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When and where to warn farmers: Analysing the value of spatio-temporal pest risk prediction for pest monitoring decisions

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Abstract

Plant pests cause significant pre-harvest loss in Indian vegetable production, threatening food security and rural livelihoods. To mitigate yield loss while avoiding excessive pesticide use, careful monitoring of crops is necessary for timely and targeted damage prevention or treatment. However, in-field monitoring is not free. Monitoring each field every day risks wasting resources and precious time needed for other management tasks. We present a novel and scalable disease risk forecasting method to assess when and where it is useful to look for symptoms. Infestation probabilities are predicted using sparse Gaussian process classification with deep kernel learning. Both abiotic suitability and spatio-temporal diffusion effects are exploited for prediction. Data inputs are crowdsourced infestation data observed via the Plantix smartphone app (case study: n=68,586), as well as daily weather records. The predictions are then used to calculate the Value of Information (VoI) for pest monitoring via a probabilistic decision model. We present two types of spatio-temporal VoI measures: individual VoI for assessing the benefits to the individual farmer, and community VoI to include the potential value generated by warning nearby farmers against disease outbreaks. As a case study, we examine the invasive pest *Tuta absoluta* in tomato production in Andhra Pradesh over a timespan of 6 years (2018 to 2023). Farmers' current practices (calendar-based monitoring and pesticide application) are compared to the proposed VoI-based practice in terms of yield loss, farm profitability and pesticide use. We find that monitoring tomato plants for symptoms of *T. absoluta* infestation is of significant value both to the respective farm itself and to its spatial neighbourhood. Automated warnings based on our pest risk prediction model could improve pest management efficiency at plot-, farm-, and regional scale.

Keywords: Decision analysis, India, insect pests, tomato, *Tuta absoluta*