Long Island Vegetable Pathology Program
2015 Annual Research Report

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Evaluation of Cornell Late Blight Decision Support System for timing fungicide applications for foliar diseases in tomato
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The goal of this experiment was to evaluate the Cornell Decision Support System (DSS) for naturally-occurring late blight on organically-grown tomato using an organic copper fungicide (Nordox 75 WG 2 lb/A) applied to a susceptible variety (Mountain Fresh Plus) and a moderately resistant variety with the Ph2 gene for resistance to late blight (Legend). The experiment was conducted in a field with Haven loam soil that has been dedicated to organic research since 2001. Tomato seedlings were transplanted on 25 June when 5-weeks-old. All 4 fungicide treatments were initiated 11 days later (July 6) when DSS was indicating conditions were favorable for LB onset. A copper fungicide approved for organic production, Nordox 75 WG, was applied at 2 lb/A for all applications.

Late blight did not develop anywhere on Long Island in 2015 and the pathogen causing this disease is too contagious and destructive to consider inoculating the plots; therefore it was not possible to evaluate the DSS for managing late blight. Symptoms of bacterial speck, Septoria leaf spot, and powdery mildew were observed. These diseases remained at a very low level, even in the non-treated control plots, therefore it was not possible to assess impact of using the DSS for these other diseases either.

Conditions remained favorable for late blight throughout the 2015 growing season. The DSS indicated times when conditions warranted making applications more or less frequently than the standard, calendar-based 7-day application schedule. The total number of applications from 6 July to 9 September was the same (10) for the 7-day application schedule and the DSS schedule for the susceptible variety. Applying fungicides more frequently than every 7 days when conditions are favorable for late blight as indicated by the DSS could result in better control than that achievable with a weekly schedule. With the moderately resistant variety it was possible to reduce the number of applications by 3. Application interval was 4 to 11 days for the susceptible variety and 8 to 13 days for the moderately resistant variety.

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Evaluation of late blight resistant tomato varieties conducted with organic practices
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The goals of this experiment, which is part of a multi-year project, were to evaluate new tomato varieties and experimental hybrids with resistance to late blight in terms of 1) susceptibility to naturally-occurring foliar diseases including late blight and 2) yield and fruit quality. The focus of the evaluation in 2015 was varieties with claims of resistance to late blight that were not bred to contain the known resistance genes. They were Wapsipinicon Peach, Pruden's Purple, Rebelski, Quadro, Cerise Rote, Clou OP, Resi, Rote Murmel, Rote Zora, and Golden Currant. The first two exhibited good resistance in a similar experiment conducted in 2015 at LIHREC; they were re-evaluated to confirm these results. The last six exhibited good resistance in several evaluations conducted in Oregon where different strains of the late blight pathogen occur than in New York. These were compared to a susceptible variety, Mountain Fresh Plus, and to Mountain Merit, a variety with the late blight resistance genes Ph-2 and Ph-3. Two additional varieties claimed to be resistant, Old Brooks and Pineapple, were included in another experiment (see following report) due to space constraints in the field where this experiment was conducted.

The experiment was conducted in a field with Haven loam soil that has been dedicated to organic research since 2001. Fertilizer was selected based on soil test results, broadcast and incorporated: Solubar (boron) 10 lb/A, manganese sulfate 6 lb/A, sulfate of potash 100 lb/A, Pro-Booster (10-0-0) 1250 lb/A, and compost 10 ton/A. Black plastic mulch and drip tape were laid over beds. Tomato seedlings were transplanted on 23 June when 5-weeks-old by hand into holes opened in the plastic mulch by a Waterwheel transplanter that also placed in the holes a starter fertilizer (Organic Gem fish fertilizer at 60 ml/gal). Varieties were arranged in a randomized block design with four replications. Plots were single rows with 10 plants at 24-in spacing. A plant of the late blight-susceptible variety SunGold was planted between plots in rows to separate plots and serve as a source of the pathogen once late blight was present. There was 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.

Late blight did not develop anywhere on Long Island in 2015 and the pathogen causing this disease is too contagious and destructive to consider inoculating the plots; therefore it was not possible to assess resistance to late blight. Other diseases developed to a limited extent. Pruden's Purple had the highest severity of bacterial speck. Rote Murmel had the fewest symptoms. Resi, Quadro, Wapsipinicon Peach, and Mountain Fresh Plus were also significantly less severely affected than Pruden's Purple based on AUDPC values. Resi had the highest severity of powdery mildew. Rebelski, Quadro, and Rote Murmel were significantly less severely affected. Very few symptoms of Septoria leaf spot were seen. There were no significant differences among varieties.

Acknowledgments: Project funded by the Agriculture and Food Research Initiative Competitive Grants Program Grant 2011-68004-30154 from the USDA National Institute of Food and Agriculture.

Evaluation of late blight resistant tomato experimental varieties
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The main goals of this experiment were to evaluate late blight-resistant tomato experimental hybrids developed by Jay Scott, tomato breeder at the University of Florida, in terms of 1) susceptibility to naturally-occurring foliar diseases including late blight and 2) yield and fruit quality. Seven of the 14 entries were bred to be resistant to late blight. Four of the entries were the original variety or experimental line that was bred to be resistant, including Solar and Tasti-Lee. Old Brooks and Pineapple were also included (see previous report).

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 seedlings were transplanted on 29 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.

The only fungicide used was Actigard. It was applied for managing bacterial speck on 20 July and 15 August. Cabbage loopers and other worms eating leaves were managed by applying Lannate (3 pt/A) on 21 August, Warrior (3.2 fl oz/A) on 28 August, and Avaunt (3.5 oz /A) on 11 September. Plants were assessed five times for occurrence and severity of foliar diseases. Fruit was harvested when ripe five times from 14 September to 5 October. Yield and fruit quality were assessed. On 30 September Brix (% soluble sugars) was measured for 3 fruit per plot and percent of 10 fruit with white tissue in their flesh was determined based on appearance of fruit cut in half.

Late blight did not develop anywhere on Long Island in 2015 and the pathogen causing this disease is too contagious and destructive to consider inoculating the plots; therefore it was not possible to assess resistance to late blight. Other diseases developed to a limited extent. Old Brooks had the highest severity of bacterial speck and the most defoliation when assessed on 22 September. Eight of the University of Florida experimental varieties were significantly less severely affected. There were no significant differences among the tomato entries in incidence of affected leaves or severity for powdery mildew or Septoria leaf spot.

The blight-resistant experimental varieties did not differ significantly in total number fruit produced or average fruit weight from their comparable varieties or lines without resistance. Average fruit weight was 0.5 lb for the seven resistant experimental varieties. One of the late blight-resistant experimental varieties had the highest fruit Brix value. While the difference was not significant, the blight-resistant experimental varieties had numerically higher Brix values than their comparable varieties or lines without resistance. These four pairs did not differ significantly in percent fruit with white tissue in fruit flesh, thus breeding for resistance did not result in selection for this negative trait.

Old Brooks produced significantly more fruit (117/plant) that were significantly smaller (0.2 lb/fruit) than all nut one entry. Pineapple produced the fewest fruit (21) that were the heaviest (0.75 lb).

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Evaluation of tomato experimental varieties resistant to late blight, early blight, and Septoria leaf spot
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The goals of this project were to evaluate disease-resistant tomato experimental hybrids developed by Martha Mutshler, tomato breeder at Cornell University, in terms of 1) susceptibility to naturally-occurring foliar diseases including late blight and 2) yield and fruit quality. There were two separate replicated experiments with crosses related to Mt Merit and to Iron Lady, the first multiple disease resistant variety from the Cornell program that has been commercialized. These commercial varieties were included for comparison. There was also an observational planting with three crosses of Brandywine with a resistant line to obtain improved versions of the Heirloom Brandywine that have resistance to the three foliar diseases plus improved fruit characteristics including reduced tendency for splitting.

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 seedlings were transplanted on 11 and 12 June when 5-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 6 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.

The only fungicide used was Actigard. It was applied for managing bacterial speck on 20 July and 15 August. Cabbage loopers and other worms eating leaves were managed by applying Lannate (3 pt/A) on 21 August, Warrior (3.2 fl oz/A) on 28 August, and Avaunt (3.5 oz /A) on 11 September. Plants were assessed five times for occurrence and severity of foliar diseases. Fruit was harvested when ripe five times from 9 September to 7 October. Yield and fruit quality were assessed.

Late blight did not develop anywhere on Long Island in 2015 and the pathogen causing this disease is too contagious and destructive to consider inoculating the plots; therefore it was not possible to assess resistance to late blight. Other diseases developed to a limited extent partly due to lack of rainfall. No significant differences were detected in incidence (percent of leaflets with speck symptoms) or severity of speck symptoms on diseased leaves.

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

An 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. Cabbage loopers and other worms eating leaves were managed by applying Lannate (3 pt/A) on 21 August, Warrior (3.2 fl oz/A) on 28 August, and Avaunt (3.5 oz /A) on 11 September.

Seeds of variety 'Iron Lady' were sown on 20 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 transferred to trays with new growing media on 10 June when it was discovered they had been inadvertently planted in contaminated growing media. Seedlings were transplanted on 26 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 and 29 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 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. 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 13 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, on 11 August spreader row plants were re-inoculated late afternoon on a rainy day after rain had fallen. Cheesecloth was used to gently rub inoculated leaves in an effort to make small wounds.

Treatments were applied weekly 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 8, 16, 23, and 30 July; 6, 13, 20, and 27 August; and 3 and 9 September. The nine treatments were K-Phite, Serenade Opti + MilStop, Double Nickel + Cueva, BlightBan, AgriPhage, K-Phite + AgriPhage, Actigard + AgriPhage with Tanos applied every 14 days, K-Phite + AgriPhage with Tanos (14-day), and K-Phite + Cueva with Tanos (14-day). 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 8 and 16 July. It was 0.5 oz/A applied in 75 gal/A on 23 and 30 July. It was 0.75 oz/A in 100 gal/A on 6 and 13 August. The isolate used to inoculate the spreader row was sent to OmniLytics for production of AgriPhage.

Leaves were examined routinely for symptoms of bacterial speck and other diseases. Percentage of leaves with symptoms (incidence) in each plot was estimated. Percentage of tissue with symptoms on affected leaves (severity) was also estimated. Canopy severity is a product of incidence times severity for affected leaves. Ripe fruit were examined for symptoms.

Bacterial speck developed to a very limited extent at least partly because conditions were dry and thus unfavorable for disease development. Rain fell on nine days in July (total of only 1.24 inches), four days in August (2.14 inches), and four days in September (2.84 inches). The overhead irrigation was not run until late August. None of the treatments had significantly lower severity of speck than the untreated control. Symptoms were not observed on fruit.

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Investigating occurrence and assisting growers manage late blight in organically-produced tomato and potato
Investigators: Margaret T. McGrath and Mollie Cohen
Location: North Fork, Long Island

Late blight is a very destructive disease of tomatoes and potatoes that has been routinely occurring on Long Island since 2009. Control of this disease is particularly challenging for organic growers because fungicides approved for organic production are not as effective as the synthetic fungicides that growers producing conventionally can use. Their efficacy is due to their ability to move into leaves and their targeted activity for the type of pathogen that causes late blight. Also, organic growers typically use an IPM approach (starting pesticide applications after disease/pest detection); however they increasingly understand that sometimes preventive treatment is needed for effective control. Late blight can be very difficult to suppress without preventive applications of a protectant fungicide, which organic growers increasingly understand.

The goal of this project was twofold. First was to help organic growers manage late blight by regularly monitoring their fields and alerting them when late blight was found. Additionally the regular monitoring throughout the season offers valuable insight into the effectiveness of different management strategies. This project is a continuation of the late blight monitoring project started in 2012.

Late blight was not observed in 2015 at these farms or at other farms being scouted through the CCE IPM program, and no reports of suspected cases were received from other farmers or gardeners on LI in 2015.

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Assessment of resistance to powdery mildew race 1 and race 2 in cantaloupe
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The objective was to determine whether resistance to powdery mildew race 1 and race 2, which has been bred into most commercial resistant cantaloupe varieties, was continuing to provide suppression of the pathogen. Excellent control has been obtained in previous experiments conducted at this location. However, in 2014 when an evaluation of resistant varieties was not conducted, powdery mildew was observed to be severe by the start of harvest in a cultural practice experiment. The resistant varieties in that experiment, Athena and Sugar Cube, were compared in 2015 to Superstar, the standard susceptible variety used in previous evaluations. 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 5 June. Beds were formed with drip tape and covered with black plastic mulch on 10 June. A waterwheel transplanter was used to make planting holes and apply starter fertilizer plus insecticide on 12 June. Seeds were sown on 17 May in the greenhouse. Seedlings were in poor condition due to contaminated growing media. Those that appeared to have growing points were transplanted by hand into the planting holes on 14 June. Seeds were placed in empty holes to replace seedlings that died within a few days of transplanting. Thus plots had plants of varying age. During the season, water was provided as needed via drip irrigation lines. Weeds were managed by applying herbicides after laying plastic (Strategy at 3 pt/A, Sandea at 0.5 oz/A, Scythe at 1%, and Roundup WeatherMAX at 22 oz/A) and hand weeding. The insecticide Asana (9.6 fl oz/A) was applied to foliage on 19 July, 28 July, and 5

August for cucumber beetles or squash bugs. The following fungicides were applied preventively for Phytophthora blight (*Phytophthora capsici*): K-Phite (1 qt/A) on 23 and 28 July; and 5, 12, 19, and 26 August; Presidio (4 fl oz/A) on 28 July and 26 August; Ranman (2.75 fl oz/A) on 5 August and 19 August; and Forum (6 fl oz/A) on 23 July and 12 August.

A randomized complete block design with four replications was used. Plots were three adjacent rows each with four plants spaced 24 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. Upper and lower leaf surfaces were assessed for powdery mildew on 15 July; 4, 10, and 17 August; and 4 Sep. Powdery mildew colonies were counted; severity was estimated when colonies had coalesced or were too numerous to count. Colony counts were converted to severity values using the conversion factor of 10 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 4 August through 17 August and also through 4 Sep. AUDPC is a summation measure of severity over time. To determine which pathogen races were present, powdery mildew differentials were grown in the same field adjacent to the plots with the melon varieties. The same procedures were used to grow these plants and assess powdery mildew.

One powdery mildew lesion was observed on 15 July in one plot of susceptible variety Superstar. Symptoms were first observed the previous week on the zucchini separator plants which had begun to produce marketable-sized fruit. The same Superstar plot was the only one with symptoms on 4 August. Severity remained low through 17 August for all varieties; however, Superstar had numerically more severe powdery mildew and was the only variety with symptoms in all plots. There were also no significant differences among the resistant and susceptible varieties on 4 Sep when powdery mildew was moderately severe in all varieties, and first fruit were ripe. Athena and Sugar Cube exhibited excellent suppression of powdery mildew when compared to Superstar in similar experiments conducted in 2011, 2012, and 2013. In the planting of the powdery mildew differentials, the susceptible differential variety (Hales Best Jumbo) was affected first with a single lesion found on 8 July. Severity remained low until 17 August. Symptoms were found on 10 August on the differential with resistance to race 1 (PMR-45), 17 August on the differential with resistance to races 1 and 2 (PMR-5), and 4 Sep on the differential with resistance to races 1, 2, and 3 (MR-1). These results confirm presence of *Podosphaera xanthii* strain(s) able to overcome resistance to races 1 and 2, which accounts for powdery mildew becoming severe on the resistant varieties.

In conclusion, it appears that the cucurbit powdery mildew pathogen has evolved to be able to overcome resistance in melons to races 1 and 2. These varieties are expected to provide some suppression of powdery mildew in the future; however, they likely will need to be treated with fungicides to obtain adequate control of powdery mildew, as is the case with resistant pumpkin and squash varieties.

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

Efficacy of fungicides for managing powdery mildew in pumpkin
Investigators: Margaret T. McGrath and Karen LaMarsh
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 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, and 11 fungicides and moderate resistance to FRAC code 3 fungicides. They were applied on a 7-day schedule starting after symptoms were first found. Some treatments were single products applied alone every week. This is not a recommended nor labeled use pattern for growers; it is done for research purposes to determine when resistance is affecting control. Products tested in 2015 were Pristine 18.5 oz/A, Quintec 6 fl oz/A, Vivando 15.4 oz/A, and Luna Experience 6 fl oz/A. There were 7 additional treatments consisting of alternations among products. All of the fungicides evaluated are registered for use in New York except Fontelis, Luna Experience and Aprovia Top.

The field was plowed on 13 April. 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 16 Apr. On 17 June the mustard was flail chopped, immediately incorporated by disking, followed by a cultipacker to seal the soil surface. On 30 June the field was lightly disked, then pumpkin seeds were planted at approximately 24-in. plant spacing within rows with a vacuum seeder. 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). The herbicides Strategy (3 pt/A), Curbit EC (1 pt/A), and Sandea (0.5 oz/A) were applied over the entire plot area on 2 July, which was followed by irrigation to activate. During the season, weeds were controlled by cultivating and hand weeding as needed. Insects were managed by applying Admire Pro (10.5 fl oz/A) in a narrow band over the planted rows on 30 June for cucumber beetles; Asana (9.6 fl oz/A) to foliage on 19 July, 28 July, and 5 August for cucumber beetles or squash bugs; and Avaunt (6 oz/A) on 3 Sep for cabbage loopers. The following fungicides were applied for Phytophthora blight (*Phytophthora capsici*): K-Phite (1 qt/A) on 9, 23, and 28 July; 5, 12, 19, and 26 August; and 2, 9, and 16 September; Presidio (4 fl oz/A) on 28 July, 26 August, and 16 Sep; Ranman (2.75 fl oz/A) on 5 August, 19 August, and 9 September; and Forum (6 fl oz/A) on 23 July, 12 August and 2 September. 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 six times on a 7-day IPM schedule (starting after disease detection) beginning on 29 July using a tractor-mounted boom sprayer equipped with twinjet (TJ60-11004VS) nozzles spaced 17 in. apart that delivered 68 gal/A at 65 psi and 2.3 mph. Plots were inspected for powdery mildew symptoms on upper and lower leaf surfaces on 28 July; 4, 10, 17, and 25 August; and 1, 14 and 23 September. 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 two assessments 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 10 August through 23 September. AUDPC is a summation measure of severity over time. Defoliation was assessed on 14 and 23 September. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 6, 13, and 16 October. Handles were considered good if they were green, solid, and not rotting.

Powdery mildew was first observed in this experiment on 28 July in 10 of the 52 plots; 1.3% of the leaves examined had symptoms. Treatments were started the next day. All treatments effectively managed powdery mildew. They were providing 94.7 to 99.5% control on upper leaf surfaces and 70 to 95% control on lower surfaces on 1 September, which was one day before the last treatment applications. Controlling powdery mildew resulted in longer leaf retention and improved fruit quality, measured in terms of handle quality, through mid-October, which is especially important for Pick-Your-Own Halloween pumpkins. Death of leaves and vines leads to handles shriveling and rotting. Five treatments consisted of individual products evaluated alone. Pristine (FRAC Code 7 and 11) applied at its highest label rate was effective in 2015; it has exhibited poor control in some previous experiments at this location. Grower standard was alternation of Vivando (FRAC U8), Quintec (13), and Torino (U6); however, recommended tank mix with a protectant fungicide was not done to be able to assess the target fungicides alone. This treatment was not significantly better than a similar treatment that differed by starting with Procure and having no application week 2 when powdery mildew severity was low. Applying Vivando with Silwet, a nonionic organosilicone surfactant, did not improve control significantly; however, severity on lower leaf surface on 14 September and defoliation on 23 September were numerically lower, and percent fruit with good handles was always higher than Vivando applied without a surfactant. The two Vivando treatments were the only ones with significantly less severe powdery mildew than the nontreated control on upper leaf surfaces on 23 September, which was 21 days after the last fungicide application. Disease severity for these treatments on lower surfaces was numerically the lowest on 23 September.

In conclusion, the new fungicide Vivando is very effective for powdery mildew. It is recommended applied with a surfactant, and used in alternation with Quintec, which also performed well in this evaluation, and with Torino, which exhibited good efficacy when tested in 2013. An alternation of these three was as effective as Vivando alone. Procure and Pristine (limit use) are recommended in addition.

Fungicide sensitivity of cucurbit powdery mildew pathogen isolates on LI in 2014
Investigators: Margaret T. McGrath and Karen LaMarsh
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*, the fungus that causes powdery mildew in cucurbits, were obtained 28 September – 3 October 2014 from five research fields and six 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-nine 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 all isolates tested were resistant to FRAC code 1 and 11 fungicides (not all of the isolates were tested with these chemistries). This supports the decision to continue not recommending these fungicides.

Boscalid (FRAC 7) resistance was detected in 41% of the isolates (all isolates were tested for this trait). This is an active ingredient in Pristine. Almost all of the resistant isolates were from research fields. All isolates were resistant from research plots that were treated with Pristine in the fungicide efficacy experiment. This indicates selection for this resistance occurred during the experiment. Only two of the 36 isolates from commercial pumpkin fields were resistant; they were from the same field. These results support use of Pristine on a limited basis in a fungicide program for powdery mildew. Boscalid-resistance was at higher levels in commercial fields in previous years. Infrequent occurrence in 2014 may reflect increased use of other chemistry by growers.

Some isolates were able to grow on leaf disks treated with 80 ppm myclobutanil (active ingredient in Rally)(FRAC 3) and/or 80 ppm quinoxyfen (active ingredient in Quintec)(FRAC 13). These isolates are not fully resistant to these fungicides.

In conclusion, documented occurrence in the cucurbit powdery mildew pathogen of resistance to some targeted fungicides (FRAC 1, 7, and 11) and variation in sensitivity to others (FRAC 3 and 13) reveals the necessity of using a resistance management program with this pathogen and is important for selecting fungicides to use. FRAC 3 and 13 fungicides (Procure and Quintec) are recommended used in alternation with Torino. Use of FRAC 7 fungicides (Pristine) should be limited. FRAC 1 and 11 fungicides should not be used.

Identification of pathotypes of the cucurbit downy mildew pathogen occurring on LI
Investigators: Margaret T. McGrath and Karen LaMarsh
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 capable of surviving in the absence of living host plant tissue; however, it produces spores capable of long-distance movement by wind. Successful dispersal to Long Island 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 Long Island 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. 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 29 June and 17 July. The first planting was delayed because the first batch of seedlings died as a result of contaminated potting mix. Each cucurbit crop type or variety (there were two cucumbers) in each planting was grown in a plot with 3 rows of 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 10 August in cucumber. The plot with the susceptible variety Straight Eight was more severely affected than the plot with Marketmore 97, documenting that resistance to pathogen strains dominate until 2004 is continuing to provide some suppression of new strains. Symptoms appeared new. Another planting of cucumber at LIHREC was also affected. The pathogen most likely was dispersed to the area 6 days earlier on 4 August when there was a brief morning rain and there was a low risk forecasted or 11 days earlier on 30 July when rain occurred late afternoon through evening and the forecasted risk was high. Previous first occurrences at LIHREC were 27 August 2008, 27 July 2009, 7 September 2010, 1 August 2011, 17 July 2012, 22 July 2013, and 2 September 2014.

Very new symptoms were found at low incidence on butternut squash on 18 August. Rain on 11 August may have provided favorable conditions for pathogen dispersal. There were reports on 22 and 29 July of this crop type being affected in NJ and PA; however, there was no forecasted risk for cucurbit downy mildew on LI between 4 and 18 August.

On 24 August a few symptoms were found on cantaloupe and watermelon. Infection likely occurred 6 days earlier when there was forecasted risk for successful pathogen dispersal and infection. On 30 August there were symptoms in acorn squash and giant pumpkin.

In conclusion, several pathotypes were dispersed to LI in 2015 resulting in downy mildew developing on all cucurbit crop types. The situation was similar in 2013. However, in 2014 only cucumber was affected.

Validation of the CDM ipmPIPE Forecasting System: Relating aerial transport of pathogen spores to outbreaks of cucurbit downy mildew

Investigators: Katie N. Neufeld (North Carolina State University), Anthony Keinath (Clemson University) and Peter S. Ojiambo (North Carolina State University), with assistance from Margaret T McGrath (LIHREC)

Location: Multiple Locations including Long Island Horticultural Research and Extension Center

Pseudoperonospora cubensis, the causal agent of cucurbit downy mildew (CDM), is an obligate parasite that cannot survive in absence of a living host. In the US, the pathogen is thought to overwinter in southern Florida where mild winters enable cucurbit host plants to survive in the field. Thus, the pathogen is presumed to be introduced annually in northern states by southerly wind currents from sub-tropical regions in southern Florida. Current disease outbreaks and forecasts of the pathogen's movement are predicted by the CDM ipmPIPE forecasting system (cdm.ipmpipe.org). The CDM ipmPIPE was established in 2008 to provide growers with a decision support system, such as disease forecasts that are based upon the current epidemic status and forecasted weather conditions, to aid them in timing the first fungicide spray to manage CDM. Forecasts are available as interactive maps that depict the risk of initial infection in specific locations.

To ensure that disease outbreaks and real-time dispersal of spores are being correctly predicted, validation of the forecasting system is being addressed through various approaches using data from rainwater samples obtained from multiple locations from 2013 to 2015 in eastern United States. Samples have been collected from eight different states: New York at Long Island Horticulture Research and Extension Center (LIHREC), Alabama, Georgia, Louisiana, North Carolina, Ohio, Pennsylvania and South Carolina after each rain and sent to North Carolina State University for processing. Rainwater collection buckets were usually deployed near actively scouted cucurbit fields. The presence of pathogen spores in collected rainwater samples will be correlated to the first onset of symptoms within the field.

Over 200 filter samples were collected over 2013 to 2015, from eight states (NY, AL, GA, LA, NC, OH, PA, SC) with the exception of Louisiana in 2013 (collected 2014-2015) and Ohio in 2015 (collected 2013-2014). NY LIHREC collected 14, 12, and 10 samples in 2013, 2014 and 2015 respectively. LIHREC's rainwater collection bucket was located near the sentinel plots and samples were obtained from June 6th to first onset of symptoms on July 22nd in 2013, June 10th to September 2nd in 2014 and June 20th to August 12th in 2015. Molecular primers that were previously developed are being used to detect presence of *P. cubensis* spores in rainwater samples. Data from samples collected over 2013 to 2015 are currently being analyzed. Presence of CDM in rainwater will eventually be related to the timing of disease onset in the sentinel plots as a final step in the validation of the CDM ipmPIPE forecasting system.

Cucurbit downy mildew: An update on population biology of the causal agent, *Pseudoperonospora cubensis*
Investigators: Anna Thomas, Ignazio Carbone and Peter S. Ojiambo (North Carolina State University), with assistance from Margaret T McGrath (LIHREC)
Location: Multiple Locations including Long Island Horticultural Research and Extension Center

Cucurbit downy mildew (CDM) caused by *Pseudoperonospora cubensis*, the most economically important disease of cucurbits resurged in the US almost a decade ago. This resurgence of CDM necessitated a need to determine the possible causes of the resurgence to limit its re-emergence in future and provide information that may be useful to control the disease. Introduction of a new pathotype, a new lineage or even new species of the pathogen, were proposed as potential reasons for the resurgence of the disease in the US.

Host range studies conducted using twelve host differentials (*Cucumis sativus, C. melo reticulatus*, *C. melo conomon*, *Citrullus lanatus*, *Cucurbita moschata, C. pepo, C. maxima*, *Luffa cylindrica*, *Lagenaria siceraria*, *Trichosanthes cucumerina*, *Benincasa hispida* and *Momardicha charantia)* suggests the presence of previously undescribed pathotypes to exist in the US. Three *P. cubensis* isolates from NY: one collected on cantaloupe from Ontario County, NY and two collected on pumpkin and acorn squash from Long Island Horticultural, Research and Extension Center were tested for their compatibility with the above differential hosts alongside a series of isolates collected across the eastern US. Isolates collected from pumpkin and cantaloupe were found to be compatible only with *C. sativus* (cucumber), *C. melo reticulatus* (cantaloupe) and *C. maxima* (Big Max pumpkin). Virulence pattern exhibited by these isolates is similar to that of pathotype 1 and hence they have been characterized as variants of pathotype I. Pathotype I was previously known to be present only in Asia. Isolate collected from acorn squash was found to be compatible with *C. sativus* and was highly compatible with squashes and *C. maxima* but not with any other differential hosts.

Reports on the occurrence of opposite mating types of *P. cubensis* were made in the US recently. Crosses between isolates belonging to opposite mating types have resulted in the formation of viable oospores under in vitro conditions. Mating types of isolates collected on cantaloupe and pumpkin from Ontario County and Long Island were determined and both were found to belong to A1 mating type. Mating types of more isolates collected on diverse host types from different locations in the state need to be determined to better understand the distribution of different mating types in NY.

An additional aspect of this study is to understand the source of inoculum for the seasonal outbreaks of CDM in the US. It has been widely proposed that the source of inoculum for CDM infections in northern states is the overwintering sources in southern Florida and that the pathogen is introduced into northern states every year during periods of strong southerly winds. However, there is no direct biological evidence to support the hypothesis of pathogen overwintering in southern Florida. Thus, one of our objective is to test the hypothesis by examining genetic differentiation and diversity among isolates collected in eastern US and be able to track the source of inoculum for seasonal CDM outbreaks in the US. Isolates from different cucurbit host types including cucumber, cantaloupe, watermelon, butternut squash, acorn squash and pumpkin were collected from throughout the eastern US including Long Island Horticultural Research and Extension Center, NY. A total of 14 isolates were sent from Long Island in 2008, 2012, 2013, 2014 and 2015. DNA extracted from 8 out of these 14 isolates collected from diverse host types (cucumber, cantaloupe, pumpkin, ornamental gourd, acorn squash and butternut squash) will be used in the genetic study aimed to understand the diversity of *P. cubensis* population in the US.

Evaluation of biopesticides for managing Phytophthora blight in pepper
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The objective of this study was to evaluate the efficacy of EPA-classified biopesticides (which contain microbes or naturally-occurring substances as the active ingredient). Several biopesticides labeled for this disease were tested together in an integrated program. The treatment was applied to a larger area than used in previous fungicide evaluations (3 adjacent rows rather than one row) so that there was more treated area around plants and less non-treated area in the experiment. The experiment was conducted in a field with Haven loam soil where Phytophthora blight has developed most years since 1994.

The biopesticide program started with a soil drench to seedlings in trays of Bio-Tam 0.075 oz/gal water + an experimental product from Marrone Bio Innovations. Peppers (variety Red Knight) were seeded 22 May and transplanted on 30 June into bare-ground. A directed soil drench spray of Bio-Tam 5 lb/A + Double Nickel 1.5 lb/A + the experimental product was made in an 8-inch band at the base of plants using a CO_2-pressurized back-pack sprayer immediately after transplanting and before drip irrigation. Biopesticides were applied to plots weekly starting 2 weeks after transplanting. A tractor-sprayer with a boom covering 21 feet (15 nozzles) was used rather than a single-row hand-held boom with 1 or 3 nozzles as in previous experiments. Bio-Tam 5 lb/A + Double Nickel 1.5 lb/A was applied twice (14 and 28 July) in alternation with Actinovate 12 oz/A + Serenade Soil 6 qt/A + Soilgard 5 lb/A (21 July). The target for these applications was soil, therefore the applications were immediately watered in by spraying the plots several times with water. These were followed by applications made to foliage on 5, 13, 18, and 25 August and 1, 8, and 15 September. Double Nickel 1.5 lb/A + Cueva 2 qt/A + Regalia 3 qt/A was applied in alternation with Actinovate 12 oz/A + Regalia 3 qt/A + Nu-Film P at 0.25% v/v.

This program was evaluated by including in the replicated experiment a non-treated control and a conventional fungicide standard 7-day program with oomycete-targeted fungicides applied to foliage, which was Revus 8 fl oz/A + K-Phite 1 qt/A + the adjuvant Induce 0.25 % v/v applied in alternation with Presidio 4 fl oz/A + K-Phite 1 qt/A. Applications were made at the same time as the biopesticide program, starting 5 weeks after transplanting for a total of 7 applications. A completely randomized block design with four replications was used.

All products tested except the one experimental one are labeled for Phytophthora blight in pepper and all the biopesticides are approved for organic production. There was an adjacent, parallel experiment on pumpkin with the same treatments (see next report).

Conditions were not favorable for Phytophthora blight during the 2015 growing season due to limited rainfall, with only 1.24 inches in July (9 days with rainfall), 2.14 inches in August (4 days), and 2.84 inches in September (4 days). More important, there was a lack of intensive rainfall events to create water-saturated soils that are most favorable for the pathogen, especially when soil is moist at the time of occurrence. Rainfall exceeded 0.75 inches on 4 August (0.8), 11 August (0.93), and 30 September (1.72). Soil was dry at the time in all cases. Overhead irrigation was set up to use to promote disease development, but it was not run until late August. Symptoms were not observed on any plants including none of the non-treated control.

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Evaluation of biopesticides for managing Phytophthora blight in pumpkin
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The objectives of this experiment and the treatments were identical to those of an adjacent experiment with pepper. See the previous report for more information. The treatments were applied to pepper and pumpkin in the two experiments at the same time. Pumpkin variety Prankster was used.

Foliar symptoms of Phytophthora blight were not observed. Fruit that had rotted and healthy fruit were counted on 21 October. Some rotting fruit had definitive symptoms of Phytophthora fruit rot with spores of the pathogen visible; some others had typical symptoms. There was a higher percentage of rotting fruit in nontreated plots (16%) than in plots treated with conventional fungicides (9%) or biopesticides (7%). One plot for each of these treatments had a higher percentage than the others (22% and 18%, respectively). Average percentage of rotting fruit for the other plots excluding these was 4.3% and 3.7%,

Plots were assessed for powdery mildew, downy mildew, and defoliation to determine whether the biopesticide program was improving control of these diseases. Powdery mildew symptoms were first observed on 31 July. The entire experiment was treated on a weekly schedule with targeted fungicides for powdery mildew (Torino, Vivando, and Quintec in alternation) beginning on 8 August and ending on 15 September. Phytophthora blight and downy mildew are caused by similar pathogens and managed by similar targeted fungicides, therefore fungicides were not also applied to the experiment for downy mildew. Powdery mildew was more severe on the lower surface of leaves in the nontreated plots (8% vs 1.5% for all treated plots) on 3 September. There were very few symptoms on upper leaf surfaces. All of the treated plots were visibly better (less symptoms of downy and powdery mildews plus less defoliation) than the nontreated plots on 14 September. At the time of the next assessment on 18 September, differences in disease severity were less pronounced primarily because of the amount of defoliation in the nontreated plots, which averaged 82% versus 9% for plots treated with conventional fungicides for oomycete pathogens (Phytophthora blight and downy mildew) and 30% for plots receiving the biopesticide program; all three treatments were significantly different. Therefore the biopesticide program did contribute to control of foliar diseases.

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Occurrence and impact of downy mildew on sweet basil in 2015
Investigators: Margaret T. McGrath
Location: Long Island Horticultural Research and Extension Center

A webpage was set up in Google Docs for those who observe downy mildew in their basil in 2015 to log reports. A webpage has been set up every year since 2009. When first set up it was anticipated that extension pathologists would be the primary users, so they were contacted about the monitoring program. However, gardeners have logged most reports. Growers have also reported. These reporters while searching the internet for what happened to their basil found an article about basil downy mildew that included requests for occurrence information with links to each year's report page. The main webpage with links is http://vegetablemdonline.ppath.cornell.edu/NewsArticles/BasilDowny.html

Attempt was made to confirm all reports by requesting photographs from the reporter; symptom descriptions were also used. After 7 years of reporting, not only is knowledge about basil downy mildew occurrence in the USA substantially better than it could have been without public help, reporters in the spreadsheet comments section provided valuable additional information including environmental conditions when basil downy mildew appeared, impact, and management practices tried. This new disease, first observed in Florida in fall 2007, was reported in eight states in 2008. Since then through the monitoring program it has been reported in 42 states plus District of Columbia. A total of 49 reports of basil downy mildew were logged in 2009, 63 reports in 2010, 63 reports in 2011, 75 reports in 2012, 64 reports in 2013, 284 reports in 2014, and 281 in 2015. These came from 20, 26, 22, 26, 20, 36, and 34 states, respectively, plus the District of Columbus. Some reports were from outside the USA: Argentina, Australia, Mexico, Baja California, Grand Cayman, Costa Rico, Puerto Rico, Jamaica, Quebec, Ontario, British Columbia, South Africa, and South Korea. Most reports of basil downy mildew were on outdoor plants; a few were of greenhouse plants. Unknowingly distributing contaminated seed is a plausible way that the pathogen was first introduced into the USA and how it has been spread long distances between geographically-separated areas. However, most occurrences reported in the USA are likely the result of infection by wind-dispersed spores. States where this disease has not yet been reported and/or confirmed are Alaska, Idaho, Nevada, New Mexico, Oklahoma, South Dakota, Utah, and Wyoming.

Some growers reported challenges managing downy mildew in 2015. There were crop losses. Gardeners also reported loosing basil to downy mildew. Several reports received in 2015 were from gardeners who had not seen downy mildew in previous years.

Acknowledgments: Project funded by USDA Specialty Crops Research Initiative Program.

Downy mildew susceptibility of sweet basil varieties and experimental resistant lines
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

Downy mildew is a new disease of basil that has occurred every year on LI since first seen in this area in 2008. This disease can have tremendous impact because affected leaves are unmarketable. The objective of this experiment was to assess the degree of resistance in experimental resistant lines grown under field conditions and exposed to naturally-occurring *Peronospora belbahrii* inoculum. The lines were obtained from Enza Zaden USA, Inc. and PanAmerican Seed. They were compared to a standard susceptible variety, DiGenova, and the first commercialized resistant variety, Eleonora.

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 5 July. Beds were formed, drip irrigation tape was laid, and beds were covered with black plastic mulch on 6 July. Weeds between mulch strips were managed with Devrinol DF-XT (2 lb/A) applied after laying plastic on 6 July and then by cultivation and hand-weeding. A waterwheel transplanter was used to make planting holes in the beds and apply starter fertilizer. To provide a source of natural inoculum within the experimental area, basil (variety DiGenova) was transplanted by hand into a spreader row on 7 July. These plants were not inoculated. Basil for the experiment was seeded on 22 June in trays in a greenhouse, placed outdoors to harden for a few days, and then transplanted by hand on 15 July. A late planting date was used to increase the likelihood of downy mildew developing during the experiment. The primary source of initial inoculum in this area is considered to be long-distance wind-dispersed spores from affected plants.

A randomized complete block design with four replications was used. Each plot contained 13 plants in 10-ft rows with 9-in. in-row plant spacing. The plots were 3 ft apart in the row. Downy mildew was assessed in each plot on 12, 25, and 28 August, and 4, 14, and 24 September. 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. Incidence of downy mildew in the plots was calculated by multiplying these values. Area Under Disease Progress Curve (AUDPC) values were calculated from 25 August through 24 September. AUDPC is a summation measure of severity over time. Percent of leaves that had dropped off of plants because of downy mildew were estimated on 14 and 24 September. At the last disease assessment on 24 September, plants were removed from plots and held upside down while in the field to be able to thoroughly examine the underside of leaves. Percentage of leaves with symptoms (incidence) was estimated.

Downy mildew developed naturally and became severe as is typical for the area. Symptoms of downy mildew were first observed on 10 August in the spreader row. No symptoms were found in plots on 12 August. Symptoms were found in 15 of the 44 plots on 18 August, 39 plots on 25 August, and all plots on 28 August. BA108 exhibited excellent resistance for one month, the duration period the disease was present and being assessed. It was significantly better than Eleonora, the first downy mildew resistant sweet basil variety available in the US, based on incidence of leaves with symptoms on 24 September (4% versus 37%; 70% for DiGenova), AUDPC (103, 672, and 1603, respectively), and defoliation (2%, 40% and 70% on 24 September). M3655Z, M4828Z, BA111, and BA113 also exhibited resistance (11% - 29% leaves affected on 24 September). The other four experimental lines evaluated did not exhibit resistance.

In conclusion, resistant experimental varieties (lines) developed recently exhibit better resistance to downy mildew than the first resistant variety released, Eleonora. Disease pressure was high in this experiment in the absence of other control practices (e.g. fungicides) and with several entries becoming severely affected.

Acknowledgments: Project funded by USDA Specialty Crops Research Initiative Program.

Assessment of downy mildew resistance in experimental sweet basil lines
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The goal of this experiment was to evaluate basil bred to be resistant to downy mildew by breeders at Rutgers University. Plants were exposed to naturally-occurring inoculum of the downy mildew pathogen under field conditions. Five segregating lines were examined in 2015. There were 60 plants of each line transplanted in a single row with a plant of the susceptible variety Italian Large Leaf planted in spots 5, 10, 15, etc. for comparison with the resistant plants and to provide a source of the pathogen throughout the planting.

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 5 July. Beds were formed, drip irrigation tape was laid, and beds were covered with black plastic mulch on 6 July. Weeds between mulch strips were managed with Devrinol DF-XT (2 lb/A) applied after laying plastic on 6 July and then by cultivation and hand-weeding. A waterwheel transplanter was used to make planting holes in the beds and apply starter fertilizer. Basil plants for the experiment were rooted cuttings. Transplanting was done on 18 August. A late planting date was used to increase the likelihood of downy mildew developing during the experiment. The primary source of initial inoculum in this area is considered to be long-distance wind-dispersed spores from affected plants. This planting was adjacent to the experiment in the previous report. Between them was a spreader row with basil variety DiGenova that was transplanted on 7 June.

Downy mildew was observed in the spreader row the day the experimental resistant lines were transplanted; thus the pathogen was present throughout the time these plants were growing. Occurrence of symptoms was assessed on each plant. On 28 August downy mildew was present on most (44 of 60) of the Italian Large Leaf plants. Affected plants had on average 8% of leaves affected. On 4 September downy mildew was observed on 6% (2 lines) or 37.5% (3 lines) of the 16 plants of the 5 lines that were examined. On 24 September all plants were examined. All Italian Large Leaf plants had symptoms with an average of 34% of leaves affected (range 1 – 90%), whereas only 19% (2 lines), 29%, 54%, and 60% of plants of the 5 experimental resistant lines had symptoms. The average proportion of leaves with symptoms on affected plants was 9%, 6% (2 lines), 15%, and 12% for these lines, respectively.

In conclusion, the experimental resistant lines developed by herb breeders at Rutgers exhibit excellent resistance with many plants developing no symptoms despite downy mildew being present throughout the duration of this experiment. The plants evaluated at LIHREC are of segregating lines, thus a range of susceptibility was expected. The plants that did develop symptoms had fewer percent affected leaves than the susceptible variety. Results obtained in 2015 confirm results from previous experiments conducted at LIHREC and further document that highly effective resistance has been identified through breeding work conducted at Rutgers University.

Acknowledgments: Project funded by USDA Specialty Crops Research Initiative Program.

Evaluation of fungicides for managing downy mildew in sweet basil
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

New and currently registered fungicides were evaluated on field-grown basil in this experiment. One of the products, Cueva, a copper fungicide, is approved for organic production. The other fungicides tested are for conventional production.

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 6 July. Beds were formed, drip irrigation tape was laid, and beds were covered with black plastic mulch on 7 July. Weeds between mulch strips were managed early in the season with Devrinol DF-XT (2 lb/A) applied before transplanting and then by cultivation and hand-weeding. A waterwheel transplanter was used to make planting holes in the beds and apply starter fertilizer. Basil variety Genovese for the experiment was seeded on 22 June in trays in a greenhouse, placed outdoors to harden for a few days, then transplanted by hand on 15 July. A late planting date was used to increase the likelihood of downy mildew developing during the experiment. The primary source of initial inoculum in this area is considered to be long-distance wind-dispersed spores from affected plants. Additionally, to provide a source of natural inoculum within the experimental area, a row of non-fungicide-treated basil plants (variety DiGenova) that extended the length of this experiment was transplanted on 7 July. 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-inch in-row plant spacing. The plots were 4 ft apart in the row. Foliar treatment applications were made with a backpack sprayer using Twin-jet nozzle(s) delivering 50 gal/A operated at 54 psi and 2.4 mph. A boom with a single (TJ60-4004EVS) nozzle was used on 28 July, 7 August, and 12 August when basil plants were small. A boom with a nozzle delivering spray over the top of the plant plus a drop nozzle directed to each side (all TJ60-8006vs) was used on 18 August, 25 August, 1 September, and 8 September. Downy mildew was assessed in each plot on 24 August, 31 August, 17 September, and 28 September. 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. Incidence of downy mildew in the plots was calculated by multiplying these values. Area Under Disease Progress Curve (AUDPC) values were calculated from 25 August through 24 September. Percent of leaves that had dropped off of plants because of downy mildew were estimated on 31 August, 17 September, and 28 September. At the last disease assessment on 28 September, plants were removed from plots and held upside down while in the field to be able to thoroughly examine the underside of leaves. Percentage of leaves with symptoms (incidence) was estimated.

Downy mildew developed naturally and became severe as is typical for the area. Symptoms of downy mildew were first observed on 10 August in the spreader row. Rain fell on 11 and 21 August. Symptoms were found on almost all plants in plots on 27 August. Applications were intended to be made weekly. The actual intervals between applications were 10, 5, 13, 7, and 7 days, respectively. The fourth application should have been made on 19 August, 2 days before it rained, instead it was made 4 days after rain. This lapse in the spray schedule is likely the main reason most treatments were ineffective. This documents the importance of maintaining a regular application schedule to manage this disease. The most effective treatment on 24 August was the program in which A20941A (an experimental fungicide being developed by Syngenta) was applied on 12 August, i.e., in the application immediately preceding rain. These plants averaged 12.5% affected leaves versus 79% for nontreated plants on 24 August, and 7.5% versus 62.5% defoliation on 31 August. The two other treatments that also had A20941A, Revus and Quadris (different application timing) also had significantly less defoliation than nontreated plants on 31 August. Cueva, Revus alternated with Quadris and the grower standard (Revus plus

K-Phite alternated with Ranman plus K-Phite) were all ineffective at least partly reflecting the impact of the lapse in the spray schedule. A variation of the grower standard (beginning with an application of Ridomil and Quadris) was highly effective in another experiment (see next report). Downy mildew was assessed as percentage of leaves with symptoms, which is a rigorous assessment, but realistic, reflecting zero tolerance for disease on fresh-market herbs.

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Evaluation of organic and conventional fungicide programs for downy mildew in sweet basil

Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The goal of this experiment was to evaluate fungicide programs with several organic or conventional fungicides applied to a susceptible variety (Italian Large Leaf) or to a variety with moderate resistance (Eleonora). 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. See previous report for information about cultural practices used.
The fungicide programs applied to both varieties on a preventive schedule were:

1. Organic fungicide program (sprayed twice/week)
   Regalia 3 qt/A soil drench 1 day after transplant and 7 days later.
   Foliar applications: MilStop 1 lb/A + Double Nickel 3 qt/A applied in alternation with Regalia 2 qt/A + Double Nickel 3 qt/A + Cueva 4 qt/A and with Trilogy 1% (12 sprays total)
2. Current conventional fungicide program with registered fungicides (7-day spray schedule)
   Ridomil Gold SL 1 qt/A soil drench 8 days after transplanting
   Foliar applications: Quadris 15.5 fl oz/A once, then Ranman 3 fl oz/A plus K-Phite 1 qt/A alternated with Revus 8 fl oz/A plus K-Phite. (6 sprays total)
3. Future conventional fungicide program includes product not yet registered that has exhibited excellent efficacy in previous experiments. (7-day spray schedule)
   Quadris once, then Orondis 2.4 fl oz/A alternated with Ranman and Revus. (6 sprays total)

Soil drenches were applied around the base of the plants using a CO_2-pressurized backpack sprayer with a boom equipped with a single Twin-jet nozzle (TJ60-11003) delivering 57 gal/A at 54 psi. Drip irrigation was run after each soil application to incorporate. Foliar treatment applications were made with a backpack sprayer using Twin-jet nozzle(s) delivering 50 gal/A operated at 54 psi and 2.4 mph. A boom with a single (TJ60-4004EVS) nozzle was used on 28 July, 7 August, and 12 August when basil plants were small. A boom with a nozzle delivering spray over the top of the plant plus a drop nozzle directed to each side (all TJ60-8006vs) was used on 18 August, 25 August, 1 September, and 8 September. Downy mildew was assessed in each plot on 24 August, 31 August, 17 September, and 28 September. 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. Incidence of downy mildew in the plots was calculated by multiplying these values. Percent of leaves that had dropped off of plants because of downy mildew were estimated on 31 August, 17 September, and 28 September. At the last disease assessment on 28 September, plants were removed from plots and held upside down while in the field to be able to thoroughly examine the underside of leaves. Percentage of leaves with symptoms (incidence) was estimated.

Downy mildew developed naturally and became severe as is typical for the area. Symptoms were first observed on 24 August in 27 of the 32 plots. On 31 August, symptoms were observed on all non-treated plants of Italian Large Leaf with an average of 44% of leaves affected. The non-fungicide-treated resistance variety, Eleonora, was similarly affected by downy mildew as the non-treated susceptible variety, Italian Large Leaf, at all assessments. There also were no differences between the two varieties for any of the fungicide programs. Foliar fungicide applications were started 13 days after transplanting and 4 weeks before symptoms were seen. The organic fungicide program was not effective for managing downy mildew on either variety, despite starting well before disease onset and the frequency of applications (twice weekly). Both conventional fungicide programs were very effective for managing downy mildew on both varieties based on incidence of symptomatic leaves. The only significant difference among these 4 treatments was incidence of affected plants on 31 August. Based on incidence of affected leaves on 17 September, these programs provided 98-100% control.

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Evaluation of biopesticides for managing downy mildew in sweet basil
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

Most biopesticides are approved for use on organically-produced crops. 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. See first report on this disease for information about cultural practices used. Foliar treatment applications were made with a backpack sprayer using Twin-jet nozzle(s) delivering 50 gal/A operated at 54 psi and 2.4 mph. A boom with a single (TJ60-4004EVS) nozzle was used on 4, 7, and 12 August when basil plants were small. A boom with a nozzle delivering spray over the top of the plant plus a drop nozzle directed to each side (all TJ60-8006vs) was used on 18, 25 and 28 August; and 1, 4, 8, and 11 September. The fungicides tested were Double Nickel, Regalia plus Double Nickel, Sil-Matrix, Procidic, Oso (not approved for organic production), and MBI-110 (an experimental product). All were tested in combination with the copper fungicide Cueva applied every third applications. Downy mildew was assessed in each plot on 27 August and 18 September. 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. Incidence of downy mildew in the plots was calculated by multiplying these values. Percent of leaves that had dropped off of plants due to downy mildew was estimated on 18 September. Percentage of leaves with symptoms (incidence) was estimated.

A seedling assay was conducted to assess whether inadequate spray coverage was a potential explanation for poor control with biopesticides and organic fungicides. Most of these products lack the ability that many conventional fungicides have to move through leaf tissue to the underside where downy mildew develops. Seedlings in pots were dipped in fungicide solutions of the same concentration as was used to spray on plants in the field experiment. The seedlings were allowed to dry in the greenhouse overnight, then put in the field next to the experiment plants for three days beginning on 23 September before returning to the greenhouse.

Downy mildew developed naturally and became severe as is typical for the area. Symptoms of downy mildew were first observed on 10 August in the spreader row, which was 6 days after the treatment applications were started. Rain fell on 11 and 21 August. Symptoms were found on almost all plants in every plot on 27 August. Applications of the biopesticides were intended to be made twice weekly. The intervals were 8, 6, 7, 3, 4, 2, 5, and 3 days. Not being able to apply the treatments more frequently than once weekly until downy mildew was widespread may partly account for lack of control with any of the fungicide combinations tested. Inadequate spray coverage may also be an explanation based on the results with the seedling assay. When the assay seedlings were examined 8 days after they were put in the field, no symptoms were found on any plants treated with Sil-Matrix, Trilogy, Cueva, or the conventional standard fungicide, Revus. There were symptoms on only 1-3 out of 10 plants treated with MBI-110, Regalia, Procidic, and MilStop, 4 plants treated with Oso, while there were 6-8 affected plants for the nontreated control, Actinovate, and Double Nickel treatments.

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Investigation of nitrogen fertility management practices in organic reduced tillage winter squash
Investigators: Margaret T. McGrath and Karen LaMarsh
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. At LIHREC compost and fertilizer were applied 4-9 June, squash was transplanted on 19 June, petiole samples were collected on 16 July, sidedressing was done on 16 July when first fruit were enlarging, and fruit were harvested twice on 20-22 September and 16 October.

Petiole nitrate values varied greatly among plots. There were no significant differences among the treatments sampled (which were those to receive sidedress) at least partly due to the variation; however, petiole nitrate values were highest for treatments that received banded bloodmeal fertilizer (13,431 ppm and 14,756 ppm for plots that also received compost). Next were treatments that received the fertilizer as a broadcast application (6165 ppm and 7026 for plots that also received compost broadcast applied). Value was lowest for treatments that did not receive any bloodmeal fertilizer just before planting (1106 ppm for no compost plots, 793 for broadcast compost plots, and 1049 for banded compost treatments).

Surprisingly there were no significant differences among treatments in yield (number or weight of marketable fruit or average fruit weight) or in fruit quality (Brix value which is a measurement of sugar content).

Limited nitrogen may have been provided by the compost because there was limited rainfall during the 2015 growing season. Drip irrigation was used to provide water to plants. Rainfall (in.) was 5.02 in June, 1.24 in July, 2.14 in August, and 2.84 in September.

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