Reducing climatic and disease risks through minimum tillage systems for vegetables

2012 Annual Report

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Summary

Reduced and modified tillage (RT) systems (e.g. no-, zone-, strip) represent strategies to reduce soil degradation and erosion and protect water quality. We have shown that zone and deep zone tillage systems can provide the environmental and economic benefits of an RT system for many vegetable crops without the harvest delays or losses observed in straight no-till. Each season, more vegetable growers express interest or try RT on their farms. It was our intent with this research to evaluate the ability of RT systems to ameliorate large fluctuations in water supply which may result from climate change, and in particular reduce crop losses to flooding, drought and vegetable diseases like Phytophthora capsici. During the first year of our project (2010), however, all of our field trials were lost in the catastrophic flooding of Hurricane Irene. As a result, we found many growers hesitant to commit to multiyear trials on their farm. Thus we were not able to continue with approach to on-farm experiments we had planned. After discussions with Northeast SARE, we have redirected our efforts to promote and expand growers testing RT on their farms.

Objectives/Performance Targets

As a result of this project's trainings and on-farm trials on reduced tillage systems, 40 growers new to RT will apply these systems on at least 20% of their land (2000 acres total), and report increased management flexibility and timeliness and improved profitability. These production cost savings will average $25 per acre, including fuel (2 gallons per acre or $8/acre) and labor ($10/acre) and income will increase from Phytophthora capsici susceptible crops by 20% or range from $700 to $4,000 per acre, depending on the crop and market.

Accomplishments/Milestones
Milestone 1

Milestone 1: Of 500 farmers attending field days or workshops about reduced tillage sponsored over the duration of the project, 250 respond to an exit survey, and 150 demonstrate increased knowledge about how these systems can improve soil health, reduce costs and affect crop diseases. NOFA NY Organic Winter Conference – January 12-14, 2012 Anu Rangarajan (PI) presented at the NOFA NY Organic Research Conference on January 12, 2012 on recent innovations and developments in organic reduced tillage. Discussions focused around zone and deep zone tillage and the goals of enhancing soil quality through minimizing soil disturbance, with applicable case studies mentioned. Organic strategies for weed suppression in a reduced tillage system were discussed on an annual and multiyear basis, describing the merits of permanent raised beds, mulching techniques and crop rotations. The soil disturbance profile was outlined for zone versus deep zone tillage with descriptions of successful vegetable crops grown in both systems. The presentation also elucidated equipment innovations, including zone builders constructed for low horsepower tractors for use on small acreage plots, as well as the most recent innovations in DZT units built to form raised beds for a permanent bed system. The experimental results discussed focused on fertility and weed management compromises for different strip planted cover crops used in DZT systems. In addition, the Cornell Organic DZT experiments with pepper and cabbage showed similar yields between conventional and DZT for 3 and 4 years, respectively. Rye/vetch cover crop residue was challenging to manage and interfered with mechanical cultivation. Though mulch reduced weed pressure it also reduced yields in cabbage 2 of the 4 years and peppers 3 of 4 years. Perennial weed pressure became problematic after 2 years, suggest that conventional plowing may be required in organic RT systems after the 3rd year. Veg Edge Newsletter – January and March 2012 Information about reduced tillage in organic and conventional vegetable production was published in the Cornell Veg Edge monthly newsletter for the months of January and March. We've also included updated information regarding our funding for growers who wish to adopt reduced tillage to their organic vegetable growing operation through the Cornell Reduced Tillage website. Reduced Tillage at the Empire State Fruit and Vegetable Expo - January 24-26, 2012 The 2012 Empire State Fruit and Vegetable Conference was sponsored by the New York State Vegetable Growers Association, Empire State Potato Growers, New York State Berry Growers Association, New York State Farmers' Direct Marketing Association, New York State Horticultural Society, Cornell University and Cornell Cooperative Extension. This was the primary winter meeting for NYS conventional vegetable growers. The Reduced Tillage team provided brief presentations at the beginning of each vegetable crop session highlighting our research and providing additional information to growers who may be interested in conducting reduced tillage trials. We reported on the successes with reduced tillage in a wide variety of large seeded and transplanted vegetable crops and shared how growers could apply for zone builder equipment loans and cost share funds to rent the equipment they need to give reduced tillage systems a try. UMass Vegetable Notes – May 25, 2012 May 25, 2012 issue included an article on DZT. Veg Notes goes out to 1,470 email subscribers in Massachusetts, New England and the Northeast region. Our field days this summer were well attended by vegetable growers this year, with almost 270 collective participants at our meetings from the spring to the fall. The Summer Twilight Field Day in Central NY was promoted by NOFA-NY and attended by both conventional and organic vegetable growers. Six growers from that field day have stated that they would like to try deep zone tillage on their plots. The LIHREC summer field day for reduced tillage on Long Island included presentations at the research farm as well as at local farms that participated in trials. The Massachusetts RT Twilight Meeting was also conducted at a

local farm that has been borrowing the Unverferth Unit and conducting deep zone tillage or some form of reduced tillage for over ten years. Ward's Berry Farm Twilight Meeting – June 26, 2012 Jim Ward has been working with reduced tillage for over 10 years, starting with no-till, and adding deep zone till in 2011 and 2012. He has borrowed the UMass zone builder each year. This twilight meeting highlighted reduced tillage, including a demonstration of the Unverferth zone builder, and gave growers a chance to see no-till and reduced-till sweet corn and pumpkins. Items covered included weed management, nutrient management, equipment adaptations, soil health. Rich Bonanno answered questions about some specific weed issues in reduced till. Attendance was ~80 growers. Evaluation: 21 filled out evaluation forms. 13 of the 21 said they had gained greater knowledge of deep zone tillage and no-till in corn and cucurbits (8 gained +1 level of knowledge, 3 gained +2 levels, 2 gained +3 levels). One said they had tried reduced tillage before, 7 said they now had plans to try it, 2 said they might try it. Cornell Organic Reduced Tillage Field Day- August 15, 2012 The Twilight Organic Field Day (Figure 1) this year was held on August 15, 2012 at the Organic Research plots of Cornell University's Homer C. Thompson Research Farm in Freeville, NY. The event showcased the continuation of our reduced tillage and strip-planted cover crop experiment in organic broccoli as well as our more recent nutrient meal/zone builder comparison experiment in organic broccoli. The event was well attended, with roughly 55 growers, gardeners and those with an agricultural interest in attendance. Nearly all of the participants in the Organic Field Day attended the reduced tillage presentation. Of those that attended the presentation, six growers demonstrated an explicit interest in conducting on-farm deep zone tillage trials and in borrowing deep zone tillage equipment. The growers who confirmed their interest were small farm owners and managers, representing Tompkins, Delaware, Onandaga and Niagara Counties. Due to their limitations of tractor size and the small area of their plots, they expressed interest in borrowing our Yeoman's zone builder, which has been specially built for tractors with lower horsepower. Twenty-seven of the growers at the Field Day were given our "Guidelines for Deep Zone Tillage in Vegetable Production" publication. The pamphlet highlights key equipment, field preparation, fertility management and planter setup issues that should be considered when starting a successful deep zone tillage program for vegetables. During the presentation, we conducted a demonstration of the Yeoman's plow through tilled ground and ground with leftover rye residue to highlight the action of the cutting disks, hilling disks and rolling baskets under varying conditions. During this year's field day, many of the growers were interested in differentiating the effects of deep zone building as it applies to different soil types. Next year we will include a more in-depth discussion of how the inversion and aeration caused by traditional plowing reduces soil organic matter accumulations and what kind of tillage can be applied to especially weedy fields to prepare them for a deep zone tillage system the following year. Long Island Reduced Tillage Field Day- August 22, 2012 The LIHREC Twilight Field Day was held on August 22, 2012. The tour began with a demonstration of the deep zone tillage equipment with a side-by-side comparison demonstrating the function of rolling basket and cultipacker attachments as planting bed shapers. Two local farms, where deep zone tillage trials were conducted, were also included in the tour. These farms implemented the equipment for production of sweet corn, pumpkin, sunflower and crucifers. The field day was conducted and moderated by Cornell Cooperative Extension and project participants (Figure 2). Cornell Reduced Tillage Website Development – Winter 2012 We are seeking to improve the design of the front page to address the kind of questions these growers will bring while still providing clear paths to the base resources. We wanted to provide the most efficient means for putting growers in contact with us and with the information we have presented on the site so they can learn more about reduced tillage, cover cropping techniques and how they can locate someone to aid them in implementing these practices on their farm. We will be reformatting the site for mobile devices as they represent a significant percentage of visits to related Cornell websites. Smartphones and platforms like the

iPad are being used by increasingly more farmers. UMass Extension website updated – December 2012 We have updated the section of the UMass Extension Vegetable Program Website that is dedicated to reduced tillage. See http://extension.umass.edu/vegetable/research-projects/deep-zone-tillage

Milestone 2

Milestone 2: 100 growers will request additional information on reduced tillage practices for their farms. In each year, these requests will come between June and October, after summer field days, and again between December and March, after winter workshops. In the spring of 2012, we were contacted by three growers looking for advice for buying zone tillage units. We spoke to them through telephone and email and consulted on the units that would best serve their soil needs and tractor ratings. These growers had been referred to us by extension agents and through the Reduced Tillage Website. Four other growers contacted us in late summer of 2012 regarding reduced tillage methods and to borrow our zone builders. These growers had attended field days and conferences the previous year and sought to conduct deep zone tillage in the summer or fall of 2012. We followed up with growers who had expressed interest in conducting deep zone tillage through our field days, conferences and elsewhere. These growers were scheduled for conference calls with local extension agents and the reduced tillage team to discuss plans for their DZT trials. They were guided through a question and answer evaluation that was used to isolate their specific needs and how the DZT units or techniques could be adjusted to suit them. Equipment modifications were conducted at the Homer C. Thompson Research farm and on site when needed. Some growers implemented DZT with small seeded vegetables for the first time. They facilitated this through a light rototilling over the deep zone tilled rows. We have been in touch with fifteen growers in Massachusetts who have begun using deep zone tillage in the past three years. They learned of DZT from one or more of the numerous on farm, field day and winter programs that have taken place in Massachusetts and around New England and New York. In particular, the NEVFC session on DZT in 2009 moderated by Jude Boucher, the UMass Field Day DZT demonstration in 2010, and the Twilight Meetings in Hadley MA at DZT fields with equipment demonstration were mentioned by growers who subsequently purchased zone building equipment of their own. About ten additional growers contacted us to discuss details of zone tillage, purchase of equipment, or to arrange for the use of UMass equipment. We are in the process of contacting each of the growers for phone interviews. Of the fifteen, four have been interviewed in depth as case studies. We will continue to follow up with growers to review and update this information. Some of these farms have Phytophthora capsici and can report observations on DZT impact.

Milestone 3

Milestone 3: Three discussion groups of farmers are formed (Western NY, Eastern NY/Long Island and MA) to review RT research results and growers innovations in RT systems. New-to-RT growers report greater confidence in implementation of RT systems on their farms. Meetings start in November 2010 and continue for duration of project. New members may be added each year. In the winter of 2012, a meeting of Cornell Professors, Graduate Students and Researchers in the fields of Horticulture, Plant Pathology and Soil Health was arranged with a select group of organic growers who have developed long-term, effective reduced tillage practices to their vegetable production operations to discuss and compare a number of reduced tillage systems. The meeting was set with the mindset of evaluating effectiveness and assessing the possible areas of growth and development, or attributes that could be applied to other forms of reduced tillage. The reduced tillage systems that were represented by the panel of growers included ridge-till, no-till

and variations on the deep zone tillage system. Crop rotations, weed suppression and disease management were discussed in relation to cover crop strategies for each RT strategy. The meeting included 6 prominent growers and 15 Cornell staff. Our reduced tillage team organized a conference call with all growers participating in on-farm trials in 2012 on February 22, as well as growers with previous experience conducting RT trials. The conference was meant to assist our research team in developing future direction for the projects and education initiatives. The growers with past experience served as our advisory panel, to help us both evaluate our findings and plan useful extension and other outreach events. The insights shared during our conference call have helped shape the project. The Peer-to-Peer focus of this process helps us define and refine the management skills needed to be successful in adapting a reduced tillage organic practice. We arranged and carried out a meeting in 2012 with Cornell Cooperative Extension agents and researchers from Northern New York to locate farmers in the region that would be interested in participating in next year's on-farm trials and setting up a comparison between conventional/existing practices and zone building. Both organic and non-organic farms would be targeted to build more RT support and grower outreach in Northern NY. Ideal fields would include those with a killed cover crop or no cover crop for the first year. We would adjust our zone builder to run just under most compaction layers at a depth of about 14 inches, with sweet corn or transplants being planted at a 30" to 36" row spacing. In winter 2013, we will establish a formal farmer to farmer network for growers in Western NY and possibly the Capital district. These areas have seen rapid and widespread adoption of RT methods in vegetable crops. We have not established any grower groups in Massachusetts. It is clear that growers have consulted each other at various times but there is no organized network.

Milestone 4

Milestone 4: After learning of research and grower trial results about impacts of DZT on soil water and P.Cap, 20 growers work with the project team to plan small trials on their own farms each year, between March and May each year. Local equipment dealers or the research team create plans to move RT equipment among demo sites. In 2012, the reduced tillage team provided deep zone tillage equipment and deep zone tillage support to local growers who demonstrated an interest in adopting reduced tillage practices to their existing vegetable production operations. A total of 19 growers across New York State conducted deep zone tillage on their farms for vegetable production in 2012. Four farms in Central NY borrowed our zone builder constructed for small farm use. One Seneca county grower (Grower 1) conducted deep zone tillage as the only field preparation for large-seeded vegetables and transplants, while also conducting DZT in conjunction with a shallow rototilling for some small-seeded crops. An Onandaga county grower (Grower 2) signed up to borrow our Yeoman's plow, which fit his tractor rating, but later decided to purchase a unit himself after learning more about the benefits of deep zone tillage. Two growers (3,4)- one in Schuyler and the other in Seneca County- borrowed equipment for late summer field preparations for the following year. Grower 5 has 3 acres. He sprayed an alfalfa sod, after which you looked at it and told him to do one more herbicide application. He borrowed your ripper. He reported that transplanting into the slot was the easiest planting he had ever done. He also sprayed twice with Sandea/Dual postplanting. He put Nitan deep. Grower 6 (Sharon Springs, NY) tested RT on 3 acres with a nice stand of rye that he killed and then ripped and applied Nitan deep in the slot. He transplanted pumpkins. Grower 7 (Kinderhook, NY) worked closely with a neighbor, sharing a DZT unit, tractor and corn picker. They tried to use the ripper to renovate their strawberries. They purchased a quick hitch to allow them to offset the unit, to better accommodate their spacings. Grower 8 has done strawberries with RT and is very happy with the response. He might also invest in a quick hitch for the same reason as Grower 7. Six

additional NY growers (8-14) have acreage in RT vegetables. These growers conduct conventional operations and have total acreages ranging from 60 to 100, with most on the upper side of the range. Five Long Island growers (15-19) utilized reduced tillage on a portion of their vegetable production plots. Two of these growers were featured in the LIHREC summer field day this past August. They provided a tour of their sweet corn, pumpkin, sunflower, and crucifer plots. Grower 20 in Massachusetts reported that his RT plots for pumpkins had great water penetration and stable water levels that allowed him to reduce the amount of irrigation he had to do this year even though it was a very dry season. This is his third season conducting DZT and his seventh season with reduced tillage. In Massachusetts, we did one educational program during 2012, the twilight meeting at Ward's Berry Farm in late June where Andy Cavanagh led a presentation and demonstration. Turnout was strong. Since it was too late to initiate DZT equipment purchase or trials for 2012, growers may not have acted on their interest in DZT till this winter.

Milestone 5

Milestone 5: Of the growers doing on-farm tests, 6 will be collaborators for in-depth research in years 1 and 2 to conduct on-farm paired comparison trials between deep zone and conventional tillage on two fields. These growers will have had a history of P. capscici and will examine transition to RT. Growers and team collect detailed yield, disease and economic/cost data to document changes in crop performance and profitability in P. capsici infested fields. In our later follow-up discussion, grower 2 stated that his primary challenges with his zone builder was its inability to handle heavy residue and pull effectively through variations in the field. He was happy with its results on level ground and has discussed making alterations to the setup for next year including redesigning the rear "roller crumbler" so that it is on a resistance type setup that can float and follow the soil surface versus his current adjustable, but fixed position, set up. On the implement itself, he thinks he can make some adjustments in terms of finding a better residue cutter and row cleaner. Furthermore, he had opposite hilling discs this past season and thinks offsetting them front to back would help a great deal as the opposite discs were getting clogged with residue and rocks. Grower 21 grows 70 acres sweet corn and 12 acres pumpkin on rented land owned by municipal, national park, or land trusts. On the home farm he grows diversified crops for his farm stand. After attending a DZT session at the New England Vegetable and Fruit Conference in NH as well as a field day and DZT demonstration at UMass Crops Research Farm, Grower 21 bought a 4-row Unverferth zone builder with a fertilizer injector and has used it for three years (2010, 2011, 2012) on all of his corn and pumpkins. He puts fertilizer through the injector and in the planter and for pumpkins also uses a sidedress. He kills winter rye with Roundup but uses oats in some fields after the landowners and neighbors objected to use of roundup on spring cover crops. Residual herbicides are used just after planting and weed control has been good. At the end of the season he uses straight disks with chisels behind and seeds cover crop with a Brillion seeder. The major benefits have been that "it saves a ton of time" to make one pass with the zone builder rather than 4 passes (plow, harrow 2X, perfecta 1X). He zone tills and plants every 4 days for succession blocks of sweet corn. Other benefits he noted are it does not dry out as fast, he can get in to spray after rainstorms because the ground is firmer between rows. Overall he likes it, it seems to work well, and he is saving time and money. Yields have been about the same. One change he has noticed is that the fields of corn appear more consistent in height, though he is not sure this has anything to do with DZT. He would like to understand better the soil changes but has not noticed significant changes thus far after three years in RT. He would like to see more residue remaining on the soil surface for cleaner pumpkins, and tried sudex planted August 2011 for 2012 crop but the residue broke down before fruit formed. He plans to continue using RT on 82 acres. Grower 22 used the UMass zone builder in 2011 on

2.5 acres of sweet corn and beans. He was pleased with the results and would have used it again in 2012 but it did not work out coordinate getting the equipment to SE MA in time for him to use it. He is now planning to purchase a 2-row zone builder. He grows about 60 acres of vegetables including some organic for CSA and wholesale; all his sweet corn is conventional. He is eager to interact more about implementing the system using his own DZT equipment. Growers 23 assumed full ownership of their farm this season, after the passing of their father in 2011. Grower 23 used some new crop rotations which allowed him to switch corn and pumpkin fields and put pumpkins into fields that had only seen corn for many years, and put corn in his P. cap-infested fields. Grower 23 used the UMass equipment in 2011 and for 2012 purchased a 3 row Unverferth zone builder. It does not have a rolling basket behind the shank, so it creates a slit rather than a 9 inch swath of tilled soil. He used it for 3 fields totalling 18 acres: 1) 6A where rye was harvested for straw, deep shanked through the stubble, planted pumpkins, treated with Sandea as residual and roundup for emerged. The field was mostly weed free except for a nightshade, the crop was excellent; 2) Butternut planted in rocky field, weather delayed application of Roundup so rye was large when killed, it was hard to find the slits and to see the crop until it grew to 3-5 leaf stage (see photos) but it grew well. 3) 5 A pumpkins in a field where P. cap had occurred previously, method similar to butternut. He uses a one row planter for pumpkin, adapted for no till conditions with a wavy coulter leading, press wheels, down pressure springs. His goal of having less rot in the pumpkins because of rye residue beneath the fruit was met. Fields were not so wet at the end of the season despite some heavy rains in the fall. Quality was excellent. New PM-resistant varieties Magic Wand and Gladiator may also have helped quality. He has not used DZT on corn because without the basket his four-row corn planter would have to be adapted to no till. He might consider baskets in the future but for now is happy to focus DZT on his pumpkins. He likes the fact that there is less work in the fields with the DZT both for field preparation and cultivation. Grower 24 grew sweet corn and pumpkins and is trying to build up his soil organic matter. Growers 25 had 200 acres of vegetables (100 acres sweet corn); fields are scattered through several towns in the Ipswich area and require significant road travel for field operations. They pull their two row zone builder with a 100 HP tractor. In 2012 they continued to use DZT on about 30 acres of corn. They also tried it on 8 acres of peas and beans which worked well despite some weed control issues. Benefits include savings in time, equipment wear and tear and fuel from doing one pass instead of two and pulling only a band instead of turned the whole surface of the field. They have focused on heavier, clay soils where they see better drainage with DZT. At the same time, they "have never seen the field wilt in DZT corn fields." They still like to irrigate sweet corn especially at silk stage, but can delay irrigations, which creates a very helpful flexibility. Challenges include managing rye if it gets too big (for example if rains delay Roundup application, or for late corn fields). How to get fertilizer to sweet corn when it needs it – especially for side dressing – is still a challenge. Conventional corn is side dressed with cultivation, and sometimes Grower 25 has side dressed and cultivated the residue in order to get N to the crop DZT fields. Residual herbicides are applied preemergence but if the application is delayed, these can usually work even if corn emerges. To kill live weeds he then uses Impact instead of Roundup. Next year he wants to try it in pumpkins, more corn, and possibly carrots. Grower 26 conducted DZT on almost 3 acres of butternut squash and beans. On-Station Experiments: University of Massachusetts: This year, UMass Extension planted and monitored the growth of sweet corn on its replicated conventional/deep-zone tillage (DZT) research plots (following corn in 2012, butternut in 2011). In DZT, winter rye was killed with glyphosate and the zone builder was used approximately two weeks later for field preparation, followed by seeding. Conventional fields were plowed and harrowed. Other practices were the same in both treatments. No irrigation was used. P. capsici has not been observed in this field and to our knowledge, the field remains non-infected. DZT plots performed similarly to conventional plots in all metrics, except in cornstalk biomass at harvest, for which DZT stalks

had statistically higher mass (Table 1). We took soil samples from all sites in the fall 2012, and had both UMass and the Cornell lab provide soil testing (Cornell soil health test was done). Despite being in DZT or conventional tillage for several years, we saw no differences in organic matter content between the two treatments in standard soil tests. One possible explanation is that in the first two years (2010, 2011), crop residue was removed from all plots following harvest; also it takes time for OM to change. We also followed water dynamics in the soil through the growing season with moisture probes placed at 6 and 9 inches deep. These data are currently be analyzed. Cornell, Homer C. Thompson Research Farm: Our research trials evaluated innovative cover crop management and equipment comparisons for Organic and Conventional Reduced Tillage Vegetable systems, as well as a multi-tiered experiment in a conventional field that analyzed intensive and reduced tillage with varying fertility rates and application methods for early and long season cabbage varieties. These experiments were replicated from 2011. An additional comparison trial of the Unverferth and Yeoman's Plow Deep Zone Tillage Units was conducted in an organic vegetable plot in 2012. This plot also included a trial comparing alternative sources for nutrient meals as possible organic amendments. The reduced tillage method used in all trials has been deep zone tillage, where a narrow slot is ripped deep enough to cut through compacted soil layers--often 9 to 12" deep in WNY vegetable soils, but sometimes extending 15 to 18". This vertical tillage is followed by fluted coulters (similar to discs) that shallowly (4-5 inches deep) disturb a soil zone about 8" wide, centered over the slot. This is where the crop is planted. Finally, a rolling basket or narrow cultipacker helps to break up soil clumps and smooth the seedbed. From 2011-2012 we evaluated strip planting strategies of winter-killed with overwintering cover crops to improve weed management and crop yields in both organic and conventional reduced tillage systems. The cover crops were planted in the preceding fall and divided into alternating in-row (planting row) and between-row mixes of cereal rye and hairy vetch or forage oats and winter peas. The treatments combinations included: 1) no cover crop (control); 2) cereal rye/hairy vetch between rows with no cover crop in row; 3) rye/vetch between and in rows; 4) oats/peas between and in rows; 5) rye/vetch between and oat/peas in row; or 6) winter peas/oats between and rye/vetch in row. Broccoli was transplanted in the spring and harvested for biomass at three intervals during the growing season. Weed biomasses, cover crop biomass, soil temperature and weather data were also collected during this time. Soil samples were harvested at regular intervals for analysis of total mineralizable nitrogen. The conventional strip-planted cover crop trials showed no significant differences amongst treatments in 2011 and 2012. Our organic research trials evaluating strip-planted cover crop techniques in 2011 demonstrated that the treatments with some combination of oats/peas produced the best yields as compared with the bare ground control that also fared similarly in 2011. In 2012, our results showed no significant differences among the cover crop treatments repeated from the previous year (Table 2). Another experiment compared conventional tillage and deep zone tillage for cabbage (Figure 3). Within those tillage treatments were sub-treatments of fertilizer application method, fertilizer rate and cultivar. The fertilizer application methods were either liquid fertilizer applied during DZT versus conventionally applied dried fertilizer. Certain plots received a side dressing of ammonium nitrate to achieve the desired fertilizer rates (0, 120, 180 lb N/A). A long season and a short season variety of cabbage were grown. At planting, all plots were given starter fertilizer. Deep zone tillage and conventional tillage methods produced similar yields (no significant differences) in 2011. The long season variety produced higher yields than the shorter season. The 120 lbs/A fertilizer rate tended to perform the best. No difference was observed amongst application methods (dry or liquid fertilizer application)(Table 3). Fertilizer rate had more impact on late season varieties in 2011. In 2012, 120 and 180 lb N/acre were similar and higher than the 0 N application rate. Thus, use of deep placed N for DZT cabbage looks promising to save growers another pass through the field by avoiding a mid-season sidedress N application. In 2012, the Unverferth and Yeoman's Plow zone builders were compared for

performance to develop DZT, and no significant differences in broccoli yield were found (Table 4). This result was important in that it demonstrated that the smaller Yeoman's Plow built specifically for small acreage growers performed as well as the larger Unverferth unit (Table 4). Subplots in the experiment compared different sources on N fertilizer for organic RT sidedress applications. Fish meal was found to be superior to chicken compost and no added fertilizer treatments (Table 4). Soymeal was similar in performance to both fishmeal and chicken compost. Application rates of these materials were standardized based upon total N content. Thus fish meal was most rapidly mineralized and made available to the developing broccoli crop. Cornell University Agricultural Experiment Station in Geneva: Evaluation of reduced tillage for management of Phytophthora blight and increased yields in snap beans, 2012. The trial was conducted at the "Phytophthora Blight Farm" located at the Agricultural Experiment Station in Geneva, NY. The soil type was an Odessa silt loam, which is a poorly drained soil formed in clay lacustrine deposits. On July 30, Valentino snap beans were seeded (in a north south direction) using a two-row, Monosem vacuum planter at 7.5 seeds per ft at a 30-inch row spacing. Fertilizer (10-20-10 supplemented with manganese and zinc) was banded during planting at 300 lb/A. Dual Magnum (1pt/A) was applied post-plant on July 31. Tillage methods were arranged in a strip design with two replications. The replications consisted of eight 80 ft. long rows for each of the tillage methods. The trial was rated for disease incidence on August 17 & 30, and September 13 & 27 with a final disease severity rating on October 4. A few plants had damping off symptoms at the beginning of the season, but these were inconsequential. Further advancement of disease did not occur. Monthly rainfall was 2.26, 1.97 and 0.65 in. for Aug, Sep and through Oct 10th respectively. To compensate for an unusually dry season overhead irrigation was applied on August 8 & 24, and September 10. Snap bean pods in 10 ft of row were hand harvested on October 11 & 12. Pods were counted, weighed and yields calculated (Table 5). Phytophthora blight incidence was not found in the harvested pods. The reduced tillage method resulted in a statistically greater yield than the conventional tillage method. Phytotoxicity was not observed in any treatment.

Milestone 6

Milestone 6: Working with research results and feedback from grower trials, the farmer discussion groups and project team collaborate to define recommended practices and profiles for reduced tillage to improve water management and reduce disease development. Participating farmers expand RT use to additional fields and crops. The level of grower interest in these systems is high and still growing. We will continue providing research-based information and facilitating the farmer-to-farmer exchange of practical information and skills. We have had numerous requests for the use of UMass and Cornell DZT equipment for the 2013 growing season. Growers have, overall, been satisfied with their cucurbit and sweet corn crops produced with reduced tillage, thus this acreage is most likely to be increased. They have found that the DZT process opens up a larger soil profile for the plants and aids in the drainage of water which is good for pumpkins when managing Phytophthora. Growers 1, 2, 6, 7, 8 and 21 through 25 have professed a desire to expand their DZT acreage in 2013. Most of the growers have discussed trying alternate strategies for dealing with cover crop residue. Some spoke of improving the kill dates for laying down or chopping cover crops more effectively. Those who have purchased units have considered adding row cleaners or variations of cutting disks.

Impacts and Contributions/Outcomes

A number of growers, in both New York and Massachusetts stated that DZT helped improve their water

drainage as well as retention during dry months. Some attributed this to the deep ripping and others to the healthier soil in between the narrow tilling rows that allowed for greater water penetration and more stable levels over the course of the growing season. Some of these growers reported needing less irrigation, saving water and labor. Growers who pursued subsequent trials stated that managing weeds with herbicides continues to be a major constraint to producing pumpkins with reduced tillage, and often with conventionally-produced pumpkins as well. The main pumpkin herbicide, Strategy, needs water to be activated. Many growers rely on rainfall because they are not set up to irrigate entire fields at one time. When a cover crop straw mulch is present on the soil surface in the reduced tilled system, more water is needed to move the herbicide through straw residue to the soil. High residue cultivator could be a valuable tool for these growers. We will follow up grower trials with additional calls and meetings in the winter to develop case studies and determine improvements to their technique and equipment setup for next year. There are a number of reduced tillage innovations that we would like to pursue further. Some of our collaborating farms have combined deep zone tillage with shallow rototilling to create suitable planting beds for small-seeded crops. When done under proper dry conditions the rototilling can be kept very shallow with little compaction resulting. We will continue to develop scale-appropriate and validated strategies that reduce tillage intensity. The average organic vegetable farm size in the upper Northeast and Midwest is 12 acres. On small vegetable farms, many growers opt for permanent bed type field designs. Further modifying this approach to reduce surface tillage will complement the already beneficial approach of confining tire traffic to alleyways. Commonly, these beds are intensively tilled, using rototillers or small plows, but we have identified two growers who have transitioned to a no-till permanent bed system. One grower's approach to reduce tillage involves regular surface mulching with compost. As the system has matured, weed pressure and weeding labor has decreased. While they have shared their approach with other growers, data documenting the performance of the system is lacking. We would still like to conduct an on-farm trial with these growers, as well as create a research plot with the aid of Cornell extension somewhere in the state to test these practices. Other growers will be able to benefit from the techniques developed and data collected regarding labor, equipment and fuel savings, and reduced weed pressure. In the fall of 2012, we seeded a variation of strip planted cover crop mixes. In this experiment, we substituted tillage radish in some plots as an alternative to deep zone tillage. This experiment serves as a comparison to our work with mechanical deep zone builders. In the spring, main plots will have either deep zone tillage using the yeoman's plow, or no primary equipment-based tillage (only tillage radish). Bio-drilling cover crops may prove a more cost-effective and energy efficient alternative to mechanical tillage when trying to alleviate the effects of subsoil compaction due to natural occurrences or intensive tilling operations, particularly for small organic farms. Forage radish has been used as a fall/ winter cover crop to alleviate the effects of soil compaction in no-till farming systems. The vertical tillage effects of the forage radish taproots have been shown to alleviate compaction in no-till systems resulting from previous plow pans. Forage radish has been shown to perform better than rye when used as a biological tillage tool. Soybean roots were shown to grow through compacted plowpan soil using channels produced by decomposing cover crop roots. This improvement of water movement and conservation is a sought after effect when conducting mechanical deep zone tillage, highlighting the potential of bio-drills as an alternative to mechanical deep ripping. Forage radish also provides excellent fall weed Suppression. Rapid and competitive fall growth, rather than allelopathy, is the most likely mechanism of weed suppression by a forage radish winter cover crop. Strategies to utilize the weed suppression of forage radish cover crops should focus on fall weed suppression and the early spring pre-plant window of weed control. The Yeoman's RT unit is a lighter weight zone builder suitable for use on smaller farms. By comparing the Yeoman's to the Unverferth (an industry standard), we assessed how well the tools handle heavy cover crop residue and if organic broccoli

establishment is affected. The 2012 equipment comparisons of the Unverferth and Yeoman's Plow zone builders showed no significant differences in crop yield. This demonstrated that the smaller Yeoman's Plow, built specifically for small acreage growers, performed as well as the larger Unverferth unit. We want to set up a repeat of this experiment in 2013.

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Attachments:

Figure 1: Conventional and Organic Growers collect at the Organic Plots of the Homer C. Thompson Research Farm before a demonstration at the Twilight Organic Field Day (Aug. 15, 2012).: http://mysare.sare.org/mySARE/assocfiles/961015Figure 1.jpg
Figure 2: Unverferth Zone Builder Demonstration at LIHREC August 22, 2012.: http://mysare.sare.org/mySARE/assocfiles/961015Figure 2.jpg
Figure 3: Long-term deep zone tillage plot of cabbage.: http://mysare.sare.org/mySARE/assocfiles/961022Figure 3.jpg
Table 2. Average Head Weight (g) and Marketable Yield (kg/ha) of Organic Broccoli, grown in Freeville, NY during the 2011 season. : http://mysare.sare.org/mySARE/assocfiles/961022Table 2.docx
Table 1: Yield of sweet corn grown in conventional and deep zone tillage at the University of Massachussets, 2012.: http://mysare.sare.org/mySARE/assocfiles/961022Table 1.docx
Table 4. Average Head Weight of Organic Broccoli with different deep zone tillage and organic fertility treatments, Freeville, NY, 2012.: http://mysare.sare.org/mySARE/assocfiles/961022Table 4.docx
Table 5: Evaluation of reduced tillage for management of Phytophthora blight and increased yields in snap beans, 2012.: http://mysare.sare.org/mySARE/assocfiles/961022Table 5.docx
Table 3: Yield of two cultivars of cabbage grown in deep zone tilled and conventionally tilled soils: http://mysare.sare.org/mySARE/assocfiles/961022Table 3.docx

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