Dialing in grapevine water stress indicators to better reflect holistic stress responses

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Abstract:

Context and purpose of the study - Current remote sensing strategies rely heavily on reflectance data and energy balance modelling using thermal imagery to estimate crop water use and stress. These approaches show great promise for driving precision management decisions, but still require work to better understand how detected changes relate to meaningful physiological changes. Under water stress, grapevines exhibit a range of responses involving both biological and physical changes within leaves and canopies. By first understanding the physical characteristics of dehydration, we may be able to pinpoint water specific stress indicators which may be important with increasing heat wave intensity and frequency during the growing season. This study aims to improve remote sensing indices to track grapevine stress by integrating both physical and biological effects.

Material and methods – Pressure-volume curve measurements were taken from field-grown grapevines to analyze short term impacts of tissue dehydration. In brief, we took branch samples of grapevines and rehydrated them overnight before leaves were excised and put through spectral and water potential measurements during a benchtop dry down. This process was repeated over the course of a growing season and in December 2022, micro-CT images were taken to analyze corresponding physical changes within leaves to spectral and water potential measurements. To test for longer term effects, a controlled and slow soil dry-down experiment was performed in a greenhouse over the course of a few months and results were visualized in micro-CT.

Results – Pressure-volume curve induced changes in leaf water content were detected using spectral indices that focused on water bands. Leaves from multiple varieties showed that plant-water relations traits (e.g. turgor loss point) change throughout the season with the turgor loss point becoming more negative as the season progressed. This correlated with the changes in spectral indices throughout the season. The controlled dry-down experiment showed the longer-term effects induced via metabolic/biological changes in the leaves typical of indices focused on pigmentation bands. This work illustrates the need to refine remotely sensed techniques used to detect grapevine stress to account for variety specific and phenological changes that distinguish between biological (long term) and physical (often short term) changes in leaves and canopies. Future efforts in this area to better integrate and represent meaningful physiological stress that impacts carbon capture and water loss from leaves will be discussed.

Keywords: Grapevine, remote sensing, spectroscopy, water potential, drought