REDUCED TILLAGE FOR VEGETABLE PRODUCTION

	Les Macare **Racing Heart Farm**	**Lincoln Fishman** **Sawyer Farm**
Location	Colfax, WI	Worthington, MA
Acres in vegetables	2	8 total; 5 in cash crops per year
Mechanization level for most field operations	By hand with hand-scale tools	With tractor
Farming style	Certified Naturally Grown	Organic practices, not certified
Farming History	I apprenticed/worked at 3 farms (ranging in size from 4 to 64 acres in veg production) prior to starting Racing Heart Farm with my partner in 2014, we bought land in 2017 and no longer had access to shared/hired tillage equipment. We bought the BCS in 2017 thinking we would use the rotary plow and power harrow for bed prep, but have since realized that hand tools are more pleasant to use, and often more effective on our 2 acres of vegetable production.	Sawyer Farm was a dairy farm from at least the 1940s on. It was likely well-managed when small dairies were profitable, but by time we got it, the pastures were worn out and topsoil had been sold from 3 acres of our main field. The farm is 40 acres total - half wooded, half open. The open piece has only about 4 acres of land suitable for normal vegetable production. The remaining 16 acres is too sloped and/or too wet for production. We are at 1600' at 42' latitude, so it's cold. We're just half an hour away from the Connecticut River Valley, where warmer temperatures offer at least two weeks of frost-free weather on both sides of our season, so early crops have never been viable for us. My partner and I started homesteading in 2007, in central PA. We moved to Sawyer Farm in 2010 and started a whole-diet CSA, with year-round vegetables, milk cows and associated value-added products, eggs, beef, pork, and chicken. The model was sustainable environmentally and economically, but not humanly! When our first child was born, we switched to a farm store and wholesale model, and have since cut almost everything out but vegetables, sold through our farm store and wholesale.

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Key motivations for using reduced tillage methods	Farmer enjoyment/ease Soil health Plant health Decreased weed pressure	Our sloped fields have always been prone to erosion. Though we cover cropped and added compost religiously, we continued to see erosion. For the first five or six years on the farm, we saw increasing crop health and yields, but then it plateaued. We had to admit that tillage was the limiting factor, and that cover crops and compost were just 'apologies' for that tillage.

Main low/no-till production method

Description	- Flail mow (or crimp) old crop or cover crop, broad-fork (when needed) - Occultatation with landscape fabric (when needed to digest crop residue, or as a place holder if that bed won't be planted soon - Amend per soil test - 10 buckets per bed (100'x30") of compost at each bed flip - Wheel hoe (when needed to loosen soil for seeder or paper pot transplanter). BCS power harrow was a great transition tool for this step, now we use the power harrow mainly to incorporate cover crop seed. - Most crops are transplanted (paper pot system or by hand when into cover crops or landscape fabric). Direct seed crops: baby brassicas, carrots, green beans and radish	We transplant many crops directly into a perennial sod of Dutch White clover. In year one, we undersow clover into standing cash crops in July. We use a heavy seeding rate -- 30-45 pounds per acre, broadcast with a chest seeder. By late August, the clover forms a full cover, and reliably overwinters. In years 2-4, we use a no-till transplanter to set crops directly into the clover sod. We mow the clover short (1.5") just before transplanting. Larger cells (72s, 48s) perform better, but 128s can work as well. We mow ~2 weeks after transplanting to set back the clover, and then mow 0-5 times thereafter, depending on crop vigor and weed pressure.
Used for the following crops/crop families:	All crops except potatoes	Main season/storage brassicas, tomatoes, beans, winter and summer squash, chard.
Favorite features	Simplicity Ease of use and maintaining of equipment Seeing soil health improve	Seriously reduced-till: In year 4-5, perennial grasses begin to move in; at that point, we plow down clover and start over. Very little weeding, and what there is is almost entirely replaced by mowing. Easy to plan. Clover can either be planted into, or plowed down, according to crop plan. Few inputs. Our other systems require mulch or plastic. Clover is perennial, so no erosion, C/N fixation, and ecosystem services abound. A pleasure to work/harvest in.

Main low/no-till production method, continued

	Racing Heart Farm	Sawyer Farm
Key considerations	We always make a crop plan, but we always change at some point in the season to accommodate for unforeseen factors. In situations where we have really tight or compacted soil, if possible we will wait to transplant in favor of direct seeding (not carrots) a cash crop OR cover crop. Also, thought should be put into what comes after a cover crop that won't deteriorate within one season. For example, the crimped rye that we planted our fall brassicas in will still be there in spring, so we need to have a plan that includes a hand transplanted, non-brassica crop for that space. The rye that was flail mowed the previous year deteriorated enough to Paper Pot into the following spring.	Clover is very competitive in early spring, so this is not a good system for 'first to market' crops. It also doesn't work for slow-growing transplants, like onions, or for heat-loving crops like cukes and peppers (at least not in our climate). And of course it doesn't work for small-direct seeded crops like carrots (though we have had luck with direct-seeded beans).
Challenges	Moving compost this way is physical, if we had a better way we would change how we do this.	The biggest challenge with this system for me has been embracing biodiversity and letting go of control. There are some yield losses, and some weeds. The whole experience has been like a trust fall.
Key equipment	Soil Penetrometer- this tool will save you a lot of labor. It will let you know when you need to broadfork and when you can skip that step. Broadfork- to loosen compacted soils making way for roots, air, water to penetrate Wheel Hoe- loosen top lay of soil for planting Field vehicle plus trailer- for moving buckets of compost. We have a Polaris Ranger EV (and love it!), plus a 6'x10' trailer. We load about 25 buckets at a time then compost half of 5 beds, reload and do the other half of the beds with the second load. Having a trailer that is low to the ground minimizes lifting heavy buckets BCS Flail Mower- take down spent crops and cover crops BCS Power Harrow- incorporate cover crops (you can also do this with a wheel hoe on a smaller scale), good tool to begin a transition away from	A nice hay mower is great for pre-transplant mowing. Something that can handle an occasional rock or ground staple. But a lawnmower will do for <1 acre. A no-till transplanter (with some modifications) is a must for >1 acre. A brushhog is nice for post-harvest mowing of crop residue; this allows the clover to fill in the space under the cash crop canopy.

Second low/no-till production method

	Racing Heart Farm	Sawyer Farm
Description	Strip tillage for potatoes: plant winter kill oats the previous fall. In spring use rotary plow to open planting furrows (strip tillage). Put into furrow; potatoes, fertilizer, compost. Flip oat 'sod' back on top of the potatoes and compost. Add hay when potato plants are about a foot tall.	Pastured Vegetables - Tarped We use 6' landscape fabric to cover pairs of beds (12' wide total). Each pair of beds is separated by a 10-12' strip of pasture. Each pair of beds has one SOLID sheet of fabric, and one sheet of fabric with HOLES, in a double row, 18" apart. The seam where the sheets meet is permanently pinned down with 8" ground staples. The outer edges of both sheets is held down with sandbags every 2'. The fabric never leaves the field. We can choose to plant through the holes, roll back the SOLID sheet for direct seeding or cover cropping, or use the SOLID sheet post-harvest for weed control. To summarize, this low-labor tarping system allows us to choose between planting through holes, planting in bare soil, or using a SOLID sheet of fabric to control weeds.
Used for the following crops/crop families:	Potatoes	Early production of all vegetables, salad greens, heat-loving crops
Favorite features	A great way to grow mulch in place and increase OM	A good solution for small quantities of high-value crops. We leave the pasture strips to grow until it's time to harvest the crop in a particular bed. These tall native/nativized grasses and forbs seem to provide habitat for pest predators, so we've seen a huge reduction in pests. In particular, we no longer use fabric to cover early brassicas, because we aren't seeing flea beetles. Cucumber and potato beetles are significantly reduced, too. Harvesting crops out of these beds is dreamy.
Key considerations	Must have a pretty good stand of oats before they winter kill	This system involves strips of pasture between permanent no-till beds, so it's not a good use of space if you're limited. It uses plastic, which we're trying to get away from. It's only useful at hand-scale, so it's no good for large plantings.

	Racing Heart Farm	Sawyer Farm
Second low/no-till production method, continued		
Challenges	last year we were in a drought and didn't water the oats, so I don't think we will be able to get much weed suppression from them	Despite the relatively low labor, this system requires a lot of planning -- what was where when, what should come next.... Each bed needs it own own thought/planning.
Key equipment	BCS Rotary Plow	We use a hay mower or brushhog to maintain the pasture between beds. Other than that, it's all by hand.
Third low/no-till production method - Sawyer Farm		
Description		Pastured Vegetables -- Permanent Mulched Beds We mow a hay field that is unsuitable for crop production. We windrow the hay until we have 5'x3' windrows. We rototill a bed next to windrow and then rake the hay onto the new bed. This bed is now in permanent no-till, and we keep adding mulch from additional hay mowings onto it.
Used for the following crops/crop families:		Cukes, tomatoes, trellised beans, leeks, summer squash
Favorite features		- Mulch is produced in situ with little labor. - Pests are seriously reduced due to (we think) pest predator habitat in adjacent pasture grasses/forbs. - Compost/nutrients get applied to pasture rather than crops. Crops get fed from continuous slow release from rotting hay. - Weeding is significantly reduced. We only do 1-2 hand weedings per season.
Key considerations		This system requires 80% of land devoted to pasture/mulch production. It is only useful for marginal land, HELs, or in a situation where land is ridiculously abundant.
Challenges		Hand transplanting into the mulch is time consuming. If you're not on top of renewing the mulch, pasture moves into the beds, necessitating their renewal (tillage) or tarping.
Key equipment		Hay mower and hay rake for mulch maintenance. Rototiller and bed shaper for initial bed establishment.

Future plans and recommendations

What are your plans for future no/low-till production on your farm?	We are always trying to increase our use of cover crops and interplanting with cover crops. We are at a size that provides income to us and one full time employee, and that seems about right for us, so we plan to stay about this size with any growth happening in plant sales and hoop house crops.	We mostly like the clover system, especially for its ecosystem services. We plan to keep exploring which crops work and which factors we can control to expand crops/yields.

	Racing Heart Farm	Sawyer Farm
What are the key transitional steps you'd recommend to farmers wanting to reduce tillage?	Start somewhere small that you think you will have success! Hoophouses generally have less compaction, and are often a good place to start. Maybe try a transition from garlic to something hand transplanted (we have done brassicas, chicories, head lettuce) without tilling in between and see what happens. Can you then rake those beds the following spring and seed or transplant without tilling? The BCS Power Harrow was a good transition tool for us, it loosens the top 1-4 inches of soil (you can set depth in a pretty controlled way), but doesn't invert the soil, and does less to compact it. Make sure your soil has a good Calcium:Magnesium ratio and has enough water- fighting against seized up soil is a struggle you don't have to have!	Reduce tillage without changing anything about your system...think about disc angle, plow/harrow depth, etc. Try undersowing Dutch White clover into standing cash crops. Even if you don't plant into it the following year, you'll have a nice overwintered cover, established pre-harvest, that's easy to terminate.
What pitfalls should farmers watch for when transitioning to low/no-till systems?	Rigidity. No-till should be making your life easier, not harder.	Don't invest in new equipment until you've ensured that the system you intend to adopt works for your farm. Be creative in reducing tillage with the equipment you already have. Look to offset likely yield losses with labor reductions.
Equipment list	We have the BCS 853 ($5999) which we bought used, Attachments for the BCS: Power Harrow, 30" model $2749- used for bed prep, and sewing cover crop seeds Rollerblade Flail Mower, $3349- taking down spent crops and cover crops Rotary Plow, "Ground Blaster" $2000- planting potatoes Soil Penetrometer from Dickey John $200 Broadfork we have many… We have used the hardpan broadfork from Johnny's and Meadowcreature (both very heavy, we prefer the Johnny's one because it has a wood handle), the harvest broadfork from Johnny's we use for digging carrots, and an number of 24"-30" regular broadforks. Landscape Fabric for occultation, we get from Nolt's along with the 8" sod staples	Drum mower (we used to use an old horse-drawn McCormick Deering High Mowing #9 sickle bar mower ($800), which worked pretty well). The drum mower powers through obstacles. It's an Ibex TM67, $5500. Belt rake (we used to use an old New Holland tow-behind side delivery rake ($400), which worked fine). Ours is an Ibex TS100, $4500. No-till transplanter (we have a Mechanical Transplanter 33-6000, finger-type). ~$6500. We added a coulter and ripper (up to 7" deep) in front of the shoe to open the slot. We also added weight to the packing wheels, and counter-weighted the drive wheel. If I could do it over, I think I would go with a Checci & Maggli carousel transplanter. Lawnmower (the taller the deck the better for powering through tall clover). Weedwhacker. Brushhog