Long Island Vegetable Pathology Program
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POWDERY MILDEW OF PUMPKIN: EVALUATION OF POWDERY MILDEW RESISTANT VARIETIES

Investigators: M. T. McGrath, S. Menasha and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

Twenty-seven Halloween-type pumpkin varieties and experimental lines plus two specialty-type decorative squashes, One Too Many and Sweet Lightning, were evaluated for their ability to resist powdery mildew relative to two standard pumpkin varieties without known genes for resistance, Howden and Sorcerer. Sweet Lightning is edible as well as ornamental. Previous experiments have demonstrated that the level of resistance is highly variable among pumpkin varieties marketed as having powdery mildew resistance or tolerance.

Seeds were planted on 24 May in the greenhouse and seedlings transplanted into black plastic mulch with drip irrigation on 12 Jun. Plots were one 20-ft row each with 8 plants spaced 30-in apart. Leaves were assessed routinely for powdery mildew beginning on 2 Aug. No fungicides were applied specifically for powdery mildew; however, copper fungicides applied for control of bacterial leaf spot (on 12 and 29 Jul; and 5, 13, 23, and 31 Aug) would have also provided some suppression of powdery mildew on upper leaf surfaces. Acrobat, Previcur Flex, Ranman, and Tanos were applied preventively for downy mildew and Phytophthora blight.

Average powdery mildew severity on lower leaf surfaces on 25 Aug on the susceptible varieties was 28% for Sorcerer, 42% for Howden, and ranged among the resistant entries from 0% for NY04-840 (experimental from the Cornell Plant Breeding Program) to 45% for King Midas. The best performing pumpkin varieties were Magician, Iron Man, Touch of Autumn, Gladiator, Rockafellow (78-90% control). Good control was also obtained with Sweet Lightning (73%) and One Too Many (82%). Wee-B-Little was included in this experiment because it has preformed well when evaluated elsewhere despite lack of known genes for powdery mildew resistance. Average powdery mildew severities on lower surfaces of Wee-B-Little leaves on all three assessment dates were not only significantly lower than the two standard varieties, but, more notably, were not significantly greater than the most effective entries with resistance genes. Severity on 25 Aug was 5%.

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

POWDERY MILDEW OF WINTER SQUASH: EVALUATION OF POWDERY MILDEW RESISTANT ACORN-TYPE SQUASH VARIETIES

Investigators: M. T. McGrath, S. Menasha and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

Four solid green acorn-type winter squash varieties, two striped acorn types, and a delicata-type squash, all with powdery mildew resistance, were evaluated for their ability to resist this disease as well as their yielding ability relative to Table Ace, a standard variety lacking powdery mildew resistance that is commonly grown.

Seeds were planted on 18 May in the greenhouse and seedlings transplanted into black plastic mulch with drip irrigation on 13 Jun. Plots were 14-ft long with six plants spaced 2 ft apart. See previous report for fungicide treatments. Leaves were assessed routinely for powdery mildew beginning on 27 Jul. Fruit were harvested, measured and weighed on 11 Sep. Fruit quality was evaluated in terms of sucrose levels. Fruit characteristics were also evaluated and overall appearance was rated on a scale of 1 (poor) to 9 (good).

Excellent control of powdery mildew (81-94%) relative to Table Ace was obtained with Royal Ace PM (the most effective), Autumn Delight, Table Star, and Taybelle PM, which all produce dark green acorn-type fruit. The two varieties producing striped acorns (white fruit with

green speckling), Harlequin and Celebration, performed at a slightly lower level than the solid green conventional acorn-types, providing 69% and 51% control, respectively. Bush Delicata, the only open-pollinated variety evaluated, provided good powdery mildew control (86%) which was statistically similar to that of Royal Ace PM, Autumn Delight, and Table Star. This heirloom-type delicata was developed by the Cornell Plant Breeding Program, as were Harlequin and Celebration.

The control variety Table Ace had the lowest marketable yield per plant, the least number of fruit per plant, and the lowest sugar content. This likely reflects impact of powdery mildew, which was severe on this susceptible variety from the first assessment on 27 Jul. Harlequin produced the statistically highest number of fruit per plant as well as the highest weight of fruit per plant. Harlequin, Celebration, Bush Delicata, and Table Star had the highest sugar content. Appearance was rated 6 for Table Ace and 8 – 8.5 for the 7 resistant varieties. Fruit production was affected by poor weed control.

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

POWDERY MILDEW OF YELLOW SUMMER SQUASH: EVALUATION OF POWDERY MILDEW RESISTANT VARIETIES

Investigators: M. T. McGrath, S. Menasha and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

Seven varieties of straightneck yellow summer squash (Conqueror III, XPT 1832 III, HMX 5712, Sunray, General Patton, Patriot II, and Success PM) and one crookneck variety (Sunglo) with resistance to powdery mildew were evaluated by comparing them to a susceptible variety that is an industry standard (Multipik). Seeds were sown on 7 Jun in the greenhouse and seedlings transplanted into black plastic mulch with drip irrigation on 19 Jun. Plots were 14-ft long with six plants spaced 2 ft apart. See previous report on pumpkin for fungicide treatments. Leaves were assessed routinely for powdery mildew beginning on 26 Jul. Squash fruit were harvested and weighed a total of eight times from 24 Jul to 24 Aug. Fruit characteristics were evaluated and overall appearance was rated on a scale of 1 (poor) to 9 (good).

All varieties tested exhibited control of powdery mildew on lower leaf surfaces, where symptoms were most severe, relative to Multipik. Conquerer III had the least resistance (26% control). It is generally not marketed as having resistance however. XPT 1832 III (17% control) was not significantly different from Conquerer III. Both were significantly more severely affected by powdery mildew on both leaf surfaces than the other six resistant varieties, which provided a very high degree of suppression (84-99%). Conquerer III and Patriot II have transgenic resistance to two viruses: WMV and ZYMV. Conquerer III also is resistant to CMV and PRSV. General Patton and Sunray have the precocious yellow gene, as does the susceptible standard variety Multipik, which masks fruit symptoms of virus infection by WMV and CMV.

General Patton produced the greatest number and weight of marketable fruit. Success PM had the lowest yield. Fruit of Multipik, Conqueror III, and Patriot II were rated 8 for overall appearance, which was the best rating given in this experiment. Success PM and HMX 5712 were rated 6, which was the lowest. Fruit production was affected by poor weed control.

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

POWDERY MILDEW OF ZUCCHINI SQUASH: EVALUATION OF POWDERY MILDEW RESISTANT VARIETIES

Investigators: M. T. McGrath, S. Menasha and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

Seven conventional green zucchini squash varieties (Payroll, Felix, Wildcat, Envy, Justice III, Judgement III, and Romulus PM), two grey zucchini varieties (Amatista and Topazio), and one golden yellow variety (Sebring Premium) with resistance to powdery mildew were evaluated by comparing them to a susceptible variety that is an industry standard (Zucchini Elite). Romulus PM is open-pollinated. Another evaluated variety (Lynx) is not marketed as having resistance but performed well in a previous experiment conducted in upstate NY in terms of both disease severity and yield, producing fruit with very good horticultural characteristics. Most varieties evaluated also have resistance to several viruses. See previous report on yellow squash for methods.

All varieties tested that are marketed with claims for resistance to powdery mildew exhibited at least 72% control on lower leaf surfaces, where symptoms were most severe, relative to Zucchini Elite. Control was at least 90% for Judgement III, Romulus PM, Wildcat, Justice III, Envy, and Sebring Premium. On upper leaf surfaces, control over the entire assessment period was at least 62% for most varieties; it was only 47-49% for Felix and Topazio which was not significantly different from Zucchini Elite, however, control was affected by copper fungicide applications. Lynx did not exhibit resistance in this study as it had in a previous experiment conducted in upstate NY.

Overall fruit appearance was rated highest for Justice III, Payroll, and Felix which all scored 8 on a 1 to 9 scale. Zucchini Elite was rated 6. The lowest rating was 2 for Romulus PM. Sebring Premium produced the greatest number and weight of marketable fruit. Total number of fruit produced was also high for the two grey zucchinis. Romulus PM had the lowest yield. Fruit production was affected by poor weed control.

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

POWDERY MILDEW OF PUMPKIN: EFFICACY AND APPLICATION TIMING OF OXIDATE

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

The objective of this study was to determine the efficacy and the optimal application timing of the fungicide OxiDate for control of powdery mildew of pumpkin. An experiment was conducted in the greenhouse so that the time of inoculation was controlled relative to the time that OxiDate was applied. Pumpkin plants were grown to the 5-leaf stage. Spores were placed on the 2 youngest, fully-expanded leaves of each plant using a fine paintbrush 48 hours before, 24 hours before, 1 hour before, 1 hour after, 3 hours after, and 24 hours after OxiDate was applied. There were 5 plants per inoculation time. All of these plants were treated with OxiDate at the same time. There were two additional groups of five plants each inoculated at the first and last times to serve as non-treated control plants. These plants were not treated with OxiDate. The experiment was conducted twice.

Oxidate was found to be ineffective for the control of powdery mildew of pumpkin. Even when applied at what was expected to be the optimal application times for this fungicide (1 hour before and/or 1-3 hours after inoculation), Oxidate did not control the development of

powdery mildew as compared to untreated plants. These results suggest that this fungicide would not be an effective choice for the control of powdery mildew on pumpkin.

POWDERY MILDEW OF PUMPKIN: GREENHOUSE EVALUATION OF THE EFFICACY OF SERENADE MAX USED ALONE OR COMBINED WITH A QOI FUNGICIDE

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

The objective of this study was to determine if there is synergistic activity when Serenade MAX is tank-mixed with a QoI fungicide (FRAC Group 11), especially with QoI resistant pathogen strains. Preliminary results from research with other pathosystems has indicated this may occur. This experiment was conducted under controlled greenhouse conditions. The QoI fungicide Amistar was used. To determine whether there was synergism, the combination was compared to each fungicide applied alone and a nontreated control. An additional treatment was included with the DMI fungicide Nova (FRAC Group 3) because it was anticipated to provide a measure of a high level of control. Treatments were Serenade MAX (1 and 2 lb/A); Amistar (3.5 and 5 oz/A); Serenade MAX (1 lb/A) + Amistar (3.5 oz/A); Serenade MAX (2 lb/A) + Amistar (5 oz/A); Nova at 5 oz/A; and a control. A randomized complete block experimental design with five replications was used. Treatments were initiated when pumpkin plants were at the five-leaf stage. They were applied weekly four times using a backpack CO_2 sprayer. Spores were placed on the 2 youngest, fully-expanded leaves of each plant using a fine paintbrush one day after the first fungicide application. Plants were evaluated for powdery mildew a total of five times beginning with growth at the inoculation sites and then severity when the pathogen had spread beyond the inoculation site.

Throughout this experiment Nova controlled powdery mildew development at the highest statistical level, providing complete control until the last assessment date. Among the other treatments, only the high rate of Serenade Max (2 lb/A) also suppressed powdery mildew growth at the inoculation site (spot diameter). Two days after the last application, severity was reduced 47-63%, compared to the nontreated control, for the six treatments with Amistar and/or Serenade MAX. There were no significant differences among these treatments, thus no indication of synergism between Amistar and Serenade MAX was found. Although the isolate used in this study is resistant to QoI fungicides based on a leaf disk laboratory assay, Amistar provided control similar to that obtained with Serenade MAX. Control with Nova was 100% at that time and 98% 11 days later when the other treatments were no longer providing control. This study has documented that Serenade MAX is an effective OMRI-listed fungicide. Additional research is needed to assess efficacy under field conditions before it can be recommended for organic production.

POWDERY MILDEW OF PUMPKIN: EFFICACY OF VARIOUS RATES OF NOVA FOR DMI FUNGICIDE SENSITIVE AND MODERATELY RESISTANT POWDERY MILDEW ISOLATES

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

The objective of the study was to determine the efficacy of four rates of Nova (1, 2, 3.5, and 5 oz/A) for control of powdery mildew using two isolates of the powdery mildew fungus differing

in sensitivity to Nova. The fungicide resistant isolate was tested to see if it could be controlled with a higher rate of the fungicide. A greenhouse experiment was conducted with a randomized complete block design including five replications. Four rates of Nova along with a non-treated control were tested. Each treatment consisted of two pumpkin plants that were inoculated with either a Nova sensitive or moderately insensitive isolate. Spores were placed on the 2 youngest, fully-expanded leaves of each plant using a fine paintbrush one day after fungicides were applied. Powdery mildew growth was assessed weekly for a total of three times beginning one week after inoculation.

The fungicide-sensitive isolate of powdery mildew tested was controlled by 2.5, 3.5, and 5 oz/A of Nova. This isolate was not controlled by 1 oz/A of Nova which is below the recommended rate on the Nova label. The insensitive isolate was not controlled by 5 oz/A of Nova. For this isolate, the diameter of the fungal spot at the inoculation sites was statistically equivalent on the non-treated pumpkin leaves as on the treated leaves. This data suggests that at the highest labeled rate of Nova (5 oz/A), it may not be possible to obtain acceptable control of powdery mildew on pumpkin when pathogen strains with this level of resistance to this fungicide are common.

POWDERY MILDEW OF CUCURBITS: BASELINE SENSITIVITY OF *PODOSPHAERA XANTHII* TO BOSCALID

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

The goal of this study was to determine the baseline sensitivity of powdery mildew fungal isolates from Long Island to boscalid, a novel active ingredient that is in the new fungicide Pristine (BASF Ag Products). It is in the carboxamide fungicide class (FRAC group 7). The first step in resistance management is determining the initial sensitivity of a pathogen population to new chemistry, before its widespread use starts selecting resistant strains. This information provides a benchmark for comparing sensitivity of pathogen isolates collected in the future to determine whether fungicide use has resulted in a decline in pathogen sensitivity, ideally before sufficient change in the pathogen results in control failure.

Baseline sensitivity to boscalid was determined using a leaf disk bioassay with squash. Isolates of the powdery mildew fungus, *Podosphaera xanthii*, were collected from a pumpkin research field at LIHREC in 2005 at the end of the season after all fungicides had been applied. The boscalid baseline sensitivity was relatively similar among isolates with the highest concentration tolerated ranging between 100 and 175 ppm. All 17 isolates tested were able to grow and produce spores on leaf disks treated with boscalid at 100 ppm; 59% tolerated 125 ppm; 65% tolerated 150 ppm; and only 6% tolerated 175 ppm. Growth of these isolates at the highest concentration that they tolerated was reduced an average of 93-98% compared to the untreated disks.

No relationship was found between boscalid sensitivity and quinoxyfen sensitivity, QoI sensitivity, DMI sensitivity, or whether Pristine was applied to the research plot where the isolate was collected. Pristine has a Section 3 US registration for use on powdery mildew on cucurbits (EPA approved on July 23, 2003) and was approved for this use in New York on Aug 22, 2005. Resistance to fungicides is an ongoing problem in plant disease control. Monitoring sensitivity of *P. xanthii* over time to fungicides at risk for resistance, prior to widespread use, provides critical information for fungicide recommendations.

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

POWDERY MILDEW OF CUCURBITS: FUNGICIDE SENSITIVITY OF *PODOSPHAERA XANTHII* ON LONG ISLAND IN 2006

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

Fungicide resistance was monitored on Long Island during the 2006 growing season using the seedling bioassay used previously. Pumpkin seedlings were treated with fungicide (Flint, Nova, Topsin M, Quintec, Endura), then placed with non-treated seedlings for about 4 hours in production and research fields where powdery mildew was developing. 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. Only one representative fungicide in each group is needed because of cross resistance (e.g. an isolate resistant to Flint is also resistant to other QoI fungicides). Several concentrations of Nova were used because DMI resistance is quantitative. Quintec and Endura were used to obtain data on current level of sensitivity to these fungicides, which will be valuable for determining in the future if the pathogen is becoming less sensitive to these fungicides. The active ingredient in Endura, boscalid, is one of the two in Pristine, which is registered for use on cucurbits. The other active ingredient in Pristine is a QoI fungicide.

For the first assay, seedlings were placed on 26 Jul at 4 sites in 4 spring commercial plantings of squash and a research squash field at LIHREC. Only 1 planting had been sprayed prior with a fungicide at high-risk for resistance development (Quadris). Resistance to QoIs was found, often at a high level, in all 5 fields. Interestingly, frequency of resistant strains was lowest in the organically-managed field and second lowest where a QoI fungicide had been applied to the crop once before the bioassay was done. Although Topsin M is rarely used on cucurbit crops since resistance development resulted in control failures in the 1970s, resistance to MBCs was usually at a higher frequency than QoI resistance, which indicates strains of the pathogen with MBC resistance are fit and able to compete with sensitive strains in the absence of selection pressure from fungicide use. Strains of the pathogen moderately resistant to DMIs (able to tolerate 40 ppm Nova) also occurred in all fields and often at a high frequency. The second assay was conducted in 6 commercial pumpkin fields and 2 research pumpkin fields at LIHREC on 8 Aug. Resistance to QoIs and MBCs and moderate resistance to DMIs were again common. A higher concentration of Nova (80 ppm) was included in this assay. A low frequency of isolates able to tolerate this concentration were detected in a few fields, including at LIHREC where in a fungicide efficacy experiment neither Nova nor Procure, another DMI fungicide, when tested alone on pumpkin were effective, in sharp contrast with 2005. A third assay was conducted in pumpkin fields on 13 Sep. A very low frequency of isolates were detected able to tolerate 80 ppm Nova or 20 ppm Quintec. A higher frequency were able to tolerate 150 ppm Endura.

In conclusion, strains of the powdery mildew fungus with resistance to QoI fungicides, with moderate resistance to DMI fungicides and/or with resistance to MBC fungicides were common before these fungicides were applied to cucurbit crops on Long Island, NY, in 2006, as also occurred in 2005. Therefore QoI and MBC fungicides are not recommended for controlling cucurbit powdery mildew. Isolates able to tolerate a higher DMI concentration were also detected in 2006. Considering that the DMI fungicides Nova and Procure were ineffective in an experiment at LIHREC with pumpkin in 2006, it is anticipated these will be ineffective in 2007.

POWDERY MILDEW OF PUMPKIN: EFFICACY OF FUNGICIDE PROGRAMS

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

This study was conducted to evaluate the efficacy of several fungicides and fungicide programs for the control of cucurbit powdery mildew. 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. Furthermore, changes in pathogen resistance to key fungicides affects the efficacy of these products, and new fungicides are being developed and registered.

The semi-bush pumpkin 'Appalachian' was direct-seeded on 20 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. Powdery mildew was first seen on 31 Jul. Fungicides were applied weekly (on 4, 11, 18, and 25 Aug; and 1, and 8 Sep) with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 inch apart that delivered 85 gpa at 100 psi.

The QoI fungicide Cabrio and the DMI fungicides Procure (6 oz/A) and Nova (at both 2.5 and 5 oz/A) did not control powdery mildew likely due to fungicide resistance. Poor control was evident from early in disease development. Procure was effective in a near-by experiment with butternut squash however, which may reflect crop differences in quantity of fungicide uptake into leaves. The best treatment was the experimental chemical LEM 17 20 SC combined with another experimental KQ926 (95-96% control on upper and lower leaf surfaces compared to untreated plots). Endura and Quintec provided statistically equivalent control on both leaf surfaces (88-89% and 88-94%, respectively). Pristine (88-91% control), which has the same active ingredients as Cabrio (pyraclostrobin) and Endura (boscalid), provided control on both leaf surfaces that was similar to Endura, thus there was no indication of synergistic activity. Endura was used as a tool to investigate activity of Pristine; it is not registered for this use. When Procure was applied in alternation with either Quintec or Pristine starting with Procure, powdery mildew was not controlled as effectively as the alternation product used alone based on severity on the lower leaf surface (64-68%). The alternation treatment that started with Quintec was as effective as Quintec alone (77%). Canopy condition and fruit quality generally corresponded to level of powdery mildew control.

POWDERY MILDEW OF PUMPKIN: EVALUATION OF BIOPESTICIDES AND BIOCOMPATIBLE FUNGICIDES

Investigators: M. T. McGrath and J.F. Davey
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, including several suitable for organic production.

The objective of this study was to evaluate 6 EPA-classified biopesticides used alone for powdery mildew in pumpkin. The focus was on 4 plant oil products because good control was achieved with a mineral oil (JMS Stylet-oil) in previous experiments conducted at LIHREC. All biopesticides (first six entries) listed below are OMRI listed (suitable for organic production) and most are exempt from EPA registration. Additional products tested were AgriLife, Genica BP 300, and Prev-Am, which are not classified as biopesticides but are considered less toxic than conventional fungicides such as chlorothalonil. Sulfur formulated as Microthiol Disperss 80W and chlorothalonil formulated as Bravo Ultrex were also included as conventional protectant fungicides for comparison. We also included a 'conventional grower standard program' with fungicides that were previously shown to provide excellent control on lower leaf surfaces. This standard was Quintec tank-mixed with Microthiol Disperss and applied in alternation with Procure + Microthiol Disperss.

Biopesticides Evaluated:

1. Eco E-RASE. 97.50% Jojoba Oil. OMRI listed. IJO Products.
2. GC-3 Organic fungicide. 30% Cottonseed Oil, 30% Corn oil, 23% Garlic extract. Exempt from EPA registration. OMRI listed. JH Biotech, Inc.

3. Proud 3. 5.6% thyme oil. OMRI listed. Bio Huma Netics, Inc.
4. Organocide. Active ingredients = 5% sesame oil; inerts = 92% fish oil + 3% emulsifiers. Exempt from EPA registration. OMRI listed. Organic Laboratories, Inc.
5. Actinovate. 0.0371% *Streptomyces lydicus* WYEC 108. OMRI listed. Natural Industries, Inc.
6. Milstop. 85% potassium bicarbonate. OMRI listed. Bioworks, Inc.

Biocompatible Fungicides Evaluated:
1. AgriLife. 5% citric acid. Biological Solutions, L.L.C.
2. Prev-Am. 0.99% Sodium tetraborohydrate decahydrate. Citrus Oil Products, Inc.
3. Genica BP 300. 2.7% liquid concentrate derived from the microbial digestion of food waste. International BioRecovery Corp. (IBR) and Converted Organics Inc.

The semi-bush pumpkin 'Appalachian' was direct-seeded on 20 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. Treatments were applied weekly on 3 Aug, 17 Aug, 23 Aug, and 1 Sep with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 inch apart that delivered 85 gal/A at 100 psi.

Powdery mildew was controlled on upper leaf surfaces by all biopesticides and biocompatible products tested (57-86% control). Control obtained with Eco E-Rase, Organocide, Prev-Am and AgriLife (76-86%) was at the same statistical level as the conventional protectant fungicide Bravo Ultrex (92%). Prev-Am, AgriLife, and Eco E-Rase also provided control on lower surfaces (46-61%). Control obtained with Prev-Am and AgriLife (52-61%) was at the same statistical level as Bravo Ultrex (77%). All biocompatibles and biopesticides controlled powdery mildew on the lower leaf surface at the same level as Microthiol Disperss (sulfur)(57%). The 'conventional grower standard program' provided excellent control of powdery mildew on upper and lower leaf surfaces (96-97%) as anticipated because of mobility of these fungicides. A variation of this conventional program, with 1 application each of Quintec and Procure combined with weekly applications of Microthiol Disperss, was as effective as the grower standard program for managing powdery mildew on upper and lower leaf surfaces (94-98%). Canopy condition and fruit quality generally corresponded to level of powdery mildew control with the notable exception of the Milstop treatment, which resulted in significantly less defoliation than the nontreated control and also significantly more fruit with solid handles, although AUDPC values did not differ significantly from the control.

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POWDERY AND DOWNY MILDEWS OF BUTTERNUT SQUASH: EVALUATION OF FUNGICIDE PROGRAMS

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

The objectives of this study were to evaluate two fungicides, Forum 480 SC and Procure 480 SC, used alone and combined, and to evaluate a fungicide program for the control of powdery mildew and downy mildew in butternut squash. Forum is registered for downy mildew and Phytophthora blight on cucurbits and Procure is labeled for powdery mildew only. One goal was to investigate any synergistic effects of these chemicals on control of either powdery or downy mildew.

Waltham butternut squash was direct-seeded by hand into black plastic mulch on 13 Jun. Plots were three 12-ft rows with 3 plants each. Treatments were applied weekly from 25 Jul until 18 Sep with a tractor-mounted boom sprayer operated at 85 gal/A and 100 psi.

Powdery mildew was first observed on 21 Jul at a very low level. Downy mildew was not observed until 15 Sep. Procure applied alone provided good suppression of powdery mildew on both leaf surfaces as expected from results of previous experiments at this facility, but in sharp contrast with results obtained in a nearby fungicide efficacy experiment conducted with pumpkin in 2006. As expected, Procure did not suppress downy mildew. Forum applied alone provided good control of downy mildew and limited suppression of powdery mildew on upper leaf surfaces only. Severity was usually numerically lower for the tank mixture of Procure and Forum than for the best single product for each disease, but was never statistically different; thus there was no indication of a synergistic effect with these fungicides for either disease. The fungicide program (Microthiol Disperss at 4 lb/A + Quintec at 4 fl oz/A followed by 4 applications of Microthiol Disperss + Gavel at 2 lb/A + Dithane at 1.22 lb/A with Nova at 5 oz/A alternated with Quintec, followed by 1 application of Microthiol Disperss + Nova + Gavel + Dithane + Curzate at 3.2 oz/A, followed by two applications of Microthol Disperss alone) provided good control of both diseases that was not significantly different from the Procure/Forum combination treatment.

DOWNY MILDEW OF BUTTERNUT SQUASH: EVALUATION OF FUNGICIDE PROGRAMS

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

The objective of this study was to evaluate registered and experimental chemicals for the control of downy mildew in butternut squash. Downy mildew has become an important problem for cucurbit growers in the northeastern US because in recent years this disease has infected plants in the area much earlier in the season than was previously observed.

Seeds of Bugle, a variety with powdery mildew resistance, were sown on 13 Jun in the greenhouse and seedlings transplanted into black plastic mulch with drip irrigation on 29 Jun. Plots were three 12-ft rows with 3 plants each. Treatments were applied weekly from 28 Jul until 19 Sep with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 inch apart that delivered 85 gal/A at 100 psi.

Downy mildew was first observed on 15 Sep only in the non-treated plot of the one replication examined. Disease severity was assessed on 18 Sep, when symptoms were widespread, and on 27 Sep. Best level of downy mildew control was obtained with the new (not yet registered) fungicide Revus (mandipropamid), the two treatments with the experimental Valent BioSciences fungicide (V-10161, used alone and in combination with Bravo Ultrex 82.5 WG), and with a fungicide program (that consisted of two applications of Bravo Ultrex 82.5 WG at 1.5 lb/A followed by one application of Bravo Ultrex + Previcur Flex 6F at 1.2 pt/A followed by one application of Bravo Ultrex + Previcur Flex + Curzate 60DF at 3.2 oz/A followed by two applications of Bravo Ultrex + Curzate). Ridomil Gold 2E performed at a slightly lower level than these fungicides and Cabrio EG was ineffective. Efficacy of Cabrio was likely affected by resistance to quinone outside inhibitor (QoI) fungicides which has been documented elsewhere in the US; however, this was not confirmed. There has also been concern that strains of the pathogen with resistance to mefenoxam could occur and affect efficacy of Ridomil fungicides.

BACTERIAL WILT OF CUCUMBER: EVALUATION OF CUCUMBER VARIETIES

Investigators: M. T. McGrath, D. O. Gilrein, and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

Breeding varieties with resistance to bacterial wilt and good yielding ability reportedly has been challenging, thus few varieties have been released. Resistant varieties are an especially valuable management tool for organic production due to difficulty achieving adequate control with other tools. The pickling type cucumber County Fair exhibited a high level of resistance

to bacterial wilt compared to Calypso in previous experiments at LIHREC (7% versus 100% severely wilted plants in 2000). The goal of this study was to evaluate wilt resistance of Little Leaf and an experimental line developed through the Cornell breeding program, which are pickling types, and a slicing cucumber type, Marketmore 80, by comparing them to County Fair and Calypso.

Seeds were sown on 27 Jun in the greenhouse and seedlings transplanted into black plastic mulch with drip irrigation on 26 Jul. Plots were 20-ft long with a plant spacing of 24-in. A randomized complete block design with four replications was used. Bacterial wilt was evaluated on 15 Sep by determining percentage of cucumber plants that were i) healthy, ii) had less than five leaves affected by bacterial wilt, iii) had more than five leaves affected by bacterial wilt, iv) had entire runners affected by wilt, or v) were dead from wilt were determined. Cucumber fruit were harvested, weighed, and measured on 14 Sep.

County Fair exhibited the best resistance to bacterial wilt based on the number of healthy plants per plot and the number of plants with more than 5 leaves affected by bacterial wilt. The Cornell experimental cucumber line also performed well in terms of bacterial wilt resistance and was rated at the same statistical level as County Fair. Marketmore 80 did not suppress bacterial wilt as compared to the standard variety (Calypso) based on the percentage of healthy plants and the number of plants with more than 5 leaves affected, but did provide control based on both the number of plants with dead runners and percent mortality. Little Leaf did have a statistically lower level of plant mortality than Calypso but did not control bacterial wilt based on the other categories evaluated. No significant differences were found between cucumber varieties in terms of total yield or number of fruit produced; however, yield potential may have been affected by poor weed control. Little Leaf fruit were found to be significantly shorter than other pickling cucumbers evaluated.

PHYTOPHTHORA BLIGHT OF PEPPER: EVALUATION OF FUNGICIDES ON PHYTOPHTHORA CROWN ROT TOLERANT AND SUSCEPTIBLE VARIETIES

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

Efficacy of fungicides for control of Phytophthora blight was determined on a Phytophthora crown rot tolerant pepper variety, Aristotle, and on a fully susceptible variety, Red Knight. Two experiments, one for each pepper variety, were set up adjacent to one another, each with six fungicide treatments. Peppers were seeded on 11-12 May in the greenhouse and transplanted on 22 Jun. A randomized complete block design with four replications was used for both experiments. Each plot consisted of two 10-ft rows of peppers spaced 34 in. apart with an in-row plant spacing of 15 in. Buffer zones between plots were 5 ft long and planted with three 'Red Knight' pepper transplants each. At-transplant fungicide treatments were applied to each plot as seedling drenches with a backpack CO_2 pressurized sprayer at 40 psi equipped with a single (TJ60 8003VS) nozzle that was calibrated to deliver 50 ml in a 6 in. band around each pepper seedling. Foliar fungicide treatments were applied with a backpack CO_2 pressurized sprayer at 40 psi equipped with three (TJ60 8003VS) nozzles that delivered 62.5 gal/A. One nozzle was positioned directly over the top of the row and one drop nozzle was on each side of the row. Applications were made weekly from 21 Jul until 15 Sep. Since Phytophthora blight had not developed naturally by mid-Aug, fruit on plants in the border area between plots was artificially inoculated on 24 Aug and 5 Sep. Overhead irrigation was used throughout the season as needed and used after each inoculation for two hours (7 to 9 PM) for three consecutive evenings to promote Phytophthora infection. Plant mortality (percentage of dying plants per plot) and disease severity (percentage of entire plot affected by Phytophthora fruit and crown rot) were assessed on 2, 11, and 16 Oct.

Symptoms of Phytophthora blight were first observed on 19 Sep on green fruit in border areas between plots and by 1 Oct the disease had spread throughout the field. Plant mortality and disease severity were significantly lower than the controls for all treatments on all assessments dates on both varieties. On 11 Oct, 97% of Red Knight nontreated control plants and 55% of

Aristotle plants were dying. Percentage of dying plants was only 17% and 5%, respectively, for a new (not yet registered) fungicide Revus (mandipropamid), 29% and 7% for another new fungicide Maestro (captan), 41% and 7% for Ranman, 49-54% and 7-18% for 2 experimental fungicides, and 49% and 8% for Ridomil Gold/Copper.

PHYTOPHTHORA BLIGHT OF PUMPKIN: EVALUATION OF BIOPESTICIDES

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

The objective of this study was to evaluate the efficacy of a combination treatment schedule of foliar and drip applications of seven EPA-classified biopesticides that are at the advanced or demonstration (labeled) level of development for Phytophthora blight on pumpkin. Phytophthora blight is a devastating disease for which there have been no adequately efficacious control options, and growers have stated that they would use chemigation as a means to control this pathogen if it was found to be effective. Three biological fungicides, Actinovate (*Streptomyces lydicus* WYEC 108), Kodiak (*Bacillus subtilis* GB03), and Yield Shield (*Bacillus pumilis* GB34), were evaluated along with a combination treatment of Promax (thyme oil) applied through the drip and Proud-3 (thyme oil) applied to the foliage. Two phosphorous acid products, ProPhyt and Fosphite, were also evaluated because a similar product, Phostrol, was found to be effective in controlling Phytophthora blight in pumpkin in a previous experiment at LIHREC. All treatments were compared to a current grower standard fungicide program of weekly alternating foliar applications of three EPA-registered, conventional fungicides labeled for this use (Forum, Gavel, and Tanos) and a second combination program with two conventional fungicides not registered that have performed well in other experiments (Maestro 80 DF and Revus) plus two registered, labeled fungicides (conventional Ranman and biopesticide ProPhyt). Some applications in these programs included Cuprofix Dispersss for resistance management. Eleven rows of black plastic mulch each with two strips of Aquatraxx™ drip tape were laid on 14 Jun. 'Munchkin' pumpkin seed was planted in a greenhouse on 14 Jun and seedlings were transplanted on 30 Jun into the plastic mulch between the two strips of drip tape. Plots were single 20-ft rows spaced at least 11 ft apart. A randomized complete block design with four replications was used. Foliar treatments were applied preventatively beginning on 26 Jul and continuing bi-weekly for most treatments on 9 Aug, 23 Aug, 7 Sep, and 21 Sep with a tractor-mounted boom sprayer operated at 120 psi and 85 gpa and equipped with D5-25 hollow cone nozzles spaced 17 in. apart. Drip applications were applied bi-weekly on alternate weeks of the foliar applications on 2 Aug, 15 Aug, 1 Sep, and 13 Sep. The tape had 12-in. emitter spacing and a flow rate of 0.45 gal/min. The injection period for each drip application was 45 minutes using a separate Mazzei® injector for each treatment. Drip tape in the four plots for each treatment was connected with blank irrigation tubing. Since Phytophthora blight did not develop on its own, likely due to low rainfall and high temperatures, the field was artificially inoculated three times on 15 Aug, 5 Sep, and 25 Sep. Pumpkin fruit were examined for symptoms of Phytophthora fruit rot and other types of fruit rot on 11 Oct. Symptomatic tissue with spores of the pathogen were considered definitive.

Phytophthora fruit rot was not found until 9 Sep and was rated one time on 11 Oct when more widespread. On this date the only treatments with significant control of definitive plus suspected symptoms of this disease were the standard treatment of weekly foliar applications of conventional fungicides and a second treatment of weekly applications of conventional foliar fungicides applied in addition to bi-weekly applications of ProPhyt through the drip irrigation system. None of the treatments consisting of biopesticides applied alone suppressed Phytophthora fruit rot relative to the nontreated control. Results are not considered definitive because disease began to develop very late in the growing season and remained at a low level (6% of nontreated fruit with definitive symptoms plus 6% with suspected symptoms).

Project funded by the IR-4 Biopesticide Grant Program

PHYTOPHTHORA BLIGHT OF PUMPKIN: EVALUATION OF HARD-RINDED VARIETIES

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

The first pumpkins developed with hard rinds (shells) that are like gourds were demonstrated to produce fruit that when mature were much less susceptible to Phytophthora fruit rot than pumpkins with conventional rinds in experiments conducted at LIHREC in 1997-8. One of these, Lil' Ironsides, is now available commercially. The goal of the experiment was to examine eight new pumpkins with this trait plus a variety with a tough skin (Cannon Ball), all developed by Harris Moran. They were compared to Lil' Ironsides and to two commonly-grown varieties with conventional soft rinds (Mystic Plus and Magic Lantern). All varieties tested, except Apprentice and Lil' Ironsides, have resistance to another important disease, powdery mildew. All 12 pumpkin varieties and experimental lines were seeded on 9 Jun in the greenhouse and transplanted into bare ground plots on 27 Jun. Plots were separated with a Multipik summer squash plant. The experimental design was a randomized complete block with five replications. Since Phytophthora blight had not developed naturally by mid-Aug, fruit of interplot squash plants were inoculated on 24 Aug and 5 Sep.

Lil' Ironsides had the lowest percentage of fruit with definitive symptoms of Phytophthora fruit rot (spores of the pathogen present) as well as definite plus those symptoms likely caused by the pathogen (0.3% on 9 Oct). Many fruit of this variety rotted because of bacterial leaf spot and other reasons however (29% healthy-appearing fruit). Apprentice had 0.4% fruit with Phytophthora fruit rot and 73% healthy-appearing fruit. These values were 2.7% and 82% for Iron Man and 3.5-6.8% and 33-68% for four experimental lines. Most of these produce small (1 to 4 lb) fruit, based on evaluations conducted elsewhere. One, HMX 6685, was the only large-fruited (20 lb) entry tested. Values were 9% and 32% for Cannon Ball, 12% and 14-35% for the two hard-rinded experimentals producing medium-sized fruit, HMX 5680 (16 lb) and HMX 5681 (17 lb), 24% and 47% for Mystic Plus, and 47% and 6% for Magic Lantern. Iron Man and HMX 5683 are the top choices among the entries evaluated because they have resistance to powdery mildew and they had relatively low proportion of fruit that were affected by Phytophthora fruit rot or another type of fruit rot in this experiment.

ORGANICALLY-PRODUCED TOMATO: EVALUATION OF A HEALTH-PROMOTING PRODUCT AND A COPPER FUNGICIDE FOR FOLIAR DISEASE MANAGEMENT

Investigators: M. T. McGrath and J. F. Davey
Location: Long Island Horticultural Research and Extension Center

AgriLife and an OMRI-approved copper fungicide (Champion WP) were evaluated for control of foliar diseases of tomato. AgriLife, a citrus acid product that reportedly promotes plant health, was used preventively beginning 2 weeks after transplanting. It was applied to the ground early in plant growth as well as to foliage throughout the growing season. Champion was also applied beginning before symptoms of foliar diseases were observed, but not until first fruit were ripe.

The experiment was conducted in a field assigned to research on organic vegetable production. Hairy vetch and rye were seeded on 20 Sep 2005 to the entire experiment area. Non-fungicide-treated Red Sun tomato seed were planted in an organic seeding mix on 7 May in a greenhouse. On 13 Jun the field was flail chopped to form a mulch layer. Seedlings were no-till transplanted on 23 Jun with Neptune's Harvest Benefits of Fish (2-4-1 N-P-K) applied as a starter fertilizer. A tractor equipped with a fluted coulter and an S-tine was used to cut 4 in. deep strips through the field. Seedlings were planted in the opening by hand. There were 10 plants spaced 2 ft. apart in each single-row plot. A randomized complete block design with four replications was used. Drip irrigation tube was laid on the soil surface next to the plants. Plants were irrigated as needed. On 12 Jul, peanut meal was applied at 625 lb/A (equivalent to 50 lb/A of N) in a 6-in

band on each side of the row, then straw was placed around the base of plants (1/2 bale/plot) in all plots. Plants were pruned, staked, and trellised. AgriLife was applied using a CO_2-pressurized backpack sprayer with a single flat-fan nozzle boom (50 psi, 43 gallons/A). Each side of the planted row was treated with the boom held sideways to obtain thorough coverage of foliage, then a second pass was made around the plot with the boom directed on the soil on each side of the plot. AgriLife treatments were applied a total of 11 times from 7 Jul to 19 Sep. Champion (2 lb/A) was applied 4 times starting on 31 Aug (when first fruit were ready for harvest). This treatment was applied with the same sprayer with directed sprays on each side of the planted row, but this treatment was not applied to the ground around the plot. Disease incidence and severity were assessed weekly beginning on 20 Sep. Red and pink fruit were harvested seven times on a weekly basis from 1 Sep to 12 Oct. Fruit were graded by size, counted, and weighed.

Powdery mildew and Septoria leaf spot developed naturally and were first observed in the field on 13 Sep. All treatments were ineffective for Septoria leaf spot, a disease occurring commonly in organically-produced tomatoes on Long Island. Powdery mildew occurs more sporadically in these production fields, but can become quite severe. On the upper leaf surface all treatments managed powdery mildew at the same level. On the lower leaf surface, AgriLife (1:50 dilution) and Champion (2 lb/A) were the most effective treatments (71-78% control) and AgriLife (1:100) provided significantly less control but did reduce disease compared to the nontreated tomatoes (51%). Yield was not increased, most likely because diseases began to develop late in the growing season. AgriLife (1:50) yielded significantly lower (lb/plant) than the other treatments suggesting this concentration applied weekly from early in plant growth is phytotoxic. The total number of fruit per plant was statistically equivalent between treatments.

TOMATO: EVALUATION OF A COMMERCIAL MEDIA CONTAINING MYCORRHIZAL FUNGI

Investigator: M. T. McGrath, J. F. Davey, and T. E. Pawlowska
Location: Long Island Horticultural Research and Extension Center

The objective of this study was to determine if tomato plants with mycorrhizal fungi yield more and are less severely affected by disease than tomatoes without these beneficial fungi under LI growing conditions. Two mycorrhizal enhanced transplant media were evaluated, ProMix BX plus Mycorise Pro® and Promix FPX plus unformulated mycorrhizal fungi (0.764 g/planting cell of an unformulated mycorrhizal inoculant that is in the commercial product DIEHARD™ Root Dip), as compared to a standard transplant media without mycorrhizal fungi, Promix FPX. There was an additional observational treatment of plain ProMix BX.

Three rows of black plastic and drip irrigation spaced 30 inches apart were laid on 20 April. Dutch white clover inoculated with nitrogen-fixing Rhizobia bacteria was sown at 20 lb/A on 21 April by scattering seed by hand between rows of plastic mulch for weed control and improving soil health. Tomato seed was planted in 36-cell standard inserts in the different growing media in a greenhouse on 7 May. On 15 Jun, before transplanting, roots of 8 extra tomato seedlings were harvested from each treatment for evaluation of colonization by mycorrhizal fungi by T. E. Pawlowska in Ithaca, NY. At this time, the wet weight and dry weight of the top of the tomato seedlings were determined. A randomized complete block design was used with four replications. Each plot consisted of one 20-ft row of 10 tomato plants. Incidence and/or severity were assessed for powdery mildew and Septoria leaf spot, which both occurred naturally. Defoliation from these diseases was also rated. Roots from one plant per plot were harvested on 22 Sep and on 12 Oct. The entire root system was dug up by hand and washed with tap water. Small sections of roots were then cut from the entire root system and fixed in 50% ethanol and shipped to Ithaca for analysis of colonization by mycorrhizal fungi. Red and pink fruit were harvested seven times on a weekly basis from 1 Sep to 12 Oct. Fruit were graded by size, counted, and weighed.

Tomato seedling growth was affected early by the different potting media used. Promix BX plus Mycorise Pro® visibly increased the growth rate of seedlings, which is most likely due to the higher nutrient levels in this media. Mycorrhizal colonization was not observed to have occurred during the 39 days from sowing to transplanting for tomato seedlings grown in either ProMix BX

+ Mycorise Pro® or in Promix FPX to which was added at seeding the unformulated mycorrhizal fungi in the commercial product DIEHARD™ Root Dip. Limited colonization of tomato roots by mycorrhizal fungi was observed on mature tomato plants, but this was not associated with treatment. Thus it was not surprising that there were no significant differences in foliar disease occurrence or in total yield. Yield data suggested that the Promix BX + Mycorise Pro® increased the number of marketable fruit per plant early in the season (harvests 1 and 2 on 23 Aug and 1 Sep) as compared to both the control and the unformulated mycorrhizal fungi treatments. However, by the end of the season there was no indication that this treatment was performing any better for yield. Furthermore, when all harvests were combined, there was no statistical difference between any treatment. Higher initial yield for transplants grown in ProMix BX + Mycorise Pro® could be due to fertilizer or other differences between this and Promix FPX rather than the mycorrhizal fungi present. Although mycorrhizal fungi have been found to occur widely on a diversity of plants in natural systems, it is possible that roots of other crop plants may more readily establish mycorrhizal associations than tomato.

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

OZONE CONCENTRATIONS IN RIVERHEAD IN 2006

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

Ozone reached sufficiently high levels to cause acute, visible injury to leaves of sensitive crops in 2006 on Long Island. Ozone also causes sensitive plants to senesce prematurely. Concentration was ≥80 ppb for at least 65 hours on 19 days in 2006: 29 May (3 hours), 30 May (4), 17 Jun (1), 18 Jun(4), 20 Jun (1), 22 Jun (1), 1 Jul (1), 2 Jul (1), 3 Jul (1), 4 Jul (2), 14 Jul (2), 17 Jul (6), 18 Jul (10), 29 Jul (1), 31 Jul (2), 1 Aug (7), 2 Aug (9), 3 Aug (8), and 23 Aug (1). Ozone was at least 50 ppb on 828 hours on 98 days and at least 60 ppb on 410 hours on 60 days. The highest concentration in 2006 (168 ppb) was reached on 18 Jul. Typically high concentrations occurred between 1200 and 2200, as in previous years. Ozone was ≥80 ppb for 60, 124, 121, 184, 77, at least 67, 94, 40, at least 10, 95, and 65 hrs in 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, and 2006 respectively.

ASSESSMENT OF OZONE CONCENTRATIONS IN RIVERHEAD USING A CLOVER BIOINDICATOR SYSTEM

Investigator: M. T. McGrath and J. F. Davey
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 1 Mar and then transplanted to 15-liter pots on 9 May. Clover was harvested every 4-5 weeks for a total of four harvests. Cutting was done at 7 cm above the soil surface. Both wet and dry weights of harvested forage (leaves, stems, and flowers) were measured.

The forage dry weight ratios (sensitive/resistant) were 1.13, 1.04, 0.80, and 0.85 for tissue harvested from clover on 21 Jun, 28 Jul, 8 Sep, and 11 Oct, respectively. Ozone exposure during these growth periods expressed as AOT40 (accumulated ozone dose over the threshold of 40 ppb between 7 am and 7 pm) was 3707, 6050, 5620, and 941 ppb.h, respectively. Percentage of leaves with ozone injury (incidence) on 21 Jun, 28 Jul, 30 Aug, 26 Sep, and 11 Oct was 45%, 39%, 39%, 72%, and 74% for the sensitive clone, respectively, and 11%, 13%, 9%, 15%, and 20% for the resistant clone. Average severity of injury on affected leaves on 28 Jul and 26 Sep was 8% and 19% for the sensitive clone, respectively, and 4% and 6% for the resistant clone. Ozone exposure was highest during the second growth period; however, ozone injury was most

severe during the last period, especially in the sensitive clone. The highest ozone episode recorded in 2006 occurred on 18 Jul, 10 days before the second harvest; concentration was at least 60 ppm for 13 hours peaking at 168 ppb.

The resistant clone did not grow as well as the sensitive clone for the first growth period, as was found in 2005. Clover cuttings were planted earlier in 2006 than previous years to provide extra time for establishment in an effort to correct this problem. These results are in contrast with results from years previous to 2005 when growth of the sensitive clone was equal to that of the resistant clone when ozone concentration was low or up to 25% lower when ozone concentration was high. Although the forage dry weight ratios do not reflect the ozone exposure, the ratio declined over time through the harvest on 11 Oct suggesting the sensitive clone was being affected. During the first growth period the sensitive clone produced 13% more biomass than the resistant clone whereas during the fourth growth period the sensitive clone had produced 18% less biomass.

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

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

Research on ozone-sensitive and ozone-resistant snap bean lines was continued in 2006 using field-grown plants. The lines, sensitive S156 and resistant (tolerant) 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. Seed were inoculated with Rhizobia then sown by hand with 2 seeds placed every 9 inches, then thinned to 30 plants per plot in a row with 4 replications. Drip tape was laid next to each row for irrigation. Bean pods were harvested when immature for fresh-market consumption from half the plants repeatedly as they developed. Bean pods were harvested when seed were mature from the rest of the plants. Plants were examined routinely for ozone injury. Injury and defoliation due mainly to ozone injury were rated. Ozone concentration data were obtained from a monitor maintained at LIHREC by the DEC Air Quality Division. The hourly values were used to calculate ozone exposure expressed as AOT40 (accumulated ozone dose over the threshold of 40 ppb between 7 am and 7 pm).

The first planting was seeded on 25 May and had emerged by 1 Jun. Injury on leaves due to ozone was first seen on 16 Jun. Ozone was at least 40 ppb for 102 hours between emergence and 16 Jun; AOT40 was 570 ppb.h. Total number and weight of bean pods harvested from 17 Jul through 13 Sep for fresh-market consumption was 26% and 43% lower for S156 compared to R331; this was a significant reduction in weight but not number. Ozone exposure also affected mature yield. From emergence to 15 Aug when mature beans were harvested, these plants had been exposed to ozone $\geq$ 40 ppb for 889 hours and AOT40 was 11646. Compared to R331, number of pods of S156 was not reduced, but number of seeds and average seed weight were reduced 21% and 42%.

The second planting was seeded on 3 Jul. Plants had emerged by 10 Jul. Injury on leaves due to ozone was first seen on 10 Aug. Ozone was at least 40 ppb for 435 hours between emergence and 10 Aug; AOT40 was 6608 ppb.h. Ozone injury to S156 significantly affected fresh-market yield compared to R331. Total number of bean pods harvested from 1 Sep through 4 Oct was almost identical, but weight of these pods was 28% lower for S156. From emergence to 4 Oct, these plants had been exposed to ozone $\geq$ 40 ppb for 782 hours and AOT40 was 9696. Compared to R331, average seed weight for S156 was reduced 21%. Number of pods and seed were not affected.

The third planting was seeded on 31 Jul. Plants had emerged by 9 Aug and the first injury due to ozone was seen on 15 Sep. Ozone was at least 40 ppb for 300 hours between emergence and 15 Sep; AOT40 was 3179 ppb.h. Although ozone injury did occur, severity was lower than for the previous plantings, reflecting the lower ozone concentrations during this growth period. From emergence to the final harvest on 10 Oct, these plants had been exposed to ozone $\geq$ 40 ppb for only 422 hours and AOT40 was only 3807. None of the fresh-market or mature bean yield parameters were significantly different for S156 and R331; thereby further documenting that under low ambient ozone on Long Island these lines yield similarly and thus this is a suitable biological tool for assessing potential impact of ambient ozone.

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

Investigators: M. T. McGrath, A. Senesac, and J. F. Davey
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 being examined is 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 is being tested for continuous pumpkin production 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 can suppress 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.

In Oct 2005, the field was mowed to remove weeds and break-up remaining fruit from that year's pumpkin crop, conventional-till plots were disked twice, then the whole field was seeded to rye at 4.5 bu/A using a non-till seeder on 31 Oct. Fertilizer (40 lb/A of N as 34-0-0) was broadcast on 10 April 2006. Dutch white clover (10 lb/A) was no-till seeded to the first 250 feet of the reduced-tillage plots and the entire length of the driveways on 12 April and subterranean clover (190 lb/A) was planted to the last 50 feet of each reduced-till plot on 13 April. On 22 May, rye was rolled twice with a coulter packer in the reduced-tillage plots and was flail chopped in conventional-till plots and driveways. Round-up WeatherMax (22 oz/A) was applied on 5 Jun in a 36-inch band over the rows where pumpkins were to be planted in the reduced-till plots. On 21 Jun an Unverferth zone builder was used to cut and fertilize rows in the reduced tillage plots. It was set up to prepare 2 rows at 68-in spacing. For each row this piece of equipment has a 20-inch coulter to open the row, shank to disrupt plow pans and create compression fissures between the shanks and 2 17-inch wavy coulters followed by a 15-inch wide rolling basket to prepare the soil for planting. Since plots were set-up for 3 rows of pumpkins, the center row was cut twice. Liquid fertilizer (9-18-9) at 25 lb/A of N was injected into the reduced-till plots with a nozzle placed on the back of the shank such that it was at about 4 inch depth. Unfortunately there was a leak in the pump gauge resulting in some fertilizer being lost on the soil surface and possibly a reduced amount being injected into the soil. The conventional-till strips were rototilled on 21 Jun. Seed was planted with a vaccum seed planter on 3 Jul with 300 lb N/A (N-P-K 10-10-10) fertilizer. Weeds were managed primarily with herbicides. Conventional-till plots were also cultivated. Round-up and was applied on 5 Jun in a 36-inch band in the reduced-till plots to control weeds and clover in the pumpkin rows as well as mark their location; there were few weeds then. Strategy (2 pt/treated A) and Round-up WeatherMax (22 fl oz/treated A) was applied over all pumpkin rows in a 36-inch band on 5 Jul and rain began about 2 hours later.

Poast (1.5 pt/treated A) was applied to all pumpkin rows on 31 July to control emerged grasses. The entire field was overhead irrigated as needed.

The subterranean clover did not grow as well as the Dutch white clover, thus it does not appear to be a better choice. The number and weight of fruit per plant were statistically equivalent, although numerically lower for the reduced-till than the conventional-till plots, and the average fruit weight was also the same for both treatments. There were significantly fewer rotten fruit per plant in the reduced tillage plots. Weed control was again poor, especially in the reduced tillage plots, due to timing of herbicide applications. Rain occurred when Strategy and Round-up were applied after planting, thus these products were ineffective. Pumpkin plants emerged before the field was dry enough to re-apply. Weeds were numerous and well established when Poast was applied 4 weeks after seeding. Cultivation done in the conventional-till plots resulted in better weed control, but it was still not considered adequate. The competition for nutrients and sunlight between weeds and pumpkin plants visually appeared to be a limiting factor especially in the reduced-till plots, but no significant effects on the overall yielding ability of this treatment were found at the end of the season.