Project Title: Organic No-till on Northeast Farms: A Practical Exploration of Successful Methods
Grantee Name: Northeast Organic Farming Association Massachusetts Chapter Inc
Project Dates: 9/29/2018 – 1/31/2022
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Project Summary

Organic No-till on Northeast Farms: A Practical Exploration of Successful Methods was a multiyear project evaluating soil carbon, pests, and yield for 9 farmers committed to performing reduced or no-till farming. Farmers were encouraged to trial different management strategies to help guide their transition as they reduced tillage. In addition to regular learning cohort discussions, farmers also participated in soil health field days throughout the three-year project duration to help farmers not directly involved in the project learn from the group farmers' knowledge and experiences. Data from soil carbon proxy testing, pest, and yield measurements found some modest improvements in soil bulk density, soil aggregation, and soil hardness. Farmers also reported a benefit from participating in the learning cohort calls and no-till methods trialing. Outreach successfully helped over 3,000 individuals learn more about soil carbon and soil carbon proxy testing, benefits of reduced and no-till agriculture, and practical implementation of different management strategies.

Project Details

Project Background & Rationale

Despite currently being a high emitter of climate change-inducing CO_2, agriculture is the one industry that has the capacity to absorb more CO_2 than it produces, with the potential to sequester between 25 and 60 tons of carbon per acre. When soil is exposed to the air, such as through tilling, carbon molecules in the soil are released into the atmosphere. Tillage reduction is a key way to keep carbon in the soil, helping agriculture to transition from a carbon source to a carbon sink.

Through a Conservation Innovation Grant (CIG) project funded by the U.S. Department of Agriculture (USDA), Northeast Organic Farming Association (NOFA) chapters in Massachusetts, New Jersey, and Connecticut have developed a learning community of farmers in the Northeast who have been integrating reduced and no-till methods on their farms. The goal of the project was to increase the practice of organic no-till farming among Northeast farmers by supporting existing low and no-till growers as they innovated and experimented with proven and new methods. To achieve these goals, the three participating NOFA chapters have spent the past three years evaluating changes in soil carbon at 9 partner farms in New Jersey, Connecticut, and Massachusetts. Farmers participated in regular calls to develop a learning community around organic reduced/no-till production and to foster and support innovation between farms. Farmers also participated in community-wide educational events and workshops to share techniques. The farms were partnered with their state extension agents to collect data on various indicators to evaluate the role of reduced and no-till in controlling and maintaining crop pests.

Methods

Farmer participants participated in learning group calls and provided records of crop yield, weed pressure, and pest observations over the project duration. NOFA/Mass staff performed soil carbon proxy tests at each farm annually to evaluate any changes in soil carbon sequestration and soil organic matter. Soil carbon proxy testing offers an indirect, field-based

measurement of soil carbon. Soil carbon contributes to regulating for a soil's water holding capacity, structure, and fertility, playing an important role both in agriculture and the environment. Soil carbon proxy testing uses indicators commonly associated with the presence of carbon to indirectly evaluate the amount of carbon in soils: soil surface biology, soil aggregation, bulk density, water infiltration rate, slake and turbidity, earthworm count, and soil hardness. Certain physical, chemical, and biological components of soil, such as soil aggregates and water infiltration rate (physical), active carbon (chemical), and earthworm and root counts (biological), are highly present in soils abundant in carbon and, subsequently, organic matter. Soil carbon proxy testing was the primary means of assessing changes in soil carbon sequestration in response to changes in tillage management and practice implementation. Soil carbon proxy testing was supplemented with farmer surveying of management practices, crop yields, and pest pressures to understand the tillage farmers were utilizing and their effects on crop production and pests.

Results

Project findings showed improvements in some soil carbon proxy test metrics, including soil hardness, bulk density, and depth to compaction, particularly when data was divided between farms performing reduced tillage and those performing no-till. Soil hardness was consistently lower for no-till farms than for reduced till farms, as was depth to compaction. However, bulk density increased for no-till farms but decreased for reduced till farms. Aside from soil hardness, bulk density, and depth to compaction, overall findings revealed mixed results on the effects of reduced and no-till management on other soil carbon metrics, crop yield, and pest pressures. Findings were also complicated by precipitation: 2019 and 2021 both had above average rainfall, particularly in 2021, which may affect some of the metrics evaluated through soil carbon proxy testing.

Farmers were requested to self-report on yield of three crops over the course of the project. By the third year of the project, only one farm found an improvement to in crop yield, for spinach, compared with previous years. Of the 5 farms responding to the 2021 survey with yield data on 13 different crops, 9 crops had about the same yield as in previous years and 4 crops had lower yields compared with previous years. These findings are nearly identical to those from year 2 of the project, yet in the first year of the project, 6 crops had higher yields than previous years, with 3 crops in failure/near crop failure, and 4 crops with approximately the same yield as in past years.

Farmers were requested to self-report on pest observations and crop damage resulting from pests, including weeds, disease, and insect pressures. Throughout the three-year project, none of the farms found a major improvement or negative impact from no-till on pests; pest interventions and estimated production costs were found to be roughly the same as prior to starting no-till. Of the possible benefits observed by some farms, cabbage worms and potato beetles were the two pests identified as potentially decreasing in prevalence over the duration of the three-year project.

No-till management trialing was successful for farmers, as they were given the freedom and support to try different methods than they may have without the support of the project learning cohort and advisors. Management strategies trialed included solarization, occultation, interseeding, and mulches for weed control, cover cropping, board crimping[1], and use of a seed drill. In some instances, the strategies were successful, such as the use of tarps allowing farmers to dramatically reduce rototiller use, whereas others were less successful, such as when legume cover crops were consumed by deer. As with the soil carbon, pest, and yield data, a longer project duration would help in evaluating the effects of management strategies: in the instance with the deer browsing on the cover crop, the farmer was able to prevent damage by installing a deer fence, but not in time to offer a full season to evaluate the effects of the cover cropping on weed control. Further detail on the practices each farm trialed, and the overall impact on soil health and production, follows below.

Practice Trialing Findings

Northslope Farm (NJ) implemented a "split farm" approach[2]. Market Garden methods include a permanent bed system between living aisles (grass and clover) where tillage is reduced. Use of hand tools (rakes, broadforks, etc.), flail mower, and power harrow rototilling for most bed transitions, such that no soil inversion or plowing occurred. Other soil health practices include compost application, intercropping, and cover cropping. In the field (non-Market Garden), instead of plowing cover crops, furrows were made into living permanent cover crops of grasses and clover, and compost was applied to furrows and lightly rolled in. Farmers used occultation to terminate cover crops, weeds, and speed digestion of crop residues. This was slower than solarization, which uses clear plastic tarps but may harm surface soil biology. Cover crops were terminated by crimping instead of mowing in order to increase residue. Targeted use of tarps for crop transitions enabled the farmers to dramatically reduce rototiller use. On-farm soil carbon proxy test findings showed improvements in root sheathing, soil aggregation score, slake and turbidity, bulk density, and soil hardness. Weeds remained an issue, and, despite an expressed commitment to reducing and eliminating tillage, the farmers felt occasional, light tillage still plays an essential role in controlling perennial weeds, such as invasive grasses in fallow fields being brought into production.

Morganics Family Farm (NJ) utilized regular mowing on its no-till field to control thistles, instead of plowing on tilled fields. They also experimented with use of intercropping for cash crops to

[1] Board crimping is a method of crimping cover crops without a tractor. The farmer walks along the bed, pressing down the cover crop and using the T post ridge to crimp the stems of the cover crop. Cover crops are often then tarped to complete the termination process.

[2] The "split farm" approach is an emerging practice in organic soil health-oriented vegetable farms at the 2 to 10 acre scale. The farmer sets aside an area on their farm, usually less than 1 acre, as a "Market Garden" and uses more typically market-garden methods, such as lots of compost and mulch, hand tools, and/or walk-behind tractors, and tarps and landscape fabric, to grow high-rotation crops. High-rotation crops are considered faster-maturing crops grown in succession in the same beds at tighter spacing, such as 10 rows of baby greens instead of 5, while low-rotation, "long-season" crops are grown using more mechanized field methods. This allows the farmer to reduced total land used to grow the same yield, setting aside more land for fallow rotation, cut and carry mulch production, livestock, or other conservation practices, or to even increase production without expanding land use.

increase diversity, with cover crop rotations between grain crops. To implement these practices, farmers used an interseeder to apply low growing clover as a perennial understory to grain crop to help control weeds. They also used a modified grain drill to seed into residues without tilling. By the third year of the project, they'd learned that they needed to install a deer fence to control deer browse. Following this failure in the second year of the project, the farmers attempted legume-grain intercropping (lentils and oats) for diversity and nutrient management. Farmers learned that intercropping of legumes and grain was ineffective until the deer fence was installed. On-farm soil carbon proxy testing showed improvements in soil cover, mostly through living cover or mulch/residue, as well as improvements in rooting depth, root sheathing, soil aggregation score, bulk density, and earthworm count. Weeds remained their biggest pest pressure in their oats production, eventually outcompeting the oats crop, leading the farmers to conclude that "significant tillage reductions can be achieved, but occasional light tillage will remain a necessary part of the system."

Ironbound Farm (NJ) used a seed drill to increase the number of days in living cover by drilling cover crops into crop residues without requiring the use of a harrow for incorporation. This allowed the farm to bring cover crop from 20-40 days in living cover to 90-120 days in cover crop living cover. Ironbound Farm joined in project Year 2, making it difficult to make any trends. Observationally, topsoil depth, soil aggregation score, soil hardness, and the depth to compaction or rocks improved between years.

Red Shirt Farm (MA) established no-till on permanent raised beds. The farmers used tarps to open new areas, followed by a BCS rotary plow to create new beds and a flail mower/power harrow after. The beds were mulch heavily with wood chips, straw, and landscape fabric, and multi species winterkill cover crop were used as much as possible. Living pathways with low growing clover and fescue mix were trialed in place of mulch and landscape fabric between permanent beds to increase living roots and improve soil health. On-farm soil carbon proxy testing showed major improvements in soil hardness and depth to compaction or rocks, particularly in 2021, where penetrometer readings were much lower throughout the depth spectrum than they had been in prior years. Improvements were also seen in soil cover, depth to deepest root, and topsoil depth.

Gaining Ground Farm (MA) was entirely no-till at project outset. Power harrows were used for fertilizer and compost incorporation on the soil surface (1-2" depth). Farmers trialed the use of rye cover crop on some parts of the farm, terminated by board crimping and tarps, to grow a mulch cover crop in place. They also added permanent perennial strips for pollinator habitat and medicinal/fruiting crops. Based upon successes from the second year of the project, of cover crops was expanded in the third year of the project, reducing the use of tarps for stale seedbedding and adding in more time in cover crops for soil health and mulch grown in place. To achieve this, the farmers intercropped multiple cash crop species for greater soil cover and greater yield per square foot. Successes from trialing board crimping to terminate cover crops led to this adoption of increased cover cropping in future years. On-farm soil carbon proxy testing showed improvements in rooting depth, soil aggregation at the 1-4" depth, and turbidity.

Freedom Food Farm (MA) utilizes a "split farm" approach, with a market garden area in permanent beds mulched with compost for high-rotation crops. The aisles were covered with wood chip mulch. In contrast, mechanization was utilized for field production, with tillage reduction practices including use of a chisel plow and harrow instead of moldboard plowing, and using animals to graze off cover crops. To implement and achieve these trials, the farmer acquired and utilized a seed drill and roller crimper, allowing the farm to grow more overwintered cover crops and avoid harrowing for direct seeded crops and cover crops to manage for better residue. They also planted garlic through a living oats and peas cover crop, which winterkills in October/November, extending days in living cover and growing some of the garlic crop's mulch needs in place. Additional mulch was applied after the oat pea cover crop winter killed. In the third year of the project, farmers used additional external funding to purchase and adopt a cut and carry mulching system[3] to harvest cover crops for mulch, reducing off-farm mulch inputs and increasing soil organic matter. On-farm soil carbon proxy testing showed moderate improvements in soil hardness, the number of observed plant species, and rooting depth. Farmers observed that after keeping carrots in the same place for 3 years, the no-till management improved soil fertility and the increased organic matter and soil debris helped the soil absorb heavy rainfall in 2021.

Assawaga Farm (CT) is a no till hand-scale farm that used compost to cover soil surface and build fertility. They adopted use of cover crops, terminated by board crimping and occultation for termination, and adopted use of straw, wood chip mulch, and landscape fabric to cover all the soil on the farm. Throughout the project, they adopted regular soil microbial testing for fungal to bacterial ratio, setting a goal to increase fungi in the soil. They also expanded on mulching and cover cropping, experimenting with different ways to overlap crops and cover crops to extend days in living cover and reduce compost use. Ideally, they hoped cover crops could replace compost as a soil surface cover and soil organic matter builder. On-farm soil carbon proxy testing showed good improvements in maintaining soil cover and in slake and turbidity as the project progressed. Over the project duration, the farmers found improvements in potato beetles on potatoes and improvements in cabbage worms and aphids.

Massaro Community Farm's (CT) reduced-till field used silage tarps as the primary cover crop termination method, instead of harrowing. Beds were still formed with a bed-former each spring after tarps were removed. Farmers trialed the use of "weed guard plus," a biodegradable paper mulch for weed suppression. By the third year of the project, due to improvements in soil structure and water drainage, and greater use of mulches for weed suppression, bed-flattening cultivation passes were no longer needed, and farmers no longer needed to use the bed former. On-farm soil carbon proxy testing confirmed improvements in water infiltration that were observed by the farmer. Soil hardness and depth to compaction also improved over the duration of the project.

[3] Cut and Carry Systems or Transferred Mulch Systems refers to when cover crops are harvested and collected as green chop, then applied by manure spreader as added mulch to cropped beds for weed suppression and organic matter.

Sub Edge Farm (CT) rented a roller crimper and seed drill from an equipment sharing program and trialed it on one field to learn how to do organic no-till with these implements. They trialed grazing of cover crops with livestock. In the third year of the project, the farmers expanded the use of the roller crimper to terminate cover crops and the seed drill for seeding to attempt no-till at a large scale on a new 100-acre field. On-farm soil carbon proxy testing showed improvements in rooting behavior, including increased depth to deepest root, root sheathing, and average depth of root termination. Sideways or balled roots, indications of compaction, were prevalent in 2019 yet not observed in 2020 or 2021. Positive improvements were also seen in topsoil depth, bulk density, and the slake test.

In several cases, having the opportunity to trial different no-till strategies gave farmers the experience and confidence to attempt or expand upon them, or similar management strategies, in other parts of the field. Many of these farmers expressed a desire to continue using these techniques long-term moving forward, possibly with some modifications, such as occasional light tillage for weed control.

While changes in soil carbon may not have been immediately observed in the short duration of this project, it's likely that positive changes will occur over time if these practices are used properly and continued over several years. As evidenced at Massaro Community Farm, there were sufficient changes in soil condition for the farmers to be able to change their management and stop needing a bed-former, as a result of greater water infiltration. While these improvements in soil structure may not have been immediately visible in testing, the practical effect of improved water infiltration allowed the farmer to make positive management changes in a short period of time.

Equipment Used for Different Management Strategies

- Flail mowers were used to prep permanent beds
- Chisel plows were used for mulching in perennial crops, in combination with a no-till drill for cover and grain crops.
- No-till drills were used to seed cover and grain crops in permanent pasture without tillage. They were also used to sow successions of beans in between successions of grain crops (i.e. garbanzos between rows of winter wheat) to be harvested together and improve stand density.
- Basket weeders were used as a replacement for harrow plows for incorporating amendments. Beds were prepped using black plastic mulch in pathways
- Yeomans plow was used in combination with a Favorable Furrow System in which a cover crop is mowed off, single shank is used to rip a 4-6" trench, compost applied, and surface lightly loosened with a rototiller. Planting occurred in furrows, while the soil around the furrows is left undisturbed.
- No-till grain/seed drill is used in combination with transferred mulch systems, roller crimping, and tarping, to seed through cover crop residue

- BCS mini-baler was used for a small-scale transferred mulch system for on-farm compost production
- BCS-mounted power harrow was used to take fields out of perennial cover crops and in combination with solarization for opening new land
- BCS walk-behind mounted roller-crimper was used to terminate cover crops and form beds. Beds were then covered with silage tarps to eliminate cover crop residue, with planting after tarp removal
- Roller-crimper was designed with a lumber plank used underfoot (with rope handles for keeping the board braced underfoot)
- Board crimper was used to terminate cover crops via crimping and occultation instead of mowing, improving residue retention. Combined with expanded use of tarping for no-disturbance stale seed bedding. Eliminated the use of a bed-former to remake beds each year.
- Broadforking was used to aerate and loosen soil, as well as create channels and holes for inoculated compost and organic fertilizer to enter soil pores more deeply than surface application

Challenges

Both reduced and no-till farming have proven benefits to soil carbon, pest pressure, and yield. As no major changes to these components, whether positive or negative, were observed over the duration of the project, it is very possible that the three-year project duration was insufficient to capture the effect of these management changes over time. The general expectation is that it can take several years for pest pressures to begin to reduce after transitioning to a no-till system, and it is likely that the duration of this project failed to capture these potential improvements. Additional challenges surrounded the nature of the self-reporting by farmers. Project coordinators had trouble getting farmers to complete management, yield, and pest surveys, and did not have 100% rates of completion for any year of the project. Having a greater rate of participation in surveys would increase the strength of the findings. Finally, from a scientific standpoint, the project was not controlled, leading to the inclusion of potential variables that may have impacted the findings of any of the measured metrics in this project. Thus, any findings associated with changes in tillage management can be interpreted as correlational but are not necessarily not causational.

<u>Summary of Outputs with Links</u>

Due to the large number of planned on-farm events and workshops, and the transition from in-person events to online events due to Covid-19, a large portion of the education events performed as a part of this project remain available as online media. Education events from 2020 and 2021 are on the YouTube channels of the affiliated NOFA chapters and are listed below. Additional written content pertaining to this project, including articles published in the NOFA quarterly newspaper, The Natural Farmer, are also available online and linked below. Final project deliverables including a discussion of findings for The Natural Farmer and a one-page Fact Sheet for Best Organic No-Till Practices are available through the NOFA/Mass website. The discussion of findings will be published in the Summer 2022 edition of The Natural

Farmer; while findings summary has been completed and is available on the NOFA/Mass website, it is not yet available through The Natural Farmer due to the timing of publication.

Report of Project Results: https://www.nofamass.org/articles/2022/04/evaluating-reduced-and-no-till-findings-from-a-three-year-study-of-northeast-farmers-utilizing-alternative-tillage-systems/
Fact Sheet for Best Organic No-Till Practices: https://www.nofamass.org/wp-content/uploads/2022/04/No-Till-Practices-Fact-Sheet.docx.pdf

Education Event Recordings

- NOFA 2021 Summer Conference No-Till Keynote Panel: From Purpose to Practicality (7/21): https://youtu.be/n0mtBa1uUiw
- Soil Carbon Proxy Testing – Observation Hoop: https://www.youtube.com/watch?v=GH-5DWOxH4A&t=7s
- Soil Carbon Proxy Testing – Soil Aggregation: https://www.youtube.com/watch?v=ntvJWhj7CAo
- Soil Carbon Proxy Testing – Digging a Hole & Subsurface Observations: https://www.youtube.com/watch?v=Iq2x0xAgRdQ
- Soil Carbon Proxy Testing – Slake Test: https://www.youtube.com/watch?v=l5mwrbkicyc
- Soil Carbon Proxy Testing – Earthworm Count: https://www.youtube.com/watch?v=TVCKhy0vmu0
- NOFA-NJ Monthly Organic Open House (5/26/21): https://youtu.be/cen8Q4FTSJw
- General video put together by NOFA-NJ: https://www.youtube.com/watch?v=6uc4nv4oaBA
- NOFA-NJ Soil Health Event at Ironbound Farm (2020): https://www.youtube.com/watch?v=cI2WxgHKmsM&t=0s
- NOFA-NJ Ironbound Farm Organic Open House (2020): https://www.youtube.com/watch?v=03-Td3S-xL0
- NOFA-NJ Soil Health Event at Ironbound Farm (2020): https://www.youtube.com/watch?v=cI2WxgHKmsM&t=23s
- CT-NOFA Soil Health Field Day at Assawaga Farm (2020): https://www.youtube.com/watch?v=qCHUUaM6lsU&t=862s
- CT-NOFA Soil Health Field Day at Sub Edge Farm (5/25/21): https://www.youtube.com/watch?v=DdohEVHQVRg
- CT-NOFA Soil Health Field Day at Assawaga Farm (9/20/21): https://www.youtube.com/watch?v=CeKbLY7JckM
- General video put together by CT NOFA: https://www.youtube.com/watch?v=nmZpW2f0crU
- NOFA/Mass Soil Health Field Day at Red Shirt Farm (2020): https://www.youtube.com/watch?v=tmdgQmagIzY&t=128s
- NOFA/Mass Soil Health Field Day at Freedom Food Farm (2020): https://www.youtube.com/watch?v=ZvMcEclrnDA

- NOFA/Mass Soil Health Field Day at Gaining Ground Farm (9/26/21): https://www.youtube.com/watch?v=mqG4sgl0pVQ
- NOFA/Mass Soil Health Field Day at Freedom Food Farm (10/10/21): https://www.youtube.com/watch?v=YZ04gvjhq_U

Newsletter Articles & Written Content

- NOFA Conservation Innovation Grant (NRCS) Project: Organic No-Till on Northeast Farms: A Practical Exploration of Successful Methods: https://www.nofamass.org/nofa-conservation-innovation-grant-nrcs-project/
- Soil Health Field Days 2020: https://www.nofamass.org/articles/2020/09/soil-health-field-days-2020/
- Interplanting and Plant Intensification: https://www.nofamass.org/event/interplanting-and-plant-intensification/
- NOFA/NJ: Organic Open Houses Iron Bound Farm Field Day: https://ctnofa.org/event/nofa-nj-presents-organic-open-houses-iron-bound-farm-field-day/
- NOFA/NJ: No Till Strategies for Soil Health Virtual Field Day: https://ctnofa.org/event/no-till-strategies-for-soil-health-virtual-field-day-at-north-slope-farm/
- Press Release, August 2018: Grassroots Organic Farmers Receive Federal Grant, Lead Northeast Study on Practical Methods for Agricultural Soil Carbon Sequestration: https://docs.google.com/document/d/1XnDE5znlXnRvCi1VhNfFq4UgFdsafYU9?rtpof=true&authuser=christine%40nofamass.org&usp=drive_fs
- November 2018: e-Newsletter: What We Mean When We Talk About Tillage: https://www.nofamass.org/articles/2018/11/what-we-mean-when-we-talk-about-tillage/
- July 2021: Be a Better Grower e-newsletter: A Primer on Sustainable Soil Management by Christine Manuck https://www.nofamass.org/articles/2021/07/a-primer-on-sustainable-soil-management/
- August 2021: Be a Better Grower e-newsletter: Soil Carbon Proxy Testing Can Help You Help Your Soil by Christine Manuck https://www.nofamass.org/articles/2021/08/soil-carbon-proxy-testing-can-help-you-help-your-soil/
- Fall 2021 The Natural Farmer. Summary of the 47th Annual NOFA Summer Conference: Sustainable Soil Management Through No- and Reduced-Tillage https://drive.google.com/file/d/1se3qzwDNpnF005Tay8BtAmHZ6W6alSxd/view (pA-10-12, pdf p. 10)

<u>Discussion of the Impact or Potential Impact of the Project to Conservation in the U.S.</u>

Soil carbon, pest, and yield data findings were generally inconclusive and was not strongly affected by tillage reductions, likely due to the relatively short project duration, variables such as precipitation, and incomplete reporting from partner farms on yield and pest observations. There are many studies that make stronger associations between soil carbon and reduced and no till management systems than this one does with its small farmer cohort and short project period. However, another study evaluating the effects of reduced or no-till farming over time

wasn't essential given the extent of the existing knowledge. A key component of the project was outreach and education about reduced and no-till management within the farming community, and this project excelled at achieving these goals and sharing knowledge pertaining to reduced and no-till management and soil carbon. The successes of outreach and education, and deliverables produced through this project, including the Best Organic No-Till Practices Fact Sheet, offers a lasting support to farmers exploring reduced or no-till farming.

All NOFA chapters participating in this project led several on-farm events, workshops, and other educational outreach efforts to help promote reduced and no-till farming. Education outreach ranged from practical implementation of no-till farming to soil carbon proxy testing demonstrations to field-based demonstrations of different equipment used by no-till farmers. In-person events were limited due to Covid-19 beginning in 2020, yet NOFA chapters adapted by offering events in online/webinar formats, virtual workshops, and YouTube videos. Based upon attendance and viewership of live and virtual events and recordings, at least 3,000 individuals participated in education events over the project duration. This has a significant potential level of impact in the Northeastern U.S., where small farms dominate the agricultural landscape and there is high potential for adoption of reduced and no-tillage management practices. Farmers frequently highlight the value of farmer-to-farmer learning experiences, and the educational materials that were produced through this project has already impacted the farming community.

Potential Next Steps

To further study the effects of reduced and no-till management changes on Northeast farms, this project should be repeated in a more controlled format evaluating management and results of soil carbon, pest, and yield. Completing the project of a longer duration, such as 5-7 years, could also capture soil's progression and changes in response to reductions in tillage, and its downstream effects on pests and yield. A longer project would also create a greater opportunity for farmers to evaluate different no-till methods and to see any effect from them on soil carbon, pests, and yield metrics. In addition, involving a larger cohort of farmer participants would provide greater statistical power to support findings and a better learning opportunity for farmers in discussing no-till approaches, successes, and failures. Finally, utilizing a more reliable self-reporting mechanism for farmers could provide more reliable pest data to help draw stronger conclusions about the effects of tillage reductions on pest pressures. Building upon the experiences from this project, potential next steps for this project would be to repeat the project over a longer duration, with more farmers and better coordination surrounding pest and yield reporting, while maintaining the more successful components of this project, particularly outreach, farmer-to-farmer education, and reduced and no-till method evaluations.

Figures

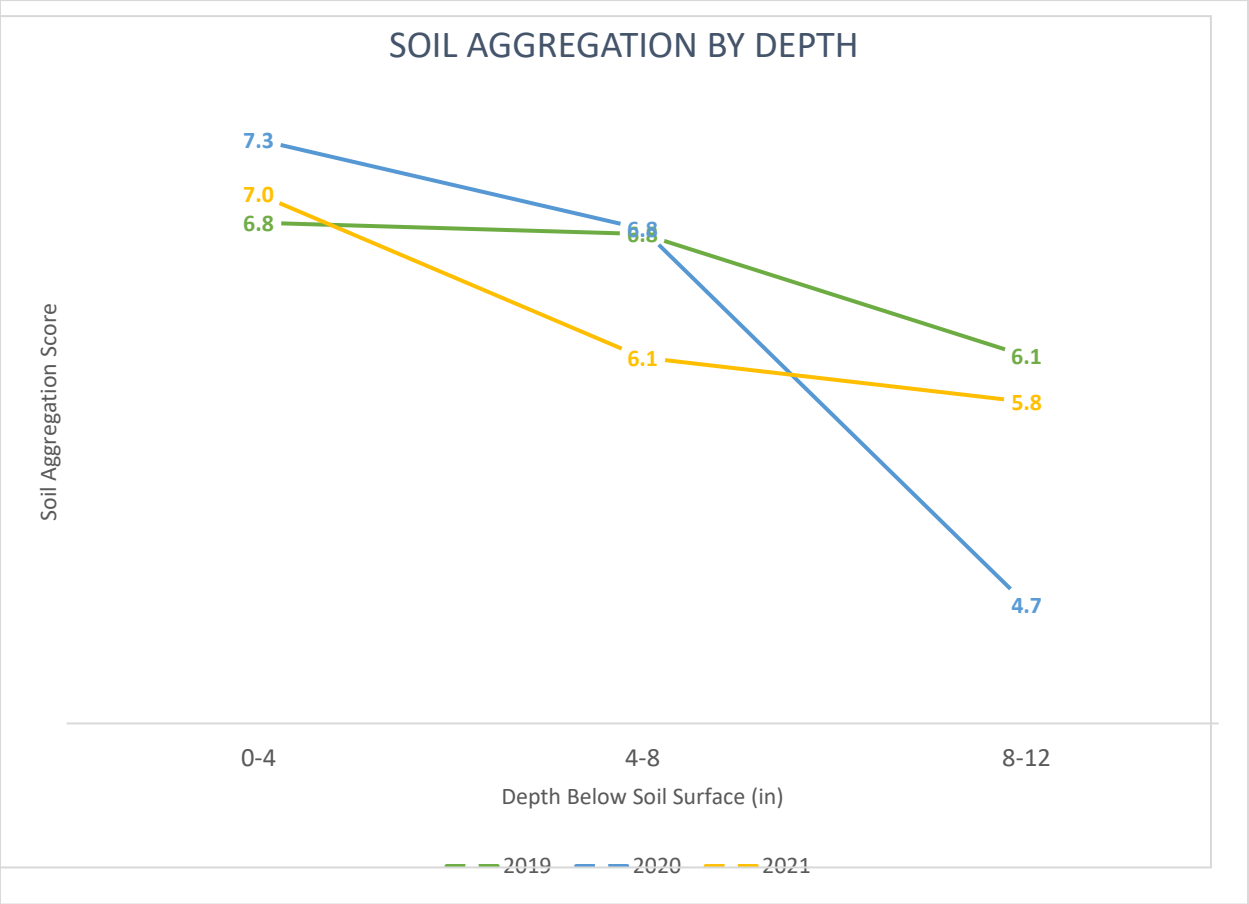

Figure 1. Soil aggregation scores at each depth throughout the duration of the project. Soil aggregation scores evaluated the strength and structure of soil aggregates at various depths below the soil surface as a direct indicator of soil structure and formation in response to changes in tillage.

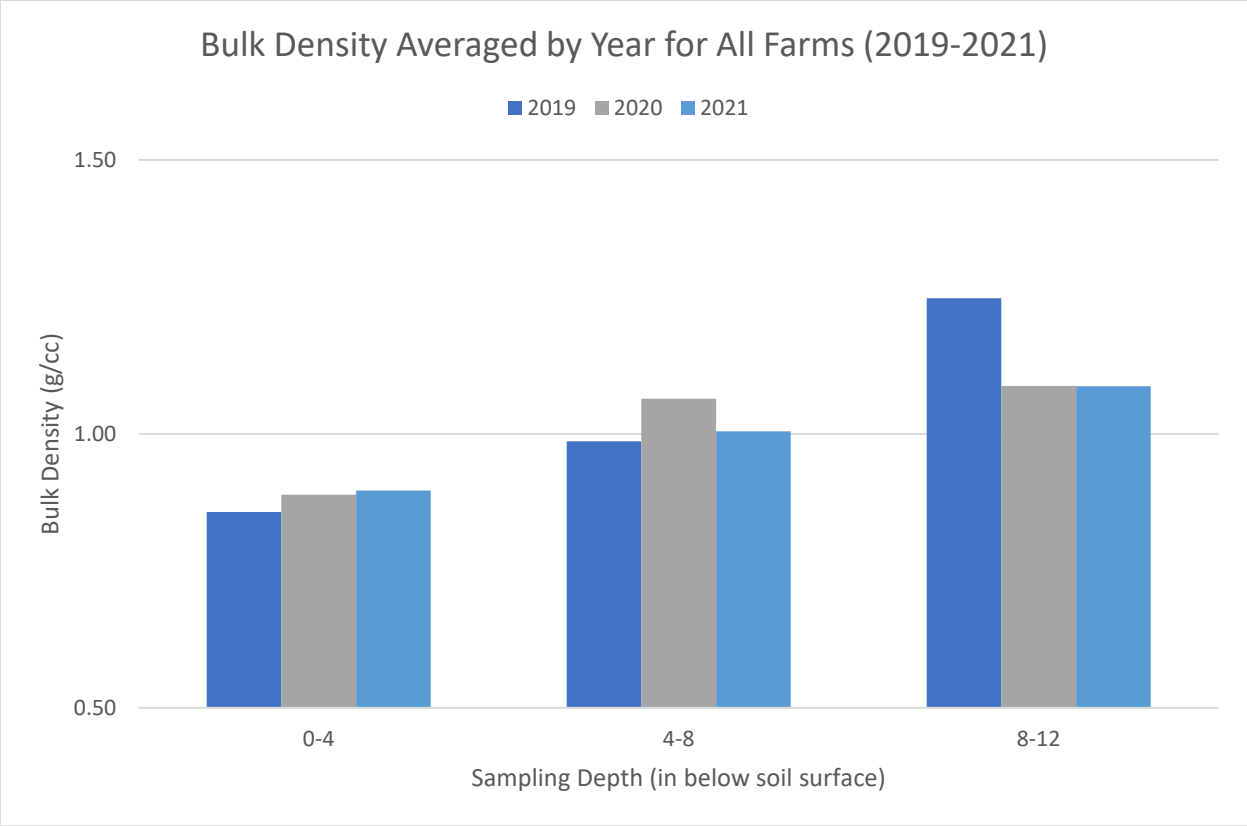

Figure 2. Bulk density (g/cc) for all farms over the project duration. Bulk density provides a measurement of the density of the soil; higher densities indicate more soil within a cubic centimeter with fewer pore spaces and channels for roots and soil biota.

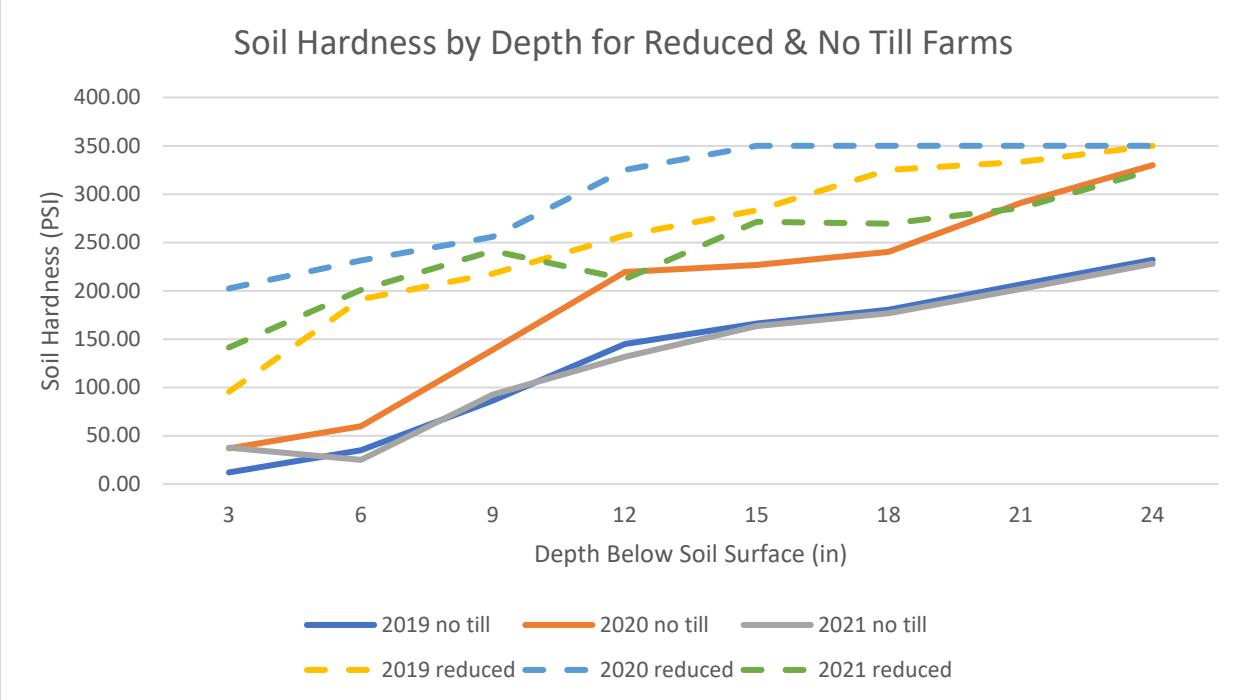

Figure 3. Soil hardness (PSI) at various depths below the soil surface for reduced till and no-till farms during 2019, 2020, and 2021. Lower soil hardness correlates to lower levels of compaction, which is a positive indicator of soil carbon.

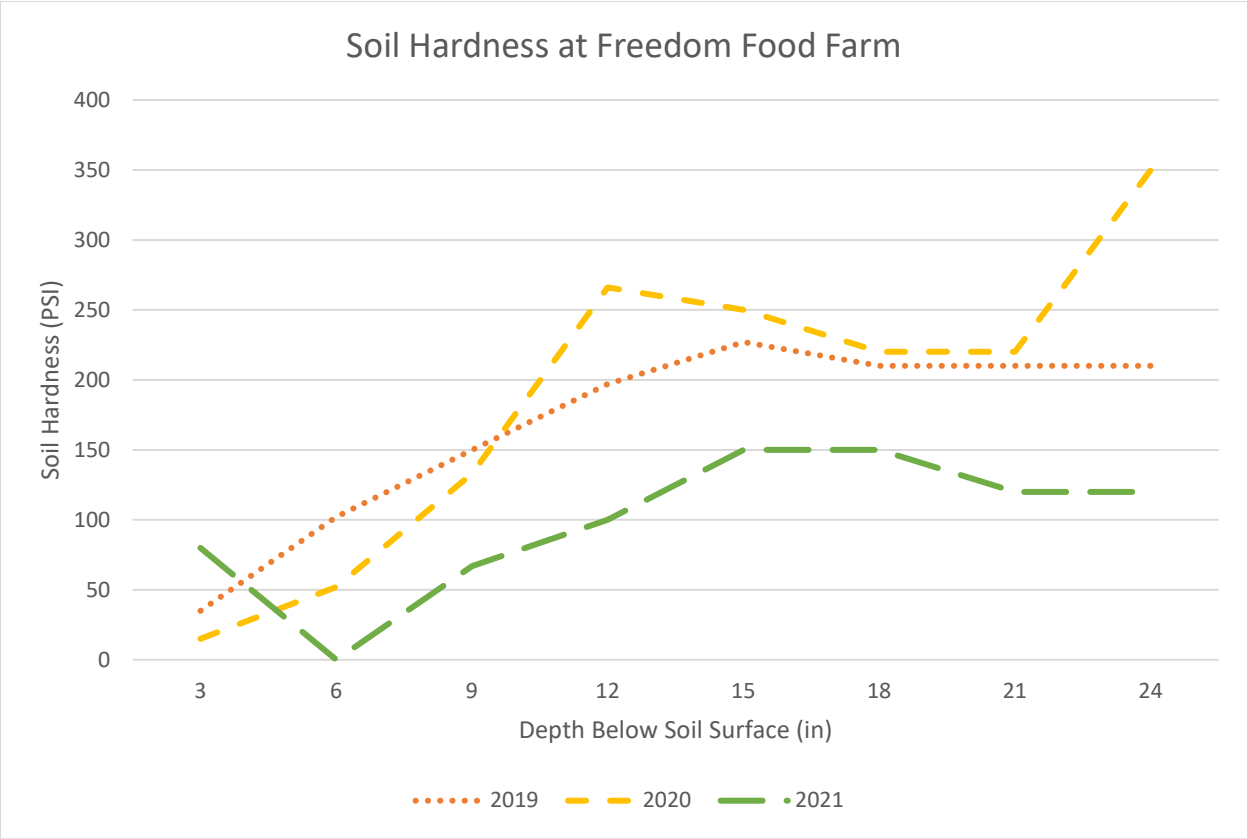

Figure 4. Soil hardness at Freedom Food Farm, based upon penetrometer readings. Lower soil hardness readings are correlated with lower compaction and improved soil carbon. Soil hardness decreased over the duration of the project, indicating a possible positive effect of the no-till management system.