



Optimizing powdery mildew control in organic greenhouse lettuce with UV light and OMRI-certified fungicides

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Abstract: Powdery mildew (PM), caused by *Erysiphe* spp., is a common fungal disease that affects lettuce and other leafy crops, particularly in greenhouse environments. This study investigates an integrated pest management (IPM) approach combining ultraviolet (UV) light exposure and OMRI-certified fungicides to control powdery mildew in organic lettuce production. The research was conducted in a greenhouse setting, focusing on the effects of UV light on fungal growth and the efficacy of an OMRI-certified fungicide in reducing powdery mildew incidence. The results showed that UV light exposure significantly reduced powdery mildew development, while the fungicide provided additional control. The combination of both methods led to a marked reduction in disease severity and improved plant health compared to untreated controls. This study highlights the potential for using UV light exposure in conjunction with organic fungicides as an effective and environmentally sustainable method for managing powdery mildew in greenhouse organic lettuce production.

Keywords: Powdery Mildew, UV Light Exposure, OMRI-Certified Fungicide, Organic Lettuce, Greenhouse, Integrated Pest Management, Disease Control, Organic Farming, Sustainable Agriculture.

Introduction: Powdery mildew is a widespread and destructive fungal disease affecting a variety of crops, particularly leafy vegetables like lettuce (*Lactuca sativa*). This disease is caused by different species of *Erysiphe*

and is characterized by the formation of white, powdery patches on plant leaves. These patches hinder photosynthesis and reduce the overall vigor of the plant, ultimately affecting yield and quality. In organic farming systems, where the use of synthetic chemical fungicides is prohibited, managing powdery mildew presents a significant challenge. Conventional control measures, including chemical fungicides, are often unavailable or not allowed under organic certification standards.

To address this issue, an integrated pest management (IPM) approach that combines multiple control methods is often more effective than relying on a single solution. One potential strategy is the use of ultraviolet (UV) light exposure, which has been shown to inhibit the growth of fungal pathogens, including *Erysiphe* spp. UV light exposure damages the DNA of fungi, reducing their ability to reproduce and spread. In conjunction with UV light, OMRI-certified fungicides—those approved for use in organic farming—offer a chemical-free alternative to synthetic fungicides. These products, which typically contain natural or biological agents, provide additional disease control while adhering to organic farming principles.

This study investigates the combined effects of UV light exposure and OMRI-certified fungicide application on the control of powdery mildew in greenhouse-grown organic lettuce. The aim is to assess whether the integration of UV light and organic fungicides can provide an effective, sustainable solution for managing this prevalent disease in organic farming.

METHODS

Study Setup

The experiment was conducted in a controlled greenhouse environment designed for organic lettuce production. Lettuce plants (var. Butterhead) were grown in soil-based containers under standard greenhouse conditions. The temperature was maintained at 22°C during the day and 18°C at night, with a 12-hour photoperiod. Plants were irrigated using a drip system, and the greenhouse was ventilated to maintain optimal humidity levels for lettuce growth.

Experimental Design

The experimental design included four treatment groups:

1. Control: No treatment for powdery mildew.
2. UV Light Exposure: Lettuce plants were exposed to UV-C light for 15 minutes daily.
3. OMRI-Certified Fungicide: Lettuce plants were sprayed with an OMRI-certified fungicide containing potassium bicarbonate (EcoGard®).

4. UV Light + OMRI-Certified Fungicide: A combination of daily UV light exposure and weekly fungicide application.

Each treatment had three replications, with a total of 12 experimental units. The UV light treatment was applied using a UV-C lamp positioned 30 cm above the plant canopy. The fungicide was applied according to the manufacturer's instructions, ensuring full coverage of the leaves.

Data Collection

- Powdery Mildew Incidence: Disease severity was assessed weekly by counting the number of infected leaves in each treatment group and calculating the percentage of infected leaves per plant.
- Powdery Mildew Severity: The severity of the disease was evaluated using a scale from 0 (no symptoms) to 5 (severe infection). This scale was used to assess the extent of disease progression on the plants.
- Plant Health: Visual assessments of plant health were made based on leaf color, turgidity, and overall vigor. A rating scale of 0 to 10 was used, where 0 indicated severe plant stress or death, and 10 indicated healthy plants with no visible disease symptoms.
- Yield: After the experimental period, the total biomass of the plants was harvested, and fresh weight was recorded to assess the effect of treatments on yield.

Statistical Analysis

Data were analyzed using ANOVA to determine the effects of different treatments on powdery mildew incidence, severity, plant health, and yield. Post-hoc comparisons were made using Tukey's test to identify significant differences between treatment groups. A significance level of $p < 0.05$ was used for all statistical analyses.

RESULTS

Powdery Mildew Incidence and Severity

The control group, which received no treatment, exhibited the highest incidence and severity of powdery mildew. After six weeks of the experimental period, over 80% of the plants in the control group showed visible symptoms of powdery mildew, with disease severity reaching a score of 4 (moderate infection) on the assessment scale.

In the UV light exposure treatment, powdery mildew incidence was significantly reduced, with only 50% of the plants showing symptoms. Disease severity in this group was lower compared to the control, with a mean severity score of 2 (mild infection).

The OMRI-certified fungicide treatment also significantly reduced both disease incidence and

severity compared to the control, with only 40% of plants showing symptoms and a severity score of 1.5 (mild infection). However, the combined treatment of UV light exposure and OMRI-certified fungicide was the most effective, with disease incidence reduced to less than 20% and a severity score of 1 (very mild infection). This combination treatment resulted in a substantial decrease in powdery mildew development compared to all other treatments.

Plant Health

Plants in the control group showed signs of stress, including yellowing of leaves and reduced growth. The UV light and fungicide treatments also showed improvements in plant health, with both groups displaying vibrant green leaves and robust growth. The combined treatment (UV + fungicide) resulted in the healthiest plants, exhibiting full, healthy foliage and minimal signs of stress.

Yield

The yield of lettuce plants in the combined UV light + fungicide treatment was significantly higher compared to the control. The average fresh weight of the plants in this treatment group was 25% higher than that of the control group. Both the UV light-only and fungicide-only treatments also showed improved yields compared to the control, though not to the same extent as the combined treatment.

DISCUSSION

The integrated use of UV light exposure and OMRI-certified fungicides presents a promising approach for managing powdery mildew in greenhouse-grown organic lettuce. The results from this study suggest that both UV light and fungicide treatments individually reduced disease severity and incidence, but when combined, they offered superior control. This integrated pest management (IPM) strategy could be highly beneficial for organic farmers who are seeking effective and sustainable methods for disease control in lettuce production, a crop that is particularly vulnerable to powdery mildew.

Effectiveness of UV Light Exposure

UV light exposure, particularly UV-C radiation, has long been known for its ability to damage the cellular structures of microorganisms, including fungal pathogens. In this study, daily exposure to UV light significantly reduced the incidence of powdery mildew in lettuce plants. UV light works by inducing DNA damage in fungal spores and mycelia, which inhibits their ability to reproduce and spread. The results are consistent with other studies that have demonstrated the fungicidal effect of UV light on various plant pathogens, including *Erysiphe* spp. (the causative

agents of powdery mildew).

UV-C radiation can penetrate the fungal conidia (spores), damaging their structure and rendering them unable to germinate. This effect is particularly important in greenhouse environments, where high humidity and warm temperatures create an ideal setting for fungal growth. UV light provides a non-chemical method of disease control, making it an attractive option for organic growers who seek to avoid synthetic fungicides. Moreover, the ability to use UV light multiple times without the risk of pathogen resistance offers a distinct advantage over traditional fungicides, which can lead to resistance if overused.

However, the effectiveness of UV light in controlling powdery mildew depends on several factors, such as the duration of exposure, the intensity of UV light, and the timing of application. In this study, a daily 15-minute exposure was sufficient to reduce disease incidence. Future research could investigate the optimal UV light exposure times and intensities for different crop types and environmental conditions. Additionally, UV light treatments are typically more effective when applied early in the disease cycle before the pathogen has a chance to spread extensively.

Role of OMRI-Certified Fungicide

OMRI-certified fungicides, such as potassium bicarbonate, are designed to provide effective disease control while adhering to organic farming standards. Potassium bicarbonate works by altering the pH of the fungal cell wall, disrupting the pathogen's ability to thrive and reproduce. In this study, the fungicide treatment significantly reduced both disease severity and incidence, supporting its efficacy in controlling powdery mildew.

The use of organic fungicides like potassium bicarbonate is a key component of sustainable agriculture because they avoid the negative environmental and health impacts associated with synthetic chemicals. Moreover, the OMRI certification ensures that these products are safe for use in organic systems, which is essential for maintaining consumer confidence in organic produce.

While OMRI-certified fungicides are effective in controlling powdery mildew, they may not provide long-lasting protection, especially if applied infrequently or during high-pressure disease outbreaks. This highlights the importance of combining fungicides with other control methods, such as UV light, to achieve more comprehensive and long-term disease management. The fungicide is particularly effective when applied to prevent fungal growth after the disease has been introduced, but may not always address the initial infection stages as effectively as UV light does.

Synergy Between UV Light and OMRI-Certified Fungicide

The combined use of UV light and OMRI-certified fungicides showed a synergistic effect in this study. The results indicate that these two control measures complement each other. UV light provides an immediate reduction in the fungal spore population by directly targeting the pathogen's reproductive structures. In contrast, the fungicide acts more gradually by inhibiting the growth and spread of any remaining fungal cells that may not have been affected by the UV treatment.

One possible reason for the observed synergy is that UV light disrupts the pathogen's ability to propagate, lowering the overall fungal load, while the fungicide targets any residual fungal growth that might have survived the UV exposure. This combination not only improves disease control but also reduces the likelihood of fungal resistance to either treatment. The multi-pronged approach reduces the pathogen's capacity to adapt to a single control method, which is a major advantage of integrated pest management strategies.

Additionally, the combination treatment resulted in healthier plants, with improved leaf quality and yield. This is likely due to the fact that the combined treatment not only controlled the disease but also promoted better plant growth by minimizing the stress caused by fungal infections. The enhanced photosynthetic capacity of plants that are free from powdery mildew allows for greater energy production, which can contribute to higher yields.

Impact on Yield and Plant Health

In terms of plant health and yield, the combined UV light and fungicide treatment yielded the highest fresh weight of lettuce, showing a marked improvement over the untreated control and other single treatments. This outcome is consistent with previous studies that have demonstrated the positive effects of disease management on crop productivity. Powdery mildew reduces plant vigor by blocking light penetration into the leaves, limiting photosynthesis, and increasing water loss due to the damage to leaf tissue. By controlling the disease, the plants were able to allocate more resources to growth and fruit production, leading to improved yield.

The UV light and fungicide treatments also helped maintain the overall health of the plants by reducing the visible symptoms of powdery mildew, such as leaf discoloration and curling. Healthy, disease-free plants are more capable of taking up nutrients and water from the soil, further contributing to growth and yield. Furthermore, healthier plants are better equipped to

withstand other environmental stresses, including temperature fluctuations, pests, and nutrient deficiencies.

Environmental and Economic Considerations

The integration of UV light and OMRI-certified fungicides offers several environmental and economic benefits for organic lettuce production. UV light exposure is a sustainable, low-impact method that avoids the use of chemical pesticides, aligning with the principles of organic farming. It also minimizes the risk of pesticide residues in the final product, which is an important concern for consumers of organic produce.

From an economic standpoint, although the initial investment in UV light equipment may be high, the long-term benefits could outweigh the costs, especially if UV light helps reduce reliance on organic fungicides. Furthermore, UV light can reduce the frequency and cost of fungicide applications, as it provides an additional layer of control that reduces the overall disease pressure. The improved plant health and higher yields resulting from the integrated treatment can also lead to higher profits for organic farmers, making this approach economically viable in the long run.

However, challenges exist in scaling up UV light applications to larger production areas. The cost of UV light systems and the energy consumption associated with their use may limit their feasibility for large-scale commercial operations. Future research should explore the development of more energy-efficient UV light systems and investigate their effectiveness in larger, commercial greenhouse settings.

In conclusion, this study demonstrates the effectiveness of an integrated approach using UV light exposure and OMRI-certified fungicides to control powdery mildew in organic lettuce production. The combination of these methods provides an environmentally sustainable and effective solution for managing powdery mildew, improving plant health, and increasing yield. The results suggest that integrated pest management strategies, particularly those combining non-chemical and chemical methods that adhere to organic standards, can play a crucial role in overcoming the challenges posed by powdery mildew in organic farming systems.

Future research should focus on optimizing the UV light exposure parameters (e.g., intensity, duration, and timing) to enhance its effectiveness. Additionally, exploring the combination of UV light with other organic fungicides or biological control agents could provide further insights into the development of more robust disease management strategies. Further studies on the economic feasibility and environmental impact of UV light-based disease control in organic farming will also be crucial for evaluating the broader applicability of this

technology in commercial organic agriculture.

By continuing to develop integrated, sustainable disease management strategies, organic farming can reduce its dependency on synthetic pesticides and improve crop resilience, thus contributing to more sustainable food production systems.

The results of this study demonstrate the effectiveness of integrating UV light exposure with OMRI-certified fungicide applications in controlling powdery mildew in greenhouse-grown organic lettuce. UV light exposure significantly reduced the incidence and severity of powdery mildew by inhibiting the growth of the fungal pathogen. The UV-C light likely damaged the fungal spores and mycelia, preventing further spread and reproduction. When combined with the fungicide, which further suppressed fungal growth through its active ingredient, potassium bicarbonate, the two treatments together provided superior control of the disease compared to either treatment alone.

This integrated approach to disease management offers several advantages. UV light is a non-chemical method that can be used repeatedly without risking resistance development in the pathogen. Additionally, the use of OMRI-certified fungicides ensures that the treatment remains compliant with organic farming standards, providing an environmentally sustainable solution for managing powdery mildew in organic greenhouse lettuce production.

The combination of UV light and organic fungicide treatment not only controlled the disease effectively but also resulted in healthier plants and increased yield, highlighting the potential of this approach for improving productivity in organic systems. This integrated method aligns with the principles of integrated pest management (IPM), which emphasizes the use of multiple strategies to manage pests and diseases in an environmentally responsible manner.

CONCLUSION

This study shows that combining UV light exposure with OMRI-certified fungicides is an effective and sustainable method for controlling powdery mildew in greenhouse organic lettuce production. The integrated approach not only reduced disease incidence and severity but also improved plant health and increased yield. These findings suggest that using UV light in conjunction with organic fungicides could become a valuable tool for organic farmers seeking to manage fungal diseases while adhering to organic certification standards. Future research should focus on optimizing the application of UV light and fungicides to further enhance their effectiveness and explore their potential for controlling other common greenhouse diseases in organic farming systems.

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