Long Island Vegetable Pathology Program
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Evaluation of conventional fungicides for downy mildew in sweet basil
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

New and currently registered fungicides were evaluated on field-grown basil in this experiment. Fertilizer (N-P-K, 10-10-10) at 1000 lb/A (100 lb/A of nitrogen) was broadcast over the bed area and incorporated on 7 Jul. Beds were formed, drip irrigation tape was laid, and beds were covered with black plastic mulch on 7 Jul. Weeds between mulch strips were managed early in the season with Devrinol DF-XT (2 lb/A) applied before transplanting and afterwards by cultivation and hand-weeding. A waterwheel transplanter was used to make planting holes in the beds and apply starter fertilizer. Basil was seeded on 20 Jun in trays in a greenhouse, placed outdoors to harden for about a week, then transplanted by hand on 21 Jul. Basil was planted late in the season since downy mildew incidence is more prevalent during that time and would increase the likelihood of disease development during the experiment. The primary source of initial inoculum in this area is considered to be long-distance wind-dispersed spores from infected plants. Additionally, to provide a source of natural inoculum within the experimental area, a border row of non-fungicide-treated basil plants that extended the length of this experiment was transplanted on 11 Jul. These plants were not inoculated. A randomized complete block design with four replications was used. Each plot had 10 plants in 8-ft rows with 9-in. in-row plant spacing. The plots were 4 ft apart in the row. Treatment applications were made with a CO_2-pressurized backpack sprayer. Soil drench treatments were applied around the base of plants immediately after transplanting, followed by drip irrigation to incorporate the fungicide. Foliar applications were made using a boom with a single twin-jet nozzle (TJ60-4004evs) delivering 50 gal/A at 55 psi and 2 mph on 22 Jul, 28 Jul, and 4 Aug when basil plants were small. A boom with three twin-jet nozzles (TJ60-8006vs), one delivering spray over the top of the plant plus a drop nozzle directed to each side, delivering 82 gal/A, was used on 11, 18, 25, and 31 Aug. Downy mildew was assessed in each plot on 15 and 22 Aug, and 2, 8, and 15 Sep. Incidence of plants with symptoms (sporulation of the pathogen visible on the underside of leaves) and percentage of leaves per plant with symptoms was estimated for 10 plants in each plot. These two values were multiplied together to calculate incidence of symptomatic leaves in the plot. Area Under Disease Progress Curve (AUDPC) values were calculated for incidence from 22 Aug to 15 Sep. Average monthly high and low temperatures (^{o}F) were 86/70 in Jul, 86/71 in Aug, and 77/61 in Sep. Rainfall (in.) was 2.93, 2.19, and 3.23 for these months, respectively.

Downy mildew developed naturally in the plots and became severe as is typical for the area. Symptoms were first observed on 15 Aug in 6 of the 28 plots. On 22 Aug, symptoms were observed in all non-treated plots on an average of 80% of plants, but very few leaves had symptoms. Foliar fungicide applications were started 1 day after transplanting and 3 weeks before symptoms were seen. All three treatments containing a rotation of Orondis Ultra, Revus, and Prophyt at various timings were equally highly effective in controlling downy mildew and exhibited good residual activity, providing more than 99% control compared to the non-treated plots two weeks after the final application. The treatment containing a rotation of Revus and Prophyt was similarly effective at controlling downy mildew, providing 99% control compared to the non-treated plots. These four highly effective fungicide programs started with a soil drench treatment of Ridomil Gold or Orondis Gold at transplanting which was 21 days before symptoms were first seen. The treatment containing a rotation of Ranman, Revus, and K-Phite was less effective at controlling downy mildew compared to the most effective treatments but still provided significant control when compared to the non-treated plots: 89% control one week after the final application. The treatment containing successive applications of an experimental fungicide, F9177-1, was much less effective than any other fungicide treatment but still provided significant control when compared to the non-treated plots: 43% control one week after the final application. The four best treatments also continued to provide stellar control of downy mildew

(>99% compared to non-treated plots) two weeks after the final fungicide application, while other treatments began to decline in their effectiveness.

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Evaluation of biopesticides and an organic copper fungicide for downy mildew in sweet basil
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The objective of this experiment was to evaluate products approved for organic production in the U.S. (Cueva, Double Nickel, and Procidic) and products being developed for this use (Forticept Agro, Howler, and Milagrum). Fertilizer (N-P-K, 10-10-10) at 1000 lb/A (100 lb/A of nitrogen) was broadcast over the bed area and incorporated on 7 Jul. Beds were formed, drip irrigation tape was laid, and beds were covered with black plastic mulch on 7 Jul. Weeds between mulch strips were managed early in the season with Devrinol DF-XT (2 lb/A) applied before transplanting and afterwards by cultivation and hand-weeding. A waterwheel transplanter was used to make planting holes in the beds and apply starter fertilizer. Basil was seeded on 20 Jun in trays in a greenhouse, placed outdoors to harden for about a week, then transplanted by hand on 21 Jul. Basil was planted late in the season since downy mildew incidence is more prevalent during that time and would increase the likelihood of disease development during the experiment. The primary source of initial inoculum in this area is considered to be long-distance wind-dispersed spores from infected plants. Additionally, to provide a source of natural inoculum within the experimental area, a row of non-fungicide-treated basil plants that extended the length of this experiment was transplanted on 11 Jul. These plants were not inoculated. A randomized complete block design with four replications was used. Each plot had 10 plants in 8-ft rows with 9-in. in-row plant spacing. The plots were 4 ft apart in the row. Foliar treatment applications were made with a CO_2-pressurized backpack sprayer using a boom with a single twin-jet nozzle (TJ60-4004evs) delivering 50 gal/A at 55 psi and 2 mph on 22 Jul, 28 Jul, and 4 Aug when basil plants were small. A boom with three twin-jet nozzles (TJ60-8006vs), one delivering spray over the top of the plant plus a drop nozzle directed to each side, delivering 82 gal/A, was used on 11, 18, 25, and 31 Aug. Downy mildew was assessed in each plot on 1, 15, and 22 Aug. Incidence of plants with symptoms (sporulation of the pathogen visible on the underside of leaves) and percentage of leaves per plant with symptoms was estimated for 10 plants in each plot. These two values were multiplied together to calculate incidence of symptomatic leaves in the plot. Percent of leaves that had dropped off of plants because of downy mildew were estimated on 2 Sep.

Downy mildew developed naturally and became severe as is typical for the area. Symptoms were first observed on 15 Aug in 14 of the 44 plots. On 22 Aug, symptoms were observed in all plots. Initially incidence of symptomatic leaves was very low. Downy mildew increased substantially by the next assessment on 2 Sep resulting in substantial defoliation in most plots. From 15 Aug through 2 Sep during the dark overnight period relative humidity was at least 85% for at least 9 consecutive hours for 14 of the 18 nights. There were three rain events: 20 Aug (1.36 in.), 22 Aug (0.56 in.), and 1 Sep (0.72 in.). None of the treatments tested in this experiment were distinguishable from the untreated control until the last assessment on 2 Sep. Among the fungicides tested for organic production, only one, the copper fungicide Cueva, was able to provide detectable control of downy mildew compared to the untreated control, and only moderately so, providing 44% control compared to the 96% control provided by the conventional grower standard treatment of Ranman alternated with Revus. This treatment was included partly to provide an assessment of control potential with the application timing. Interestingly, adding the biological fungicide Howler to the grower standard rotation of Ranman and Revus provided statistically similar control compared to the standard rotation of Ranman and Revus despite applying these on a 14-day interval, although the rotation with Howler was numerically less effective, providing 58% control compared to 96% control with the standard rotation. Results from this experiment add to previous results documenting that it is difficult to manage downy mildew organically in basil.

Evaluation of Procidic fungicide for downy mildew in sweet basil using plant-dip treatment procedure
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

A greenhouse experiment was conducted to test Procidic, an organic fungicide, at several concentrations under controlled conditions. Basil (variety Genovese) was seeded on 6 June in 48 cell inserts in ProMix soil media and moved to individual pots on 24 June. Plants were arranged in a randomized complete block design with four reps. Plants were treated with Procidic fungicide by submerging entire plants one at a time in a fungicide solution on 5 July. This plant-dip procedure was used to achieve complete coverage of plant tissue with fungicide. Four concentrations were used. Plants were inoculated with downy mildew the following day by placing single tiny droplets of a conidial suspension (7×10^4 spores/ml) on the lower surface of four individual leaves on each plant and placing the plants on their side in moisture chambers. Plants were placed in moisture chambers overnight periodically (about 4 times a week) over two weeks. Moisture chambers were constructed by placing trays of basil plants between two milk crates and then covering the crates with a large black garbage bag and adding a small amount of water (~50 ml) and sealing the bag. Plants were then evaluated for development of downy mildew symptoms over several days.

Procidic was effective at the higher rates tested. No symptoms developed on plants treated with doses equivalent to 20 and 40 fl oz/A applied at 50 gpa. There was inconsistent development of downy mildew symptoms among plants within a treatment even in the control treatment. Most likely the inoculation method was not reliable enough to consistently produce disease. This may account for numerically greater percent affected leaves on plants treated with Procidic at 30 fl oz/A (6.3% 15 days after treatment) than 20 fl oz/A (0%), and on plants treated with 10 fl oz/A (31.3%) than untreated control plants (18.8%).

Efficacy of organic fungicides for downy mildew in sweet basil determined using a plant-dip treatment procedure
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

A greenhouse experiment with basil was conducted at the Long Island Horticultural Research and Extension Center (LIHREC) in Riverhead, NY. Basil (variety Genovese) was seeded in ProMix soil media on 22 Aug in 48-cell flats and transferred to individual pots on 6 Sep. Plants were arranged in a randomized complete block design with four replications. On 13 Sep basil plants were trimmed down to the third node to obtain uniform height. Plants were treated with multiple fungicides by submerging the entire plant in a fungicide solution on 20 Sep. This procedure was used to achieve complete coverage of plant tissue with fungicide, which cannot be achieved using a standard pesticide sprayer for field applications. Plants were left in the greenhouse to dry, then the following day all of the plants were placed outdoors among field-grown basil that was heavily infected with downy mildew so that natural inoculation could occur. The plants were left outside for 3 days and then returned to the greenhouse. They were placed in moisture chambers, which were bins enclosed in garbage bags, every night for a week to encourage spore production. Plants were evaluated on 30 Sep and 3 Oct for development of downy mildew symptoms using two different ways. Severity based on sporulation was determined by estimating the amount of visible sporulation covering each of the plant's foliage.

Severity based on symptoms was determined by estimating the total amount of necrosis (browning) of the plant's foliage caused by downy mildew. Sporulation was seen on some necrotic tissue, such that there was overlap of these estimates. Yellowing of leaf tissue was not sufficiently distinct to assess.

Most basil plants became very severely affected by downy mildew by ten days after treatment. None of the organic fungicides evaluated were effective in controlling downy mildew on basil when compared statistically to the control treatment. The conventional fungicide Revus was highly effective. It was included in this experiment as a known effective check treatment to validate the procedure. The other conventional fungicide in this experiment, Oso, was not effective. It is a contact biopesticide like most of the organic products tested. Cueva is an organic copper fungicide.

Evaluation of fungicides for powdery mildew on pumpkins
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The primary objective of this study was to evaluate the efficacy of several fungicides with mobility that enables them to move to the lower surface of leaves where powdery mildew develops best. They have single-site mode of action, which puts them at risk for resistance development. Both new (Prolivo) and currently registered products were tested in an area where in previous years strains of the pathogen were detected with resistance to FRAC code 1, 7, 11, and 13 fungicides and moderate resistance to FRAC code 3 fungicides. An experiment with field-grown pumpkins was conducted at the Long Island Horticultural Research and Extension Center (LIHREC) in Riverhead, NY, in a field with Haven loam soil. The field was plowed on 13 Apr. Ammonium nitrate fertilizer (34-0-0) was applied on 14 Apr at 235 lb/A (80 lb/A N). Mustard biofumigant cover crop ('Caliente 199') was seeded at 10 lb/A by drilling on 19 Apr. On 15 Jun the mustard was flail chopped, immediately incorporated by disking, followed by a cultipacker to seal the soil surface. Pumpkins were planted with a vacuum seeder at approximately 24-in. plant spacing on 23 Jun. The seeder applied fertilizer in two bands about 2 in. away from the seed. Controlled release fertilizer (N-P-K, 15-5-15) was used at 675 lb/A (101 lb/A N). Strategy 3 pt/A, Sandea 0.5 oz/A and Roundup PowerMax 22 oz/A were applied prior to seedling emergence for weed control on 25 Jun using a tractor-mounted sprayer. Select Max 16 oz/A was applied on 20 Jul to control grasses. During the season, weeds were controlled by cultivating and hand weeding as needed. Initial moisture for seed was provided using overhead irrigation. Drip tape was laid along each row of pumpkin seedlings on 30 Jun. The following fungicides were applied to control Phytophthora blight (caused by Phytophthora capsici): K-Phite 1 qt/A on 16 Jun, Forum 6 oz/A and K-Phite 1 qt/A on 24 Jun, Presidio 4 oz/A and K-Phite 1 qt/A on 30 Jun, Presidio 4 oz/A on 12 Aug, Ranman 2.75 oz/A on 20 Aug, Revus 8 oz/A on 29 Aug, Ranman 2.75 oz/A on 2 Sep, Forum 6 oz/A on 12 Sep, and Presidio 2 oz/A on 21 Sep. Plots were three 15-ft rows spaced 68 in. apart. The 20-ft area between plots was also planted to pumpkin. A randomized complete block design with four replications was used. Treatments were applied five times on a 7-day IPM schedule (starting after disease detection) beginning on 9 Aug using a tractor-drawn boom sprayer equipped with twinjet (TJ60-11004VS) nozzles spaced 17 in. apart that delivered 72 gal/A at 50 psi and 2.3 mph. Plots were inspected for powdery mildew symptoms on upper and lower leaf surfaces on 9, 16, 22, and 29 Aug; and 9 and 16 Sep. The primary source of initial inoculum in this area is considered to be long-distance wind-dispersed spores from affected plants. At each assessment, nine young, nine mid-aged, and nine old leaves (selected based on leaf physiological appearance and position in the canopy) were rated in each plot, except at the last assessment when five leaves were rated. Powdery mildew colonies were counted; severity was assessed by visual estimation of percent leaf area affected when colonies could not be counted accurately because they had coalesced and/or were too numerous. Colony counts were converted to severity values using the conversion factor of 30 colonies/leaf = 1% severity. Average severity for the entire canopy was calculated from the individual leaf assessments. Area Under Disease Progress Curve (AUDPC) values were calculated from 22 Aug through 16 Sep. Defoliation was assessed on 23 and 28 Sep. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 6, 13, and 24 Oct. Handles were considered good if they were green, solid, and not rotting.

Powdery mildew was first observed in this experiment on Aug 9 in 18 of the 32 plots on less than 2% of the leaves examined. Treatments were started right after this assessment. All of the fungicides controlled powdery mildew compared to the non-treated control based on at least AUDPC values. Five treatments consisted of individual products evaluated alone. This is neither a labeled nor recommended use pattern for growers. Such evaluations, however, identify appropriate rates for new products and monitor efficacy of registered fungicides at risk for resistance development in order to develop management recommendations for growers. Pristine (FRAC Code 7 and 11) applied at its highest label rate was least effective, providing only 77% and 43% control on upper and lower leaf surfaces, respectively, based on AUDPC values. It was ineffective at the last assessment for managing powdery mildew on lower leaf surfaces. This fungicide has exhibited variable efficacy in previous experiments at this location where resistance was first documented in 2008. Procure (FRAC 3) and Quintec (FRAC 13) provided stellar control across all measurements and were as effective as the grower recommended rotation in 2016 of Vivando (FRAC U8), Quintec, and Torino (FRAC U6), with all providing 100% control on upper leaf surfaces and 91% to 98% control on lower surfaces based on AUDPC values. The rotation of Fontelis (FRAC 7) and Vivando was also highly effective at all assessments although poor control was obtained with Pristine, another FRAC 7 fungicide. Prolivo (FRAC U8) was similarly effective at the two application rates tested. Both treatments were as effective as the grower recommended rotation for controlling powdery mildew on upper leaf surfaces but less effective on lower leaf surfaces, providing 66% and 73% control versus 97% based on AUDPC values. Interestingly, the higher rate of Prolivo had numerically higher AUDPC values than the lower rate and was ineffective for reducing defoliation. Controlling powdery mildew resulted in longer leaf retention and improved fruit quality, measured in terms of handle quality, through mid-Oct, which is especially important for Pick-Your-Own Halloween pumpkins. Death of leaves and vines leads to handles shriveling and rotting. The least effective treatment, Pristine, failed to perform significantly better than the non-treated control in both % defoliation and fruit quality. No phytotoxicity was observed.

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Fungicide sensitivity of cucurbit powdery mildew pathogen isolates on LI in 2015
Investigators: Margaret T. McGrath and Cheyenne Voigt
Location: Long Island Horticultural Research and Extension Center

Fungicide resistance can be a major constraint to effectively managing powdery mildew in cucurbit crops. Fungicides that are most effective for managing powdery mildew (because they are mobile and thus can redistribute from where deposited on upper leaf surfaces to the lower surface where powdery mildew develops best) are also more prone to the pathogen developing resistance (because they typically have single site mode of action). The pathogen, *Podosphaera xanthii*, has a long history of developing resistance, being the first pathogen to have been documented to have done so in the USA. Resistance to benomyl (FRAC Code 1), the first at-risk fungicide registered for this use, was detected in 1967. The next chemical class registered for cucurbit powdery mildew was the DMI (demethylation inhibitor) fungicides (FRAC Code 3). Bayleton, the first fungicide in this group labeled for cucurbit powdery mildew, was registered for this use in the USA in April 1984. Just two years later there were the first reported control failures documented through university fungicide efficacy experiments. QoI (quinone outside inhibitor) fungicides (FRAC Code 11) were the next chemical class developed for this disease. Quadris was registered in the USA in spring 1999. Control failures were reported from several states throughout the USA in 2002, and resistance was detected. Pristine, the first SDHI (FRAC Code 7) fungicide, was registered in August 2003. Resistance was detected on LI in 2008. Quintec, the first FRAC Code 13 fungicide, was registered in 2007.

The objective of this study was to determine fungicide sensitivity of pathogen isolates (i.e. individuals) by testing them in the laboratory on treated leaf disks. Isolates of *Podosphaera xanthii* were obtained 16 September to 1 October 2015 from three research fields and two commercial plantings. Most isolates came from pumpkin. This was near the end of the growing season when fungicide programs for powdery mildew were generally complete. Isolates were maintained on leaf tissue on agar media in Petri dishes (culture plates) until tested. Fifty-seven isolates were tested.

For the leaf disk bioassay, pumpkin seedlings at the cotyledon leaf stage (about seven-days-old) were sprayed with various fungicide doses in a laboratory fume hood, the treated plants were left there to dry overnight, then disks were cut from the cotyledons and placed on water agar in sectioned Petri plates. Each plate has four sections thus there were three treatments per plate plus a nontreated control. Each plate was used to test one isolate. Six disks with the same treatment were placed in each section. Disks were inoculated by transferring spores from culture plates to each disk center. Then plates were incubated at room temperature under constant light. Amount of pathogen growth on the disks was assessed after 10 days of incubation when the control treatment usually had good growth of the pathogen, with white sporulating pathogen growth covering an average of about 50% of leaf disk area. The percent leaf disk area with symptoms of powdery mildew was recorded for each disk and averaged for each treatment. An isolate was considered to be insensitive (resistant) to a particular fungicide concentration if it was able to grow and produce spores on at least half of the disks. Due to limitations in the number of isolates and fungicide doses that can be done in each bioassay, the procedure was conducted multiple times over many weeks to obtain information on sensitivity to several fungicides.

The bioassay revealed that most isolates tested were resistant to FRAC code 1 and 11 fungicides (not all of the isolates were tested with these chemistries): 86.7% and 96.4%, respectively. This supports the decision to continue not recommending these fungicides. Resistance has been common for many years.

Boscalid (FRAC 7) resistance was detected in 78.6% of the isolates (only one isolate was not tested for this trait), which is higher than previous years. Resistance was first detected on Long Island in 2009. This is an active ingredient in Pristine. All 19 isolates from commercial pumpkin fields were resistant (able to grow unsuppressed on leaf disks treated with 500 ppm) as were all but one of the 26 isolates from research plantings that were treated with fungicides at risk for resistance development. Surprisingly, 14 of 15 isolates were resistant from plots not treated with Pristine (they were treated weekly with Quintec alone or in alternation with Vivando and Torino). In contrast, all isolates were sensitive to boscalid that came from the nontreated control plots in this fungicide efficacy experiment and also all isolates from a winter squash research planting at LIHREC being managed organically. This suggests that applying Pristine or Quintec selects for boscalid resistance, an unexpected finding considering these fungicides are in different chemical classes. The sensitive isolates were able to tolerate 25 ppm boscalid, but their growth was often reduced compared to growth on non-treated disks.

Resistance to quinoxyfen (FRAC 13), the active ingredient in Quintec, was detected for the first time. Thirty-eight of the 57 isolates were able to grow on leaf disks with 200 ppm quinoxyfen, with most not exhibiting reduction in growth relative to the non-treated control disks. They came from two commercial fields and two research plantings where Quintec was used in rotation with other chemistry as recommended for commercial production and from research plots treated with just Quintec or Pristine in a fungicide efficacy experiment. An isolate able to tolerate 200 ppm quinoxyfen is not expected to be controlled by Quintec because 212 ppm is the concentration of quinoxyfen when applied at 6 fl oz/A (highest label rate) and 50 gal/A. Putative quinoxyfen-resistant isolate was tested and confirmed by Dow AgroScience researchers. All quinoxyfen-resistant isolates were resistant to boscalid, and those isolates tested were found to also be resistant to QoI (FRAC Group 11) fungicides and MBC (FRAC Group 1) fungicides. Occurrence of multi-fungicide-resistant isolates could account for why quinoxyfen resistance was detected in plots treated with just Pristine but not non-treated plots. Most quinoxyfen-resistant isolates also tolerated 120 or 200 ppm myclobutanil (FRAC Group 3).

All eight isolates from non-treated research plots in the fungicide efficacy experiment and all four isolates from an organically-managed research planting grew poorly or not at all on 40 ppm quinoxyfen. They were boscalid-sensitive (one was not tested) and three were also QoI-sensitive. Sensitive isolates dominating the pathogen population on nearby plants not treated with fungicides at risk for resistance development also suggests selection of resistant isolates occurred during the 2015 season. Quintec and also Pristine were as effective as other treatments in the fungicide efficacy experiment which suggests selection of the resistant isolates occurred during the 2015 season and not fast enough to affect efficacy.

In conclusion, results from this study documenting occurrence in the cucurbit powdery mildew pathogen of resistance to multiple targeted fungicides (FRAC 1, 7, 11, and 13) and variation in sensitivity to others (FRAC 3) reveals the necessity of using a resistance management program with this pathogen and is important for selecting fungicides to use. Torino (FRAC U6), Vivando (U8), and Proline (3) are considered the current best choices for managing powdery mildew in cucurbit crops. Use of Quintec should be limited. FRAC 1, 7 and 11 fungicides are not recommended.

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Fungicide sensitivity of cucurbit powdery mildew pathogen isolates from Wisconsin in 2015
Investigators: Margaret T. McGrath, Amanda J. Gevens and Cheyenne Voigt
Location: Long Island Horticultural Research and Extension Center

Eleven isolates of the cucurbit powdery mildew pathogen were obtained from a fungicide efficacy experiment conducted in Wisconsin in which Rally (FRAC 3 fungicide) performed poorly. They were tested to determine their sensitive to this and other fungicides following procedures described in previous report.

They all exhibited some tolerance to 40 ppm myclobutanil, the active ingredient in Rally, with limited growth on some of the 6 disks used in the assay in at least one of the two replications of the assay (it was repeated to confirm results). Two isolates tested at lower concentrations also exhibited reduced growth at 20 ppm myclobutanil and good growth at 2 ppm. The fungicide dose is 150–300 ppm in a field application of Rally at 2.5-5 oz/A (label rate range) when applied at 50 gal/A. Thus resistance to myclobutanil does not appear to be the explanation for poor control with Rally in the fungicide efficacy experiment.

All of the WI isolates were resistant to QoI fungicides. Surprisingly only one was resistant to boscalid in contrast with the isolates from Long Island (see previous report). Only 4 exhibited no suppression of growth at 25 ppm boscalid, thus most of these isolates were fairly sensitive to this chemistry.

Evaluation of biopesticides for powdery mildew on pumpkins
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The main objective of this experiment with field-grown pumpkin of a susceptible variety was to evaluate biopesticides in development for organic production. OMRI-listed Serenade Opti was included as an organic standard. K-Phite is a biopesticide not allowed in organic production that is labeled for cucurbit powdery mildew. The field was plowed on 13 Apr. Ammonium nitrate fertilizer (34-0-0) was applied on 14 Apr at 235 lb/A (80 lb/A N). Mustard biofumigant cover crop ('Caliente 199') was seeded at 10 lb/A by drilling on 19 Apr. On 15 Jun the mustard was flail chopped, immediately incorporated by disking, followed by a cultipacker to seal the soil surface. Pumpkins were planted with a vacuum seeder at approximately 24-in. plant spacing on 23 Jun. The seeder applied fertilizer in two bands about 2 in. away from the seed. Controlled release fertilizer (N-P-K, 15-5-15) was used at 675 lb/A (101 lb/A N). Strategy 3 pt/A, Sandea 0.5 oz/A and Roundup PowerMax 22 oz/A were applied prior to seedling emergence for weed control on 25 Jun using a tractor-mounted sprayer. Select Max 16 oz/A was applied on 20 Jul to control grasses. During the season, weeds were controlled by cultivating and hand weeding as needed. Initial moisture for seed was provided using overhead irrigation. Drip tape was laid along each row of pumpkin seedlings on 30 Jun. The following fungicides were applied throughout the season to control Phytophthora blight (caused by Phytophthora capsici): K-Phite 1 qt/A on 16 Jun, Forum 6 oz/A and K-Phite 1 qt/A on 24 Jun, Presidio 4 oz/A and K-Phite 1 qt/A on 30 Jun, Presidio 4 oz/A on 12 Aug, Ranman 2.75 oz/A on 20 Aug, Revus 8 oz/A on 29 Aug, Ranman 2.75 oz/A on 2 Sep, Forum 6 oz/A on 12 Sep, and Presidio 2 oz/A on 21 Sep. Plots were three 15-ft rows spaced 68 in. apart. The 20-ft area between plots was also planted to pumpkin. A randomized complete block design with four replications was used. Treatments were applied four times on a 7-day preventive schedule beginning on 5 Aug using a tractor-drawn boom sprayer equipped with twinjet (TJ60-11004VS) nozzles spaced 17 in. apart that delivered 72 gal/A at 50 psi and 2.3 mph. Plots were inspected for powdery mildew symptoms on upper and lower leaf surfaces on 9, 17, 19, 24, and 31 Aug. At the first assessment 30-50 older leaves were examined in each plot. For subsequent assessments, nine young, nine mid-aged, and nine old leaves (selected based on leaf physiological appearance and position in the canopy) were rated in each plot, except at the last assessment when five leaves were rated. Powdery mildew colonies were counted; severity was assessed by visual estimation of percent leaf area affected when colonies could not be counted accurately because they had coalesced and/or were too numerous. Colony counts were converted to severity values using the conversion factor of 30 colonies/leaf = 1% severity. Average severity for the entire canopy was calculated from the individual leaf assessments. Area Under Disease Progress Curve (AUDPC) values were calculated from 17 Aug through 31 Aug. Defoliation was assessed on 14 Sep. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 2 and 14 Oct. Handles were considered good if they were green, solid, and not rotting.

Powdery mildew was first observed in this experiment on 9 Aug in 46 of the 48 plots on less than 6% of the leaves examined. This was 4 days after the first treatment application. K-Phite was the only biopesticide that performed significantly different from the non-treated control when tested alone. It was effective only on upper leaf surfaces, providing 67% control based on AUDPC values. The other biopesticides were ineffective at all assessments (not all data shown). While Howler was ineffective tested alone, when applied in rotation with Vivando and Quintec, control achieved was not significantly different from the conventional grower recommended rotation of Vivando, Quintec, and Torino despite half as many applications of these conventional fungicides (94% versus 99% control on upper leaf surfaces, respectively, based on AUDPC values). AUDPC values for severity on lower leaf surfaces also did not differ significantly between these two treatments; however, only the conventional rotation differed significantly from the non-treated control. Only these two treatments had significantly less defoliation than the non-treated control. Fruit quality was improved only with the rotation that included Howler based on the 14 Oct assessment. No phytotoxicity was observed.

Evaluation of management programs without chlorothalonil for powdery mildew in pumpkin
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The purpose of this experiment was to examine means to reduce use of chlorothalonil-based fungicides because of concern about their potential impact on bees. Two alternative multi-site mode of action fungicides, Tritek and Microthiol Disperss, were evaluated on a pumpkin variety resistant to powdery mildew, Bayhorse Gold, as well as a susceptible variety, Gold Challenger. They were compared to Bravo Ultrex used alone and as part of a fungicide program for powdery mildew. Both alternatives are approved for organic production. The field was plowed on 13 Apr. Ammonium nitrate fertilizer (34-0-0) was applied on 14 Apr at 235 lb/A (80 lb/A N). Mustard biofumigant cover crop ('Caliente 199') was seeded at 10 lb/A by drilling on 19 Apr. On 15 Jun the mustard was flail chopped, immediately incorporated by disking, followed by a cultipacker to seal the soil surface. Pumpkins were planted with a vacuum seeder at approximately 24-in. plant spacing on 23 Jun. The seeder applied fertilizer in two bands about 2 in. away from the seed. Controlled release fertilizer (N-P-K, 15-5-15) was used at 675 lb/A (101 lb/A N). Strategy 3 pt/A, Sandea 0.5 oz/A and Roundup PowerMax 22 oz/A were applied prior to seedling emergence for weed control on 25 Jun using a tractor-mounted sprayer. Select Max 16 oz/A was also applied on 20 Jul to control grasses. During the season, weeds were controlled by cultivating and hand weeding as needed. Initial moisture for seed was provided using overhead irrigation. Drip tape was laid along each row of pumpkin seedlings on 30 Jun. The following fungicides were applied throughout the season to control Phytophthora blight (caused by Phytophthora capsici): K-Phite 1 qt/A on 16 Jun, Forum 6 oz/A and K-Phite 1 qt/A on 24 Jun, Presidio 4 oz/A and K-Phite 1 qt/A on 30 Jun, Presidio 4 oz/A on 12 Aug, Ranman 2.75 oz/A on 20 Aug, Revus 8 oz/A on 29 Aug, Ranman 2.75 oz/A on 2 Sep, Forum 6 oz/A on 12 Sep, and Presidio 4 oz/A on 21 Sep. Plots were three 15-ft rows spaced 68 in. apart. The 20-ft area between plots was also planted to pumpkin that was partly treated in the process of applying treatments to adjacent plots. A completely randomized split plot design with four replications was used with variety as the whole plot factor and treatment as the split plot factor. Treatments were applied five times on a 7-day IPM schedule (starting after disease detection) beginning on 8 Aug using a tractor-drawn boom sprayer equipped with twinjet (TJ60-11004VS) nozzles spaced 17 in. apart that delivered 72 gal/A at 50 psi and 2.3 mph. The primary source of initial inoculum in this area is considered to be long-distance wind-dispersed spores from affected plants. Plots were inspected for powdery mildew symptoms on upper and lower leaf surfaces on 7, 15, and 22 Aug, and 2, 9, and 16 Sep. At each assessment, nine young, nine mid-aged, and nine old leaves (selected based on leaf physiological appearance and position in the canopy) were rated in each plot, except at the last assessment when five leaves were rated. Powdery mildew colonies were counted; severity was assessed by visual estimation of percent leaf area affected when colonies could not be counted accurately because they had coalesced and/or were too numerous. Colony counts were converted to severity values using the conversion factor of 30 colonies/leaf = 1% severity. Average severity for the entire canopy was calculated from the individual leaf assessments. Area Under Disease Progress Curve (AUDPC) values were calculated from 7 Aug through 16 Sep. Defoliation was assessed on 23 and 28 Sep. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 5, 10, and 19 Oct. Handles were considered good if they were green, solid, and not rotting.

Powdery mildew was first observed in this experiment on 7 Aug in 33 of the 48 plots on 2% of the leaves examined. The resistant variety, Bayhorse Gold, was less severely affected by powdery mildew than the susceptible variety, Gold Challenger, across all measurements of severity, which resulted in less defoliation. Interestingly, variety had no effect on fruit quality, which was only significantly affected by fungicide treatments. A significant variety by treatment interaction was present in many of the measurements of powdery mildew severity, and most significant for severity on the lower leaf surface. The sulfur-based fungicide, Microthiol Disperss, was as effective as the chlorothalonil-based fungicide, Bravo Ultrex, across all measurements of severity for both varieties. The mineral oil-based fungicide, Tritek, effectively managed powdery mildew, but not as well as Microthiol Disperss. Relative to the non-treated susceptible variety, control of powdery mildew on upper leaf surfaces based on AUDPC values was 89%, 93%, and 59% for Bravo Ultrex, Microthiol Disperss, and Tritek, respectively for the susceptible variety and 97%, 96%, and 76%, respectively for the resistant variety. Effectively managing powdery mildew on lower leaf surfaces necessitated using targeted fungicides able to move through leaves. No significant differences were detected between the fungicide programs with a rotation of Luna Experience, Vivando, and Torino that had Bravo Ultrex as the multi-site fungicide or had Microthiol Disperss and Tritek. Relative to the non-treated susceptible variety, control of powdery mildew on lower leaf surfaces based on AUDPC values achieved with these two fungicide programs was 87% with Bravo and 97% with the Bravo alternatives for the susceptible variety, and 94% and 96%, respectively, for the resistant variety.

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Evaluation of Halloween pumpkin varieties resistant to powdery mildew
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The purpose of this experiment was to evaluate pumpkin varieties for their ability to suppress powdery mildew when used as the sole management program and also combined with a fungicide program for powdery mildew. Focus was on recently released varieties. Controlled release fertilizer (N-P-K, 19-10-9) at 525 lb/A (101 lb/A of N) was broadcast over the bed area and incorporated on 20 Jun. Beds were formed, drip tape was laid, and beds were covered with black plastic mulch on 21 Jun. A waterwheel transplanter was used to make planting holes in the plastic and apply starter fertilizer plus insecticide (Admire Pro) on 22 Jun. Two pumpkin seeds were placed by hand into the soil for each hole on 22 Jun. After emergence plants were thinned to 1 plant per hole. Plots were three adjacent rows each with four plants spaced 48 in. apart. Rows were spaced 68 in. apart. To separate plots and provide a source of inoculum, two plants of a powdery mildew-susceptible zucchini squash variety (Spineless Beauty) were planted between each plot in each row. Weeds were managed by applying Strategy 3 pt/A, Sandea 0.5 oz/A and Roundup PowerMax 22 oz/A to soil between the mulched beds on 21 Jun using a tractor-mounted sprayer. Additionally, landscape cloth was laid over soil between the mulched beds and hand weeding was done as needed. During the season, water was provided as needed via drip irrigation. The following fungicides were applied to control Phytophthora blight (caused by Phytophthora capsici): Ranman 2.75 oz/A on 20 Aug and 3 Sep, Revus 8 oz/A on 29 Aug, Forum 6 oz/A on 12 Sep, and Presidio 2 oz/A on 21 Sep. The experiment that received a fungicide program for additional control of powdery mildew was sprayed with a tractor-drawn sprayer at weekly intervals starting at first observation of symptoms. The program was: Vivando 15 oz/A on 8 and 31 Aug and 14 Sep, Torino 3.4 oz/A on 18 Aug and 7 Sep, and Procure 8 oz/A on 24 Aug. Plots were inspected for powdery mildew symptoms on upper and lower leaf surfaces on 8, 17 and 25 Aug, and 2 Sep. At each assessment, nine young, nine mid-aged, and nine old leaves (selected based on leaf physiological appearance and position in the canopy) were rated in each plot, except at the last assessment when five leaves were rated. The primary source of initial inoculum in this area is considered to be long-distance wind-dispersed spores from affected plants. Powdery mildew colonies were counted; severity was assessed by visual estimation of percent leaf area affected when colonies could not be counted accurately because they had coalesced and/or were too numerous. Colony counts were converted to severity values using the conversion factor of 30 colonies/leaf = 1% severity. Average severity for the entire canopy was calculated from the individual leaf assessments. Area Under Disease Progress Curve (AUDPC) values were calculated from 8 Aug through 2 Sep. Defoliation was assessed on 26 Sep. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 5, 14, and 20 Oct. Handles were considered good if they were green, solid, and not rotting.

Powdery mildew was first observed in both experiments on 8 Aug in all plots, on 30% of leaves sampled. In the variety assessment with no fungicides applied for powdery mildew control, disease pressure was high in general, especially on the upper leaf surface. Only two powdery mildew-resistant pumpkin varieties, Progress and Rhea, were able to significantly reduce powdery mildew severity when compared to the susceptible variety Gold Challenger (Rhea was only significantly different on the lower leaf surface). No variety was significantly distinguishable from other varieties in % defoliation or fruit quality. In the second experiment, the same pumpkin varieties were evaluated for ability to suppress powdery mildew when treated with targeted fungicides for this disease. Severity was generally low, as expected, especially on the upper leaf surface. Due to the low levels of disease on the upper leaf surface, there were no significant differences between any of the varieties in those measurements. Based on powdery mildew severity on the lower leaf surface, varieties Ares, Rhea, Superior, and Progress performed significantly better than the susceptible variety Gold Challenger. Progress performed especially well with 73% control relative to Gold Challenger. Based on overall powdery mildew severity measured as the sum of the four AUDPC values, the most resistant variety was Progress, followed by Superior, then Rhea. Ares, Bayhorse Gold, Eagle City Gold, and Kratos was last. Progress produced smaller pumpkins then the other varieties. Kratos produced the largest fruit. Overall, no variety was able to significantly outperform Gold Challenger in % defoliation or fruit quality.

*Acknowledgments***:** Project funded by the Friends of Long Island Horticulture Grant Program.

Identification of pathotypes of the cucurbit downy mildew pathogen occurring on LI
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

Cucumber, acorn and butternut squashes, cantaloupe, watermelon and giant pumpkin (*Cucurbita maxima*) were grown in a sentinel plot at LIHREC to determine when the different pathotypes of the cucurbit downy mildew pathogen were successfully dispersed to Long Island. The pathotypes differ in ability to infect the different cucurbit crop types. This pathogen is not known to be surviving in the absence of living host plant tissue; however, it produces spores capable of long-distance movement by wind. Successful dispersal to LI occurs when there is a source of spores (affected cucurbit crops in another region) and conditions are favorable for dispersal (wind currents moving from affected crops to LI at night or during overcast days when spores will be protected from solar radiation), and also for deposition of spores and then for infection (rain is ideal as it moves spores out of the wind currents down to plants and infection occurs when leaves are wet or humidity is high). This can occur any time during the growing season. With knowledge of when downy mildew is occurring on LI and which cucurbit crop types are at risk, growers can target their applications of fungicides with specific activity for downy mildew (oomycete) pathogens. Sentinel plots at LIHREC are being done every growing season as part of the national forecasting program for cucurbit downy mildew (http://cdm.ipmpipe.org/). There are similar sentinel plots at universities throughout the eastern USA each year.

To ensure leaf tissue for infection was present throughout the growing season, seedlings were transplanted into plots at two times, on 8 June and 12 July. Each cucurbit crop type or variety (there were two cucumbers) in each planting was grown in a plot with 3 rows of at least 5 plants at 24-inch spacing. Seedlings were transplanted into beds with controlled release fertilizer and drip tape covered with black plastic mulch. Insecticides and fungicides with targeted activity for powdery mildew were applied. Leaves were examined routinely for symptoms.

Symptoms of downy mildew were first observed on 8 August. Only the susceptible cucumber variety Straight Eight had symptoms. Only a few very new appearing lesions were observed on a total of 4 leaves in the 2 plantings. This was the first known observation of cucurbit downy mildew on LI in 2016. There was low risk forecast on 1 August by the forecasting program, which is when the pathogen most likely was dispersed successfully to LI. One week is typical latent period from infection to visible symptoms. Prior to this forecast there was one moderate risk forecast on 1 July and seven low risk forecasts on 4, 13, 14, 16, 18, 22 and 25 July; no risk forecast on other dates. Previous first occurrences at LIHREC were 27 August 2008, 27 July 2009, 7 September 2010, 1 August 2011, 17 July 2012, 22 July 2013, 2 September 2014, and 10 August 2105. On 15 August there were substantially more symptoms in Straight Eight in both plantings and symptoms were observed on the resistant variety Marketmore.

Symptoms of downy mildew were found in cantaloupe on 17 August. Only one plant in the second planting appeared to be affected. Symptoms looked fairly new. Overall severity was estimated to be <1%. There was high risk forecast on 10 August (when 0.07 inch rain fell at this location) and on 11 August (no rainfall).

None of the other cucurbit crop types developed symptoms and there were no reports of downy mildew on these crops in other plantings on LI in 2016, therefore, only pathotypes able to infect cucumber and cantaloupe were dispersed to LI in 2016. In contrast, all crop types became infected in 2013 and 2015, whereas only cucumber was affected in 2014.

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Efficacy of fungicides for managing downy mildew organically in cucumber
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The goal of this field experiment was to test two new organic fungicides in development, Milagrum Plus and Forticept Agro. Fertilizer (N-P-K, 10-10-10) at 1000 lb/A (100 lb/A of nitrogen) was broadcast over the bed area and incorporated on 20 Jun. Beds were formed with drip tape and covered with black plastic mulch on 20 Jun. Seeds were sown on 5 Jul in the greenhouse. Seedlings were transplanted by hand into the holes in the beds on 1 Aug. During the season, water was provided as needed via drip irrigation. For initial weed control Strategy 3 pt/A, Sandea 0.5 oz/A, and Roundup PowerMax 22 oz/A were applied on 27 Jun by tractor-sprayer between the rows. Weeds were also managed by hand weeding and covering soil next to mulched rows with landscape cloth. Plots were single 18-ft rows with 9 plants at 24-in. spacing. Rows were 4 ft apart. The plots were 6 ft apart within the row initially until plants began to vine partly filling the area. Vines were moved as needed to maintain plot separation. A randomized complete block design with four replications was used. Fungicides were applied weekly for 7 weeks beginning on 8 Aug with a backpack CO_2-pressurized sprayer equipped with a single-nozzle boom and a TJ60-4004EVS nozzle delivering 50 gal/A operated at 55 psi and 2.4 mph. Downy mildew severity was assessed on 29 Aug, and 7, 14, and 26 Sep by estimating incidence of symptomatic leaves in each plot and rating severity on nine representative affected leaves. Incidence and average severity for symptomatic leaves were used to estimate canopy severity.

Fruit was removed from plants to maintain plant growth; yield was not assessed. Area Under Disease Progress Curve (AUDPC) values were calculated from 29 Aug through 26 Sep.

Downy mildew developed naturally in this experiment, and progressed in severity steadily after disease onset. Only one treatment, copper fungicide Nordox, controlled downy mildew significantly compared to the untreated plots based on AUDPC values. The Milagrum Plus and Forticept Agro treatments showed some activity early in the season, with both providing control on 7 Sep, but failed to hold up when disease pressure increased as the growing season continued. It should also be noted that even the Nordox treatment failed to control downy mildew later in the season, and with the entire season taken into account, only provided 29% control relative to the untreated plots. This level of effectiveness would not be acceptable in commercial settings. No phytotoxicity was observed.

Efficacy of fungicides for downy mildew in cucumber assessed with using a plant-dip treatment procedure
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

Managing plant diseases with fungicides effectively requires having information about product efficacy, especially with a disease like cucurbit downy mildew caused by a pathogen (*Pseudoperonospora cubensis)* prone to developing resistance to fungicides. A seedling bioassay was used to determine sensitivity of a pathogen population in New York to several fungicides. The seedlings were treated with full and half rates of several fungicides labeled for this disease, including fungicides known or suspected of efficacy having been affected by resistance. The bioassay was conducted at the Long Island Horticultural Research and Extension Center (LIHREC) in Riverhead, NY. Cucumber (variety Silver Slicer) was seeded on 24 Aug in individual 4-inch pots containing ProMix soil media. Plants were arranged in a randomized complete block design with four replications. On 6 Sep the cucumber plants received an application of Procure fungicide to control a small outbreak of powdery mildew in the greenhouse. Plants were treated with multiple fungicides labeled for downy mildew by briefly submerging the entire plant in a fungicide solution on 15 Sep. Each replication had two control plants and one plant treated with each of the fungicide treatments. Plants were left in the greenhouse to dry, then the following day all of the plants were placed outdoors among field-grown cucumbers that were heavily infected with downy mildew so that the bioassay seedlings could be infected naturally. The plants were left outside for 3 days, during which time the pots were enclosed in plastic bags to minimize need to add water, and then returned to the greenhouse. They were placed in moisture chambers, which were bins enclosed in garbage bags, every night for a week to encourage spore production. Plants were evaluated on 26 Sep and 29 Sep for development of downy mildew symptoms. Severity based on sporulation was determined by estimating the amount of visible sporulation covering each of the plant's foliage. Severity based on symptoms was determined by estimating the total amount of necrosis (browning) of the plant's foliage caused by downy mildew. Sporulation was seen on some necrotic tissue, such that there was overlap of these estimates. Yellowing of leaf tissue was not sufficiently distinct to assess.

Most of the fungicides were shown to be extremely effective at controlling cucumber downy mildew at full and half label rates, including Zing! (FRAC code 22 + M5), Ranman (21), Bravo Ultrex (M5), Curzate 50DF (27), Presidio 4SC (43), Zampro (40 + 45) and Previcur Flex (28). Quadris (11), Forum (40), and Revus (40) were much less effective than the other fungicides evaluated in this experiment, with at least one assessment value not significantly different from the control plants. None of these fungicides had been applied to the field-grown cucumbers that were the source of inoculum for the bioassay seedlings. Resistance of *Pseudoperonospora cubensis* to QoI fungicides has been documented and this chemistry has been ineffective in field efficacy experiments in the U.S., thus Quadris was anticipated to be ineffective in the bioassay. In U.S. field experiments Revus has been shown to be very effective at controlling downy mildew on other cucurbit hosts, but not cucumber. Thus this bioassay confirms that Revus is ineffective for downy mildew occurring on cucumber. Forum has been ineffective in recent U.S. field experiments. The FRAC code 40 active ingredient in Forum (dimethomorph) is also in Zampro. Presidio and Previcur Flex have exhibited poor efficacy in recent U.S. field fungicide evaluations, thus it was surprising these fungicides exhibited good efficacy in this bioassay.

Evaluation of disease-resistant tomatoes developed by Cornell breeder, experiment 1
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The goal of this experiment was to evaluate disease-resistant tomato hybrids developed by Martha Mutschler, Cornell plant breeder, in terms of yield, fruit quality, and disease resistance. All of the seven entries were bred to be resistant or tolerant to late blight, early blight, and Septoria leaf spot. Two of the entries are commercially available, Iron Lady and Stellar. They were compared to five new experimental varieties.

The experiment was conducted in a field with Haven loam soil. Controlled release fertilizer (15-5-15) was applied at 675 lb/A product (100 lb/A N) with a 2-row fertilizer spreader over rows that subsequently were covered with plastic while drip tape was laid. Before transplanting, herbicide was applied between the plastic strips with a shielded sprayer. A tank mix of Devrinol DF (4 lb/A), Metribuzin (1.33 lb/A) and Roundup PowerMax (22 oz/A) was used.

Tomato plants were seeded in the greenhouse on 4 May. Tomato seedlings were transplanted on 9 June when 6-weeks-old into holes opened in the plastic mulch by a Waterwheel transplanter that also placed in the holes a starter fertilizer (Black Label Zn (6-20-0) at 1 fl oz per gallon). Seedlings not growing well or that had died were replaced within two weeks of transplanting. Plots were single rows with 5 plants at 24-in spacing. Treatments were arranged in a randomized block design with four replications, each occupying one row. There was a 6-foot non-planted space between plots in a row and 8.5 feet between plants in adjacent rows. Plants were staked and trellised using a modified Florida weave as is standard practice in the region for fresh-market tomatoes. Lannate LV was sprayed at 3 pt/A on 19 July, 9 August, and 27 August for general insect control. No fungicides were applied.

No foliar symptoms of fungal, oomycete, or bacterial diseases were observed. Late blight did not develop anywhere on Long Island in 2016. Early blight and Septoria leaf spot also did not develop in the research plots. These fungal diseases occur sporadically on Long Island, especially early blight. Hot, dry conditions during most of the growing season in 2016 were unfavorable for these diseases.

The main problem encountered during the growing season was Tomato Spotted Wilt Virus. Most likely the plants were initially infected with the virus while growing in the greenhouse, the disease remained present in the field throughout of the entire season. Severely infected plants died or were rogued resulting in the loss of two plants from the experiment.

Fruit were harvested on 23 August, 31 August, 7 September, and 12 September. Harvested fruit were then evaluated for marketability and sorted based on defects and weighed. Defects observed included vertical cracking, large blossom scar, catface, zippering, and horizontal cracking. Fruit that was too rotten to weigh was included in total fruit count and documented before discarding.

Quality of ripe fruit were evaluated on 13 and 14 September by LIHREC and CCE staff, growers and others attending the annual Plant Science Day at LIHREC, and two gardener groups (Cornell and Master Gardeners). Characteristics assessed were shape, size, internal and external appearance, and taste. These were assessed on a 1-5 scale, with 5 being excellent. Overall impression was assessed based on whether or not it was a tomato the rater would buy. Average ratings were calculated for the 2 evaluation dates. Additionally five organic growers evaluated select hybrids that they grew themselves.

The disease-resistant experimental varieties did not differ significantly in total number fruit produced, total amount of marketable fruit produced, or total weight of marketable fruit produced. One variety, E-5 produced larger marketable fruit when compared to most of the other varieties. Variety E-2 produced fewer fruit with vertical cracks when compared to the commercial variety Stellar. Varieties E-2 and E-4 produced fewer fruit with large blossom scar/catface when compared to variety E-5.

Results from fruit quality evaluations revealed that Martha Mutschler has succeeded in improving the quality of the fruit of her disease-resistant hybrids, which has been a main goal of her recent breeding efforts. Among hybrids in this experiment, Iron Lady, the first disease-resistant hybrid released from Mutschler's program, received the lowest or second lowest average rating for taste on the 2 evaluation dates. Stellar ranked higher, being third or fifth out of 7. Entry 5 was the best, ranking second for both dates. There was more variation between the 2 evaluations in how the entries ranked for percent raters indicating they would buy the tomato.

Acknowledgements: Project funded by the New York State Department of Agriculture Specialty Crop Block Grant Program.

Evaluation of disease-resistant tomatoes developed by Cornell breeder, experiment 2
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The goal of this experiment was to evaluate disease-resistant tomato hybrids developed by Martha Mutschler, Cornell plant breeder, in terms of yield, fruit quality, and disease resistance. The three experimental varieties were bred to be resistant or tolerant to late blight, early blight, and Septoria leaf spot. They were compared to Mt Merit, a related commercial variety.

Cultural practices and field preparation are the same as detailed in the report above.

Tomato plants were seeded in the greenhouse on 4 May. Tomato seedlings were transplanted on 8 June when 6-weeks-old into holes opened in the plastic mulch by a Waterwheel transplanter that also placed in the holes a starter fertilizer (Black Label Zn (6-20-0) at 1 fl oz per gallon). Seedlings not growing well or that had died were replaced within two weeks of transplanting. Plots were single rows with 5 plants at 24-in spacing. Treatments were arranged in a randomized block design with four replications, each occupying one row. There was a 6-foot non-planted space between plots in a row and 8.5 feet between plants in adjacent rows. Plants were staked and trellised using a modified Florida weave as is standard practice in the region for fresh-market tomatoes. Lannate LV was sprayed at 3 pt/A on 19 July, 9 August, and 27 August for general insect control. No fungicides were applied.

No foliar symptoms of fungal, oomycete, or bacterial diseases were observed. Late blight did not develop anywhere on Long Island in 2016. Early blight and Septoria leaf spot also did not develop in the research plots. These fungal diseases occur sporadically on Long Island, especially early blight. Hot, dry conditions during most of the growing season in 2016 were unfavorable for these diseases.

Fruit were harvested on 23 August, 30 August, and 12 September. Harvested fruit were then evaluated for marketability and sorted based on defects and weighed. Defects observed included vertical cracking, large blossom scar, catface, zippering, and horizontal cracking. Fruit that was too rotten to weigh was included in total fruit count and documented before discarding.

Quality of ripe fruit were evaluated on 13 and 14 September by LIHREC and CCE staff, growers and others attending the annual Plant Science Day at LIHREC, and two gardener groups (Cornell and Master Gardeners). Characteristics assessed were shape, size, internal and external appearance, and taste. These were assessed on a 1-5 scale, with 5 being excellent. Overall impression was assessed based on whether or not it was a tomato the rater would buy. Average ratings were calculated for the 2 evaluation dates. Additionally five organic growers evaluated select hybrids that they grew themselves.

The disease-resistant varieties did not differ significantly in total fruit, total marketable fruit, or total marketable fruit weight. Variety Mt Merit produced larger marketable fruit than varieties E-10 and E-12. Variety E-10 had a lower percentage of fruit with vertical cracks than Mt Merit.

Among the 4 hybrids in experiment 2, Mt Merit ranked third for taste and third or fourth based on percent of raters that would buy it, while Entry 11 consistently ranked first or second for both.

Acknowledgments: Project funded by the New York State Department of Agriculture Specialty Crop Block Grant Program.

Evaluation of Cornell half-heirloom disease-resistant tomatoes
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The main goal of this experiment was to evaluate tomato experimental hybrids developed by Martha Mutschler Cornell plant breeder, in terms of yield and fruit quality. These hybrids are crosses of her disease-resistant breeding lines with a popular heirloom variety, Brandywine. In addition to resistance, she also selected for half-heirloom hybrids less prone to cracking and with smaller blossom scar than Brandywine.

Cultural practices and field preparation are the same as detailed in the first tomato report above.

Tomato plants were seeded in the greenhouse on 4 May. Tomato seedlings were transplanted on 8 June when 6-weeks-old into holes opened in the plastic mulch by a Waterwheel transplanter that also placed in the holes a starter fertilizer (Black Label Zn (6-20-0) at 1 fl oz per gallon). Seedlings not growing well or that had died were replaced within two weeks of transplanting. Plots were single rows with 5 plants at 24-in spacing. Treatments were arranged in a randomized block design with four replications, each occupying one row. There was a 6-foot non-planted space between plots in a row and 8.5 feet between plants in adjacent rows. Plants were staked and trellised using a modified Florida weave as is standard practice in the region for fresh-market tomatoes. Lannate LV was sprayed at 3 pt/A on 19 July, 9 August, and 27 August for general insect control. No fungicides were applied.

The main problem encountered during the growing season was Tomato Spotted Wilt Virus. Most likely the plants were initially infected with the virus while growing in the greenhouse, the disease remained present in the field throughout of the entire season. Severely infected plants died or were rogued resulting in the loss of 15 plants from the experiment.

No foliar symptoms of fungal, oomycete, or bacterial diseases were observed. Late blight did not develop anywhere on Long Island in 2016. Early blight and Septoria leaf spot also did not develop in the research plots. These fungal diseases occur sporadically on Long Island, especially early blight. Hot, dry conditions during most of the growing season in 2016 were unfavorable for these diseases.

Fruit were harvested on 23 August, 1 September, and 9 September. Harvested fruit were then evaluated for marketability and sorted based on defects and weighed. Defects observed included vertical cracking, large blossom scar, catface, zippering, and horizontal cracking. Fruit that was too rotten to weigh was included in total fruit count and documented before discarding.

Quality of ripe fruit were evaluated on 13 and 14 September by LIHREC and CCE staff, growers and others attending the annual Plant Science Day at LIHREC, and two gardener groups (Cornell and Master Gardeners). Characteristics assessed were shape, size, internal and external appearance, and taste. These were assessed on a 1-5 scale, with 5 being excellent. Overall impression was assessed based on whether or not it was a tomato the rater would buy. Average ratings were calculated for the 2 evaluation dates. Additionally the Cornell Gardeners and five organic growers evaluated select hybrids that they grew themselves.

The heirloom variety Brandywine produced less total marketable fruit, less total fruit, and less marketable fruit by weight when compared to the breeding hybrids. All of the varieties produced a high percentage of fruit with vertical cracks, between 40 and 60% of the total fruit, but the cracks on the half-heirloom hybrids were smaller (not quantified). The Brandywine variety produced a higher percentage of fruit with zipper deformity compared to the other hybrids.

When looking at the consumer evaluations of the varieties it appears that Martha Mutschler was successful in improving the characteristics of the Brandywine tomato with breeding. E-15 consistently outperformed Brandywine in ratings of desirability and scored similarly in terms of taste. It was second to Brandywine for taste based on fruit from plants grown and evaluated by the Cornell Gardeners. This half-heirloom hybrid is going to be marketed as BrandyWISE by Fruition Seeds.

Acknowledgments: Project funded by the New York State Department of Agriculture Specialty Crop Block Grant Program.

Evaluation of biopesticides for bacterial speck in tomatoes
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

Cultural practices and field preparation are the same as detailed in the first tomato report above.

Seeds of variety 'Iron Lady' were sown on 18 May in the greenhouse. This variety was selected because it is resistant to late blight, early blight and Septoria leaf spot, thereby minimizing need for fungicides to manage these other diseases. Seedlings were transplanted on 27 June by hand into holes opened in the plastic mulch by a Waterwheel transplanter that also placed in the holes a starter fertilizer (Black Label Zn (6-20-0) at 1 fl oz per gallon). Seedlings not growing well or that had died were replaced within two weeks of transplanting. Plots were single rows with 9 plants at 24-in spacing. Treatments were arranged in a randomized block design with four replications, each occupying one row. There was a 6-foot non-planted space between plots in a row and 8.5 feet between plants in adjacent rows. Plants were staked and trellised using a modified Florida weave as is standard practice in the region for fresh-market tomatoes.

Source of inoculum for the experiment was an inoculated spreader row in the center of the field. Variety 'Plum Regal' was used because it is resistant to late blight. An isolate of *Pseudomonas syringae* pv. *tomato* from a Long Island farm was used. To ensure the isolate was virulent, a tomato seedling was inoculated and the isolate was cultured from symptomatic tissue. Seedlings for the spreader row were inoculated in the greenhouse on 23 June. They were kept in a different greenhouse from the experiment plants. They were given water with fertilizer to promote tender growth. Bacteria were removed from plates of PDA after growing there for 3 or 4 days by pouring deionized water on the plate and gently loosening the bacteria with a plastic scrapper. A spray bottle was used to spray the inoculum on the upper surface of leaves late in the day, and then the plants, still in flats, were enclosed in plastic bags over night so that the leaves remained wet to promote infection. Some leaves were gently rubbed in an effort to make small wounds. They were still wet the next morning when the bags were removed. This process was repeated daily for 5 days until adequate disease development was achieved. Symptoms were seen six days after the first inoculation. The inoculated plants were put outside to harden where they were overhead watered to promote additional disease development. Spreader row was transplanted to the field on 8 July, which was five days after the first treatment application. A line of overhead irrigation pipe with fine sprinkler nozzles was set up next to the spreader row to promote speck development in the experiment by running irrigation late in the day at least once a week in between treatment applications. Flowers were removed from spreader plants to promote leaf production. Because few symptoms developed from the spreader row inoculum, on 8, 11, 25 August and 1 September all plants in the experiment were re-inoculated late afternoon by spraying plants with sterile water containing *P. syringae* bacteria.

The treatments listed below were made using a CO_2-pressurized backpack sprayer with a boom that has a single twin-jet nozzle (TJ60-11004VS), calibrated to deliver 50 gal/A when operated at 54 psi and 2.4 mph. Each side of the planted row was treated with the boom held sideways to obtain thorough coverage of foliage and to mimic the coverage obtained with a drop nozzle on a tractor sprayer. Application dates were 6, 13, 20, and 27 July; 3, 10, 17, 24 and 30 August; and 9 September. The application rate for Actigard and the gallonage used to make the application were increased over time. The rate was 0.33 oz/A on 6 and 13 July. It was 0.5 oz/A applied in 75 gal/A on 20 and 27 July. It was 0.75 oz/A in 100 gal/A for the rest of the treatments. The isolate used to inoculate the spreader row was sent to OmniLytics for production of AgriPhage.

Unfortunately the experiment was unsuccessful. Bacterial speck symptoms were only found in a few plots at very low levels during inspections, including on the untreated control plants. This was at least partly due to the variety used (Iron Lady) being resistant to speck, which was determined after the experiment was conducted. The Cornell plant breeder who developed the variety did not intentionally select for this trait that is in some of her breeding material. Additionally, the dry and hot summer weather in 2016 was not conducive to development of bacterial diseases. There was limited additional development of speck in the spreader row despite the use of overhead irrigation to provide conditions favorable for speck development. An additional factor that may have added to conditions being unfavorable is the wide spacing of research plot rows, compared to rows in commercial fields, to accommodate putting out treatments as this would result in less humid conditions due to better air circulation.

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Monitoring late blight occurrence in tomatoes and potatoes on Long Island
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Commercial farms & Long Island Horticultural Research and Extension Center

Late blight is a very destructive disease of tomatoes and potatoes that has been occurring more regularly on Long Island since 2009, albeit irregularly in terms of location and date of initial occurrence. Growers need to know when late blight is present in the region to be able to effectively manage this disease with judicious use of fungicides, especially products with targeted activity that they would not otherwise need to apply. Additionally there is need to monitor the pathogen for appearance of new genotypes able to overcome resistant varieties with the Ph-2 and Ph-3 genes that have been providing effective control of the pathogen genotypes present since 2009.

Monitoring for late blight occurrence was conducted in coordination with the CCE-Suffolk IPM Program. Potato and tomato crops were scouted weekly for diseases and insect pests at several farms participating in the IPM Program. Tomato crops at three organic farms were scouted weekly specifically for late blight through the project being reported. This project is a continuation of the late blight monitoring project started in 2012. The information obtained contributes to the national monitoring program, which maps reports at USABlight.org.

A sentinel plot with Mt Fresh Plus (susceptible to late blight) and Mt Magic (Ph-2 and Ph-3 genes conferring resistance) was maintained at LIHREC. No fungicides were applied. Cultural practices and field preparation are the same as detailed in the first tomato report above. Project collaborators in other areas (NC, PA, and upstate NY) had similar plantings to also monitor for late blight and specifically for pathogen genotype able to overcome resistance.

Late blight was not observed in 2016 in the sentinel plots or in any commercial plantings at any farms, and no reports of suspected cases were received from other farmers or gardeners on LI.

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Investigation of nitrogen fertility management practices in organic reduced tillage winter squash
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

Providing adequate fertility, in particular nitrogen, is one challenge of successfully producing organic crops with reduced tillage.

Similar experiments were conducted at Cornell's facility in central NY (Freeville) and University of Maine facility in Monmouth. Additional research on organic reduced tillage production systems and management practices was conducted at these locations and at the University of Michigan as part of this 5-yr project.

Research trials were established at three locations (Freeville, Long Island, and Monmouth, ME) to test how different sources, placement, and timing of nitrogen (N) fertility affected acorn squash production. We replicated a core set of treatments designed to evaluate different N fertility levels achieved through a combination of pre-plant applications of compost (at 80 lb N/A) and bloodmeal (40 lb N/A) applied either banded (concentrated) over the strip-tilled area, or broadcasted over the entire area. These applications were incorporated by using a Perfecta cultivator and an Unferverth deep zone builder over the rows, which also prepared them for transplanting. Additionally, there was a sub-treatment receiving additional N just prior to flowering through a "side-dress" application of bloodmeal (40 lb N/A). The goal of these treatments was to determine which of these N sources and placement could satisfy needs of a main-season crop. Each location included a control with no nitrogen applied. Amount of N applied ranged from 0 to 120 lb N/A. 'Honeybear' bush acorn squash was transplanted in early summer and harvested at crop maturity, with dates varying by location. We sampled plant petioles prior to the sidedress for treatments receiving this as an indicator of plant available N, plant leaf and stem biomass at harvest, and total squash yield and quality.

The field experiment conducted at the Long Island Horticultural Research and Extension Center (LIHREC) in Riverhead, NY, was on Haven loam soil. The experiment consisted of 14 different treatments organized in a randomized complete block design with 4 replications. Cover crop of organic oats (100 lb/A) and Organic Purple Forage Peas (50 lb/A) was drilled on ?? after ??. The field was prepared for planting with a disk cultivator on 27 May to manage weeds. Fertilizer and compost regimes differed between treatments but were first applied on 2 Jun, including a broadcast application of bloodmeal fertilizer (12-0-0) and compost from LI Compost. Banded applications of bloodmeal were made on 3 Jun in a 10-inch band over the rows to be planted. The fertility treatments were incorporated by running an Unverferth zone builder over all the planting rows and then lightly disking the entire field. Seeds were sown on 25 May in the greenhouse. A waterwheel transplanter was used to prepare holes at 24-in spacing. Seedlings were transplanted by hand into the holes in the field on 14 and 15 Jun. Plots were 3 20-ft rows at 68-inch spacing. During the season, water was initially provided by overhead irrigation following transplanting, then drip irrigation was installed on 29 Jun. Plant petiole samples were taken on 13 Jul, just prior to side-dress treatment of additional bloodmeal. Weeds were controlled through cultivation on a semi-weekly basis after transplanting until squash plants became too big to fit cultivation implements between the planted rows. Hand weeding was also used throughout the growing season; a total of 18 man hours was devoted to weeding from 22 June through 17 Aug. Powdery mildew was managed by applying Double Nickel (2 qt/A) + Regalia (2 qt/A) on 15 Jul, 26 Jul, 4 Aug, and 11 Aug, Milstop (5 lb/A) on 11 Aug, Sil-Matrix (0.8%), Regalia (4 qt/A) on 31 Aug, and Microthiol Disperss (5 lb/A) on 26 Aug, 31 Aug, and 10 Sep. Acorn squash were harvested from the center row of each plot on 21 Sep through 26 Sep. Fruit were evaluated for marketability and weighed. Brix (sucrose) measurements were also performed on two first-formed fruit from two plants per plot. Promptly after harvest, slices of flesh from the side area of fruit were frozen to facilitate being able to obtain fluid, following thawing, for measuring Brix with a refractometer.

Results for the fertilizer treatments were fairly inconclusive. No single treatment produced a statistically significant effect on yield in any of the multiple measurements taken. Although numerically there appears to be trend towards a lack of initial application of compost or bloodmeal having a negative effect on yield. This experiment was in a field used in previous years for experiments on compost, and subsequently soil was amended with compost in areas where compost had not been applied to plots in an effort to compensate for compost applied to plots. Residual compost may have contributed substantial fertility for the squash. The results also may have been affected by Phytophthora blight (Phytophthora capsici) that was present in low levels towards the end of the growing season and became more prevalent during harvest especially in some plots.

Chemical analysis of petiole samples was also fairly inconclusive of the treatments sampled there was no significant difference in available nitrogen as nitrate in petioles taken from treatments that received nitrogen soil amendments and treatments that received none or fewer nitrogen amendments. For example both full amendments treatments, Bd-Bd-Sd and Bc-Bc-Sd, averaged 24470 and 24163 ppm nitrate per plot respectively, this is a similar to the treatments that received less nitrogen, No-Bd-Sd and No-Bc-Sd, which average 25559 and 24553 ppm respectively. Again the effects of residual compost from experiments in previous years may have effected these results.

Weeds were managed very effectively with not a lot of time spent on hand weeding. Factors that likely contributed to this success were the winter cover crop controlling spring weeds, reduced tillage limiting soil disturbance that brings weed seeds to near soil surface, appropriately timed cultivation, and also hand weeding when squash plants and weeds were small.

Powdery mildew was assessed on 20 Jul, 27 Jul, 15 Aug, 25 Aug, and 16 Sep in plots receiving no fertilizer (no-no-no in the tables) and the highest rate (160 lb/A; Bd-Bd-Sd). Plots were inspected for powdery mildew symptoms on upper and lower leaf surfaces. At each assessment, nine young, nine mid-aged, and nine old leaves (selected based on leaf physiological appearance and position in the canopy) were rated in each plot, except at the last assessment when five leaves were rated. Powdery mildew colonies were counted; severity was assessed by visual estimation of percent leaf area affected when colonies could not be counted accurately because they had coalesced and/or were too numerous. Colony counts were converted to severity values using the conversion factor of 30 colonies/leaf = 1% severity. Average severity for the entire canopy was calculated from the individual leaf assessments. Disease levels were only significant on 16 Sep. No differences were found between the two treatments indicating no impact of fertility on severity. Overall the average disease severity on 16 Sep for the upper leaf surface was 0.5% and 6.6% for the lower leaf surface. Compared to disease severity ratings taken on the same date on a resistant pumpkin variety treated weekly with an organic fungicide, Tritek or Microthiol Disperss, the control achieved with the organic fungicide program applied to a resistant squash variety in this experiment was excellent. The pumpkin experiment with resistant variety Bayhorse Gold had an average disease severity of 13% on the upper leaf surface and 31.8% on the lower leaf surface when sprayed with Tritek on a weekly basis and 3.7% on the upper leaf surface and 48.3% on the lower leaf surface when sprayed with Microthiol Disperss.

Oriental beetle grubs were the most important insect pest occurring in this experiment. They nibbled on bottom of acorn squash in contact with soil. Damage was observed on harvested fruit. Subsequently grubs were found under many of the unharvested fruit in the outside rows of plots. The extent of damage is considered unusual for the region. Adults were likely attracted to the field to lay eggs in spring by organic matter present, possibly the oat/pea cover crop or the compost applied for fertility. Grubs can move in soil toward something that attracts them. Squash fruit would be especially attractive place to be as they provide cover (protection) and warmth (fruit absorb sun heat). Cucumber beetles and squash bugs were also observed on the squash plants.

Acknowledgments: Project funded by USDA Organic Research and Extension Initiative.

Investigation of winter-hardy cover crop practices in organic reduced tillage cabbage
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The goal of this experiment was to examine various combinations of winter hardy cover crops for use in reduced-till crop production. An actively growing ground cover may improve early spring weed control, but the increase in ground residue could cause problems in reduce-till systems. The addition of various winter hardy legumes may also provide additional fertility benefits.

Similar experiments were conducted at Cornell's facility in central NY (Freeville) and Michigan State University. Additional research on organic reduced tillage production systems and management practices was conducted at these locations as part of this 5-yr project.

Research trials were established at the three locations to test how different winter hardy cover crops and fertilizer practices affected cabbage production. Four different cover crop combinations were planted; rye, rye plus hairy vetch, rye plus crimson clover, and rye plus Austrian winter pea. Plus rye cover crop with an amendment of bloodmeal fertilizer applied as a side-dress in early August. 'Farao' cabbage were seeded in early summer, transplanted in mid-summer and harvested at crop maturity, with dates varying by location.

A field experiment was conducted at the Long Island Horticultural Research and Extension Center (LIHREC) in Riverhead, NY, on Haven loam soil. The experiment consisted of the 5 treatments described above organized in a randomized complete block design with 4 replications. Cover crops were seeded on 25 Sep 2015 after disking the field. Biomass was determined on 7 Jun by cutting plant tissue at ground level in two 0.25 m^2 quadrants in each plot. Cover crop leaf tissue was sorted, dried, and weighed for each quadrant. Cabbage were seeded on 7 Jun in 48 cell trays and placed in the greenhouse. On 6 July a Perfecta cultivator was run through all plots to manage weeds (shallow cultivation) followed by an Unverferth zone builder to perform deep zone tillage in all plots. Cabbage was transplanted into the field using a four person cabbage transplanter on 7 and 8 July. During the season, water was initially provided by overhead irrigation. Plots were switched to drip tape irrigation on 21 Jul. Weeds were controlled by cultivation and hand weeding throughout the growing season. Weed pressure was high with 41 man-hours of hand weeding performed in the cabbage plots (total of 270 sq ft) over the entire season. Flea beetles were also a significant problem, insecticides were applied throughout the season to control this pest; Entrust 80W 1.5 oz/A on 20 July, Mycotrol ESO 1 qt/A on 3 Aug, and Entrust 80W 1.5 oz/A on 9 Aug. Entire plant diameters were recorded for ten plants per plot on 22 Aug, as well as cabbage head diameters recorded on 13 Sept. Cabbage were harvested in 20 foot sections from the middle row of each plot on 12 Oct. Cabbage plants were counted and weighed as well as cabbage heads. 5 plants were selected from each plot and a wedge from each head was cut and dried and weighed, the plant frame was also dried and weighed.

The multiple cover crop combinations failed to produce statistically significant differences in many of the measurements taken throughout the growing season. All of the cover crops had similar amounts of total plant biomass in early summer right before they were flail mowed. Also, neither of the cover crop treatments produced a measurable effect on plant development when compared to other treatments. Only one yield measurement, frame dry weight, showed differences between the treatments. Rye with the added bloodmeal fertilizer amendment produced significantly larger plant frames when compared to the rye and crimson clover cover crop. This trend is also represented numerically in the other yield measurements but wasn't statistically significant. These results are inconclusive overall, perhaps the high weed pressure throughout the experiment had an effect on the results. The field site for this experiment in retrospect probably was not a good location due to known quantity of weeds present in previous years and annual ryegrass that had re-seeded following use as a living mulch. Additionally, the crimson clover re-seeded throughout the experiment. Flail chopping was done for all plots at the ideal time for the hairy vetch (full flower with first pods), at which time most of the clover flower heads were brown and dry. Unfortunately weed pressure data was not recorded for this experiment.

Acknowledgments: Project funded by USDA Organic Research and Extension Initiative.

Investigation of winter-kill cover crop practices and tillage radish in organic reduced tillage snap peas
Investigators: Margaret T. McGrath and Zachary F. Sexton
Location: Long Island Horticultural Research and Extension Center

The goal of this experiment was to examine tillage (forage) radish grown as a winter-kill cover crop for preparing soil for reduced-till crop production. The long, large tap root of tillage radish has potential to disrupt compacted soil layers and thus has potential to be used in place of deep zone tillage equipment. Additionally, the channels left after the roots decompose enable subsequent vegetable crop roots to grow through compacted layers.

Similar experiments were conducted at Cornell's facility in central NY (Freeville), University of Maine facility in Monmouth, and Michigan State University. Additional research on organic reduced tillage production systems and management practices was conducted at these locations as part of this 5-yr project.

Research trials were established at the four locations to test how different winter kill cover crops and tillage practices affected sugar snap pea production. Three different cover crops were planted; oats, tillage radish, and oats combined with tillage radish. Plus there was an unplanted control. These cover crop systems were also tested with two different tillage regimes implemented before seeding; shallow conventional tillage alone or combined with deep-zone strip tillage in the planting row. This was done to compare tillage radish to deep zone tillage and to determine if there was benefit to using both. 'Sugar Ann' snap peas (Johnny's Selected Seeds) were seeded in mid-spring and harvested at crop maturity, with dates varying by location. Weed biomass was assessed in fall and early spring to compare the weed suppression effects of each cover crop system.

A field experiment was conducted at the Long Island Horticultural Research and Extension Center (LIHREC) in Riverhead, NY, on Haven loam soil. The experiment consisted of the 8 treatments described above organized in a completely randomized split plot design with 4 replications. Tillage regime was the whole plot factor and cover crop was the split plot factor. Cover crops were seeded on 25 Sep 2015 after disking the field. Biomass was determined on 22 Oct by cutting plant tissue at ground level and pulling radishes in two 0.25 m^2 quadrants in each plot. Oat, radish and weed leaf tissue was separated, dried, and weighed for each quadrant. Length of radish roots above and below ground was measured, and then the roots were dried and weighed. On 31 Mar 2016 weeds were assessed by estimating percent of surface area covered by weed growth in each plot, then a Perfecta cultivator was run through all plots to manage weeds (shallow cultivation) followed by an Unverferth zone builder to perform deep zone tillage in the strip till plots. Peas were seeded on 6 Apr at 1-inch spacing. During the season, water was provided by overhead irrigation. Weeds were controlled by cultivation and hand weeding throughout the growing season. Peas were harvested in 10 foot sections from the middle two rows of each plot on 15 Jun through 17 Jun. Peas were evaluated and sorted for marketability then plants and pods were dried and weighed.

When comparing weed suppression by cover crops late in the fall, all of the cover cropping systems greatly reduced the amount of weed biomass compared to the control plots with no cover crops. Annual ryegrass was the main weed. All of the treatments produced similar amounts of total plant biomass.

Results were slightly different in the spring. When looking at estimated weed coverage and percent weeds of total plants in late March all of the cover crops significantly reduced the amount of weeds compared to the control plot, but the oats cover crop was significantly less effective when compared to radish and oats plus radish.

Cover crop was shown to have a statistically significant effect on pea yield through all of the yield measurements, with radish associated with highest yield, tillage was only significant when looking at total plant weight where deep zone tillage resulted in larger plants than conventional tillage. There was no significant interaction between cover crop and tillage in any of the yield measurements. When looking at individual treatment combinations the radish/deep zone tillage and oats + radish/deep zone tillage combinations resulted in numerically higher yield for all measurements which were significantly different from some other treatment combinations only for total plant weight.

One major effect of cover cropping was the improvement of plant stands. Pea plant stands were highly variable from plot to plot. The same cover crop, tillage practice combinations that produced the most yield also had the best plant stands at harvest time. Deep zone tillage combined with tillage radish improved pea plant stands when compared to either tillage regime with no cover crop and deep zone tillage with oats. More interesting, when looking at the average plant size (based on weight) there was no significant difference between treatments meaning that yields were not improved due to enhanced plant growth including pods, but rather due to improved plant stands.

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