

MANAGING CUCURBIT MILDEWS: NEW CHALLENGES AND NEW OPPORTUNITIES

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There are two mildew diseases affecting cucurbit crops: powdery mildew and downy mildew. Both fungal pathogens produce wind-dispersed spores that can be moved long distances, thus they cannot be avoided. Fungicides and resistant varieties have been important for managing these diseases. Unfortunately, both pathogens have demonstrated ability to evolve new strains that are not controlled as effectively as the previous ones by a specific fungicide or plant resistant gene. Pathogen adaptation to fungicides and resistant varieties is a major challenge to effectively managing these important diseases. An integrated program with an alternation amongst targeted (single site mode of action) fungicides applied to resistance varieties is recommended to minimize selection pressure for pathogen strains able to overcome either plant resistance genes or fungicides, and to maximize control. It is important to recognize that the primary goal is to slow selection of a new pathogen strain rather than to manage it once it has reached a high enough proportion in the pathogen population that can affect control; therefore, management needs to be implemented beginning when each new fungicide or resistance gene becomes commercially available. There is a table available on-line to assist with fungicide selection for the mildew diseases at http://www.northeastipm.org/ipm_resource_detail.cfm?id=6820.

Powdery mildew management program often needs adjustments each year as the pathogen and management tools change. Research is conducted every year in NY to monitor changes in the pathogen and to evaluate new fungicides and resistant varieties in order to be able to develop management guidelines. Control of powdery mildew with fungicides and resistant varieties in 2010 was found to have been affected by changes in the pathogen.

Melon varieties with resistance to pathogen races 1 and 2 did not suppress powdery mildew in 2010 as well as in previous years. Very few symptoms have been observed on these resistant varieties in previous evaluations, equating to over 90% control compared to a susceptible variety. For example, control was 96-100% on upper leaf surfaces in the variety evaluations conducted in 2009. When evaluated on 19 Aug 2010, control was 69-89% on upper leaf surfaces and 70-95% control on lower in one trial in which fruit were not quite mature, while only 2 of 9 resistant varieties had significantly less severe symptoms than the susceptible variety included for comparison in another trial in which harvest had begun. Severity (average proportion of leaf tissue with symptoms of powdery mildew) ranged from 34% to 67% on upper leaf surfaces of the resistant varieties compared to 73% on the susceptible, while on lower surfaces it was 15% to 45% versus 61%. Occurrence of powdery mildew on melon differentials for this pathogen further documented change in the pathogen. The change in NY may be the same as occurred in GA where a new pathogen race (S) was detected a few years ago and powdery mildew has no longer been adequately suppressed by melon varieties with resistance to races 1 and 2.

Resistant squash and pumpkin varieties exhibited variable control from ineffective to moderately good in 2010, but this was generally similar to recent years, indicating the change in the pathogen detected previously is stable. The resistance genes in squash and pumpkin are different from those in melon. The powdery mildew pathogen races are defined based on their ability to infect melon varieties with specific resistance genes. Races have not been described yet for squash and pumpkin. Most commercial plant breeders are using the same major source of resistance in these crops, which was obtained from a wild cucurbit relative by the Cornell

Breeding Program. Resistant varieties can vary in ability to suppress powdery mildew due to modifier genes they possess and whether they have one or two copies on the major resistance gene. Often in recent variety evaluations, varieties with resistance from both parents (homozygous; PMRR; some times referred to as 'resistant') have been less severely affected by powdery mildew than varieties with resistance from one parent (heterozygous; PMR; aka 'intermediate resistance' or 'tolerant'). Most varieties are PMR. Five variety evaluations with different cucurbit crop types were conducted in 2010 on Long Island. The susceptible variety, included in each evaluation to assess powdery mildew suppression, had more symptoms than the resistant varieties, but this difference was not always statistically significant. The resistant yellow summer squash varieties (Cheetah, PM Success, and Sunray) provided effective control on upper (73-78%) and lower (70-74%) leaf surfaces. Among the 7 zucchini varieties evaluated, only Amatista and Reward suppressed powdery mildew on both upper (52-67%) and lower (59-61%) leaf surfaces. Dunja, Golden Glory, Envy, and Payroll exhibited control of powdery mildew on lower leaf surfaces (54-63%). Soleil was the only variety that did not differ significantly in powdery mildew severity from Spineless Beauty at any assessment. All 3 acorn-type winter squash varieties (Sweet REBA, Tay Belle PM and Honey Bear) effectively suppressed powdery mildew on both upper (47-60%) and lower (49-73%) leaf surfaces. In contrast, none of the butternut-type winter squash varieties effectively suppressed powdery mildew on upper leaf surfaces, and only Bugle (PMRR) was significantly less severely affected on lower leaf surfaces than the susceptible variety; while none of the pumpkin varieties suppressed powdery mildew on either leaf surfaces. Both PMR and PMRR varieties and experimentals were included in these evaluations; no consistent benefit was detected to having homozygous resistance.

Mobile fungicides recommended for powdery mildew in 2010 were Quintec (active ingredient in FRAC Code 13), Procure or related fungicides (Code 3), and Pristine (Codes 7 + 11). Quintec is currently labeled for use on cucurbit crop types producing a non-edible peel (melon, pumpkin, winter squash, and gourd). Mobile fungicides are needed to effectively control powdery mildew on lower leaf surfaces, but are at risk for resistance development due to their single site mode of action. It is critical to apply mobile fungicides in alternation and also tank-mixed with a protectant fungicide (e.g. chlorothalonil, copper, oil, sulfur) for resistance management, to improve control, and to comply with label restrictions. For example, the Quintec label specifies no more than 2 consecutive applications plus a crop maximum of 4 applications. The other labeled chemistry (Code 1) and Code 11 fungicides were not recommended because resistant strains had been detected at high frequencies in previous years, including 2009, and the type of resistance to these groups is qualitative, thus resistant strains are completely resistant and cannot be controlled by using high rates, short spray intervals, or another fungicide in the same group.

Changes in sensitivity to key fungicides were detected in the cucurbit powdery mildew pathogen population in 2010, adding to the challenge of effectively managing this important disease. One of the 3 main recommended fungicides, Pristine, was ineffective for the first time in the annual fungicide evaluation conducted on Long Island with pumpkin. Note that, while testing a fungicide solely provides valuable information on its inherent activity and indicates when resistant pathogen strains are present and can reach a sufficient proportion of the population to affect product efficacy, this is not a labeled and/or recommended use pattern, and it does not indicate what would happen when the fungicide is used within an integrated management program. In 2010, pathogen strains resistant to the main active ingredient in Pristine, boscalid (FRAC Code 7), were detected in the research field as well as commercial fields much more commonly than in 2009. Two methods are used to examine pathogen sensitivity to fungicides: 1) a bioassay with seedlings treated with different fungicides at various doses put in a field for about 5 hours to be exposed to spores of the pathogen population present there and 2) a laboratory assay to determine sensitivity of individual pathogen isolates obtained from affected crops. Resistance to boscalid was detected with both methods. Resistance is conclusive because these strains tolerate a dose in the assays (500 ppm) that is in the range of an application dose.

Another recommended fungicide, Procure, was no longer effective at the last disease severity assessment in the fungicide evaluation while the third recommended fungicide, Quintec, was highly effective. Sole use of each of these 3 fungicides was shown to affect pathogen sensitivity to that fungicide through a bioassay conducted on 21 Sept, which revealed that the proportion of pathogen strains with some insensitivity to a fungicide was greatest in the plot treated with that fungicide. Ability to select for pathogen strains less sensitive to Quintec documents the vulnerability of this fungicide to resistance development and the need to use an integrated management program. Control failure due to resistance to Quintec has occurred with other powdery mildew pathogens. Effective control was achieved in another experiment where an integrated fungicide program was used that consisted of an alternation of Pristine, Quintec, and Procure all applied with Kocide to a resistant variety. Fungicide sensitivity of the pathogen population in this field did not exhibit any selection for less sensitive strains as occurred in the fungicide evaluation plots, in fact it was similar to that in another experiment where no fungicides were applied based on results from the bioassay conducted on 21 Sept.

The bioassay conducted in spring crops at the start of powdery mildew development in the region revealed that resistance to MBC fungicides (FRAC Code 1) and to QoI fungicides (Code 11) was again present at a high level (average of 95% and 94% of the population, respectively). These fungicides would have been ineffective. This finding confirms the decision to not recommend fungicides in these groups in 2010.

Prospect looks good for improved control of powdery mildew in the future. There are fungicides on tract for registration soon with novel active ingredients that are highly effective for powdery mildew. They include Torino (Gowan Company) and Luna (Bayer CropScience). Hopefully these will be registered before the pathogen has developed resistance to Quintec so that all can be used together in a fungicide resistance management program. Other new fungicides for powdery mildew include Switch (FRAC Codes 9 and 12), which is not considered as effective as other registered products, and three in FRAC Code 3 (Tebuzol, Folicur, and Inspire Super), which are not considered more effective than Procure.

Recommendations for managing powdery mildew in 2011 include select resistant varieties and apply fungicides on a weekly schedule beginning before or as soon as first symptoms develop using a mobile fungicide at high label rate combined with a protectant each application. Quintec is the main mobile fungicide to use on labeled crops (pumpkin, winter squash, gourd, melon) where the crop rotational restriction is acceptable. Use Procure (or another Code 3 fungicide) and Pristine in alternation with Quintec or with each other where Quintec is not used. It is critical to examine the underside of leaves when scouting for first symptoms and evaluating efficacy of control. Recent crop additions to the Quintec label have increased the options of what can be planted within 12 months of the last application.

Downy mildew has continued to be important every year during the growing season. Before 2004 this disease occurred sporadically in the northeast and often late in the season. Now it can occur before fruit production is done, when loss of leaves, which can occur quickly when downy mildew is not managed, can impact yield and fruit quality. Fortunately there are several opportunities for improving control in 2011 rather than new challenges to face with this disease.

An important tool for managing downy mildew is the forecasting web site at <http://cdm.ipmpipe.org>. The risk of downy mildew occurring throughout the eastern US is forecast and posted three times a week. Growers can now subscribe to receive customizable alerts by e-mail or text message, thereby avoiding the need to regularly check the web site. Success of the forecast system depends on knowledge of where downy mildew is occurring, therefore prompt reporting of outbreaks by growers is critical.

Cucumber varieties with resistance to the old pathogen strains provide significant but insufficient suppression. This was documented in experiments conducted on Long Island in 2008 and 2009 with Straight Eight, an old variety lacking resistance. Calypso (pickling type) and Poinsett 76 and Marketmore 76 (slicers) had the lowest overall severity.

Applying fungicides continues to be the main management practice for downy mildew. Dithane now has a supplemental label that includes pumpkin, winter squash and gourd. And the targeted fungicide Presidio was just registered thereby further increasing the arsenal for NY growers. The full list of mobile fungicides with different modes of action recommended for managing downy mildew includes: Ranman (FRAC Code 21), Forum (40), Revus (40), Presidio (43), Curzate (27), Tanos (27), Gavel (22), and Previcur Flex (28). Alternating among fungicides in different FRAC Groups (different codes) and tank-mixing them with a protectant fungicide (except for Gavel which contains mancozeb) is recommended for delaying resistance development, minimizing the impact of resistance when it occurs and it is often required to comply with the restrictions on most labels. Curzate and Tanos have some curative activity (up to 2 days under cool temperatures) but limited residual activity (about 3-5 days). Presidio has an advantage over Curzate and Previcur Flex of also being effective for Phytophthora blight. Both diseases are often of concern for most cucurbit growers. Presidio has a long rotational interval of 18 months for non-labeled crops, which can be a constraint on production. All cucurbits, fruiting vegetables, tuberous and corm vegetables (except potato), and leafy vegetables are now labeled; carrot, sugar beet, potato and rotational wheat will be labeled soon; and rotational field corn is expected in 2012. All of the mobile fungicides listed above have proven effective in university fungicide efficacy evaluations. Efficacy of Revus has varied among crop types with control being good on pumpkin but poor on cucumber. Based on results from an analysis of all published data from these evaluations, Presidio is the most effective fungicide, followed by Previcur Flex and then Ranman. However, there is concern that resistance may be developing to Previcur Flex based on reduced performance in some recent fungicide evaluation studies compared to previous results. All of the mobile fungicides are at risk for development of fungicide resistance because of their single site mode of action. And the downy mildew pathogen is considered prone to developing resistance. Resistance to mefenoxam and metalaxyl and to strobilurins is sufficiently common that fungicides with these active ingredients (e.g. Ridomil and Cabrio), which use to be highly effective, exhibited little to no efficacy in several recent evaluations. Resistance to the active ingredient in Tanos and Curzate has been detected in Europe. An important fact for NYS growers to realize is that, while in NY Presidio is new chemistry (FRAC Code 43), it has been used in other states the past 3 years, and the downy mildew pathogen moves long distances each season, so the pathogen occurring in NY in 2011 is part of the US population that has been exposed to this 'new' fungicide for 3 years already. The analysis of fungicide efficacy data also revealed that combining mobile fungicides with a protectant fungicide improved control; thus there is an additional benefit to this standard practice for managing resistance. None of the downy mildew fungicides are effective for powdery mildew unfortunately.

Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.