Long Island Vegetable Pathology Program
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SENSITIVITY TO FUNGICIDES OF THE POWDERY MILDEW FUNGUS ON LONG ISLAND IN 2007

Investigators: M. McGrath and G. Fox
Location: Long Island Horticultural Research and Extension Center

Application of fungicides continues to be the principal practice for managing powdery mildew in cucurbit crops, but successful control is challenged by development of resistance to key fungicides. While there are varieties with genetic resistant to this disease, an integrated program is recommended to reduce selection pressure for pathogen strains able to overcome the genetic resistance in the plant as well as fungicide resistance. The pathogen develops best on the lower surface (underside) of leaves, thus a successful management program necessitates controlling the pathogen on the lower as well as the upper surface. It is difficult to directly deliver fungicide to the lower surface, even with new nozzle types and air assist sprayers. Consequently, an important component of fungicide programs has been fungicides able to move to the lower leaf surface. Most of these fungicides are systemic (e.g. Topsin M, Nova) or have translaminar activity (e.g. Flint, Amistar, Quadris). Some, notably the new fungicide Quintec, have high volatility enabling redistribution from upper to lower leaf surfaces. Unfortunately these fungicides are prone to resistance development because they have single site mode of action.

The goals of this study were to use a seedling bioassay to 1) determine fungicide sensitivity of the cucurbit powdery mildew fungal population on LI at the start of disease development and 2) monitor sensitivity during the growing season. This information was used to guide fungicide recommendations. For the assay, pumpkin seedlings were treated with fungicide (Flint, Nova, 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). Only one concentration of Flint was used because QoI resistance is qualitative. Several concentrations of the other fungicides were used because resistance is known or suspected to be quantitative. Endura (which is not registered for use on cucurbits) was used rather than Pristine (which is registered) because Endura has only one of the active ingredients in Pristine, boscalid. The other active ingredient in Pristine is a QoI fungicide.

The first bioassays were conducted in commercial spring plantings of zucchini on 29 Jun in one field and on 13 Jul after mildew was found in four more fields. Resistance to QoI fungicides (FRAC Group 11) was found in only 4 of the 5 fields, but at 3 sites it was at a very high level (89-100%). Considering this type of resistance is qualitative, thus resistant pathogen strains are completely uninhibited, and the pathogen spores can be dispersed widely by wind, these fungicides were not recommended for controlling powdery mildew in 2007. Sensitivity to DMI (Group 3) fungicides varied among fields. In 3 of the 5 fields strains were detected tolerating 100 ppm myclobutanil, the active ingredient in Nova. This is considered a moderately high level of insensitivity that could affect control with DMI fungicides, especially with the lowest label rate. This level of insensitivity may be the reason Nova at the highest rate was ineffective when tested at LIHREC in 2006. A very low frequency of tolerance of 120 ppm was found in 1 field. A low frequency of isolates tolerating 175 ppm boscalid (key ingredient in Pristine) were detected in all fields. An extremely low frequency of isolates tolerating 5 ppm of quinoxyfen, active ingredient in Quintec, were found in 4 fields.

Similar results were found in the first bioassay conducted in pumpkin fields and research plots on 10 Aug. This indicates that bioassays conducted in spring crops provide a good indication of what the fungicide sensitivity will be for the pathogen population in main season crops.

With the exception of boscalid, fungicide sensitivity did not change substantially during the season based on bioassays conducted on 22 Aug and 6 Sep. Frequency of isolates tolerating 175 ppm boscalid was higher in most fields examined on these dates, especially where Pristine was used and in research plots where only Endura was applied.

Based on these results, Quintec was predicted to be the most effective fungicide, and Procure was predicted to be slightly more effective than Pristine. This is what occurred in the following study. When these fungicides are applied at the highest label rate, the rate of active ingredient is 1.36 oz/A quinoxyfen for Quintec applied at 6 oz/A, 4 oz/A triflumizole for Procure at 8 oz/A, and 4.66 oz/A boscalid for Pristine at 18.5 oz/A. Concentration in spray solution varies greatly with the gallonage used to make the application. When applied at 50 gpa, the concentration is 212, 599, and 698 ppm for Quintec, Procure, and Pristine, respectively, which is 42, 5, and 4 times higher than the highest concentrations tolerated by powdery mildew strains detected in commercial fields (5, 120, and 175 ppm, respectively).

EVALUATION OF FUNGICIDES FOR MANAGING POWDERY MILDEW ON PUMPKIN

Investigators: M. McGrath and G. Fox
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The primary objective of this study was to evaluate the efficacy of several individual fungicides and a fungicide program for control of cucurbit powdery mildew. Impact of fungicide resistance on product efficacy is a major issue with control of this common disease. Yearly testing is needed because of frequent changes in the pathogen's sensitivity to fungicides. Therefore three products at risk of resistance affecting efficacy (Procure, Pristine, and Quintec) were tested alone and at intermediate and full (highest) label rates in 2007. Individual product testing is the best way to assess resistance impact. This is not a labeled use pattern because of resistance. A fungicide program with these products, two experimental conventional fungicides, and two 'alternative' products were also evaluated. Pumpkin variety Sorcerer was direct-seeded on 21 Jun. Treatments were started on 31 Jul, after detecting powdery mildew at a moderate low level in all plots, with subsequent applications made weekly on 7 Aug, 14 Aug, 23 Aug, 29 Aug, and 5 Sep with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 inches apart that delivered 86 gal/A at 100 psi.

All treatments suppressed powdery mildew on upper leaf surfaces. The most effective treatments were the fungicide program (alternation among Quintec, Procure, and Pristine; all tank-mixed with Microthiol Disperss), Quintec, and Pinpoint, an experimental being developed by Valent (93-98% control on upper leaf surfaces and 74-81% control on lower surfaces). Procure and Pristine were not as effective, but they did provide adequate control (87-91% and 52-78% control on upper and lower leaf surfaces, respectively). While there was numerically a slightly lower level of control with the intermediate rates than with the highest rates, there were no significant differences between the two rates of Procure and Pristine evaluated. The pathogen has exhibited reduced sensitivity to DMI fungicides (FRAC Group 3) and to boscalid (Group 7), the active ingredients in Procure and Pristine, respectively; thus there was concern that the intermediate rates might no longer be as effective as the highest label rates. Endura was as effective as Pristine, as occurred in 2005 and 2006. This confirms that boscalid, the common active ingredient in these products, is the effective component in Pristine. It is not surprising that pyraclostrobin, the other component in Pristine, is not contributing to control considering that resistance to this group of fungicides (Group 11) in the cucurbit powdery mildew fungus has been found commonly in the experiment area in the past, and in 2007 as well. Procure was slightly more effective than Pristine (75-78% and 52-58% control on lower leaf surfaces, respectively). The opposite result was obtained in 2006. Two formulations were tested of Inspire, the other experimental conventional fungicide. It contains a new DMI fungicide (Group 3) considered to have higher inherent activity than the currently-registered DMIs, Nova and Procure. Neither treatment with these formulations was more effective than Procure (88-91% and 33-45% control on upper and lower leaf surfaces, respectively); however, the new fungicide was applied in alternation with Bravo and thus on a 14-day interval while Procure was applied on a 7-day interval. Polyoxin at 28 and 71 oz/A was as effective as the conventional fungicides for powdery mildew on upper surfaces (86-88% control) but not on lower surfaces (27-32% control), which was not unexpected considering it is not mobile. The active ingredient in this biopesticide is produced by a specific bacterium naturally found in soil. It inhibits the action of an enzyme needed by the target fungi for making chitin, an essential component of fungal cell walls. Genica BP 300, which is a liquid concentrate derived from the microbial digestion of food waste, provided the lowest level of control on upper leaf surfaces (60%) and did not control powdery mildew on lower surfaces.

EVALUATION OF POWDERY MILDEW RESISTANT PUMPKIN VARIETIES

Investigators: M. McGrath, S. Menasha and G. Fox
Location: Long Island Horticultural Research and Extension Center

There are many pumpkin varieties now on the commercial market that are advertised as having resistance to powdery mildew. Previous experiments have demonstrated that the level of resistance among these varieties can be highly variable. In this study nine Halloween-type pumpkin varieties 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, Fantasia and Sorcerer. Sweet Lightning is edible as well as ornamental.

Seedlings were transplanted into black plastic mulch with drip irrigation on 15 Jun. Plots were two adjacent rows each with four plants spaced 24 in apart. Rows were spaced 68 in apart. A plant of Multipik, a susceptible summer squash variety, was planted between each plot in each row to separate plots and provide a source of inoculum. No fungicides were applied with activity for powdery mildew. Disease severity was evaluated on both leaf surfaces. Mature fruit were harvested and weighed in Sep.

All varieties evaluated for powdery mildew resistance exhibited control of powdery mildew on upper leaf surfaces relative to the susceptible variety Fantasia on 27 Jul (46-100% control), which was early in powdery mildew development, except 20 Karat Gold. All varieties, except 20 Karat Gold and King Midas, exhibited control on lower surfaces (63-100%). These two also did not exhibit control when compared to Sorcerer and Howden in 2006. Other varieties evaluated listed in order of degree of control on upper leaf surfaces were Wee-B-Little (100%), Rockafellow (99%), One Too Many (99%), Sweet Lightning (99%), Magician (98%), Spartan (96%), Iron Man (96%), Prankster (74%), and Super Herc (63%). Powdery mildew was significantly more severe on the upper surface of old leaves of Fantasia (16.8%) than of Sorcerer (6.2%), and numerically more severe on lower surfaces (23% versus 9%). None of the evaluated varieties were significantly less severely infected on both leaf surfaces than Sorcerer. Interestingly, Wee-B-Little was the only variety that was less severely affected on upper surfaces. This variety was not bred to have resistance, but it has exhibited resistance in previous experiments conducted in NY and elsewhere. Powdery mildew became severe on all varieties during August; another assessment was not made.

The varieties evaluated exhibited a range in fruit quality and size, which ranged from 0.6 lb/fruit for Wee-B-Little to 13.6 lb/fruit for Super Herc.

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EVALUATION OF POWDERY MILDEW RESISTANT PUMPKIN EXPERIMENTALS

Investigators: M. McGrath, S. Menasha and G. Fox
Location: Long Island Horticultural Research and Extension Center

Five experimental pumpkins being developed by Outstanding Seeds were compared to Sorcerer.

Seedlings were transplanted into black plastic mulch with drip irrigation on 14 Jun. Plots were two adjacent rows each with four plants spaced 24 in apart. Rows were spaced 68 in apart. A plant of Multipik, a susceptible summer squash variety, was planted between each plot in each row to separate plots and provide a source of inoculum. No fungicides were applied with activity for powdery mildew. Disease severity was evaluated on both leaf surfaces. Mature fruit were harvested and weighed in Sep.

All experimentals exhibited control of powdery mildew on lower leaf surfaces relative to Sorcerer on 2 Aug when severity on this susceptible variety was 13% (73-97% control). Best suppression was provided by 6888 and 8405 (94-97%), which was significantly better than control provided by 8491 (73%). On upper surfaces, average powdery mildew severity on 8491 (18%) was not significantly different from severity on Sorcerer (33%). Control provided by the other experimentals was 75-93%.

Average weight of fruit for 8491 (15 lb) was significantly greater than for Sorcerer (10.6 lb). Fruit weight for the other experimentals was 11.3 lb for 8408, 8.4 lb for 6899, 7.4 lb for 6888, and 6.2 lb for 8405. All experimentals produced fruit with nice shape and good dark orange color.

EVALUATION OF POWDERY MILDEW RESISTANT ZUCCHINI SQUASH VARIETIES

Investigators: M. McGrath, S. Menasha and G. Fox
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Successful control of powdery mildew in zucchini maintains plant productivity. Growers need information on performance of resistant varieties in terms of disease suppression and yield to guide their selection of the most appropriate varieties for their operation. The objective of this study was to evaluate six green zucchini varieties, three experimental lines, two grey zucchini varieties (Amatista and Topazio), and one golden yellow variety (Sebring Premium) with resistance by comparing them to a susceptible variety that is an industry standard (Zucchini Elite). Romulus PM is open-pollinated. Many varieties evaluated also have resistance to virus. An additional reason this experiment was conducted is the need to monitor resistant varieties in order to detect new races able to overcome the resistance gene when they develop.

Seedlings were transplanted into black plastic mulch with drip irrigation on 15 Jun. Plots were two adjacent rows each with six plants spaced 24 in apart. Rows were spaced 68 in apart. A plant of Multipik, a susceptible summer squash variety, was planted between each plot in each row to separate plots and provide a source of inoculum. No fungicides were applied with activity for powdery mildew. Disease severity was evaluated on both leaf surfaces. Fruit were harvested twice weekly eight times (12 Jul – 7 Aug), separated into marketable and unmarketable grades based on length, weighed and evaluated. Fruit were given to growers to also evaluate.

Only Romulus PM and Amatista exhibited control of powdery mildew on upper leaf surfaces (91% and 42% on 9 Aug) and lower surfaces (99% and 63%) relative to Zucchini Elite. Results from a similar evaluation in 2006 with many of the same varieties were substantially different. All resistant varieties were significantly less severely affected than Zucchini Elite in 2006. Degree of control on 9 Aug 06 was 77-100% on upper and 58-99% on lower leaf surfaces. These results, plus those obtained in experiments with other powdery mildew resistant squash in 2007, suggest the pathogen has evolved a new strain able to overcome the one major, recessive gene for resistance that all these varieties have. Romulus PM was less severely affected by powdery mildew than the other varieties because it is homozygous resistant and has at least one modifier gene.

HMX 7729 produced the greatest number of marketable fruit, but did not differ significantly in yielding ability from Justice III and RSQ6006. Romulus PM had the lowest yield among the green zucchini types, as in 2006. This was partly due to delayed fruit production: this is the only variety with no fruit at the first and second harvest dates. Sebring Premium also had low yield initially. All varieties produced fruit with acceptable characteristics, which were rated at least 7 out of 9, except for Romulus PM.

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EVALUATION OF POWDERY MILDEW RESISTANT STRAIGHTNECK YELLOW SUMMER SQUASH VARIETIES

Investigators: M. McGrath, S. Menasha and G. Fox
Location: Long Island Horticultural Research and Extension Center

Successful control of powdery mildew in summer squash maintains plant productivity. Growers need information on performance of resistant varieties in terms of disease suppression and yield to guide their selection of the most appropriate varieties for their operation. An additional reason this experiment was conducted is the need to monitor resistant varieties in order to detect new races able to overcome the resistance gene when they develop.

Seedlings were transplanted into black plastic mulch with drip irrigation on 15 Jun. Plots were two adjacent rows each with six plants spaced 24 in apart. Rows were spaced 68 in apart. A plant of Zucchini Elite, a susceptible zucchini variety, was planted between each plot in each row to separate plots and provide a source of inoculum. No fungicides were applied with activity for powdery mildew. Disease severity was evaluated on both leaf surfaces. Fruit were harvested twice weekly eight times (12 Jul – 7 Aug), separated into marketable and unmarketable grades based on length, weighed and evaluated. Fruit were given to growers to also evaluate.

Powdery mildew increased on the susceptible variety Multipik from a very low level on 20 Jul (less than 1% severity on old leaves) to about 30% on both leaf surfaces on 9 Aug. All varieties tested exhibited control of powdery mildew on upper (35-89%) and lower (60-93%) leaf surfaces relative to Multipik. Degree of control generally was less than that achieved in 2006 when a similar experiment was conducted with these varieties. No symptoms were found on HMX 5712 or Sunray on 9 Aug 2006 (e.g. 100%

control) when Patriot II was exhibiting 71% and 63% control on upper and lower leaf surfaces and Success PM had 76% and 75% control, respectively. Other powdery mildew resistant squash types and pumpkins evaluated in additional experiments at LIHREC in 2007 also exhibited reduced suppression. The pathogen may have evolved to overcome the main resistant gene in these varieties. Success PM was less severely affected by powdery mildew than the other varieties likely because it is homozygous resistant and has at least one modifier gene.

Sunray produced the greatest number and weight of marketable fruit, but did not differ significantly in yielding ability from Multipik. General Patton yielded best in 2006. Success PM had the lowest yield, as in 2006. This was partly due to delayed fruit production: this is the only variety with no fruit on the first harvest date and it had the fewest fruit at the second harvest in 2007. All varieties produced fruit with acceptable characteristics, which were rated at least 7 out of 9.

Project funded by the Friends of Long Island Horticulture Grant Program

EVALUATION OF POWDERY MILDEW RESISTANT ACORN SQUASH VARIETIES

Investigators: M. McGrath, S. Menasha and G. Fox
Location: Long Island Horticultural Research and Extension Center

Successful control of powdery mildew in winter squash is critical to ensure leaves remain healthy until fruit mature and obtain high sugar content, which results in good flavor and storability. Weight of fruit can be lower when powdery mildew is not controlled. Growers need information on performance of resistant varieties in terms of disease suppression and yield to guide their selection of the most appropriate varieties for their operation. An additional reason this experiment was conducted is the need to monitor resistant varieties in order to detect new races able to overcome the resistance gene when they develop. Two solid green acorn-type winter squash varieties and two striped acorn types, 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.

Seedlings were transplanted into black plastic mulch with drip irrigation on 19 Jun. Plots were three adjacent rows each with four plants spaced 24 in apart. Rows were spaced 68 in apart. A plant of Multipik summer squash, a susceptible variety, was planted between each plot in each row to separate plots and provide a source of inoculum. No fungicides were applied with activity for powdery mildew. Disease severity was evaluated on both leaf surfaces. Mature fruit were harvested, weighed and evaluated.

Autumn Delight, the only variety evaluated with resistance from both parents, was the only variety that exhibited control of powdery mildew on upper and lower leaf surfaces relative to Table Ace (71% and 74%). While the other varieties had numerically lower powdery mildew severity values, only Table Star differed significantly from Table Ace for severity on lower leaf surfaces (36% control). In sharp contrast, all varieties effectively suppressed powdery mildew in a similar experiment conducted in 2006, providing 63-93% control on upper leaf surfaces and 51-92% control on lower surfaces. These results, plus those obtained in experiments with other powdery mildew resistant squash, suggest the pathogen has evolved a new strain able to overcome the one major, recessive gene for resistance that all these varieties have. Celebration produced the greatest number and weight of marketable fruit. Harlequin also produced significantly more fruit than the green acorn squash varieties, but less than Celebration. Fruit of Harlequin had the highest sugar content. Fruit of Table Star and Celebration also had significantly higher sugar content than fruit of Table Ace; Autumn Delight was the only variety with fruit that did not have significantly higher sugar content than Table Ace. External appearance was rated 4 for all. Autumn Delight was the only one rated 5 for cavity size, internal appearance, and also flesh color while most of the rest were rated 4. Fruit of Celebration were orange, yellow, green, and white speckled. Harlequin fruit were green and white. The other three varieties produced dark green fruit. Table Star had a white ring around the stem resembling a star

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EVALUATION OF POWDERY MILDEW RESISTANT MUSKMELON AND SPECIALTY TYPE VARIETIES

Investigators: M. McGrath, S. Menasha and G. Fox
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Successful control of powdery mildew in melon is critical to ensure leaves remain healthy until fruit mature and obtain high sugar content, which results in good flavor. Weight of fruit can be lower when powdery mildew is not controlled. Growers need information on performance of resistant varieties in terms of disease suppression and yield to guide their selection of the most appropriate varieties for their operation. An additional reason this experiment was conducted is the need to monitor resistant varieties in order to detect new races able to overcome the resistance genes when they develop.

Seedlings were transplanted into black plastic mulch with drip irrigation on 11 Jun. Plots were three adjacent rows each with four plants spaced 24 in apart. Rows were spaced 68 in apart. A plant of Multipik summer squash, a susceptible variety, was planted between each plot in each row to separate plots and provide a source of inoculum. No fungicides were applied with activity for powdery mildew. Disease severity was evaluated on both leaf surfaces. As they reached maturity, melon fruit were harvested, weighed, measured, and fruit characteristics evaluated. Four growers also evaluated the muskmelon types.

Powdery mildew was first observed on 26 Jul at a very low level (1 spot in two plots). On 14 Aug powdery mildew severity on the susceptible variety Superstar averaged 48% on upper leaf surfaces and 20% on lower surfaces. All of the varieties tested with powdery mildew resistance exhibited at least 48% suppression of mildew on upper leaf surfaces. The honeydew Crème de Menthe was the only variety not significantly less severely affected by powdery mildew than Superstar on lower leaf surfaces. The specialty melons, most of which are not advertised as having resistance to both race 1 and 2, exhibited less suppression of powdery mildew than the muskmelons, which all have resistance to both races. The other specialty type varieties evaluated were Bolero (Crenshaw melon), Dorado (canary melon), and Vicar (Galia). Four of the six muskmelons exhibited a very high level of suppression (at least 99%). One of these four, Wrangler, was rated best by all five evaluators. Two others, Strike and Goddess contain two different sources of resistance in contrast with Athena, which exhibited 65% and 85% control. Strike yielded as much as Superstar (14.6 lb/plant) which was significantly more than Goddess, Wrangler, and Lil' Loupe (10.2-11 lb), but not Maverick and Athena (12-12.6 lb)

Project funded by the Friends of Long Island Horticulture Grant Program

EVALUATION OF AN INTEGRATED PROGRAM FOR MANAGING POWDERY MILDEW WITH RESISTANT SQUASH VARIETY AND REDUCED FUNGICIDE PROGRAM

Investigators: M. McGrath and G. Fox
Location: Long Island Horticultural Research and Extension Center

An integrated management program with fungicides applied to a resistant variety is recommended for managing powdery mildew in cucurbit crops in order to ensure effective control and to manage pathogen evolution to overcome either management tool. This pathogen has an established ability to develop resistance to fungicides. It has also developed new races in response to powdery mildew resistant cantaloupe varieties. As powdery mildew resistant squash and pumpkin varieties grow in number and become more widely used, there is growing concern that the pathogen will evolve new races in response to this selection pressure. The goal of this study was to evaluate two reduced fungicide programs applied to Payroll, a resistant zucchini variety: fungicides applied every 14 days and fungicides applied when powdery mildew exceeded the action threshold of 1 leaf with symptoms out of 50 older leaves examined. Symptoms were observed every week, thus for the second program fungicides were applied every 7 days. These treatments were compared to nontreated Payroll and to a susceptible variety, Spineless Beauty, that was nontreated or treated with fungicides weekly. The fungicide program was Pristine (14.5 or 18.5 oz/A) + Microthiol Disperss (4 lb/A) alternated with Procure 480SC (8 fl oz/A) + Silwet (2 fl oz/A) + Microthiol Disperss. Plants were established by hand-seeding on 19 Jun into black plastic mulch with drip tape. Fungicide treatments were applied with a tractor-mounted boom sprayer from 27 Jul through 14 Sep, for a total of 8 applications for the weekly spray programs. Sprayer was equipped with D5-25 hollow cone nozzles spaced 17 inches apart that delivered 86 gal/A at 100 psi.

The resistant variety did not provide the level of control observed in 2006, suggesting that the pathogen has already evolved to overcome genetic resistance. Similar results were observed in the squash variety evaluations in 2007. Nontreated Payroll was significantly less severely affected by powdery mildew than nontreated Spineless Beauty on 8 and 14 Aug, but these two treatments did not differ significantly on 24 and 30 Aug. Based on a summation of powdery mildew severity over the entire assessment period

(AUDPC), Payroll provided some suppression of mildew on lower leaf surfaces (18% control). Consequently, the integrated program with fungicides applied every 7 days to Payroll was more effective than applying fungicides every 7 days to the susceptible variety (68% versus 31% control), and resulted in 3.3 more marketable fruit/plant. Applying fungicides every 14 days to Payroll resulted in control equivalent to that achieved with fungicides applied every 7 days to Spineless Beauty (37%).

EVALUATION OF INTEGRATED PROGRAMS WITH BIOPESTICIDES AND A RESISTANT VARIETY FOR POWDERY MILDEW IN PUMPKIN, BUTTERNUT SQUASH, AND CANTALOUPE

Investigators: M. McGrath and G. Fox
Location: Long Island Horticultural Research and Extension Center

Powdery mildew is an important disease of cucurbits occurring every year. Management is usually needed to avoid a reduction in market quality and/or yield. Biochemical biopesticides contain naturally-occurring substances. Biopesticides are valuable for managing powdery mildew in conventionally and organically produced cucurbit crops. Most biopesticides are approved by OMRI for organic production. The objective of this experiment was to further evaluate two biopesticides, Organocide (5% sesame oil) and Milstop (85% potassium bicarbonate) that effectively controlled powdery mildew in experiments conducted previously with pumpkin. Three parallel, adjacent field experiments were conducted with different cucurbit types. Biopesticides were evaluated alone and in integrated programs with powdery mildew resistant varieties and/or conventional, mobile fungicides (Quintec, Pristine, and Procure) plus another protectant fungicide, Kocide 3000. The integrated programs evaluated consisted of biopesticides plus conventional fungicides applied on a 7-day spray interval to a susceptible variety and on a 14-day spray interval to a variety with resistance to powdery mildew. Plants were direct-seeded into black plastic mulch with drip irrigation.

Product efficacy varied among crop types. The biopesticides were most effective applied to butternut squash. Powdery mildew was suppressed well on upper leaf surfaces by Organocide applied alone to the susceptible variety (Butternut Supreme) as well as to the resistant variety (Betternut 401). The degree of control on upper leaf surfaces was not significantly different from that achieved by also applying conventional fungicides with Organocide in integrated fungicide programs applied to either variety. Surprisingly, most of the integrated fungicide programs tested did not improve control significantly over Organocide applied alone on lower leaf surfaces. Milstop suppressed powdery mildew on upper leaf surfaces of the susceptible variety. Defoliation however was lower in plots treated with an integrated fungicide program than those treated with Organocide, which was better than the nontreated only for the resistant variety. None of the treatments affected yield. The resistant variety produced a greater number of fruit of a slightly smaller size than the susceptible variety.

In pumpkin, powdery mildew was suppressed by Organocide applied alone to the susceptible variety (Sorcerer) or in an integrated fungicide program applied to both varieties. Organocide suppressed powdery mildew on upper leaf surfaces but not on lower leaf surfaces, which is not unexpected considering it is not mobile. Degree of powdery mildew control was related to canopy condition in late August to early September. Milstop did not significantly reduce powdery mildew severity or improve canopy conditions relative to the nontreated control for either variety. Fruit quality expressed as percentage of fruit with good handles was best for both Sorcerer and Magic Lantern treated with the fungicide programs on 25 Sep and 1 Oct, however these values were significantly higher than non-treated pumpkins only for Sorcerer.

In cantaloupe, powdery mildew was suppressed only with the integrated fungicide program applied to Diva, the susceptible variety. This is partly due to the fact the varieties were inadvertently switched and thus the susceptible variety was sprayed on a 14-day interval, which is considered too long for powdery mildew control in a variety without genetic resistance. Additionally, the resistant variety provided a very high level of control thus there was not an opportunity to achieve visible improvement in disease severity. However, an integrated program with fungicides applied to a resistant variety will continue to be recommended for managing new pathogen races that might appear able to overcome the resistance in Athena, which is to races 1 and 2. This appears to have already occurred in GA. A biopesticide applied on a 14-day interval could be a good tool for this task. None of the treatments affected yield.

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EVALUATION OF FUNGICIDE PROGRAMS FOR MANAGING PHYTOPHTHORA BLIGHT IN CUCURBITS

Investigators: M. McGrath and G. Fox

Location: Long Island Horticultural Research and Extension Center

Acorn squash 'Autumn Delight' was direct-seeded in a field dedicated to research on Phytophthora blight, which developed in at least part of the field in 1991 to 1993, 1995 to 1999, and 2003 to 2006. Acorn-type winter squash was selected because this type of squash is semi-bush, thus plots are more manageable than with a vining-type pumpkin variety, and because it produces several fruit per plant. Treatment applications were made weekly on a preventive schedule using a backpack CO_2 pressurized sprayer operated at 40 psi and 60 gal/A. Programs included combinations of currently-registered products (alternation of ProPhyt with Ranman or ProPhyt with Ranman, Forum, and Tanos plus copper or Bravo applied each time) and ProPhyt alternated with Ranman and two new fungicides expected to be registered in 2008 (Presidio and Revus). All programs were started on 18 Jul, 3 weeks after seeding before symptoms were seen, and continued on a weekly schedule through 3 Oct for a total of 12 applications. Two programs were on IPM schedules with only copper or Bravo applied when rain was not forecasted.

Conditions were generally dry and unfavorable for blight in 2007; however, the few rain events were adequate for blight to develop. All of the fungicide programs tested were effective: 9-22% fruit rotted in treated plots by 1 Nov compared to 71% in non-treated plots. All programs also effectively managed downy mildew, which was not surprising considering that most of these fungicides are also labeled for this disease.

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FOLIAR AND DRIP APPLICATIONS OF BIOPESTICIDES EVALUATED FOR MANAGING PHYTOPHTHORA BLIGHT IN CUCURBITS

Investigators: M. McGrath and G. Fox

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, made in alternation, of EPA-classified biopesticides that are at the demonstration (labeled) level of development for Phytophthora blight in cucurbits. Two types of biopesticides, phosphite and thyme oil, were evaluated. For the thyme oil treatment, Promax was applied through the drip and Proud-3 was applied to the foliage. Two phosphorous acid products, ProPhyt and Fosphite, were evaluated alone and also applied just through the drip combined with new conventional fungicides applied to foliage. These treatments were compared to a nontreated control and to a conventional 'standard' treatment with several recently-registered fungicides applied in alternation to foliage of acorn squash. Mazzei® injectors were used to apply products through drip. Applications to foliage were made using a backpack CO_2 pressurized sprayer operated at 40 psi and 60 gal/A from 2 Aug through 4 Oct.

Conditions were dry and unfavorable for Phytophthora blight during most of the growing season. Symptoms were first observed on 17 Sep. Affected fruit were observed in two nontreated (control) plots and in two plots treated with thyme oil (Promax and Proud 3). Foliar symptoms of Phytophthora blight were more common than fruit symptoms on 17 Sep. Most were observed in the nontreated and thyme oil-treated plots, but all treatments had at least 1 affected plant in 1 of the 4 plots. Additional affected fruit were observed on 26 Sep, three weeks after the last drip application. Most were in the nontreated and thyme oil-treated plots: total of 23 and 17 fruit, respectively. There were also 13 affected fruit in the plots treated with just Fosphite and 17 in plots treated with just ProPhyt. No fruit rotting because of *Phytophthora* or another cause were observed in the other three treatments which included foliar applications of conventional fungicides. The thyme oil treatment was ineffective under the conditions of this experiment in which Phytophthora blight began developing late in the growing season. This treatment was also ineffective in a similar experiment conducted in 2006 when blight also began developing late in the season. The phosphite treatments were moderately effective. There were no significant differences among the paired treatments with the two phosphite biopesticides. The two treatments consisting of a phosphite product applied through the drip and alternated with foliar applications of the phosphite product + copper fungicide were effective based on the final assessment made on 23 Oct, but not the assessment on 3 Oct, which was made one day before the last application. Control with these treatments was 46% and 55% based on incidence of definitive and suspected Phytophthora fruit rot on 23 Oct. Phosphites likely are most effective when applied to actively growing

plants. At that time during this experiment environmental conditions were not favorable for Phytophthora blight. These biopesticides might be more effective when blight begins to develop earlier in the season. These two phosphite fungicides were ineffective in 2006 when blight also began developing late in the season and a copper fungicide was not included. Excellent control was obtained with the two treatments consisting of drip-applied phosphite alternated with applications of conventional foliar fungicides (Presidio alternated with Revus): 98-100% control of Phytophthora fruit rot on 23 Oct. This level of control was not significantly different from that obtained with conventional foliar fungicides (Forum, Ranman, Tanos, Manex, and Cuprofix) applied every 7 days for 10 weeks. Control was also good in 2006 with similar treatments that included copper plus Forum, Tanos, Ranman, Maestro, and/or Revus. Incidence of Phytophthora fruit rot was lower in this experiment than in the other two experiments with pumpkin and acorn squash in this research field, which were conducted on bare ground. Many affected fruit were on bare ground in this experiment suggesting that the plastic mulch was providing some protection to the fruit; however, there were enough affected fruit on the mulch to indicate the degree of protection was moderate.

Project funded by the IR-4 Biopesticide Demonstration Grant Program

HARD-RINDED PUMPKIN VARIETY EVALUATION FOR PHYTOPHTHORA FRUIT ROT

Investigators: M. T. McGrath and G. M. Fox
Location: Long Island Horticultural Research and Extension Center

The first pumpkins developed with hard (lignified) 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. The goal of the experiment conducted in 2007 was to continue research started in 2006 to examine new pumpkins with this trait plus a variety with a tough skin (Cannon Ball), all developed by Harris Moran. Two experimentals have been named and are commercially available for the 2008 season: Warlock (HMX 6685) and Gargoyle (HMX 5683). Seedlings were transplanted into bare ground in a field dedicated to research on Phytophthora blight.

Few symptoms of fruit rot were observed until the end of Sep. A high percentage of fruit of the susceptible varieties, Magic Lantern and Mystic Plus, developed symptoms (42-50% by 18 Oct). Cannon Ball did not have significantly fewer affected fruit than these susceptible varieties (58%), suggesting that a tough skin is not a sufficient barrier for *Phytophthora capsici*. Apprentice had the fewest fruit with symptoms of Phytophthora fruit rot (10%) and the most healthy-appearing fruit (90% on 3 Oct). This variety also performed well in 2006. Gargoyle had a similarly low proportion of affected fruit (12%). Lil' Ironsides (36% affected fruit) and Iron Man (35%) did not perform as well as in 2006, when less than 3% of fruit developed definitive plus suspected symptoms by 9 Oct; however, these did not have significantly more affected fruit than Apprentice in 2007. Three experimentals (HMX 4682, 4684, and 5681) had a statistically similar proportion of fruit with Phytophthora fruit rot as Apprentice (14-26%). Warlock and HMX 7791 have a new source of the hard shell trait than the other varieties and experimentals in this experiment. This trait is associated with a softer, carvable, hard shell. These two differed greatly in the proportion of fruit that developed symptoms of Phytophthora fruit rot (18 and 76%); however, many fruit of Warlock rotted due to other causes, consequently these two experimentals had a similar low percentage of healthy-appearing fruit (56 and 67% on 3 Oct, which was similar to the susceptible varieties).

Project funded by New York State Ag & Markets

ON-FARM EVALUATION OF CLOVER-PLANTED SPRAYER DRIVEWAYS TO AVOID CONDITIONS FAVORABLE FOR PHYTOPHTHORA BLIGHT

Investigators: M. McGrath and G. Fox
Location: Long Island Horticultural Research and Extension Center

Phytophthora blight often has been observed to start on pumpkin fruit and plants located in or adjacent to sprayer driveways during scouting of commercial plantings. Sprayer driveways create conditions favorable for Phytophthora blight onset and for pathogen spread. Tire tracks compact the soil, consequently soil in this area can become saturated with water first in a field, which is favorable for disease onset. Disease in driveways is especially problematic because if a sprayer contacts diseased tissue, the pathogen could be moved throughout the field. Also, if the driveway is on a slope, water from rain or

irrigation moving along the tire tracks could move the pathogen. Once Phytophthora blight starts to develop in a field, water from rain, irrigation and even dew are sufficient for subsequent disease development. In sharp contrast, this potentially very devastating disease has stopped occurring at LIHREC where driveways in pumpkin experiments are now seeded to clover. Clover improves drainage, minimizes compaction, and might promote biological control of the blight pathogen.

For this study red clover was seeded in driveways at two commercial u-pik pumpkin fields where Phytophthora blight has occurred recently. Seeding was done 1 day or about 3 weeks after seeding pumpkins using a Brillion seeder or a drop seeder on a lawn mower. Clover was slow to grow at least partly due to limited rain and no irrigation for at least 4 weeks after seeding. However it did eventually form a good stand. The benefit of clover driveways as a management practice for Phytophthora blight could not be assessed in 2007 because disease development was limited in these fields likely because fungicides were applied for blight and conditions were generally dry and unfavorable for this disease. Blight development was not associated with any driveways, including those not planted to clover. Both growers felt the clover driveways were easy to prepare and worthwhile because of additional benefits for customers of being attractive and easier to walk and push a wheel-barrel through than their usual driveways, which were seeded to small-fruited pumpkins or left unplanted and weedy.

Project funded by the Friends of Long Island Horticulture Grant Program

OCCURRENCE OF FUNGICIDE RESISTANCE AND IMPACT ON MANAGING DOWNY MILDEW IN CUCUMBER

Investigators: M. McGrath and G. Fox
Location: Long Island Horticultural Research and Extension Center

The main goal of this study was to determine if strains of the pathogen with resistance to Ridomil (FRAC group 4) and QoI fungicides (FRAC group 11) were present and affecting control. This was achieved by applying Ridomil Gold EC and Cabrio alone weekly, and comparing these two treatments with a nontreated control and a currently recommended fungicide program. Cucumber was direct-seeded on 11 Jul. Fungicides were applied weekly beginning on 9 Aug using a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 86 gal/A at 100 psi. Downy mildew symptoms were first seen on 14 Aug. Ridomil and Cabrio did not control downy mildew probably due to resistance, which has been documented elsewhere in the US. Similar results were obtained where similar experiments were conducted elsewhere in the eastern US in 2007, indicating that resistance is widespread. These fungicides use to be highly effective. Downy mildew was effectively controlled by Tanos 50DF (8 oz/A) + Manzate Pro-Stick (3 lb) alternated with Previcur Flex 6F (1.2 pt) + Manzate Pro-Stick (3 lb). On 13 Sep, 10% of leaf tissue on mid-aged to old leaves were affected in plots treated with this fungicide program while all leaves were dead in this age category in the Ridomil, Cabrio and nontreated plots. For mid-aged to young leaves on this date, 6% of the tissue had symptoms where the fungicide program was applied while 50-64% of this leaf tissue was symptomatic in the other plots. Managing downy mildew had a substantial impact on yield. Fruit of the pickling-type variety used in this experiment were harvested from 30 Aug to 27 Sep. Total number of marketable fruit was 30-42% lower in the plots where downy mildew was not controlled. Total weight was 41-46% lower.

Project funded by the Southeast Region IPM Grant Program

EVALUATION OF FUNGICIDE PROGRAMS FOR MANAGING DOWNY MILDEW IN BUTTERNUT SQUASH

Investigators: M. McGrath and G. Fox
Location: Long Island Horticultural Research and Extension Center

Two new fungicides expected to be registered in 2008, Revus and Presidio, were tested as components of fungicide programs. These were compared to a currently recommended fungicide program (Tanos + EBDC fungicide alternated with Previcur Flex + EBDC fungicide). Butternut squash was direct-seeded on 11 Jul. A late planting date was used because downy mildew can start to develop late in the growing season. Fungicides were applied weekly for 10 weeks beginning on 9 Aug, before symptoms were seen, using a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 86 gal/A at 100 psi. All of the fungicide programs provided a similar, good level of control. For example, on 28 Sep, an average of 79% of leaf tissue was brown and dead in nontreated plots whereas

only 11-14% was affected in the fungicide-treated plots. On 8 Oct, these values were 92% and 13-24%, respectively. Four programs consisted of Revus tank-mixed with Manex or Bravo and alternated with Previcur Flex + Manex or Quadris + Bravo. Presidio at two rates was tank-mixed with Bravo and alternated with Ridomil Gold Bravo. Based on results of the previous experiment with cucumber, it is unlikely that Quadris or Ridomil contributed to control. Thus the effective products in four of these six effective programs were a mobile fungicide with activity specific for pathogens like downy mildew applied every 14 days and a protectant fungicide (Manex or Bravo) applied every 7 days. Control was not improved when an effective mobile product was applied every week; however, alternating among mobile fungicides applied on a 7-day interval is recommended to reduce the chance of resistance developing to the mobile fungicides, all of which are considered to be at risk.

OZONE CONCENTRATIONS IN RIVERHEAD IN 2007

Investigators: M. McGrath and G. Fox
Location: Long Island Horticultural Research and Extension Center

Ozone reached sufficiently high levels to cause acute, visible injury to leaves of sensitive crops in 2007 on Long Island. Ozone also causes sensitive plants to senesce prematurely. Concentration was $\geq$80 ppb for 47 hours on 14 days in 2007: 1 Jun (2 hours), 26 Jun (3), 27 Jun (2), 28 Jun (4), 8 Jul (7), 9 Jul (6), 17 Jul (4), 30 Jul (3), 2 Aug (5), 4 Aug (5), 7 Aug (1), 8 Aug (1), 30 Aug (1), and 31 Aug (3). Ozone was at least 50 ppb on 670 hours on 85 days and at least 60 ppb on 339 hours on 55 days. The highest concentration in 2007 (108 ppb) was reached on 2 Aug. Typically high concentrations occurred between 1200 and 2200, as in previous years. Ozone was $\geq$80 ppb for 60, 124, 121, 184, 77, at least 67, 94, 40, at least 10, 95, 65, and 47 hrs in 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, and 2007 respectively.

Following an episode of high ozone during 30 July through 4 Aug, Halloween pumpkin crops, which are a very important commodity on LI, were examined to assess the extent of injury. Injury was substantially more severe than had been observed previously on this crop in this region. Affected leaves died prematurely (evident early in Sept), which was likely a factor in early vine decline and consequent reduced fruit quality, in particular poor handles (peduncles). ozone was at least 70 ppm for 3, 2, 5, 11, 0, and 10 hours on those days. By 4 Aug, ozone exposure for these pumpkin crops had already greatly exceeded the long-term critical level of ozone exposure for crops during a 3-month period of 3000 ppb.h for daytime AOT40 (accumulated dose over a threshold of 40 ppb, calculated as the sum of the differences between the hourly mean ozone concentration and 40 ppb for each hour when the concentration exceeds 40 ppb). By 4 Aug the AOT40 value for 7am through 7pm had reached 7106 ppb.h for pumpkins emerged by 25 Jun and 5862 ppb.h for those emerged by 30 Jun. The 3-month values were 10,698 and 9,722 ppb.h, respectively, for these starting dates.

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

Investigators: M. McGrath and G. Fox
Location: Long Island Horticultural Research and Extension Center

Research on ozone-sensitive and ozone-resistant snap bean lines was continued in 2007 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 to investigate the impact of ambient ozone (O3) on plant productivity. 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 O3-sensitive snap bean line S156 yielded less than the tolerant line R331 when grown under ambient O3 conditions on Long Island in 2007. Total weight and number of bean pods harvested for

fresh-market consumption from planting 1 (14 May) plants was 23% and 11% lower, respectively, for S156 compared to R331 (pods were harvested from 9 July through 30 July). There was a 30% and 18% reduction in these yield variables, respectively, for planting 2 (12 June) plants (30 July through 5 Sept). Reduction was 29% and 10%, respectively, for planting 3 (11 July) plants (29 Aug through 3 Oct). These differences were not always significant. Mature yield was also reduced for S156 compared to R331. For plants in planting 1, number of pods produced by S156 was reduced 10% compared to R331, number of seeds was reduced 22% and average seed weight was reduced 20%. There was a 17%, 24%, and 32% reduction in these yield variables, respectively, for planting 2 plants; and a 30%, 38%, and 28% reduction in these yield variables, respectively, for planting 3 plants. From emergence until the last fresh-market pod harvest, plants in the three plantings were exposed to O3 that was at least 40 ppb for 627, 791, and 605 hours, respectively. During these growth periods of 63, 79, and 78 days, O3 exposure expressed as AOT40 was 7,643 ppb.h, 10,451 ppb.h, and 6,827 ppb.h, respectively. These values greatly exceed the long-term critical level of ozone exposure for crops of 3000 ppb.h accumulated over three months. These AOT40 values for the 3 bean plantings are not closely related to the level of yield reduction in the sensitive bean line compared to the tolerant line, which documents the need for a more detailed examination of O3 exposure, which is the goal of a national research team involved with this project. This data from LI contributes to the database of plant response to ambient O3. An extensive set of data from multiple locations, environmental conditions, and O3 concentrations is needed in order to model O3 impact on plant productivity.