Disentangling drought-responsive traits with focus on Arabidopsis

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SUMMARIES

Summary

In recent decades, the frequency and severity of drought events have significantly increased due to climate change. This rise in drought occurrences has led to adverse consequences, including reduced global water availability which results in increased forest mortality or significant losses in crop yield. Consequently, there is an urgent need to gain a comprehensive understanding of the mechanisms underlying drought-induced plant mortality, particularly in herbaceous species that include numerous economically important crops. Acquiring this knowledge is crucial for the precise prediction of plant mortality and for the development of drought-resilient crop varieties. To deepen our comprehension of drought responses in herbaceous species and to gain insights into the diverse strategies employed by a single species to withstand drought stress, we analyzed a comprehensive dataset of anatomical and hydraulic traits of stems and leaves in eight different genotypes of *Arabidopsis thaliana*, including both wild-type and transgenic mutants. This dataset, discussed primarily in chapters 1 and 2 (and partly also in chapter 3), is used to showcase the strategies utilized by these genotypes during drought experiments (discussed in chapters 2 and 3). We also included a preliminary screen of the expression levels of four well-known drought marker genes associated with ABA-dependent and ABA-independent pathways (discussed in chapter 2). In chapter 3, we specifically focused on the impact of the overexpression of the *JUNGBRUNNEN1* (*JUB1*) gene on drought response in Arabidopsis and tomato.

The findings of our study highlight that each Arabidopsis genotype employed a unique combination of anatomical and hydraulic traits in stems and leaves to respond to water deficit conditions. This variation can be summarized into two distinct strategies: (1) one group of plants (*soc1ful* knockout, Sha ecotype, and *AHL15* overexpression) improved their drought response by developing a more negative stem P_{50}, thicker intervessel pit membranes, a more lignified inflorescence stem, and a gradual reduction of the low initial stomatal conductance (g_s) during drought, allowing for a relatively high and stable leaf water potential (Ψ_l) during onset of drought.

Additionally, these three genotypes showed reduced transcript levels of drought stress marker genes and minimized chlorophyll loss in leaves during drought. (2) Another group of plants (*JUB1* overexpression genotypes in Arabidopsis and tomato) relies solely on maintaining high Ψ_l for drought tolerance, possibly due to the accumulation of osmoprotectants in leaves, while the other drought-responsive traits have not been recorded (except for lower initial stomatal conductance in Arabidopsis *JUB1OX*). The ability to maintain high Ψ_l is particularly critical during the early stages of drought, prior to stomatal closure, as it prevents the water potential from reaching a critical threshold that could lead to cavitation and embolism formation. Once embolism occurs in the xylem, the synergistic effects with anatomical traits become significant, as these functional xylem traits (in)directly contribute to preventing the formation and spread of embolism. Overall, our results underscore the remarkable adaptive capabilities of herbaceous plants in responding to challenging drought conditions and highlight marked differences among genotypes within the same species. This intraspecific variation in drought responses shows that a more detailed assessment of drought-responsive traits is required to explore the full potential of increasing crop yield in a world facing global warming that needs to feed billions of people.