Physiological and Transcriptomic Responses to Drought in Ponderosa Pine

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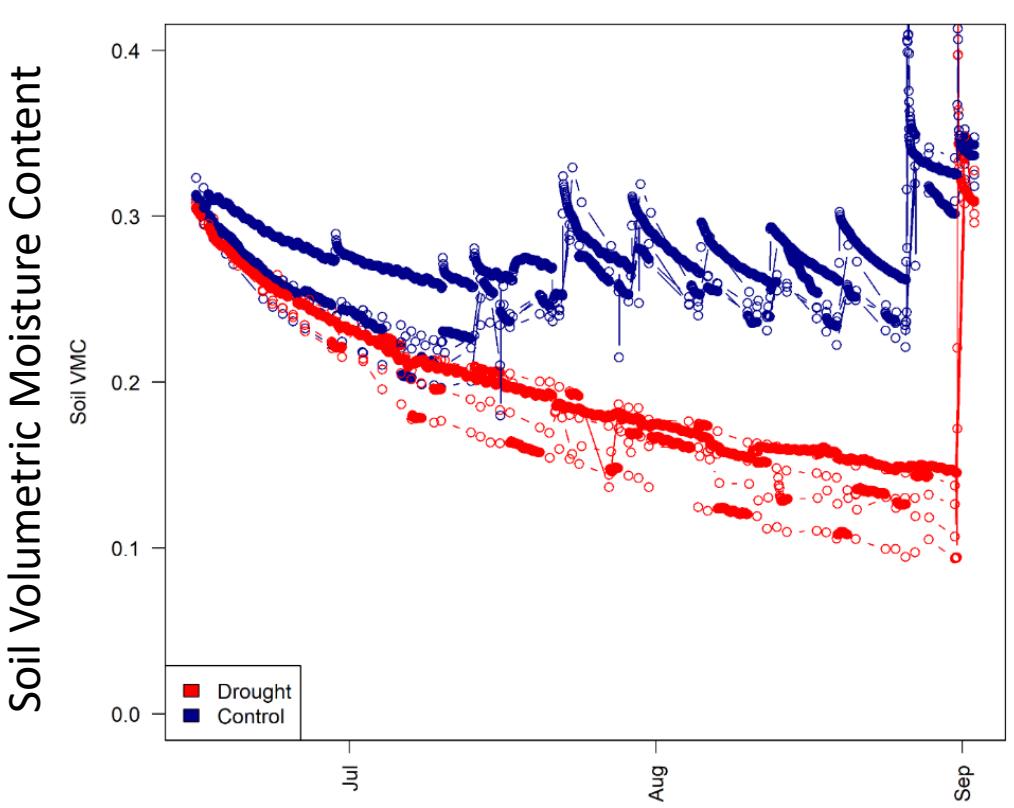
Raised Beds Experiment

- 22 Families from BC's only A-class orchard + 5 B-class seedlots
- 10 beds evenly split between Control and Drought treatments (5 each)
- Each bed contained 5 replicate blocks
- Experiment ran for 2 summers (2020 and 2021)

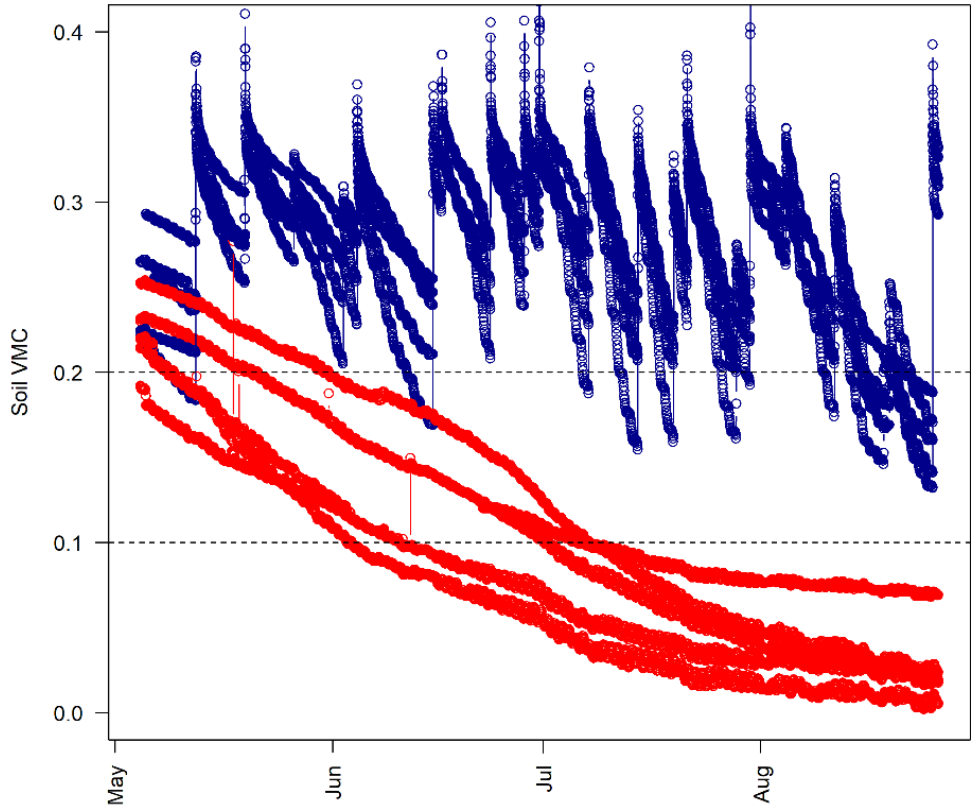
Drought Treatment

- Rain-exclusion roofs raised in June of 2020 and March of 2021
- Control beds were drip irrigated once a week
- Removed in September

Dry-down in drought treated beds



Summer 2020



Summer 2021

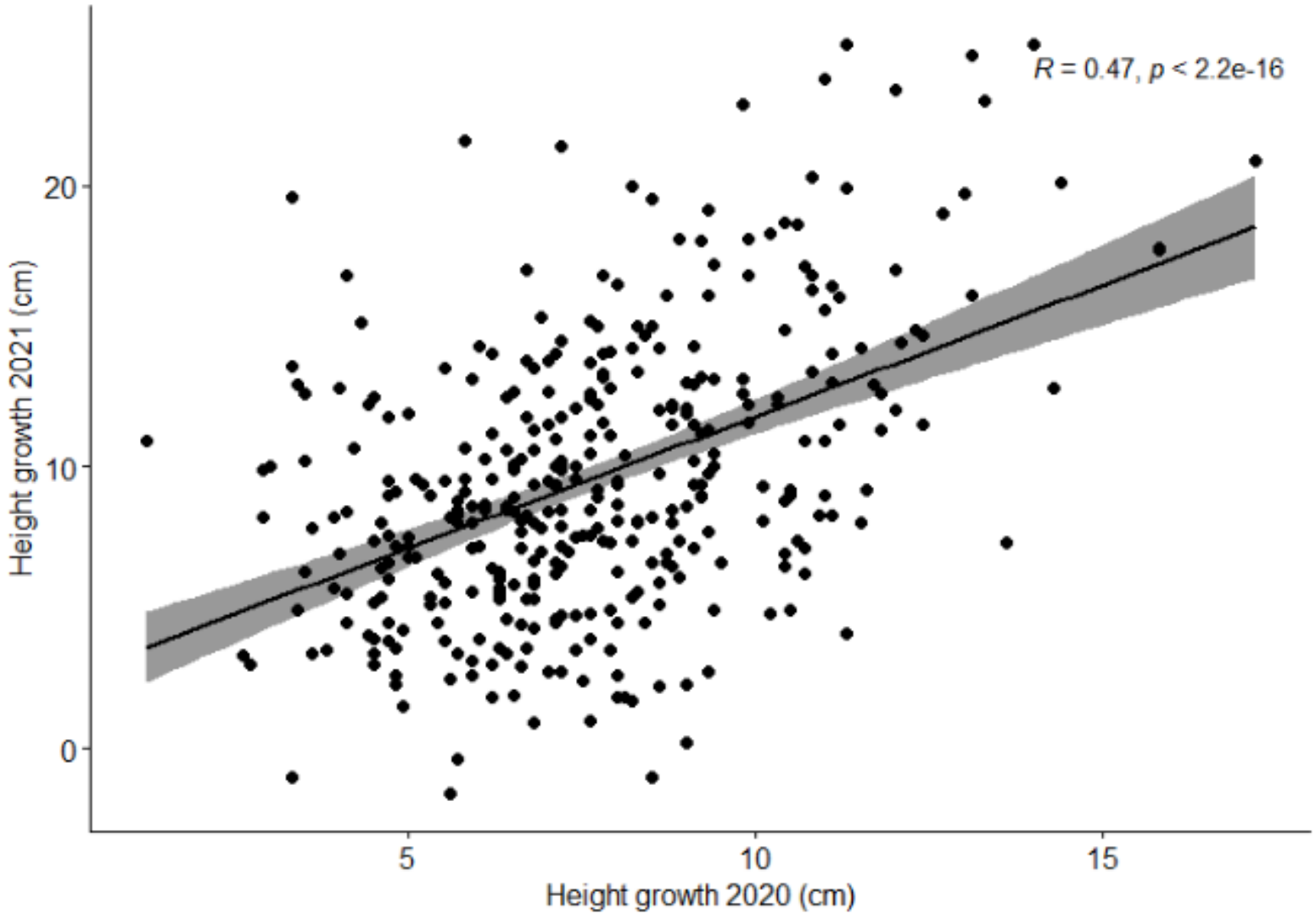
Trait measurements

- Height measurements were taken throughout 2020 and 2021
- Needle lengths, water potential, and $\delta^{13}C$ were measured in late August/early September of 2020

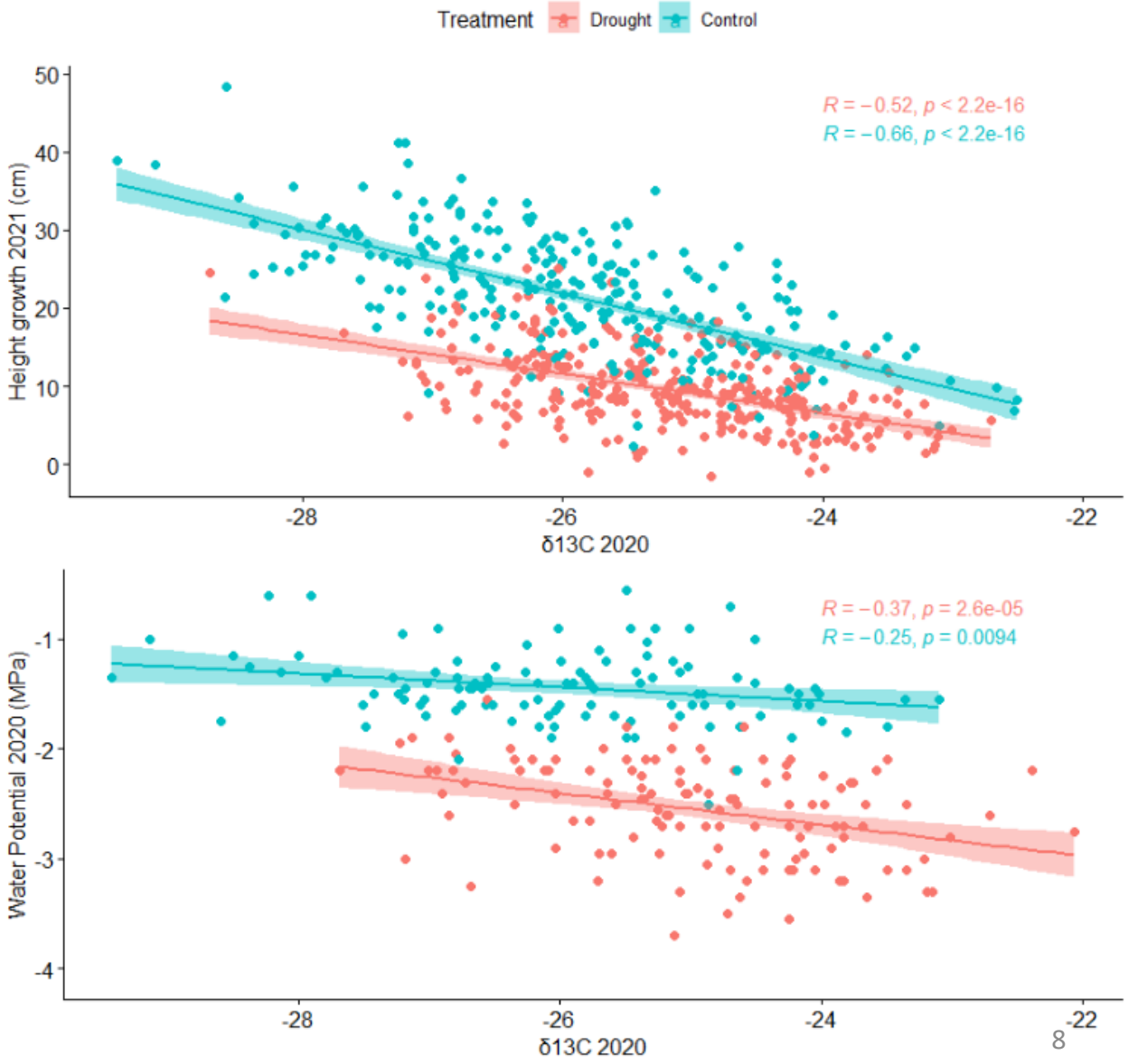
Measured traits are drought-responsive, and may have genetic contributions

	Treatment	Class	Family
Height Growth 2020	* - lower in drought	** - higher in A	***
Height Growth 2021	*** - lower in drought	NS	*
Needle length 2020	*** - shorter in drought	* - longer in B	***
Water Potential 2020	*** - lower in drought	N/A	***
$\delta^{13}C$ 2020	*** - higher in drought	N/A	***

No trade-off found between growth and drought tolerance



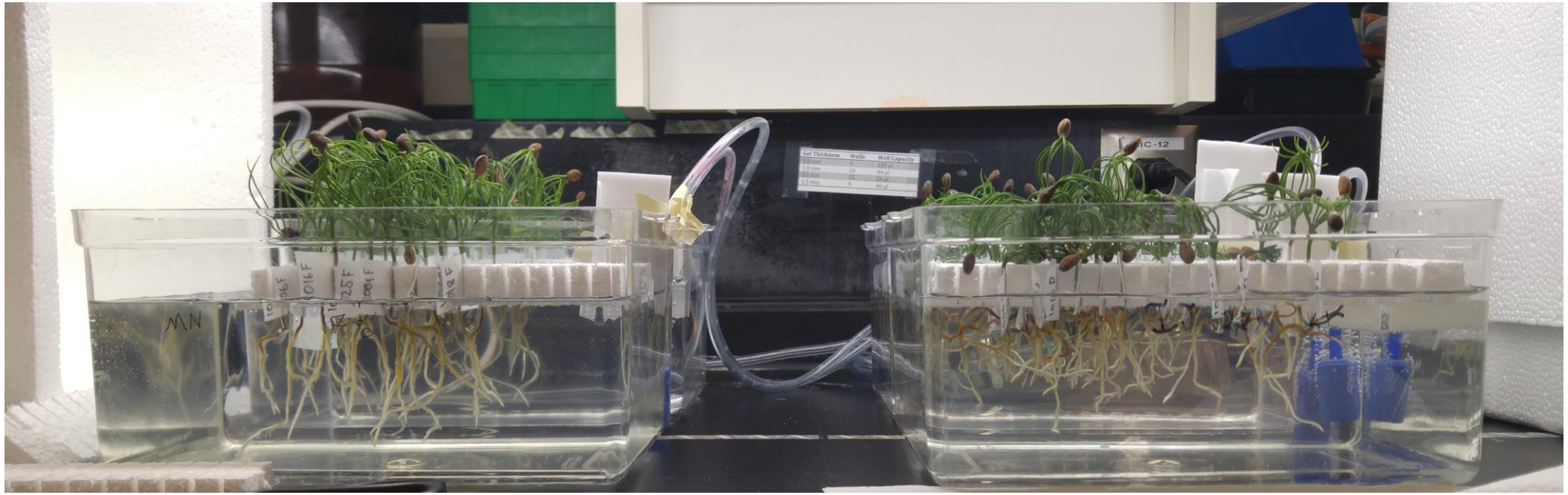
The fastest growing seedlings had lower water use efficiency



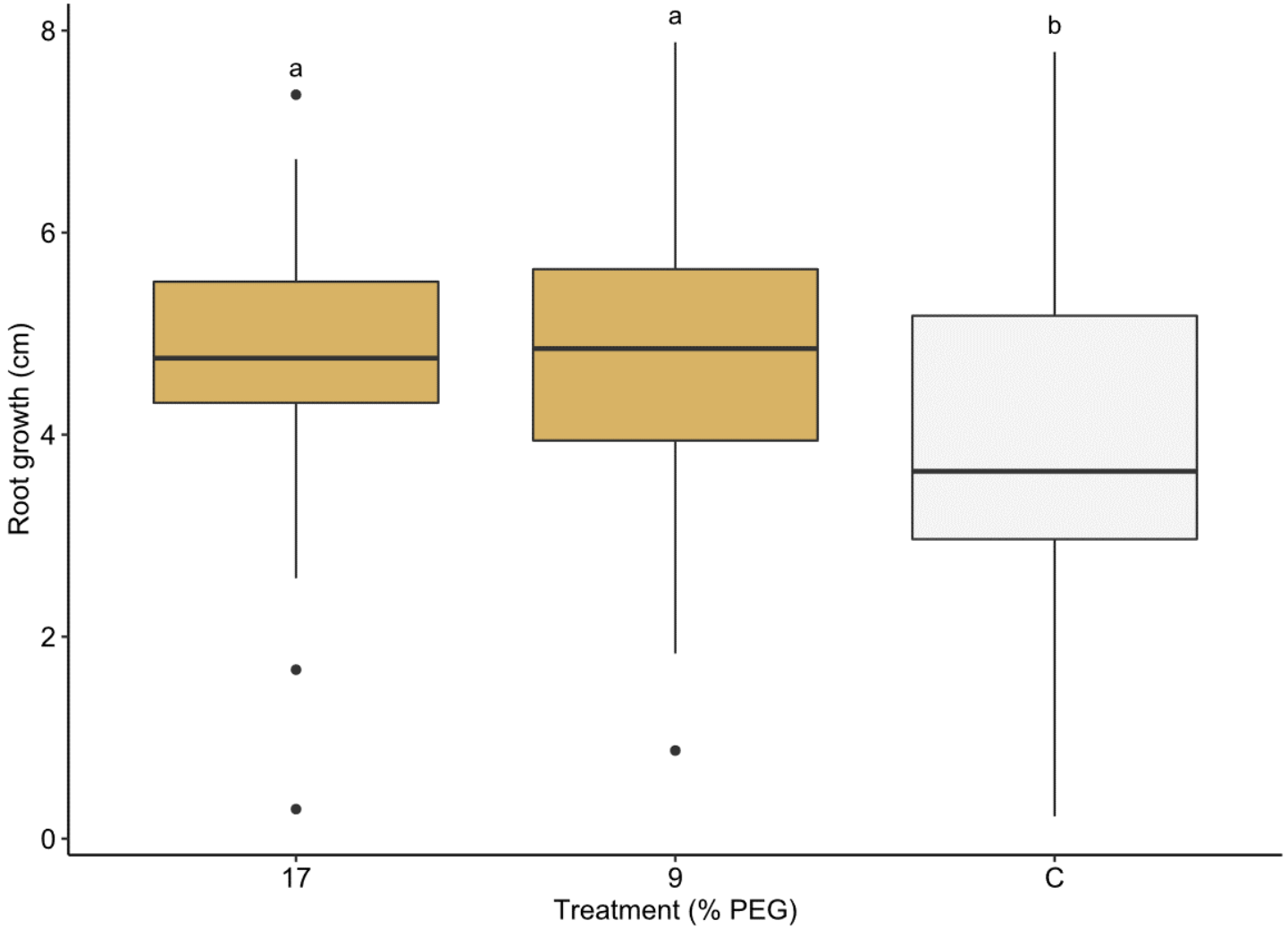
- Conclusion: Successful individuals may be using a drought avoidance strategy, possibly via the root system

Root responses are difficult to access in soil: Polyethylene-glycol (PEG)-induced osmotic stress of hydroponically-grown seedlings.

- Roots were inaccessible in raised beds
- Growing in solutions provides an easy way to measure root growth
- Osmotic stress can be applied by increasing the concentration of PEG
- Measured root length once a week for 2-3 weeks



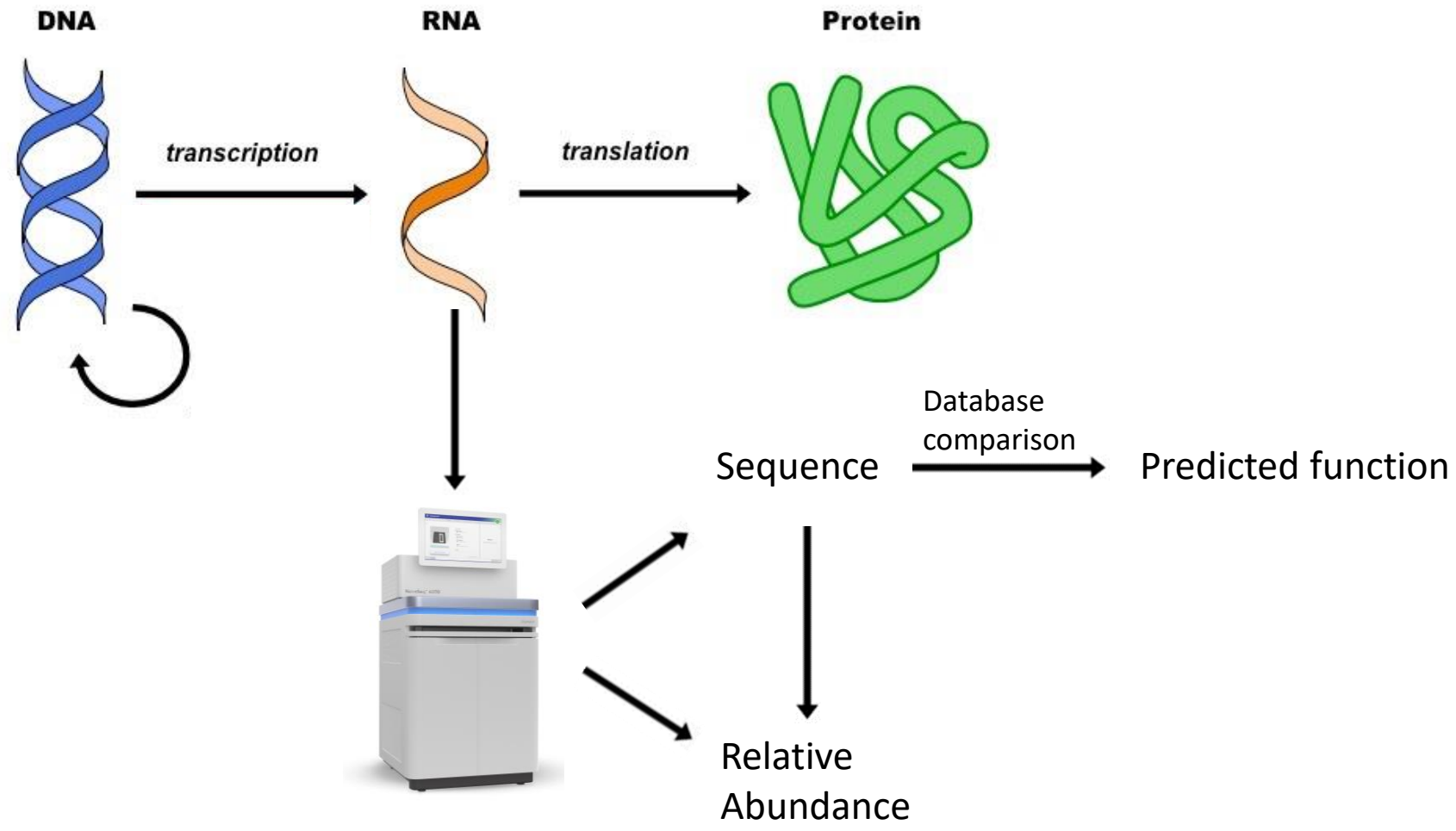
Low to intermediate osmotic stress actually stimulates root growth!



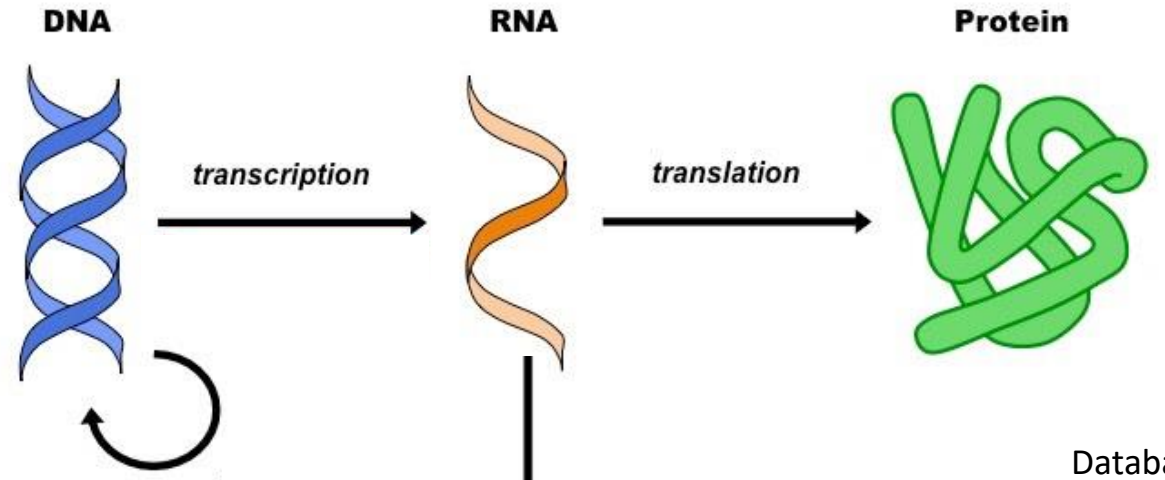
High osmotic stress (22% PEG) inhibits root growth

Family responses differ significantly

Transcriptomics – the study of RNA molecules



First characterization of a drought transcriptome in ponderosa pine

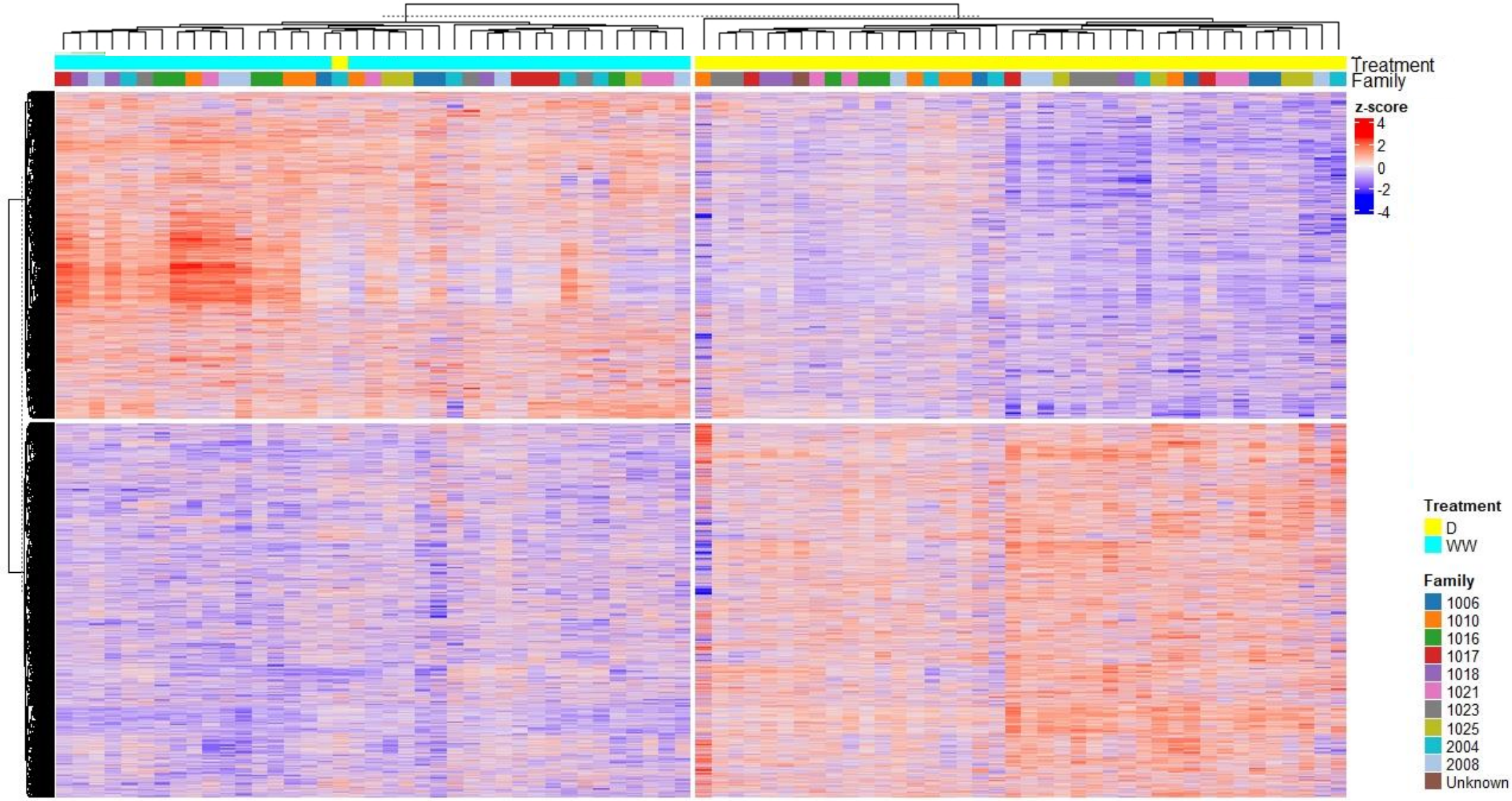


Sequence → Database comparison → Predicted function

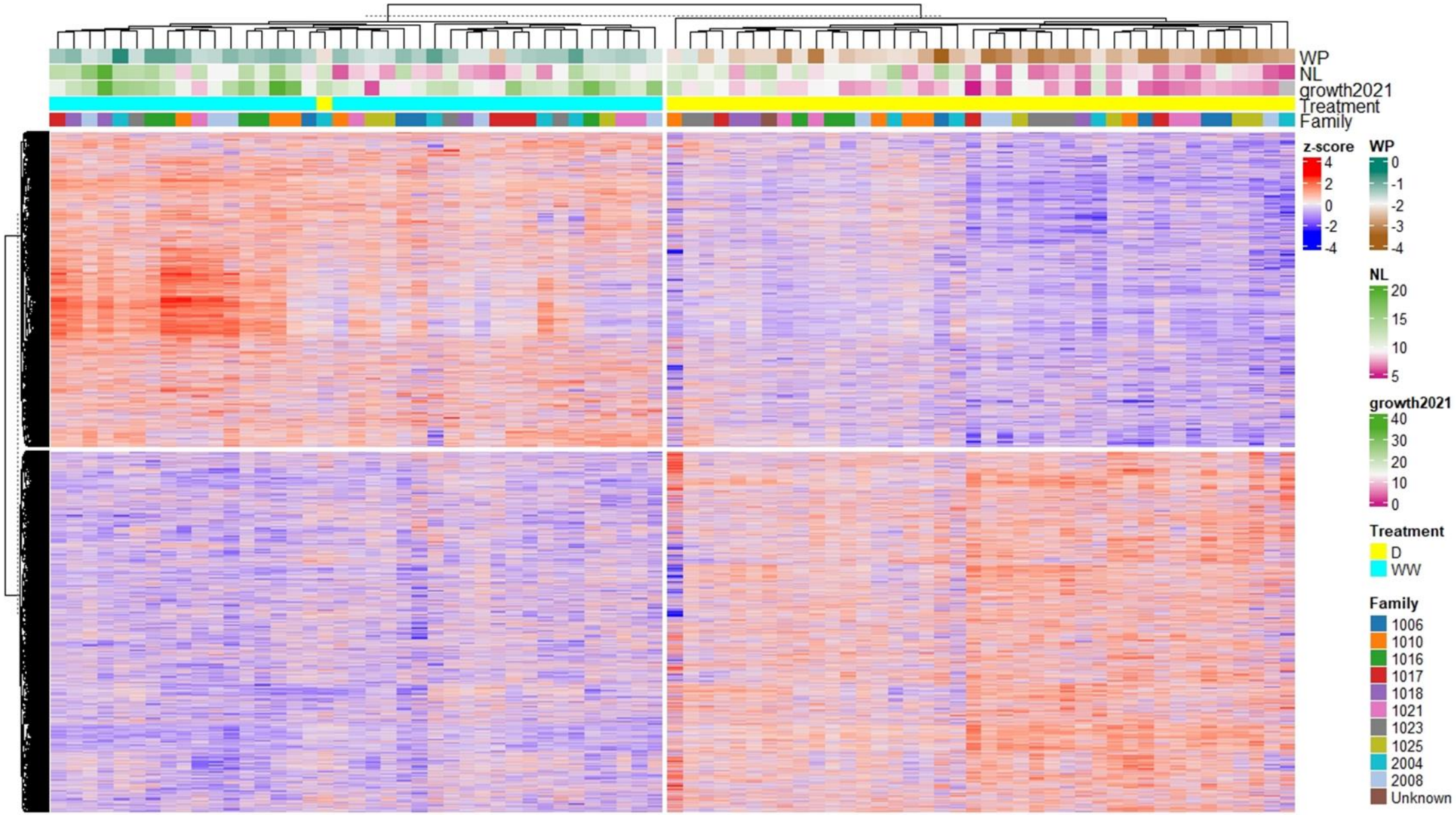
Relative Abundance

Measured from needles of 79 individuals total from the 5 lowest/highest water potential families in late August 2020

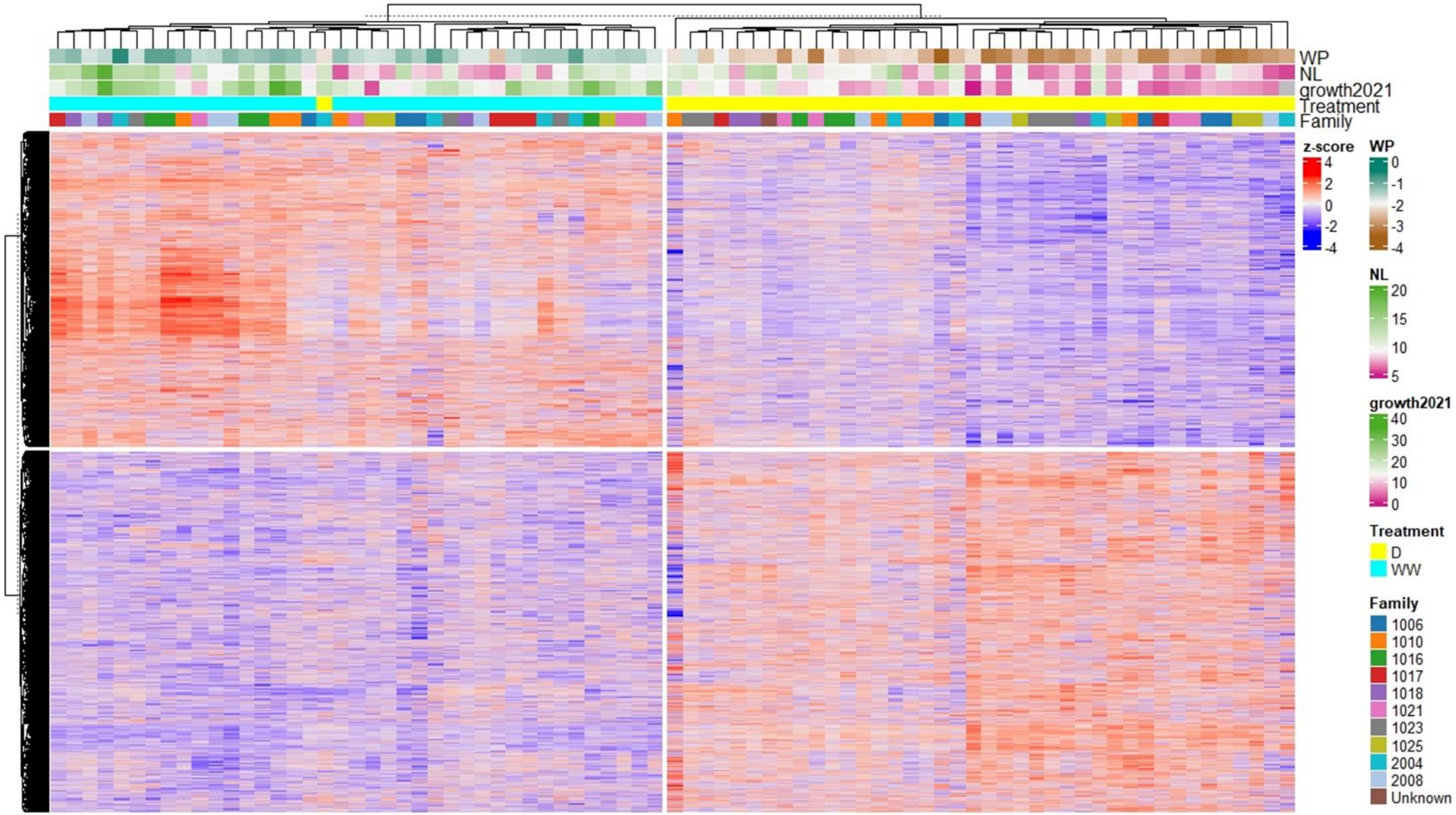
Over 10 thousand genes have drought responsive expression in ponderosa pine needles



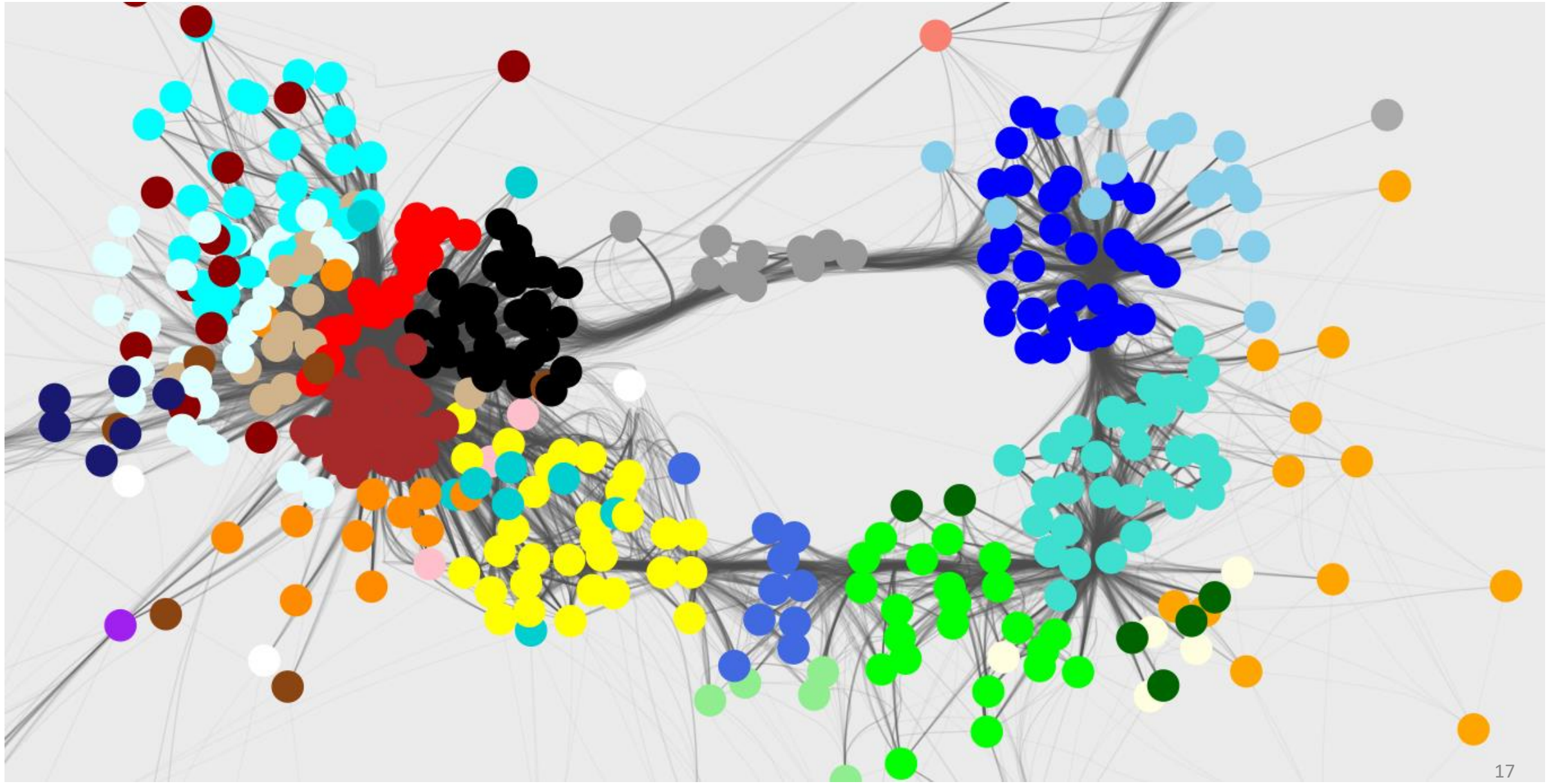
Differential expression in needles is intermediate for some individuals, in agreement with physiological traits



Families 1016 and 1010 lie predominantly within the intermediately stressed group



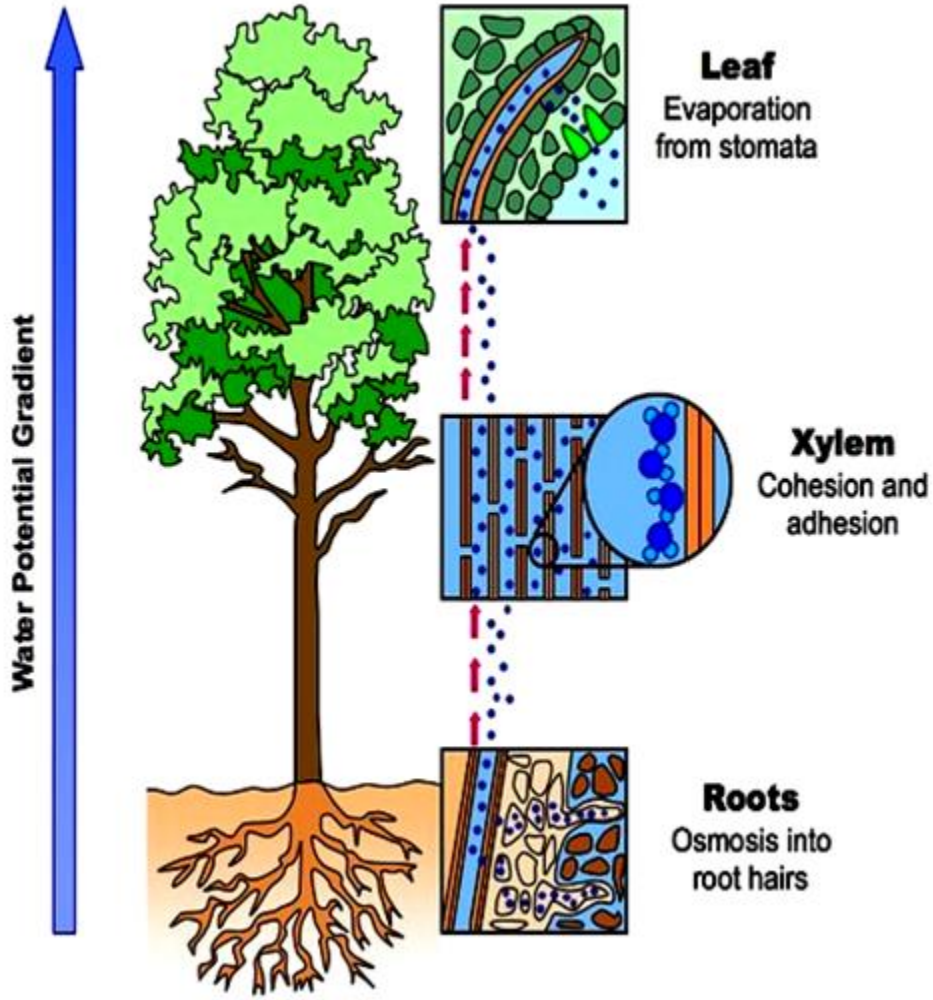
Groups of co-expressed genes positively correlated with growth are highly connected



Highly positively correlated gene groups contain distinct functions

- Photosynthesis
- Stomatal development and closure to balance water loss and gas exchange
- Regulation of xylem development might increase hydraulic conductivity or reduce the risk of embolisms
- Terpenes and other antioxidants may reduce damage from reactive oxygen species during stress

- Future direction: study the root system



Summary

- Traits varied significantly among families from BC's only A-class orchard
- There do not seem to be trade-offs between selecting for height growth and drought tolerance
- The fastest growing individuals may have used a drought avoidance strategy
- We identified genes with potential roles in drought tolerance for further study

Acknowledgements

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