Long Island Vegetable Pathology Program
2004 Annual Research Report

Margaret Tuttle McGrath

Plant Pathology and Plant-Microbe Biology, Cornell University
Long Island Horticultural Research and Extension Center
3059 Sound Avenue, Riverhead, NY 11901
mtm3@cornell.edu

POWDERY MILDEW OF CUCURBITS: OCCURRENCE OF FUNGICIDE RESISTANCE ON LONG ISLAND

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Application of fungicides continues to be the principal practice for managing powdery mildew in pumpkin, but successful control is challenged by development of resistance to key fungicides. There are very few varieties with genetic resistant to this disease. Powdery mildew is the most common disease occurring every year throughout Long Island. The pathogen develops best on the lower surface (e.g. underside) of leaves, thus a successful management program necessitates controlling the pathogen on the lower as well as the upper surface. It is difficult to directly deliver fungicide to the lower surface, even with new nozzle types and air assist sprayers. Consequently, an important component of fungicide programs has been fungicides able to move to the lower leaf surface. Most of these fungicides are systemic (e.g. Topsin M, Nova) or have translaminar activity (e.g. Flint, Amistar, Quadris). Some, notably the new fungicide Quintec, have high volatility enabling redistribution from upper to lower leaf surfaces.

Unfortunately, these fungicides effective on lower leaf surfaces have been prone to resistance development due to their single-site mode of action. Additionally, the cucurbit powdery mildew fungus has demonstrated ability to evolve new strains resistant to these fungicides often due to changes in their metabolic pathways where the fungicide acts on the pathogen. Presence of resistant strains has been associated with control failure. With some fungicides, including benzimidazoles (e.g. Topsin M), this change renders the pathogen strain completely resistant to the fungicide (qualitative resistance). With other fungicides, including the DMI (demethylation inhibiting) fungicides (Bayleton, Nova, and Procure), pathogen strains exhibit a range in fungicide sensitivity depending on the number of genetic changes they possess that affect the fungicide's ability to function (quantitative resistance).

To use fungicides at-risk for resistance wisely, growers need to know the proportion of the pathogen population that is resistant before the first application and how much the population changes with use. The goal of this project was to determine the proportion of resistant strains at the start of powdery mildew development on Long Island before QoI or DMI fungicides were used on cucurbit crops and to examine the impact of applying these fungicides on frequency of resistance.

In 2002, resistance to strobilurin or QoI (quinone outside inhibiting) fungicides (Flint and Quadris) was detected on Long Island and several other sites in the US for the first time. Resistance was qualitative. In 2003, QoI resistant strains were shown to be present at a low level at mildew onset, their frequency increased greatly during the season, efficacy was affected, and they occurred in pumpkin crops not treated with QoIs. Strains with moderate resistance to DMI fungicides were also present.

Fungicide resistance was monitored on Long Island during the 2004 growing season using the seedling bioassay that was used in 2003. Squash seedlings were treated with fungicide (Flint, Nova, Topsin M), then placed with non-treated seedlings in a production field with powdery mildew for 4 hours to overnight. Two concentrations of Nova were used for the second bioassay because DMI resistance is quantitative. Isolates able to tolerate 20 ppm Nova are considered to have a moderate level of DMI resistance. The higher concentrations (40 and 80 ppm) have been tolerated by few isolates tested previously. The seedlings were kept in a greenhouse until symptoms of powdery mildew were visible, which took at least one week. Then severity (percent tissue with symptoms) was visually estimated for each leaf. Frequency of resistant pathogen strains in a field was estimated by calculating the ratio of severity on fungicide-treated plants relative to non-treated plants for each group, then determining the field average.

For the first assay, seedlings were placed on 29 Jul in spring plantings of squash and in pumpkin fields that had not been sprayed with fungicides at high-risk for resistance development. Resistance to QoIs was found, often at a high level, in all 8 fields. Moderate resistance to DMIs and resistance to benzimidazoles was also common in all fields. In the 7 commercial production fields, an average of 44% of the pathogen population (range of 15% to 84%) was resistant to QoI fungicides, 66% (32-91%) were moderately resistant to DMIs, 40% (1-64%) were resistant to both QoIs and DMIs, and 69% (31-91%) were resistant to benzimidazoles. Powdery mildew was evidently at too low a level in the research field at LIHREC to obtain sufficient infection of seedlings to obtain a definitive estimate of the frequency of resistance; however, resistance to all 3 classes of fungicides was detected.

The assay was conducted in pumpkin fields on 20-21 Aug. Strains able to tolerate a high concentration of Nova (80 ppm) were detected in 1 field. Resistance to QoIs and benzimidazoles and moderate resistance to DMIs were common.

In conclusion, strains of the powdery mildew fungus with resistance to QoI fungicides, with moderate resistance to DMI fungicides and/or with resistance to benzimidazole fungicides were common before these fungicides were used on Long Island in 2004. Resistance to benzimidazole fungicides has evidently persisted in the pathogen population despite their reduced use. Based on results from 2004 and from previous years, neither QoI nor benzimidazole fungicides are recommended for managing powdery mildew in cucurbits. Since pathogen strains have been detected that are able to tolerate high concentrations of DMI fungicides, these fungicides should be used at a high label rate in a fungicide program for managing resistance.

POWDERY MILDEW OF PUMPKIN: EVALUATION OF CURRENTLY REGISTERED FUNGICIDES AND NEW FUNGICIDES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Fungicide programs for managing powdery mildew need to be evaluated yearly because fungicides continue to be the primary tool used to manage this important disease, changes in pathogen resistance to key fungicides affect their efficacy, and new fungicides are being developed and registered. The fungicide program recommended to growers in 2004 was Quintec, which was granted 24c registration in NY, plus a protectant fungicide applied in alternation with a DMI fungicide (Nova) plus a protectant fungicide beginning after detecting disease at the IPM threshold and continuing on a weekly basis.

Most treatments evaluated in 2004 were similar to this program in that they were also based on the recommendations to alternate among fungicides at-risk for resistance development and to tank-mix these at-risk fungicides with protectants, some included fungicides not yet registered in NY. The protectant used was Microthiol Disperss (sulfur) because it has been the most effective protectant for powdery mildew on both upper and lower surfaces in previous experiments. Two other products examined have federal registration and hopefully will be registered in NY before the next growing season. Procure is a DMI fungicide like Nova, but it has more active ingredient (50% versus 40%) and is labeled at a higher rate. Procure can be applied at up to 8 oz/A, which provides 4 oz/A of a.i., while the highest rate of Nova is 5 oz/A, providing only 2 oz/A a.i. Pristine contains a new systemic active ingredient, boscalid, as well as the QoI pyraclostrobin.

The semi-bush pumpkin 'Appalachian' was direct-seeded on 1 Jul. As for previous experiments, treatments were initiated after the IPM threshold of one leaf with powdery mildew symptoms of 50 old leaves examined was reached. Upper and lower (under) surfaces of 5 to 25 leaves in each plot were examined weekly for powdery mildew. Average severity for the entire canopy was calculated from the individual leaf assessments. Area under the disease progress curve (AUDPC) was calculated for severity over all assessment dates (9 Aug – 13 Sep) to obtain a summation value for the entire epidemic. Fungicides were applied weekly (on 11, 18, and 24 Aug; and 1, 7 and 14 Sep) with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 85 gpa at 100 psi. Sixteen isolates were collected for fungicide sensitivity testing on 9 Aug from nontreated plots, and on 23 Aug and 23 Sep from nontreated plots and plots treated with Procure and Quintec or Flint. Their sensitivity to QoI and DMI fungicides was assessed using a leaf disk bioassay.

Flint (2 oz/A) tank-mixed with sulfur (4 lb/A Microthiol Disperss) and applied in alternation with Procure (8 oz/A) plus sulfur effectively controlled powdery mildew on pumpkin through the end of August. By the 13 Sep assessment, control on the underside of leaves had dropped to 69% compared to 93% where a similar program was used with Quintec substituted for Flint and 98% where Quintec was applied alone on the same dates. Quintec will never be recommended as a stand-alone product because it is at-risk for resistance development. It was tested alone to assess its efficacy. Control at that time was 87% with Pristine (14.5 oz/A) plus sulfur applied in alternation with Nova (5 oz/A) plus sulfur. This degree of control was not significantly different from that obtained with Procure and Quintec. In contrast, control observed in several commercial pumpkin fields on Long Island in 2004 was very poor on lower leaf surfaces despite the fact growers had used Nova as well as Quintec under a 24c crisis exemption. Since control was excellent on upper leaf surfaces, application timing was good. Poor control was at least partly due to a delay in the first application of Quintec as product was not available when powdery mildew was first observed. Excellent control was reported elsewhere in NY. Powdery mildew cannot be effectively controlled when fungicide applications are started after the disease is established. Based on AUDPC values, which summarize severity over the entire season, control on the lower surface of leaves was significantly more effective when block applications of Procure and Quintec were used than when a strict alternation was used (88% versus 98%). The block application schedule was Procure + sulfur (week 1, 4, 5), Quintec + S (week 2,3), and sulfur alone (week 6).

Strains of the powdery mildew pathogen resistant to fungicides were present at the start of the experiment, became more common following fungicide use, and likely affected efficacy. Of the 14 isolates tested from nontreated pumpkins on 9 Aug before treatments were started, 14% were resistant to QoI fungicides and 79% were moderately resistant to DMIs. On 23 Aug, frequency of QoI-resistant strains was 20% in plots receiving the block alternation schedule of Procure and Quintec while it was 44% in nontreated plots, 45% where Procure and Quintec were alternated weekly, and 71% where Procure was alternated with Flint. Frequency of isolates moderately resistant to DMIs for these treatments was 80%, 69%, 73%, and 94%, respectively. On 23 Sep, frequency of QoI-resistant strains was 43%, 44%, 60%, and 80%, respectively, and frequency of moderately DMI-resistant strains was 93%, 94%, 90%, and 100%. Most QoI-resistant strains (92%) were also moderately resistant to DMIs. Four of the 123 isolates tested tolerated Nova at 50 ppm ai. Presence of resistant strains likely affected efficacy of QoI and DMI fungicides.

While not as effective as the treatments with conventional fungicides based on AUDPC values, Vigor-K applied weekly with 0.5% SprayTech oil did suppress powdery mildew well on both upper and lower leaf surfaces (71 and 65% control, respectively). Vigor-K is a product developed to improve plant disease defense ability by Agro-K Corporation.

POWDERY MILDEW OF BUTTERNUT SQUASH: EVALUATION OF EXPERIMENTAL FUNGICIDES COMPARED TO PROGRAMS WITH NEW AND REGISTERED PRODUCTS

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

The objective of this experiment was to compare two experimental fungicides of high priority for the IR-4 program, which funded the work, to current and future grower standard fungicide programs. The IR-4 program uses information from experiments such as this to support registration of new pesticides on minor use crops, which includes all vegetables. The current US standard fungicide program consisted of a DMI fungicide (Procure) tank-mixed with a protectant fungicide (sulfur formulated as Microthiol Disperss) and applied in alternation with a QoI fungicide (Flint) plus sulfur. These fungicides were federally registered for this use in the US at the time of the study; Procure was not registered in NY. Control with this program was anticipated to be compromised by QoI resistance based on results from 2003. Therefore a future program was also included with Quintec substituted for Flint. At the time, Quintec had a federal label for other crops and was granted a 24c registration in NY.

Squash was grown on black plastic mulch with a clover living mulch between the rows of plastic. Black plastic mulch and drip irrigation were laid on 12 May. Dutch white clover (11 lb/A) was drilled at 7-in. row spacing in the driveways between plots on 12 May and seed was hand-spun on 14 May over the approximately 32-inch-wide bare soil strips between the plastic strips after smoothing the soil with a rototiller. Greenhouse-grown seedlings of Waltham butternut were transplanted on 23 Jun. Weeds were managed by applying the herbicides Sandea to the entire field before transplanting and Round-up Ultra over the clover between plastic, and hand-removal.

Applications were made weekly (27 Jul; 4, 11, 18, 24, and 30 Aug; and 6 Sep) with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 85 gpa at 100 psi. Upper and lower surfaces of 5 to 50 leaves in each plot were examined for powdery mildew approximately weekly from 26 Jul through 15 Sep. Area under the disease progress curve (AUDPC) was calculated for severity over all assessment dates to use as a disease summation value.

Powdery mildew remained substantially less severe in this experiment than in previous experiments conducted at this location with Waltham butternut squash due at least partly to the occurrence of downy mildew and perhaps also due to the fungicides used to manage it. Severity on nontreated plants, while higher than all other treatments, remained less than 1% on the upper surface of leaves, and on the lower surface it averaged only 6% on 30 Aug and 23% on 15 Sep. Treatments were started early in powdery mildew development: 1 day after symptoms were observed in 25 of 28 plots on only 66 of the 1400 older leaves examined. There were significant differences in powdery mildew severity among treatments on 10 Aug, when powdery mildew was more severe on squash receiving the current standard program than on squash receiving any other treatment. Resistance to QoI fungicides was shown to be common on Long Island at the start of powdery mildew development through another project. There were no significant differences between the two grower standard programs. Both experimental fungicides (Japanese material NF-149 and Valent's V-10118) applied at the higher rate were significantly more effective than the two grower standard programs based on AUDPC values. There were no significant differences between the experimental fungicides applied at the higher rate. Defoliation rated in Sep may have been partly due to downy mildew. There were no significant differences among treatments in average fruit weight, number of fruit, or total weight of fruit.

In conclusion, two experimental fungicides have been documented to have excellent efficacy for powdery mildew of cucurbits.

POWDERY MILDEW OF PUMPKIN: EVALUATION OF BIOPESTICIDES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

A highly effective protectant fungicide is an important element of a fungicide program for managing fungicide resistance and powdery mildew. Protectant fungicides are needed because they control pathogen strains resistant to high-risk fungicides and, since they have low resistance risk, they will reduce the impact on control when resistance develops to other fungicides being used. There are numerous products available to choose from.

The objective of this study was to evaluate several protectants that are also biopesticides, as defined by EPA, used alone and integrated in a program with conventional fungicides for powdery mildew in pumpkin. The focus was on 6 plant oil products because good control was achieved with a mineral oil (JMS Stylet-oil) in previous experiments conducted at LIHREC. Most are OMRI listed and/or exempt from EPA registration. A hydrogen dioxide product was also tested. Sulfur (Microthiol Disperss) and chlorothalonil (Bravo Ultrex) were included as conventional protectant fungicides for comparison. Combination fungicide programs were tested that included fungicides shown previously to provide excellent control on lower leaf surfaces: Procure is systemic and Quintec redistributes very well due to its high volatility. The 'conventional grower standard program' was Quintec tank-mixed with Microthiol Disperss and applied in alternation with Procure + Microthiol Disperss. This is a future standard since Quintec was available in 2004 through Section 18 registration and Procure was registered federally but not yet in NY.

Biopesticides evaluated:

1. Bugitol. 0.42% Capsaicin and related Capsaicinoids, 3.7% Allyl Isothiocyanate. Champon Millennium Chemicals.
2. Eco E-RASE. 97.50% Jojoba Oil. OMRI listed. IJO Products.
3. GC-3 Organic fungicide. 30% Cottonseed Oil, 30% Corn oil, 23% Garlic extract. Exempt from EPA registration. OMRI listed. JH Biotech, Inc.
4. JMS Stylet-oil. 97.1% paraffinic oil. OMRI listed. JMS Flower Farms, Inc.
5. Organocide. Active ingredients=5% sesame oil; inerts = 92% fish oil + 3% emulsifiers. Exempt from EPA registration. Organic Laboratories, Inc.
6. OxiDate. 27% hydrogen dioxide. BioSafe Systems.
7. Sporan. Active ingredients=17.6% Rosemary Oil; Other Ingredient = 82.4% Wintergreen Oil. Exempt from EPA registration. OMRI listed. EcoSmart.
8. Trilogy. 70% clarified hydrophopic extract of neem oil. Certis USA L.L.C.

The semi-bush pumpkin 'Appalachian' was direct-seeded on 2 Jul. As for previous experiments, treatments were initiated after the IPM threshold of one leaf with powdery mildew symptoms of 50 old leaves examined was reached. Upper and lower (under) surfaces of 5 to 50 leaves in each plot were examined weekly for powdery mildew. Average severity for the entire canopy was calculated from the individual leaf assessments. Area under the disease progress curve (AUDPC) was calculated for severity over all assessment dates (6 Aug to 16 Sep) to obtain a summation value for the entire epidemic. Fungicides were applied weekly (on 6-7, 12, 19, and 25 Aug; and 1, 6 and 12 Sep) with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 85 gpa at 100 psi.

The 'conventional grower standard program' provided excellent control of powdery mildew on upper and lower leaf surfaces as anticipated. Severity on 16 Sep was numerically lower than all other treatments; AUDPC value for mildew on lower leaf surfaces was significantly lower than all other treatments. All botanical oils tested provided some control of mildew on upper leaf surfaces. GC-3 organic fungicide, Organocide and Eco E-Rase were as effective as Microthiol Disperss, JMS Stylet-oil, (mineral oil) and Bravo Ultrex. GC-3 was the most effective product based on its AUDPC value for mildew on lower leaf surfaces being significantly lower than three other products (Trilogy, Sporan and Bugitol). Microthiol Disperss provided good control. Mildew severity on upper surfaces was not significantly different from the 'grower standard'; however, mildew was significantly more severe on lower surfaces beginning with the 3 Sep assessment. At the last assessment on 16 Sep, severity on lower surfaces was not significantly different from that on nontreated pumpkins. JMS Stylet-oil also provided good control. Mildew was often numerically more severe than on pumpkin treated with Microthiol Disperss; however, these differences were not significant. Bravo Ultrex also provided good control. Although mildew usually was numerically more severe than on pumpkin treated with Microthiol Disperss or JMS Stylet-oil, these differences were not significant. Trilogy and Bugitol effectively controlled mildew on upper leaf surfaces for the duration of the experiment. However, severity on lower surfaces was not significantly different from the nontreated control on 3 and 16 Sep or for the AUDPC value. Bugitol may have been more effective if the first application had been made 4-5 days earlier when most other treatments were started. Sporan and the hydrogen dioxide product, OxiDate, were effective against powdery mildew based on severity being significantly less than the nontreated for the IPM schedule on 23 Aug. However, the rate and treatment schedules used did not provide full season control. According to the Sporan label, addition of an approved adjuvant is required to improve spreading and sticking. Perhaps Sporan would be more effective when used with the recommended adjuvant, ThermX 70, which was not available when the experiment was conducted, rather than NuFilm P. Control of powdery mildew on lower leaf surfaces obtained with Microthiol Disperss, Trilogy, or OxiDate was improved by tank-mixing these products with Quintec or Procure for the first three applications. Improved control was evident through 3 Sep, 15 days after the last tank-mix application. Mildew was more effectively controlled on lower leaf surfaces with the 'conventional grower standard program' which included Quintec or Procure in all seven applications. Canopy condition generally corresponded to level of powdery mildew control. One notable exception is that Bravo-treated pumpkins had the least defoliation. This was likely due to additional control of downy mildew.

In summary, the hydrogen dioxide product and all botanical oils tested provided some control of mildew on upper leaf surfaces. GC-3 organic fungicide, Organocide and Eco E-Rase were as effective as Microthiol Disperss, JMS Stylet-oil, (mineral oil) and Bravo Ultrex. These are suitable for organic production as well as conventional.

Project partly funded by the IR-4 Biopesticide Demonstration Grant Program.

POWDERY MILDEW OF PUMPKIN: EVALUATION OF COMPOST TEA AND BIOFUNGICIDES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

The goal of this project was to evaluate foliar treatments suitable for managing powdery mildew in organically-produced pumpkins. Products tested included the biofungicides Sonata (*Bacillus pumilus*) and Serenade (*Bacillus subtilis*), copper hydroxide formulated as Champion, and mineral oil formulated as JMS Stylet-oil. All are registered for use in the US. All but Sonata have been approved by OMRI for organic production. To assess the level of control achieved with these treatments, there were also nontreated pumpkins in this experiment and a conventional fungicide program of Quintec plus sulfur (Microthiol Disperss) applied in alternation with Procure plus Bravo. All treatments were evaluated on pumpkin variety Appalachian. Compost tea was also tested on powdery mildew resistant (PMR) Hobbit. At this time compost tea cannot legally be used for disease control as it is not a NYS registered pesticide. Thus this part of the work is strictly for research purposes.

Pumpkins were grown in black plastic mulch with a clover living mulch between the rows of plastic. Black plastic mulch and drip irrigation were laid on 12 May. Dutch white clover (11 lb/A) was drilled at 7-in. row spacing in the driveways between plots on 12 May and seed was hand-spun on 14 May over the approximately 32-inch-wide bare soil strips between the plastic strips after smoothing the soil with a rototiller. Greenhouse-grown seedlings were transplanted on 25 Jun. Weeds were managed by applying the herbicides Sandea to the entire field and Round-up Ultra over the clover between plastic before transplanting, and hand-removal.

Compost tea was applied separately from the other treatments beginning 16 Jul, 3 weeks after transplanting and before powdery mildew was observed. Fungal-based compost (4 lb dairy manure-based vermicompost and 4 lb leaf-based compost) was brewed with 12 oz Fertrell Liquid Kelp, 4 oz fish hydrolysate (Organic Gem Liquid Fish 3-3-3 or Neptune's Harvest Benefits of Fish 2-4-1), and 16 oz humic acid (Fertrell Bio-Hume) for about 24 hour in a 60-gal Sotillo brewer. Compost tea was filtered, Nu-Film-P (6 oz/A) and fish hydrolysate (1 oz/30 gal) were added, then it was applied undiluted to foliage on 16, 23, and 29 Jul; 4, 11, 17, and 25 Aug; and 1 and 8 Sep. To minimize potential damage to microbes in the compost tea, it was applied at low pressure (40 psi) using a nozzle with a large orifice that causes little resistance (FloodJet). Most applications were made before 10 am. Samples of the leaf-based compost, tea, and leaves were submitted to the Soil Foodweb Laboratory in Port Jefferson, NY, for analysis of the organism biomass content. Compost samples were submitted on 28 Apr and 8 Sep. Samples of the tea were collected on 8 Sep from the brewer and from the spray nozzle. The two samples were collected to determine if the spray nozzle had a detrimental impact on the microbes. Leaves were collected before and after tea was applied on 8 Sep to assess the delivery and deposition of microbes.

Fungicide treatments were started after the IPM threshold of one leaf with powdery mildew symptoms of 50 old leaves examined was reached in most plots (27 Jul). Treatments were applied weekly with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 85 gal/A at 100 psi (27 Jul; 4, 11, 18, 24, and 30 Aug; and 6 Sep). Upper and lower surfaces of 5 to 50 leaves in each plot were examined weekly for powdery mildew beginning when fruit were starting to enlarge. Average severity for the entire canopy was calculated from the individual leaf assessments. Area under the disease progress curve (AUDPC) was calculated for severity over all assessment dates (26 Jul to 15 Sep). Canopy condition was assessed on 1 and 9 Sep. Number of plants that appeared dead and quality of fruit handles were assessed on 15, 22, and 30 Sep and 6 Oct. Yield was determined.

Powdery mildew was first observed on 26 Jul in 19 of 36 plots of susceptible Appalachian on only 71 of the 1800 older leaves examined. Symptoms also were found at that time in 1 of 8 plots (4 of 400 leaves) of PMR Hobbit. Powdery mildew became moderately severe. Neither Sonata nor compost tea suppressed powdery mildew when used alone. Compost tea also did not significantly improve control achieved with the PMR variety. Based on the analysis of tea prepared on 9 Sep, fungal activity was low (0.91 and 0.45 ppm for tea from brewer and nozzle, respectively) while active bacterial biomass was in a good range (16 and 54.4 ppm, respectively), thus the tea is considered bacterial with good fungal biomass. The leaf-based compost had very high fungal activity before the experiment was started (99.8 ppm on 28 Apr); it was only 36.8 ppm on 8 Sep. Active bacterial biomass increased from 47.8 ppm in April to 69.4 ppm in Sep. The leaf organism assay revealed that leaf coverage with bacteria and fungi was inadequate on leaves collected immediately before tea application. Leaves collected about 1 hour after tea was applied were 61% covered by bacteria and 5% covered by fungi, which is considered adequate. A tea with more fungal activity may be needed to suppress powdery mildew. Effective control with compost tea may necessitate modifying application timing, such as applying late in the day and/or starting earlier in crop development, perhaps including a seed treatment. Compared to nontreated pumpkins, powdery mildew was significantly less severe on pumpkins treated with both compost tea and either Sonata, Serenade, or JMS Stylet-oil. Based on AUDPC values, level of control was 50-71% on upper leaf surfaces and 47-57% on lower leaf surfaces. Champion was as effective as the standard program of Quintec + sulfur (Microthiol Disperss) alternated with Procure + Bravo. Control was 84% and 88%, respectively, on upper leaf surfaces based on AUDPC values and 65% and 80% on lower leaf surfaces (these numbers are not statistically different).

Sonata applied with Champion did not improve control over that obtained with Champion alone. The four treatments providing the best control of powdery mildew (both treatments with the PMR cultivar, standard fungicide program, and Champion) had less defoliation, fewer dead plants, and more fruit with solid handles on all assessment dates (select data shown). On 6 Oct, there were 1-2.25 dead plants for these treatments and 2.5-5.5 for the other treatments. There were no significant differences in average fruit weight among treatments for each cultivar (data not shown), which were 4.7 lb for nontreated Hobbit, 7.3 lb for compost tea-treated Hobbit, and ranged for Appalachian from 12.1 lb for nontreated to 14.2 lb for Sonata + Champion treated plants. Among treatments tested on Appalachian, average weight of fruit exceeded 15 lb/plant (data not shown) for the 3 with the lowest AUDPC values: standard program, Champion, and Sonata + Champion. No phytotoxicity was observed.

Project partly funded by the IR-4 Biopesticide Grant Program.

POWDERY MILDEW OF CUCURBITS: DETERMINATION OF PATHOGEN RACE

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Differential melon genotypes were grown near the powdery mildew experiments to determine which races of the pathogen were present. Topmark is susceptible to all races. PMR-45 is resistant to race 1 and PMR-6 is resistant to races 1 and 2. Seedlings were transplanted into black plastic mulch on 23 Jul.

Powdery mildew developed on both Topmark and PMR-45, but not on PMR-6; therefore, both race 1 and race 2, but not race 3, occurred in 2004. Similar results were obtained in previous years. Therefore melon varieties with resistance to both race 1 and race 2 are needed to effectively control powdery mildew.

POWDERY MILDEW OF CUCURBITS: EVALUATION OF POWDERY MILDEW RESISTANT PUMPKIN AND WINTER SQUASH VARIETIES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

A nested statistical design was used with variety nested in crop and five replications. Plots were single rows of 8 plants at 30-in. spacing. A plant of the gourd Turk's Turban was planted between each plot. This gourd was shown previously to be very susceptible to wilt due at least partly to it being highly attractive to cucumber beetles which vector the bacteria that cause wilt. Each row contained a replication. Seedlings were started in the greenhouse on 25 May and transplanted into black plastic mulch on 8-9 Jun.

The primary goal of this experiment was to determine whether heightened bacterial wilt susceptibility found previously in 2 powdery mildew resistant (PMR) pumpkin varieties was associated with PMR and came from crosses to incorporate PMR into pumpkin and squash (both are *Cucurbita pepo*); therefore, in addition to PMR pumpkins and squashes from a diversity of plant breeders, 3 entries were the *Cucurbita moschata* line with PMR and 2 segregating populations derived from the *C. moschata* line. Segregating population #1 is the first cross of the *C. moschata* line with *C. pepo* (*C. moschata*-*C. pepo*). Segregating population #2 is the first backcross (*C. pepo*-*C. moschata*). Plants were examined routinely for cucumber beetles and symptoms of wilt. While cucumber beetles were present from 28 Jun, and many Turk's Turban plants died due to wilt, symptoms remained at too low a level in the pumpkins and squashes for meaningful comparison.

The other goal of this experiment was to evaluate several PMR varieties grown under a reduced-fungicide program with applications made about every 14 days. Nova + Bravo Weather Stik were applied on 23 Jul and 20 Aug, and Quintec + Bravo Weather Stik or Flouronil (2 lb/A) on 8 and 26 Aug. Upper and lower surfaces of 5 to 25 leaves in each plot were examined for powdery mildew on 27 Jul, 3 Aug, and 25 Aug. Fungicides were applied because an integrated program is recommended for slowing selection of pathogen strains able to overcome PMR or able to resist the action of the fungicides, and also because with some PMR varieties control of powdery mildew has been improved by applying fungicides on a 14-day schedule. Powdery mildew colonies were counted; severity was assessed when colonies could not be counted accurately. Average severity for the entire canopy was calculated. Mature pumpkin fruit were harvested from 4 replications and weighed on 13, 15, 20, and 24 Sep. Squash fruit were harvested on 1 Oct.

Among the pumpkins evaluated, best season-long suppression of powdery mildew on both upper and lower leaf surfaces was obtained with both of the Cornell University lines evaluated (NY01-609 and NY01-605A), an experimental from Harris Moran Seed Company (HMX 2689), and Harris Moran's Magician. Severity of powdery mildew was also low on the *C. moschata* line and the 2 segregating populations. Other PMR entries with significantly less powdery mildew on lower leaf surfaces than both Sorcerer and Howden, the susceptible varieties included for comparison, were Touch of Autumn, both lines from Brent Loy at the University of NH (NH1755A and NH1771A), Gold Bouillon, 3 experimentals from Rupp Seed (03RPX763, 03RPX764, and RPX 03515), Merlin, and Hobbit. Magic Lantern, Rupp experimental RPX 03516, and an experimental from Meyer Seed International (MSX6009) did not have significantly less severe powdery mildew than Sorcerer and Howden.

Fruit weight varied significantly among the pumpkins evaluated. Listed in order by fruit size were Touch of Autumn (average fruit weight of 2 lb with the largest fruit weighing 3.8 lb), NY01-605A (3.3 and 7.1 lb), NH1771A (4.3 and 14.4 lb), Hobbit (5.7 and 12.5 lb), NH1755A (9.1 and 13.8 lb), Merlin (9.6 and 16.6 lb), NY01-609 (9.8 and 19.0 lb), Magician (11.1 and 16.5 lb), RPX 03515 (11.4 and 18.6 lb), Sorcerer (11.7 and 23.8 lb), Magic Lantern (11.8 and 19.6 lb), Gold Bouillon (12.0 and 26.2 lb), HMX 2689 (12.6 and 21.1 lb), RPX 03516 (13.0 and 27.3 lb), MSX6009 (13.3 and 30.6 lb), 03RPX763 (13.7 and 23.4 lb), 03RPX764 (15.2 and 25.4 lb), and Howden (15.3 and 28.3 lb). Number of fruit produced per plant also varied significantly. Howden and Merlin averaged only 1.5 fruit/plant. At least 3 fruit/plant were produced by NY01-609, NY01-605A, RPX 03516, Hobbit, and Touch of Autumn. Rupp experimental 03RPX764 was the most popular among growers and others who selected their top 3, MSX6009 was second, and Sorcerer was third. Other pumpkins receiving high ratings were Howden, Magic Lantern, Magician, and HMX 2689.

Both PMR acorn-type winter squashes, Cornell University line NY98-768-7L and Royal Acorn PM, were significantly less severely affected than Table Ace on lower leaf surfaces. Fruit weight did not vary significantly among these squashes, averaging 1.5 lb. Royal Acorn PM produced significantly more fruit than the others (6.9 vs 3.8 and 4.9 fruit/plant, respectively).

EVALUATION OF COMPOST AS A FERTILIZER SOURCE AND FOR MANAGING PHYTOPHTHORA BLIGHT IN PUMPKIN

Investigator: M. T. McGrath and D. D. Moyer
Location: Long Island Horticultural Research and Extension Center

A long-term study was started in 2001 to examine the benefits of yearly soil amendments of commercially-available composts for improving soil health and managing diseases as well as the utility of compost as a source of nutrients to reduce chemical fertilizer inputs. Compost has been shown to be effective for suppressing several soilborne plant diseases. In 2004 we examined one of our main goals, evaluating yearly compost amendments over a 3-year rotation out of susceptible crops for managing Phytophthora blight in pumpkin. Research is being done where blight occurred in 1991 to 1993, 1995 to 1999, and 2001.

Each June since 2001 compost has been spread on the 8 amended plots at a rate of approximately 45 wet tons/A (20 dry tons/A) with a Millcreek compost spreader, then hand-raked as needed to obtain even distribution before disking to incorporate the compost up to about 6 in. depth. Plots are 28.3 ft wide and 45 ft long with at least 20 ft between plots that were end-to-end. Phytophthora blight occurred on pumpkin in this field in 2001 despite the use of a brewery-waste compost of higher microbial activity than the yard-waste compost that was ineffective in previous experiments at LIHREC. Compost was applied about two weeks before seeding pumpkin in all 3 experiments. The goal of the 2004 experiment was to determine if compost applied over 4 successive years in a field planted to non-host crops for 2 years (sweet corn in 2002 and snap bean in 2003) would be beneficial for suppressing Phytophthora. When the 2003 experiment was initiated snap bean was not recognized as a host of *P. capsici*. However, no symptoms of blight or above ground indications of root rot were observed. The hypothesis tested in 2004 is that microbes in compost or soil microbes that utilize compost as a food source include those that can biologically control the pathogen *Phytophthora capsici* through competition or antagonism, and that several years of compost amendments are needed to increase the concentration of these microbes in the soil such that they have a controlling effect on the pathogen. Soil samples from these plots in fall 2003 revealed that compost-amended plots had greater activity of microbes that decompose cellulose than non-amended plots.

Composted yard waste was obtained in 2004 from Long Island Compost Corp in East Moriches, NY. Based on nutritional analysis performed by the University of MA Soil and Plant Tissue Testing Laboratory, the compost was 1.28% N (10.2 lb/yd^3) and thus was anticipated to provide 50 lb/A of N assuming 10% availability. Therefore on 16 Jun 04, 500 lb/A of 10-10-10 fertilizer (50 lb/A of N) was broadcast over compost plots and 1000 lb/A was applied to non-compost plots. Compost was spread on 17 Jun, followed by disking. Pumpkin was seeded in the plots on 23 and 24 Jun. Fungicides were applied as needed for downy and powdery mildews. The field was irrigated when soil was dry due to inadequate rainfall. It also was irrigated (approx. 0.25 in.) on 15, 16, and 17 Sep to provide conditions favorable for Phytophthora blight. Plots were examined routinely for symptoms of Phytophthora blight. Fruit rotting due to Phytophthora and other causes were counted on 13 Oct, 20 Oct, and 1 Nov. Yield was determined on 1 Oct by measuring length and width of all mature fruit. Weight was estimated for these fruit using a regression equation developed by measuring and weighing representative fruit.

Conditions were dry during most of the 2004 growing season and thus not conducive for Phytophthora blight. Daily rainfall exceeded 0.5 in. on only 5 days in Aug and Sep: 1.1, 0.62, 0.88, 2.15, and 3.84 in. on 15 Aug, 16 Aug, 21 Aug, 18 Sep, and 29 Sep, respectively. The first symptoms observed were fruit rot on 4 Oct. The earliest observation of Phytophthora blight in all research fields at LIHREC in 2004 was 2 Sep in another pumpkin experiment. There were no significant differences between treatments in proportion of fruit with Phytophthora fruit rot or rot of any type, which included black rot, bacterial soft rot, and Phytophthora-like symptoms lacking sporulation. Variation was high among plots for both treatments. For example, proportion of fruit in a plot with Phytophthora fruit rot on 1 Nov averaged 23% for non-amended plots (range of 0 to 67%) and 20% (2 to 48%) for compost-amended plots. Phytophthora fruit rot reached substantially higher incidence in this experiment compared to all other pumpkin experiments at LIHREC in 2004, and occurrence was more widespread in this field. There were no significant differences between treatments in yield despite the fact that compost-amended plots had more green leaves than nontreated plots late in the growing season.

Therefore, while compost soil amendments have not proven useful for managing Phytophthora blight, compost has proven useful as a partial replacement for chemical fertilizer.

PHYTOPHTHORA BLIGHT OF SQUASH: EVALUATION OF CURRENTLY REGISTERED FUNGICIDES AND NEW FUNGICIDES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

On 8 Jul, 16-day-old seedlings of 'Sunray', a powdery mildew resistant variety of yellow summer squash, were transplanted into bareground in a field where Phytophthora blight has occurred previously. Plots were 20-ft long with 10 plants in a single row. Herbicides Strategy and Sandea were applied on 9 Jul, then activated by irrigating lightly; Poast and Sandea were applied on 26 Jul. Hand-weeding was done as needed. Treatments were applied weekly beginning before first fruit reached marketable size (7, 12, 19, and 26 Aug; and 2, 8 and 15 Sep) with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 95 gal/A at 125 psi. Plants were examined routinely for symptoms of Phytophthora blight. About once a week fruit that had reached marketable size were removed and discarded between plots. Pumpkin fruit with Phytophthora fruit rot were placed on 2 and 14 Sep among squash plants in the south buffer end of the field beyond the plot area since blight had not been observed on any squash plants in plots. The field was overhead irrigated on 3, 14, 16, 17, and 23 Sep to disperse *Phytophthora* spores and provide conditions favorable for disease development. Strong winds with tropical storms on 10 and 18-19 Sep damaged plants.

Conditions were dry during most of the 2004 growing season and thus not conducive for Phytophthora blight. Daily rainfall exceeded 0.5 in. on only 5 days in Aug and Sep: 1.1, 0.62, 0.88, 2.15, and 3.84 in. on 15 Aug, 16 Aug, 21 Aug, 18 Sep, and 29 Sep, respectively. Symptoms were first observed in this field on 7 Sep on squash plants outside the experiment area. On 23 Sep tip blight was observed in plots. There were no significant differences in percent of plants with symptoms of tip blight on 27 Sep. There was substantial variation among plots. Incidence was 61% (range of 0-100%) for nontreated, 33% (0-677%) for VCP, 48% (22-83%) for Kocide 2000 + Manex applied in alternation with Acrobat + Kocide, 49% (0-90%) for Tanos (10 oz/A) + Kocide + Manex applied in alternation with Acrobat + Kocide, 69% (27-100%) for Tanos (8 oz/A) + Kocide + Manex applied in alternation with Acrobat + Kocide, and 72% (18-100%) for New Phos Blend. VCP and New Phos Blend are products developed to improve plant disease defense ability by Agro-K Corporation. Acrobat has a federal registration for Phytophthora blight. Tanos has a federal registration for Phytophthora blight only in peppers. Neither fungicide has been registered yet in NY.

PHYTOPHTHORA BLIGHT OF PEPPER: EVALUATION OF CURRENTLY REGISTERED AND NEW FUNGICIDES ON SUSCEPTIBLE AND PHYTOPHTHORA-RESISTANT VARIETIES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Two experiments with pepper were conducted adjacent to another fungicide evaluation experiment conducted on summer squash in a field where Phytophthora blight has occurred previously. Pepper seedlings started in the greenhouse on 29 Apr and 1 May were transplanted into bareground on 17 and 21 Jun. Plots were 10-ft long with 16 plants in offset double rows. There was a row of plants of Susceptible pepper variety Camelot extending through the center of the field to serve as a spreader row where blight could be encouraged.

On 22 Jun soil treatments were made in an 8-in band to each side of the double row using a CO_2-pressurized backpack sprayer with a single nozzle boom equipped with an 8002E even flat fan nozzle operated at 60 gpa and 20 psi. The field was irrigated afterwards to incorporate. Foliar treatments were applied weekly (23 Jul, 4, 12, 19, and 26 Aug; 2 and 13 Sep) or bi-weekly with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 95 gal/A at 125 psi. Plants were examined routinely for symptoms of Phytophthora blight. Conditions were dry during most of the 2004 growing season and thus not conducive for Phytophthora blight. Pumpkin fruit with Phytophthora fruit rot were placed on 2 Sep among pepper plants in the south buffer end of the field beyond the plot area since blight had not been observed on any pepper plants in plots, then the field was irrigated to disperse *Phytophthora* spores and provide conditions favorable for disease development. Leaf spots caused by *Phytophthora* were observed on a few pepper plants on 10 Sep. Affected plants were more numerous in the south buffer area on 14 Sep when affected leaves and fruit were collected from these plants and placed on plants in the spreader row, then the field was irrigated. A tropical storm on 18 Sep delivered 2.15 in. of rain providing conditions favorable for Phytophthora blight. Most plants in the spreader row developed blight symptoms by 27 Sep. More pumpkins with Phytophthora fruit rot were placed between plots on 27 Sep. Another storm on 29 Sep delivered 3.84 in.

Susceptible pepper variety Camelot was used in the experiment that entailed evaluating treatments of Ridomil Gold and/or Prophyt made after transplanting followed by 4 foliar applications of Ridomil Gold Copper applied every 14-day alone or with Prophyt. Symptoms of Phytophthora blight were first observed on plants in this experiment on 27 Sep. Symptoms were not present throughout the experiment until 13 Oct. On both 13 and 26 Oct, leaf spots and stem cankers were only found in nontreated plots, suggesting that all treatments evaluated were effective and provided control for more than a month after the last application.

Paladin, a pepper variety with resistance to the crown rot phase of Phytophthora blight, was used to evaluate 4 foliar fungicide programs involving Tanos and 5 fungicide programs with Ridomil Gold after transplanting followed by foliar fungicide treatments with experimental fungicides. Varying concentrations of Tanos were tank-mixed with Manex plus Kocide 2000 and applied in alternation with Manex tank-mixed Kocide 2000. The grower standard programs included for comparison were Manex plus Kocide 2000 applied weekly and Ridomil Gold Copper applied in alternation with Manex plus Kocide. Although Phytophthora blight became severe on Camelot plants in the spreader row and in the buffer area, no symptoms were observed on any Paladin plants, including those that were not treated with fungicides and those next to affected Camelot plants. This documents the value of using resistant varieties to manage Phytophthora blight.

ORGANICALLY-PRODUCED TOMATO: NITROGEN FERTILITY AND FOLIAR DISEASE MANAGEMENT

Investigator: M. T. McGrath and D. D. Moyer
Location: Long Island Horticultural Research and Extension Center

The goals of this experiment, which was conducted in the LIHREC organic research block, were 1) to examine the benefits of using an organic fertilizer to augment the nitrogen provided by a vetch cover crop and 2) to evaluate compost tea used alone or with other foliar treatments for managing diseases affecting tomato leaves. The biofungicide Sonata produced by AgraQuest was tested alone or used with compost tea. Compost tea and Sonata were applied on a preventive schedule. Another treatment was compost tea applied preventively plus rescue treatments of fungicides approved for organic production following disease detection. At this time compost tea cannot legally be used for disease control as it is not a NYS registered pesticide. Thus this part of the work is strictly for research purposes.

'Red Sun' tomato seed were hot water treated (25 min at 122 F) to control seed-borne bacterial pathogens on 29 April, then placed in trays with an organic soil-less mix on 5 May. The seedlings were put outside to harden off on 28 May. The hairy vetch cover crop was flail chopped on 1 Jun to form a mulch. Seedlings were no-till transplanted 11 Jun with fish hydrolysate fertilizer (approx. 2.8 ml/plant of Organic Gem Liquid Fish 3-3-3 diluted in water 1:64). A tractor equipped with a fluted coulter and an S-tine was used to cut 4-in. deep strips through the field. Seedlings were placed in these holes by hand. There were 10 plants spaced 2-ft apart in each single-row plot. Drip irrigation tube was laid on the soil surface next to the plants. Plants were watered as needed. Plants were pruned then trellised to maintain up-right growth habit. Weeds were managed by mowing between plots and hand-weeding in the planted rows. Straw was placed around the base of plants (1/2 bale/plot) on 28 Jul because the straw from the vetch cover crop was not sufficient to suppress weeds.

Peanut meal was applied at 625 lb/A (equivalent to 50 lb/A of N) to the high nitrogen treatment plots on 23 Jun to supplement the nitrogen provided by the vetch mulch.

Foliar disease management treatments were applied using a CO_2-pressurized backpack sprayer with a single nozzle boom. Each plot side was treated with the boom held sideways to obtain thorough coverage. Compost tea was applied separately from the other treatments. Fungal-based compost (4 lb dairy manure-based vermicompost and 4 lb leaf-based compost) was brewed with 12 oz Fertrell Liquid Kelp, 4 oz fish hydrolysate (Organic Gem Liquid Fish 3-3-3 or Neptune's Harvest Benefits of Fish 2-4-1), and 16 oz humic acid (Fertrell Bio-Hume) for about 24 hour in a 60-gal Sotillo brewer. Compost tea was filtered, Nu-Film-P (6 oz/A) and fish hydrolysate (1 oz/30 gal) were added, then it was applied undiluted to foliage on 8, 16, 23, and 29 Jul; 4, 11, 17, and 25 Aug; and 1 and 8 Sep. To minimize potential damage to microbes in the compost tea, it was applied at low pressure (40 psi) using a nozzle with a large orifice that causes little resistance (FloodJet). Most applications were made before 10 am. Samples of the leaf-based compost, tea, and leaves were submitted to the Soil Foodweb Laboratory in Port Jefferson, NY, for analysis of the organism biomass content. Compost samples were submitted on 28 Apr and 8 Sep. Samples of the tea were collected on 8 Sep from the brewer and from the spray nozzle. The two samples were collected to determine if the spray nozzle had a detrimental impact on the microbes. Leaves were collected before and after tea was applied on 8 Sep to assess the delivery and deposition of microbes. Fungicides were applied at 50 psi and 50 gpa using a TwinJet (TJ110-8003) nozzle. Sonata was applied on 11, 17, and 25 Aug; and 1, 8 and 17 Sep immediately after compost tea. Rescue treatment consisted of JMS Stylet oil applied for powdery mildew on 25 Aug and 1 Sep and the copper fungicide Champion applied on 3, 12 and 17 Sep.

Disease severity and defoliation were rated as percent leaves and leaf area affected on 1, 9, 16, and 24 Sep and 1 Oct. Red and pink fruit were harvested weekly from 26 Aug through 7 Oct. Fruit were graded by size, counted, and weighed.

Powdery mildew, bacterial speck and Septoria leaf spot developed naturally. Powdery mildew was first observed on 20 Aug. Septoria leaf spot and bacterial speck were seen on 1 Sep. No significant differences were detected among treatments in disease severity or yield. On 24 Sep, severity of powdery mildew ranged from 35% for the no peanut meal + compost tea treatment to 62% for the peanut meal + Sonata treatment, while incidence of Septoria leaf spot was 28% for peanut meal + no foliar treatment and 56% for peanut meal + compost tea. Based on the analysis of tea prepared on 9 Sep, fungal activity was low (0.91 and 0.45 ppm for tea from brewer and nozzle, respectively) while active bacterial biomass was in a good range (16 and 54.4 ppm, respectively), thus the tea is considered bacterial with good fungal biomass. The leaf-based compost had very high fungal activity before the experiment was started (99.8 ppm on 28 Apr); it was only 36.8 ppm on 8 Sep. Active bacterial biomass increased from 47.8 ppm in Apr to 69.4 ppm in Sep. The leaf organism assay revealed that leaf coverage with bacteria and fungi was inadequate on leaves collected immediately before tea application. Leaves collected about 1 hour after tea was applied were 76% covered by bacteria and 17% covered by fungi, which is considered very good. A tea with more fungal activity may be needed to suppress fungal diseases. Effective control with compost tea may necessitate modifying application timing, such as applying late in the day and/or starting earlier in crop development, perhaps including a seed treatment.

In conclusion, neither additional nitrogen fertilizer nor compost tea increased yield and the foliar disease control treatments were ineffective for the diseases that occurred.

Project funded by NYS Dept. of Agriculture & Markets and the IR-4 Biopesticide Grant Program.

OZONE CONCENTRATIONS IN RIVERHEAD IN 2004

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Although ozone concentration in 2004 was lower than during the previous 8 years, levels reached on Long Island caused acute, visible injury to leaves of sensitive crops. Ozone also causes sensitive plants to senesce prematurely. Concentration was $\geq$80 ppb for at least 10 hours on 4 days in 2004: 11-12 May and 9-10 Jun. Tomato plants of variety 'Jolly Elf' with severe ozone injury submitted to the Diagnostic Lab on 16 May revealed that the ozone episode a few days earlier was sufficient to affect Long Island agriculture. The maximum concentration was 80 ppb on 11 May and 83 ppb on 12 May. Ozone was at least 50 ppb on 10 and 9 hours on these days, respectively. Ozone also reached high levels on 7 May (67 ppb) and 13 May (64 ppb). The highest concentration in 2004 (104 ppb) was reached on 9 Jun, which was earlier than most previous years. Ozone monitoring equipment malfunctioned from 1 Aug through 23 Aug when high levels also may have occurred. Typically high concentrations occurred between 1200 and 2200, as in previous years. Ozone was $\geq$80 ppb for 60, 124, 121, 184, 77, at least 67, 94, and 40 hrs in 1996, 1997, 1998, 1999, 2000, 2001, 2002, and 2003, respectively.

ASSESSMENT OF AMBIENT OZONE IMPACT ON PLANT PRODUCTIVITY USING A SNAP BEAN BIOINDICATOR SYSTEM

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Research on ozone-sensitive and ozone-resistant snap bean lines was continued in 2004 using both field- and pot-grown plants. The lines, sensitive S156 and resistant R331, were developed at the USDA-ARS Air Quality Research Unit in Raleigh, NC, to be used as bioindicators of ozone pollution. These lines yield similarly under low ozone concentrations.

There were 3 successive field plantings to be able to assess the impact of ambient ozone occurring throughout the growing season. Pots were seeded at the same time as field planting 2.

Plots were seeded by hand with 2 seeds placed every 9 inches, then thinned to 15 plants per sub-plot. Wax beans were planted between plots and sub-plots. Weeds were managed by applying herbicides, Eptam and Treflan, before seeding and hand-weeding. Bean pods were harvested when immature for fresh-market consumption from some plants repeatedly as they developed. Mature bean pods were harvested for seed from the rest of the plants. Plants were examined routinely for ozone injury. Injury and defoliation due mainly to ozone injury were rated.

The first field planting was seeded on 19 May. Plants had emerged by 1 Jun. Open flowers were seen on 28 Jun. The highest ozone episode recorded in 2004 occurred on 8-9 Jun; concentration was at least 60 ppm on 17 hours peaking at 104 ppb. Injury on leaves due to ozone was first seen on 12 Jul. Ozone was at least 40 ppb for 262 hours between emergence and 12 Jul. Injury increased quickly, becoming quite severe by 19 Jul. Only S156 was affected on 16 Jul, with 71% of leaflets having visible injury (incidence) and average severity on these leaves of 25%. On 6 Aug, incidence was 89% and 68% for S156 and R331, respectively, but these values were not significantly different; severity was 69% and 19%, respectively, which was a significant difference. Defoliation due to ozone injury was significantly different on 12 Aug: 78% in S156 and only 8% in R331. Ozone injury to S156 affected fresh-market yield compared to R331 beginning at the third harvest on 4 Aug. Number and weight of beans harvested on 12 and 21 Jul from the 2 lines did not differ significantly. These variables were reduced by 21% and 55% on 4 Aug and by 73% and 79% on 30 Aug, respectively. Total weight of pods harvested for fresh-market consumption over the 4 harvest dates was reduced 46% while number of pods was reduced 32%.

The second field planting was seeded on 16 Jun. Plants had emerged by 21 Jun. Open flowers were seen on 23 Jun. Injury on leaves due to ozone was first seen on 9 Jul. Ozone was at least 40 ppb for 216 hours between emergence and 9 Jul, with a peak of 70 ppb. On 6 Aug, incidence of injury was 26% and 1% for S156 and R331, respectively, which was a significant difference; severity was 8% and 1%, respectively, which was not significantly different. Incidence was 30% and 3% on 12 Aug, respectively, and 64% and 10% on 19 Aug. Severity was 12% and 1% on 12 Aug, 38% and 3% on 19 Aug, 45% and 24% on 27 Aug, and 66% and 41% on 10 Sep, with differences significant beginning on 19 Aug. Defoliation due to ozone injury was first evident in S156 on 6 Aug. It remained below 5% until 19 Aug when defoliation was first seen in R331. Defoliation was 19% and 2% in S156 and R331, respectively, on 27 Aug and 42% and 8% on 10 Sep. Ozone injury to S156 affected fresh-market yield compared to R331, but not consistently. Significant differences were detected on 4 and 19 Aug and 17 Sep, but not on 11 and 27 Aug. Total weight of pods harvested for fresh-market consumption over the 5 harvest dates was reduced 44.5% while number of pods was reduced 31%.

The third field planting was seeded on 22 Jul. Plants had emerged by 28 Jul. Open flowers and first injury due to ozone were seen on 23 Aug. Ozone monitor unfortunately was not working during most of Aug. In past years ozone generally has been lower in Aug than in Jun or Jul. Incidence and severity of ozone injury remained low. Defoliation was observed in only 2 plots of S156 on 13 Sep (5%). Weight and number of fresh-market pods harvested from S156 and R331 on 9, 16 and 30 Sep did not differ significantly.

Ozone injury was more severe on pot-grown plants. On 6 Aug, incidence of injury was 66% and 15% for S156 and R331, respectively, and severity was 8% and 3%, respectively; these values were significantly different. Incidence was 60% and 15% on 19 Aug, respectively. Severity was 50% and 9% on 19 Aug and 66% and 22% on 27 Aug. Defoliation due to ozone injury was first evident in S156 on 6 Aug. Defoliation was 2% and 1% in S156 and R331, respectively, on 6 Aug and 53% and 19% on 27 Aug. There was substantial variation in growth of plants in pots, which affected ability to detect significant differences in yield. Total weight of pods harvested for fresh-market consumption over the 6 harvest dates was reduced 25% for S156 compared to R331 while number of pods was reduced 24%; however, these values are not significant.

In conclusion, the ozone-sensitive snap bean line sustained more injury due to ambient ozone and yielded less than the resistant line throughout most of the 2004 growing season in 2 of 3 successive field plantings. Both fresh-market yield and dry bean yield were lower for S156 than R331. Planting 1 (19 May) and 2 (16 Jun) exhibited very similar reductions that were also similar to reductions detected in previous years. Ozone evidently was too low following the third planting (22 Jul) to cause much injury or to affect yield.

DEVELOPMENT OF BUTTERFLY BUSH VARIETIES GROWN UNDER NATURALLY HIGH OZONE ON LONG ISLAND

Investigator: M. T. McGrath and S. Clark
Location: Long Island Horticultural Research and Extension Center

Butterfly bush (*Buddleia*) has been shown to be sensitive to ozone and to exhibit varietal differences in ozone sensitive through research using controlled exposures to ozone conducted in AL. The goal of this multi-year study is to examine development of 7 varieties on Long Island where ambient ozone is naturally high every summer. The varieties are Bonnie, Black Knight, Harlequin, Pink Delight, Potter's Purple, Royal Red, and Summer Beauty.

Plants are being grown in the ground and irrigated daily with low volume spray stakes (Roberts Irrigation). They are arranged in a randomized block design with 4 replications and 2 plants per replication. Two plants of Bonnie have died. Plant height, length of inflorescences, and number of inflorescences with all dead flowers, some open flowers, and all unopened flowers were determined. Dead inflorescences were removed when counted.

Black Knight once again was the first variety to have open flowers. Most Bonnie and Royal Red plants also had flowers that were open on 9 Jul. Average number of inflorescences (dead, open, and unopened) on 26 Jul on Black Knight was significantly greater than on Summer Beauty, Harlequin, and Bonnie (142 vs 62 – 102). These 3 varieties also had the fewest inflorescences on 12 Aug when Royal Red and Potter's Purple had the most (68 – 83 vs 174 - 185). Bonnie had the fewest inflorescences at the last count on 27 Oct while Harlequin and Summer Beauty had the most (277 vs 482 - 590); however, these differences were not significant. Potter's Purple was among the varieties with the most inflorescences with open flowers on all assessment dates. Average inflorescence length did not differ significantly among varieties, ranging from 2.8 in. for Royal Red to 4.0 in. for Summer Beauty.

Potter's Purple and Black Knight were the tallest plants (66.5 and 57.5 in. respectively); Summer Beauty and Harlequin were the shortest (45.25 and 44.75 in.).

REDUCED-TILL PUMPKIN PRODUCTION IN RYE STRAW MULCH PLUS CLOVER LIVING MULCH

Investigator: M. T. McGrath and D. D. Moyer
Location: Long Island Horticultural Research and Extension Center

A long-term study was started in 2004 to address the impact of reduced tillage on soil health and diseases of vegetable crops. The 1.7-A field for this study is divided into 4 replicate sets of reduced tillage and conventional tillage strip plots extending the length of the field (20 ft X 300 ft) separated by driveways. The production system examined in 2004 was pumpkin zone-till seeded into rye straw mulch with a Dutch white clover living mulch planted between the pumpkin rows. This idea arose from discussions with an organic farmer who successfully grows pumpkins on plastic mulch with clover planted between the plastic. The system will be tested for continuous pumpkins by switching location of clover and pumpkin strips each year. Using a clover living mulch between rows of a crop provides an opportunity to put some land into a cover crop where rotation out of crops is not feasible due to the value of the land, as is the case for many Long Island fields. A living mulch also suppresses weeds. Soils with good health have higher organic matter content and higher microbial activity than poor quality soils, consequently there is greater potential for biological control of soil-borne pathogens. Straw and clover mulches provide a ground cover that can be a barrier for the pathogen. Thus this production system may be an effective management practice for pumpkin fruit rots, which are mostly caused by soil-borne pathogens and tend to be worst where rotation is minimal as is common for u-pick fields.

The field was planted to cover crops in 2003, then no-till seeded to rye on 2 Nov 2003. Fertilizer (176 lb/A of 34-0-0) was broadcast on 6 April 2004. Dutch white clover was no-till seeded to reduced-till plots and driveways on 11 May when rye was just starting to head out. Rye was rolled twice with a coulter packer in reduced-till plots on 2 June when rye was pollinating. Some rye stood back up immediately after rolling, but most stayed down. Rye was flail chopped in conventional till plots and driveways. Round-up was applied on 4 June in a 36-in band over the rows where pumpkins were to be planted in the reduced-till plots.

Two pieces of equipment were available for reduced tillage in 2004. Reduced tillage plots were divided in half and worked on 7 June. A zone-till cart built by Andy Williamson, vegetable farmer in Maine, was used in the north half. It was set-up to prepare single rows using 3 17-in wavy coulters to prepare a tilled strip with fertilizer tubes on the outer 2 coulters to inject liquid starter fertilizer. Amount of fertilizer (lb/A) applied to single rows is 12.5 N, 40 P, 25 K, 0.285 lb zinc, and 0.25 lb boron. An Unverferth zone builder was used in the south half of the reduced tillage plots after fertilizer (600 lb/A of 10-10-10) was broadcast over these subplots as well as the conventional-tillage plots. It was set-up to prepare 2 rows at 68-in spacing. For each row it has a 20-in coulter to open the row, shank to disrupt plow pans and create compression fissures between the shanks, and 2 17-in wavy coulters followed by a 15-in wide rolling basket to prepare the soil for planting. This unit was not equipped with a fertilizer tank. The Unverferth unit produced a wider bed that was deeper in the center where the shank went through than the zone-till cart (13-14 in. deep versus 4-5 in.).

In mid-June, rye that remained standing was flail chopped and conventional-tillage plots were rototilled. On 23 Jun pumpkin was seeded with 400 lb/A 10-10-10. There were 3 rows spaced 68-in apart in each plot. To achieve a similar concentration of N-P-K in all plots, the zone-till cart plots were side-dressed with 50 lb/A N as 10-10-10 on 27 Jul. On 25 Jun the herbicide Strategy was applied in a 34-in-wide band over all pumpkin rows and the insecticide Admire 2 was applied for cucumber beetles in a 7-in band. The field was irrigated lightly on 28 Jun, 2 Jul and 6 Jul. On 20 Jul the herbicides Sandea and Poast were applied, then the field was irrigated on 23 Jul.

Pumpkin plants did not grow well. Stand was very poor in the conventional-tillage plots perhaps because the soil was extremely dry and the light irrigation did not provide enough water to compensate for low rainfall (only 0.88 in. during Jun). Soil did not appear as dry in the reduced-till plots, which was expected due to both less tillage and presence of a mulch layer. For yield measurements, 15-ft-long sub-plots were established within plots where plant stand was best in the conventional-tillage plots. Conventional-tillage sub-plots averaged only 6.9 plants (range of 3 to 11), whereas there were 17.25 (16-18) plants in the Unverferth and 17 (14-19) in the zone-till cart reduced-tillage sub-plots. Plants were moved into the conventional-tillage sub-plots to obtain a stand similar to the reduced-tillage sub-plots. Pumpkin plants throughout the field became yellow by 6 Aug indicating insufficient N or possibly injury from Sandea; however, yellowing did not disappear as expected with Sandea injury. Plants remained small compared to plants of this variety in other experiments.

Weeds were not managed adequately possibly due to irrigation not being done promptly (within 24 – 48 hr) and weeds being too well established at the time of application. Clover grew well, eventually covering most plot area except about a 7-in wide strip where the pumpkins were seeded. Rye straw partly covered the soil surface through the season.

Pumpkins in sub-plots were harvested and weighed on 17 and 20 Sep. Numerically more fruit were harvested from the reduced-tillage sub-plots (average of 16.75 fruit from both compared to 14 and 14,5 from adjacent conventional tillage sub-plots) and the average fruit weight was greater (8.9 lb for Unverferth sub-plots, 10.1 lb for zone-till cart sub-plots, and 7.8 and 8.4 lb for adjacent conventional tillage sub-plots, respectively); however, these differences were not statistically significant.

Penetrometer measurements were made on 23-24 Sep outside of the sub-plot areas in each plot. Soil depth at which the penetrometer reading reached 300 psi in the planted row averaged 7.5 in. for the zone-till cart sub-plots, 6.7 in. for adjacent conventional-till plots, 14.4 in. for the Unverferth sub-plots, and 4.6 in. for adjacent conventional-till plots, while in other pumpkin experiments it was 10.6 in. where the entire field was conventionally tilled with a disk and 7.6 in. where plastic mulch was used.

Friends of Long Island Horticulture Grant Program funded this project and provided half of the funds for purchasing the no-till seeder.

COMPARISON OF NO-TILL ORGANICALLY-PRODUCED PUMPKINS GROWN FROM SEED OR TRANSPLANTS

Investigator: M. T. McGrath and D. D. Moyer
Location: Long Island Horticultural Research and Extension Center

'Appalachian' pumpkin was planted no-till in the LIHREC organic research block. The hairy vetch cover crop was flail chopped on 1 Jun to form a mulch. A tractor equipped with a fluted coulter and an S-tine was used to cut 4-in. deep strips through the field on 10 Jun. By hand in these strips seeds were placed in pairs every 2 ft and 4-week-old greenhouse-grown seedlings were transplanted on 25 Jun. Each received fish hydrolysate fertilizer (approx. 2.8 ml/plant or seed pair of Organic Gem Liquid Fish 3-3-3 diluted in water 1:64). Peanut meal was applied over the row in about a 6-in band at 625 lb/A (equivalent to 50 lb/A of N) on 30 Jun to supplement the nitrogen provided by the vetch mulch. For each planting method there were 4 plots each with 8 plants in a randomized complete block design. Direct-seeded plots were thinned to single plants where both seeds germinated. Straw was placed around the base of plants on 28 Jul because the straw from the vetch cover crop was not sufficient to suppress weeds. Hand-weeding was done as needed. Water was provided through drip irrigation tube laid on the soil surface next to the plants. Fungicides were not used to manage powdery mildew and other diseases. Fruit were weighed and handle quality recorded on 6 Oct.

Both transplanted and direct-seeded pumpkins appeared to grow equally well. Not surprisingly, the older plants grown from transplants were larger for several weeks and began flowering sooner than the direct-seeded ones. Powdery mildew and downy mildew caused leaves to die prematurely; most died by 15 Sep. Plants grown from transplants produced more fruit than direct-seeded plants (0.9 vs 0.7 fruit/plant and 12.1 vs 8.4 lb/plant, respectively), fruit were heavier (13.7 vs 12.4 lb/fruit), and more fruit had good, solid handles (64% vs 53%); however, these differences were not statistically significant. These transplants yielded similarly to those grown on black plastic mulch in the nontreated plots of another experiment, which averaged 1.1 fruit/plant, 13.3 lb/plant, and 12.1 lb/fruit.