

Leaf mortality and a dynamic hydraulic safety margin prevent significant stem embolism in the world's top wine regions during drought.

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Grapevine is a crop of global economic importance that faces major challenges, notably through increased drought exposure. In order to maintain or even increase sustainability, it is critical to have a complete and accurate understanding of grapevine's physiological behavior under drought. Nevertheless, studies report conflicting results regarding variety-specific behaviors. Examining multiple varieties, we utilized a combination of novel approaches to define water stress thresholds for a series of critical variables in maintaining vascular system integrity (water potential and stomatal regulation, stem embolism, leaf mortality, and recovery). We then compared the failure threshold under drought with a long-term field water status survey, across multiple varieties and climate conditions, in two of the world's top wine regions, Napa and Bordeaux. We simultaneously assessed stomatal behavior in response to decreasing soil water availability and increasing evaporative demand, revealing a complex dynamic that defies the strict anisohydric/isohydric paradigm. Although inter-varietal differences were small, inter-organ and ontogenic differences were much greater, with the pressure inducing 50% loss of hydraulic conductivity Ψ_{50} decreasing along the growing season: from -2.1MPa in July to -3.2MPa in October. The unrecoverable water potential was observed at ~50% loss of hydraulic conductivity in the stem and ~80% leaf mortality. However, the minimum stem water potentials experienced in the field over the last decade have never passed Ψ_{50} . This large safety margin is facilitated by hydraulic vulnerability segmentation promoting petiole embolism and leaf mortality. The water stress thresholds defined here provide a robust guide for informing viticultural management strategies under drought.

Keywords

Hydraulic conductivity, stomatal conductance, xylem embolism, safety margin, grapevine