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Zone Tillage Trials on Commercial Vegetable Farms in Vermont

Summary: A dozen commercial vegetable farms across Vermont participated in on-farm zone-tillage (ZT) trials during 2010-2012. Many obstacles were encountered, from undersized tractors on farms, inadequate preparation of land for ZT, and excessive rain in spring 2011 that prevented use of ZT. Successes were also documented. Collectively these farm experiences yielded valuable insight into the equipment and practices necessary to effectively implement zone tillage on the relatively small-scale, organically-inclined farms that typify Vermont vegetable production.

Key lessons learned:

- 90 hp tractor is the minimum needed to easily pull a two-row zone tiller in a variety of conditions
- the zone tiller can be configured to a single row on center, making it easier to use in winter squash
- a thick, very dead cover crop is key to non-chemical weed control with zone tillage
- a narrow zone minimizes weed growth; cultivation of the zone can be a challenge
- the zone tiller can be modified to a one-row system to reduce weight and weed issues
- insect and diseases may vary in the zone tilled residue vs. bare ground
- when the system works well crop yields are comparable to 'bare ground'

Background. Most vegetable growers in Vermont rely upon repeated aggressive annual tillage such as disk harrowing and/or rotovating to incorporate residues and create a seed bed. However, growers are beginning to recognize that this is detrimental to soil health. Recent work in nearby states demonstrated that zone tillage can prepare soil for vegetable crops without excessive soil disturbance. However, most of this work was on larger vegetable farms that use herbicides to kill cover crops prior to tillage. This project explored the potential for using ZT on relatively small farms that generally don't use herbicides.

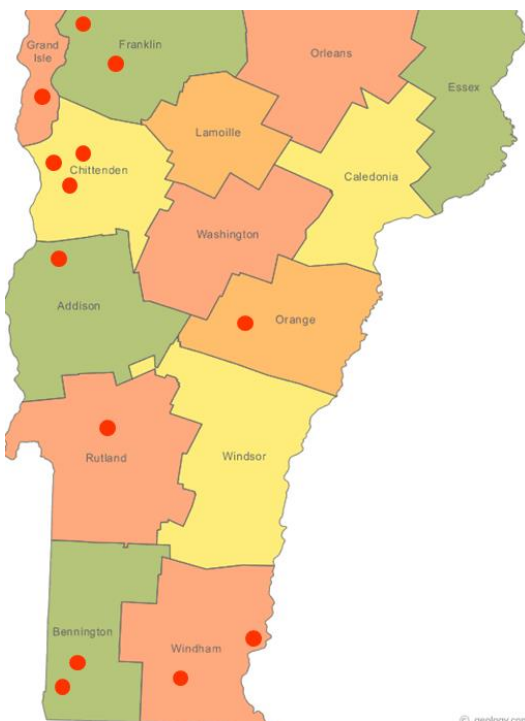


Approach. An Unverferth Model 130 2-row 'Ripper-Stripper' was purchased from Champlain Valley Equipment for zone tillage. It cost \$7,540 plus chains for lifting the unit and welding lift hooks to the frame. This photo shows the parts of the zone-tillage tool that hang off the frame, or toolbar, to work each planting row: far left is a single fluted coulter (only the edge is visible) to cut residues ahead of the subsoiler, or ripper, followed by two wavy coulters to move residue out of the planting zone 'strip' then a rolling basket to break up clods and smooth the seedbed in the strip.



A used 6x10 Pequa equipment trailer was also purchased, and the zone tiller was moved from farm to farm on a trailer pulled by a truck that was purchased by UVM Extension for use by this project (and others), once it was determined that it would be difficult to rent a vehicle to pull an equipment trailer. A power-washer was purchased by this project to thoroughly clean the zone tiller between farm visits to avoid the spread of soil-borne disease.

There were a variety of challenges during this project. At the outset, the used trailer brake system was not functional and required repair before the ZT unit could be moved. Then the welded-on lift hooks broke off the ZT frame immediately on use – so chains were then just wrapped around the frame to lift the unit. Several of the participating farms did not have tractors capable of either lifting the ZT unit off the trailer or pulling it afterwards. Then, extremely wet spring weather in 2010 prevented use of the ZT as planned. Farmers also had a range of success in killing cover crops prior to zone tillage, and in establishing and managing crops in the zone tilled residue.



The following farms took part in this project; the level of their involvement, their experiences, and the type of information they collected ranged greatly and are described below.

- Boyd Family Farm, Wilmington
- Clearbrook Farm, Shaftsbury
- Harlow Farm, Westminster
- Hudak Farm, St. Albans
- Intervale Community Farm, Burlington
- Jericho Settler's Farm, Jericho/Richmond
- Lincoln Farm, Randolph Center
- Paul Mazza's Fruits and Vegetables, Essex Junction
- Pomykala Farm, Grand Isle
- River Berry Farm, Fairfax
- Rockville Farm Market, Starksboro
- State Line Farm, Shaftsbury
- Wood's Market Garden, Brandon

[Boyd Family Farm, Wilmington](#). This highly diversified farm has a total of 10 acres of crop land, of which two are in vegetables each year. Bucky Boyd used a John Deere 5400 4wd 80 hp tractor to pull the 2-row ZT. “It snorked a little but it pulled OK even though it had to work pretty hard. We zone-tilled two acres of bare ground that had already been plowed. Then we planted all kinds of vegetables in the tilled strips: squash, cukes lettuce, onions, etc. One small section was not zone tilled. The difference we saw is that it drained better with zone tilling; it would dry out quicker than the other spots, and for the most part our field drains fairly good but I have a hard clay based down a foot and half or so and the zone tiller was definitely ripping into that and it helped. I liked it, I think it’s got a place, it’s a good tool.”

[Clearbrook Farm](#), Shaftsbury. This farm prepared about an acre of land with several sections in different cover crops. They used the 2-row ZT in winter rye that had been mowed and the straw taken off, and into hairy vetch that had been mowed once. Because of rain they were delayed and transplanted crops in late June, about 9 days after tilling. “Before transplanting I ran over the strips with some Bezzerides cultivators turned almost straight to lighten up the soil and kill weeds” says Andrew Knafel, the farm



owner. “We also transplanted cole crops into the zone-tilled hairy vetch. A couple of weeks later I came in with a sidedresser to apply organic fertilizer to the rows and lightly mix it in with Bezerrides spyders. The corn got tall, but it was weedy and there was not a great yield either. The cole crops got super weedy. In both crops I couldn’t manage the weeds in the zone tilled strip during the season because there was too much trash and organic material on the surface. Our traditional mechanical weed control tools could not deal with it. And even between the strips there was not enough residue to control weeds so they came through. For this to work we would need to plan ahead and prepare ground the previous year with a stale seed bed to reduce weed pressure; and we’d have to leave more residue between the rows or incorporate it so we could cultivate.”

Transplanted sweet corn in zone-tilled strips of mowed winter rye at Clearbrook Farm.

[Harlow Farm](#), Westminster. Brandon Allen, field manager, collaborated on the trials over 3 years at Harlow Farm. “We used a John Deere 6415 with 95 hp and it pulled the ZT unit fine, with one or two rows. In 2010 we ran the 2-row ZT on bare soil before transplanting sweet corn into half an acre next to the same area planted without the ZT. It was all killed by frost the following week. In 2011 we had a long 2-acre field that had winter rye; we plowed it and then spread compost and disked the whole field. Then we marked the rows and ran the ZT the short way across the field, using it only on half of each sweet corn planting. We transplanted and could tell no difference in growth or yield between ZT and not. In 2012 we cultipacked 3 acres of standing winter rye in middle of May, which killed it pretty well.



Then we ran the one-row ZT on June 12 (image to left) and transplanted summer squash the following week. It seemed we should have waited until the day before using the ZT to cultipack the rye so it would have been thicker. The weeds really got ahead of the squash. It was also hot and dry after we planted and the field did not have irrigation so that slowed the crop down. Plus, some of the workers were not careful about how deep to set the transplants so it didn't really work well. We also zone-tilled a 3-acre pumpkin field on river bottom soil after we had plowed rye, spread compost and disked. Then we

transplanted right into the ZT rows. We only left two rows not ZT which was not enough to see if there would be any differences, because you couldn't see any. There are still a few things I would like to try with the ZT and organic farming; trying it on small acreage is the best way."

[Hudak Farm](#), St. Albans. Richard Hudak manages 25 acres of vegetables and 15 of cover crops. He used the ZT in 2010 and 2011 in squash in pumpkins and a small trial with sweet corn; he took off one of the units to run it as a single row ZT. In 2012 he set up his own strip-till system using a Yeomans plow on a toolbar. His 90 hp 4 WD Kubota pulled the unit with no problem. Richard thinks that cover crop management is a key to success with organic reduced tillage. "I try to get a very thick, dead mulch to make strips in. With conventional no-till most growers lay winter rye down in early June but I wait until mid-June when it's fully mature. I make sure to get a good stand by seeding densely at 150 lb./A. To kill the rye in 2010 I used a roller crimper but in 2011 I used a cultipacker. I put a lot of weight on it and that seemed to work; it didn't crimp as well as the crimper but it didn't bridge as much over dips in the soil, either. I didn't see a significant difference in the killing of the rye. They both gave good results, the later you put the rye down the better they both work. If it's earlier a lot of rye is going to stand back up. But by some point later in June when you lay it down it doesn't have a lot of urge to rebound.



In both years I transplanted about 5 acres of pumpkin and squash immediately after using the zone tiller, about the third week of June. I set up narrow Lilliston row gangs and made a quick pass right in the narrow zone 6 to 8 inches on each side of the transplants a week or 10 days later. I got a very good yield in both years, the equivalent of about 1,000 twenty pound Howden pumpkins.

Richard Hudak in zone-tilled pumpkins 8/4/10

I did a small plot with the ZT for transplanted sweet corn and it worked well. The plants don't get as vigorous at the start but they make up for it in the end. There may be N tie up and the soil is cooler so they just don't jump like on open ground. In the end the maturation is the same in my opinion.

In 2012 I decided to mow the rye because I've been struggling with volunteer vetch. I found when you roll a cover with both rye and vetch in it some of the vetch will survive, enough to make seeds. They spread readily and become a problem. So I mowed instead of rolling to be sure and kill the vetch when it was in flower. That presents an additional challenge since it is harder to make the zone in mowed rye. When it's rolled it tends to stay in place but after mowing it tends to gather even with good coulter, and you may have to have someone walk alongside the unit and remove the residue to prevent bunching. After mowing with a bush hog I went back with a flail mower when it was dry. Then I cut the planting strips using a single [Yeomans Keyline plow](#) after I made a pass with a row cleaner and a coultter on a tool bar. Just before the vine crop ran I went in again with a Yeomans shank 18 inches to each side of the row to improve deeper rooting and help the crop cope with droughty conditions. The soil disturbance with the Yeoman is so little that it can be done without damage to the nearby crop. In the end there was more weed pressure than previous years because the rye broke down faster after mowing, so I cultivated late in the season with Lillistons, which can handle a lot of trash.

So in 2012 it was a kind of hybrid approach. Ideally I would take a piece of land and go over it with a tine weeder to kill weeds before even seeding the cover crop, then make the zones after rolling and that would reduce the weed pressure. This coming year I'm going to put together a system with Yeoman shanks; they are easy to pull and do minimum disturbance to the soil and are less expensive than the ZT. You just buy the shanks and a good coultter that you put on a standard tool bar. I bought 5 shanks and will set up different systems to accommodate different row crop spacings. The shanks are very easy to move around on the tool bar.

When I first heard about ZT I was skeptical even though I am interested in soil conservation. So I tried it and the first time it didn't work that well but partly you are dealing with compacted soil and you need to fix that over time. If you have a long-term weed management strategy this system can work. There is potential for enormous benefit to soil organic matter compared to the way we used to crop. With this new system you produce two crops really, one for the soil and one for market, it's great."

[Intervale Community Farm](#), Burlington. Andy Jones, farmer at this CSA operation, participated in the ZT trial in 2010, 2011, and 2012 using a Same 85 hp tractor which pulled fine. The farm grows 25 acres of diversified organic vegetables on Hadley-Winooski-Limerick alluvial soil. Andy says "we're always looking for effective methods to improve the organic matter levels and soil structure of our sandy soils. We used the ZT 2010 and 2012 primarily to grow butternut squash. In 2011 an unusually wet spring forced us to abandon our rotation and we had to scrap use of the ZT with cover crops but we did use it extensively on bare ground prior to later-planted Brassicas and other crops.



In 2010 we transplanted Waltham butternut squash into a ZT winter rye cover crop on May 28. Plants were started from transplants in 50-cell plug trays on May 9. At transplanting, seedlings were thoroughly coated in kaolin clay ('Surround') to reduce early feeding damage from cucumber beetles. Plants were set 24" in-row, with 72" between rows. We had three treatments: 0.5 acre of winter rye was flail mowed prior to zone tilling, 0.5 acre was rolled with an 8' Brillion cultipacker and 0.5 acre was grown on bare ground. The ZT was set for a zone 12" wide, with a tillage depth of 14-16", with a single shank on the toolbar. Mowing, rolling, zone tilling and transplanting all occurred on the same day in the ZT plot. Tillage began earlier in the bare ground plot, with transplanting occurring on the same date as the

ZT plot. On June 10 all the transplants were sidedressed with 40 lb. /A peanut meal (8-1-2). The October 2009 sown winter rye crop provided incomplete ground cover after spotty germination so weed control was a problem in the ZT plots. With the wide tilled zone and a poor mulching effect in between the zones, many annuals and winter annuals took hold, despite 20 hours of hoeing in each ZT plot, although the rolled rye prevented weed breakthrough better than the flail-mowed rye. We did manage to forestall the weeds sufficiently during the critical period for crop growth so overall yields across all three treatments were similar, about ten 20-bushel bins per half acre section or 20,000 lb./A. Insect damage and disease appeared similar throughout the three plots. Aside from the kaolin applied at transplanting, we did not apply any insect or disease control material. We noticed no difference in disease incidence for either foliar powdery mildew or fruit gummy stem blight. One notable difference was that the ZT squash were cleaner than the bare ground specimens, subsequently reducing the amount of time required to clean them.

In 2011 we weren't able to plant butternut squash using the ZT due to wet conditions in June, but we used the ZT pre-plant before or after conventional tillage practices on about 6 acres of later planted sweet corn, brassicas, and root crops in order to address subsoil compaction in late September. For this we set the ZT at 14-16" depth in a two-row configuration. We saw significant drainage differences at ZT, even in our sandy fields. In a fairly compacted field where compost had been made we used to have standing water after a thunderstorm, but after using the ZT in the fall after thunderstorms in the spring there was a lot less standing water and it drained away faster than in the past.

In 2012 we transplanted Waltham butternut squash into a single-row ZT winter rye cover crop on May 31. Plants were started in 50-cell plug trays on May 8. At transplanting, seedlings were coated in Surround and set 24" in-row, with 72" between rows.

The winter rye sown Oct. 7, 2011 provided excellent ground cover, and was divided into two treatments prior to zone tilling: 0.5 acre was rolled with an 8' I&J roller-crimper, and 0.5 acre was flail mowed and incorporated. The ZT was set to make the narrowest possible zone, 4-6" wide, at a depth of 14-16", with a single shank on the toolbar. Rolling, zone tilling, and transplanting all occurred on the same day in the ZT plot. Mowing and tillage began earlier in the bare ground plot, with transplanting occurring on the same date as the ZT plot.

Weed control was very good in the ZT till plot; the narrow zone and a healthy winter rye stand, coupled with a lower weed seedbank resulted in a very low weed population and minimal need for hand weeding. With only 2-3 hours of weeding in the ZT plot, weed control costs were significantly less than the several cultivations and two hand hoeings needed in the bare ground treatment. The primary weed problem in the zone till treatment was winter rye, which did not fully kill with the roller crimper, despite waiting until the rye was quite mature. We did not attempt to control the winter rye that rebounded after the crimping, which probably had some negative consequences.

Roller-crimping mature winter rye



Bare ground squash yield was good in the bare ground plot at 12 bins (24,000 lbs./A equivalent) but yield in the ZT plot was about half of normal at 5 bins (10,000 lbs./A equivalent) and fruit was much less mature, perhaps in part because insect damage was a significant problem and set plants back in the ZT plot. While both treatments had Surround applied to transplants, cucumber beetle damage was worse in the ZT plot. Perhaps the rebounding rye protected cucumber beetles from predators, or that they prefer

environments with more residue. In addition, there was damage from armyworms, which were plaguing the rye and grassy headlands in that section of the field shortly after the plot was rolled. About 50% of ZT plants died out in the first few weeks after transplanting. A considerable number of these were likely due to insects, but many may have suffered due to an unfilled shank cavity right below the transplant. We use a waterwheel transplanter, and usually have very good results, but creating a 14" deep hole in a narrow band right below the plants may have created a problem. Nitrogen tie-up may also have been a problem. Weak, yellow growth was the rule in the ZT vines until early August, after which it was too late to catch up. Interestingly the incorporated rye didn't seem to result in N tie-up even immediately after planting, despite having more carbonaceous material in contact with the soil. Competition from the living rye may have been a stronger factor.



Conclusions. First, a thick, even cover crop is essential for good weed control in an organic system. In 2010 our rye wasn't dense enough, and the field had a higher weed seedbank, leading to significant weed problems. In 2012, we had a rye cover crop with complete ground cover and a field with lower weed seedbank. After a full season we had no more than a couple of person hours into weeding the ZT squash, with near perfect control; weed control worked better than I hoped in 2012.

Squash seedlings in bare ground (left) and ZT plots

Second, fertility management is an important aspect for us to investigate more carefully. While our 2012 weed control was excellent, our crop growth was not. The ZT butternut was severely stunted with very slow growth, resulting in low yield compared to conventional tillage. It isn't clear to me which factors (N tie up, lack of fertility, insect pressure, plant rooting and ZT slot) are responsible for the anemic growth, but we need to find out. We may need to amend the fall before with manure or compost, fertilize right into the zone after ZT followed by sidedressing, or perhaps work with a rye-vetch mixture, though that may be difficult to kill.

Third, cover crop mortality could use some tweaking. The I & J roller was better than our own cultipacker, but even with that tool we had quite a bit of rye bounce back shortly after rolling. We waited until pollen shed and full heading, with rye around 6' height, but even that didn't seem to do the trick with our 5/31 rolling. I would wait another week to see if that improves rye mortality, though this starts to get late for planting butternut. If direct seeding, we could run through the field with the mower after sowing if the rye was bouncing back.

Fourth, the single row ZT doesn't have huge horsepower requirements, so it could be of use to smaller growers. That said the ZT does require some lift height, so that could be a problem. Faster ground speed makes a nicer zone, though, so an undersized tractor won't work as well for several reasons.

Despite our mixed results I like the ZT and feel that it has tremendous potential for reducing tillage in vegetable crops. I'm excited about the potential of the ZT and its application in winter squash and pumpkins. I'd like to try it with winterkilled oats and some early Brassicas, though soil temperature and root maggots may negate that as a successful strategy. Looking at legume mixtures to provide organic-sources of nitrogen will also be an area that I would like to investigate."

Regrowth of rye and vetch in rows of squash



[Jericho Settler's Farm](#), Jericho/Richmond. This farm is owned by Christa Alexander and Mark Fasching. They tried the ZT in 2012, at their Richmond field on Hadley silt loam. The farm has 30 acres of vegetable total. They used a Kubota 8540, 85 hp that pulled the 1-row unit fine. They planted winter squash on a quarter acre, half of which was vetch and rye that was prepared conventionally by mowing, plowing, rotovating and laying black plastic mulch; the other half was roller crimped. Strips were zone tilled and winter squash transplanted the first week of June.

“Most of the rye stayed down but vetch regrew in about 30% of the area; we mowed this with a push mower before the squash vines ran out, that knocked it back some, but by end of season we had a growing rye/vetch cover crop amongst the vines. One good thing was that the area grew a cover crop and we didn't have to incorporate and plant another cover in the fall, we just mowed down the vines. However, the plastic bed plants grew a lot faster, were greener and healthier, set more and bigger fruit, and yield was easily double what the ZT beds produced. We did not adjust the roller basket correctly, so we did not get a well-worked soil line to transplant into; we did not realize we had done this incorrectly at the time, having never seen one of these work in real life. The transplants went into a furrow which was not very friable, so they were water and nutrient stressed from lack of root establishment after transplanting. Thus plants were stunted, production was very low. We need to learn more from other farmers about how they made the machine work, best size of transplants, fertilization techniques, etc. Not sure if we'll do more; maybe if we really up our winter squash production, but it's such a minor crop for us I'm not sure if ZT is worth the time to get the equipment, etc. But we like experimenting, so we'll probably try some more before throwing in the towel.”



Marking rows while zone-tilling killed rye

[Lincoln Farm](#), Randolph Center. Sam Lincoln used the ZT in 2010 on 6 acres and in 2011 on 2.5 acres with conventional production techniques. Winter rye straw was killed with Roundup two weeks prior to being rolled flat; in some areas rye straw was harvested and baled before rye stubble was sprayed with a quart of Roundup and zone tilled a few days later. The dates of these activities were from May 20th through June 7th both years, and the ZT was pulled with a 4440 John Deere 165 hp tractor. The yield of sweet corn from the zone tilled area was 700 dozen per acre. A pumpkin crop was also grown and yield was good but not measured. “The zone till experiment for us was very beneficial. It showed how much time we could save if we eliminated all our tillage passes, even on a small scale.

It also made me recognize that I would have to be a better planner to start using reduced tillage implements. I need to make sure my fields are smoothed and level when I know I won't be tilling them in the future, I need to time my cover crop plantings to be well established to have adequate biomass in the spring and I need to be on top of my weed control program. With reduced tillage and planting into a rolled down cover crop, there's no chance of mechanical weed control during the growing season (with any tools that I currently own). I am currently seeking used zone till equipment to add to my planter."

[Paul Mazza's Fruits and Vegetables](#). This is one of the largest vegetable farms in Vermont, with 250 acres throughout Jericho, Williston, Essex and Colchester. After attending Extension presentations where the benefits of zone tillage were described, Paul purchased a 4-row Unverferth unit in 2011. He uses a 4-row planter for sweet corn so he was concerned that the 2-row unit purchased with CIG funds and available



for trial would not line up exactly, and would take more time to use on his large fields. Due to wet weather in 2011 he could not use the unit, and in 2012 he found that the zone builder was only adjustable for 30 to 34-inch rows and he uses 36-inch spacing. "We hope to have an extension built and use it in the future."

Paul Mazza with his 4-row Unverferth Zone Builder

[Pomykala Farm](#), Grand Isle. Bob Pomykala used the ZT in 2010 on 2 acres and in 2012 on 4 acres, using an 80 hp tractor. The farm cultivates a total of 70 acres. "In 2010 I had just plowed in a good stand of winter rye cover crop. The ZT was set up as a two row, and used on May 27. I had trouble because it got plugged up by the plowed rye straw, which had to be pulled away periodically. I planted pumpkin and squash using conventional methods and had a good crop.

In 2012 I had a good stand of winter rye. I mowed two passes around the field to get a good headland to work from, and then proceeded to knock down the rye with a roller-crimper, as well as a few rows at the end with our own cultipacker, for comparison. The rye was starting to head out, but was not shedding pollen. Evidently that is why it bounced back up after a few days after I had used the ZT as a one row unit, and seeded the crops, so I just mowed the rye with our haybine and let the straw lay over the seeded row. The pumpkins and squash came right up through the straw.



Cultipacking mature winter rye

After the rye was crimped or rolled I used the ZT on May 18 and planted pumpkins and squash with a 1-row seeder, banding 500 lb./A 10-10-20 fertilizer. I sprayed the field with 2 qt./A Strategy and 0.5 oz./A Sandea. The herbicides took care of all germinating weeds except thistle. I directed a spray of roundup to just hit the Thistle, and not the crop, 3 weeks after seeding. I sprayed Pounce once for cucumber beetle at 4 oz./A and I sprayed 4 times for powdery mildew with Bravo at 1 qt./A. I don't usually spray for powdery mildew, but the crop was late maturing due to lack of rain, so I needed to keep the vines healthy as long as I could.

Pumpkins maturing on top of ZT rye residue



We had 2 acres of Waltham butternut squash that yielded 150 bushels/A, a low yield due to lack of rain. I was unable to irrigate in June, so a lot of early growth was missed. We also had two acres of pumpkins, and the yield was also low. However, the quality of the fruit was excellent, thanks to the fruit laying on straw, instead of bare ground. We have heavy clay soil, and when butternut squash or pumpkins lay on as its maturing, the crop will develop a darker color and skin wrinkling where it lays, making it unattractive. We had the cleanest crop of pumpkins and butternut we ever had. The squash was very clean, having no blemishes whatsoever. The pumpkins occasionally had some dirt on them, but no blemishes. I would like to use the ZT again. I think it would be good to have a thicker stand of winter rye. Adding a bracket so it can be used as a one row or two makes it a much more versatile machine. It is much easier to pull using the one row.

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The zone tiller is a very well-constructed piece of equipment, but is hard to use for those growers without 80 hp tractors. Removing one tillage row helps, but it is still heavy, and the row as off-center. If you take a unit off the Unverferth ZT to make it a 1-row system, it cannot be centered because the front coulter shank can't be attached dead center on the front of the frame due to the supports the 3-point hitch. So I built a narrower bracket that fit in the space available dead center on the frame. I used the same kind of U-bolts that hold the other brackets to the frame and I welded ¾ inch metal to make the bracket narrower so it would fit, leaving the same size opening for the square coulter shaft, which must be able to slide up and down. The unit with subsoilers and baskets attach to the back part of the frame and are not affected by the 3-point hitch supports; one of those can be centered. So now the unit can potentially till 1, 2 or 3 rows."



Standard bracket for the front coulters shank is on the left; the narrower front coulters bracket custom-made by Bob Pomykala is on the right, located dead-center on the frame.

[River Berry Farm](#), Fairfax. This 50 acre diversified farm tried to use the ZT in 2010, but their Kubota 4WD M6800 70hp tractor couldn't get it off the trailer. Part of the issue was that the rear tires weren't loaded so that made it difficult to get the necessary lift.

[Rockville Farm Market](#), Starksboro. Eric and Keenan Rozendaal raise 25 acres of organic produce. Eric used the 2-row ZT in 2010 on two acres of bare ground early in the season, about May 12th, with a Case MX 75 hp which pulled it fine but sometimes had to engage the 4x4. "We transplanted mixed crops, mostly spring broccoli. Unfortunately, I don't have any significant data for yield but one thing we did observe was the overall drainage was much better in the section we zone tilled. I thought it was a good project, I'm not sure if we will continue with ZT. Seems like we have other mountains to climb first."

[State Line Farm](#), Shaftsbury. John Williamson used a 70 hp 4WD Challenger tractor with the ZT unit. It could lift the tiller easily but didn't have enough power to pull it. "We have clay and slate ledge soil that is hard to plow through."

[Wood's Market Garden](#), Brandon. Jon Satz grows 60 acres of organic vegetables and berries. In 2010 he used a New Holland TS100 with 100 hp and it pulled the 2-row ZT even in heavy soil. Jon experimented with making zones on both light soil and heavy soil in different fields in mid-May, into vetch and also winter-killed oats, just to see how the ZT worked in his soils and what kind of a seed bed it made, he did not plant crops into the strips; he tilled the fields before planting a few weeks later. "I can't see the ZT working organically unless we have a field with low weed pressure and a thick cover crop. I worry about weed control in the zone; I could see some kind of modified cultivator to work the ZT row, like small Budding baskets. We've been experimenting with different cover crops for their reduced tillage potential in oilseed crops and we August-seeded a hairy vetch and oat cover where the oats winter killed and next spring the vetch was gorgeous. But we couldn't get it to kill until we crimped it the



second half of June when pods were just starting to form, and it still didn't kill completely, but it was good enough. One thing about killed cover crop is it really cools the soil off so you have to consider that when you plant into it. I think fall Brassicas would fit nicely into a late planted cover after it is allowed to mature and the soil allowed to warm up."

Jon Satz feels the soil temperature in strips made into winter-killed oats.

Soil Compaction: There were 26 fields on 7 farms in this study sampled for subsurface soil compaction (6-18" depth) using a penetrometer and following the Cornell soil health test protocol. The results showed that the average reading per farm ranged from 205 psi to 500 psi, with an overall average of 343 psi for all farms/fields. According the Cornell Soil Health Assessment Training Manual (B.K. Guguino, et al., 2009), roots cannot penetrate the soil with penetrometer readings above 300 psi.

After using the ZT, the subsurface compacted layer of the soil is broken through. Penetrometer readings measured little or no resistance directly in the ZT row. Readings taken on all farms ranged from 0-50 immediately after ZT, down to the depth the subsoiler was set at (maximum of 22" deep). It is not known the extent to which use of the ZT for many years will alleviate subsoil compaction in an entire field over time, but it clearly reduces compaction in the planting zone in the year it is used.

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Sue Hawkins power-washing the ZT unit to avoid the spread of soil borne diseases between farms.

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