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Powdery Mildew of Hemp

Powdery mildew, which is characterized by white powdery spots on leaves (Figure 1), stems, and flowers is among the greatest disease issues faced by hemp (*Cannabis sativa*) growers regardless of being indoors or outdoors. Controlled environment production facilities generally incorporate intensive cropping systems and can be ideal environments for the development of many diseases caused by fungi. This article will discuss powdery mildew signs/symptoms, infection, and cultural treatment, preventative fungicides, and sanitation.



Figure 1. White powdery growth on hemp leaves infected with powdery mildew. Image: Erica Hernandez, Griffin GGSPRO.

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Identification

Powdery mildew in hemp is a pathogenic fungus comprising several closely related species in the genus *Golovinomyces*. It is most recognizable by white patches of powdery-looking spots (Figure 2). These fungal colonies can cover large areas on leaves, stems, and flowers (Figure 3). Powdery mildew infected plants may also appear stunted, and leaves appear brown. Though it rarely kills plants, heavily infected leaves can limit photosynthesis, reduce nutrient availability, and lead to leaf necrosis and defoliation. Infected flowers will also display white mycelial growth, which would be considered lower quality product and may trigger a rejection of the project based on a state's microbial pathogen testing.

Infection Process

Infection during the growing season occurs by conidia. Conidia are asexual spores that under a microscope resemble oblong ovals that sit atop a stack of conidiophores (more oblong oval-like shapes, Figure 4) that protrude from the epidermal layer of the plant. Once on the leaf surface, the conidia penetrate the epidermal cells through root-like organs called haustoria. These rootlike organs take water and nutrients from the plant's cells without killing them. After the tissues are colonized, the spreading of the fungi's mycelia (fungal threads, Figure 5) resembles the fuzzy white formation associated with powdery mildew. Under ideal conditions, the conidia can germinate in a few hours and penetrate the cell wall in less than 24 hours. The reproduction and spread of additional conidia can occur within 7 days after initial infection. Despite the ability to penetrate the plants epidermal layer, infection isn't reported to proceed further into the plant via vascular or pith tissues, i.e. become systemic.



Figure 2. A hemp plant exhibiting relatively early signs of powdery mildew (white, powdery spots). Image: Bret Timmons, Cornell University.



Figure 3. Hemp powdery mildew can infect flower buds. Image: Bret Timmons, Cornell University.



Figure 4. Hemp powdery mildew at 200x magnification. Circled is a conidiophore, a stalk that produces spores (conidia). Image: Erica Hernandez, Griffin GGSPRO.



Figure 5. White mycelia (fungal threads) from hemp powdery mildew. Image is a leaf with advanced powdery mildew at 200x magnification. Image: Erica Hernandez, Griffin GGSPRO.

Optimal Conditions for Development

Research on powdery mildew indicates that conidia can survive a wide variation of temperatures and humidity. Optimal temperature ranges for powdery mildew are believed to be between 69-84 °F. High humidity levels promote fungal growth, but low humidity promotes spore dispersal. Low leaf moisture is also more favorable for powdery mildew.

Cultural Controls and Sanitation

Powdery mildew can affect all plant stages of development. Instituting protocols to manage or prevent infection include:

- Biosecurity measures to quarantine incoming plant material until it can be screened
- Removing plant debris
- Disposing of heavily contaminated or dead material
- Utilizing sanitary uniforms, shoe covers, hair nets, beard nets, and gloves
- Positioning footbaths with disinfectant at the entrance to grow rooms
- Sanitizing tools with detergent and disinfectant
- Training employees on disease control
- Decreasing worker movement from areas with potential contamination to clean rooms
- Using air filtration systems and replace filters as recommended
- Regular cleaning of dehumidifiers and fans
- Maintaining humidity levels lower than 50-60%
- Using fans to move air within the canopy to break up microclimates

Managing microclimates within dense plant canopies is also an area of concern. Moisture can accumulate on inflorescences and create optimal environments for mildew. Control microclimates through plant management techniques such as:

- Cutting back leaves and/ or branches to allow for increased airflow
- Training the plant canopy to open up space for increased airflow through pruning techniques such as topping
- Proper plant spacing

One of the benefits of controlled environments is year-round production, which if not managed correctly, can spread inoculum across the continued crop cycles. Additionally, managing the climate and humidity can help to avoid fungal epidemics but may come at the cost of reprioritizing energy-saving measures.

Genetics as a Control

Utilizing cultivars that are more resistant to powdery mildew is one of the best first steps for powdery mildew control. Unfortunately, the scale to which hemp breeders screen for disease resistance is not the same as it is for traditional crops. In the future we may see more hemp cultivars specifically selected for powdery mildew resistance.

Nutrient Management

Nitrogen - high nitrogen has been documented to negatively affect crop resilience to powdery mildew. It is recommended that fertility rates be managed properly to reduce plant susceptibility to infection.

Silicon - Silicon can improve plant health through increasing plant cell rigidity. Soluble silicon products applied to the rootzone have shown to increase silica deposition in leaf epidermal cells, which can reduce haustoria formation. Dixon et al. (2022) found an average of 80% reduction in disease severity when compared to a nontreated control. Rootzone delivered silica is preferred over foliar treatments due to a higher rate of accumulation within the plant.

Growers should use caution when selecting a product, as all silicon containing products are not equal.

Lighting Controls

Ultraviolet B and C light (UV-B 280-320nm, UV-C 200-280 nm) has been shown to be effective in other crops at controlling the germination and spread of powdery mildew. While there are a limited number of experiments analyzing the effects of UV light on *Cannabis sativa*, an experiment conducted with UV-C light on a non-hemp cultivar showed the disease to be significantly reduced. While UV light lacks residues unlike some pesticides, UV-C light is harmful to living organisms and must be used with caution as it may harm/kill plants as well as has negative impacts on human vision and skin). Warning! Short-term or prolonged UV exposure poses serious risks to people. Personal Protective Equipment (PPE) or alternative safety measures must be utilized to avoid exposing non-target organisms. UV light can damage or kill plants if not used in appropriate doses. Currently, there is no established protocol for UV treatment of powdery mildew in hemp.

Water as a control measure

Powdery mildew conidia can be damaged when immersed in water on leaves. Although this may seem like a good control measure when others are not available, the side effects of promoting fungal growth through high humidity and possible introduction of diseases like fusarium warrant a different approach.

Preventive Fungicides

The EPA maintains a list of pesticides that are approved for use on hemp in the United States. A number of these pesticides have either preventative or curative action against powdery mildew through a variety of modes of action.

Please note: Not all the products mentioned in this bulletin are registered or approved for use on hemp in all states. This bulletin is not intended to provide recommendations for specific production sites, which may be subject to state or local regulation. It is the grower's responsibility to understand federal, state, and local regulations regarding pesticide use on cannabis crops. Some pesticides are approved by some states and not by others. Additionally, some states conduct residue testing for products listed for hemp/cannabis. It is the grower's responsibility to understand the action levels for this testing and to make decisions regarding use of these products.

Curative options include pesticides with potassium bicarbonate as an active ingredient (ex: MilStop or Carb-O-Nator). Potassium ions disrupt membrane function of conidia and hyphae, while bicarbonate has a desiccating effect. Products utilizing *Bacillus spp.* of beneficial bacteria work through colonization of leaf surfaces and excluding fungal spores from taking hold. Oil-based options (ex: Suffoil-X and others) can cover and smother fungal spores, preventing further spread of disease. Even certain plant extracts have been shown to trigger an Induced Systemic Resistance response in hemp, which is particularly useful in fighting off powdery mildew preventatively. (ex: Regalia CG) Certain fertilizer-based products, such as those containing potassium silicates, can form physical barriers on leaf surfaces and strengthen plant cells themselves against infiltration by fungal hyphae.

Sanitation Products

Good sanitation practices both in the production area and on the crop itself have significant impacts on the spread and persistence of powdery mildew. Powdery mildew spores exist ubiquitously in the environment, but with good end of crop sanitation and beginning of crop sprays can help fend off infestations. Sanitizers should be used as a first step, turning the leaf surface into a "clean slate" and ready for colonization with beneficial bacteria.

A limited number of sanitizers have been approved for direct plant contact in the case of hemp, all of which contain hydrogen peroxide in some form - ZeroTol 2.0, TerraClean 5.0, and OxiPhos, all from BioSafe Systems. Utilization of a sanitizer as a spray or fog can help deal with both existing outbreaks of powdery mildew and prevent future, though their use alone is not enough to be considered a curative treatment.

The full list of products approved by the EPA for use on hemp is [here](#).

In summary

Powdery mildew on hemp plants grown in controlled environments is a difficult pest to control, due to its rate of spread and lack of approved products for control. Still, powdery mildew can be effectively managed and controlled with the right measures put into place. While there are not a lot of approved chemicals on the market to control powdery mildew, there are other treatment options and management techniques that growers might find suitable.

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Figure 6. Advanced powdery mildew of hemp has infected nearly all the leaves of this plant. Image: Bret Timmons, Cornell University.

Disclaimer: Mention of trademarks or brand names is for informational purposes only and does not imply its approval to the exclusion of other products that may be suitable. Always follow the pesticide label. The label is law!



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