

## VEGETABLE DISEASE MANAGEMENT RESEARCH CONDUCTED IN 2007 ON LONG ISLAND, NY

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Field experiments were conducted in 2007 on managing powdery mildew in cucurbits with resistant varieties and fungicides, Phytophthora blight in pumpkin and acorn squash with fungicides and hard-rinded pumpkin varieties, and downy mildew in cucurbits with fungicides. Biopesticides and conventional fungicides were tested. Fungicide sensitivity was examined in the cucurbit powdery mildew fungus. Full reports on these and other experiments conducted in 2007 will be published in Plant Disease Management Reports and/or on the web at <http://www.longislandhort.cornell.edu/>.

Evaluation of powdery mildew resistant cucurbit varieties. The resistant squash and pumpkin varieties evaluated in 2007 did not suppress powdery mildew in 2007 as well as in 2006, suggesting that the pathogen may have evolved to overcome the resistant gene that these all share. In contrast, the melon varieties tested with resistance to races 1 and 2 provided good suppression.

Among the zucchini varieties evaluated, only Romulus PM and Amatista exhibited control of powdery mildew on upper leaf surfaces (91% and 42%, respectively, on 9 Aug) and lower surfaces (99% and 63%) relative to Zucchini Elite. Severity on upper/lower leaf surfaces on 9 Aug was 3%/0% for Romulus PM, 19%/9% for Amatista, 33%/26% for Zucchini Elite, and 22-30%/11-28% for the other ten varieties and experimentals. 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 was the only variety with no fruit at the first and second harvest dates. Other varieties tested were Payroll, Wildcat, Justice III, Judgment III, Felix, Envy, Paycheck, Sebring Premium, and Topazio.

All five varieties and experimentals tested of yellow straightneck summer squash 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. Severity on upper/lower leaf surfaces on 9 Aug was 4%/2% for Success PM, 34%/29% for Multipik, and 15-23%/5-12% for the others. 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. 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. General Patton was also included in this evaluation.

Autumn Delight, the only acorn squash 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. 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.

All of the muskmelon and specialty melon varieties tested with powdery mildew resistance exhibited at least 48% suppression of mildew on upper leaf surfaces relative to the susceptible variety Superstar. 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 tested, 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).

Evaluation of conventional fungicides and biopesticides for cucurbit powdery mildew. An experiment was conducted on pumpkin with the main goal of evaluating several individual fungicides at risk for resistance. 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 at intermediate and full (highest) label rates. 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. Treatments were started on 31 Jul, after detecting powdery mildew at a moderate low level in all plots, with subsequent applications made weekly through 5 Sep with a tractor-mounted boom sprayer (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); however, the new fungicide was applied in alternation with Bravo and thus on a 14-day interval while Procure was applied every 7 days.

Another goal of this experiment was to evaluate alternative fungicides. Polyoxin 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.

Two biopesticides, Organocide (5% sesame oil) and Milstop (85% potassium bicarbonate), were evaluated in three parallel, adjacent experiments with different cucurbit types. They 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. 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 (Butternut 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 on 25 Sep and 1 Oct for both Sorcerer and the resistant variety Magic Lantern treated with the fungicide programs, however these values were significantly higher than non-treated pumpkins only for Sorcerer. The resistant cantaloupe variety, Athena, provided a sufficiently high level of control that not even the fungicide program applied on a 7-day schedule resulted in improved control. The susceptible variety, Diva, was inadvertently treated on a 14-day interval, thus it was not surprising that powdery mildew was suppressed only when mobile fungicides were applied. None of the fungicide treatments affected yield.

Another experiment was conducted to evaluate two reduced fungicide programs applied to Payroll, a resistant zucchini variety: fungicides applied every 14 days and fungicides applied every week that 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 (18.5 oz/A) + Microthiol Disperss (4 lb/A) alternated with Procure 480SC (8 fl oz/A) + Silwet (2 fl oz/A) + Microthiol Disperss. 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%).

Sensitivity to fungicides of the powdery mildew fungus on Long Island in 2007. A seedling bioassay was used 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. 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 2 of the 5 fields, but at these sites it was at a very high level (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.

Evaluation of conventional fungicides and biopesticides for Phytophthora blight. Two experiments were conducted in 2007 with acorn squash. Foliar treatment applications were made weekly on a preventive schedule using a backpack CO<sub>2</sub> pressurized sprayer operated at 40 psi and 60 gal/A. In the first experiment, 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.

The goal of the second experiment 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. 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. 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. Additional affected fruit were observed on 26 Sep, three weeks after the last drip application and one week before the last foliar application (during this four-week period foliage was treated each week because plants were no longer actively growing and thus were not expected to take up much product through roots). Most affected fruit on 26 Sep were in the nontreated and thyme oil-treated plots. There were also some in the plots treated with just Fosphite or ProPhyt. 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. 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. Control with these treatments was 46% and 55% based on incidence of definitive and suspected Phytophthora fruit rot on 23 Oct. 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 through 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. 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.

Evaluation of pumpkin varieties producing hard-rinds for managing Phytophthora fruit rot. 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). 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%). This variety also performed well in 2006. Gargoyle had a similarly low proportion of affected fruit (12%). Lil' Ironsides (36%) 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).

Evaluation of fungicides for cucurbit downy mildew. Two experiments were conducted in 2007. In the first, neither Ridomil Gold nor Cabrio applied alone weekly on a preventive schedule to cucumber were effective likely because of fungicide resistance. Documenting impact of resistance was the main goal of this experiment. Downy mildew was effectively controlled by Tanos + Manzate Pro-Stick alternated with Previcur Flex + Manzate. A tractor-mounted boom sprayer was used. Downy mildew had a substantial impact on yield. Total number of marketable fruit was 30-42% lower in plots where downy mildew was not controlled (non-treated and plots treated with Ridomil and Cabrio). Total weight was 41-46% lower. In the other experiment, two new fungicides expected to be registered in 2008, Revus and Presidio, were tested as components of fungicide programs applied to butternut squash. These were compared to a currently recommended fungicide program (Tanos + Manex alternated with Previcur Flex + Manex). Fungicides were applied weekly for 10 weeks beginning on 9 Aug, about 1 month after seeding and before symptoms were seen. 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. 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 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.