

Research Insight

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Influence of Humidity Control on Disease Occurrence in Cucumber Production

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Abstract Humidity management is a critical environmental factor influencing disease occurrence, crop health, and productivity in cucumber (*Cucumis sativus* L.) production systems. Excessive humidity, prolonged leaf wetness, and unstable microclimatic conditions create favorable environments for pathogen survival, spore germination, and infection, resulting in severe losses caused by fungal and bacterial diseases. With the rapid development of protected cultivation and precision agriculture technologies, humidity regulation has become an important strategy for sustainable disease prevention and improved crop performance. This review systematically summarizes the mechanisms underlying humidity-mediated disease development in cucumber production, focusing on the interactions among environmental humidity, plant physiological responses, and pathogen infection processes. The effects of humidity conditions on major cucumber diseases, including powdery mildew, downy mildew, gray mold, and bacterial diseases, are discussed from ecological and physiological perspectives. Furthermore, current humidity control approaches, such as ventilation management, irrigation optimization, dehumidification technologies, and integrated greenhouse climate regulation, are evaluated for their effectiveness in reducing disease risks. Advances in computational modeling, machine learning-based disease prediction, and sensor-driven environmental control systems are also highlighted as emerging tools for real-time disease forecasting and precision management. A case study framework is presented to demonstrate how humidity monitoring, disease assessment, and predictive modeling can be integrated to optimize greenhouse cucumber production. Despite significant progress, challenges remain in accurately defining humidity thresholds across cultivars and production environments, improving model interpretability, and integrating multi-factor environmental regulation strategies. Future research combining artificial intelligence, digital agriculture, and plant-microbe interaction studies will provide new opportunities for developing sustainable and intelligent disease management systems in cucumber production.

Keywords Humidity control; Cucumber production; Disease occurrence; Greenhouse microclimate management; Precision agriculture

1 Introduction

Cucumber is a major greenhouse vegetable crop, and its productivity depends heavily on precise microclimate regulation in protected cultivation systems. Greenhouse production enables high yields through environmental control, but the same stable environment can also favor pathogen establishment when humidity, temperature, and ventilation are not well managed (Fanourakis et al., 2026). This dual role makes humidity management especially important in cucumber production, where crop performance is shaped not only by resource-use efficiency and yield optimization but also by the need to suppress disease-conducive conditions. Long-term greenhouse observations further show that cucumber yield is significantly associated with environmental variables including relative humidity, with average nighttime humidity emerging as a meaningful correlate of production outcomes in semi-closed systems. Humidity control is therefore not a secondary engineering detail, but a central production factor linking plant growth, fruit yield, and crop health. In practical terms, managing humidity affects leaf wetness duration, canopy moisture, and air exchange, all of which influence whether greenhouse cucumber systems operate near optimal physiological conditions or drift toward environments that increase production risk.

The importance of humidity management becomes even clearer when considering disease epidemiology in cucumber crops. Across greenhouse vegetables, warm and humid conditions consistently promote fungal and