Coupling an epidemiological and economic model to optimize management of hop powdery mildew at the landscape level

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Abstract

Developing sound management strategies for plant diseases requires consideration of aspects of pathogen spread, the effectiveness of control measures, and the resulting economic costs. This is exemplified with hop powdery mildew in the western United States, one of the most challenging and expensive diseases affecting the U.S. hop industry. In this environment, primary inoculum of the pathogen can be limiting to epidemic development due to the absence of the asicergous stage of the fungus. However, the disease can spread rapidly and damage crop yield and quality due to the density of hop yards, the susceptibility of varieties that are widely grown, and the potential for long-distance dispersal of the pathogen. We developed an epidemiological model that estimates disease development and spread taking into account the fungicide effects, and the expected crop damage. We then coupled this epidemiological model to an economic model of expected revenue and costs. The coupled model was parameterized using data collected from a census sample of commercial hop yards in Oregon during 2014 to 2017, including the monthly incidence of plants with powdery mildew, fungicides and other disease control measures applied by growers, and estimated revenue depending on the severity of powdery mildew on the cones. We introduce this model and demonstrate its application in simulating epidemics and their associated costs due to factors such as the frequency of primary inoculum and its spatial location, the proportion of the crop planted to resistant cultivars, and market conditions. The model can be further extended to apply optimal control theory for epidemics, quantify the effectiveness of cooperation in area-wide disease management, and answer questions that cannot be easily addressed through field experimentation.

Key words. Disease ecology, epidemiology, modeling, powdery mildew