Reducing climatic and disease risks through minimum tillage systems for vegetables

2013 Final Report

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Summary

The objectives were to promote farmer adoption of reduced and modified tillage (RT) systems and to investigate the efficacy of deep zone tillage systems to reduce the disease severity in crops affected by *Phytophthora capcisi*. It was our intent to evaluate the ability of reduced tillage (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 second full year of our on-farm experiments (2011), however, all of our trials were lost in the catastrophic flooding of Hurricane Irene (August 25, 2011). As a result of the devastating losses, several of our grower collaborators were hesitant to commit fields 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 NESARE, we redirected our efforts to promote and expand growers testing RT on their farms. Over three years, 64 on-farm trials of RT systems were conducted on NY and MA vegetable farms. In a survey at the end of the project, 37 farmers reported a total of 540 new acres committed to RT. Farmers reported 46% fewer equipment passes preparing fields, 40% less fuel and water use for fields established with RT, and 70% less labor hours overall in RT fields.

Despite setbacks associated with Irene, about half of the farmers in New York who responded to our survey (11) had increased their acreages farmed with RT from 2010 to 2013, and all but two of these farmers indicated they plan to increase their RT acreages in 2014. A total of about 540 new RT acres were reported

from the respondents, and overall about 9,800 acres are in RT as of 2013. This included one organic vegetable farmer who wrote: "We are a certified organic farm. I feel we have proven that R.T. can fit into any type of farming operation. Thanks for doing the survey, Get the word out!" Most of the remaining growers we heard from (9) had the same acreages in RT in 2013 as they had in 2010, but 4 of these growers also planned to increase RT acres this year.

In Massachusetts, survey results indicated that total acreage in vegetable production increased during the project period (2010 –2013) from 1,174 acres to 1,415 acres, and vegetable acreage in RT increased from 247 acres to 609 acres, a 362 acre increase. Acreage in reduced tillage increased at a faster rate than conventional tillage on surveyed farms, with 43% of their acreage currently in reduced tillage.

Introduction

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 expressed interest in or try RT on their farms. Over the life of the project, 16 different outreach events were hosted by Cornell or University of Massachusetts, both on station or in grower collaborator fields. A total of 1300 farmers participated in these events and 628 reported an increase in knowledge about the benefits and challenges of RT systems.

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*. Experiments at research station sites with *P. capscisi* infestation did support benefits of RT to reduce *P cap.* incidence. However, the project suffered a major setback with Hurricane Irene, and all of our on-farm trials were lost. Because these on-farm trials were at the basis of our entire experimental design (multiple year, crop rotation based examination of disease incidence) and economic analysis, we were forced to redirect our efforts.

As a result, we focused the remainder of the project on facilitating greater adoption of RT. We used on-farm and on-station research, workshops, and field trials to evaluate and then promote RT systems to improve water management and soil quality and fuel and labor costs. We verified the benefits and challenges of RT using an online survey at the end of the project.

Objectives/Performance Targets

Performance Target: 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.

Materials and Methods

Our strategy to enhance adoption of RT systems had two main thrusts: farmer outreach and on-farm/station experimentation. Our outreach efforts focused on presentations in newsletters, at conferences, via

videoconferences, and most importantly at summer field days. These field days provided excellent opportunities to demonstrate zone tillage equipment as well as highlight some of the research going on at stations or on farms. Through these field days and other outreach events, we were able to identify farmers who wanted to test RT on their farms (64 supported through grant). For some of these farms we were able to facilitate the loan of RT equipment. This occurred in central NY, Long Island, and MA. Some of the smaller growers rented tractors to allow them to test RT on their farms.

Our on-station experiments explored production of different crops in RT systems with efforts to address some challenges observed by growers. We also had access to two experiment station fields (Geneva NY and Long Island) with *P. capscisi* infestation to allow us to test the impact of RT on disease progression. We examined cover crop combinations and management in advance of RT, pumpkin, sweet corn, and cabbage production and fertilization, and pepper, pumpkin and snap bean infection by *P. capsici* under conventional versus RT management.

As mentioned above, our on-farm trials, which were at the center of the research, had to be abandoned in 2011. The original design was to work with these farms over three years, using RT in *P. capcisi* infested fields. We planned to assess changes in soil quality, water management and disease progress. Our approach started with sweet corn, followed by a suscepted crop, and each farm had two fields committed to the project. After the hurricane flooded most of our test fields (which of course were fields that had heavy *P. capcisi* infestation due to periodic flooding and poor drainage), growers were unwilling to commit to this long term study. Thus, we focused the remainder of our effort on general promotion of RT through our outreach and trials, without a focus the original performance target.

Results and Discussion/Milestones

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.

Over the life of the project, 16 different outreach events were hosted by Cornell or University of Massachusetts, both on station or in grower collaborator fields. A total of 1300 farmers participated in these events and 628 reported an increase in knowledge about the benefits and challenges of RT systems. Example comments provided on these evaluations included, “Great demo! Lots of useful information”, “Super interesting!”, “Deep Zone Tillage was the best –very informative.”

Presentations at annual grower meetings (e.g. Empire State Fruit and Vegetable Expo, New England Vegetable and Berry Conference) linked the benefits of RT to soil health and farm management. Hosting the events on station allowed for the project team to demonstrate the use of various RT tools (e.g. Unverferth Zone Builder or Yeoman’s plow), observe a variety of crops being grown in an RT system and hear directly from other growers about experiences with adapting RT to their own farms. On-farm trials provided growers a chance to ‘ground-truth’ the RT system in the climate and soils similar to their own farms. A video conference hosted between NY and MA allowed the team to include presentations by other specialists (e.g. weed scientist, cover crop specialists) to help address a broad range of questions on management challenges of adopting an RT system to a farm.

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.

Field days and events allowed the team to identify growers keenly interested in testing RT on their farms. Most of these growers who stated their knowledge had improved as a result of field events requested additional information from the project team. We sent emails for additional follow up with these growers. Of these, 54 requested phone consultations, and 25 collaborated with the team to plan summer trials. In the winter months, the team cultivated relationships with these growers, hosting conference calls among interested farmers and planned for equipment loans to those interested in testing on farm.

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.

Only one formal grower discussion group was formed during the project. As a result of the broad interest in RT in Western NY, grower Donn Branton (key advisor on this project) and Carol MacNeil (CCE Soil Health Educator) initiated a grower discussion group on RT systems. The group met in 2012 and 2013. The group also planned for summer field days in 2013 focused on soil health and RT systems.

Growers in other regions however, were not in favor of a group discussion format. The project team initiated informal extension-mediated discussions among growers, and the extent of these meeting structures have been informal and varied to meet growers' schedules. Most of the discussion that the project team facilitated has been a part of the twilight meetings listed above or through individual and group mediation. Given the relatively low number of growers with experience in deep zone tillage (DZT), a formal discussion group between growers was less likely to be informative without the direct input and heavy mediation by extension agents to support growth and supplement gaps in knowledge. Instead, the team focused on winter grower meetings and videoconferences at which growers presented experiences coupled with in field discussions to allow problem solving in real time.

In 2010, we hosted a videoconference with four participating locations, titled “Planning the Transition to Reduced Tillage Systems: Equipment, Fertility and Weed Control.” Sixty people attended, including 46 growers, 6 Cornell Cooperative Extension Educators, 3 Cornell staff, 4 Cornell Faculty and one University of Vermont extension educator. The program included presentations on Incorporating Cover Crops into Reduced Tillage Systems, Setting Up a Reduced Tillage Trial on Your Farm, Equipment Options, A Quick Overview, Deep-Placed Nitrogen Experiences, Equipment for Liquid Fertilizer Application, Weed Management in Reduced Tillage Systems, and Disease Management in Reduced Tillage Systems. Two growers described their fertilization programs for vegetables on their farms. The videoconference included time for discussions among participants at each location, and three locations had experienced reduced tillage growers present to share their experiences. This event was very successful.

Planter clinics were held in three regions of NY in February, following the videoconference. These hands-on clinics emphasized how to make your planter work optimally. Eighty-seven people attended the planter clinics. While the videoconference was a one day event, the relationships fostered among growers across the state remained active throughout the project. While not formally a facilitated discussion group, the long-term benefit has been a peer-to-peer support network of willing grower mentors. A similar video conference was hosted across both states in 2011. Coupled with on farm field days, a grower community interested in RT was cultivated.

Milestone 4: After learning of research and grower trial results about impacts of deep zone tillage (DZT) on soil water and *P.Capcisi*, 20 growers work with the project team to plan small trials on their own farms each year, between March and May each year.

Each year, we nearly met our goal of 20 on-farm trials with RT; overall, we hosted 64 on farm trials, with 17, 22 and 25 in each year, respectively. Growers predominantly grew sweet corn, pumpkins and squash, but some also tested cabbage, peppers, broccoli, snap beans, sunflowers, and other brassicas.

Primary challenges reported from growers were related to cover crop / crop residue management and weed control. Some growers attempted to plant into a killed sod with poor results. We also conducted 17 on-station experiments across three sites (Ithaca, Long Island, Western MA). These experiments included demonstrations for field days (sweet corn, winter squash), comparisons of *Phytophthora capsici* incidence in conventional versus deep zone tilled fields (pumpkins, snap beans, peppers), and evaluations of alternative cover crop combinations to reduce residue interference in DZT fields. The trials examining P cap suggested some reduction in incidence in pumpkins and snap beans in DZT fields (LI, Geneva NY), but only 2 of 3 years had conducive conditions for the development of the disease.

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.

At the start of our project we identified 6 grower collaborators who had a fields infested with *P. cap*. All of these growers were willing to commit two fields to the project for 3 years, starting in 2010. Most of these fields were in areas that were prone to flooding or had areas that were poorly drained.

In August, 2011, however, all of our 6 on-farm trials were lost during Hurricane Irene. In addition, we found other growers now hesitant to commit to multi-year trials on their farm, since they felt it risky to not retain full flexibility of production planning with the changing climate. Thus, the very core of our experimental design, which focused on these on-farm experiments, had to be discontinued. After discussions with Northeast SARE, we redirected our subsequent grant efforts to further promote and expand growers testing RT on their farms. We were able to support 64 on-farm trials with RT as well as 17 on-station experiments to demonstrate or refine RT practices.

Performance Target:

While we were not able to fully achieve our performance target as defined at the start of the project, we supported the increased adoption of RT by vegetable growers in the Northeast. Based upon the responses on benefits of adopting RT systems on vegetable farms, savings exceeded the performance target estimate of $25/acre. Estimates of the cost per acre for conventional tillage prior to vegetables would include moldboard plowing ($32), disking ($14) and final harrow ($10) for a total of $56/acre. Using RT, growers reported 46% savings or $26 per acre. Additional savings would include reduced wear on tractors, reduce costs of irrigation, and labor hours saved with cultivation.

Impact of Results/Outcomes

New York Grower Response to Reduced Tillage in Vegetables

We have reached out via a combination of email, telephone and/or postal mail to just over 70 (primarily) New York vegetable growers associated with the project during the last four growing seasons to assess their experiences and outcomes with the final verification survey. Nearly one-third of these growers (22 from New York State and one from Maine) have shared about their recent on-farm experiences with using reduced or modified tillage (i.e., no-, zone-, or strip tillage methods) systems, describing costs, benefits and challenges.

The farmers who responded to the survey ranged in size from 4 to 3,000 acres; they had been practicing reduced tillage methods for periods ranging from just one season up to 25 years, averaging 9 to 10 years of RT experience. Four of the 23 farmers were new to RT, having shifted acres of their vegetables to RT in

the period since 2010. Two of these did not grow any vegetables with RT in 2013: the first of these was a small vegetable farmer limited by cost and large investment of time/energy borrowing equipment, which he did one year, and said he was very impressed with the good soil drainage he obtained with RT in a very wet year. "Loved everything about zone-builder except cost for my small operation," he wrote. The other was a larger grower (~400 veg acres in 2013) who tried RT in cabbage in 2012 and wrote: "Many major equipment modifications are needed to go full blown no-till. Sometimes the seed bed isn't quite as good in the no-till situation unless conditions and timing is perfect. Timeliness to get the crop in is critical. Have a lot of experience with min/no till in row crops. Believe in the system." (The latter indicated he would expand RT in 2014).

About half of the farmer respondents (11) had increased their acreages farmed with RT from 2010 to 2013, and all but two of these farmers indicated they plan to increase their RT acreages in 2014. A total of about 540 new RT acres were reported from the respondents and overall about 9,800 acres are in RT as of 2013. This included one organic veggie farmer that wrote: "We are a certified organic farm. I feel we have proven that R.T. can fit into any type of farming operation. Thanks for doing the survey, Get the word out!" Most of the remaining growers we heard from (9) had the same acreages in RT in 2013 as they had in 2010, but four of these growers also planned to increase RT acres this year.

Massachusetts Grower Response to Reducing Tillage in Vegetables

Fourteen growers using reduced tillage on a variety of vegetable crops in Massachusetts were surveyed during winter 2013 to measure the impacts of this SARE project. Thirteen of the growers surveyed have used reduced tillage for less than 5 years, and one grower has used reduced tillage for 10 years. Survey results indicate that their total acreage in vegetable production increased during the project period (2010 –2013) from 1,174 acres to 1,415 acres: a 241 acre increase. During the project period, vegetable acreage in reduced tillage increased from 247 acres to 609 acres; a 362 acre increase. Acreage in reduced tillage increased at a faster rate than conventional tillage on surveyed farms, with 43% of their acreage currently in reduced tillage.Six of the growers plan to extend their acreage in reduced tillage by 55 acres in 2014, and only one will reduce acreage by 10. Specific crops grown with reduced tillage are reported in Figure 1. While no differences were reported in incidence of *Phytophthora* blight, other soil factors that influence the occurrence of this disease were improved. The impacts on soil factors reported by growers include less soil compaction and more soil health over all (Fig. 2).

Economic Analysis

Using reduced tillage was expected to impact field preparation, cultivation hours, pesticide applications, water use, labor hours, fuel consumption, soil health, soil compaction, marketable yields and *Phytophthora* blight. All these factors have an influence on the economic viability of the farm. Therefore, growers were asked to report on these factors using the scale of more, less or the same for each of the factors listed in Figure 2.

Economic impacts of RT reported by NY growers

The farmers reported substantial differences between conventional and reduced tillage systems in the time and resources they put into growing their vegetable crops (Fig. 2). All but one farmer who responded reported needing much less **field prep time** (including number of tractor passes) with their RT crops (46% less time/tractor passes, averaged across the farmers). Similarly, all but three farmers who compared reduced and conventional tillage with respect to **cultivation hours**/passes said it was substantially less work cultivating their RT acres; 11 farmers who estimated how much less work they had done reported a decrease of nearly 70%, on average. Not surprisingly, all but two of the farmers who responded to a

question about tractor wear told us their RT crops put less wear and tear on their tractors—the 13 growers that quantified this estimated about 40% less, on average. In fact, all farmers surveyed reported putting significantly fewer overall total labor hours into their RT crops—again, an average of about 40% fewer. No farmer reported needing more time or work for their RT crops.

Our survey data afforded a comparison between reduced and conventional tillage practices of several additional factors impacting vegetable operation economic viability and sustainability. As expected, all but one farmer who responded to a survey question about **fuel consumption** told us they burned less fossil fuels in the RT side of their farms—again, nearly 40% less, averaged across the growers (no grower said they used more fuel in their RT crops). Nearly half of the farmer respondents (10) indicated they needed less water to irrigate their RT crops, estimating an average of just under 40% less water used. Seven other farmers told us they used the same amount of water to irrigate their RT and conventionally tilled crops. About half of the farmer respondents (12) told us they had conducted the same **number of pesticide applications** in their reduced and conventional tillage vegetables. Five farmers indicated they had used, on average, about 20% more pesticide applications in their RT crops, while two farmers reported using around 20% fewer applications on their RT acres. The farmers were also asked to compare their soil health and degree of soil compaction between reduced and conventional tillage vegetables. Of the 16 growers that responded to the question about **soil health**, two-thirds said the soil tilled less was healthier. Nine growers that subjectively estimated *how much* healthier reported numbers ranging from 10% to 100% 'better,' with an average of 50%. The remaining one-third said they did not perceive RT had an effect on soil health on their farms. All but two of 20 farmers who responded to a similar question about **soil compaction** said RT did not compact their ground as much as conventional tillage; 10 farmers provided estimates of the difference between reduced and conventional tillage on their farms, which ranged from 25% to 75% and averaged about 50%.

When asked to compare **marketable yields** of their vegetables between reduced and conventional tillage systems, just one of the 19 growers who responded to the question reported lower yields (of 5%) from reduced tillage fields. Of the remaining farmers, half told us there was no difference between the two systems, and half reported higher yields from their reduced tillage acres; the four farmers that offered estimates of this increase reported an average of 15% higher yields with RT. When subsequently asked specifically to compare their observations of the incidence of Phytophthora blight, nine of the 13 growers who answered the question told us there was no difference in damage between RT and conventional tillage systems on their farms, three reported a lower incidence with RT, and just one reported more Phytophthora damage in his crops grown with RT.

Economic Impacts of RT reported by MA growers

Responses from MA growers was similar to NY. Cost savings during production were widely reported. The RT systems reduced field preparation time, cultivation, total labor hours, tractor wear, fuel consumption and soil compaction. Eleven growers reported less tractor wear and labor hours, resulting in economic savings. All respondents reported a reduction in field preparation time ranging from 20-66% and a reduction in fuel consumption ranging from 35-70%. Irrigation and marketable yields were similar between conventional and RT systems.

Publications/Outreach

Over the life of the project, 16 dofferent outreach events were hosted by Cornell or University of Massachusetts either on station or in grower collaborator fields. A total of 1300 farmers participated in these events and 628 reported an increase in knowledge about the benefits and challenges of RT systems.

These events were the most effective strategy to recruit growers to testing RT. Hosting the events on station allowed for the project team to demonstrate the use of various RT tools (e.g. Unverferth Zone Builder or Yeoman's plow), observe a variety of crops being grown in an RT system and directly hear from other growers about experiences with adapting RT to their own farms. These events were very effective at recruiting new grower collaborators to testing RT in subsequent years. On-farm trials provided growers a chance to 'ground-truth' the RT system in the climate and soils similar to their own farms.

A video conference hosted between NY and Massachusetts allowed the team to include presentations by other specialists (e.g. weed scientist, cover crop specialists) to help address a broad range of questions on management challenges of adopting an RT system to a farm. While the videoconference was a one day event, the relationships fostered among growers across the state remained active throughout the project. The long term benefit has been a peer-to-peer support network of willing grower mentors. A similar video conference was hosted across both states in 2011. Coupled with onfarm field days, a grower community interested in RT was cultivated.

Presentations at annual grower meetings (e.g. Empire State Fruit and Vegetable Expo, New England Vegetable and Berry Conference) linked the benefits of RT to soil health and farm management. Growers who had adopted RT presented about their experiences, transitions and challenges. These events allowed for general promotion of the system, but were less effective in securing new grower collaborators. Growers were often pulled between different sessions of interest. In 2012, for example, the NY team decided to host presentations in commodity focused sessions, since those were sessions that often had the highest grower attendance (and pesticide credits).

Articles were published in grower newsletters in both MA and NY, focused on the benefits of RT, equipment available for sharing and general project background. While these articles reached the highest number of beneficiaries, these resulted in few grower requests for followup. Yet, in a 2013 survey of Vegetable Notes readers, with a 23% response rate (340 people), readers were asked the following question: As a result of information provided by UMass Extension through meetings, newsletters, websites, or other means, do you use reduced tillage practices? Seventy three growers or 28.7% of respondents use reduced tillage practices as a result of UMass Extension outreach.

Farmer Adoption

Through the life of the project, we have interacted with about 90 farmers in NY and MA, who we know have adopted RT for vegetables. Our survey results summarize the feedback from 37 of those farmers. Growers using reduced tillage were asked about the relative importance of benefits of using reduced tillage (Figure 3). Saving time, fuel and labor as well as increasing soil drainage and crop drought tolerance were among the most important benefits. Soil quality or organic matter conservation were of secondary importance, but more important to NY farmers. This is likely as a result of the strong Cornell Soil Health Program which has been promoting RT systems for soil health as well. In MA, farmers were most likely to adopt reduced tillage practices when they were able to borrow the equipment and try it for themselves or if they attended a field demonstration. Growers will continue to have access to borrow the UMass Deep Zone Tiller during the 2014 season. Six growers have requested to trial the equipment already this year. In NY,8 growers have borrowed units for on-farm trials.

Areas Needing Additional Study

We were not able to definitely show that RT systems that involve deep ripping can reduce the incidence and spread of *Phytophthora capsici*. One of our on-station studies did suggest this as possible, but in one other, tillage made do difference and in the third experiment, the climate conditions were not conducive to disease development. Therefore, additional research is needed to investigate the impact of RT systems on

this disease.

Among the growers surveyed about the challenges of using reduced tillage on their farms, herbicide application timing, crop establishment, need for high tractor horse power, and rocky soils were cited. The dependence on Roundup and need for better weed control also were major challenges to using reduced tillage. Reduced tillage unit size, crop rotation, and lack of knowledge or experience with reduced tillage were reported as being minor issues.

We have received inquiries from Organic farmers who are interested in reduced tillage for their farms. This topic needs further research and extension efforts. Management of cover crop residue and crop fertility remain challenges in organic RT systems that have no soil inversion as part of primary tillage. We found that in fields with minimal crop residue (such as after an oat pea cover crop or bareground), yields were higher in organic RT with peppers, broccoli and cabbage.

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Attachments:

Figure 2.: http://mysare.sare.org/mySARE/assocfiles/988702Figure 2.docx
Figure 1.: http://mysare.sare.org/mySARE/assocfiles/988702Figure 1.docx
Figure 3: http://mysare.sare.org/mySARE/assocfiles/988711Figure 3.docx

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