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

Investigator: 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 isolates from Long Island to the new fungicide Quintec (Dow Agro-Sciences, LLC), which contains a novel active ingredient, quinoxyfen, that is in FRAC group 13. 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 quinoxyfen was determined using a leaf disk bioassay with squash. Isolates of powdery mildew, *Podosphaera xanthii*, were collected from a pumpkin research field at LIHREC throughout the 2004 growing season. Fifteen isolates were maintained in the lab on squash cotyledons suspended on 75% water agar. The isolates that were used in the study were selected based on their sensitivity to quinone-outside-inhibiting (QoI, FRAC group 11) and demethylation inhibiting (DMI, FRAC group 3) fungicides. Squash seedlings at the first true leaf stage were treated with five concentrations of quinoxyfen ranging from 0 to 10,000 ppb. Ten-day-old cultures of powdery mildew were used to inoculate the leaf disks. After a 10-day incubation period, disease severity and disease incidence were evaluated using a dissecting microscope.

Quinoxyfen baseline sensitivity varied among powdery mildew isolates. All 15 isolates tolerated 10 ppb, exhibiting some decrease in severity on these disks compared to 0 ppb. The highest concentrations tolerated ranged from 100-10,000 ppb. No relationship was seen between quinoxyfen sensitivity and QoI sensitivity, DMI sensitivity, collection time, or whether Quintec was applied to the research plot where the isolate was collected. Quintec does not yet have a Section 3 US registration. It was granted a Section 18 registration in NY in 2004 and 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: EFFICACY INVESTIGATION FOR PRISTINE AND ITS COMPONENT FUNGICIDES USING QOI-RESISTANT AND QOI-SENSITIVE ISOLATES

Investigator: M. T. McGrath and J. F. Davey
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Presently Pristine and Nova are the only mobile fungicides registered in NY that are recommended for managing powdery mildew in cucurbits. The QoI fungicides Amistar, Cabrio, Flint, and Quadris (FRAC group 11) are no longer recommended following an investigation conducted in 2003 and 2004 on Long Island that documented widespread occurrence of strains of the powdery mildew fungus (*Podosphaera xanthii*) highly resistant to QoIs and consequent poor control. Mobile fungicides able to move to the lower (e.g. underside) of leaves are an important component of fungicide programs because this pathogen develops best on the lower leaf surface. It is difficult to directly deliver fungicide to the lower surface, even with new nozzle types and air assist sprayers. Pristine (a new product for powdery mildew from BASF Ag Products) contains a novel active ingredient, boscalid (group 7), and pyraclostrobin (group 11). In order to develop sound fungicide recommendations for growers, information is needed on the efficacy of boscalid and whether boscalid acts synergistically with pyraclostrobin, especially for QoI-resistant strains of this pathogen. A series of experiments were conducted under controlled greenhouse conditions with pathogen isolates varying in QoI sensitivity to obtain this information.

Three experiments were conducted with summer squash at the 3- to 7- leaf stage that were 21- to 30-days-old. Fungicide treatments were applied with a backpack CO_2 pressurized sprayer at 50 psi equipped with one TJ60 8004VS nozzle that delivered 50 gal/A. Treatments included nontreated, Pristine at 14.5 oz/A, Cabrio at 9.28 oz/A, and Endura at 5.22 oz/A. These rates are the recommended rate for Pristine and rates of Cabrio and Endura to provide the same quantity of pyraclostrobin and boscalid, respectively, as the Pristine treatment. An additional treatment of Endura at 6.66 oz/A was included in two experiments. Each plant was inoculated one day after treatment with one of three isolates of *Podosphaera xanthi*. Spores were transferred to a defined spot on a leaf using a fine paintbrush. One isolate was previously found to be highly sensitive to Flint (50% trifloxystrobin, FRAC group 11), another was highly insensitive to Flint and the last isolate was moderately insensitive Flint. After 10 days, colony diameters of each powdery mildew isolate were measured for each treatment. A randomized complete block design with four replications was used.

The sensitive isolate was controlled at the statistically highest level by Pristine, which provided 84%, 93%, and 90%, respectively, for the three experiments. The active ingredients in Cabrio and Endura worked synergistically when used together in the form of Pristine resulting in 55% and 27% vs. 84% control for the first experiment and 65% and 23% vs. 93% control for the second experiment. In experiment 3, there were no statistical differences between treatments for this isolate. The insensitive powdery mildew isolate evaluated was not controlled by Cabrio in any of the experiments. Endura at the low rate also did not statistically control this isolate in two of the experiments. However, when the two active ingredients from these fungicides: pyraclostrobin and boscalid were used together in the form of Pristine, powdery mildew growth was statistically decreased in two of three experiments. The same trend was found with the moderately insensitive isolate. This isolate was not controlled by Cabrio when used alone and was not controlled by the low rate of Endura when used alone in two of three trials. However, in one trial when those two active ingredients were used together in the form of Pristine, the isolate was controlled statistically better than the control.

In conclusion, Pristine proved to be an effective fungicide for control of powdery mildew when dealing with isolates with a range of sensitivity to QoI fungicides (FRAC group 11). The two active ingredients in this fungicide, pyraclostrobin and boscalid, were found to work in a synergistic manner to control powdery mildew. However, synergistic activity was not evident in a field experiment where conditions were less controllable (see following report).

POWDERY MILDEW OF PUMPKIN: EVALUATION OF FUNGICIDE PROGRAMS

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

The primary objective of this study was to evaluate the efficacy of several fungicides and fungicide programs for the control of cucurbit powdery mildew in an area where in 2004 strains of the pathogen with QoI resistance and moderate DMI resistance were detected before fungicide use. 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 29 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. Two preventative applications of Microthiol Disperss 80WP (4 lb/A) were made for one treatment to determine if early control of the disease could be achieved with this product resulting in a delay in when the IPM threshold was reached and thus a delay in when to start applications of the more expensive mobile fungicides which are also at risk for resistance development. Upper and lower (under) surfaces of 5 to 25 leaves in each plot were examined weekly for powdery mildew. Average severity for the entire canopy was calculated from the individual leaf assessments. Area under the disease progress curve (AUDPC) was calculated for severity over all assessment dates (23 Aug – 9 Sep) to obtain a summation value for the entire epidemic. Fungicides were applied weekly (on 17, and 24 Aug; and 1, 8 and 14 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 most effective fungicide applied on a 7-day interval was Procure 50WS (6 oz/A), providing 98% and 93% control on upper and lower leaf surfaces, respectively. Nova 40W (5 oz/A) was not significantly less effective (91% and 82% control, respectively). Neither of these products should ever be used commercially as a stand-alone product because of high risk for control failure due to resistance development. They were tested alone to determine whether resistance to the DMI fungicides has developed to the point of affecting their efficacy, which has not occurred as demonstrated by these results. Pristine (14.5 oz/A) was significantly less effective on lower leaf surfaces than Procure (46% control). Another treatment was Endura, a formulated product not registered for use on cucurbits with the active ingredient boscalid, which is one of the two active ingredients in Pristine. Endura provided a similar level of control as Pristine: 87% and 56%. This indicates that 1) the second active ingredient in Pristine, the QoI fungicide pyraclostrobin, is not contributing to control because of QoI resistance and that 2) there is not a synergistic relationship between pyraclostrobin and boscalid. However, Pristine was found to be more effective than Endura due to synergy in a greenhouse experiment where disease development from controlled, point inoculations was studied (see previous report).

The fungicide program tested was a three-way alternation among Pristine plus sulfur (Microthiol Disperss at 4 lb/A), Quintec plus sulfur and Nova plus sulfur for a total of 5 applications. Efficacy was not affected by whether the alternation started with Pristine or Quintec (96-96% and 71-74% control). For another treatment sulfur was applied twice on a preventive schedule before initiating the fungicide program at the IPM threshold. These two applications did not delay when threshold was reached which was one objective of this treatment. Control achieved with this treatment was not significantly better than the other treatments with the fungicide program: 98% and 87%.

POWDERY MILDEW OF BUTTERNUT SQUASH: EVALUATION OF EXPERIMENTAL FUNGICIDES COMPARED TO REGISTERED FUNGICIDES

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

The objective of this study was to evaluate an experimental fungicide (V-10118) from Valent Biosciences, Inc. relative to a DMI fungicide (Procure). Both V-10118 and Procure are mobile in plants, thus assessment focused on powdery mildew control on the lower leaf surface. Procure is not registered for this use in NY; however, its efficacy was shown through other experiments to be similar to that of the DMI Nova, which is registered in NY.

Squash was grown on black plastic mulch with a clover living mulch between the rows of plastic. Black plastic mulch and drip irrigation were laid on 11 May. Dutch white clover was broadcast-seeded between plastic strips as a living mulch to control weeds on 13 May. Greenhouse-grown seedlings of Waltham butternut were transplanted on 14 Jun. Weeds were controlled with one application of the herbicide Roundup Weathermax on 23 Jun, hand weeding, and mowing the clover strips before the squash vines grew off the plastic.

Treatments were applied weekly on 28 Jul, 4 Aug, 11 Aug, 18 Aug, and 25 Aug 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. Upper and lower surfaces were examined weekly for powdery mildew beginning on 20 Jul when fruit were starting to enlarge. Area under the disease progress curve (AUDPC) was calculated for severity over all assessment dates to use as a disease summation value.

Powdery mildew was first observed on 20 Jul at an extremely low level (2 older leaves out of 200 examined). Symptoms were found in half of the plots on 26 Jul, thus fungicide treatments were started 2 days later. V-10118 provided effective control of powdery mildew (90.6% and 96.1% control on the lower leaf surface for the low and high rates tested respectively) that was similar to that obtained with Procure (90.2%). There was a trend of lower severity with the higher rate of V-10118, but these treatments did not differ significantly, even when the full data set was analyzed including the plot with values that were outliers.

In conclusion, both rates of the experimental fungicide have excellent efficacy for powdery mildew of cucurbits.

POWDERY MILDEW OF PUMPKIN: EVALUATION OF BIOPESTICIDES AND BIOCOMPATIBLE FUNGICIDES

Investigator: 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.

The objective of this study was to evaluate several EPA-classified biopesticides used alone for powdery mildew in pumpkin. The focus was on 6 plant oil products because good control was achieved with a mineral oil (JMS Stylet-oil) in previous experiments conducted at LIHREC. Most are OMRI listed and/or exempt from EPA registration. A hydrogen dioxide product was also tested. Additional products tested were AgriLife and Prev-Am, which are considered biocompatible but are not classified as biopesticides under the EPA definition. Sulfur formulated as Microthiol Disperss 80W and chlorothalonil were also included as conventional protectant fungicides for comparison. There was also a 'conventional grower standard program' with fungicides shown previously to provide excellent control on lower leaf surfaces: It was Quintec 2.08SC tank-mixed with Microthiol Disperss 80W and applied in alternation with Procure 50WS + Microthiol Disperss 80W. Procure 50WS is systemic and Quintec 2.08SC redistributes very well due to its high volatility.

Biopesticides evaluated:

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

Biocompatible fungicides

1. AgriLife. 5% citric acid. Biological Solutions, L.L.C.
2. Prev-Am. 0.99% Sodium tetraborohydrate decahydrate. Citrus Oil Products, Inc.

The semi-bush pumpkin 'Appalachian' was direct-seeded on 29 Jun. As for previous experiments, most treatments were initiated after the IPM threshold of one leaf with powdery mildew symptoms of 50 old leaves examined was reached. Treatments were applied on 12 Aug, 19 Aug, 26 Aug, 2 Sep, 11 Sep, and 18 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. The preventative Oxidate treatment was applied every 3-4 days on 12, 16, 20, 24, and 29 Aug, and 2, 6, 11, 14, and 18 Sep. OxiDate also was applied following a curative schedule with the first three consecutive applications on 1, 2 and 3 Sep when powdery mildew reached a level of being easily seen but not severe (average severity on older leaves was 1% on upper surfaces and 2% on lower surfaces). Additional applications for this treatment were made every 3-4 days on 6, 11, 14, and 18 Sep. Sporan was applied with the adjuvant BioLink (2 pt/100 gal). GC-3 organic fungicide was applied with Natural wet adjuvant (8 fl oz/A). Upper and lower (under) surfaces of 5 to 50 leaves in each plot were examined weekly for powdery mildew. Average severity for the entire canopy was calculated from the individual leaf assessments. Area under the disease progress curve (AUDPC) was calculated for severity over all assessment dates (16 Aug to 23 Sep) to obtain a summation value for the entire epidemic.

All biopesticides and biocompatible products tested were controlling powdery mildew early in disease development based on the assessment on 23 Aug. But based on the AUDPC value for powdery mildew severity on upper leaf surfaces, the following products did not provide full season control (AUDPC not significantly lower than the AUDPC for nontreated pumpkins): OxiDate (AUDPC value 14% lower with the curative application schedule, 5% lower with the IPM schedule), Sporan (24% lower), GC-3 (17%) and AgriLife (24%). OxiDate was applied at a higher rate and more frequently in 2005 than in a similar experiment in 2004 in which it also was not effective. Due to inherent low residual activity, OxiDate appears to be unsuitable as a stand-alone product for cucurbit powdery mildew when conditions favor abundant spore production and rapid develop development. Organocide (sesame oil) (45% control), and Eco E-Rase (jojoba oil) (52%) were as effective as Microthiol Disperss 80W (57%) and the conventional protectant fungicide Bravo Ultrex (72%). Eco E-Rase (19%), as well as Bravo Ultrex (21%), also provided significant control on lower leaf surfaces based on the AUDPC value. The 'conventional grower standard program' provided excellent control of powdery mildew on upper and lower leaf surfaces as anticipated. Severity on 16 Sep was numerically lower than all other treatments and significantly lower than most treatments. AUDPC value for mildew on lower leaf surfaces was significantly lower than all other treatments. A variation of this conventional program, with 1 application each of Quintec 2.08SC and Procure 50WS combined with weekly applications of Microthiol Disperss 80W, was as effective as the grower standard program for managing powdery mildew on upper leaf surfaces (75% vs 93%) but not on lower surfaces (42% vs 75%); however, it significantly improved control over applying Microthiol Disperss 80W alone based on AUDPC for lower leaf surfaces (15% vs. 42%). Canopy condition and fruit quality generally corresponded to level of powdery mildew control with the notable exception of the AgriLife treatment, which resulted in significantly less defoliation (53%) than the nontreated control (80%) and also significantly more fruit with solid handles (59.3% vs. 34.9%) although AUDPC values did not differ significantly from the control.

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POWDERY MILDEW OF PUMPKIN: EVALUATION OF COPPER FUNGICIDES

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

The objective of this study was to compare different formulations of copper fungicides in their ability to control powdery mildew on pumpkin. Several formulations of copper hydroxide as well as one basic copper sulfate fungicide (Cuprofix) were evaluated in this study. Additional treatments were JMS Stylet-oil (organic formulation), a mineral oil, used alone or mixed with various commonly-used fungicides to address grower concerns about phytotoxicity. Three rows of black plastic mulch 30 inch apart were laid on 11 May. Dutch white clover was broadcast-seeded between plastic strips as a living mulch to control weeds. Plots were three 12-ft rows spaced 68-in apart. Each row consisted of 3 plants each spaced 24 inch apart, 15 ft was left unplanted between plots. All treatments were started on 28 Jul after the IPM threshold of one leaf of 50 old leaves examined with powdery mildew symptoms (Plant Dis. 80:910-916) was reached in 25 of the 32 plots. Treatments were applied weekly on 28 Jul, 4 Aug, 11 Aug, 18 Aug, and 25 Aug 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. Upper and lower surfaces of 50 leaves were examined weekly for powdery mildew beginning on 26 Jul when fruit were starting to enlarge. Canopy condition including defoliation was assessed on 24 Aug. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 15 Sep. Handles were considered good if they were green or brown, solid, and not rotting.

Powdery mildew was first observed on 26 Jul in 26 of 32 plots on 79 of 1600 older leaves examined. No significant differences were detected among five copper fungicides in terms of powdery mildew control on upper leaf surfaces (82–97% control) or lower surfaces (29-51% control). JMS Stylet-oil was not as effective as expected based on results from previous experiments. It was less effective than Kocide DF for controlling powdery mildew on both upper and lower leaf surfaces based on AUDPC values. Additionally, JMS Stylet-oil was the only treatment that did not have significantly less defoliation on 23 Aug than the nontreated control. However, pumpkin treated with JMS Stylet-oil had a high percentage of fruit with good handles that was similar to pumpkin treated with copper fungicides and significantly greater than nontreated pumpkin. No phytotoxicity was observed when JMS Stylet-oil was tank-mixed with Bravo Ultrex, Quintec, Kocide 2000, Nova, or Microthiol Disperss.

POWDERY MILDEW OF MUSKMELON: COMPARISON OF RESISTANT VARIETIES UNDER A REDUCED-FUNGICIDE PROGRAM

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

The objective of this study was to evaluate several powdery mildew resistant muskmelon varieties receiving a recommended reduced fungicide program for managing selection of new pathogen races. Four powdery mildew resistant varieties (Athena, Aphrodite, Eclipse, and Minerva) were compared to a powdery mildew susceptible variety, Delicious 51. Eclipse is resistant to race 1 of the powdery mildew fungus while the others are also resistant or tolerant to race 2. Both races have been present in recent years on Long Island. Three rows of black plastic mulch 30 inch apart were laid on 11 May. All muskmelon varieties were planted on 3 Jun in the greenhouse and were transplanted by hand into the plastic mulch on 21 Jun. For the reduced fungicide program applications were made just twice and on a 10-day interval rather than 7-day interval recommended for varieties without resistance. Plots were three 10-ft rows spaced 68-in apart. Each row consisted of two plants spaced 24 inch apart. There was 10 ft between plots. Upper and lower surfaces of 5 to 50 leaves in each plot were examined weekly for powdery mildew beginning on 20 Jul when fruit were starting to enlarge. Average severity for the entire canopy was calculated from the individual leaf assessments. Percent defoliation due to powdery mildew was assessed on 31 Aug. Marketable fruit were weighed and sugar content assessed for 1 or 2 fruit per plot on 31 Aug and 9 Sep. Over-ripened and green fruit were counted.

Powdery mildew was first observed on 8 Aug when first fruit appeared to be full-sized. Powdery mildew was effectively controlled with resistant varieties receiving a reduced fungicide program. These two fungicide applications were not sufficient for managing powdery mildew in the susceptible variety; consequently, this variety had significantly more leaves that had died by 31 Aug than the resistant varieties. There were no significant differences in powdery mildew severity or defoliation among resistant varieties. Delicious 51 produced significantly more fruit than the resistant varieties, with 5.2 marketable and overripe fruit/plant versus 3.0 fruit/plant for Athena to 3.6 fruit/plant for Eclipse (P=0.04). Fruit counts including immature fruit were 7.5 fruit/plant for Delicious 51 versus 3.8 fruit/plant for Minerva to 4.5 fruit/plant for Eclipse (P=0.01). Greater fruit number was off-set by lower individual fruit size. No significant differences were detected in sugar content; however, Delicious 51 fruit averaged only 8.8 percent sucrose, which could reflect inadequate powdery mildew control, while percent sucrose was 9.4 for Minerva, 10.1 for Eclipse and Athena, and 12.1 for Aphrodite.

POWDERY MILDEW OF CUCURBITS: DETERMINATION OF PATHOGEN RACE

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

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

Powdery mildew developed on PMR-45 and Topmark, but not on PMR-6, indicating that both race 1 and 2 were present, but no additional races.

POWDERY MILDEW OF PUMPKIN: EVALUATION OF POWDERY MILDEW RESISTANT VARIETIES

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

A nested statistical design was used with variety nested in crop and four replications. Plots were single rows of 8 plants at 30-inch spacing. A plant of the gourd Turk's Turban was planted between each plot. This gourd was shown previously to be very susceptible to wilt due at least partly to it being highly attractive to cucumber beetles which vector the bacteria that cause wilt. Each row contained a replication.

The primary objective of this study was to compare varieties of pumpkin with a range of powdery mildew resistance under a reduced-fungicide program with applications made about every 14 days. Bravo Ultrex + Nova was applied two times on 21 Jul and 20 Aug and one application of Bravo Ultrex + Quintec was made on 5 Aug. Fungicides were applied because an integrated program is recommended for slowing selection of pathogen strains able to overcome PMR or able to resist the action of the fungicides, and also because with some PMR varieties control of powdery mildew has been improved by applying fungicides on a 14-day schedule. Commercial varieties of pumpkin along with experimental varieties from breeding programs in New York, New Hampshire, and Rupp seeds were evaluated. These were compared to two pumpkin varieties without genes for resistance, Howden and Sorcerer. Upper and lower surfaces of 50 leaves were examined routinely for powdery mildew beginning on 2 Aug when fruit were starting to enlarge. Average severity for the entire canopy was calculated from the individual leaf assessments. Pumpkin fruit were harvested and weighed on 20-21 Oct.

Among the pumpkins evaluated, best season-long suppression of powdery mildew on both upper and lower leaf surfaces, quantified as AUDPC, was obtained with two experimental varieties from the Cornell Plant Breeding program, XP6899 (99.9% control on the upper and lower leaf surfaces), Magician (99.0 and 99.9%) and Gold Boullion (99.8 and 99.6%); however, none of the other entries had significantly more severe powdery mildew with the exceptions of RPX 760 and Touch of Autumn. Size of fruit produced by the entries with powdery mildew resistance ranged from an average weight of 0.6 lb for Bumpkin to 11.2 lb for RPX 764.

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

Fruit weight varied significantly among the pumpkins evaluated. Listed in order by fruit size were Bumpkin (average fruit weight of 0.65 lb with the largest fruit weighing 0.79 lb), Touch of Autumn (1.6 and 2.25 lb), NY01-605A (2.6 and 3.75 lb), NH1788 (2.9 and 6.14 lb), Hobbit (4.5 and 14.64 lb), XP6888 (5.0 and 8.16 lb), NY01-609 (6.3 and 11.12 lb), Magician (6.4 and 12.9 lb), XP7899 (6.6 and 11.82 lb), Magic Lantern (7.3 and 16.66 lb), RPX 760 (7.6 and 12.32 lb), Merlin (7.6 and 15.6 lb), Sorcerer (7.8 and 14.16 lb), Gold Bouillon (9.0 and 16.26 lb), Gladiator (9.9 and 15.62 lb), Howden (10.0 and 20.28 lb), RPX 763 (10.5 and 19.06 lb), NH1799 (10.7 and 16.4 lb), and RPX 764 (11.2 and 22.02 lb)

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

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

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

The objective of this study was to evaluate two commercial varieties with powdery mildew resistance (Royal Acorn and Sweet REBA) along with an experimental variety (NH Bush Acorn) exhibiting resistance from the University of New Hampshire breeding program. Sweet REBA was developed by the Cornell University breeding program. These were compared to a variety without known genes for resistance, Table Ace. A reduced-fungicide program is recommended on powdery mildew resistant (PMR) varieties for managing selection of new pathogen strains able to overcome powdery mildew resistance or able to resist the action of the fungicides; therefore, the entire experiment was treated with fungicides on a 14 day interval beginning after detecting powdery mildew. Plots were 20-ft long with eight plants spaced 30 inch apart. One plant of the gourd 'Turk's Turban' was planted between each plot. A randomized complete block design with four replications was used. The reduced-fungicide program for powdery mildew consisted of Bravo Ultrex 82.5WG (2.7 lb/A) + Nova 50W (5 oz/A) applied on 21 Jul and 20 Aug and Bravo Ultrex 82.5WG (2.7 lb/A) + Quintec 2.08SC (4 fl oz/A) applied on 5 Aug. Upper and lower surfaces of 50 leaves were examined routinely for powdery mildew beginning on 3 Aug when fruit were starting to enlarge. Powdery mildew colonies were counted; severity was assessed when colonies could not be counted accurately because they had coalesced and/or were too numerous. Average severity for the entire canopy was calculated from the individual leaf assessments. Canopy condition including defoliation was assessed on 13 Sep. Fruit were harvested and weighed on 17 Oct. Fruit quality was evaluated in terms of sucrose levels.

Powdery mildew severity remained low in all varieties. There were no significant differences in severity among the PMR varieties, which were all significantly less severely affected on lower leaf surfaces than susceptible Table Ace based on the assessment on 22 Aug and AUDPC (0.2-1.1 vs 4.1%). Sweet REBA (24%) and NH bush acorn (20%) had significantly less defoliation on 13 Sep than the others (48-56%). NH bush acorn produced significantly smaller fruit and less fruit by weight per plant than the others, but the fruit had substantially higher sucrose levels. There were no significant differences among varieties in number of fruit per plant, width of fruit, or width of fruit cavity.

PHYTOPHTHORA BLIGHT OF PEPPER: EFFICACY OF TERRACLEAN (A HYDROGEN DIOXIDE PRODUCT FROM BIOSAFE SYSTEMS, LLC.)

Investigator: 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 of TerraClean, a new hydrogen dioxide product, for controlling Phytophthora blight of pepper. This product is labeled as a soil treatment for a broad spectrum of soil-borne pathogens both bacterial and fungal. Soil was sterilized with a soil steamer at 180°F for 4 hours to ensure that the planting medium was free of pathogens. Sixteen inch circular pots were filled with the sterilized soil and four greenhouse grown pepper plants were transplanted per pot. One day after transplanting, soil two inches deep and two inches from the stem of each pepper plant was inoculated with 5 ml of a sporangial suspension of *Phytophthora capsici* (5,000 sporangia/ml). The soil was treated with four different concentrations of TerraClean through a drip system that delivered 1 liter of solution per hour to each pot after inoculation. The concentrations evaluated were 1:1000, 1:500, 1:250, and a control. A randomized complete block design was used with four replications. A second treatment of 1:1000 and 1:500 was applied three days later for two of the treatments and SuperBio, a microbial mix of beneficial organisms, was also added to the soil of one treatment. Pepper plants were observed over a three week time period for symptoms of disease stress. The first symptoms of wilting and stem lesions were observed six days after inoculation. Lesions lengths were measured at this time. Plants were then evaluated for disease progress for the duration of the experiment. Disease progress was evaluated in terms of the presence, absence, and length of stem lesions from *Phytophthora* as well as defoliation.

Disease pressure was high in this study, at least one of the four plants in each pot became infected with *Phytophthora*. Results were variable, higher rates and multiple applications of TerraClean did not correspond with increased disease control. Further studies with higher rates or increased number of applications of this product may yield better results.

PHYTOPHTHORA BLIGHT OF SQUASH: EFFICACY OF CURRENTLY REGISTERED FUNGICIDES

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

The objective of this study was to evaluate several fungicide programs recommended by the IR-4 program for the control of Phytophthora blight in cucurbit crops. On 14 Jul, 15-day-old seedlings of ‘Sunray’, a powdery mildew resistant variety of yellow summer squash, were transplanted into bareground in a field where Phytophthora blight has occurred previously. Plots were 20-ft long with 10 plants in a single row. Two treatments included seedling drenches with 6.75 fl oz ProPhyt (0.5%) two days before transplanting. Foliar fungicide applications were made on 8 Aug, 16 Aug, 22 Aug, 29 Aug, 9 Sep, 12 Sep, and 21-23 Sep with a tractor-mounted boom sprayer equipped with four D5-25 hollow cone nozzles per row spaced 17 inch apart that delivered 85 gal/A at 120 psi. Since Phytophthora blight had not developed naturally, likely due to low rainfall, on 25 Aug fruit of border squash plants were inoculated with a single mycelial plug of Phytophthora capsici cut with a number nine cork borer from the edge of a 10-day-old actively expanding culture. The field was overhead irrigated immediately afterwards. On 31 Aug all border plants were examined for symptoms of Phytophthora blight and any plants that had not developed symptoms were re-inoculated by placing a single infected squash fruit near the base of the plant. Disease incidence (percentage of infected plants per plot) was assessed on 7 Sep. Phytophthora crown rot and fruit rot percentages were both assessed on 19 Sep and 26 Sep.

Symptoms of Phytophthora fruit rot were first seen on inoculated border plants on 29 Aug and on plants in treatment rows on 7 Sep. Although nontreated control plots usually had numerically highest values for fruit rot and crown rot on 19 and 26 Sep, significant differences were only detected for crown rot on 26 Sep. Treatments with Cuprofix 36.9 DF tank-mixed with Ranman 400 SC, NOA 446510, V-10161 + Previcur Flex, and Tanos 50DF were providing effective control on 26 Sep. Previcur Flex was ineffective when tank-mixed with Reason 500 SC plus Cuprofix 36.9 DF. Treatments with fungicides labeled for this use, Forum 4.16 SC and Gavel 75 DF, were ineffective. Phytophthora blight started to develop eight weeks after the soil-drench application of ProPhyt to seedlings before transplanting, which is probably too long a time for it to contribute to control in this experiment.

Project funded by the IR-4 Project.

PHYTOPHTHORA BLIGHT OF PEPPER: EVALUATION OF DUPONT FUNGICIDES

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

The primary objective of this study was to evaluate the addition on a 14-day application interval of either Tanos or an experimental fungicide, DPX-JE874, to a 7-day fungicide program with the EBDC fungicide Manex plus the copper hydroxide Kocide 2000. Three other fungicide programs evaluated consisted of different formulations of an experimental copper, DPX-GFJ52, applied with Tanos and Manex. Each plot consisted of one 15-ft row of peppers spaced 15 inch apart. Rows were spaced 68 inch apart, and the buffer zone from one plot to the next was 5 ft planted with two pepper transplants each. Fungicides were applied with a backpack CO2 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 either side of the row. Applications were made on 8 Aug, 16 Aug, 23 Aug, 1 Sep, 8 Sep, 17 Sep, 23 Sep, and 30 Sep. Since Phytophthora blight had not developed naturally, likely due to low rainfall, the main stem of pepper plants in the border area between plots was inoculated with a single mycelial plug of Phytophthora capsici cut with a number nine cork borer from the edge of a 10-day-old actively expanding culture on 25 Aug. No pepper fruit had developed at this time. On 14 Sep all border plants were inoculated again with infected squash fruit from a neighboring Phytophthora blight experiment. On 22 Sep 16.9 fl oz of a sporangial suspension (3,381 sporangia/fl oz) was sprayed onto the growing tip of each border plant between plots and more infected squash fruit was placed at the base of these plants to encourage disease development. Pepper fruit were just starting to form in the field at this time. Disease incidence (percentage of infected plants per plot) was assessed on 3, 17, 24, and 31 Oct.

Symptoms of Phytophthora blight were first observed on 30 Sep in 4 out of 36 plots. Over the week of 7 Oct to 14 Oct there was a total of 17.75 inch of rainfall, which promoted Phytophthora blight development throughout the field. Although nontreated control plots usually had numerically highest incidence of Phytophthora blight, none of the fungicide programs had significantly lower incidence; however, conditions were highly favorable for Phytophthora blight in this experiment.

PHYTOPHTHORA BLIGHT OF SQUASH: EVALUATION OF DUPONT FUNGICIDES

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

The objective of this study was to evaluate several fungicide programs for the control of Phytophthora blight on summer squash. Treatments applied were alternated with applications of Forum (6.2 fl oz/A) + different formulations and rates of copper hydroxide. Two treatments included seed that was treated with a water-based slurry of Apron XL LS (0.007 fl oz) on 13 Jul before planting. Summer squash were direct seeded by hand on 14 Jul. Each plots consisted of one 30 ft row of summer squash spaced 24 inch apart. Rows were spaced 68 inch apart, and the buffer zone from one plot to the next was 10 ft planted with three squash transplants each. Throughout the season on 15 Aug, 19 Aug, 25 Aug, 8 Sep, 14 Sep, 19 Sep, and 21 Sep mature squash fruit were harvested to keep the plants from declining. Fungicide applications were made on 9 Aug, 16 Aug, 22 Aug, 29 Aug, 5 Sep, 12 Sep, and 21 Sep. Since Phytophthora blight had not developed naturally, likely due to low rainfall, on 25 Aug fruit of border squash plants were inoculated with a single mycelial plug of Phytophthora capsici cut with a number nine cork borer from the edge of a 10-day-old actively expanding culture. The field was overhead irrigated immediately afterwards. On 31 Aug all border plants were examined for symptoms of Phytophthora blight and any that had not yet become infected were re-inoculated by placing a single infected squash fruit near the base of the plant. Disease incidence (percentage of infected plants per plot) was assessed on 17 Sep. Phytophthora crown rot and fruit rot percentages were both assessed on 20 Sep and 26 Sep.

Symptoms of Phytophthora fruit rot were first seen on inoculated border plants on 29 Aug and on plants in treatment rows on 7 Sep. Although nontreated control plots usually had numerically highest values for fruit rot and crown rot on 20 and 26 Sep, significant differences were not detected. Phytophthora blight started to develop eight weeks after the seed treatment with Apron, which is probably too long a time for it to contribute to control in this experiment.

PHYTOPHTHORA BLIGHT OF PUMPKIN: EFFICACY OF ALTERNATIVE PRODUCTS

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

The objective of this study was to evaluate several alternative products for their ability to control Phytophthora blight in pumpkin. SprayHandler reportedly affects soil structure and porosity, thus it might improve water drainage enough that conditions will not be favorable for the onset of Phytophthora blight. Companion and AgBlend are microbial products. An experiment was conducted at LIHREC in a field where Phytophthora blight had developed in 1991 to 1993, 1995 to 1999, 2003, and 2004. On 22 Jul, the field was rototilled, 'Cotton Candy' pumpkin seed was planted by hand. This was a replanting due to poor germination of the first planting made on 3 Jul. Each plot consisted of three 25-ft rows of pumpkin with 24-inch plant spacing and 68-in row spacing. The unplanted buffer zone between plots was 20 ft. Applications of SprayHandler and AgBlend were made on 24 Jun, 1 Aug, 22 Aug, and 12 Sep. Applications for the Companion treatment and the conventional fungicide program with Acrobat applied in alternation with Phostrol were made on 9 Aug, 16 Aug, 22 Aug, 29 Aug, 6 Sep, 12 Sep, 19 Sep, 27 Sep and 3 Oct. All Applications were made 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. Pumpkin canopy condition including percentage of foliage dieback was rated on 22 Sep. A penetrometer was used on 27 Jul and 19 Oct to measure soil compaction at 3-inch increments to 15 inch depth. Disease severity (percentage of infected fruit per plot) was assessed on 26 Sep, 3 Oct, 17 Oct, and 24 Oct.

Conditions were dry during most of the 2005 growing season and thus not conducive for Phytophthora blight. None of the treatments with alternative products had significantly lower percentage of fruit with Phytophthora rot (10-29% on 24 Oct) than the nontreated control (28%) or significantly higher percentage of marketable fruit at the end of the experiment (17-27 vs 23). Pumpkins treated with Acrobat alternated with Phostrol, a conventional fungicide program for Phytophthora blight in pumpkin, had significantly more marketable fruit (35) than pumpkins that were nontreated (23) or pumpkins that received most of the alternative product treatments. These fungicide-treated pumpkins had the lowest percentage fruit with Phytophthora rot (1.5%), but this wasn't significantly different from the other treatments. Foliage dieback due primarily to downy mildew was significantly lower in the pumpkins treated with Acrobat and Phostrol than in all other treatments. The SprayHandler treatment did not significantly affect soil compaction based on penetrometer resistance readings at any depth on either assessment date.

ORGANICALLY-PRODUCED TOMATO: EVALUATION OF HAIRY VETCH PLUS RYE MULCH AND A HEALTH-PROMOTING PRODUCT FOR FOLIAR DISEASE MANAGEMENT

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

The objective of this study was to evaluate hairy vetch plus rye mulch used alone or combined with applications of AgriLife for control of foliar diseases of tomato by comparing these treatments to tomatoes grown in bare-ground. AgriLife, a citrus acid product that reportedly promotes plant health, was applied to the ground early in plant growth as well as to foliage throughout the growing season.

The experiment was conducted in a field of Haven loam soil that has been assigned to research on organic vegetable production. Hairy vetch (40 lb/A) and rye (2 bu/A) were seeded on 8 Oct 04. Non-fungicide-treated tomato seed was hot-water treated at 50 C for 25 minutes to control seed-borne bacterial pathogens and then seeded in an organic soil-less mix on 2 May 05 in a greenhouse. On 28 May the field was flail chopped to form a mulch layer. On 3 Jun plots receiving the bare-ground treatment were prepared by raking away the vetch/rye mulch then using a hand-held rototiller. Seedlings were put outside to harden on 31 May and were no-till transplanted on 7 Jun with Neptune's Harvest Benefits of Fish (2-4-1 N-P-K) as a starter fertilizer. A tractor equipped with a fluted coulter and an S-tine was used to cut 4 inch deep strips through the field. Seedlings were placed in these holes by hand. There were 10 plants spaced 2 ft. apart in each single-row plot. Plots were spaced five ft. apart. 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. Bare-ground plots were rototilled again on each side of the planted row on 27 Jun. Peanut meal was applied at 625 lb/A (equivalent to 50 lb/A of N) and straw was placed around the base of plants (1/2 bale/plot) in all plots on 27 Jun. In addition to the straw, weeds were managed throughout the growing season by mowing between plots and hand weeding in the planted rows. Plants were pruned, staked, and trellised. AgriLife was applied using a CO_2-pressurized backpack sprayer with a single flat-fan nozzle boom. 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 was applied at 1:200 on 13, 21, 28 Jun, 5, 12 Jul, as well as on 1, 8, 16, 23, and 30 Sep. In the middle of the season AgriLife was applied at a higher rate of 1:100 on 19, 22, 27 Jul, and 1, 5, 8, 16 Aug. Entrust was applied to help control Colorado potato beetle on 8 and 25 Aug. Leaf mold incidence (percentage of plants infected per plot) and severity (percentage of leaf tissue infected per plot) were rated on 15, 27 Sep, 3, and 17 Oct. Canopy condition including defoliation was assessed on 23 Sep. Red and pink fruit were harvested five times on a weekly basis from 10 Aug to 5 Oct. Fruit were graded by size, counted, and weighed.

Rye plus vetch did not produce as good a straw mulch as in previous years and several plants died due to fertilizer burn from peanut meal placed in contact with the stem. Although this experiment consequently was not as successful as previous ones, valuable information was gained from the experience. The vetch stand was not as dense as in previous years when seeding was done about 1 month earlier in the fall (6-12 Sep). When the cover crop was mowed, evidently the vetch was not sufficiently in flower to completely kill it and the rye had some mature seeds, consequently the cover crops became weeds. It was valuable to learn that peanut meal can damage young tomato stems sufficiently to kill the plant.

Leaf mold developed naturally and was first observed in the field on 6 Sep. Neither incidence nor severity were lower for tomato grown in hairy vetch mulch than tomato grown in bare-ground. Hairy vetch mulch has suppressed disease in other experiments and been shown to activate defense genes in tomato. In the current experiment there may not have been sufficient hairy vetch biomass since it was grown with rye plus the vetch stand was not as dense as in previous experiments when seeded earlier. Vetch is commonly grown with rye as a winter cover crop because rye protects the vetch when young and serves as a support for the vetch to grow up on. Tomato plants treated with AgriLife had numerically lowest disease ratings at all assessments with incidence on 27 Sep being significantly lower than the other treatments. There were no significant differences in yield among treatments.

ORGANICALLY-PRODUCED TOMATO: EFFICACY OF ORGANIC PRODUCTS FOR FOLIAR DISEASE MANAGEMENT

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

The objective of this study was to compare two fungicide programs with OMRI-approved products for their control of foliar diseases of organically-produced tomatoes. The products tested were Champion (77% copper hydroxide) and Organocide (5% sesame oil). Organocide was applied alone and also in combination with Champion to evaluate any phytotoxic effects of the combination of the two fungicides. Organocide combined with a copper fungicide was observed to provide good control of foliar diseases, better than obtained with copper alone, under farm conditions. A replicated experiment is needed to confirm this observation and to address the concern that combining copper with an oil could be phytotoxic to the tomato foliage.

The experiment was conducted in a field of Haven loam soil that has been assigned to research on organic vegetable production. Hairy vetch (40 lb/A) and rye (2 bu/A) were seeded on 8 Oct 04. Non-fungicide-treated tomato seed was hot-water treated at 50 C for 25 minutes to control seed-borne bacterial pathogens and then seeded in an organic soil-less mix on 2 May 05 in a greenhouse. On 28 May the field was flail chopped to form a mulch layer. Seedlings were put outside to harden on 31 May and were no-till transplanted on 7 Jun with Neptune's Harvest Benefits of Fish (2-4-1 N-P-K) as a starter fertilizer. A tractor equipped with a fluted coulter and an S-tine was used to cut 4 inch deep strips through the field. Seedlings were placed in these holes by hand. There were 10 plants spaced 2 ft. apart in each single-row plot. Plots were spaced five ft. apart. A randomized complete block design of three treatments with four replications was used. The three treatments consisted of Organocide applied alone, Organocide combined with Champion, and a nontreated control. Drip irrigation tube was laid on the soil surface next to the plants. Plants were irrigated as needed. Peanut meal was applied at 625 lb/A (equivalent to 50 lb/A of N) and straw was placed around the base of plants (1/2 bale/plot) in all plots on 27 Jun. In addition to the straw, weeds were managed throughout the growing season by mowing between plots and hand weeding in the planted rows. Plants were pruned, staked, and trellised. Organic fungicides were applied using a CO_2-pressurized backpack sprayer with a single twin jet nozzle boom. Applications were made on 8, 16, 23 and 30 Sep. Entrust was applied to help control Colorado potato beetle and fruit worms on 8 and 25 Aug. Leaf mold incidence (percentage of plants infected per plot) and severity (percentage of leaf tissue infected per plot) were rated on 15, 28 Sep, 3 and 17 Oct. Canopy condition including defoliation was assessed on 23 Sep. Red and pink fruit were harvested four times on a weekly basis from 10 Aug to 20 Sep. Fruit were graded by size, counted, and weighed.

Early in the season many of the plants in the field died due to a root and stem rot presumably resulting from the application of peanut meal. The fertilizer was applied directly to the soil around the base of the plant, rather than spread in a band across the planted row, and was observed to stimulate fungal growth around the tomato stems. In one week's time many of the tomato plants had developed a root and stem rot and died resulting in an uneven number of plants per plot. Leaf mold developed naturally and was first observed in the field on 6 Sep. No significant differences were found in the levels of control of leaf mold or yield for any of the treatments. No phytotoxicity was found for any of the products tested and defoliation was not significantly different between treatments.

In conclusion, Organocide tank-mixed with Champion appears to be a safe combination for tomato. Additional testing is needed on efficacy for disease control and impact on yield because the plant stand was inadequate in this experiment to make definitive assessments.

SNAP BEAN: EVALUATION OF COMPOST AS A FERTILIZER SOURCE AND INVESTIGATION OF CROP SUSCEPTIBILITY TO PHYTOPHTHORA BLIGHT

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

A long-term study was started in 2001 to examine the benefits of yearly soil amendments of commercially-available composts for improving soil health and managing diseases as well as the utility of compost as a source of nutrients to reduce chemical fertilizer inputs. Compost has been shown to be effective for suppressing several soil-borne plant diseases. Research is being done where Phytophthora blight occurred in 1991 to 1993, 1995 to 1999, 2001, and 2004. Snap bean was selected for the experiment in 2005 to investigate susceptibility to Phytophthora blight and occurrence of Asian soybean rust as well as assess benefits of compost amendments.

Each June since 2001 compost has been spread on the 8 amended plots at a rate of approximately 20 dry tons/A (40-45 wet tons/A) with a Millcreek compost spreader, then hand-raked as needed to obtain even distribution before disking to incorporate the compost up to about 6 inch depth. Plots are 28.3 ft wide and 45 ft long with at least 20 ft between plots that are end-to-end. Composted yard waste was obtained from Long Island Compost Corp in East Moriches, NY. Based on nutritional analysis performed by the University of MA Soil and Plant Tissue Testing Laboratory, the compost was 0.79% N (7 lb/yd^3) and thus was anticipated to provide 30 lb/A of N assuming 10% availability. Considering that some additional N likely would be provided by compost amendments made each of the previous 4 years, compost was concluded to be a sufficient source of nutritents for snap bean. Therefore chemical fertilizer was only applied to non-compost plots: 400 lb/A of 10-10-10 fertilizer (40 lb/A of N) was broadcast over these plots on 14 Jun. Compost was spread on 16 Jun, followed by disking of all plots. Herbicides Treflan and Eptam were applied on 12 Jul and then beans were seeded in the plots on 13 Jul. The beans were also cultivated on 9 Aug for weed control. The field was irrigated when soil was dry due to inadequate rainfall. It also was irrigated (approx. 0.25 inch) on 22, 23, and 24 Sep to provide conditions favorable for Phytophthora blight. Plots were examined routinely for symptoms of Phytophthora blight, rust, and other diseases. Yield was determined on 21 Sep by harvesting five ft of the center row of beans from each plot. Wet and dry weights were recorded for each plot along with plant and bean pod counts. Percent of plot area with weeds was assessed on 15 Sep.

No significant differences in yield or plant biomass were detected, indicating that adequate fertility was obtained by using compost in place of chemical fertilizer. Plants from compost-amended plots produced an average of 23 pods weighing 111 gram versus 21 pods also weighing 111 gram for plants from non-compost plots. Weight of leaves and stems was 130 and 128 grams, respectively. Root weight was 4.6 and 6 grams, respectively. Plant productivity evidently was not affected by the greater weed growth in the compost plots: average of 51% coverage of plot area by weeds when assessed at the end of the season on 15 Sep versus 19% in non-compost plots). Based on test results for soil samples collected before compost was amended in 2005 from the other plots in this field (see following report on tomato), compost plots had significantly more P (29%), K (68%), Mg (104%), Ca (107%), Al (25%), Mn (81%), and Zn (248%) as well as significantly more organic matter (63%). No significant differences were detected between compost and non-compost plots in soil compaction based on penetrometer readings on 27 Jul at 3, 6, 9, 12, or 15 inch depth or depth at which the reading reached 300 psi. However, the readings were lowest for the compost plots (eg 125 versus 152 for non-compost plots at 12-inch depth). There was a lot of variation among replications.

Symptoms of Phytophthora blight (wilting plants with leaf blight) were not observed in any of the bean plots. This might have been due to the 2005 growing season being drier than usual, and thus unfavorable for blight; however, conditions were not much more favorable in 2004 when pumpkins grown in this field were affected by blight. Additionally, symptoms were not observed when snap beans were grown in the field in 2003 despite previous occurrence of blight on pumpkin. Losses due to blight in snap bean have been occurring in MI since 2003 when the disease was first detected on this new host. Lack of blight occurrence on snap bean at LIHREC suggests that blight on bean in MI could be due to a new strain of the pathogen with this unique pathogenicity that evolved in MI.

Asian soybean rust, a new disease in the US, did not become as severe a problem in 2005 as feared and did not spread far enough from where established in the southeast to be a concern in NY, thus it was not surprising that symptoms were not observed in this experiment.

In conclusion, compost has proven useful as a replacement for chemical fertilizer. Snap bean does not appear to be susceptible to strains of the Phytophthora blight pathogen (*Phytophthora capsici*) occurring at LIHREC; however, it is possible that conditions were too dry and thus blight could not develop.

TOMATO: EVALUATION OF COMPOST AS A FERTILIZER SOURCE AND OF A COMMERCIAL PREPARATION CONTAINING MYCORRHIZAL FUNGI

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

The goals of this study were 1) to determine whether tomato receiving a combination of yard-waste compost and conventional chemical fertilizer would yield as well as tomato receiving an equivalent amount of nitrogen from just conventional fertilizer and 2) to evaluate benefits of adding mycorrhizal fungi to tomato roots in terms of their establishment on tomato roots and impact on tomato yield, phosphate uptake and disease suppression. Incorporating an organic amendment such as yard-waste compost into soil is also a way to improve soil health and possibly affect disease occurrence. Mycorrhizal fungi are now recognized as serving important functions for plants in natural ecosystems that would also benefit plants in agricultural systems. For example, through their associations with plant roots, these soil fungi increase the plant's nutrient supply, especially phosphorous, by essentially functioning as the plant's root system and also by acquiring nutrient forms normally unavailable to plants. They can also assist with water uptake under drought conditions and provide protection against plant pathogens. Their hyphae and hyphal secretions contribute to soil structure. Soil fertilization and disturbance through normal agricultural practices limits natural establishment of these associations. In this study DIEHARD™ Root Dip, a commercial product containing several types of mycorrhizal fungi plus beneficial bacteria and additives to promote rapid root development was compared to a nontreated control and a formulation with just the mycorrhizal fungi from the manufacturer. Tomato plants were grown in compost-amended plots as well as non-amended plots to determine whether presence of organic matter from compost would affect success of mycorrhizal fungi.

Seed of 'Brixy', a plum-type tomato, were planted on 10 May in the greenhouse. Soil samples were taken from each plot on 12 May for chemical analysis to determine long-term impact of compost amendments. Two groups of seedlings were treated on 8 Jun by applying either DIEHARD™ Root Dip or unformulated mycorrhizae to the surface of the potting mix around each tomato stem in their trays. The remaining seedlings were left non-treated. The gel DIEHARD™formulation slowly moved into the potting mix with watering. The liquid unformulated mycorrhizae preparation immediately penetrated into the mix. Plants were moved outside to harden on 10 Jun. Composted yard waste was obtained from Long Island Compost

Corp in East Moriches, NY. Based on nutritional analysis performed by the University of MA Soil and Plant Tissue Testing Laboratory, the compost was 0.79% N (7 lb/yd^3) and thus was anticipated to provide 30 lb/A of N assuming 10% availability. Additional N was assumed to be provided by compost amendments made each of the previous 4 years. Therefore on 14 Jun 05, 1000 lb/A of 10-10-10 fertilizer (100 lb/A of N) was broadcast over the 4 non-compost plots and 500 lb/A of 10-10-10 fertilizer (50 lb N) was applied to the 4 compost plots. Compost was spread on 16 Jun, followed by disking. An Unverferth zone builder was used followed by a rototiller to prepare the soil on 20 Jun. Three rows of black plastic mulch were laid on 22 Jun through all plots. Tomato seedlings were treated again by dipping root balls into either the formulated or unformulated mycorrhizae preparations on 24 Jun (approx. 15 ml was absorbed into each root ball), then immediately transplanting into the plastic mulch. Each row in a plot (eg subplot) was randomly assigned to one of the three mycorrhizae treatments (DIEHARD™, unformulated, or non-treated). There were 10 plants per row at 2-ft spacing. Tomato plants were staked and trellised. Weeds were managed by applying herbicide (Sencor) between plastic rows on 6 Jul and hand weeding as needed. Colorado potato beetles and fruit worms were controlled by applying Entrust on 24 Aug and Warrior on 7 Sep. Mankocide was applied on 27 Sep for leaf mold. Tomato plants were examined routinely for disease symptoms. Plants with TSWV were rouged. Nutrient content of leaves was assessed on 11 and 25 Aug. The root system of one plant per subplot was removed on 29 Aug and on 26 Oct, then transported to the lab of a Cornell scientist in Ithaca with the expertise to examine the roots for mycorrhizal fungi. Ripe fruit were harvested 7 times on 26 Aug, 2 Sep, 8 Sep, 19 Sep, 26 Sep, 5 Oct, and 19 Oct.

Annual compost amendments are having a long-term impact on soil. Several nutrients were significantly higher in compost than non-compost plots before amendment in 2005: P (32 and 25 ppm), K (205 and 122 ppm), Ca (843 and 408 ppm), Mg (167 and 82 ppm), Zn (1.1 and 0.3 ppm), Mn (3.2 and 1.8 ppm), and Al (53 and 42 ppm). Organic matter was also higher: 3.9% versus 2.4%.

Overall yield did not differ significantly for tomato grown in compost-amended plots and non-compost plots. These plants produced an average of 141 and 152 fruit/plant with marketable fruit weighing 17 and 14 lb/plant, respectively. Therefore adequate fertility was obtained by using compost in place of half the chemical fertilizer input provided to conventionally-grown tomatoes. The only significant differences in yield on individual harvest dates were on the first and second dates when total number of fruit from non-compost plots was greater than compost plots due to greater quantity of cull fruit, which were mostly due to blossom end-rot; number of marketable fruit did not differ significantly.

Leaves from compost plots had significantly higher potassium (K) content than leaves from non-compost plots (3.8% vs 3.3%) but significantly lower manganese (Mn) content (34 vs 107 ppm). No other significant differences were found in nutrient content of leaves (%N, %P, %Ca, %Mg, %S, ppm B, ppm Cu, ppm Al, ppm Zn, or ppm Fe) due to compost treatment or mycorrhizal fungal treatment.

Leaf mold caused by *Cladosporium fulvum* developed naturally in the tomato plots and was first observed on 22 Sep. No significant differences were found between the compost and non-compost plots or between the formulated, unformulated and non-treated mycorrhizal sub-plots in leaf mold incidence (percentage of infected plants per plot) or severity (degree of infection on each plant) based on evaluations made on 26 Sep, 3 Oct, and 19 Oct.

Mycorrhizal fungi were not observed in roots of any tomato plants examined, indicating that if these beneficial fungi did occur naturally in this field they were not able to establish relationships with tomato and suggesting the procedures used were not adequate for establishment of introduced mycorrhizal fungi on tomato roots. Consequently it is not surprising that neither yield, leaf nutrient content, nor disease occurrence was found to differ significantly among the subplots with these treatments.

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OZONE CONCENTRATIONS IN RIVERHEAD IN 2005

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 2005 on Long Island. Ozone also causes sensitive plants to senesce prematurely. Concentration was ≥80 ppb for 95 hours on 25 days in 2005: 5 Jun (3 hours), 7 Jun (1), 8 Jun (6), 25 Jun (3), 11 Jul (5), 19 Jul (4), 20 Jul (2), 21 Jul (5), 22 Jul (6), 24 Jul (1), 26 Jul (3), 27 Jul (2), 2 Aug (3), 3 Aug (5), 4 Aug (2), 5 Aug (7), 11 Aug (8), 12 Aug (5), 13 Aug (3), 21 Aug (2), 26 Aug (1), 2 Sep (3), 8 Sep (1), 12 Sep (5), and 13 Sep (9). Ozone was at least 50 ppb for 656 hours on 94 days and at least 60 ppb for 322 hours on 50 days. The highest concentration in 2005 (126 ppb) was reached on 5 Aug. Typically high concentrations occurred between 1200 and 2200 hours, as in previous years. Ozone was ≥80 ppb for 60, 124, 121, 184, 77, at least 67, 94, 40, at least 10, and 95 hrs in 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, and 2005 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 12 April and then transplanted to 15-liter pots on 18 May. Clover was harvested every 4 weeks. 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 1.36, 1.16, 1.0, 0.88, and 1.07 for tissue harvested from clover on 16 Jun, 19 Jul, 15 Aug, 12 Sep, and 26 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 2412, 1774, 5538, 2069, and 1397 ppb.h, respectively. Percentage of leaves with ozone injury (incidence) on 19 Jul, 15 Aug, 12 Sep, and 26 Oct was 41%, 34%, 17% and 16% for the sensitive clone, respectively, and 12%, 2%, 6%, and 10% for the resistant clone. Average severity of injury on affected leaves on 19 Jul and 15 Aug was 10% and 42% for the sensitive clone, respectively, and 6% and 2% for the resistant clone. Ozone exposure was highest during the third growth period, when the most ozone injury was observed in the sensitive clone. The highest ozone episode recorded in 2005 occurred during this growth period on 5 Aug; concentration was at least 60 ppm for 7 hours peaking at 126 ppb.

The resistant clone did not grow as well as the sensitive clone, in contrast with previous years when growth of the sensitive clone was up to 25% lower than the resistant clone. Although the forage dry weight ratios do not reflect the ozone exposure, the ratio declined over time through the harvest on 12 Sep suggesting the sensitive clone was being affected. During the first growth period the sensitive clone produced 36% more biomass than the resistant clone whereas during the fourth growth period the sensitive clone had produced 14% less biomass. Similar growth at the last harvest on 26 Oct was expected because the ozone exposure was low during this growth period.

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 2005 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.

Plots were inoculated with Rhizobia then seeded by hand with 2 seeds placed every 9 inches, then thinned to 15 plants per sub-plot. Yellow wax beans were planted between plots and sub-plots. Plots were single rows. The 4 replications were in 2 adjacent rows spaced 34-inch apart. There were 3 successive plantings which were arranged end-to-end in the same 2 rows. Drip tape was laid next to each row for irrigation. Bean plants did not grow equally well in the two rows. The row with poor growth was side-dressed with fertilizer assuming there had been a problem with fertilizer placement when the whole field was fertilized before the first planting. Large variation in plant growth between rows compromised detecting significant differences in yield among the lines. Weeds were managed by applying herbicides, Eptam and Treflan, before seeding and hand-weeding. Bean pods were harvested when immature for fresh-market consumption from half the plants repeatedly as they developed (one sub-plot). Bean pods were harvested when seed were mature from the rest of the plants (other sub-plot). 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 17 May. Plants had emerged by 31 May. Open flowers were seen on 1 Jul. Injury on leaves due to ozone was first seen on 21 Jun. Ozone was at least 40 ppb for 174 hours between emergence and 21 Jun; AOT40 was 1814 ppb.h. Injury increased quickly, becoming quite severe by 26 Jul. On 27 Jul, severity was 75% and 24% for S156 and R331, respectively, which was a significant difference; incidence was 93% and 28%, respectively, which was also significantly different. Defoliation due to ozone injury was significantly different on 27 Jul: 66% in S156 and only 8% in R331. From emergence to 27 Jul, these plants had been exposed to ozone $\geq$ 40 ppb for 446 hours and AOT40 was 5536. Ozone injury to S156 significantly affected fresh-market yield compared to R331 only for the second of three harvests, which was on 28 Jul. Total number and weight of bean pods harvested from 18 Jul through 18 Aug for fresh-market consumption was 14% and 17% lower for S156 compared to R331; however, this was not a significant reduction. Ozone exposure affected mature yield. From emergence to 18 Aug when mature beans were harvested, these plants had been exposed to ozone $\geq$ 40 ppb for 707 hours and AOT40 was 9501. Compared to R331, number and dry weight of pods of S156 were reduced 31% and 43% (significant at P=0.10 and 0.05, respectively). Number and dry weight of seed were reduced 32% and 45% (significant at P=0.07 and 0.06). Average seed weight was reduced 17% (significant).

The second planting was seeded on 17 Jun. Plants had emerged by 29 Jun. Open flowers were seen on 19 Jul. Injury on leaves due to ozone was first seen on 26 Jul. Ozone was at least 40 ppb for 212 hours between emergence and 26 Jul; AOT40 was 2859 ppb.h. On 1 Aug, incidence of injury due to ozone was 18% and 3% for S156 and R331, respectively, which was not significantly different; severity was 27% and 6%, which was also not significantly different. By 17 Aug injury had increased to an average incidence of 89% and 31% and severity of 80% and 38% for S156 and R331, respectively; these values were significantly different. From emergence to 17 Aug, these plants had been exposed to ozone $\geq$ 40 ppb for 475 hours and AOT40 was 6984; these values are slightly greater than those for the first planting when at a similar level of ozone injury and stage of development (9-11 days after first harvest). Defoliation due to ozone injury was 73% and 15% in S156 and R331, respectively, on 17 Aug, 74% and 20% on 31 Aug, 79% and 26% on 7 Sep, 83% and 26% on 16 Sep, and 98% and 36% on 21 Sep, all being significantly different. Ozone injury to S156 significantly affected fresh-market yield compared to R331. Total number of bean pods harvested from 6 Aug through 24 Sep for fresh-market consumption was 39% lower for S156 and pod weight was 49% lower. From emergence to 26 Sep when mature bean pods were harvested, these plants had been exposed to ozone ≥ 40 ppb for 800 hours and AOT40 was 10,451. Compared to R331, number and dry weight of pods of S156 were reduced 36% and 44% (not significant however). Number and dry weight of seed were reduced 22% and 40% (not significant). Average seed weight was reduced 24% (significant).

The third planting was seeded on 13 Jul. Plants had emerged by 19 Jul. Open flowers and first injury due to ozone were seen on 10 and 5 Aug, respectively. Ozone was at least 40 ppb for 250 hours between emergence and 5 Aug; AOT40 was 3953 ppb.h. On 5 Aug, incidence of injury was 2% and 0.5% for S156 and R331, respectively, which was not significantly different; severity was 63% and 16%, respectively, which was significantly different. Incidence was 3% and 0.3% on 17 Aug, respectively, 2% and 10.3% on 24 Aug, and 44% and 13% on 7 Sep. Severity was 30% and 16% respectively on 17 Aug, 4% and 10% on 24 Aug, and 49% and 11% on 7 Sep. Defoliation due to ozone injury was 30% and 4% in S156 and R331, respectively, on 7 Sep, 90% and 36% on 16 Sep, and 100% and 56% on 21 Sep, all being significantly different. From emergence to the first harvest on 17 Sep, these plants had been exposed to ozone ≥ 40 ppb for 601 hours and AOT40 was 8548. From emergence to the last harvest on 27 Oct, these plants had been exposed to ozone ≥ 40 ppb for 743 hours and AOT40 was 9563. Total number of bean pods harvested for fresh-market consumption was 46% lower for S156 and pod weight was 56% lower. Compared to R331, number and dry weight of mature pods of S156 were reduced 42% and 64%; number and dry weight of seed were reduced 56% and 66%; and average seed weight was reduced 22% (all significant).

In summary, the ozone-sensitive snap bean line (S156) sustained more injury due to ambient ozone and yielded substantially less than the resistant line (R331) throughout the 2005 growing season in 3 successive field plantings. Both fresh-market yield and dry bean yield were lower for S156 than R331. Total weight of bean pods harvested for fresh-market consumption was 17%, 49% and 56% lower for S156 in the 3 plantings, respectively. Dry weight of mature pods was 43%, 44%, and 64% lower. Average seed weight was reduced 17%, 24%, and 22%.

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

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

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

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

The first open flowers were seen on 12 Jul. Average number of opened inflorescences per plant on 19 Jul for Black Knight (26), Bonnie (23) and Royal Red (22) was significantly greater than for Summer Beauty (13), Pink Delight (9). Harlequin (6), and Potter's Purple (1). Late in the growing season (18 Oct) Royal Red (14) and Potter's Purple (13) had significantly more open inflorescences than the other varieties (6-9). Average inflorescence length was significantly shorter for Harlequin (2.3 in), Royal Red (2.5), and Black Knight (2.8) than for Bonnie (3.5), Summer Beauty (3.8), Potter's Purple (4.1), and Pink Delight (4.2). The total number of inflorescences per plant produced throughout the season was higher for Royal Red (665) than Bonnie (327) and Black Knight (463); there were no significant differences amongst the other varieties (498 – 578).

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

Investigator: M. T. McGrath, D. D. Moyer, 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 2004, 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 5.3 bu/A using a non-till seeder on 13 Oct.

Fertilizer (50 lb/A of N as 34-0-0) was broadcast on 14 April 2005. Dutch white clover was no-till seeded to reduced-till plots and driveways on 15 April when rye was 5-8 inch tall. On 31 May, rye was flail chopped in conventional-till plots and driveways and in reduced-till plots rye was rolled twice with a coulter packer. Rye was starting to produce seed. Some rye lifted back up in the reduced-till plots after rolling, so rye was re-rolled on 6 Jun. Rolled rye then was green in contrast with the yellow chopped rye. Round-up WeatherMax (22 oz/A) was applied on 14 Jun in a 36-inch band over the rows where pumpkins were to be planted in the reduced-till plots. On 20 Jun an Unverferth zone builder was used to cut 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. The conventional-till strips were mowed on 20 Jun. A finger-weeder was used to pull straw out of these strips. Conventional-till strips were subsoiled and rototilled on 23 Jun. Soil was very dry and broke apart easily to a pulverized appearance in both reduced-till and conventional-till plots.

On 29 Jun granular fertilizer (10-10-10) at 25 lb/A of N was broadcast and incorporated in conventional-till plots. On 6 Jul liquid fertilizer (9-18-9) at 25 lb/A of N was injected into the reduced-till plots using the Unverferth zone builder at about 2-4 inch depth 3 to 7 inches from center where pumpkin seed were to be placed. It was not possible to mount the liquid fertilizer tank and pump on the pumpkin seeder as planned, and the wheel for the ground-driven pump did not contact the ground until the rows were re-worked, thus these rows were worked 3 times, including 20 Jun, rather than once as intended. Additionally, the center row was done twice each time with fertilizer banding done on both sides of center. The reduced-till rows became sunken likely due to the extra working. Pumpkins were seeded on 6 Jul, 3 rows per plot spaced 68-in apart. On 2 Aug all pumpkin rows were side-dressed with 34-0-0 at 30 lb/A of N. Conventional-till plots were cultivated to incorporate the fertilizer and control weeds.

Weeds were managed primarily with herbicides. Conventional-till plots were also cultivated. Round-up was applied on 14 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, plus the fungicide Ridomil Gold, was applied over all pumpkin rows in a 36-inch band on 7 Jul. Rainfall on 8 Jul (0.6 inch) and 9 Jul (0.42 inch) should have been adequate for activating the herbicide. Plants were slow to emerge likely because of poor seed placement (seed were found just below the surface as well as more than 2 inch deep) and also perhaps inadequate water under extremely dry conditions. Emerged pumpkins were not observed until 13 days after seeding. Poast (1.5 pt/A)and Sandea (0.5 oz/A) were applied to control emerged grass and broadleaf weeds on 9 Aug when pumpkin plants had 2-5 leaves and thus could tolerate the Sandea, at least 5 days had passed after cultivation, and rain was forecast. Unfortunately weeds had grown too big to be controllable by Sandea.

One half of the field was overhead irrigated when dry throughout the season and the other half was left non-irrigated. Pumpkins were harvested on 27 Sep from 15-ft sections of each plot. Fruit were harvested from additional sections on 30 Sep to determine the impact of the double band of fertilizer applied to the center reduced-till pumpkin rows. A penetrometer was used on 18 Oct to measure soil compaction at 3-inch increments to 15 inch depth.

The major differences found in this trial were between the irrigated and non-irrigated sections of the field. Average fruit weight was 4.9 lb for both conventional-till and reduced-till pumpkins grown with irrigation, which was significantly greater than fruit weight for the non-irrigated pumpkins (2.7 lb and 2.3 lb, respectively). Pumpkins grown under conventional tillage produced more fruit than those grown under reduced tillage in the irrigated half of the field (3 versus 1.9 fruit/plant) but not the non-irrigated half (2 versus 1.5 fruit/plant). Average fruit weight did not differ significantly between the reduced-till pumpkin rows receiving 25 lb/A of liquid N in a single band before planting and those receiving 50 lb/A of N in a double band. Fruit weight also did not differ significantly for plants in the outer and inner rows of conventional-till pumpkins.

Penetrometer readings were always lowest for measurements made in the row of the reduced-till plots, as expected due to the deep shank on the Unverferth zone builder, but these values were not significantly different from the measurements made in the row of the conventional-till plots. Readings were always significantly greatest for measurements made between the rows of the reduced-till plots, which was not too surprising considering the extra tractor traffic through these plots for establishment. For example, at 9-inch depth readings were 19 psi for in row of reduced-till plots, 61 psi for in row of conventional-till plots, 99 psi for between rows of conventional-till plots, and 289 psi for between rows of reduced-till plots.

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