**FINAL REPORT:** On-Farm Management of Cutworms in Organic No-Till Corn
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1. Project Summary

Wilson (2007) identified black cutworm as a serious pest to corn established in the organic no-till corn planting system that posed a considerable barrier to system adoption. As no-till planting systems offer substantial benefits in terms of erosion prevention, tillage and cultivation reduction, and time and energy savings, it is important to overcome barriers to adoption. This project provides additional investigation of the pest management challenge posed by black cutworm and explores options for organic management. OFRF support enabled a multidisciplinary approach that brought together a Pennsylvania State University (PSU) entomology group led by Dr. Mary Barbercheck, Rodale Institute (RI) research and production staff, and a pioneering organic no-till farmer (Kirby Reichert) to further develop pest management options for the organic no-till corn planting system.

At both locations, RI research staff led field trials comparing OMRI-approved cutworm control treatments to untreated control plots in 2008 and 2009 (planned to repeat again in 2010). In both years, and again in the third year, RI researchers monitored for cutworm moths, cutworm and other pest larvae, and cutworm damage to the corn crop in terms of population size, characteristic plant injuries, and yields.

Barbercheck's group analyzed field trial soil samples for various entomologic and physical characteristics. Barbercheck also conducted laboratory trials to assess the efficacy of all field applied biocontrol treatments on lepidopteran larvae under controlled conditions. Barbercheck's analyses revealed that both sites were characterized by a highly diverse and variable entomologic communities comprised of both pest species and entomophagous beneficials. Lab incubations in both years showed highly active communities of native soil fungi and nematodes that killed most lepidopteran bait. Applied controls were not as effective as the native pathogens in terms of lepidopteran control.

In both 2008 and 2009, cutworm pest pressure on corn established with the no-till planting method was low with no significant differences between treatments in terms of larvae populations, corn populations, cutworm damage to corn plants, or yield. Spatial trap data of moth flight patterns suggested that lower sites surrounded by treelines or other buffer habitat were more protected from cutworm flights than hilltop sites without trees or other predator refugia. We attribute the low pest pressure in 2008 to the poor sychronicity between the time when cutworm larvae population was highest and the timing of the vetch bloom and corn planting (cutworm pressure preceded corn planting in 2008). In 2009, there were very low cutworm populations at both sites and, despite an attempted seeding of incubated, lab-hatched cutworms, observed numbers of cutworm larvae and cutworm-mediated corn damage were low and did not differ between treatments. These two years of data indicate that the challenge posed by cutworm predation is: highly episodic, perhaps not as severe a barrier to system adoption as originally feared, and better controlled by system and landscape management than by purchased applications of OMRI-approved biocontrols.

2. Introduction to Topic

Researchers have completed the first two years of a three-year field trial testing the efficacy of National Organic Program (NOP)-approved cutworm controls in an organic no-till corn system. The organic no-till system relies on leguminous cover crops rolled at corn planting to form a nitrogen-rich, weed-suppressive mat. While the rolled cover crop mat has shown excellent weed suppressive, erosion prevention, and energy- and time-saving capacities, it has also supported large cutworm populations and subsequent severe crop losses (Wilson 2007). Severe cutworm infestations reduced corn populations 34-67% (Whitford et al. 1989). These losses noted at the Rodale Institute's experimental farm, as well as by numerous farmers, motivated our study.

Black cutworm (*Agrotis ipsilon*) moths arrive in storm fronts in early spring and preferentially lay their eggs in lush cover crops, crop residue, or weeds (Showers et al. 1985). When temperatures exceed 50°F (10°C), the cutworm eggs begin to mature. Much like each corn variety requires a certain number of growing degree units (GDUs) to reach physiological maturity, developing cutworms also require a certain number of heat units to reach maturity (and their most damaging stage of development instars 3-5). From year to year, the timing of the peak influx, or biofix, of cutworm moth varies with the timing of weather front arrivals. Then from the biofix, heat units begin accumulating at different rates – faster for warm springs, slower for cool ones. Cutworms are most damaging 312-430 heat units after the biofix. Generally, in eastern Pennsylvania, it takes about 30 days from the time of the biofix for the cutworm moth to mature to its developmental stage with greatest damage potential.

3. Objectives Statement

This project was undertaken to evaluate several cutworm control tactics in organic no-till corn so as to reduce challenges faced by farmers and ultimately increase adoption of the biological no-till system. Our specific objectives are to: 1) Conduct on-farm and on-station trials to identify effective management strategies for cutworm in organic no-till planted corn; and 2) Implement a multi-tiered dissemination plan to share relevant findings with farmers, researchers, educators, and other stakeholders.

4. Materials and Methods

*Cutworm Moth Flight Monitoring*

We monitored two types (one expensive research version and one inexpensive farmer-accessible version) of cutworm traps placed in 3 locations at the RI for cutworm moths from early April through late May/early June (6 traps total). Each morning, we counted and collected the moths in each trap. In 2008 we used cone traps and sticky wing traps at each location and in 2009 we used cone traps and unitraps at each location. The inexpensive trap type was changed between 2008 and 2009 because the sticky wing traps are unspecific and were less effective than the cone traps with pheromone lures. Unitraps with pheromone lures, another less expensive type of trap, were used in conjunction with the cone traps in 2009. Pheromone lures were refreshed (replaced) every 14 days.

*Cutworm Larvae Incubation and Application*

Due to extremely low pest pressure in 2009, 10,000 cutworm eggs were ordered from Benzon Research in Carlisle, PA on 5/21/09. The eggs arrived on 5/28/09, were incubated at 29°C and 50% humidity until 6/1/09, when >90% of larva appeared to have hatched and were evenly applied in corn cob meal via Davis Applicators to a) the Rodale Institute (8AM); b) Reichert's (6:30 PM).

*Cutworm Larvae Monitoring*

In 2008 prior to planting (late May-early June), we surveyed the soil within 0.25 $m^2$ quadrants to a depth of 3 inches for larval cutworms. After planting, surface transect monitoring was conducted weekly in 6” bands in 1 m of row per treatment plot (1m/10’x10’ plot). In 2009, surface transect monitoring was conducted weekly for cutworm moths, eggs, and larvae at both locations in three 1-m transects per plot (72 m/location/sampling event) from May 20-July 15. Both years, larvae were packed in an ethanol-glycerin solution and sent to Pennsylvania State University (PSU) for identification and analysis.

*Factors, Plot Design and Replication*

There were three factors planned in the study: location, planting time, and cutworm treatment. Our locations were two farms: the Rodale Institute farm in Kutztown, Berks County, PA (“Rodale”) and Kirby Reichert’s farm in Grantville, Dauphin County, PA (“Reichert”). In 2008, both farms had an “early” and a “late” planting date. At Rodale we planted on June 6 and June 16 and at Reichert’s we planted on June 12 and June 19. The planting dates were planned to capture two hairy vetch bloom stages, “early” bloom and “full” bloom at the two locations. Unfortunately, it rained all but 5 days in June of 2009 and we were only able to establish corn on one planting date at each location, at “full” bloom stage. In 2009, Reichert’s corn was planted on June 10 and Rodale’s corn was planted on June 16.

After each planting date, we delineated plots for 4 replicates of the six OMRI-approved cutworm controls and an untreated control (Table 1). In 2008, all 112 plots were 10’ by 10’. In 2009, all 48 plots were 10’ by 20’. In 2008, we applied treatments at prescribed times ranging from planting to post-emergence (Table 1). In 2009, since cutworms were artificially seeded, treatments were applied one week later and prior to corn planting at both locations. Since we needed to apply some treatments in an aqueous solution, all plots received 2 gallons of water or solution.

**Table 1.** OMRI-approved cutworm treatments tested

| **Brand name (Source)** | **Species (if applicable) and method of application** |
|---|---|
| Dipel-DF (Valent) | *Bacillus thuringiensis* var. kurstaki, applied to VE corn plants (2008) or hairy vetch (2009) in solution via backpack sprayer (application rate 0.25-2 lbs/acre; 0.5-4 t/Gal) |
| Diatomaceous earth (2008 only) | Applied to moistened soil in corn furrow |
| Entrust ® (Dow AgroSciences) | 80% spinosad (spinosyns A and D) from *Saccharopolysora spinosa*, applied to VE corn plants (2008) or hairy vetch (2009) in solution via backpack sprayer (application rate: 0.5 to 3 oz/acre) |
| Ecomask (BioLogic Company) | *Steinernema carpocapsae*, an insect-killing nematode applied to VE corn plants (2008) or hairy vetch (2009) with a watering can via vermiculite slurry (application rate: 70,000 active units (AUs)/$ft^2$) |

| | |
|---|---|
| *Steinernema riobrave* (Barbercheck lab – lab reared) | *Steinernema riobrave* an insect-eating nematode, actively seeks out prey, applied to hairy vetch (2009) with a watering can via vermiculite slurry<br>(application rate: 8750 AUs/row feet) |
| Scanmask (BioLogic Company) (2008 only) | *Steinernema feltiae*, an insect-eating nematode, actively seeks out prey, applied to VE corn plants with a watering can via vermiculite slurry<br>(application rate: 8750 AUs/row feet) |
| Mycotrol (BioWorks) | *Beauveria bassiana* (GHA strain), entomopathogenic fungus spores, Applied to VE corn plants (2008) or hairy vetch (2009) in watering can solution<br>(application rate: ¼ to 1 qt/ acre) |
| None (water only) | 2 gallons (1 watering can) water |

*Corn Stand Establishment, Populations, and Foliar Damage*

We surveyed one (2008) or three (2009) 3.28-ft (1-m) lengths of row within each plot after corn plant emergence (approximately weekly). We noted the number of corn plants, their growth stage, and cutworm or other foliar damage. The final corn population was determined when the corn plants reached growth stage V5 and were no longer vulnerable to cutworm predations (~4 weeks after planting). Stand establishment was determined as the percent of the seeding rate that the final population represented.

*Soil Chemical and Biological Properties*

A composite soil sample comprised of 10 random cores each (2.54 cm X 15.25 cm) were collected from the Scanmask and *S. riobrave*, Mycotrol, and Ecomask treatment plots prior to nematode application. Post-application soil samples were taken one week later and were comprised of 10 cores sampled near the four crop rows in each plot. This sampling depth represents the most biologically active zone in the soil profile. Each soil core sample was placed in a plastic garbage bags and thoroughly mixed to form the composite sample. This composite sample was then divided in the laboratory into three portions of approximately 250 mL each. These triplicate sub-samples were used for physical and biological analyses. The sub-samples for soilborne insect pathogen analysis were placed in plastic containers (Reynolds 473 mL deli containers) and stored at room temperature until the baiting and extraction procedures, which are described in detail below. The two sub-samples used for characterizing soil physical properties (gravimetric soil water content and matric potential) were placed in plastic Ziploc bags.

<u>Soil Matric Potential</u>

For each soil sampling date, soil matric potential was determined using the filter paper method (Hamblin 1981). Briefly, oven-dried filter paper (Whatman No. 42, 55 mm dia.) of known weight was sandwiched between two pieces of filter paper and buried in ~250 mL of soil contained in Ziploc bags. The bags were sealed and stored in a sealed box and the filter paper was allowed to equilibrate with the water in the soil for 48 hrs. The moistureequilibrated filter paper was removed, brushed to remove attached soil particles, and reweighed to obtain a wet weight. The percentage moisture of the filter paper was calculated as [(wet weight - dry weight) / dry weight] x 100 = % moisture of filter paper. The water potential (-kPa) for each percentage was determined from a conversion factor relating percentage moisture of the filter paper to soil matric potential (Hamblin 1981).

<u>Soil Gravimetric Moisture</u>

For each soil sampling date, gravimetric soil moisture was determined by placing ~50 g of wet weight soil in pre-weighed 10 cm X 6.25 cm tin soil cans (Gardner 1986). The cans containing the weighed moist soil were dried in a bench-top oven (VWR 1324, Sheldon Manufacturing) at 45°C for 72 hrs. The dried samples were then weighed to obtain the dry weight of soil. Percentage soil moisture was calculated as [(wet weight soil - dry weight soil) / dry weight soil] x 100 = % soil moisture.

<u>Soil-borne Insect Pathogens</u>

A baiting bioassay method using *Galleria mellonella* as a host insect was used to detect entomopathogenic nematodes and fungi in soil samples (Goettel et al. 1997; Kaya and Stock 1997). Soil samples were collected as described above. Soil (~250 mL) was placed in 473 mL deli container (Reynolds) along with 5 last-instar wax moth larvae (*Galleria mellonella*). The baited soil samples were stored at room temperature in the dark for up to 7 days. The cadavers were then removed and placed in 59 mL cups (Solo) with lids for symptoms and signs of infection to develop. The containers of soil were then re-baited with five new larvae and incubated for an additional 7 days. Soil samples were re-baited with larvae until there were no signs or symptoms of nematode infection.

Cause of death was identified as fungal (*Metarhizium antisopliae or Beauveria bassiana)*, entomopathogenic nematode, or other. The nematode family was determined by the color of the cadaver. An ocher color indicated the presence of *Xenorhabdus nematophila*, the bacterium associated with *Steinernema*, whereas a red color indicated the presence of *Photorhabdus luminescens*, the bacterium associated with *Heterorhabditis* (Kaya and Stock 1997). If there was uncertainty as to the infecting nematode species, the cadavers were dissected. Cadavers exhibiting symptoms of fungal infection were held individually in humid chambers (59 mL Solo cups) until sporulation. Sporulating cadavers were then classified as being infected with *Beauveria* (white spores) or *Metarhizium* (green spores) (Goettel and Inglis 1997).

*Yields*

Plot yields were assessed in 2009 via hand harvests of 8'-long sections from the two center rows in each plot.

*Statistical analyses*

SPSS (version 13.0) performed a MANOVA on the full dataset, tested for significant differences between treatments with Tukey's post hoc test, and calculated Pearson's correlation coefficients and significance for bivariate correlation between each pair of variables (cutworm populations, corn plant populations numbers of damaged corn plants, and yield).

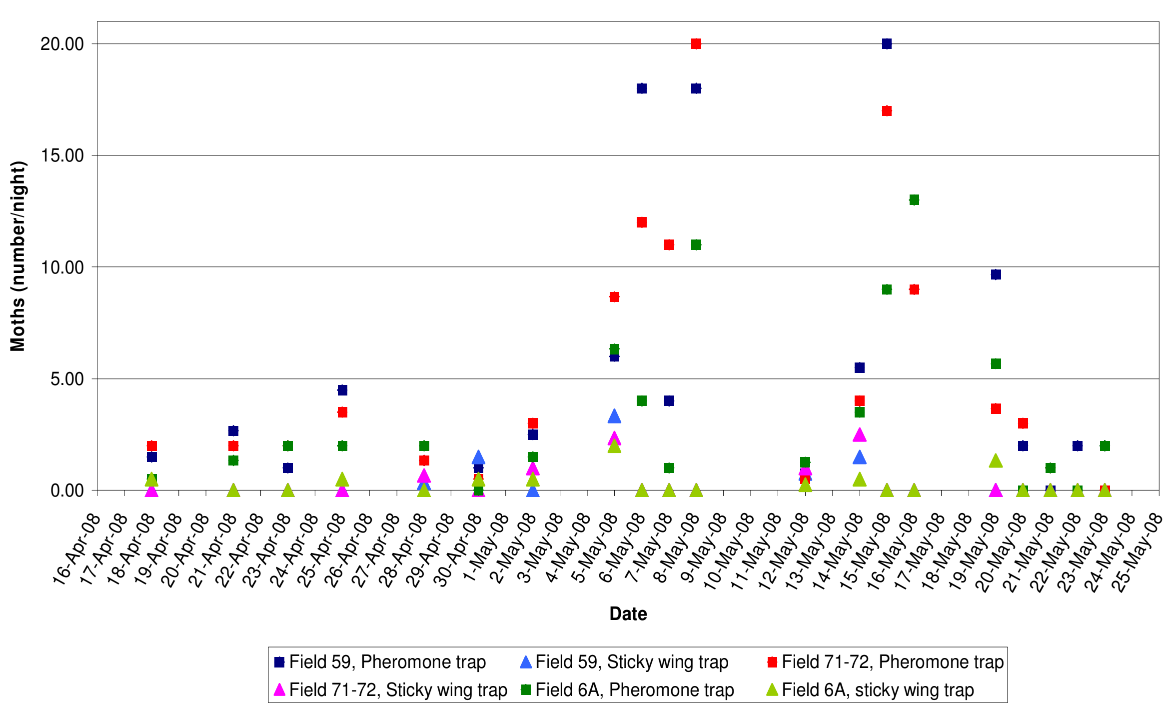
5. Project Results

*Pest Pressure – Moth Trapping*

Overall, most moths arrived on hilltops (59% or 305/514) in May (82% or 420/514). There were significantly more moths caught in 2008 (488 moths) than in 2009 (26 moths; $p<0.005$). In 2008, the largest influx of 20 or more moths, or biofix, of cutworm moths arrived at Rodale on May 8, 2008 in Field 71-72, the field used for this trial (29 moths, Figure 1). Based on 2008 GDUs, the subsequent time of greatest corn plant damage would have ranged from June 6 or June 7 through June 11 or June 13, 30-38 days after the biofix. Therefore, the planting dates, and subsequent dates when the corn plants would have been vulnerable (after June 16) did not coincide with the dates when the cutworms were in their most damaging stages (June 6-13; Table 2). There was no biofix of moths in 2009 – the most moths caught in a night was 4.

The pheromone traps were much more effective than the sticky traps (used in 2008) or the unitraps with pheromone lures used in 2009 capturing moths (Figure 1). On May 8, when pheromone traps captured 20, 18, and 11 moths at the 3 respective trapping locations, we found no cutworm moths in any of the sticky wing traps. Additionally, we observed birds eating insects from the sticky traps, but not from the pheromone traps. Therefore, sticky wing traps were not utilized in 2009 and another less expensive trap, a unitrap with a pheromone lure, was used. The unitraps were not effective even when augmented by adding soapy water to the trap – not a single cutworm moth was caught in a unitrap.

**Figure 1.** Black cutworm moths (*Agrotis ipsilon*) trapped April-May 2008
in 3 fields (6A, 59, and 71-72) with 2 trap types (pheromone and sticky wing)
The Rodale Institute, Berks County, PA



| Table 2. June 2008 periods of cutworm damage danger (red) and corn plant vulnerability (green) | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | | | | | |

*Pest Pressure – Cutworm Larva*

In 2008, we observed very few cutworms in our in-row cutworm larva surveys (0-3 cutworms per meter, mode of 0, Figure 2). Cutworm treatments did not affect the number of cutworms observed (SPSS ANOVA). Location significantly affected the number of cutworms we observed (p<0.001). We observed significantly more cutworms at Reichert's farm than at Rodale. There was also a significant interaction effect between location, cutworm treatment, and planting time (p<0.05). Pearson's bivariate correlation analysis also detected a marginally significant (p=0.045) negative (-0.155) correlation between the number of cutworms observed and the damaged corn, indicating that cutworms were not the primary cause of the observed corn plant injuries.

**Figure 2. Histogram of cutworm observations**

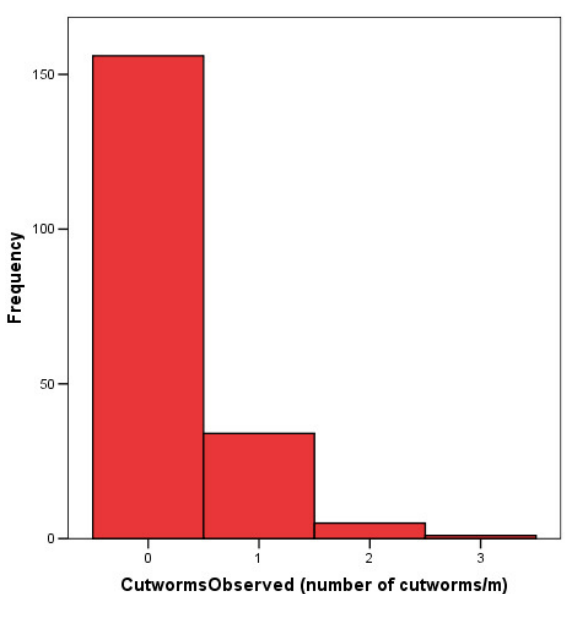
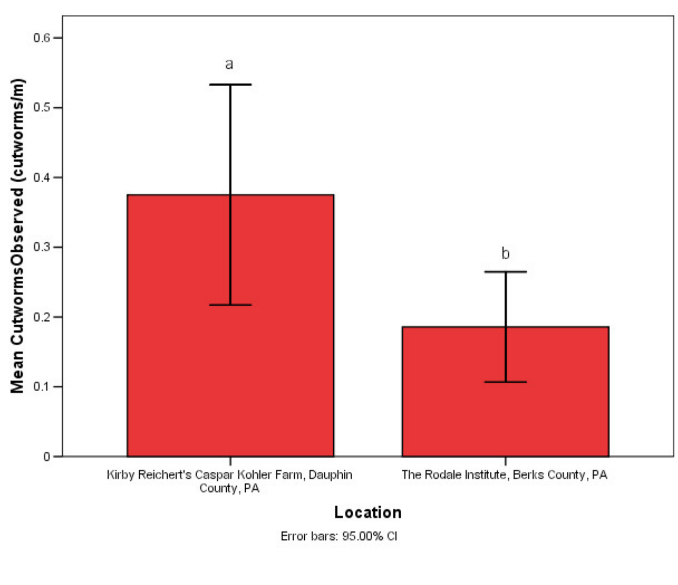



**Figure 3. Cutworm surveys find a significant difference in cutworm numbers between study sites**




Even fewer cutworm larvae were found in 2009 (sum=18 larva) than in 2008 (sum=47 larva), despite seeding both field sites with hatched larvae at a rate of 100 larva/$m^2$ that year. The cutworm pest pressure was so low in 2009 that we were unable to detect any biocontrol treatment effects on larvae populations in the field. Larvae populations were not correlated with stand establishment or yield in 2009.

Observed larvae populations were below the economic threshold for treatment recommended for conventional growers in both years and were not significantly correlated with other measures of crop performance (stand establishment, yield). Thus, in the first two years of this trial, cutworm larvae did not affect corn performance and cutworm control treatments did not affect cutworm larvae populations.

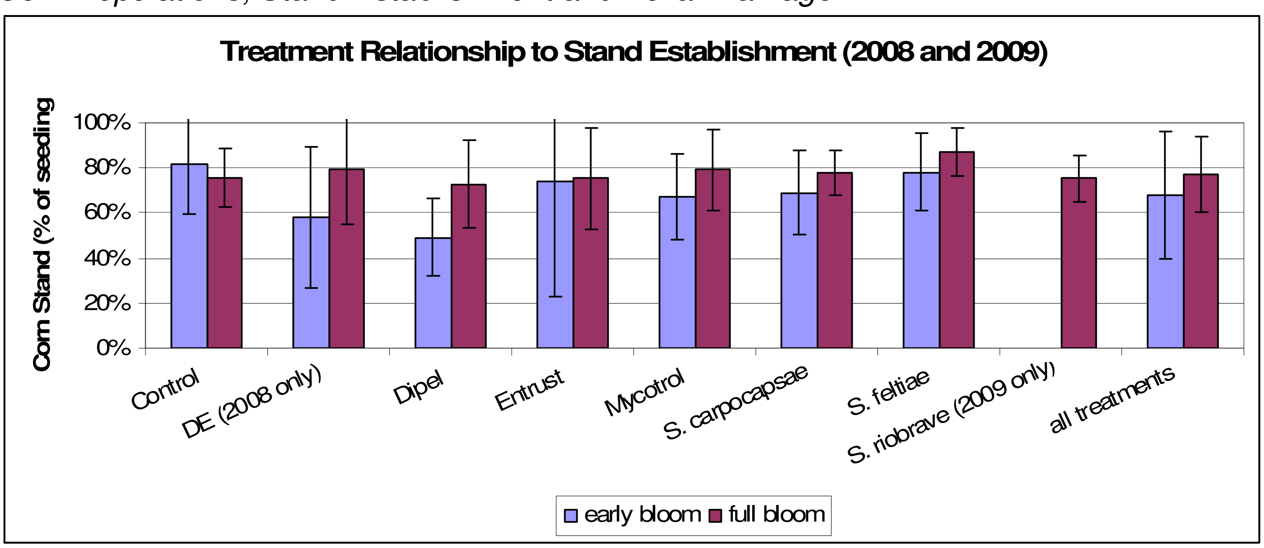
**Table 3.** Early Season Insect Community – means ± standard deviation

| Date | Millipede | Enchytraeid | Lepidoptera | Carabidae | Elateridae | Staphylinidae | Curculionidae |
|---|---|---|---|---|---|---|---|
| Roll 1 | 0.25 ± 0.49 | 1.00 ± 2.63 | 0.25 ± 0.63 | 0.08 ± 0.27 | 0.28 ± 0.64 | 0.03 ± 0.16 | 0.18 ± 0.45 |
| Roll 2 | 0.25 ± 0.63 | 0.38 ± 0.95 | 0.1 ± 0.38 | 0 ± 0 | 0.13 ± 0.40 | 0.05 ± 0.32 | 0.35 ± 0.95 |
| Roll 3 | 0.25 ± 0.54 | 0.35 ± 1.76 | 0.73 ± 1.71 | 0.15 ± 0.36 | 0.28 ± 0.68 | 0.05 ± 0.22 | 0.53 ± 1.53 |
| Roll 4 | 0.08 ± 0.35 | 0.48 ± 1.83 | 0.38 ± 0.90 | 0.1 ± 0.38 | 0.2 ± 0.52 | 0.05 ± 0.22 | 0.45 ± 1.15 |
| Plow | 0.10 ± 0.30 | 1.28 ± 3.99 | 0.13 ± 0.40 | 0.08 ± 0.27 | 0.18 ± 0.45 | 0.15 ± 0.48 | 0.33 ± 0.80 |

2008 community data has been compiled and indicates that there was a diverse insect community comprised of entomophagous and herbaceous insects (Table 3). However, there were no significant differences in community assemblage between treatments.

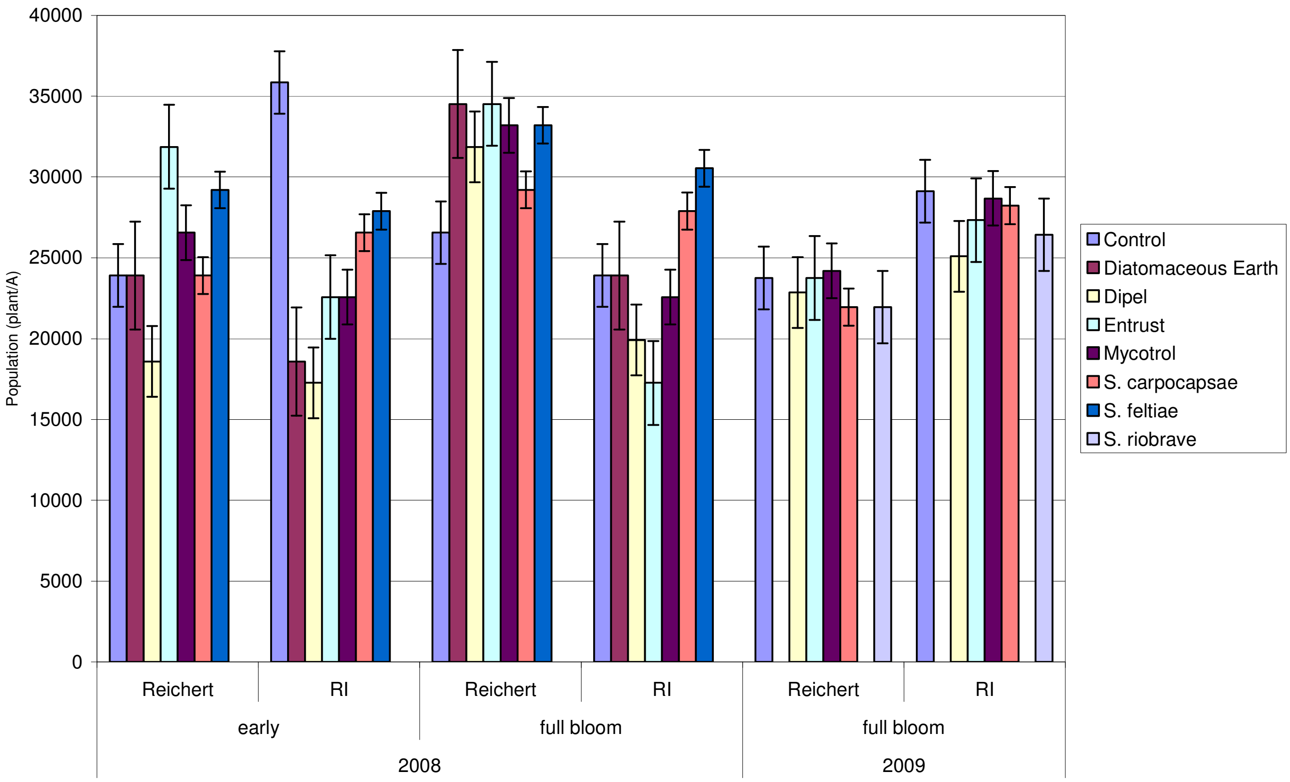
*Pest Pressure/Soil Biological Properties – Lab Efficacy of Treatments*
Since field populations were so low in both years, lab incubations of Lepidopteran larvae with field applied biocontrols (nematodes and Mycotrol) were used to assess potential treatment efficacy. In both years, it appears that the treatments were unsuccessful in infecting or killing larvae bait and that most incubated larvae were killed by a native soil fungus, *Metarhizium anisopliae*. Thus, it appears that the applied treatments are not as effective as a native soil pathogen in overcoming cutworm larva.

*Corn Populations, Stand Establishment and Foliar Damage*




Stand establishment was about 75% of the seeding rate overall, resulting in slightly lower than ideal populations in most treatments (range: 17,500-35,000; grand mean: 26,034). Stand establishment was not correlated with metrics of cutworm pest pressure nor was it affected by cutworm treatment (control plot mean population was 27,500 or 80% stand establishment). In 2008, we observed extensive bird grazing on corn seedlings at Rodale and attributed sub-optimal corn populations to bird predation. In 2009, we observed extensive seed molding and failed germination in the flooded seed furrows at Rodale and anecdotally attributed poor stand establishment there to poorer site drainage and extremely wet weather.

**Treatment Average Corn Populations**




2008 corn plant populations at the RI averaged 24,085 plants/A overall with treatment averages ranged from 17,257 to 35,842 plants/A, while those at Reichert's averaged 28,636 plants/A overall and ranged from 18,585 to 34,515 plants/A. Location significantly affected the corn populations, with Reichert's corn populations significantly higher than those at Rodale ($p<0.01$; Figure 4). There were also significant interaction effects between treatment and location on planting date. There was also a significant interaction effect between location and planting time on corn population ($p<0.01$), but the populations in the early plantings did not differ from the populations in the late plantings. Tukey's post hoc test determined that corn populations in plots treated with Dipel (Bt) were significantly lower than populations in both the plots treated with Scanmask ($p=0.005$), an entomophagous nematode that actively seeks out prey, and in untreated control plots ($p=0.041$; Figure 5).

There were significant differences in the amount of corn plant foliar damage between locations and planting times ($p<0.001$ for both). There was more foliar damage on the earlier planted corn than on the later planted corn (Figure 6). There was also more damage at the Rodale Institute than at Reichert's farm (Figure 7). There was a severe early season Japanese beetle infestation at Reichert's farm and thus Japanese beetles, not cutworms were responsible for much of the foliar damage observed at Reichert's farm. In 2009, we did not observe any instances of clear cutworm damage, although slug damage was noted at both locations. In addition, in 2009 there was a severe early season hail storm at Reichert's farm which was responsible for much of the foliar damage observed there.

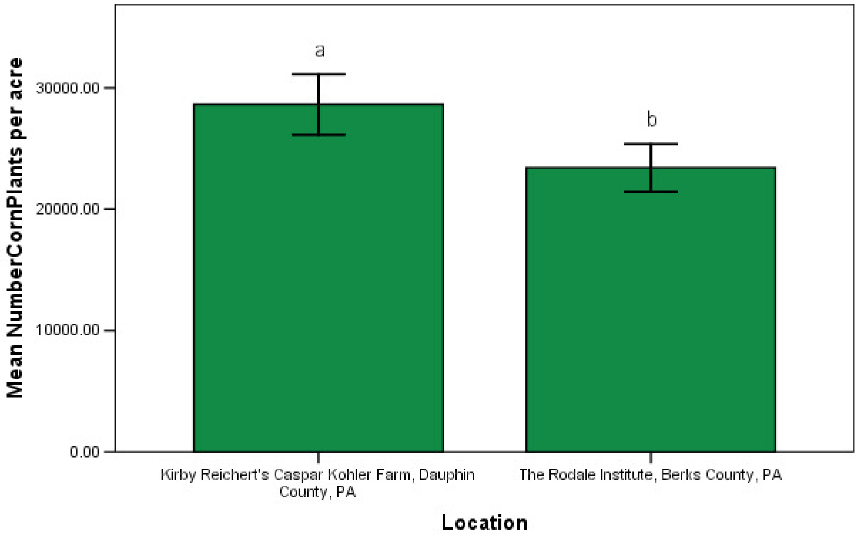
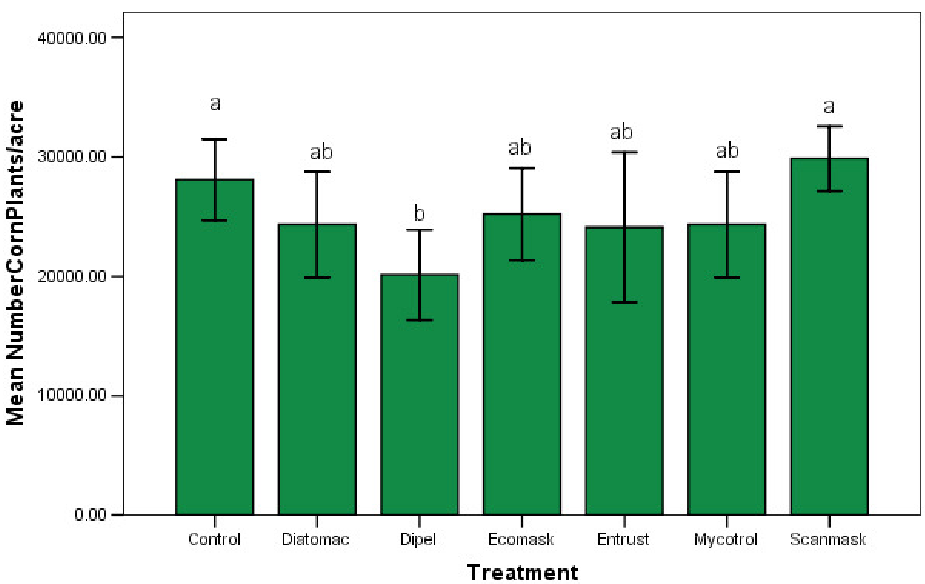



**Figure 4. Corn populations differ significantly by location**

Error bars: 95.00% CI

**Figure 5. Corn populations in plots treated with various cutworm control agents**




Error bars: 95.00% CI

Figure 6. Foliar damage on 2 plantings across locations

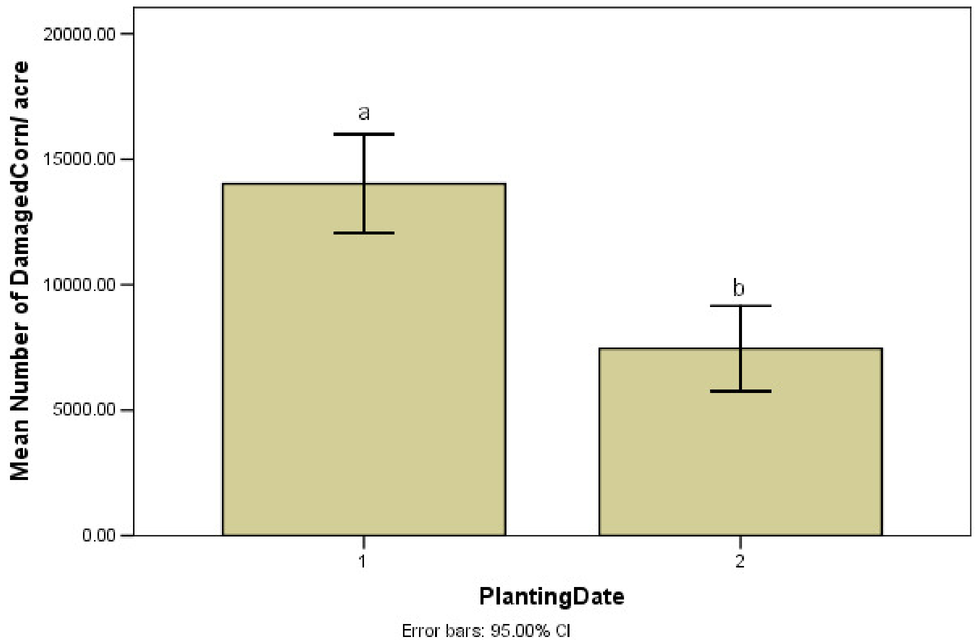
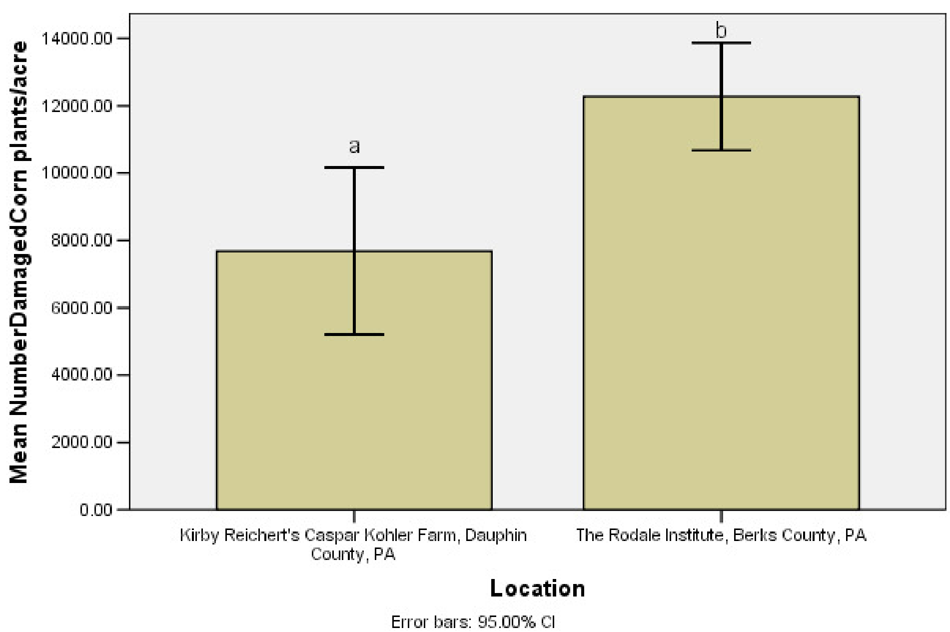



Figure 7. Foliar damage on corn plants at two study sites



6. Conclusions and Discussion

The most interesting finding of this study was the distribution of the pest pressure and its implications for pest management in organic systems. A greater proportion of cutworm moths were caught in traps on unprotected hilltop sites compared to lower elevation sites bordered by buffer habitat (see addenda photos). Since this pest moves in on storm fronts, land management strategies that physically protect production fields, such as treelines, may offer cutworm management services. In addition to physically blocking pest influxes, treelines and other buffer strips provided important habitat for birds that were frequently observed catching insects or eating insect larva from the ground at both sites. These large communities of natural pest managers, while frustrating to the objectives of this project, may provide greater promise to organic producers considering this production system rather than the economically prohibitive biocontrol treatments tested.

The lack of sufficient cutworm pest pressure at the time when the corn plants were most vulnerable severely limited the value of the field trials of cutworm control treatments (despite attempts to seed a pest pressure in 2009). However, the lab incubations provided valuable controlled tests of the nematode and fungal controls' efficacy under controlled conditions. The absence of treatment effects in the lab incubation further suggests that the purchased treatments were not effective treatment options. Further, the apparent efficacy of a native soil fungus suggests that additional studies on the best means of delivering reactive pest management treatments may be necessary.

While cutworm pest pressure was not a challenge to field production of no-till organic corn in 2008 or 2009, other factors contributed to sub-optimal stand establishment and yields. In 2008, data suggested that there was a large community of herbaceous pests aside from cutworms that contributed to lower corn populations and observed foliar damage, although yields at both sites averaged more than the local yield goal of 130 bu/A for all treatments. In 2009, the primary production challenge for this system was yield. In 2009, the wet weather and the weed growth it supported greatly challenged the capacity of this system to produce yields. Plots at both field trials were overtaken by thick growth of annual and perennial weeds within a month of planting, which was likely responsible for the lower yields observed (see photo addenda).

Findings from our first two years of research will be incorporated into plans for the third year of field and laboratory experiments, which will be solidified in our third collaborator meeting scheduled for March 4, 2010. Measuring the landscape influence on pest pressure will be a key objective of this last year of data collection. In addition we will likely explore the efficacy of the treatments in more controlled incubation trials without soil. Lastly, a survey is planned to be posted with a project outreach article to get a broader assessment of the threat posed by cutworms to organic no-till corn producers. These changes will allow us to address questions remaining in our third year of research.

7. Outreach

Numerous outreach events have featured the no-till organic planting system and preliminary results from the cutworm control trial over the past two years. An article summarizing project results has been written for our website and is scheduled to be posted in May. Descriptions of outreach events follow:

**Keystone Farm Show**, Harrisburg, PA, February 2009. Farm Manager Jeff Moyer and Communications Manager Greg Bowman distributed no-till planting system educational and research materials to attendees and displayed our no-till roller-crimper at this farmer-oriented event.

**Organic No-Till: New Farming Strategy for the 21st Century,** Rodale Institute, July 2008. This field day focused on demonstrations of no-till practices and equipment for small farm vegetable production along with cultural weed and other pest management for grain crops and cover crops for every farm. This project was featured in Jeff Moyer's no-till equipment presentation and RI agronomist Dave Wilson's "utilization of cover crops in organic no-till corn" presentation. A survey of attendees was used to assess impact.

*Methodology and response rate.* The Field Day at The Rodale Institute on July 18, 2008 was evaluated via a survey that was administered on-site at the end of the event. We administered the survey to a total of 93 participants and received back 63 valid surveys, a response rate of 68%.

*Demographics and background data.* The respondents are predominantly male (60%), with a median age falling in the 40-60 years group. The occupational distribution shows that over 56% -- 35 individuals -- report full- or part-time farming as their primary occupation. About 11% of survey respondents are educators and 34% report holding other occupations. The survey results show that the majority of respondents (almost 70%) learned at least one sustainable agriculture practice at this field day.

Results from the survey are positive, encouraging, and show interest and involvement on the part of the participants. We first asked respondents to rate the quality of presentation and usefulness of information for each individual presentation at the field day. Results clearly show variation in assessment across presentations, with some getting as high as 54% of "Excellent" ratings for quality while others getting a more modest 32% of the highest mark.

In addition to an overall assessment of respondents' satisfaction with the presentations, we asked a series of questions about the effect of attending the field day on their attitudes, perceptions, and motivations. Results show that the field day successfully accomplished its objective to educate a broad audience and to increase their awareness and understanding of organic and sustainable techniques. The majority of respondents agreed or strongly agreed with all statements assessing the range of attitudinal dimensions and suggest that the field day has motivated people to learn more about the topics presented and to expand their work in sustainable/organic agriculture. Over 87% of participants responded that they will consider incorporating cover crops into their practices as of result of information received at this field day. 29% of farmer attendees reported that the field day's content and activities greatly increased their confidence in the effectiveness of organic no-till practices. In a similar fashion, 41% of farmers strongly agreed that the field day increased their motivation to try organic practices on their farm. None of the 63 respondents had a strong disagreement with any one of the four statements formulated to measure their perceptions and motivations.

In assessing the impact of the field day in advancing knowledge, it is impressive to find that a sizeable 70% (44 respondents) indicate that they learned a new sustainable practice at the field day. What is even more impressive is that 68% (43 respondents) indicate that they will definitely make a change in their practice in the next two years as a result of attending the field day. Finally, 100% of respondents made suggestions for future topics and/or activities for our educational events. Combined, these findings clearly show interest, potential for measurable impact in the adoption of new techniques, and the need for more information and training in the future.

**Pennsylvania Association for Sustainable Agriculture (PASA) Annual Conference** in State College, PA, February 2009 and 2010. Research staff presented no-till planting system materials to attendees and displayed RI's no-till roller-crimper to an audience of 1,700 (in 2009) and 2,100 (in 2010) conference attendees. In 2010, project director Jeff Moyer presented project results to an audience of ~75 in a talk entitled "Innovations in Organic No-Till."

**Rodale Institute's On-Farm Field Day entitled "Cashing in on Soil Health"** held July 17, 2009 in Kutztown, PA. The Cutworm Control Trial and preliminary 2008 and 2009 results were presented along with the following topics: Carbon Credits - Significance, Opportunities, Structure, Benefits to Farmers and Industry; Rotational No-Till - Rotation Considerations and Where to Fit Cover Crops into Your Rotation; Cover Cropping Benefits - Soil Quality Factors, Nutrient Cycling, Moisture Considerations, Cover Crop and Seed Selections and Planting Considerations; Weed Management Practices in a No-Till Mulch Cover; No-Till Equipment Lecture and Planting Demonstration; Compost Turner Demonstration, and Web Soil Survey.

The majority of the 2009 Field Day was comprised of a wagon tour of the different research projects at Rodale Institute, with a focus on the Farming Systems Trial and demonstrations of no-till practices and equipment along with various aspects of soil testing, cover crop selection, and weed management. Several speakers gave technical presentations about the trial layouts and results. Following is a summary of the survey responses we received after the field day.

*Methodology and response rate.* The 2009 Field Day at Rodale Institute was evaluated via a survey that was administered on-site at the end of the event. We administered the survey to a total of 72 participants and received back 64 valid surveys, a response rate of 89%.

*Demographics and background data.* The occupational distribution showed that over 40% -- 26 individuals -- reported full- or part-time farming as their primary occupation. About 9% of survey respondents were educators and 50% reported holding other occupations, most of them with the government.

*Key findings.* Results from the survey were positive, encouraging, and showed interest and involvement on the part of the participants. We first asked respondents to rate the quality of presentation and usefulness of information for each individual presentation at the field day. Results clearly showed variation in assessment across presentations, with some getting as high as 68% of "Excellent" ratings for quality while others getting a more modest 40% of the highest mark. Furthermore, notable differences emerged in the opinions between farmers and non-farmers – with farmers giving higher marks for the field tour and non-farmers giving higher marks for the indoor presentation.

The variation of responses across occupations is of particular interest to our future work as we design events to best meet the educational and training needs of our audience. Results suggest that targeted events – with presentations and activities tailor-made for specific occupational groups -- may be of interest especially to farmers who show interest in more practical, hands-on approaches.

In addition to an overall assessment of respondents' satisfaction with the presentations, we asked a series of questions with respect to perceptions, motivations, and attitudes as well as advancing personal knowledge and professional needs. Over 92% of respondents stated that the field day increased their awareness of the environmental benefits of organic practices, their confidence in the topics presented, and their motivation to further explore sustainable/organic agriculture practices. In assessing the impact of the field day in advancing knowledge, it was impressive to find that a sizeable 79% (51 respondents) indicated that they had learned a new sustainable practice at the field day.

What was even more impressive was that almost the same number (50 respondents) indicated that they would make a change in their practices in the next two years as a result of attending the field day. Finally, numerous respondents made suggestions for future topics and/or activities for our educational events which the team can use in designing upcoming field days. Combined, these findings clearly showed interest in the adoption of the no-till organic planting method and the need for more information and training in the future.

8. References

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9. Addenda (photos, theses, publications) Please see attached photo addenda. Publications are pending further trial results.