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Life cycle of downy mildew of cucurbits

UC IPM Home > Homes, Gardens, Landscapes, and Turf > Powdery Mildew on Vegetables Pests in Gardens and Landscapes Revised 11/08 In this Guideline: Powdery mildew on melon leaves. Sugar pea foliage damaged by powdery mildew, Erysiphe polygoni. Powdery mildew causes irregular yellow blotches on tomato leaves. Brownish spots on pea pod from powdery mildew infection. Powdery mildew is a common disease on many types of plants. There are many different species of powdery mildew fungi (e.g., Erysiphe spp., Sphaerotheca spp.) and each species only attacks specific plants. A wide variety of vegetable crops are affected by powdery mildews, including artichoke, beans, beets, carrot, cucumber, eggplant, lettuce, melons, parsnips, peas, peppers, pumpkins, radicchio, radishes, squash, tomatillo, tomatoes, and turnips. Powdery mildews generally do not require moist conditions to establish and grow, and normally do well under warm conditions; thus they are more prevalent than many other leaf-infecting diseases under California's dry summer conditions. IDENTIFICATION AND DAMAGE Powdery mildew first appears as white, powdery spots that may form on both surfaces of leaves, on shoots, and sometimes on flowers and fruit. These spots gradually spread over a large area of the leaves and stems. An exception is one of the powdery mildews that affects artichokes, onions, peppers, and tomatoes: it produces yellow patches on leaves but little powdery growth. Leaves infected with powdery mildew may gradually turn completely yellow, die, and fall off, which may expose fruit to sunburn. On some plants, powdery mildew may cause the leaves to twist, buckle, or otherwise distort. Powdery mildew fungal growth does not usually grow on vegetable fruits, although pea pods may get brownish spots. Severely infected plants may have reduced yields, shortened production times, and fruit that has little flavor. LIFE CYCLE All powdery mildew fungi require living plant tissue to grow. Year-round availability of crop or weed hosts is important for the survival of some powdery mildew fungi. Special resting spores are produced, allowing overwinter survival of the species that causes the disease in cucurbits, lettuce, peas, and certain other crops. Most powdery mildew fungi grow as thin layers of mycelium (fungal tissue) on the surface of the affected plant part. Spores, which are the primary means of dispersal, make up the bulk of the white, powdery growth visible on the plant's surface and are produced in chains that can be seen with a hand lens; in contrast, spores of downy mildew grow on branched stalks that look like tiny trees. Powdery mildew spores are carried by wind to new hosts. Although humidity requirements for germination vary, all powdery mildew species can germinate and infect in the absence of free water. In fact, spores of some powdery mildew fungi are killed and germination is inhibited by water on plant surfaces for extended periods. Moderate temperatures (60° to 80°F) and shady conditions generally are the most favorable for powdery mildew development. Spores and fungal growth are sensitive to extreme heat (above 90°F) and direct sunlight. MANAGEMENT The best method of control is prevention. Planting resistant vegetable varieties when available, or avoiding the most susceptible varieties, planting in the full sun, and following good cultural practices will adequately control powdery mildew in many cases (Table 1). However, very susceptible vegetables such as cucurbits (cucumber, melons, squash, and pumpkins) may require fungicide treatment. Several least-toxic fungicides are available but must be applied no later than the first sign of disease. Resistant Varieties In some cases, varieties resistant to powdery mildew may be available. If available, plant resistant varieties of cantaloupe, cole crops, cucumber, melons, peas, pumpkins, and squash. If you plant more susceptible varieties, you may need to take control measures. Table 1. Host Plants and Control Measures for Powdery Mildew Species. Hosts Fungus species Controls cucumbers, endive, lettuce, melons, potato, pumpkin, squash Erysiphe cichoracearum resistant varieties of lettuce, cucumber; water sprays; fungicides if necessary on squash and pumpkin broccoli, Brussels sprouts, cauliflower, and other cole crops; radicchio, radishes, turnips Erysiphe cruciferarum not usually required tomatoes Erysiphe lycopersici fungicides if necessary peas Erysiphe pisi resistant varieties; sprinkler irrigation carrots, parsley, parsnips Erysiphe heraclei tolerant varieties beets Erysiphe polygoni tolerant varieties artichoke, eggplant, peppers, tomatillo, tomatoes Leveillula taurica rarely required; fungicides if necessary beans, black-eyed peas, cucurbits, okra Sphaerotheca fuliginea resistant varieties for some; fungicides if necessary Cultural Practices Plant in sunny areas as much as possible, provide good air circulation, and avoid applying excess fertilizer. A good alternative is to use a slow-release fertilizer. Overhead sprinkling may help reduce powdery mildew because spores are washed off the plant. However, overhead sprinklers are not usually recommended as a control method in vegetables because their use may contribute to other pest problems. Fungicide Application In some situations, especially in the production of susceptible cucurbits, fungicides may be needed. Fungicides function as protectants, eradicants, or both. A protectant fungicide prevents new infections from occurring whereas an eradicant can kill an existing infection. Apply protectant fungicides to highly susceptible plants before the disease appears. Use eradicants at the earliest signs of the disease. Once mildew growth is extensive, control with any fungicide becomes more difficult. The products listed here are for home garden use. Commercial growers should consult the UC Pest Management Guidelines. Fungicides Several least-toxic fungicides are available, including horticultural oils, neem oil, jojoba oil, sulfur, and the biological fungicide Serenade. With the exception of the oils, these materials are primarily preventive. Oils work best as eradicants but also have some protectant activity. Oils To eradicate mild to moderate powdery mildew infections, use a horticultural oil such as Saf-T-Side Spray Oil, Sunspray Ultra-Fine Spray Oil, or one of the plant-based oils such as neem oil or jojoba oil (e.g., E-rase). Be careful, however, to never apply an oil spray within 2 weeks of a sulfur spray or plants may be injured. Also, oils should never be applied when temperatures are above 90°F or to drought-stressed plants. Some plants may be more sensitive than others, however, and the interval required between sulfur and oil sprays may be even longer; always consult the fungicide label for any special precautions. Sulfur Sulfur products have been used to manage powdery mildew for centuries but are only effective when applied before disease symptoms appear. The best sulfur products to use for powdery mildew control in gardens are wettable sulfurs that are specially formulated with surfactants similar to those in dishwashing detergent (e.g., Safer Garden Fungicide) However, sulfur can be damaging to some squash and melon varieties. To avoid injuring any plant, do not apply sulfur when air temperature is near or over 90°F and do not apply it within 2 weeks of an oil spray. Other sulfur products, such as sulfur dust, are much more difficult to use, irritating to skin and eyes, and limited in terms of the plants they can safely be used on. Copper is also available to control powdery mildew but is not very effective. Biological Fungicides Biological fungicides (such as Serenade) are commercially available beneficial microorganisms formulated into a product that, when sprayed on the plant, destroys fungal pathogens. The active ingredient in Serenade is a bacterium, Bacillus subtilis, that helps prevent the powdery mildew from infecting the plant. While this product functions to kill the powdery mildew organism and is nontoxic to people, pets, and beneficial insects, it has not proven to be as effective as the oils or sulfur in controlling this disease. How to Use Apply protectant fungicides, such as wettable sulfur, to susceptible plants before or in the earliest stages of disease development. The protectant fungicides are only effective on contact, so applications must provide thorough coverage of all susceptible plant parts. As plants grow and produce new tissue, additional applications may be necessary at 7- to 10-day intervals as long as conditions are conducive to disease growth. If mild to moderate powdery mildew symptoms are present, the horticultural oils and plant-based oils such as neem oil and jojoba oil can be used to reduce or eliminate the infection. WARNING ON THE USE OF PESTICIDES REFERENCES Flint, M. L. 1998. Pests of the Garden and Small Farm: A Grower's Guide to Using Less Pesticide. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3332. Gubler, W. D., and D. J. Hirschfelt. 1992. Powdery Mildew. In Grape Pest Management. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3343. pp 57-63. McCain, A. H. 1994. Powdery Mildew. HortScript #3, Univ. Calif. Coop. Ext. Marin County. PUBLICATION INFORMATION Pest Notes: Powdery Mildew on Vegetables UC ANR Publication 7406 Authors: R. M. Davis, Plant Pathology, UC Davis; W. D. Gubler, Plant Pathology, UC Davis; S. T. Koike, UC Cooperative Extension, Monterey County Produced by University of California Statewide IPM Program Top of page Species of single-celled organism Pseudoperonospora cubensis P. cubensis on cucumber leaf Scientific classification Clade: SAR Phylum: Oomycota Order: Peronosporales Family: Peronosporaceae Genus: Pseudoperonospora Species: P. cubensis Binomial name Pseudoperonospora cubensis(Berk. & M.A. Curtis) Rostovzev Pseudoperonospora cubensis is a species of water mould known for causing downy mildew on cucurbits such as cantaloupe, cucumber, pumpkin, squash and watermelon. This water mould is an important pathogen of all these crops, especially in areas with high humidity and rainfall, such as the eastern United States. In most years the disease is an annual, late-season problem on squash and pumpkin in the eastern and central United States, however, since 2004 it has become one of the most important diseases in cucumber production.[1] Considered a highly destructive foliar disease of cucurbits, successful breeding in the mid-twentieth century provided adequate control of downy mildew in cucumber without the use of fungicides. The resurgence in virulence has caused growers great concern and substantial economic losses, while downy mildew in other cucurbit crops continues to be a yearly hindrance. Symptoms and signs The pathogen causes angular chlorotic lesions on the foliage. These lesions appear angular because they are bound by leaf veins. During humid conditions, inspection of the underside of the leaf reveals gray-brown to purplish-black fungal growth. This downy material is the sporulation of the pathogen. Magnification of the sporulation reveals the acutely and dichotomously branched sporangiophores bearing lemon-shaped sporangia. Eventually, leaves will turn necrotic and curl upwards. The disease is sometimes called wildfire because of how rapidly it progresses, as if the crop were burned by fire. Symptoms on watermelon and cantaloupe are different from on other cucurbits; leaf spots are typically not angular and turn brown to black in color. Often, an exaggerated upward leaf-curling will occur. Regardless of which cucurbit is involved, only the leaves are infected, not fruit, flowers, stems or roots. Disease of the leaves results in three major effects: 1. reduced yields, 2. a greater proportion of misshapen fruit, especially in cucumber, and 3. sunscalded fruit, due to increased exposure to direct sunlight, especially in watermelon and winter squash. Pathogen biology Pseudoperonospora cubensis is an obligate parasite or biotroph, meaning that it requires live host tissue in order to survive and reproduce. Because of this characteristic, the pathogen must overwinter in an area that does not experience a hard frost, such as southern Florida, and where wild or cultivated cucurbits are present. The spores are dispersed via wind to neighboring plants and fields and often over long distances. Symptoms appear 4 to 12 days after infection. The pathogen thrives under cool and moist conditions, but can do well under a wide range of conditions. Optimum conditions for sporulation are 59 °F (15 °C) with 6 to 12 hours of moisture present, often in the form of morning dew. Even when high daytime temperatures are not favorable for the pathogen (>95 °F or >35 °C), nighttime temperatures may be very suitable. Oospores (thick-walled, resting spores) of P. cubensis are rare and their role in nature is unknown.[2] Host specificity, pathotypes Within the cucurbit family, P. cubensis isolates will exhibit a specific host range, that is, it will infect certain cucurbits and not others. For example, if cucumber and squash are grown side-by-side sometimes only the cucumber is diseased. When a pathogen exhibits this type of host specificity within a plant family, it is referred to as a pathotype. At least five pathotypes of P. cubensis have been described in the U.S.[3][4] More recent studies in the Czech Republic have revealed more pathotypes.[5] Disease management Controlling downy mildew requires the use of resistant cultivars, fungicide applications and early detection. Resistant cultivars[6] - Host resistance is an important tool in disease control and should be used whenever possible. Cultivars resistant to downy mildew have been developed for cucumber and cantaloupe and to a lesser extent for squash and pumpkin. Although cucumber downy mildew has been severe on resistant cultivars, these cultivars are more effective than susceptible cultivars in delaying infection. Chemical control - Chemical control is highly recommended because downy mildew is an aggressive and destructive disease and satisfactory control without the use of fungicides is unlikely. Both protectant and systemic products should be applied. Fungicides are most effective when applied prior to infection and reapplied at 5- to 7-day intervals. The following products have proven to be the most effective fungicides in cucumber downy mildew control in North Carolina trials conducted annually from 2004 to 2008: Presidio (fluopicolide, Valent), Ranman (cyazofamid, FMC), Previcur Flex (propamocarb, Bayer), Curzate (cymoxanil, DuPont), Tanos (famoxadone and cymoxanil, DuPont), and Gavel (zoxamide and mancozeb, Dow AgroSciences). These products should be applied in a program to prevent pathogen resistance, that is, rotated with fungicides of a different mode of action. Protectant fungicides such as chlorothalonil and mancozeb should be used as mixing partners. Biological control - Although many biological control products have been evaluated for their ability to control downy mildew, none have proven effective and are not recommended for use. Early detection & forecasting - Many growers have lost the battle against downy mildew by waiting until they could clearly see the disease before initiating sprays. Early detection of downy mildew and immediate or preventative fungicide application is imperative for the control of this disease. A forecasting system exists to assist growers in timing their fungicide applications for maximum benefit. The system tracks outbreaks of the disease and provides a forecast or risk assessment for future outbreaks. References ^ Holmes, G., Wehner, T. and Thornton, A. 2006. An old enemy re-emerges: downy mildew rears its ugly head on cucumber, impacting growers up and down the Eastern U.S. American Vegetable Grower, Feb. pp. 14-15. ^ Nowicki, Marcin; et al. (15 May 2013), "A simple dual stain for detailed investigations of plant-fungal pathogen interactions", Vegetable Crops Research Bulletin, 77: 61–74, doi:10.2478/v10032-012-0016-z, S2CID 49587635, retrieved 2013-05-24 ^ Thomas, CE; Inaba, T; Cohen, Y (1987). "Physiological specialization in Pseudoperonospora cubensis". Phytopathology. 77 (12): 1621–1624. doi:10.1094/phyto-77-1621. ^ Thomas, CE, 1996. 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