Beyond a single temperature threshold: applying a cumulative thermal stress framework to plant heat tolerance

Alicia Cook[1], Enrico Rezende[2], Katherina Petrou[1], and Andrea Leigh[1]

[1]University of Technology Sydney
[2]Pontificia Universidad Catolica de Chile

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Abstract

Most plant thermal tolerance studies focus on single critical thresholds, which limit the capacity to generalise across studies and predict heat stress under natural conditions. In animals and microbes, thermal tolerance landscapes describe the more realistic, cumulative effects of temperature. We tested this in plants by measuring the decline in leaf photosynthetic efficiency (F_V/F_M) following a combination of temperatures and exposure times, then modelled these physiological indices alongside recorded environmental temperatures. We demonstrate that a general relationship between stressful temperatures and exposure durations can be effectively employed to quantify and compare heat tolerance within and across plant species and over time. Importantly, we show how F_V/F_M curves translate to plants under natural conditions, suggesting that environmental temperatures often impair photosynthetic function. Our findings provide more robust descriptors of heat tolerance in plants and suggest that heat tolerance in disparate groups of organisms can be studied with a single predictive framework.

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