Abstract

Objective: Surveillance is critical for the rapid implementation of control measures for diseases caused by aerially dispersed plant pathogens, but such programs can be resource-intensive, especially for epidemics caused by long-distance dispersed pathogens. The current cucurbit downy mildew platform for monitoring, predicting and communicating the risk of disease spread in the United States is expensive to maintain. In this study, we focused on identifying sites critical for surveillance and treatment in an attempt to reduce disease monitoring costs and determine where control may be applied to mitigate the risk of disease spread.

Methods: Static networks were constructed based on the distance between fields, while dynamic networks were constructed based on the distance between fields and wind speed and direction, using disease data collected from 2008 to 2016. Three strategies were used to identify highly connected field sites. First, the probability of pathogen transmission between nodes and the probability of node infection were modeled over a discrete weekly time step within an epidemic year. Second, nodes identified as important were selectively removed from networks and the probability of node infection was recalculated in each epidemic year. Third, the recurring patterns of node infection were analyzed across epidemic years.

Results: Static networks exhibited scale-free properties where the node degree followed a power-law distribution. Betweenness centrality was the most useful metric for identifying important nodes within the networks that were associated with disease transmission and prediction. Based on betweenness centrality, field sites in Maryland, North Carolina, Ohio, South Carolina and Virginia were the most central in the disease network across epidemic years. Removing field sites identified as important limited the predicted risk of disease spread based on the dynamic network model.

Conclusions: Combining the dynamic network model and centrality metrics facilitated the identification of highly connected fields in the southeastern United States and the mid-Atlantic region. These highly connected sites may be used to inform surveillance and strategies for controlling cucurbit downy mildew in the eastern United States.