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Exploring zoxamide sensitivity in *Plasmopara viticola* populations: implications for fungicide management in precision agriculture

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Abstract

Fungicides play a critical role in managing grapevine downy mildew caused by the oomycete P*lasmopara viticola*, a biotrophic and polycyclic pathogen with a high risk of fungicide resistance. Zoxamide, categorized as a low to medium resistance risk, disrupts cell division by inhibiting tubulin polymerization. Resistance to zoxamide is uncommon in field isolates. This six-year study (2017-2022) aimed to detect and quantify zoxamide sensitivity in *P. viticola* populations across varying resistance pressures in Italian grapevine regions. Analysis of 126 samples from 57 vineyards, mainly in North-Eastern Italy, revealed that most samples exhibited EC_{50}, EC_{95}, and MIC values below 0.1 and 10 mg/L of zoxamide, respectively. Nineteen vineyards showed reduced sensitivity (MIC>100 mg/L), but only four samples were characterized by 24-54% resistant oospores at >100 mg/L of zoxamide. Notably, samples treated 4-5 times displayed a broader distribution of toxicological parameters, suggesting a heightened need to manage fungicide applications to reduce selection pressure. In conclusion, oospore assays proved valuable not only for detecting the overall sensitivity profile of populations but also for quantifying resistant individuals within them, enabling a better identification of critical factors affecting zoxamide sensitivity and highlighting the need for improved management practices in a precision agriculture context.

Keywords: plant disease, integrated pest management, disease control, fungicide resistance.