# Optimal Control of a Stochastic Plant Disease Model with Climate-Dependent Transmission Rates

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## Abstract

Plant diseases remain a significant challenge in agricultural systems, often leading to reduced crop productivity under varying environmental conditions. In this study, a stochastic compartmental model is developed to describe the transmission dynamics of plant disease by incorporating climate-dependent variability in the infection process. The plant population is divided into susceptible, infected, and removed classes, and the transmission rate is assumed to fluctuate with environmental factors such as temperature and humidity. These variations are represented through stochastic perturbations, allowing the model to capture realistic uncertainty in disease spread. The basic reproduction number is derived, and the existence and stability of the disease-free and endemic equilibrium states are analysed to understand the long-term behaviour of the system. The influence of key parameters on disease dynamics is further examined through a bifurcation analysis. An optimal control strategy is introduced to represent intervention measures such as pesticide application and treatment efforts, and the control problem is formulated using Pontryagin's Maximum Principle to minimize the infected population and the cost of control. Numerical simulations are carried out to illustrate the impact of stochastic effects and the effectiveness of the proposed control strategy under different environmental conditions. The results suggest that incorporating climate-dependent transmission and adaptive control mechanisms provide a more realistic framework for managing plant disease dynamics in agricultural systems.

**Keyword:** Stochastic modelling, plant disease dynamics, optimal control, climate-dependent transmission, SIR model.