



Long Island Vegetable Pathology Program 2013 Annual Research Report

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Evaluation of biopesticides for foliar diseases in organically-produced tomato
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

Tomato is an important crop that is routinely affected by diseases. It is important for both organic and conventional diversified vegetable growers, which are common in the northeastern US. Fresh tomatoes picked ripe are one of the most popular local vegetables during summer. Foliar diseases are a common occurrence wherever tomatoes are grown. All plantings are affected, even those grown under protection (greenhouses and high tunnels) and in small home gardens. Foliar diseases need to be controlled in tomatoes to maintain yield. There are several foliar disease affecting tomatoes, including Septoria leaf spot, early blight, bacterial speck, late blight, powdery mildew and leaf mold. Yield is reduced when foliar diseases are not adequately controlled because the pathogen also infects fruit and/or death of infected leaves reduces fruit production and fruit quality, especially flavor. Diseases are often the reason tomato crops are abandoned before the last fruit are harvested. A long harvest period is needed with fresh market tomatoes for retail marketers because of consumer demand. Organic growers on Long Island have identified tomato as a high priority for research. Therefore tomato is a good crop choice to target for biopesticide evaluations. Most biopesticides are approved for organic production.

The experiment was conducted in a field with Haven loam soil that has been dedicated to research on evaluating fungicides on organically-produced crops. Organic fertilizer at 105 lb/A N was spread over rows to be planted, then incorporated. Three products were used each at 700 lb/A: Pro-Grow 5-3-4, Cheep Cheep 4-3-3, and 6-0-6 Cottonseed blend. Next, drip tape was laid as the rows were being covered with black plastic mulch. A living mulch was established between strips of plastic mulch by broadcasting Dutch white clover and annual ryegrass seed with a hand-operated spreader, then lightly raking to incorporate. The living mulch plus weeds that grew were mowed routinely. Some weeds were removed by hand. Tomato variety ‘Jasper’ was selected for this study because it has resistance to late blight and has demonstrated susceptibility to Septoria leaf spot, the primary disease of interest in this experiment. Seeds were sown on 17 May in the greenhouse. Seedlings were transplanted on 21 June by hand into holes opened in the plastic mulch by a waterwheel transplanter that also placed in the holes a starter fertilizer, Neptune’s Harvest Benefits of Fish (2-4-1 N-P-K). Plants were staked and trellised following standard procedure for fresh-market tomato production. Thrips and tomato fruit worms were managed by applying Entrust (8 fl oz/A) on 16 and 23 July. Plots consisted of 10 plants in a single row with 24-in. plant spacing and 68-in. row spacing. There was 5-ft spacing between plots in a row.

A completely randomized block design with four replications was used. Plots for each of the four replications were in two adjacent rows. There was a spreader row planted between replications 1 and 2 also between replications 3 and 4. Foliar treatment applications were made using a CO₂-pressurized backpack sprayer with a boom that has a single twin-jet nozzle (TJ60-11003) delivering 50 gal/A at 54 psi. Each side of the planted row was treated with the boom held sideways to obtain thorough coverage of foliage mimicking a drop nozzle on a tractor sprayer. A preventive 7-day application schedule was used. Applications were made on 16, 20, and 27 August and on 6, 13, 17, and 24 September. Leaves were examined routinely for disease symptoms. All diseases that occurred started from naturally-occurring inoculum. Leaves with Septoria leaf spot collected from an organic farm were put in the canopy of each plot on 28 August to increase the amount of inoculum. Disease severity was assessed by counting number of leaves with symptoms when incidence was low. When symptoms were more common, estimations were made of the percentage of leaves in each plot with symptoms (incidence) and the severity of symptoms on these affected leaves. Canopy severity was calculated with these values. Defoliation was assessed as percent of leaves that had died.

During the 2013 growing season, as rainfall decreased, conditions became progressively less favorable for development of foliar diseases. Symptoms were first observed of Septoria leaf spot on 7 August, of late blight on 28 August, and of powdery mildew on 3 September. No significant differences were detected among treatments in amount of leaves affected by Septoria leaf spot. The biopesticide treatment with the lowest values on the first three assessments was Optiva alternated with Cueva. No significant differences were detected among treatments in amount of leaves affected by powdery mildew. Three biopesticide treatments had low values on the first three assessments: Double Nickle + Cueva, Regalia + Cueva, and Actinovate + Badge X2. Late blight was also assessed to determine if control achieved with the resistant variety was improved by any of the treatments. Few symptoms were found, in contrast with a near-by variety evaluation, and there were no significant differences among treatments.

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Evaluation of fungicides for controlling white mold 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 new fungicides to obtain data to support their registration for white mold (aka timber rot) caused by *Sclerotinia sclerotiorum*. It was conducted in a field with Haven loam soil where a similar experiment was conducted in 2012. A spring cover crop of peas and oats were grown before the experiment was planted. Strips of the cover crop were left to provide a wind break between the tomato rows during June. This field is sometimes used for research on organically-produced crops, therefore organic fertilizer was used. A combination of three fertilizers (Pro-Gro, Cheep Cheep, and 6-0-6 Cotton seed blend) each at 700 lb/A (105 lb/A N total) were spread over the rows to be planted with tomatoes with a 68-inch fertilizer spreader, then they were incorporated. Next drip tape was laid as the rows were covered with black plastic mulch. Seeds of Tomato variety 'Finishline' were sown on 30 April in the greenhouse. Seedlings were transplanted on 5 June by hand into holes opened in the plastic mulch by a Waterwheel transplanter that also placed in the holes a starter fertilizer, Neptune's Harvest Benefits of Fish (2-4-1 N-P-K). Plants were staked and trellised following standard procedure for fresh-market tomato production. Weeds were managed by mowing between rows with a sickle bar mower and removing by hand those weeds that grew next to the tomato plants. The following fungicides with targeted activity for late blight were applied beginning immediately after detection of first symptoms: Ranman (2.75 oz/A) on 17 Aug, Presidio (4 fl oz/A) on 23 Aug, Forum 4.16SC (6 oz/A) on 30 Aug, and Ridomil Gold EC (1/4 pt/A) on 13 Sep. Plots consisted of 10 plants in a single row with 24-in. plant spacing and 68-in. row spacing. There was 8-ft spacing between plots in a row. A completely randomized block design with four replications was used. Treatments were applied as soil drench and foliar sprays. A preventive application schedule was used. Drench applications were made on 20 June and 11 July by pouring 3.38 fl oz of fungicide solution around the base of each plant. Foliar applications were made on 18 July, 29 July, 16 Aug, 28 Aug, 11 Sep, and 24 Sep using a CO₂-pressurized backpack sprayer with a boom that has a single twin-jet nozzle (TJ60-11003) delivering 49 gal/A when operated at 54 psi and 2.5 mph. Each side of the planted row was treated with the boom held sideways to obtain thorough coverage of foliage mimicking a drop nozzle on a tractor sprayer. On two separate occasions, fruit were removed from every plant to encourage foliar growth. Artificial inoculation was used. Frozen ascospores were obtained from Helene R. Dillard, Cornell University, NYSAES, Geneva, NY. They were kept frozen until used. Every other plant was wounded, by breaking branches to provide sites for infection before inoculation; then a water solution of ascospores of *S. sclerotiorum* was sprayed on all plants using a hand-pump sprayer. Inoculation was done four times when rain was expected to provide conditions favorable for infection. Inoculations were made on: 6 Aug, 13 Aug, 27 Sep, and 30

Sep. Plants were examined for symptoms on 15 Aug, 26 Aug, 12 Sep, 17 Sep, 26 Sep, 14 Oct, and 29 Oct. In an attempt to provide favorable conditions for disease development over night, water was applied to foliage late in the day using a tractor sprayer operated at about 65 or 100 gal/A. This was done just before the third inoculation and on several evenings following this inoculation.

Symptoms of white mold were not seen. Conditions were not favorable following inoculations. Ascospore viability and infection likely were compromised after the first inoculation by sunny conditions that occurred afterwards when the forecasted cloudy conditions dissipated. A heavy downpour after the second inoculation probably removed a lot of ascospores that had just been sprayed on the tomato plants. Late summer through fall was an unusually dry period in the area where the study was conducted. There were very few evenings with heavy dew as commonly occurs during fall in this region.

Acknowledgments: Project funded by the IR-4 Program.

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

Tomato is an important crop that is routinely affected by diseases. It is important for both organic and conventional diversified vegetable growers, which are common in the northeastern US. Fresh local tomatoes are one of the most popular items during summer, therefore they are grown by many organic and conventional growers. There are several foliar disease affecting tomatoes, including Septoria leaf spot, early blight, bacterial speck and spot, late blight, powdery mildew and leaf mold. Foliar diseases are a common occurrence wherever tomatoes are grown. All plantings are affected, even those grown under protection (greenhouses and high tunnels) and in small home gardens. Resistant varieties would be a valuable tool for managing these diseases, particularly late blight because it occurs sporadically and can be difficult to control with fungicide applications started after onset. Organic growers on Long Island have identified tomato as a high priority for research. 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 and 2) yield and fruit quality.

The experiment was conducted in a field with Haven loam soil that has been dedicated to research on organically-produced crops since 2001. Organic fertilizer at 105 lb/A N was spread over rows to be planted, then incorporated. Three products were used each at 700 lb/A: Pro-Grow 5-3-4, Cheep Cheep 4-3-3, and 6-0-6 Cottonseed blend. Drip tape was laid as the rows were covered with black plastic mulch. A living mulch was established by broadcasting a combination of annual ryegrass seed and clover seed with a hand-operated spreader between rows of plastic mulch, then lightly raking to incorporate. The living mulch plus weeds that grew were mowed routinely. Some weeds were removed by hand. Tomato seed were sown in an organic seeding mix in the greenhouse on 10 May. Seedlings were fertilized with BioLink 3-3-3 organic liquid fertilizer starting at the one-leaf stage. Seedlings were transplanted by hand on 17 June into holes opened in the plastic mulch by a waterwheel transplanter that also placed in the holes a starter fertilizer, Neptune's Harvest Benefits of Fish (2-4-1 N-P-K).

A completely randomized block design with four replications was used. Plots consisted of 10 plants in a single row with 24-in. plant spacing and 68-in. row spacing. A yellow cherry-type tomato plant (variety Sungold) separated plots within rows. The 13 plots in each replication were arranged in two adjacent rows. Following standard procedure for fresh-market tomato production on Long Island, plants were staked and trellised as they grew using the Florida weave

trellising system with 4-ft stakes placed between plants. Water was provided as needed through drip tape laid beneath the plastic mulch. Thrips and tomato fruit worms were managed by applying Entrust (8 fl oz/A) on 16 and 23 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. No fungicides were applied. Leaves were examined for symptoms of any foliar disease nine times from 31 July to 10 October. Late blight and other diseases observed were assessed by estimating the percentage of leaves in each plot with symptoms (incidence) and the severity of symptoms on these affected leaves. Canopy severity was calculated by multiplying these values. Area Under Disease Progress Curve (AUDPC) was calculated for late blight severity from 6 September through 10 October for all entries. Ripe fruit were harvested on 21 and 30 August, 6, 13, 20, and 26 September, and 10 October. Fruit quality was evaluated by project staff and by public groups. Attributes assessed included appearance, taste, and overall quality rated on a 1-5 scale with 5 being excellent.

Late blight was first observed on Long Island, NY, in 2013 on 25 July in a commercial tomato crop in Riverhead. At LIHREC the first symptoms were observed on 16 August in this experiment. US-23 was the only genotype of the late blight pathogen found in the region in 2013, including at LIHREC.

All entries with *Ph2* and *Ph3* major genes for resistance exhibited good suppression of late blight, confirming results obtained in a similar evaluation in 2012. This was most evident on 12 September. Iron Lady is the only variety with homozygous resistance (*Ph2* and *Ph3* genes from both parents); in contrast with expectation, it was not significantly less severely affected by late blight than the other three varieties with heterozygous resistance (one copy of *Ph2* and *Ph3*) (Mountain Merit, Defiant PHR, and Mountain Magic). Canopy severity of late blight on 12 September was 72% for Mountain Fresh Plus, the susceptible variety included for comparison, and 1-3% for the four resistant varieties. Four entries with unknown resistance also effectively suppressed late blight: Matt's Wild Cherry (0% severity on 12 September), Lemon Drop (6%), Jasper (9%), and Mr Stripey (12%). These were included in the evaluation because they exhibited resistance in other evaluations. Mountain Magic and Matt's Wild Cherry were the most effective of all entries exhibiting resistance. They exhibited 93% and 98% control, respectively, over the entire assessment period (AUDPC values) compared to Mountain Fresh Plus. The entry with just *Ph3*, Plum Regal (homozygous *Ph3*), was effective compared to Mountain Fresh Plus only based on the 6 September assessment (25% versus 79% severity). Both New Yorker (*Ph1*) and Legend OP (*Ph2*) were as severely affected by late blight as the susceptible varieties, which suggests neither *Ph1* nor *Ph2* on their own are effective against US-23, which was the most common genotype of the pathogen in the northeast in 2012 and 2013. Plum Regal and Legend OP provided some suppression in 2012 in an evaluation at this location; however, all plants in that experiment were sprayed five times with organic fungicides labeled for managing late blight.

Few symptoms were observed of powdery mildew and Septoria leaf spot. No significant differences were detected among the entries.

Most tomatoes evaluated produce red slicer-type fruit. The susceptible variety, Mountain Fresh Plus, produced the fewest marketable fruit. Defiant yielded the most fruit among all varieties producing red slicer-type fruit. These varieties did not differ significantly from all of the others. Varieties rated highest for taste (average rating >4) and 'would buy' (>89%) were Jasper, Matt's Wild Cherry, and Mountain Magic. Lemon Drop also was rated high. Among red slicer-types, Defiant and Mt Merit rated similarly high (3.7 for taste and 76-77% would buy).

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Investigating occurrence and assisting growers manage late blight in organically-produced tomato and potato

Investigators: Amanda Gardner and Margaret T. McGrath

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 start applying fungicides after observing symptoms of a disease. 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 is 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. During the 2013 season, four organic farms were scouted on a weekly basis from the beginning of June until the beginning of October. All four farms were located on the North Fork of Long Island, and three of the four were involved with the project in 2012. Compared to the previous four years on Long Island, late blight started to develop later in 2013 with symptoms not observed until mid-summer.

During 2013, the first case of late blight on Long Island was found on July 25 during the weekly scouting visit to Farm 1. At first late blight was only found on a few tomato plants. The grower had been following a late blight preventive spray program, but right before late blight appeared, there was a longer than usual interval between consecutive sprays. The grower felt that this small gap in the spray program might have given the pathogen the window of opportunity it needed to infect the plants. The spray program was also targeting bacterial speck, which had appeared earlier in the growing season. During the weeks that followed symptoms of late blight developed throughout the field. Some varieties became more severely affected than others; none were varieties bred to have resistance to late blight because fruit type, size and quality drive variety selection, and the grower was wary of trying a variety that might not meet customer expectations. This grower was able to achieve adequate control and sufficient yield to satisfy customers by continuing a weekly spray program of copper plus biological fungicides.

Farm 2 was near and east of Farm 1. Thus there was high potential for eastward wind to move spores of the late blight pathogen from Farm 1 to Farm 2. Upon hearing that late blight was in the area, the grower at Farm 2 began to treat his tomatoes with fungicides. Unlike Grower 1, Grower 2 had a combination of both resistant and susceptible tomato varieties in his field, with resistant varieties primarily in later plantings to serve as insurance in case late blight developed. Despite the close proximity of the two farms, late blight was not found at Farm 2 until August 16. Even though the grower continued to spray his fields for late blight, the susceptible varieties became severely infected. The resistant varieties however held up very nicely. The grower reported that even with late blight present, there were plenty of symptomless ripe fruit to harvest. Losses did not occur as in previous years, notable 2009. Another disease detected at this farm was tomato spotted wilt. Plants with this viral disease were found before late blight scattered throughout the field and suffered from stunted growth. This disease, which has been rare on Long Island in recent years, was also reported at several conventional farms in 2013.

Late blight was found at Farm 3 on August 23. At first there was only a few leaf lesions in the older of the two plantings, which had several susceptible varieties. This grower had decided not to use a preventive fungicide program because of the limited occurrence of late blight in 2013 in

contrast with previous years. After learning that late blight was present in his field, the grower decided to apply a copper fungicide hoping to protect the tomatoes primarily in his second planting, which were much healthier overall than plants in the first planting. Unfortunately a part on his sprayer broke and he had to wait for a replacement to come in. By the time he finally got the part, late blight had already spread to the second planting. The tomatoes on these younger plants had not yet reached maturity and the fruit on these plants became infected before they had a chance to ripen. Grower 3 destroyed the plantings. Having none of his own to sell, the grower had to buy tomatoes to stock his own stand. Septoria leaf spot also developed at Farm 3, beginning very early in crop development. Symptoms were found during the first scouting. This disease might have limited production in the first planting.

Both potatoes and tomatoes were grown at Farm 4. The potatoes remained free of late blight the entire season. This grower had a large diversity of both resistant and susceptible varieties of tomatoes, including all available late blight-resistant varieties. This grower uses neem oil to manage late blight and other diseases on plants. Late blight was not found at Farm 4 until October 4. Being that it was so late in the season, late blight did not affect yield. The grower felt that it was a very good year for tomatoes, and due to the unusually mild and dry fall weather, there was an exceptionally long harvest period for tomatoes. Septoria leaf spot also developed at Farm 4, but it was not as severe as at Farm 3.

The four growers differed in their approach to late blight management. Overall Grower 2 had the most success in managing late blight. The combination of resistant varieties and fungicide treatments worked well. Growers 1 and 3, who relied solely on fungicides for late blight management, did not have as good success, especially Grower 3 who did not use a preventive fungicide program and was not able to promptly start applications. The success at Farm 4 cannot be assessed, because late blight was found during the last scouting visit of the season. It is unclear as to whether the fact that late blight was not found there until October 4 was due to the success of the management program or (probably more likely) the physical location and geography of the farm. Taking into consideration what was observed during both the 2012 and 2013 growing seasons it seems that the area does not provide conditions that are conducive to the spreading of spores, perhaps because of the hedgerows that both surround the farm and separate each of the fields. Just the opposite can be said about Farm 1: this area seems to be very favorable for late blight. In 2012 this farm was one of the earliest to get late blight on Long Island. Potatoes have not been grown in these fields on Farm 1, therefore the pathogen is originating off-farm. It might be coming from plants growing from contaminated potato tubers in a near-by garden, field, or cull/compost pile. The topography of Farm 1 might facilitate spore deposition.

Integrated management strategies that utilize both fungicides and resistant varieties are the most successful approach for managing late blight. However the resistant varieties are not always the varieties that customers are seeking. By growing both customer favorites and resistant varieties, growers can have something to fall back on in case fungicide treatments fail to protect the more susceptible customer favorites. Alone, organic fungicide treatments are not highly effective at controlling late blight once the pathogen is present in the field. The most successful spray programs are ones in which applications are made consistently. After the trouble they had with late blight during the 2013 season, both Growers 1 and 3 are considering growing resistant varieties for the 2014 season.

In conclusion, this project was successful. The first detection of late blight on Long Island occurred during the project scouting activity. Scouting can enable detecting a disease early in development when there are few symptoms because of the effort put into thoroughly examining a crop. This detection likely occurred at least a few days before the grower would have found symptoms through less intensive routine crop inspections. Thus this grower and other growers in the region were aware of late blight being present earlier than if the scouting was not being

conducted. An alert was sent to all Long Island growers immediately after detection. The growers and researchers involved in this project gained valuable information about late blight occurrence, development, and management. Knowledge was also gained about other diseases.

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Investigating potential of tomato fruit with late blight to serve as a source of inoculum for volunteer seedlings growing out of these fruit

Investigators: Margaret T. McGrath and Amanda Gardner

Location: Long Island Horticultural Research and Extension Center

The impetus for this project was an outbreak of late blight in a greenhouse for which volunteer tomatoes appeared to be a possible source of the pathogen (*Phytophthora infestans*). An experiment conducted in fall 2011 at LIHREC documented that infection of seedlings (crop ‘volunteers’) is possible when they emerge from tomato fruit with symptoms of late blight. The goal of an experiment conducted in fall 2013 was to continue the research and determine if the results from 2011 were repeatable.

Fruit of eight tomato varieties that were naturally infected with genotype US-23 of *P. infestans* were obtained from a garden and research planting on Long Island. Most fruit were mature (based on fruit color) and had symptoms of late blight. Immature, green fruit were used for one variety. For another variety (SunGold) three types of fruit were used: mature, immature, and mature with no symptoms. These fruit were collected from the same plants. Additionally, seeds were removed using running water to wash them out from symptomatic fruit of two varieties, then replaced with seeds of a commercial seed-lot. This was done to test the hypothesis that *P. infestans* was surviving in the fruit tissue rather than on seeds or in the gel surrounding them. *Phytophthora infestans* is not able to survive tomato seed processing in the USA (it might be able to if it produces oospores, the result of sexual reproduction, which is not known to occur in the USA). Fruit of these 11 treatments were put on a thin layer of potting mix in separate seeding trays. The skin of fruit of larger fruit types was slit with a razor blade because the thicker skin impeded emergence of seedlings in the previous experiment. The fruit were covered with potting mix. Ten treatments were set up on 17 Oct. The last was done on 22 Oct. The trays were placed on benches in a greenhouse with space between to avoid cross-contamination. Water was sprinkled on the potting mix as needed through out the experiment to maintain adequate moisture for seedling germination. Trays were examined weekly for seedling emergence and symptoms of late blight. Seedling that developed symptoms were removed and brought to the laboratory to confirm the symptoms were caused by *P. infestans*. Confirmation was done by using a Phytophthora test kit or by examining the seedlings under a microscope for the characteristic spores of the pathogen before or after incubating them in a moist chamber. Asymptomatic seedlings were transplanted into pots to provide more room for their roots to grow. Only seedlings originating from the same fruit were planted together in a pot. Seedlings growing in thick clusters were gently separated as plants were repotted to minimize disturbance of roots and the fruit tissue. The pots had anywhere from 1 to 31 plants.

The first seedlings to emerge were observed 14 days after putting the fruit in trays. These were SunGold (mature fruit) and Black cherry volunteer seedlings and seedlings of Finishline from commercial seed put in symptomatic fruit. After 14 days, volunteer seedlings had emerged from mature fruit of Wapsipinicon Peach, Black Zebra, and Sakura Honey and green SunGold fruit (confirming the seed were mature although the fruit did not appear to be). Seedlings were observed from mature fruit of Orange Banana on day 26; mature, asymptomatic fruit of SunGold

on day 40; and mature fruit of Juane Flamme on day 89 (these germinated after the soil surface was disturbed and the amount of soil above the fruit was reduced).

Late blight developed on volunteer seedlings of Black cherry, SunGold, Wapsipinicon Peach, and Sakura Honey and seedlings developing from commercial seed put in affected fruit. For all of these, symptoms were first seen 21 to 33 days after setting up the trays and 5 to 19 days after emerged seedlings were first seen. Lower stems turned dark brown on affected seedlings. Most seedlings with symptoms were observed between 12 and 26 Nov. After this period additional symptomatic seedlings were only found growing from fruit of Black cherry and Wapsipinicon Peach. The last affected seedlings were observed on 7 Jan 2014 when the experiment was terminated. Black cherry was the first to develop symptoms; 58% of the 356 seedlings that emerged became affected during the experiment. All 20 seedlings of Sakura Honey became affected. During the experiment, symptoms developed on 13% of the 101 seedlings of SunGold that emerged from ripe fruit, 63% of the 30 seedlings of SunGold that emerged from green fruit, and 32% of the 557 seedlings that emerged from fruit of Wapsipinicon Peach. Of the commercial seed put in affected fruit tissue, late blight developed on 33% of the 3 seedlings emerging from SunGold fruit and 75% of the 36 seedlings emerging from Wapsipinicon Peach fruit. No or very few pathogen spores were observed on seedlings when first removed from the greenhouse; abundant sporulation occurred on seedlings incubated in a moist chamber for at least 24 hours.

No symptoms developed on any of the 40 seedlings that emerged from asymptomatic mature fruit of SunGold, thus these fruit were not latently infected. No symptoms developed on any of the 45 seedlings of Orange Banana or 13 seedlings of Black Zebra. Lack of symptoms on these three indicate that there was no or minimal movement of the pathogen between trays or pots. No seedlings emerged from immature fruit of Finishline fruit. Seedlings did not emerge from fruit of Juane Flamme until near the end of the experiment after the soil surface was disturbed.

In conclusion, *P. infestans* can survive for several weeks in affected tomato fruit tissue that is covered by soil mix and this pathogen can infect volunteer seedlings emerging from this fruit.

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Powdery mildew resistant melon variety evaluation

Investigators: Margaret T. McGrath, Sandra Menasha, and Karen LaMarsh

Location: Long Island Horticultural Research and Extension Center

Powdery mildew is a very common disease that can reduce yield (fruit quantity and/or size) and market quality (flavor, color, storability, etc) in melons. Successful control of powdery mildew in melon is critical to ensure leaves remain healthy until fruit mature and obtain high sugar content, which results in good flavor. The objectives of this variety evaluation, which is part of a multi-year project, were 1) to continue to monitor adaptation in the pathogen that has been reducing the effectiveness of powdery mildew resistance in cucurbit crops, 2) to determine whether varieties with resistance to races 1 and 2 more effectively suppress powdery mildew than varieties with resistance to only race 1, and 3) to evaluate resistance, fruit quality, and yield of new varieties.

The experiment was conducted in a field of Haven loam soil. 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 transplanted by hand into the planting holes on 14 June. 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 primarily in transplant holes. The following insecticides were applied for cucumber beetles: Admire Pro (2.8 fl oz/1000 ft) in the transplant water on 12 June, Hero (10 fl oz/A) on 5 July, and Asana (9.6 fl oz/A) on 10 July. Thrips were managed by applying Entrust (8 fl oz/A) on 18 July, and Radiant (6 fl oz/A) on 29 July. No fungicides were applied to manage powdery mildew. The following fungicides were applied preventively for Phytophthora blight: ProPhyt (3 qt/A) on 16 July, Ranman 400 SC (2.75 fl oz/A) on 18 July and 2 August, Presidio (4 fl oz/A) on 10 August, and Forum (6 oz/A) on 28 July and 18 August. Topsin M (8 oz/A) was applied preventively on 29 July for anthracnose; this fungicide is no longer effective for powdery mildew due to resistance.

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, 22, and 29 July and on 5, 12, 20, and 27 August. 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 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 5 August through 12 August. Ripe fruit were harvested on 13, 20, and 27 August.

Powdery mildew developed naturally. Symptoms were first observed on 15 July. All resistant varieties provided a high level of suppression of powdery mildew as compared to Superstar, the susceptible standard cantaloupe variety with no known genes for resistance. Degree of control obtained ranged from 95% to 100% based on AUDPC values for severity on both leaf surfaces and from 83% to 100% based on severity on 12 August. Eclipse, which has major-gene resistance only to race 1 of the powdery mildew pathogen, was not significantly more severely affected by powdery mildew than all the varieties with resistance to races 1 and 2, suggesting that race 1 was the dominant race present. Varieties resistant to races 1 and 2 also provided excellent suppression in similar experiments conducted in 2011 and 2012, but not in 2010. Eclipse has not always been as effective.

Most of the resistant varieties evaluated produce standard cantaloupe fruit (Eclipse, Athena, Verona, and Majus). Sugar Cube produces small (personal-sized) fruit, SXM 7057 is a canary-type melon, Angelina is a honeydew-type, Inbar is a Galia-type, and Samoa is a Harper-type. Sugar Cube produced the most fruit.

Fruit of Sugar Cube had the numerically highest sucrose concentration (14% Brix) and received the highest taste rating (9). Sucrose content typically is related to taste. Samoa, SXM 7057, and Athena also had good fruit quality (11-12% Brix and taste rating of 7-8). Fruit quality was the worst for Superstar (6% Brix and taste rating of 4 which is fair), which was at least partly due to the impact of unsuppressed powdery mildew on foliage, documenting the importance of managing foliar diseases.

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

Identification of races of the cucurbit powdery mildew pathogen occurring on LI

Investigators: Margaret T. McGrath and Karen LaMarsh

Location: Long Island Horticultural Research and Extension Center

Races of the powdery mildew pathogen affecting cucurbit crops (*Podosphaera xanthii*) are defined based on their ability to infect melon varieties and experimentals with different genes for resistance. These melons are considered to be differentials. It is important to know what races are occurring in order to know what resistance genes are needed to effectively suppress powdery mildew in melons. Ten melon differentials were grown next to the resistant melon variety evaluation described in the previous report. Seeds were put in petri dishes for germination on 7 June. Germinated seeds were transplanted to flats on 13 June in the greenhouse. Seedlings were transplanted on 26 June by hand into holes opened in plastic mulch by a Waterwheel transplanter. Cultural practices were similar to those for the melon variety evaluation (see previous report). Powdery mildew severity was evaluated on both leaf surfaces on 6, 20, and 27 August.

Powdery mildew on 6 August was moderately severe (average severity on upper leaf surfaces of 23-24%) on the susceptible differential variety and the differential with resistance to race 0 in one of the two replicate plantings. Leaves on these plants had died by 20 August. Powdery mildew was slower to develop in the second replication. In contrast, on 6 August, average severity was 2% on the differential with resistance to race 1 (PMR-45), and 0% on the differentials with resistance to race 1 and 2 (PMR-5) and the differential with resistance also to race 3 (MR-1). There was little change in severity on these plants on the other assessment dates. Some powdery mildew was seen on Edisto 47, which is reported to be resistant to races 1 and 2. Symptoms were also seen on PI 414723 and WMR-29.

Based on these observations, race 1 of the powdery mildew pathogen was dominant on Long Island in 2013. A very low percentage of the pathogen population was race 2. These results are similar to those obtained in previous years at this location, indicating that the race structure of the pathogen population has not changed. These conclusions based on powdery mildew occurrence on the differentials explain the high degree of suppression observed with the resistant melons evaluated (see previous report).

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 single-site mode of action for the cucurbit powdery mildew pathogen. 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. The field was plowed on 3 April. Fertilizer (N-P-K, 10-10-10) was broadcast at 500 lb/A then incorporated. Caliente 199 mustard biofumigant cover crop was seeded at 10 lb/A on 5 April. It was flail chopped, incorporated by disking, then the soil surface was sealed with a cultipacker on 18 June, which was at least 3 weeks after flowering commenced. The field was tilled on 25 June to prepare for planting. Pumpkin seeds were planted at approximately 24-in. plant spacing within rows with a vacuum seeder on 27 June. 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 27 June, which was followed by irrigation to activate. During the season, weeds were controlled by cultivating and hand weeding as needed. Cucumber beetles were managed by applying the insecticide Admire Pro (2.8 fl oz/1000 ft) in a narrow band over the planted rows immediately after the herbicide application on 27 June. The

following fungicides were applied preventively for Phytophthora blight and downy mildew: ProPhyt (2 qt/A) on 16 July; Ranman 400SC (2.75 fl oz/A) on 28 July, 3 August, 24 August, and 7 September; Forum (8 oz/A) on 8 August, 14 August, 31 August and 14 September; and Presidio (4 fl oz/A) on 10 and 30 August. Seedlings that developed crown rot symptoms of Phytophthora blight during the second half of July were rogued. No Phytophthora fruit rot or downy mildew was observed in the field. Plots were three 15-ft rows spaced 68 in. apart. The 20-ft distance between plots in the row was also planted to pumpkin, which received some treatment fungicide as the applications were made. Vines that grew into the driveways were re-directed into the plots.

A randomized complete block design with four replications was used. Treatments were applied five times on a 7-day schedule beginning on 6 August 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 weekly on 1, 8, 13, 19, and 26 August, and 4 and 10 September. Initially the examined leaves were selected from the oldest third of the foliage based on leaf physiological appearance and position in the canopy. Mid-aged and young leaves were also assessed beginning on 19 August. At least nine leaves were examined in each plot on each assessment date. 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 19 August through 10 September. Defoliation was assessed on 4 September, 10 September, and 7 Oct. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 17 September and 7 Oct. Handles were considered good if they were green, solid, and not rotting.

Powdery mildew was first observed in this experiment on 1 August in 21 of the 52 plots. Most treatments were 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. Among currently registered fungicides, Pristine (FRAC Code 7 and 11) applied at its highest label rate was effective, providing 94% and 93% control on upper and lower leaf surfaces, respectively, based on AUDPC values. In previous years at this location, pathogen isolates resistant to both components of this fungicide have been detected, and the fungicide has exhibited variable performance including failure in previous evaluations. Procure (FRAC 3) applied at its highest label rate was equally effective (97% and 95% control). Quintec (FRAC 13) was not significantly more effective (99% control on both surfaces). The grower standard program with these fungicides (Quintec, Procure, Quintec, Pristine, Quintec), which was recommended in 2013 in NY along with a protectant fungicide, also performed very well, as did the alternation of Quintec with Fontelis, a recently-registered FRAC 7 fungicide. Similar control was obtained with the three new fungicides at all rates and combinations tested (IKF-309, IKF-5411, and Vivando). Leaves died more slowly in all treated plots compared to the nontreated control, which is important for maintaining solid handles on pumpkin fruit. Based on these results, pathogen strains with resistance to FRAC Code 3 or 7 chemistry were not present at a frequency able to impact efficacy of these fungicides in 2013, in contrast with some previous years.

Fungicide sensitivity of cucurbit powdery mildew pathogen isolates on LI in 2012

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. 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 in September 2012 near the end of the growing season from three research fields and six commercial plantings of pumpkin. They were maintained on leaf tissue on agar media in Petri dishes (culture plates) until 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 on a laboratory shelf under constant light supplied by aquarium bulbs. 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.

Sensitivity to fungicides at risk for resistance development was determined for 55 isolates collected in 2012. Resistance to QoI fungicides (FRAC code 11) was detected in 85% of the isolates tested (not all isolates were tested with this fungicide). Resistance to boscalid (tolerant of 500 ppm boscalid)(FRAC code 7) was detected in 16% of the isolates tested. These isolates came from the three research fields and three of the six commercial plantings. All isolates tested that were sensitive to 500 ppm boscalid were able to grow on leaf disks treated with 100 ppm boscalid. With myclobutanil, the active ingredient in Rally, a DMI (FRAC code 3) fungicide, 13% of isolates tolerated 80 ppm and 45% tolerated 40 ppm. All but one of the remaining

isolates that were tested further were found to be able to tolerate 10 ppm myclobutanil. With quinoxyfen, the active ingredient in Quintec (FRAC code 13 fungicide), 13% of isolates tolerated 80 ppm and 27% tolerated 40 ppm. All of the remaining isolates that were tested further were found to be able to tolerate 10 ppm quinoxyfen. One isolate was insensitive to 80 ppm myclobutanil and to 80 ppm quinoxyfen as well as being fully resistant to boscalid and FRAC Code 11 fungicides. Existence of pathogen isolates like this one with resistance or elevated insensitivity (compared to other isolates) to all labeled fungicide chemistries is a concern for continued effective management of cucurbit powdery mildew with currently-registered fungicides.

Investigation of cross resistance to SDHI fungicides in the cucurbit powdery mildew fungus

Investigators: Margaret T. McGrath and Karen LaMarsh

Location: Long Island Horticultural Research and Extension Center

Succinate dehydrogenase inhibitor (SDHI) fungicides (FRAC code 7) are important for managing cucurbit powdery mildew because their mobility in leaves enables control on the lower leaf surface where the pathogen, *Podosphaera xanthii*, develops best, and due to high potential for resistance development in the pathogen, applying an SDHI fungicide in alternation with other mobile fungicides also at risk for resistance development is recommended for managing resistance. Boscalid, the first SDHI fungicide developed, was registered in 2003. Strains of *P. xanthii* resistant to 500 ppm boscalid were first detected in the US in 2008. This dose is in the range of the field application rate. Boscalid-resistant strains were associated with control failure with the fungicide Pristine, which has boscalid as an active ingredient.

The goal of this study was to determine if sensitivity to new SDHI fungicides was correlated with sensitivity to boscalid (phenomenon called cross resistance). New SDHI fungicides include penthiopyrad (formulated as Fontelis), registered in the US for cucurbit powdery mildew in March 2012, fluopyram (Luna fungicides), registered in February 2012, and fluxapyroxad (Merivon) which has not yet been registered. Knowledge about occurrence of cross resistance is needed to be able to provide growers with sound recommendations about fungicides to use to manage cucurbit powdery mildew.

Isolates of *Podosphaera xanthii* were collected in September 2012 from research and commercial cucurbit crops that had been treated with fungicides to manage powdery mildew. For this study, 14 isolates were selected from this collection based on their previously determined sensitivity to boscalid: half were sensitive and half were resistant (able to grow on leaf disks treated with 500 ppm boscalid). The leaf disk bioassay described in the previous report was used.

Boscalid-resistant isolates were able to grow on disks cut from cotyledon leaves sprayed with 50 and 500 ppm penthiopyrad (formulated as Fontelis) and on disks with 50 and 500 ppm fluxapyroxad (Merivon). These isolates were more sensitive to fluopyram (Luna Privilege), being able to tolerate 10 ppm but not 50 ppm fluopyram. Only one of the seven boscalid-sensitive isolates tested was able to grow on leaf disks treated with 500 ppm penthiopyrad and 500 ppm fluxapyroxad. Most boscalid-sensitive isolates were unable to grow on leaf disks treated with 50 ppm fluxapyroxad or 50 ppm penthiopyrad. Based on these results, fluopyram appears to differ in activity from other SDHI fungicides. Fluopyram is in a different chemical group, pyridinyl-ethyl-benzamide. The other SDHI fungicides tested are carboximides (pyridine-carboximide and pyrazole-carboximide). The structure and shape of the fluopyram molecule differs from that of the carboximides, which enables it to get deeper in the binding site and to bind more tightly than the others (George Musson, Bayer CropScience, personal communication).

Luna fungicides are recommended over other SDHI fungicides for managing powdery mildew in labeled cucurbit crops because fluopyram does not exhibit cross resistance with the other SDHI fungicides. Currently only watermelon is labeled. Until Luna labels are expanded to include other cucurbit crops, either Fontelis or Pristine is recommended used sparingly in a fungicide program with other mobile fungicides in FRAC group 3, 13, and U6.

Demonstration of integrated management program for Phytophthora blight in pumpkin
Investigators: Margaret T. McGrath and Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

The experiment described in a preceding report entitled “Efficacy of fungicides for managing powdery mildew in pumpkin” was conducted in a field where Phytophthora blight occurred on pumpkin in 2012. The management program implemented included growing a mustard biofumigant, using drip irrigation in an effort to minimize occurrence of saturated soils favoring disease onset, subsoiling between rows to improve drainage, weekly applying fungicides with targeted activity for oomycete pathogens, and destroying the first plants affected. A few young plants developed crown rot, perhaps because the drip tape was right next to the plant stem and the soil became saturated around the plant during irrigation. All fruit were examined at the end of the season: no symptoms of Phytophthora fruit rot were found. Phytophthora blight did develop in 2013 in another experiment with cucurbit crops at LIHREC where few management practices were implemented. Several plants died due to crown rot and winter squash rot developed fruit rot.

Efficacy of copper fungicides for managing powdery mildew in zucchini
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 copper fungicides approved for organic production (OMRI-listed) for managing cucurbit powdery mildew. Two conventional copper fungicides, Champ 2F and Cuprofix Ultra 40, were included for comparison. The experiment was conducted in a field in Riverhead on Haven loam soil. Controlled release fertilizer (N-P-K, 15-5-15) at 675 lb/A (101 lb/A of N) was broadcast over the bed area and incorporated on 8 June. Beds were formed with drip tape and covered with black plastic mulch on 11 June. A waterwheel transplanter was used to make planting holes and apply starter fertilizer plus insecticide on 11 June. Seeds were sown on 24 May in the greenhouse. Seedlings were transplanted by hand into the planting holes on 12 June. 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), mowing between plastic strips, and hand weeding primarily in transplant holes. The following insecticides were applied for cucumber beetles: Admire Pro (2.8 fl oz/1000 ft) in the transplant water on 11 June, Hero (10 fl oz/A) on 5 July, and Asana (9.6 fl oz/A) on 10 July. Thrips were managed by applying Entrust (8 fl oz/A) on 18 July and Radiant (6 fl oz/A) on 29 July. No fungicides aside from the treatments were applied to manage powdery mildew. The following fungicides were applied preventively for Phytophthora blight and downy mildew: ProPhyt (3 qt/A) on 16 July, Ranman 400 SC (2.75 fl oz/A) on 18 July and 2 August, Presidio (4 fl oz/A) on 10 August, and Forum (6 oz/A) on 28 July and 18 August. Plots were single rows with eight plants spaced 24 in. apart. Rows were spaced 68 in. apart.

A randomized complete block design with four replications was used. Fungicides were applied weekly starting after powdery mildew symptoms were first observed. Applications were made with a backpack CO₂-pressurized sprayer and a hand-held boom with a nozzle delivering spray over the top of the plant plus two drop nozzles (all TJ60-8006vs) that delivered 50 gal/A when

operated at 55 psi and 2.4 mph. Upper and lower leaf surfaces were assessed for powdery mildew on 8, 15, 22, and 29 July and on 5 and 12 August. 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 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 29 July through 12 August. Fruit was removed from plants to maintain plant growth; yield was not assessed.

Powdery mildew developed naturally. Symptoms were first seen on 8 July in 22 of the 32 plots. Conditions were very favorable for powdery mildew in 2013 at this location. Cueva was the only fungicide that was not effective; however, it was applied at the rate recommended for this use by a company representative, which is a quarter of the highest rate. Cueva is labeled for use at 0.5 – 2 gal/A. There were no significant differences among the copper fungicides tested in terms of suppression of powdery mildew on upper leaf surfaces. Degree of control obtained with the effective fungicides ranged from 40 to 64% based on AUDPC values for severity on upper leaf surfaces. Treatments listed based on AUDPC values starting with the smallest (least powdery mildew) are: Cuprofix Ultra 40 (2 lb/A), NuCop HB (2.66 pt/A), Champ 2F (1.33 pt/A), Basic Copper 53 (2 lb/A), Nordox 75WG (1 lb/A), and Badge X2 (1.25 lb/A). Treatments were ranked in the same order with AUDPC values for both the upper and lower leaf surfaces. Powdery mildew was not suppressed on lower leaf surfaces by any of the copper fungicides, which is not surprising as these are contact fungicides. Lack of control on lower leaf surfaces, where powdery mildew develops best, likely compromised control of this disease on upper leaf surfaces. No phytotoxicity was observed.

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Organic copper fungicides compared for crop safety, residue, and mixing ability

Investigators: Margaret T. McGrath and Karen LaMarsh

Location: Long Island Horticultural Research and Extension Center

There are several different copper fungicides approved for use in organically-produced crops. Copper fungicides are important tools for managing diseases that cannot be effectively managed with cultural practices alone. They have broad-spectrum activity, acting on bacteria as well as fungi. Following many years of use, there is a lot more information on efficacy of copper fungicides than the newer biological products. Manufacturers of some biologicals recommend that they be used in a management program with copper fungicides (often in alternation or at low label rate). Thus it appears copper fungicides will continue to be important for managing diseases especially organically. Copper fungicides differ in their active ingredient, use rate, re-entry interval, and the amount of copper. Copper is an inorganic compound thus it does not breakdown like organic compounds and consequently copper can accumulate in soil when used intensively. Plants take up some copper from soil because it is a micronutrient. Similarly, humans need a small amount of copper in their diets. Metallic copper equivalent (MCE) is a commonly used measure of the quantity of copper in fungicides.

Three experiments were conducted at LIHREC to evaluate three copper fungicides registered recently (Badge, Cueva, and Nordox) applied to three vegetable crops (lettuce, Brussels sprouts, and tomato). The goals of the experiments were to determine whether there were differences among these products in ease of mixing, amount of visible residue on plants, crop safety, and efficacy. They differ in active ingredient, labeled rate, MCE, and REI. All three are OMRI-listed. Cueva was applied at 2 qt/A and Nordox 75WG at 1 lb/A to all crops. Badge X2 was applied at 0.75 lb/A to Brussels sprouts and at 1.75 lb/A to the other crops. They were compared with a standard organic copper fungicide, Basic Copper 53 applied at 4 lb/A to tomato and 3 lb/A

to the other crops, which are the maximum-label rates. The rate used was the maximum label rate for the crop or the rate recommended by the manufacturer. Maximum rate for Cueva is 2 gal/A and for Nordox it is 1.25 lb/A for lettuce, 2 lb/A for crucifer crops, and 2.5 lb/A for tomato. Amount of residue was assessed by applying these four fungicides at least three times on a weekly interval to plots of tomato, lettuce (Romaine and butterhead), and Brussels sprouts in three adjacent replicated experiments. The later two crop types were also examined for injury from the treatment. Applications were made using a CO₂-pressurized backpack sprayer with a boom that has a single twin-jet nozzle (TJ60-11003) calibrated to deliver 50 gal/A when operated at 54 psi and 2.4 mph. The boom was held over the top of the lettuce plants to deliver spray down on the plants similar to a standard boom sprayer. To obtain thorough coverage of foliage and fruit of tomato and Brussels sprouts, the boom was held sideways, perpendicular to the ground, thereby mimicking a drop nozzle on a tractor sprayer. Applications were made to lettuce on 28 August and on 5, 11, and 19 September; to Brussels sprouts on 30 August, and 5, 11, and 19 September; and to tomato on 30 August, 5 and 11 September.

Procedures used to establish and maintain the plots were as follows. Controlled release fertilizer was spread with 2-row fertilizer spreader over rows to be covered with plastic. A 15-5-15 blend was used at 800 lb/A product (120 lb/A N) for Brussels sprouts and 675 lb/A product (100 lb/A N) for tomato. Two blends with faster nitrogen release were compared for lettuce. They provided 120 lb/A N, 68 lb/A P, and 100 lb/A K. Beds were formed with drip tape and covered with black plastic mulch. Herbicide was applied between the plastic. A waterwheel transplanter was used to make planting holes and apply starter fertilizer. Tomato and Brussels sprouts seeds were sown on 5 May in the greenhouse. Seedlings were transplanted by hand into the planting holes on 7 June. The plots consisted of 8 plants in a single row with 24-in. plant spacing and 68-in. row spacing. Lettuce seeds were sown on 9 July in the greenhouse. Seedlings were transplanted by hand into the planting holes on 2 August. The plots consisted of two adjacent rows of 13 plants of each variety on each bed with 9-in. plant spacing and 68-in. spacing between beds. During the season, water was provided as needed via drip irrigation lines.

Clear plastic bottles were used to prepare the fungicide solutions for application, which facilitated observations on mixing ability. The bottles were filled with the quantity of water needed, next the product was added, then the container was shaken before spraying. Cueva was observed to mix most readily into water, none of the product settled to the bottom of the container. In contrast, vigorous shaking was required with Basic Copper 53 to get product that settled into solution. NuCop was similar, but it was not as difficult to loosen settled material. After spraying, there was no residue of Cueva visible on the inside of the bottle. More time was needed for clean up with Basic Copper 53 and Nordox 75WG because both left residue on the inside of the bottle.

The copper fungicides tested also differed in amount of visible residue on plants and occurrence of injury to treated plants (crop safety). The most residue was observed on leaves of all crop types (tomato, lettuce and Brussels sprouts) and on tomato fruit on plants treated with Basic Copper 53. Less residue was observed on plants treated with Nordox (red color) or Badge; neither was consistently better across all crops. Cueva left the least amount of residue. Nordox caused the most injury to lettuce and Brussels sprouts; Basic Copper 53 caused slightly less injury; Badge caused much less injury; while Cueva caused very little damage. All products affected the Butterhead lettuce variety much more severely than the Romaine.

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 Karen LaMarsh
Location: Long Island Horticultural Research and Extension Center

Cucumbers, squashes, melons and pumpkins were grown in sentinel plots 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. This activity is also being done every growing season as part of the national forecasting program for cucurbit downy mildew.

To ensure leaf tissue for infection was present throughout the growing season, seedlings were transplanted into plots at two times, on 5 June and 10 July. Only fungicides with targeted activity for powdery mildew were applied. Leaves were examined routinely for symptoms.

Symptoms of downy mildew were first observed on cucumber on 22 July. This cucurbit type is susceptible to all pathotypes thus it is expected to be affected first. Symptoms were observed on muskmelon on 6 August, on butternut squash on 16 August, on giant pumpkin (*Cucurbita maxima*) on 19 August, and on watermelon and acorn squash on 10 September. Thus pathotypes of the pathogen able to infect all cucurbit crop types were detected on LI in 2013.

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

The cucurbit downy mildew (CDM) pathogen, being an obligate parasite, cannot survive without live host tissue. Every year, the pathogen is re-introduced into northern states via spores that are dispersed long distances by wind currents from sub-tropical regions in southern Florida. Current disease observations and forecasts of the pathogen's movement are predicted by the CDM ipmPIPE forecasting website (cdm.ipmpipe.org). The CDM ipmPIPE was established to provide growers with management oriented information, such as disease forecasts that are based upon the current epidemic status and forecasted weather conditions, to help them make decisions on management of CDM. Forecasts are available as interactive maps that depict the risk of infection in specific locations along predicted pathways of spore transport.

To validate that forecasts are projecting real-time movement of spore dispersal, rainwater samples are being collected from several locations and analyzed for presence of CDM. Collecting was started in 2013 and will continue through 2015. Rainwater will be collected from eight different states: New York (at LIHREC), Alabama, Georgia, Louisiana, North Carolina, Ohio, Pennsylvania and South Carolina after each rain and sent to North Carolina State

University for processing. Collection buckets will be located near actively scouted cucurbit fields. Presence of CDM spores within rainwater will be correlated to the first onset of symptoms within the field.

In 2013, a total of 71 rainwater samples were collected from 7 states (NY, AL, GA, NC, OH, PA, SC), of which 14 samples were from LIHREC. LIHREC's rainwater collection bucket was located near the sentinel plots and samples were obtained from 6 June to first symptoms on 22 July. Currently, molecular diagnostic approaches are being developed to quantify the number of spores in the rainwater samples. These quantified spore numbers will eventually be related to the timing of disease onset in the sentinel plots as a final step in the validation process.

Population biology and ecology of cucurbit downy mildew pathogen, *Pseudoperonospora cubensis*, in eastern United States

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

It has been widely proposed that the source of inoculum for cucurbit downy mildew infections in the northern states is the overwintering sources in sub-tropical locations in southern Florida. Thus, every year, the pathogen is thought to be re-introduced into northern states during periods of strong southerly winds. However, there is no direct biological evidence to support the hypothesis of the pathogen overwintering in southern Florida. Thus, the objective of this study is to test the hypothesis by examining genetic differentiation and diversity among isolates collected in eastern US. A second objective is to see if we can identify an association between specific pathogen phenotypes (e.g., pathotype or fungicide resistance) and molecular markers that would help to predict the phenotype of any given isolate.

Isolates from different cucurbit host types including cucumber, cantaloupe, butternut squash, acorn squash and giant pumpkin were collected from throughout the eastern US including at LIHREC in 2012 and 2013. A total of 9 isolates were collected from LIHREC. DNA has been extracted from 5 isolates that were originally collected from diverse host types (Single lesion isolates) in Long Island. SNP markers will be used in our subsequent analysis to see if we can trace back the source of inoculum to southern Florida or elsewhere. We are now in the process of extraction of SNPs from the collected isolates. The results of this study may help us identify the source of inoculum for infection in the southeast, northeast and the Great Lakes regions.

Examination of new downy mildew resistant cucumbers

Investigator: Margaret T. McGrath and Karen LaMarsh

Location: Long Island Horticultural Research and Extension Center

Observational (non-replicated) plantings of experimental varieties of cucumber with new sources of resistance to downy mildew were included with the downy mildew sentinel plots at LIHREC for the national forecasting program for cucurbit downy mildew (cdm.ipmpipe.org). The varieties examined included two developed by Cornell plant breeders (Michael Glos, Michael Mazourek, and Bill Holdsworth). Breeders at Seminis (Monsanto Vegetable Seeds) are the first to release new slicer-type cucumber varieties described as having new resistance to downy mildew: SV3462CS and SV4719CS. These two plus four new experimental varieties from Seminis were examined in 2013. Marketmore 97 was also examined because in Dr. Mazourek's experiments in Geneva, NY, this variety has exhibited moderate resistance, performing better than other cucumber varieties bred to be resistant to previous strains of the downy mildew pathogen present in the USA before 2004. Also included was a PI accession that is a source of

new resistance to downy mildew (PI 197088). There were two plantings of the cucumbers at the same time as the two plantings of the sentinel plots.

Symptoms of downy mildew were first found on 22 July in the first planting (transplanted on 5 June) on Straight Eight, the cucumber variety included in the planting that has no known genes for resistance to downy mildew. Severity remained low until 6 August when 70% of the foliage of Straight Eight was estimated to have symptoms. At that time severity was still low (below 3%) on all resistant cucumbers. On 14 August, severity was 80% for Straight Eight, 45% for SV3462CS, 40% for SV4719CS, 20% for Marketmore 97, while only 1% for Cornell experimentals (NY13-601 and DMR-NY264) and PI 197088. Leaves severely affected by downy mildew died. On 26 August, defoliation was 70% to 100% for the first four varieties while at most 15% for NY13-601 and DMR-NY264. These experimentals exhibited excellent resistance through the last assessment on 23 September when severity was 14% for NY13-601 and 0% for DMR-NY264 and PI 197088.

In the second planting (transplanted on 10 July), symptoms of downy mildew were first found on 30 July on Straight Eight. Severity remained low until 14 August when 55% of the foliage of Straight Eight was estimated to have symptoms. Severity then was low for all the downy mildew resistant cucumbers: 0% for DMR-NY264 and PI 197088, 4% for Marketmore 97, and 7% to 14% for the new Monsanto experimental varieties (SV8592CS, SV4220CS, SV4941CS, and SV7887CS). Foliage remained healthy through the last assessment on 23 September only on plants of NY13-601 and DMR-NY264. All the other plants were defoliated at that time.

Level of suppression of downy mildew achieved with the genetic resistance in NY13-601 and DMR-NY264 appeared to be better than that achievable with chemical control. More symptoms of downy mildew were observed on fungicide-treated cucumber plants in an adjacent fungicide evaluation experiment that included new and current downy mildew fungicides (see next report).

Efficacy of fungicides for managing downy mildew in cucumber

Investigators: Margaret T. McGrath and Karen LaMarsh

Location: Long Island Horticultural Research and Extension Center

The experiment objectives were to 1) evaluate new mobile fungicides (Zampro and GWN-10126) with targeted activity for the type of fungus causing downy mildew and 2) examine the efficacy of Presidio. Presidio was one of the most effective fungicides for downy mildew in cucurbit crops; however, it has exhibited poor to no control in several fungicide efficacy experiments in the eastern US recently, suggesting that resistance has developed. Downy mildew is an important disease affecting cucumbers every year on LI. Other cucurbit crops are also often affected depending on the pathotype of the pathogen that occurs. Foliage can be killed quickly in the absence of management, leading to loss of yield and/or fruit quality.

The experiment was conducted in a field in Riverhead, NY, on Haven loam soil. 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 June. Beds were formed with drip tape and covered with black plastic mulch on 20 June. A waterwheel transplanter was used to make planting holes in the beds and apply starter fertilizer (20-20-20 Nutri-Leaf) plus insecticide on 24 June. Seeds were sown on 24 May in the greenhouse. Seedlings were transplanted by hand into the holes in the beds on 25 June. During the season, water was provided as needed via drip irrigation lines. Weeds were managed between mulched rows by applying a tank mix of Strategy (3 pt/A), Sandea (0.5 oz/A), Scythe (1%), and Roundup WeatherMAX (22 oz/A) on 21 June, and by hand weeding especially in the transplant holes. Cucumber beetles were managed with Admire Pro (7.5 fl oz/A) applied with the transplanter on 24 June. Plots were single 18-ft rows with 12 plants at 18-in. spacing. Rows

were 8.5 ft apart. The plots were 9 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 5 weeks beginning on 18 July, one day after symptoms were first observed, using a backpack CO₂-pressurized sprayer equipped with a single-nozzle boom and an 8006VS nozzle delivering 50 gal/A operated at 54 psi and 2.4 mph. It was intended that the treatments be applied on a preventive schedule. Downy mildew severity was assessed on 23 and 30 July and 6, 14, and 19 August 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 30 July through 19 August.

Downy mildew developed naturally in this experiment. Treatments were started 1 day after symptoms were first seen. Presidio was ineffective at all assessments. GWN-10126 was the most effective of the three oomycete fungicides evaluated singly. It was the only treatment providing effective suppression at the last assessment on 19 August. Zampro and the grower standard program were also effective based on the 14 August assessment. Degree of control achieved with these three treatments at that time was 63% to 75%. Zampro is a new fungicide not yet registered in NYS that contains the active ingredient in Forum plus a new ingredient targeting downy mildew fungi. The grower standard program was an alternation among mobile fungicides (Ranman, Forum, Presidio) tank mixed with Bravo.

Evaluation of fungicides and biopesticides for managing downy mildew in basil

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. New and currently registered fungicides for organic and conventional production were evaluated.

The experiment was conducted in a field with Haven loam soil. 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 8 July. Beds were formed with drip tape and covered with black plastic mulch on 9 July. Weeds between mulch strips were managed early in the season with Devrinol DF-XT (2 lb/A) applied before transplanting and then by mowing. A waterwheel transplanter was used to make planting holes in the beds and apply starter fertilizer on 10 July. To provide a source of natural inoculum within the experimental area, basil was transplanted into a spreader row on 5 July before transplanting the plots. The spreader row was on the west side of the experiment with rows of sorghum-sudangrass planted earlier to the west of the spreader row to provide a more favorable environment for downy mildew to become established by creating shade and blocking air movement, thereby promoting a more humid area. These plants were not inoculated. Sweet basil (variety 'Italian Large Leaf') for the experiment was seeded on 14 June in trays in a greenhouse, placed outdoors to harden, then transplanted 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 had 13 plants in 10-ft rows on black plastic mulch with 9-in. plant spacing. The plots were 5 ft apart in the row. Fungicides were applied weekly on a preventive schedule. Applications were made with a

backpack CO₂-pressurized sprayer and a hand-held boom operated at 55 psi and 2.4 mph. A boom with a single TJ60-8006vs nozzle delivering 50 gal/A was used on 7 and 14 August when basil plants were small. A boom with a nozzle delivering spray over the top of the plant plus two drop nozzles (all TJ60-8006vs) delivering 50 gal/A was used when plants were larger on 21 and 28 August and on 5 and 13 September. Downy mildew was assessed in each plot every week beginning on 6 August. The percentage of leaves per plant with symptoms (sporulation of the pathogen visible on the underside) was estimated for 10 plants in each plot. Two of the last disease assessments were done on plants removed from plots to be able to obtain a thorough examination of the underside of leaves. Plants were removed on 13 September and 1 October, assessed, then held in plastic bags at ambient temperature until reassessed on 16 September and 4 October to examine impact of disease development during the time from harvest through purchase. Area Under Disease Progress Curve (AUDPC) values were calculated from 23 August through 25 September.

Downy mildew developed naturally. Symptoms of downy mildew were first observed on 6 August in 4 of the 48 plots. Foliar fungicide applications were started the next day. Incidence of leaves with downy mildew was assessed rather than severity because any amount of symptoms renders a leaf unmarketable. Downy mildew was not suppressed by products suitable for organic production: a program with currently registered fungicides (Regalia soil drench followed by foliar applications of Actinovate alternated with Trilogy) and a fungicide in development (Bioguard applied to soil and foliage). The other biopesticide tested, ProPhyt, a phosphorous acid fungicide, was effective based on the last assessments. The most effective conventional fungicide treatments consisted of a soil drench of ProPhyt or Regalia followed by foliar applications of Zorvec, a new fungicide in development. Based on AUDPC values, the level of control obtained with these two treatments was 90% and 91%. These treatments were not significantly better than Zorvec used alone (76% control) or than foliar treatments with Zampro (84%), Revus (81%), or Ranman (72%). Ranman applied in alternation with a new biopesticide product, Fracture, was not as effective as the best treatments (42%). Presidio was ineffective. These five fungicides are registered in the USA; only Ranman is labeled for use for basil downy mildew at this time. Treatments might have been more effective if applied on a preventive schedule as intended. However, this study documents the difficulty of effectively managing downy mildew in basil with fungicides. The destructive assessment procedure was not useful because affected leaves were more likely than healthy leaves to drop off plants during harvest, transport out of the field, and holding until the subsequent assessment, which skewed the results.

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

Assessment of downy mildew susceptibility in basil cultivars, breeding lines, and crosses in New York, 2013.

Investigators: Margaret T. McGrath and Karen LaMarsh

Location: Long Island Horticultural Research and Extension Center

The goal of this experiment was to compare susceptibility of several spice types of basil, Rutgers breeding lines, and crosses made by project collaborators working on developing resistant varieties at Rutgers. This experiment was next to the basil experiment described in the previous report. The same production practices and assessment procedures were used. Basil for the experiment was seeded on 14 June in trays in a greenhouse, placed outdoors to harden for a few days, then transplanted on 23 July. Rooted cuttings prepared by the collaborators at Rutgers were used for a few entries.

Symptoms of downy mildew were first observed on 7 August in eight of the 84 plots. Downy mildew became severe on DiGenova, which was included in the experiment to serve as a standard susceptible variety of sweet basil for comparison. On 5 September, an average of 75%

of leaves on DiGenova plants had symptoms, while in sharp contrast, there were six entries that had only 0 – 10% incidence. Among these six were basil varieties identified at Rutgers as having good levels of resistance to use in a breeding program and two crosses made with one of these (Spice) and a sweet basil *Fusarium* resistant line. Compared to DiGenova, reduction in disease incidence over the entire assessment period, measured by Area Under Disease Progress Curve (AUDPC) calculated for all assessments, was 43 – 97% for the five Rutgers crosses evaluated. AUDPC values for the three least susceptible spice types were 99.3 – 99.7%. Through this experiment it was documented that some lines being used to breed downy mildew resistant sweet basil exhibit a very high level of resistance under environmental conditions on Long Island, and a good to excellent level of resistance is being obtained in crosses produced at Rutgers. The degree of control of downy mildew achieved with plant resistance was on the order of that achieved in the adjacent experiment with two of the treatments with the most effective new fungicide.

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

Evaluation of downy mildew-resistant basil varieties in New York, 2013.

Investigators: Margaret T. McGrath and Karen LaMarsh

Location: Long Island Horticultural Research and Extension Center

The objective of this experiment was to evaluate six sweet basil experimental varieties developed by Enza Zaden seed company. This experiment was next to the basil experiments described in the previous two reports. The same production practices and assessment procedures were used. These plants were transplanted on 23 July.

Symptoms of downy mildew were first observed on 7 Aug in six of the 28 plots. All plots had symptoms on 16 Aug. One of the six experimental varieties (BA104) exhibited resistance to downy mildew based on incidence of leaves with symptoms. This is a stringent measurement for resistance; however, any amount of downy mildew on a leaf can render it unsalable for fresh market. BA104 had numerically fewer affected leaves at all assessments. The difference was significant on 19 September when an average of 41% of leaves of BA104 had symptoms versus 65% for DiGenova, which was used as the susceptible comparison variety. Reduction in disease incidence for the entire assessment period, measured by AUDPC, was 28%.

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

Monitoring program for downy mildew occurrence in basil in the USA

Investigators: Margaret T. McGrath

Location: Long Island Horticultural Research and Extension Center

Downy mildew is a new disease of basil in the USA. It was first detected in FL in Oct 2007. There were several reports in the eastern USA in 2008, including on Long Island. A monitoring program was started in 2009 to obtain information on occurrence each year in the US, to determine whether this pathogen can move northward through the eastern USA in a traceable manner, as occurs with the cucurbit downy mildew pathogen, and to assist growers be prepared for downy mildew occurrence in their basil crop by providing information on where the disease is occurring. Monitoring also will assist with determining whether seed is becoming a less important source, as expected.

Each year a spreadsheet accessible by anyone has been set-up in Google Docs. The link is posted in an article about the disease, which is also up-dated annually. It is at <http://vegetablemendonline.ppath.cornell.edu/NewsArticles/BasilDowny.html>. In addition to date

and location of the occurrence, growers and gardeners making reports have often included information about the occurrence and management experience, all adding to knowledge about this new disease. Those reporting are asked to include their e-mail address. As part of the SCRI project supporting this activity, everyone reporting has been contacted to obtain more information and provide assistance with diagnosis to confirm the report. The monitoring program has resulted in samples being obtained for another researcher on the project for his investigation of biodiversity in the pathogen. There were 64 reports posted in 2013. These documented occurrence of basil downy mildew in the USA in CA, CT, DC, FL, IL, LA, MA, MD, ME, NH, NJ, NY, OH, RI, SC, TN, VA, VT, WI, and WV. This disease likely occurred in other states as well. A report was also made from Australia.

Downy mildew is now recognized to be established in the USA and is anticipated to continue occurring every year on Long Island and elsewhere. The need to apply fungicides to control downy mildew has forced a change in the production of a crop that rarely needed pesticide applications previously.

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

Unusual disease occurrence associated with atypically dry fall weather

Investigator: Margaret T. McGrath

Location: Long Island Horticultural Research and Extension Center

Powdery mildew developed on lettuce in both research fields with this crop at LIHREC. Symptoms were first seen on 9 October. Both varieties being grown were affected: Romaine variety Ideal Cos and Boston variety Adriana. The disease developed rapidly. Leaves became covered on both surfaces with characteristic white growth of powdery mildew. Symptoms developed on most leaves. Plants were full grown (at marketable size), which is when powdery mildew is reported as most likely to occur in lettuce. This disease had not been observed on Long Island or in upstate NY during the past 25 – 40 years (*personnel communication*, T. Zitter, G. Abawai, and J Lorbeer). Conditions were unusually dry and warm during fall 2013. The typical heavy fall dews were rare. Powdery mildew develops on lettuce more commonly in Arizona when conditions are warm and dry. The pathogen causing powdery mildew on lettuce, *Golovinomyces cichoracearum*, also infects some weeds and cucurbit crops, but this fungus has very rarely been found to be the one causing powdery mildew on cucurbit crops on LI when examined. Microscopic examination of spores is needed to distinguish this fungus from *Podosphaera xanthii*, the primary pathogen causing powdery mildew in cucurbits. Powdery mildew may have developed on lettuce in 2013 because conditions were atypically favorable for the pathogen and/or because a strain of the pathogen able to infect lettuce was present in 2013.