Optimal Control in a Vectored Plant Disease Model for a Crop with Continuous Replanting, Roguing and Insecticide Spray

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Vector-transmitted diseases of plants have had devastating effects on agricultural production worldwide, resulting in drastic reductions in yield for crops such as cotton, soybean, tomato, and cassava. In this investigation, we apply a plant-vector-virus model with continuous replanting to study how disease control is impacted by selection of cuttings, roguing and insecticide use. We extend the model of Holt et al. [1] and Jeger et al. [2] to include two types of replanting strategies, referred to as frequency- and abundance-replanting. In the frequency-replanting model, replanting of infected cuttings is dependent on the *selection frequency* parameter, denoted ϵ, of infected plants, whereas in the abundance-replanting model, replanting is based on plant abundance via a *selection rate* parameter also denoted ϵ. The models differ in the replacement rate of plants in the field. Frequency-replanting has a slower replacement rate than abundance-replanting. The two models are analyzed and new thresholds for disease elimination are defined and compared for each model. Parameter values for cassava, whiteflies, and African cassava mosaic virus serve as a case study. A numerical sensitivity analysis illustrates how the equilibrium densities of healthy and infected plants vary with changes in parameter values. For a fixed selection frequency or rate, optimal control theory is used

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to study how the two disease models respond to control via roguing that removes infected plants or via insecticide use that decreases vector abundance. Differences in optimal control strategies in the two models are seen for large values of ϵ. Our analysis and simulations demonstrate that control with roguing and insecticides is in general better than a single control (only roguing or only insecticide) and that selection frequency also impacts the plant abundance.

References

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