

2008 UPDATE ON VEGETABLE PATHOLOGY RESEARCH CONDUCTED ON LONG ISLAND, NY

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Field experiments were conducted in 2008 on managing powdery mildew in cucurbits with resistant varieties and fungicides, Phytophthora blight in pumpkin and squash with fungicides and hard-rind pumpkin varieties, Phytophthora blight in pepper with resistant varieties and fungicides, foliar diseases (Septoria leaf spot and powdery mildew) of tomato with fungicides, and downy mildew in cucumbers with resistant varieties and fungicides. Biopesticides approved for organic production were tested, often as the focus of the experiment, for downy mildew, powdery mildew, and Septoria leaf spot. Fungicide sensitivity was investigated in the cucurbit powdery mildew fungus. Biofumigant mustard cover crop was looked at for Phytophthora. 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/>.

Sensitivity to fungicides of the cucurbit powdery mildew fungus. 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, therefore, an important component of fungicide programs has been fungicides able to move to the lower leaf surface. Unfortunately these mobile fungicides are prone to resistance development because they have single site mode of action.

The goals of this study were 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 was accomplished by conducting seedling bioassays with fungicide-treated seedlings in squash and pumpkin plantings. This information was used to guide fungicide recommendations. For the assay, pumpkin seedlings were treated with fungicide (Topsin M, Flint, Rally, Procure, 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 about 10 days. 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. Additionally isolates (individuals) of the powdery mildew pathogen were collected from research and commercial plantings and then tested in the laboratory.

Resistance to Topsin M and to Flint were detected in all squash plantings where the bioassay was conducted on 17 Jul. Therefore for managing powdery mildew in 2008 fungicides were not recommended in these chemical classes, which are the MBC (FRAC Code 1) and QoI (Code 11) fungicides, respectively. Proportion of the pathogen population estimated to have resistance varied among the plantings from 18-100% for Topsin M and 21-100% for Flint. Strains of the pathogen were detected with low sensitivity to Code 3 and 7 fungicides, tolerating 120 ppm of myclobutanil (active ingredient in Rally) and 175 ppm boscalid (a.i. in Endura), respectively.

All of the isolates collected from commercial pumpkin crops in Sep were resistant to QoI fungicides. 7% tolerated 80 ppm myclobutanil and 7% tolerated 125 ppm boscalid.

Evaluation of fungicides for managing powdery mildew on pumpkin and treatment impact on pathogen sensitivity to fungicides. The primary objective of this study was to evaluate the efficacy of several individual fungicides and fungicide alternations for the control of cucurbit powdery mildew. Both new and currently registered products were tested. Impact on product efficacy of the pathogen becoming less sensitive, and eventually resistant, to fungicides 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 because individual product testing is the best way to assess resistance impact. This is not a labeled use pattern because of resistance. Procure and Pristine have been registered for use on pumpkin and other cucurbit crops for a few years. Quintec was registered only for use on melon in 2008. Its label is anticipated to be expanded to include pumpkin in late 2009.

Pumpkin variety Sorcerer was direct-seeded on 20 Jun. Controlled release fertilizer was used. Powdery mildew was first observed on 22 Jul on 0.7% of leaves examined. Treatments were started on 30 Jul when powdery mildew infection had reached the IPM threshold in most plots, with subsequent applications made weekly on 5, 13, 19, and 27 Aug, 5 Sep, and 11 Sep with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 inches apart that delivered 96 gal/A at 100 psi. Upper and lower leaf surfaces were inspected for powdery mildew symptoms weekly beginning on 22 Jul. Last assessment was 2 Sep. Pathogen isolates (e.g. individuals) were collected from select plots and tested in a laboratory assay to determine their sensitivity to fungicides.

All treatments suppressed powdery mildew on both leaf surfaces. Applications were started when incidence of symptomatic leaves was at a very low level (6% of the older leaves examined). Differences in efficacy were mostly evident on lower leaf surfaces. As in previous experiments, degree of control of powdery mildew was inversely related to defoliation and directly related to fruit quality in terms of handle condition.

Quintec applied weekly at 4 fl oz/A, the lowest label rate, was the most effective treatment, providing 100% and 99% control on upper and lower leaf surfaces, respectively, based on AUDPC values (a summation measure of disease severity over all assessment dates). Similar control was achieved with labeled use patterns consisting of Quintec alternated with Procure or Rally, following a simple or 2-spray block alternation. The Quintec treatment with Rally also included sulfur each week, and thus had both components of a recommended fungicide resistance management program (alternation of at-risk fungicides tank-mixed with a protectant fungicide). This treatment started with sulfur alone thus there was one less spray of a mobile fungicide.

Both Procure at 8 fl oz/A and Pristine at 18.5 oz/A, the highest label rates for both, provided excellent control (93% and 94% on lower surfaces, respectively) which was not significantly different from that achieved with Quintec. In contrast, powdery mildew was not controlled well on the lower surfaces of leaves in many commercial pumpkin crops on LI where at least one of

these fungicides was used in the fungicide program. This may reflect differences in spray coverage or application timing (starting when powdery mildew well established or not maintaining a 7-day spray interval), which are especially important for these fungicides because the pathogen is developing resistance.

Four new fungicides were evaluated. Quadris Top was the least effective of all treatments tested in 2008 providing 89% and 67% control of powdery mildew on upper and lower leaf surfaces, respectively. Lower efficacy was detected from the first disease ratings analyzed, which were taken on 18 Aug after 3 applications. Efficacy likely reflects the fact the pathogen has developed qualitative resistance to the chemical group (FRAC Code 11) for one active ingredient in Quadris Top (azoxystrobin) and the pathogen is developing quantitative resistance to the chemical group (Code 3) for the other active ingredient (difenoconazole). Difenoconazole was expected to be more effective than the active ingredients (myclobutanil and triflumizole) in currently registered fungicides in this group (Rally and Procure); however, recent laboratory assays revealed that pathogen isolates are equally sensitive or less sensitive to difenoconazole than to myclobutanil and triflumizole. Resistance developing to this fungicide chemical group could be a reason that Inspire Super, another new fungicide containing difenoconazole evaluated at LIHREC in 2008, was numerically not as effective at the lowest rate tested compared to the highest (14 and 20 fl oz/A). The other 2 new fungicides tested are at an earlier stage in development.

Fungicide sensitivity testing of powdery mildew pathogen isolates collected from this research field revealed a decrease in pathogen sensitivity during the experiment likely in response to use of fungicides that are at risk for resistance developing (e.g. Rally, Procure, Pristine). Isolates were collected on 18 Aug from nontreated plants in part of the field not used for experiments and on 16 Sep from several plots. 60% of the isolates collected on 18 Aug and 92% of those collected on 16 Sep were resistant to Code 11 fungicides. With this high frequency of resistant strains, the Code 11 (QoI) component of Quadris Top and Pristine likely contributed little if anything to control. None of the 18 Aug isolates or 16 Sep isolates from nontreated plots tolerated 80 ppm myclobutanil (active ingredient in Rally) or 125 ppm boscalid (an active ingredient in Pristine). In contrast, 80% of the 16 Sep isolates from plots treated with Pristine alone tolerated 125 ppm boscalid, and 50% of the 16 Sep isolates from plots treated with Procure alone tolerated 80 ppm myclobutanil (both Code 3 fungicides). Thus fungicide use during a growing season appears to be selecting for less sensitive isolates. Dose in the spray tank for these treatments applied at 96 gpa was 156 ppm myclobutanil, 274 ppm triflumizole, and 364 ppm boscalid. These concentrations are all higher than what the pathogen tolerated in the laboratory assays.

Evaluation of powdery mildew resistant varieties. Five experiments were conducted with different cucurbit crop types. An important goal of this work was to determine whether squash and pumpkin varieties with homozygous resistance (e.g. two copies of the main powdery mildew resistance gene; PMRR) are better protected against powdery mildew than varieties with heterozygous resistance (PMR). This was the case in variety evaluations conducted in 2007 but not in 2006. Most commercial resistant squash varieties have PMR. The resistant pumpkin varieties tested provided poor to good suppression, with PMRR generally better. Zucchini and summer squash varieties provided poor to excellent suppression, with PMRR better. Good but variable suppression was obtained with resistant acorn squash, with PMRR better. PMRR striped acorns did not provide as good suppression as PMRR green acorns. Excellent suppression was obtained with both PMR and PMRR butternut squash. Good to excellent suppression was obtained with melon varieties that have resistance to races 1 and 2.

Efficacy of biopesticides for managing foliar diseases in organically-produced tomato. The objective of this study was to evaluate for foliar diseases in tomato fungicides that are approved for organic production and are defined as biopesticides by EPA. The products were Actinovate SP (0.0371% *Streptomyces lydicus*), Companion (0.03% *Bacillus subtilis* GB03), MOI-106 (5%

extract of *Reynoutria sachalinensis*), Organocide (5% sesame oil), Sporatec AG (18% rosemary oil, 10% clove oil, and 10% thyme oil), and Taegro (*Bacillus subtilis* var. *amyloliquefaciens* strain FZB24 24.5%). Taegro is the only product tested that is not labeled for foliar diseases in tomato and not yet OMRI-listed. BioLink, an organic surfactant and penetrant, was applied with Actinovate and with Sporatec. Sporatec was also tested tank-mixed with Saf-T-Side, an OMRI-listed spray oil emulsion with 80% petroleum oil that is labeled for use as a fungicide, insecticide, and miticide. Treatments with biopesticides were compared to a nontreated control and also an organic standard consisting of copper fungicide applied weekly and a conventional fungicide program (Actigard alternated with Kocide + Dithane and Flint on some dates). Kocide 3000 was selected for the copper fungicide because it was anticipated that in the future it would be listed again by OMRI.

Seedlings were no-till transplanted on 1 Jul into straw mulch from spring-planted triticale. Organic fertilizer was used. Additional straw mulch was spread around plants. Plants were staked and trellised following standard procedure for fresh-market tomato production. Most treatment applications were made using a CO₂-pressurized backpack sprayer with a boom that has a single twin-jet 110-degree nozzle that delivered 74 gpa at 50 psi. Each side of the planted row was treated with the boom held sideways to obtain thorough coverage of foliage. Applications were made weekly beginning on 21 Jul for the conventional fungicide program and on 20-21 Aug for most of the other treatments, which was before diseases were expected to begin developing based on crop physiology. Disease incidence, severity and defoliation were assessed for the major diseases that developed. Incidence was assessed as the proportion of leaflets with symptoms. Severity was assessed for symptomatic leaflets only. Severity for the entire canopy was calculated by multiplying the average symptomatic leaflet severity value by incidence.

Conditions were not ideal for tomato production in 2008 with several severe rainstorms that included hail and strong winds as well as heavy rain. Diseases developed naturally in the research field. Symptoms were not seen until around the time that the first ripe fruit were seen, which was 9 Sep. The third or fourth application was made for each of the biopesticide treatments on 10 Sep. Dates of first observations were 10 Sep for powdery mildew, 15 Sep for Septoria leaf spot and 3 Oct for late blight. All treatments provided some suppression of powdery mildew. Septoria leaf spot became more severe, with incidence and severity being numerically higher than for powdery mildew on nontreated plants, and degree of control was not as high as that obtained for powdery mildew, even with the standard organic fungicide. Based on degree of control calculated from canopy severity at the 6 Oct assessment, Taegro was moderately effective for powdery mildew (56% control) but ineffective for Septoria leaf spot. Actinovate was moderately effective for powdery mildew (75% control) and for Septoria leaf spot (58%). Companion provided 98% control of powdery mildew and 68% control of Septoria leaf spot. MOI-106 also provided excellent suppression of powdery mildew (100%) and moderate control of Septoria leaf spot (61%). Level of control of Septoria leaf spot was significantly better when MOI-106 was applied in alternation with Kocide 3000 rather than used every week (94% control). Organocide also provided excellent suppression of powdery mildew (99%) and moderate control of Septoria leaf spot (54%). Level of control of Septoria leaf spot was significantly better (95%) when Organocide was applied at half the rate tank-mixed with Kocide 3000 at the lowest labeled rate. Sporatec AG applied with the surfactant BioLink controlled powdery mildew but not Septoria leaf spot. However, excellent control of both diseases (97% and 100%) was obtained when Sporatec was mixed with Saf-T-Side. Degree of control of both diseases obtained with MOI-106 alternated with Kocide, Organocide plus Kocide (at low rates), and Sporatec plus Saf-T-Side was not significantly different from the organic standard or the conventional fungicide program. Degree of disease control was related to the amount of subsequent defoliation. Taegro was the only product tested that did not provide sufficient control of foliar diseases to decrease defoliation compared to non-treated plants. This experiment needs to be repeated to assess efficacy under more severe disease pressure.