Long Island Vegetable Pathology Program
2003 Annual Research Report

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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 products able to move through a leaf because they have systemic or translaminar activity. Unfortunately, these fungicides have been prone to resistance development due to their single-site mode of action and the cucurbit powdery mildew fungus has demonstrated ability to evolve new strains with changes in their metabolic pathways where the fungicide acts on the pathogen. With some fungicides, including the Benzimidazole fungicides Benlate and 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 and Nova, 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). 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. Cross-resistance occurs with QoI fungicides.

To use QoIs wisely, growers need to know the proportion of the pathogen population that is QoI resistant before the first application and how much the population changes with QoI 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 QoI and DMI fungicides on frequency of resistance. A seedling bioassay was used. Summer squash seedlings were grown in growth chambers to ensure they wouldn't be exposed to powdery mildew before conducting the bioassay. Seedlings received 1 of 4 treatments: no fungicide, Flint (50 ppm), Nova (20 ppm), or a combination of both. They were dipped in the fungicide solutions, and then allowed to dry overnight before setting in a cucurbit crop in groups of four plants with the four treatments. There were 2 to 7 groups per field. The concentration of Nova used was one of the highest concentrations tolerated in previous studies by at least a small proportion of isolates tested. Very few isolates have been found able to tolerate 80 ppm. Isolates able to tolerate 20 ppm Nova are considered to have a moderate level of DMI resistance. They are fully resistant to Bayleton, being associated with ineffective control with this DMI fungicide, and moderately resistant to Nova, being associated with good control at the highest label rate and reduced control at the lowest rate of Nova. After being in fields for 4 hours to overnight, 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.

The first seedling bioassay was conducted on 27 Jul in early plantings of summer squash and pumpkin where neither QoI or DMI fungicides had been applied yet this year. It revealed QoI resistance in 1 of 5 fields (61% frequency in that field) and low level of moderate DMI resistance in all fields (1 - 25% frequency).

Powdery mildew severity was assessed on 19-21 Aug in 4 commercial pumpkin fields where fungicide sensitivity was going to be monitored. Powdery mildew was much more severe on the lower surface of leaves than expected based on the fungicides being used. Average severity on upper/lower leaf surfaces was 0.1/5%, 0/11%. 4/11%, and 0/18%. Good control on upper leaf surfaces indicates application timing was good. Protectant fungicides (e.g. Bravo, copper) only work where deposited, which is mostly the upper surface. Systemic fungicides provide most of the control on lower surfaces.

The second bioassay was conducted on 31 Aug to determine the level of resistance in commercial pumpkin fields and research plots at Cornell. In most fields there was little powdery mildew on upper leaf surfaces while lower surfaces were severely affected, and several leaves had died, likely due to poor control of powdery mildew. Nontreated seedlings became severely infected, with some leaves completely white due to powdery mildew, which revealed the large quantity of spores in the air. QoI resistance was detected in all 7 fields (61 – 100% frequency), including one field where Nova was used but not QoIs. Moderate DMI insensitivity was detected in all fields as well (12 – 56% frequency).

A third bioassay was conducted on 25 Sep to determine if resistant strains were sufficiently widespread on LI to be present where no QoI or DMI fungicides were used. Two of these 3 fields were being organically managed. QoI resistance was detected in these fields (2, 38, and 56% frequency) and also in the fields included in this bioassay where QoI and/or DMI fungicides had been used (88 - 97% frequency).

Powdery mildew severity on seedlings treated with Nova generally was similar to severity on seedlings treated with both Nova and Flint for each field, which suggests that most isolates moderately insensitive to DMIs were also resistant to QoIs. Almost all individual isolates tested in 2002 using a laboratory assay were either sensitive to both chemical groups or insensitive to DMIs and also resistant to QoIs.

In conclusion, strains of the powdery mildew fungus with resistance to QoI and/or DMI fungicides were present at a low level before these fungicides were used on Long Island in 2003. Frequency of resistant strains increased substantially when these fungicides were used. Resistance explains poor control observed on lower leaf surfaces in late Aug. Resistant strains were common at the end of the growing season, even occurring in crops not treated with QoI or DMI fungicides.

Project funded by Friends of Long Island Horticulture Grant Program and the New York State Integrated Pest Management Grant Program.

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 2003 was a QoI fungicide, Flint or Quadris, 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 2003 were related to this recommendation. The protectants tested were Bravo and Microthiol Disperss (sulfur). In previous experiments, Bravo has provided excellent control of powdery mildew on upper surfaces while sulfur has been almost as effective, whereas sulfur as been more effective than Bravo for powdery mildew on lower surfaces. Other products examined were Procure, a new DMI with federal registration, and Quintec, a new fungicide not yet registered on any crops in the US.

The semi-bush pumpkin ‘Appalachian’ was direct-seeded on 27 Jun. 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 in most plots (35 of 36 in 2003). Upper and lower (under) surfaces of 5 to 50 leaves in each plot were examined weekly for powdery mildew beginning on 31 Jul when fruit were starting to enlarge. Fungicides were applied weekly (on 7, 14, 20, and 26 Aug; and 6 and 17 Sep) with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 110 gpa at 100 psi. The last two applications were delayed by rainy weather.

Flint alternated with sulfur controlled powdery mildew, but more effective control was obtained with Flint plus sulfur alternated with Nova or Procure plus sulfur (78/55% vs 97-99/76-82% control on upper/lower leaf surfaces, respectively, on 25 Aug). Nova and Procure were equally effective in this program with Flint and sulfur. Control was not improved significantly by applying a DMI fungicide weekly (eg Flint plus sulfur plus Nova alternated with Procure plus sulfur; 92/68% control). Quadris plus Bravo alternated with Procure plus Bravo was not as effective as a similar program with Flint and sulfur (95/40% and 97/75% control, respectively), perhaps because sulfur is more effective than Bravo on lower surfaces. Pathogen strains resistant to QoI and/or DMI fungicides were common in this area by the end of Aug (see previous report), which is the likely explanation for control being moderate on lower leaf surfaces when assessed on 8 Sep for programs with these fungicides (19-52%) but good with the experimental fungicide (91%).

A fungicide program consisting of Flint plus sulfur applied week 1, Procure plus sulfur applied week 2, then sulfur applied alone on subsequent weeks was not significantly less effective than a fungicide program with Flint or Procure included in all weekly sulfur applications (68/24% and 89/34% control on 8 Sep for these 2 programs, respectively). A similar reduced-spray fungicide program with just the first 2 applications on 7 and 14 Aug controlled powdery mildew through 25 Aug as effectively as the full-season program, but by 8 Sep powdery mildew was as severe on these plants as on the non-treated plants.

As found in previous experiments, efficacy of powdery mildew control was related to leaf longevity (defoliation on 22 Sep ranged from 19% with the new fungicide to 76% for nontreated plants) and proportion of fruit with good solid handles (91% and 42% on 10 Oct, respectively, for these treatments). There were no significant differences in quantity of marketable fruit or average fruit weight for the treatments assessed, which were nontreated, Quintec, and two others.

POWDERY MILDEW OF ACORN SQUASH: EFFICACY OF GENETIC CONTROL, USED ALONE AND COMBINED WITH FUNGICIDES

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

The objectives of this study were to determine the degree of control obtained with powdery mildew resistant (PMR) varieties of acorn squash and to evaluate an integrated control program with fungicides applied on a reduced schedule (14-day interval) to these resistant varieties. The resistant varieties were evaluated by comparing them to nontreated and fungicide-treated susceptible varieties. Taybelle PM is heterozygous for the incompletely dominant resistance gene, which means it has one allele for resistance from one parent. It is horticulturally similar to Taybelle. Autumn Delight is homozygous for resistance to PM, thus it has an allele from both parents, and compares to Table Ace. Seed of these four cultivars were obtained from Seminis Vegetable Seeds, Inc. Siegers and Stokes Seeds carry all 4 varieties. A homozygous resistant experimental line from Seminis, 10605, was also evaluated.

Transplants were seeded in the greenhouse on 27 May and planted into bare ground on 27 Jun. Upper and lower (under) surfaces of 5 to 50 leaves in each plot were examined approximately weekly for powdery mildew. Symptoms were first observed on the susceptible varieties on 31 Jul and on the resistant varieties on 14 Aug. Fungicide applications were started the day of detection. Applications were made weekly (31 Jul; 7, 14, 20, and 26 Aug; and 6 and 17 Sep) with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 110 gpa at 100 psi. The last two applications were delayed by rainy weather. The fungicide program was Flint (2 oz/A) plus Bravo (2.7 lb/A) applied in alternation with Procure (6 oz/A) plus Microthiol Disperss (sulfur)(4 lb/A) then Microthiol Disperss applied alone the last week. Defoliation was assessed during September. Representative samples of 10 ripe fruit were harvested from each plot and weighed on 1 and 14 Oct, remaining fruit were counted. Percentage of sucrose was determined using a hand refractometer for two fruit per plot.

Fungicides suppressed powdery mildew well through 26 Aug, then control declined, especially on the lower surface of the susceptible varieties, possibly due to fungicide resistance. On 9 Sep, level of control obtained with weekly applications was 92% and 97% on the upper leaf surface for Taybelle and Table Ace, respectively, but only 43% and 48% on the lower surface of these leaves. Control was 87% and 79% on 26 Aug. Systemic fungicides provide most of the control on lower surfaces while protectant fungicides also function on the upper surfaces. Good control on upper leaf surfaces indicates application timing was good. Resistance to the 2 types of systemic fungicides for powdery mildew were common on LI by the end of August (see other report on this topic). In an adjacent experiment, 100% of the isolates were resistant to QoI fungicides, such as Flint, and 56% were moderately insensitivity to DMI fungicides, such as Procure, based on a seedling bioassay conducted on 31 Aug.

With heterozygous resistance, powdery mildew was managed better with chemical control (fungicide-treated Taybelle) than with genetic control (non-treated Taybelle PM) on upper surfaces of leaves (94% and 51% control), similar control was obtained on lower leaf surfaces (67% and 66% control). Numerically there was less defoliation with chemical control, but differences were not significant. With homozygous resistance, powdery mildew was managed better with genetic control (non-treated Autumn Delight) than with chemical control (fungicide-treated Table Ace) based on powdery mildew severity on lower leaf surfaces (93% and 58% control); chemical control was better based on defoliation. Based on severity on 9 Sep, control of powdery mildew on upper leaf surfaces of PMR varieties was improved significantly by applying fungicides. Reduced fungicide program (14-day spray interval) was as effective as a standard program (7-day interval) when applied to resistant Taybelle PM. Reduced fungicide program applied to susceptible Table Ace was not as effective as a standard program based on severity on lower leaf surfaces on 9 Sep.

Controlling powdery mildew with resistant varieties and/or fungicides did not affect yield as much as in a parallel experiment conducted in 2002. Plants treated with fungicides tended to produce fewer fruit of lower weight than fungicide-treated plants, but these differences were not significant. Fruit of 10605 and Table Ace tended to be smaller than the other varieties (1.5 lb/fruit versus 1.7 for Taybelle). Sucrose content of fruit, a measure of fruit quality, did not vary significantly among treatments or varieties.

In conclusion, growing varieties with resistance to powdery mildew is an effective and economic means to manage powdery mildew. Although neither control of powdery mildew nor yield were improved significantly by applying fungicides to Taybelle PM or Autumn Delight, there was a trend toward improvement plus an integrated program with two applications on a 14-day schedule would reduce selection pressure for new races of the pathogen able to overcome the resistant variety and pathogen strains resistant to the fungicides. Although seed of Taybelle PM and Autumn Delight is priced slightly higher than seed of Taybelle and Table Ace, overall production costs are lower because of the cost difference between a 7- and 14-day fungicide program. It will cost about $1096 less to grow an acre of Autumn Delight sprayed thrice compared to Table Ace sprayed seven times and $131 less for Taybelle PM compared to Taybelle.

Project funded by the New York State Integrated Pest Management Grant Program

POWDERY MILDEW OF BUTTERNUT SQUASH: EFFICACY OF GENETIC CONTROL, USED ALONE AND COMBINED WITH FUNGICIDES

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

The objectives of this study were to compare Bugle, a new cultivar of butternut squash that has homozygous resistance for powdery mildew (e.g. an allele of the resistance gene from each parent), to a susceptible standard cultivar, Waltham Butternut, and to determine if there is a benefit to integrating chemical control with host-plant resistance by applying fungicides to the resistant cultivar. Bugle was developed by the Cornell Plant Breeding program. Seed is available from Rupp Seed Co and SeedWay. In addition to a nontreated control, each cultivar received a grower standard fungicide program (Flint + Bravo applied in alternation with Procure + sulfur on a 7-day schedule) and a reduced fungicide program (standard program applied on a 14-day schedule).

Seeding was done in the greenhouse on 29 May. Waltham was reseeded on 10 Jun due to poor germination. Seedlings were transplanted into black plastic mulch with drip irrigation on 24 Jun. Upper and lower (under) surfaces of 5 to 50 leaves in each plot were examined approximately weekly for powdery mildew. Symptoms were first observed on the susceptible variety on 29 Jul and in most plots of the resistant variety on 14 Aug. Fungicide applications were started within two days of detection. Applications were made weekly (31 Jul; 7, 14, 20, and 26 Aug; and 6 and 17 Sep) with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 110 gpa at 100 psi. The last two applications were delayed by rainy weather. The fungicide program was Flint (2 oz/A) plus Bravo (2.7 lb/A) applied in alternation with Procure (6 oz/A) plus Microthiol Disperss (sulfur)(4 lb/A) then Microthiol Disperss applied alone the last week. Defoliation was assessed 4 times beginning on 29 Aug. Representative samples of 6 ripe fruit were harvested from each plot and weighed on 29 Sep and 8 Oct, remaining fruit were counted. Percentage of sucrose was determined using a hand refractometer for two fruit per plot.

On the susceptible variety Waltham, powdery mildew was controlled more effectively with a standard fungicide program (7-day spray interval) than with a reduced fungicide program (14-day interval). Both fungicide programs were equally effective at reducing defoliation. Severity was similar on Waltham receiving 7 fungicide applications as on the non-fungicide-treated powdery mildew resistant (PMR) variety Bugle. Defoliation, however, was significantly lower for Bugle on 4 and 15 Sep indicating that genetic control might have been more effective than chemical control. Powdery mildew causes leaves to senesce prematurely. Efficacy of chemical control was likely compromised by fungicide resistance. A seedling fungicide sensitivity bioassay conducted in this field on 31 Aug revealed that resistance to QoI fungicides (e.g. Flint) was very common (estimated frequency of 100%) and most of the pathogen population (54%) also was moderately insensitivity to DMI fungicides (e.g. Nova and Procure). Control of powdery mildew on PMR Bugle was not improved significantly by applying fungicides. A reduced fungicide program, however, could function to delay selection of a new pathogenic race able to overcome this resistance.

Applying fungicides to control powdery mildew did not affect yield significantly for either variety. Fungicide treatment did not affect size, quantity, or sucrose content of fruit produced. Non-fungicide-treated Bugle produced significantly smaller fruit than fungicide-treated Waltham (1.8 vs 2.9 lb) but more fruit/plant (8 vs 5.6); consequently, total fruit weight did not vary significantly between them (13.7 versus 16.2 lb mature fruit/plant).

In conclusion, growing varieties with resistance to powdery mildew is an effective means to manage powdery mildew. Although neither control of powdery mildew nor yield were improved significantly by applying fungicides to Bugle, an integrated program with two applications on a 14-day schedule is recommended to reduce selection pressure for new races of the pathogen able to overcome the resistant variety and strains of the pathogen that are resistant to the fungicides. The greater cost of seed of Bugle, $48.50/lb versus $15.15/lb for Waltham, is offset by the additional fungicide applications needed to affectively control powdery mildew in

Waltham. It will cost about $16 more to grow an acre of Waltham sprayed seven times than an acre of Bugle sprayed thrice.

Project funded by the New York State Integrated Pest Management 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 11 Aug.

Powdery mildew was first observed on 29 Aug. Symptoms 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 2003. 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 MUSKMELON: EVALUATION OF NEW NOZZLES AND AN AIR ASSIST SPRAYER FOR IMPROVING SPRAY COVERAGE AND DISEASE CONTROL ON UNDERSIDES OF LEAVES

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

Effective control of powdery mildew in a cucurbit crop necessitates controlling the disease on the underside of leaves. Conditions are more favorable for development of powdery mildew on the lower compared to upper surface. A contact, protectant fungicide applied with conventional nozzles is deposited almost exclusively on the upper surface of leaves. Leaves die prematurely when powdery mildew is not controlled effectively on the underside. Thus systemic fungicides have been critically important for powdery mildew control. Unfortunately, systemic fungicides are at-risk for resistance development. The powdery mildew fungus has demonstrated high potential for developing resistance. A means to improve spray deposition on the leaf underside would reduce grower dependence on systemic fungicides. It would also improve resistance management by increasing the proportion of the pathogen population exposed to the low-resistance-risk contact fungicide used in programs with systemic fungicides. It would be even more valuable for organic growers because there are no systemic fungicides that are approved for organic production.

New nozzles for conventional spray booms reportedly improve coverage by delivering more spray to the leaf underside and also by reducing drift. The sprayer used in this study was a tractor-drawn unit equipped with an air assist boom and a separate hydraulic boom set-up with multiple nozzles on a single nozzle body. Two novel nozzles (twin jet and air induction) were compared to 3 traditional nozzles (flat fan, hollow cone, and cone jet). All are considered ideal for applying fungicides. Twin-jet nozzles use forward and rearward pointing flat fans, thus providing two chances to hit the plant. They apply the same total amount of liquid as a conventional flat fan. Air induction (air inclusion or venturi) nozzles are flat fan nozzles where an internal venturi creates negative pressure inside the nozzle body. Air is drawn in through two holes in the nozzle side, mixing with the spray liquid. The emitted spray contains large (300 micron) droplets filled with air bubbles and virtually no fine, drift-prone droplets. Normally droplets this large would bounce off their target. However, because of the air they explode on impact and spread over the leaf as the air absorbs the impact load. Coverage is similar to that of finer sprays produced by traditional nozzles.

Another approach to improving coverage is to use an air assist sprayer. Air assist sprayers use air as a carrier for the pesticide. A fan is used that moves air at a fast speed thereby pushing the spray into the canopy and also generating turbulence that moves spray to undersides of leaves. Nozzle velocity can be up to 180 mph. This is an expensive means to improving coverage because it entails purchasing a new sprayer rather than just new nozzles. Another benefit of improved deposition is the potential to maintain good control but with lower pesticide rates.

'Superstar' seedlings were transplanted on 17 Jun, 21 days after seeding, into black plastic mulch with drip irrigation. The contact fungicide Bravo Ultrex (2.7 lb/A) was applied with each nozzle on 29 Jul, and 5 and 14 Aug. An additional treatment was a currently recommended fungicide program for cucurbit powdery mildew, Quadris (15.4 oz/A) + Bravo applied in alternation with Nova (5 oz/A) + JMS Stylet oil (1.5%) using the flat fan nozzles. This treatment was included to determine if a sufficient amount of Bravo could be deposited on low leaf surfaces with any of the nozzles tested to achieve a similar level of control as that obtained with the systemic fungicides Quadris and Nova. Unfortunately powdery mildew started to develop before the sprayer could be prepared for seasonal use, and thus powdery mildew was more severe than desired at the time of the first application. Powdery mildew severity on upper and lower (under) leaf surfaces was determined weekly. Spray coverage was also assessed by attaching 22 water sensitive paper cards in pairs to both leaf surfaces for each nozzle type on 28 Aug, then applying a fungicide with good worker safety (potassium bicarbonate formulated as Armicarb). Proportion of each card that changed color due to spray deposit was assessed visually.

Average powdery mildew severity on 28 Jul, one day before the first application, was 1.7% on upper leaf surfaces and 0.6% on lower surfaces. There were no significant differences in disease severity among treatments on 4 Aug. Based on severity on 12 Aug, Bravo applied with all nozzle types controlled powdery mildew on upper leaf surfaces but not on lower surfaces. Only the standard fungicide program with systemic fungicides (Quadris + Bravo alternated with Nova + JMS Stylet oil) had significantly less severe powdery mildew on lower surfaces than the nontreated control (*P*-value 0.076). Performance order for both leaf surfaces starting with the best was twin-jet flat fan, air assist and conejet, D3-45 hollow cone, flat fan, and air inclusion.

Spray deposition on water sensitive cards located on the upper surface of leaves differed significantly among nozzle types. Performance order was twin-jet flat fan (94% coverage), hollow cone, air inclusion, conejet, flat fan, and air assist (64%). Thus twin-jet flat fan provided the numerically best spray coverage and best control of powdery mildew, but it is important to note that these values were not significantly different from the other nozzles. There was very little deposition on cards located on the lower surface of leaves, ranging from 0% coverage with conejet to 4.4% with the air assist sprayer.

These results cannot be considered conclusive because powdery mildew was substantially more severe than the action threshold at the start of treatments. In a previous experiment conducted in 2001, neither the air assist boom nor the novel nozzles improved control achieved with Bravo applied with conventional nozzles on a hydraulic boom. This study has demonstrated that it is challenging to improve spray coverage on the lower surface of muskmelon leaves by changing spray equipment.

Project funded by the East End Institute

POWDERY MILDEW OF PUMPKIN: EVALUATION OF NEW NOZZLES AND AN AIR ASSIST SPRAYER FOR IMPROVING SPRAY COVERAGE AND DISEASE CONTROL ON UNDERSIDES OF LEAVES

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

The previous experiment conducted on muskmelon was also conducted on pumpkin. These two cucurbit crops were selected because they have different canopies. Muskmelon leaves are much smaller and shorter than pumpkin leaves. Also, most leaves in the muskmelon canopy are at the same level whereas the pumpkin canopy consists of a few layers of leaves. Fungicide applications were made at the same time (29 Jul, and 5 and 14 Aug).

'Appalacian' seedlings were transplanted on 12 Jun, 21 days after seeding, into black plastic mulch with drip irrigation. Unfortunately powdery mildew started to develop before the sprayer could be prepared for seasonal use, symptoms developed quickly, and thus powdery mildew was quite severe at the time of the first application. Consequently none of the treatments were able to control powdery mildew on the lower surface of leaves. Average severity on 31 Jul, two days after the first application, was 23% on upper leaf surfaces and 37% on lower surfaces. Neither the air assist boom nor the novel nozzles (air inclusion, twin-jet flat fan, and conejet) improved control achieved with Bravo applied with conventional nozzles (D3-45 hollow cone, flat fan) on a hydraulic boom. The standard fungicide program with systemic fungicides (Quadris + Bravo alternated with Nova + JMS Stylet oil) provided the best control of powdery mildew on upper leaf surfaces, but it was only significantly better than Bravo applied with conejet nozzles. Performance order starting with the best was flat fan, air inclusion, air assist, D3-45 hollow cone, twin-jet flat fan, and conejet.

Spray deposition on water sensitive cards differed significantly among nozzle types. Performance order for deposition on the upper surface of leaves was twin-jet flat fan (85% coverage), flat fan, air inclusion, hollow cone, air assist, and conejet (59%). There was very little deposition on cards located on the lower surface of leaves, ranging from 0% coverage with conejet to 3% with the air assist sprayer.

These results cannot be considered conclusive because powdery mildew was very severe at the start of treatments.

Project funded by the East End Institute

NO-TILL PUMPKIN PRODUCTION IN RYE STRAW MULCH PLUS CLOVER LIVING MULCH

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

The project goal is to improve soil health and management of soil-borne fruit rot diseases in pumpkin using reduced tillage and clover living mulch. Pumpkin was no-till seeded into straw mulch with a clover living mulch planted between the pumpkin rows. To provide a comparison with pumpkins grown in a conventional, bareground system, four plots randomly located among the mulch plots were rototilled before seeding (21 May and 27 Jun) and as needed to manage weeds (22 Jul and 11 Aug).

Rye and Austrian winter pea were planted with a conventional grain drill on 3 Oct 2002. Dutch white clover was no-till drilled in strips through the field into the rye plus pea cover crop on 2 May 2003. Driveways between plots were also seeded to clover. Cover crop was rolled on 6 and 10 Jun with a tractor-drawn roller. This did not adequately kill the cover crop, therefore they were flail chopped on 16 Jun. Granular 15-15-15 fertilizer was broadcast on 17 Jun at 100 lb/A of N. Herbicide Round-up was applied to straw strips on 24 Jun to kill the Austrian pea. Pumpkins were no-till seeded on 30 Jun. The seeder was equipped with a single fluted coulter to open the soil for the seed. There were 2 15-ft rows of pumpkin per plot at 8-ft row spacing with about a 3-ft wide strip of clover between these rows. Herbicides Command + Curbit were applied in 12-in band on 1 Jul over the pumpkin rows. Herbicides Sandea and Poast were applied on 29 Jul. Poast was applied again on 21 Aug. Clover in the driveways was cut with a tractor-drawn mower on 22 Jul. A lawn mower was used to cut weeds and clover next to plants on 25 Jul. Weeds in the pumpkin rows were removed by hand.

Clover grew well, despite being seeded several weeks later than desired and into rye that was up to 2-ft tall. It tolerated tractor traffic very well, which was evident in an adjacent experiment where applying treatments necessitated driving through the field up to 9 times each week. Clover also permitted driving under wetter conditions than could be done with a bare-ground driveway.

There were no significant differences between tilled and mulched plots in numbers of plants, mature fruit, or green fruit. Fruit from the tilled plots were larger (9.7 versus 6.9 lb/fruit, respectively). Plants did not grow in the tilled plots as well as in an adjacent experiment conducted in a conventionally tilled and fertilized field. Although the same variety was planted with the same seeder in both experiments just 3 days apart, fruit were larger in the conventional production system (average fruit weight of 13.2 lb/fruit). This most likely is due to better placement of fertilizer and better weed control in the conventional field.

In conclusion, a straw mulch plus clover living mulch production system for pumpkins has good potential to improve soil health and management of soil-borne fruit rot diseases. Pumpkins likely will grow better if seeded using zone tillage rather than no-till, fertilized with a liquid injected into the ground rather than a dry formulation placed on the surface, and treated with a better herbicide program. In future experiments, methods will be modified to correspond more closely to those being used by a few growers in the northeast who are growing pumpkins successfully using zone tillage.

Project funded by Friends of Long Island Horticulture 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. The products tested are either OMRI-approved (biofungicide Serenade and copper fungicide Champion WP), or are in OMRI review (biofungicide Sonata). Compost tea was also evaluated, used alone or combined with a biofungicide to determine if the nutrients in tea would be beneficial for the biological control agents in the biofungicide. To assess the level of control achieved with these treatments, there were also nontreated pumpkins in this experiment and a conventional fungicide program of Flint plus sulfur (Microthiol Disperss) applied in alternation with Procure plus Bravo.

Pumpkins were grown in a rye straw mulch plus clover living mulch production system. Cultural practices used are as described in the previous report, except that Command and Curbit were not applied to half the field to determine the degree of weed control achieved with the straw mulch.

Compost tea was applied separately from the other treatments beginning before powdery mildew was observed. A fungal compost (dairy manure-based vermicompost + grape pumice) was brewed for at least 24 hour in a Sotillo brewer. Compost tea was filtered and applied at full strength (no dilution) with nuFilm P (6 oz/A) to foliage on 19 and 30 Jul; 1, 5, 12, 19, 22, and 28 Aug; and 5, 9, 12, and 17 Sep. Additionally, tea was applied as a soil drench using a watering can on 23 Jul due to wet conditions. On 28 Aug the tea sat in the spray tank for 10 hours before it could be applied while the sprayer pump was fixed. The tea used on 19 Jul and 5 Sep brewed for 48 hr because equipment malfunction and rainy weather, respectively, prevented application the previous day. To minimize potential damage to organisms 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 tea were collected from the brewer and from the spray nozzle on 5 Aug. They were submitted to the Soil Foodweb Laboratory in Port Jefferson, NY, for analysis of the organism biomass content. The two samples were collected to determine if the sprayer had a detrimental impact on the organisms.

Fungicide treatments were started on 6 Aug after the IPM threshold of one leaf with powdery mildew symptoms of 50 old leaves examined was reached in all 32 plots. This threshold was shown previously to be as effective as using a preventive schedule (Plant Dis. 80:910-916). Treatments were applied weekly with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 110 gal/A at 100 psi.

The pumpkin plants did not grow as vigorously as in an adjacent conventionally tilled field. This may be partly due to pumpkin plants needing some tillage, such as is provided by a zone tillage planting system, and the dry fertilizer not being moved by water to the roots adequately. Poor growth of the plants may have impacted disease occurrence and control with some of the treatments tested. Compost tea did not suppress powdery mildew when used alone or combined with Serenade. Sonata used alone did not suppress powdery mildew. However, compost tea and Sonata used together did suppress powdery mildew based on severity on lower leaf surfaces. Based on the analysis conducted by the Soil Foodweb NY, the compost tea used in this experiment was strongly bacterial. Both active and total bacterial biomass were high (33.8 and 576 μg/ml). Bacterial biomass was higher for the compost tea sample from the nozzle, likely reflecting that nuFilmP can be a food source for bacteria. There were few fungi in the tea. Active and total fungal biomass was only 1.28 and 1.73 μg/ml, respectively. A more fungal compost tea may be needed to suppress powdery mildew. Additionally, the organisms in compost tea may be better able to establish on leaves when applied before night rather than in the morning. Sonata applied with Champion did not improve control over that obtained with Champion alone. Champion was as effective as the standard program of Flint + sulfur alternated with Procure + Bravo.

The rye straw mulch did not provide adequate weed suppression. By mid-July there were numerous weeds in the straw strips where only Round-up was used before planting, especially in the planted row where the coulter disturbed the soil, and there were weeds in the straw mulch strips outside the band where Curbit and Command were applied. Hand weeding in the pumpkin rows where only Round-up was used was not feasible because of the quantity of weeds and presence of straw. Each pumpkin plant was covered with a plastic container, then Round-up was applied on 18 July to one section and the other was treated with 10% acetic acid, which is approved for organic production. Plants were uncovered 3 hours later. Acetic acid killed leaf tissue of treated weeds the day it was applied, but it did not kill weeds as well as Round-up, thus there were more weeds several weeks later where acetic acid was applied.

There were no significant differences among treatments in number of mature fruit, number of green fruit, or average fruit weight (6.63 lb/fruit).

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

BACTERIAL WILT OF CUCURBITS: SUSCEPTIBILITY OF PUMPKIN VARIETIES

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

The first commercially available powdery mildew resistant (PMR) pumpkin varieties, Merlin and Magic Lantern, were shown through previous research at LIHREC to be more susceptible than some other pumpkin varieties to another important disease, bacterial wilt. These varieties were developed in areas where bacterial wilt was not observed, thus this susceptibility couldn't be detected. The objective of the 2003 study was to determine whether wilt susceptibility was linked to mildew resistance by comparing 3 closely-related pumpkins that differ in their reaction to powdery mildew. Sorcerer has no PMR genes. Magic Lantern has 1 PMR parent and Magician (formerly HMX 0683) has 2 PMR parents. Cornell's Department of Plant Breeding is the source of this resistance. Sorcerer and Magic Lantern are very closely related having one common parent and the other parents being very closely related. If wilt susceptibility is genetically linked to mildew resistance, then Sorcerer would be least susceptible to wilt and Magician would be most susceptible.

On 12 Jun, 21-day-old seedlings were transplanted into black plastic mulch with drip irrigation. Plots were single rows of 10 plants. The gourd Turk's Turban was planted between each of the 6 replications and at both ends of the 3 rows. This variety was previously shown to be very attractive to cucumber beetles, which vector bacteria that cause wilt, and very susceptible to wilt. Plants were examined weekly for beetles, feeding damage, and wilt. Cucumber beetles were moved from another experiment on 25 Jun after finding none in this experiment.

Number of beetles on plants differed significantly among varieties on 7 Jul (average of 2.4 beetles/plant on Sorcerer, 3.4 on Magic Lantern, and 4 on Magician), but not on 30 Jun or 14 Jul. No significant differences were detected in feeding damage. Symptoms of wilt were first seen on 14 Jul. Magic Lantern had the highest percentage of plants with any symptoms of wilt and the highest percentage of plants that were at least 50% wilted on all assessment dates; however, differences among the 3 varieties were not significant. In comparison, Turk's Turban had a similar number of beetles/plant on each assessment date, but more feeding damage and higher incidence of wilt. For example, on 15 Aug, 92% of Turk's Turban plants were at least 50% wilted whereas 45% of the pumpkin plants were similarly affected.

Not surprisingly, the PMR varieties had significantly less powdery mildew than susceptible Sorcerer and the least severely affected was Magician, which has resistance from both parents. Severity on 7 Aug was 7/10% on upper/lower leaf surfaces for Magician, 20/27% for Magic Lantern, and 47/45% for Sorcerer. Many crown leaves on Sorcerer plants had died likely due to severe powdery mildew. Compared to Sorcerer, the PMR varieties had higher percentage of good fruit with solid handles and lower percentage of soft fruit when assessed on 5 Sep.

In conclusion, heightened susceptibility to bacterial wilt exhibited by the PMR pumpkin variety Magic Lantern is not genetically linked to powdery mildew resistance. Incidence of wilt in Magic Lantern was similar to its incidence in Sorcerer, a closely-related variety without resistance to powdery mildew, and in closely-related Magician which has resistance to powdery mildew from both of its parents.

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 16 Jul, 30-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. Herbicides Curbit and Sandea were applied on 18 Jul, then incorporated by irrigating. Weeds were suppressed until 5 Aug. Poast was applied for grass weeds on 11 Aug. Hand-weeding was done as needed.

Fungicides evaluated were Phostrol, Acrobat plus Champion (copper), and a new experimental material which was tested alone and in alternation with Acrobat plus Champion. These treatments were applied weekly beginning when first fruit reached marketable size (Aug 7, 15, 21, and 28 and 6 and 15 Sep) with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 125 gal/A at 100 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.

Melon fruit with Phytophthora fruit rot were placed on 26 Aug in the north and south ends of the field before the plots since blight had not been observed on any squash plants. On 8 Sep, Phytophthora blight was observed on a few squash plants in one plot and on some discarded fruit in the field. There were 4 days with rain the previous week: 0.15 in. on 31 Aug, 0.1 in. on 1 Sep, 0.87 in. on 2 Sep, and 0.4 in on 4 Sep. No more rain occurred until mid-Sep. Total of 1.99 in. of rain falling over 4 days (0.1, 0.52, 0.82, and 0.55 in. on 13, 14, 16, and 19 Sep) evidently provided favorable conditions for this disease. On 16 Sep there were no significant differences among treatments in proportion of plants with tip blight, which ranged from 26% to 62%, or proportion of fruit with Phytophthora fruit rot, which ranged from 51% to 77%. All plants were completely blighted on 22 Sep.

In conclusion, none of the fungicide treatments were able to suppress Phytophthora blight on a very susceptible crop under the very favorable conditions for blight development of this experiment.

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 fertilizer to augment the nitrogen provided by the rye-vetch cover crop and 2) to evaluate compost tea used alone or with a biofungicide for managing foliar diseases in tomato. The fertilizer was peanut meal (8-8-8) and the biofungicide was Sonata produced by AgraQuest. Rye was seeded in fall 2002 and vetch was frost-seeded in 2003.

'Paragon' tomato seed were hot water treated (25 min at 122 F) to control seed-borne bacterial pathogens on 2 May, then placed in trays with an organic soil-less mix on 6 May. Fish emulsion was applied on 29 May because many seedlings were yellow and not growing well. Salts were found to be high in the mix. Trays were watered heavily on 2 June in an effort to leach salts out, then fish emulsion was re-applied. By 12 June the plants had recovered and were growing well. On 16 Jun the seedlings were put outside to harden and the rye-vetch cover crop was mowed to form a mulch. Seedlings were no-till transplanted 10 days later. A tractor equipped with a fluted coulter and an S-tine was used to cut deep strips through the field. Seedlings were placed in these holes by hand. There were 10 plants at 2-ft spacing per single-row plot and 8 ft between plots within a row. Rows were spaced 11-ft apart. 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.

Peanut meal was applied at 50 lb/A of N (625 lb/A) to the high nitrogen treatment plots on 17 July to supplement the nitrogen provided by the vetch mulch. Weeds were managed by mowing between plots and hand-weeding in the planted rows. Straw was placed around the base of plants on 6-7 Aug because the straw from the vetch cover crop was not sufficient to suppress weeds. One bale was used per plot.

Compost tea and Sonata treatments were applied using a CO_2-pressurized backpack sprayer and a single nozzle boom. The boom was held sideways and each side of plots was treated. A fungal compost was brewed for at least 24 hours in a Sotillo brewer. Compost tea was filtered and applied at full strength (undiluted) with nuFilm P (6 oz/A) on 18, 23, and 30 Jul; 1, 5, 12, 19, 22, and 28 Aug; and 5, 9, 12, 17, and 24 Sep. The tea used on 5 Sep was brewed for 48 hr because of rainy weather on 4 Sep. To minimize potential damage to organisms in the compost tea, it was applied at low pressure (40 psi) using a nozzle with a large orifice (FloodJet). Most applications were made before 10 am. Tea was applied as a soil drench with a watering can on 23 Jul due to wet conditions. Samples of the tea were collected on 5 Aug and submitted to the Soil Foodweb NY laboratory in Port Jefferson for analysis of the organism biomass content. Sonata (2 qt/A) was applied on 12, 19, and 26 Aug; and 6, 15, 22, and 26 Sep with a TwinJet (TJ110-8003) nozzle at 50 psi and 50 gpa. Red fruit and those turning red were harvested weekly from 27 Aug through 15 Oct. Fruit were graded by size, counted, and weighed. Severity of the major diseases occurring and defoliation were rated as % leaf area affected.

First fruit were noted on 25 July. At that time, plants that had received peanut meal were observed to be larger and greener than those that hadn't. Compost tea treatments did not have a detectable impact on plant appearance. Plants receiving peanut meal produced numerically more marketable fruit (at least 2.5 inch in diameter) than those that didn't (13 vs 10 per plant), but this difference was not statistically significant.

Powdery mildew and Septoria leaf spot developed naturally. Symptoms of powdery mildew were first observed in one plot on 3 Sep. Septoria leaf spot was seen on 8 Sep. These diseases became widespread in the field by 22 Sep causing severely affected leaves to die. A few spots due to early blight and leaf mold were seen; incidence was too low to rate. No significant differences were detected among treatments; however, disease severity was numerically lowest where Sonata and compost tea were applied. Based on the analysis conducted by Soil Foodweb NY, the compost tea used in this experiment was strongly bacterial. Both active and total bacterial biomass were high (33.8 and 576 μg/ml). Bacterial biomass was higher for the compost tea sample from the nozzle, likely reflecting that nuFilmP can be a food source for bacteria. There were few fungi in the tea. Active and total fungal biomass was only 1.28 and 1.73 μg/ml, respectively.

In conclusion, the rye-vetch cover crop did not provide sufficient nitrogen. Plants side-dressed with peanut meal generally were visibly larger and greener than those that didn't, and they produced more fruit, however, this difference was not statistically significant. Large variation in yield among plots may have hampered ability to detect significant differences. Applying a bacterial compost tea to foliage 1 to 2 times per week did not suppress the fungal diseases that occurred. A more fungal compost tea may be needed to suppress fungal diseases of tomato. Additionally, the organisms in compost tea may be better able to establish on leaves when applied before night rather than in the morning. The biofungicide Sonata showed some promise for managing powdery mildew.

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

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

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

The primary project goal is evaluating yearly soil amendments of commercially-available composts plus 3-year rotation for managing Phytophthora blight. Research is being done where blight occurred in 1999 through 2001. Additionally, compost is being examined as a soil-building amendment and fertilizer for rotation crops. Snap bean was grown in 2003.

Soil samples collected on 11-17 Jun before the 2003 compost amendment, and analyzed by Cornell's ICP Analytical Lab in the Department of Horticulture, revealed significant differences between the compost and non-compost plots due to previous amendments. Compost plots had significantly higher organic matter (4% vs 3.2%) and more available P, K, Mg, Mn, and Zn. pH was 6.2 for both treatments. No available N was found for the samples collected on 11 and 12 Jun.

One-year-old compost made from leaves and fruit waste was obtained from Briermere Farms. Nitrogen content was determined to be 0.77% (equivalent to 6.7 lb/cu yd) through analysis conducted by the University of MA Soil and Plant Tissue Testing Laboratory. Applied at 40 t/A (wet weight), this compost was expected to provide 30 lb/A N assuming 10% availability. Fertilizer (15-15-15) was applied on 14 Jul at 50 lb/A N to non-compost plots and at 20 lb/A N to compost plots to obtain a similar level of N in both. Then compost was spread and disked to incorporate. Herbicides Eptam and Treflan were applied 17 Jul. 'Strike' snap beans were coated with inoculant on 15 Jul and seeded on 17 Jul a couple hours after herbicide treatment. The field was overhead irrigated and machine-cultivated when needed. No hand-weeding was done. There was more available nitrogen in non-compost than compost plots based on pre-sidedress nitrogen test (PSNT) conducted on composite soil samples collected on 5 Aug (48 vs 23 mg/kg available NO_3). Petiole samples were collected on 22 Aug when most plants had 5 trifoliates and a few plants had started to produce flower buds. Two-plot composite samples were analyzed by Cornell's ICP Analytical Lab. Nitrogen content did not differ significantly (2.6 and 2.1 %NH for compost and non-compost plots, respectively).

Although weed coverage of compost plots was almost twice that of non-compost plots (20 and 11%, respectively, on 10 Sep), this difference was not significant. Jimson weed seed evidently was in the compost since this weed was found in 4 of 8 compost plots (13 plants), while there were only 5 plants in 2 of 8 non-compost plots, and it does not occur in other research fields at this facility. Jimson weed density averaged 56 plants/A for compost plots.

Plants were examined routinely for symptoms of disease during the growing season and more intensively at harvest. A very few pods were found affected by Pythium, white mold, or Anthracnose. Insect pests were not observed.

Thickness of the bean plant canopy was assessed by determining light penetration, which was measured using a Licor light meter to measure light level at the top of the canopy and on the ground between rows for 3 locations per plot on 10 Sep. Non-compost plots had lower light penetration values indicating a thicker canopy than compost plots.

Yield was assessed by removing two 3-ft sections of plants from each plot on 15-22 Sep. A second yield assessment was made by removing 4 plants per plot on 2 Oct. Plants in the non-compost plots yielded significantly more than those in the compost plots based on the first yield assessment (24.4 vs 20.7 marketable-sized pods/plant), but not the second (28.1 vs 29.8). Plant stand did not vary significantly among treatments (70,147 plants/A in compost plots and 74,626 in non-compost plots).

In conclusion, yearly amendments of compost are having a long-term impact on nutrient availability and organic matter content of soil. The compost may not have provided the expected quantity of N or it provided N more slowly than chemical fertilizer; consequently, plants receiving all 50 lb/A N as fertilizer formed a thicker canopy and out-yielded plants receiving a combination of compost and chemical fertilizer.

Project funded by the New York State Integrated Pest Management Grant Program.

OZONE CONCENTRATIONS IN RIVERHEAD IN 2003

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

Ozone once again reached levels on Long Island that could cause acute, visible injury to leaves of sensitive crops. Ozone also causes sensitive plants to senesce prematurely. Concentration was ≥80 ppb for only 40 hrs on 8 days in 2003: 24-27 June; 2, 4-5 July; and 16 Aug. Ozone was ≥80 ppb for 60, 124, 121, 184, 77, at least 67, and 94 hrs in 1996, 1997, 1998, 1999, 2000, 2001, and 2002, respectively. The highest concentration (118 ppb) was reached on 27 June. Typically high concentrations occurred between 1200 and 2200, as in previous years. The worst ozone episode in 2003 was earlier than previous years.

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

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

An ozone-sensitive clone and an ozone-resistant clone of the commercial white clover line ‘Regal’ were used to estimate the concentrations of ambient ozone and its effects on plants. These clones were selected because they have similar growth rates in the absence of ozone stress. This system is being used in other locations throughout the world. Cuttings were planted in 1-liter pots on 17 April and transplanted to 15-liter pots on 21 May. In contrast with previous years, the sensitive clone grew better after planting than the resistant clone, thus these plants were larger when transplanted. Clover was to be harvested every 4 weeks as in previous studies, but only two harvests could be made due to woodchuck feeding that could not be prevented by surrounding the area with a fence. Cutting was done at 7 cm above the soil surface. Both wet and dry weights of harvested forage (leaves, stems, and flowers) were measured.

Ozone injury was first observed on clover on 6 Jun. The sensitive clone was more severely injured, with 9.8% of leaves having symptoms and average severity on these leaves of 30.5% on 23 Jun, compared to 0.1% and 0.6%, respectively, for the resistant clone. Better initial growth of the sensitive clone compared to the resistant clone confounded the utility of this bioindicator system for assessing impact of ozone. Weight of forage harvested on 23 Jun from the sensitive clone was 44% greater than from the resistant clone, in sharp contrast with previous studies conducted at LIHREC in which the resistant clone produced as well as the sensitive one or better when ozone concentration had been high.

The sensitive clone had slightly more ozone injury than the resistant one when assessed on 26 Aug: 1.4% and 0.1% of leaves had symptoms for the sensitive and resistant clones, respectively, and average severity on these leaves was 1% and 0.1%.

The forage dry weight ratio (sensitive/resistant) was 0.81 for tissue harvested on 4 Sep. This value is similar to that obtained in previous years. The resistant clone had 24 flowers/pot versus only 8 flowers/pot for the sensitive clone.

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 2003 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. Pots were seeded on 19 Jun and field plots were hand-seeded on 27 Jun. In the field, weeds were managed by applying herbicides, Eptam and Treflan, on 17 Jun, mechanically cultivating and hand-weeding. Leafhoppers were managed by applying Di-Syston in furrow with the seed and Orthene 75S to foliage on 15 Jul. Bean pods were harvested when immature for fresh-market consumption from some plants (18 Aug and 3 or 5 Sep). 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.

Ozone injury was first observed on 4 Aug when plants were flowering. The sensitive line sustained more injury than the resistant one. On 18 Aug, 0.5% and 34% of leaves had symptoms for pot-grown R331 and S156, respectively, and average severity on these leaves was 1% and 30%. For field -grown plants, incidence was 9% and 41%, respectively, and severity was 10% and 44%.

Fresh-market yield and dry bean yield were lower for S156 than R331 indicating that ambient ozone affected plant productivity. Weight of fresh-market pods was 39% lower for pot-grown S156 than R331 (*P*-value=0.035) and 35% lower for field-grown S156 (*P*-value=0.18). Number of fresh-market pods was 20% lower for both pot- and field-grown S156 compared to R331, but these differences were not statistically significant. Weight of mature seed was 31% lower (*P*-value=0.0007) for pot-grown S156 than R331 and 29% lower for field-grown S156 (*P*-value=0.067). Number of seed was reduced only for field-grown S156 (48%, *P*-value=0.039).

In conclusion, ambient ozone reached sufficiently high concentrations on Long Island in 2003 to affect productivity of a sensitive snap bean.