Increased greenhouse emissions have altered Earth’s climate, and rapid climate change has brought warm droughts—especially in semi-arid regions—leading to forest die-off and dieback[1-2]. Physiological stresses associated with climate change pose a great risk to tree survival, as future climate changes are likely to increase the intensity of droughts[3].

Pine pines (Pinus edulis) have a high drought tolerance[2] but have succumbed to widespread drought-induced mortality in recent decades, likely due to hydraulic failure[4-5]. Xylem hydraulic failure occurs when the water potential surpasses a species-specific threshold and results in xylem embolism[6].

Remotely sensing hydraulic failure is presently not possible. Chlorophyll fluorescence (Fv/Fm) is a proxy frequently used in agricultural systems to detect water stress in plants.

Objectives

• Quantify the relationship between drought stress and chlorophyll fluorescence in P. edulis.
• Document variation of chlorophyll fluorescence within and between trees during drought stress.

Methods

Methods

We measured the ratio of fluorescence (Fv/Fm) of each branch (n=5 per tree) and the water potential (MPa) of the tree at pre-dawn, once a week for 9 weeks.

Results

Figure 3. We compiled all 2,250 of the data points from throughout the experiment and graphed the relationship between water potential and Fv/Fm. The dashed line at -2.5 MPa indicates the pre-dawn water potential at which drought stress induced stomatal closure.

Discussion & Predictions

• Our data indicates that chlorophyll fluorescence is an indicator of drought-induced water stress in P. edulis. Our results also indicated that variation in chlorophyll fluorescence increases within a tree the longer drought stress prolongs.
• With further observations, we predict Fv/Fm will decrease exponentially as drought continues and will be a useful proxy of hydraulic failure, and therefore useful for determining if a tree will survive after drought stress is relieved.
• Continued research may allow us to quantify a lethal limit of drought stress as well as predict which trees will undergo the phenomenon of dieback and then recover rather than face mortality.

Impact

• While our study was focused on the photosynthetic capacity of dark-adapted samples, solar-induced fluorescence (SIF) could be used to predict chlorophyll fluorescence remotely. Future satellite observations of SIF could provide means of linking this research to ecosystem measurements.
• Continued research on drought-induced tree mortality will improve our ability to more accurately predict models of tree mortality. Refining predictions of tree mortality will further our understanding of climate change impacts on forests and feedbacks between terrestrial vegetation and climate.

Literature Cited


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