ year to terminate crops, plant new cover
Light tillage	4-5 times/ year to maintain walkway weeds	1 time/ year to stale seedbed walkways, incorporate cover seeds	0-1 times/ year to terminate crops, plant new cover
Planting	Single pass with waterwheel transplanter	Single pass with waterwheel transplanter	Single pass with waterwheel transplanter
Weed management	Plastic mulch and cultivating (light tillage)	Plastic mulch and mowing	Cover crop-based mulching, with backup mowing
Fertility management	Broadcast and incorporated at prep *and* targeted through fertigation	Broadcast and incorporated at prep *and* targeted through fertigation	Spread on preceding cover crop, *then only* targeted through fertigation
Annual bare soil	100% of field for ~2-3 weeks; 40% of field for 12 weeks/ year	100% of field for ~2-3 weeks	Nearly 0%
Annual CC biomass vs. control	5000-7000 lbs/Ac baseline	additional 2400-3600 lbs/Ac (40% increase) from covered in-season walkways	additional 2000-4000 lbs/Ac from denser winter stands
Water availability/ Drought resistance vs. control	N/A	similar or slight improvement	significant improvement
Potential crops	All, especially nightshades and brassicas	All, especially nightshades and brassicas	Primary: Squash, pumpkins; possibly nightshades
Economic viability	Normal/ high	Comparable to control; possibly higher in drought years	Risky--Strongly needs experimentation

Effects and evaluation

Agronomic Effects
Across the board, we are hoping that these practices will create richer, healthier soils that better retain water and support healthier crops. In order to objectively track each system's effect on soil health, we will monitor the following indicators, included in Cornell's Comprehensive Assessment of Soil Health (CASH), which we expect to improve over time: Active carbon, organic matter percentage, soil water capacity, soil protein index, and soil respiration index. Improvements in these measurables will be weighed alongside practices' ability to maintain *net profitability* compared against each other.

*Net profitability = (Marketable yield * Price/ lb) - (Supply costs + Labor costs + Fuel costs)*

We will evaluate these effects in the following ways. Beginning in late 2024, we will begin submitting annual soil samples from treated fields for CASH testing and comparing results in the above measurables before and after implementation of those practices. Because System 2 requires advance planning to establish the proper cover crops, in 2025 we will begin tracking *labor hours* and *yields* in treated fields. As we rotate crops around our farm, in 2025 and 2026, some of these systems will be implemented on fields that are already part of the ongoing longitudinal soil health benchmark study being organized by Future Harvest and the Pennsylvania Association for Sustainable Agriculture.

Note on rotations: We grow a wide variety of vegetables in our operation. As part of our pest and disease management regimen, we rotate crops between fields and sometimes between different sites year after year. We will not be using dedicated fields for each practice throughout the length of the study, and so it will also be of significant interest to see how these measurables change as fields rotate in and out of these conservation tillage systems.

Carbon Effects
We expect all of the practices detailed above to have a net carbon benefit, when compared against conventional tillage and cover cropping practices. We expect the net benefit will be greatest in System 2, followed by System 1, with potential for modest improvements in the Control. In all cases, by increasing living covers in total mass, area covered, and longevity, we expect that our soils will store more atmospheric carbon as soil organic matter. By reducing tillage, we likewise expect to reduce our soil's carbon losses and reduce the total amount of greenhouse gasses emitted during tractor operations.

Partnering with Future Harvest, we will evaluate these outcomes using a mix of COMET modeling, and regionally appropriate literature reviews from University of Maryland and University of Maryland Extension. By using the same CASH analysis as is used in the PASA soil health benchmark study, we will be able to use this data to compare our systems against historical data from our own farm, as well as a wider set of farms and practices in the region. As part of the data tracking listed above, we will also track tillage passes and depths as they occur on treated fields

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Education and outreach

We are very excited about the educational and outreach potential of this project. It will have a major impact on our 25-acre (and growing!) operation, where profitable carbon farming strategies will be adopted as widely as possible, with systems potentially adapted to other crops like kale, cabbage, peppers, and melons in the future. Beyond our own farm, we will work with regional and national partners to share our results both during and after the term of this grant. We have included in our application a letter of support from Future Harvest, with whom we intend to utilize equipment purchased through this grant to pursue at least one (and hopefully several) future USDA SARE on-farm research grant to trial and refine our no-till organic system. Specifically, once we have gathered some preliminary results from Year 1, we will design a rigorous, 2-acre controlled study of System 2 to observe the effect of vine-length variety on squash and pumpkin yields. Ideally, we would then build on the results of this initial 1-year trial with another 3-year experiment (2026-28) on 2 or more acres that also incorporates fertilization rates as a variable. We will also be working with Future Harvest to estimate the carbon impacts of our practices.

We have also included a letter of support from the County. We plan on conducting these trials at the county's Agricultural Center and Park. This property contains buildings that house our local USDA, Soil Conservation District, and UME staff, as well as 16 acres of prime farmland. In 2023 County opened this land to rent for local farms. There is a low baseline presence of noxious weeds, and experiments conducted here would be an excellent demonstration of these practices' potential to convert tilled, conventional ground into a no-till, organic cropping system. According to the county's easement, crops may not be grown here for profit, so we will donate produce from these trials to the Maryland Food Bank or other organizations. Accordingly, we have included all labor costs related to practices employed at this site as part of our grant request on the attached budget.

Experimenting with these practices at the Ag Center also holds tremendous educational potential. It is centrally located and hosts thousands of farmers, school children, and curious l ocals each year. Therefore it is ideally situated to publicize the potential of these techniques by holding a Field Day in 2025 related to the use of the roller-crimper and no-till transplanter. We will also share these tools with the county–which has recently banned glyphosate on county property–so their field crops manager may experiment with it in non-organic systems for their corn, sunflower, and pumpkin plantings.

The Ag Center is a public space, so this is an excellent opportunity to educate the public about organic and regenerative agriculture. We will post clear and informative signage about our practices and trials, as well as the carbon storage potential of agricultural soils. In Fall 2025, we will end the first season's trials with an educational volunteer opportunity for the public to help harvest the produce for donation to the Maryland Food Bank. In 2026, we will publish the results of any potential SARE grant through USDA’s website, through a conference presentation, and also share the results locally at another Field Day demonstrating the no-till tools in action again.

The County has also been working to establish and improve their agriculture equipment sharing program. When this process is finalized and publicized, we would like to also loan out the roller-crimper alongside these tools to allow other local farms to explore adopting cover crop-based no-till on their farms.

Squash, pumpkins, and tomatoes are three of the most widely grown vegetable crops in the Mid-Atlantic. Pumpkins alone account for 2000 acres in Maryland and 10,000 in Pennsylvania and Virginia. If and where we can demonstrate the above carbon farming practices to improve soil health while maintaining profitability, they are simple practices without large capital barriers to entry. We are also obviously happy to work with the experts at MDA to refine, improve, and share any of our work and its results more widely around the state.

Project Timeline

- Spring/ Summer 2024: purchase equipment and immediately begin experimenting with:
  - Control system on all relevant acreage (any crops receiving cover crops in winter 2024 (or about 80% of the farm)
  - System 1 (living walkways) on limited summer and fall production (~1 acre squash, ¼ acre each pumpkins, tomatoes, eggplant)
  - Limited trial of System 2 to familiarize ourselves with the equipment (~¼ acre squash)
  - Seed living walkways (low-growing clovers + nurse grain) in Fall brassica crop to be managed with brush cutter
- Fall 2024
  - Seed 75+% of Fall cover crops with seed drill
  - Use seed drill to establish high rate single species covers for 2025 no-till trials
  - CASH tests to evaluate measurables baseline
  - Apply for 2025 USDA SARE research grant to employ the above equipment and systems, evaluating one or two of the above questions regarding System 2: fertilizer rate and/ or squash vine type
- Spring/ Summer 2025
  - Control system: Practice tilled walkway system as a control on <50% of tomato, pumpkin, and eggplant production; 1 acre of squash
  - System 1: Practice living walkway system on >50% of tomato, pumpkin, eggplant production; >1 acre of squash
    - Potentially expanding living walkways to more crops and acreage depending on successes and perceived labor demands from 2024
  - System 2: Conduct one-year SARE grant to specifically measure no-till efficacy and evaluate fertilizer rates and timing in ~1 acre squash, ~½ pumpkins
  - Info-sharing:
    - Planting field day to demonstrate No-till organic system and tools at County Ag Center
      - Post signage in high traffic area regarding No-till practices and the experiment
    - Fall Harvest field day to publicize initial results and harvest squash and pumpkins for donation
- Fall 2025
  - CASH tests to evaluate effects of practices on soil health
  - Establish single species covers for other 2026 no-till trials
  - Apply for 2026-8 three-year USDA SARE research grant regarding System 2 no-till best practices
    - Pursue further, refined questions raised during initial no-till trials
- 2026
  - Depending on successes and fine-tuning, adopt living walkways to additional species and acres, up to 100% of transplanted plasticulture crops on the farm
  - Potential second longer term USDA No-till trial

On-farm no-till trial of ¼ acre tomatoes, ¼ acre eggplant

Info-sharing:

- Another Field Day during cover roll-down, squash planting at County Ag Center
    - Post signage in high traffic area regarding No-till practices and the experiment
    - Present 1st SARE grant report

Potential equipment sharing

- Announcement through County Soil Conservation District to loan roller-crimper for other local trials

CASH tests to evaluate effects of practices on soil health

Fall soil test data used to calculate carbon sequestration/ GHG impacts for distribution through Future Harvest and other partner

Budget

MDA Grant Request		Other Funding Sources	
Labor (for Sys. 2 No-Till trials): 2 acres in 2025 and '26 each		**Labor (for all other practices): >10 acres total over 3 years**	
Crew labor for planting, harvest, mowing and other field work @$22/ hour: ~40 hours/ acre/ year; 2 acres, 2 years	$3,520	Crew labor for planting, harvest, mowing and other field work @$22/ hour: ~50 hours/ acre/ year: 10 acres over 3 years	$11,000
Tractor operator labor for planting, harvest, mowing and other field work: ~16 hours/ acre/ year: 2 acres, 2 years	$2,880	Tractor operator labor for planting, harvest, mowing and other field work: ~20 hours/ acre/ year: 10 acres over 3 years	$9,000
Owner labor for monitoring, maintenance, data collection @$45/ hour: ~2 hrs/ week for 12 weeks, 2 years	$2,160	Owner labor for monitoring, maintenance, data collection @$45/ hour: ~2 hrs/ week for 12 weeks, 3 years	$3,240
		*SARE Grant reporting**	*$800*
Materials - Equipment		**Materials - Equipment**	
Roller Crimper: 908R 8' I&J Mfg. w/ shipping	$8,480	50-70 hp tractor (Kubota L5030 and JD2640)	$14,500
No-till Waterwheel transplanter unit: Nolts Produce Supply	$4,810	Celli 62" Articulating Spader	$7,100
Walk-Behind brush cutter: DR PRO 26 (15.5 HP)mower	$2,999	Cultivating Tractor (Electrified Allis Chalmers Model G)	$7,200
Seed Drill: eg 7' Field Tuff 14x6"	$4,300	Vicon Pendulum Spreader	$2,230
Flail Mower: TITAN 72" w/ shipping	$3,950	Nolts RB448 Mulch layer w/ drip and fertilizer attachments	$3,050
Trailer: eg, Cargo Pro 8 x 14 Aluminum w/ title	$3,999		
Materials - Supplies		**Materials - Supplies**	
Greenhouse production (propane, trays, media, etc) @560/ acre/ year	$2,240	Greenhouse production @560/ acre/ year ($7.78/ tray)	$5,600
Crop Seeds @$370/ acre/ year	$1,480	Crop seeds: 10 acres over 3 years	$3,700
Durable, outdoor educational signage	$1,000	*Cover crop seeds for County Trial @$125/ acre: 4 acres**	*$600*
Funds for 3 field days (snacks, printed materials, etc)	$4,000	*Cover crop seeds for all other acreage @$105/ acre: 10 acres***	*$1,050*
		Fertilizer costs (~$200/ acre)	$2,800
Direct Expenses		**Direct Expenses**	
Ground rent @$250/ acre/ year	$500	Cropland mortgage interest (~$60/ acre/ year)	$600
Tractor rentals at Co. Ag Center: <5 days/ year @$50/ hour, 2 years	$600		
Subcontractor/ Consulting		**Subcontractor/ Consulting**	
Six CASH tests annually, for 3 years, @ $150 each, plus shipping	$2,850	Future Harvest technical assistance w/ COMET and other carbon modeling: 45-50 hrs/ year	$6000
Total	***$49,768***		***$78,470***