Tree seed germination under stress

Oscar F. Nunez Martinez[1,2], Stefan Heinen[2], Yasmin Bom[2], Katharina Bräutigam[1,2]

[1] Cell and Systems Biology, University of Toronto, Toronto, ON, Canada
[2] Department of Biology, University of Toronto Mississauga, Mississauga, ON, Canada

Background

- Tree seed germination: critical for maintenance of healthy natural forests and the regeneration of disturbed sites
- Climate fluctuations and anthropogenic activities can lead to increased soil salinity
- Seed germination of wind-distributed seeds are likely especially susceptible to environmental conditions.

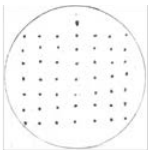
Research Questions

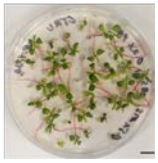
- How is seed germination in native poplars affected by salinity and osmotic effects?
- What are the effects of these treatments on seedling development post germination?
- What are threshold concentrations?
- Is there an interplay between salinity and sex in germination and early seedling development in poplars?

Methods

- **Germination assay & time series**

Populus deltoides seeds were grown under controlled environmental conditions on a series of salt concentrations





Methods

- Germination scoring
- Seedling growth monitoring
- DNA extraction
- PCR-based sex determination
- Weight determination

Results

- Germination and early seedling development are affected differently by different stressors.

Fig 1: Seeds from mature *P. deltoides* were obtained and used to study germination and post-germination processes under different levels of salinity.

- Different salt and osmolyte treatments have concentration-dependent but distinct effects on seed germination, seedling development and survival.

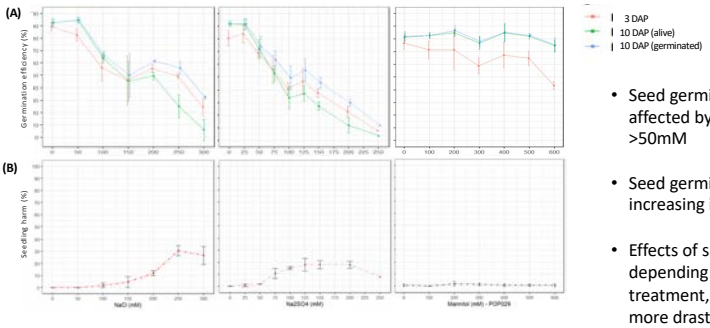


Fig 2: Germination efficiency and damage of *P. deltoides* seeds under various salt and osmolyte concentrations. **(A)** Total germination three and then days after plating (DAP) is given in red and blue, respectively. As high salt concentrations can result in seedling lethality, the percentage of living seedlings at 10 DAP was also recorded (green). **(B)** Seedling lethality at various salt and osmolyte concentrations recorded at 10 DAP. Percent harm corresponds to the number of dead seedlings relative to the total number of germinated seeds.

- Seed germination was clearly affected by salt concentrations >50mM
- Seed germination declined with increasing ion concentrations
- Effects of salinity differed depending on the nature of the salt treatment, with Na_2SO_4 causing more drastic effects.
- Osmotic effects alone delayed seed germination but did not affect survival ("no harm").

- Seedling weight remains largely unaffected by low and moderate salt and osmolyte concentrations.

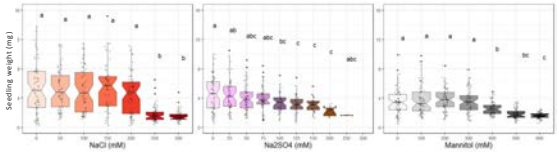


Fig 3: Weight distribution of living *P. deltoides* seedlings at 10 DAP depending on salt and osmolyte concentrations. Significant differences between treatments (P<0.05) are denoted by lower case letters.

- Lower ion and osmolyte concentrations had little effect on seedling weight.
- Accumulation of seedling biomass was, however, affected at higher concentrations.

Results (cntd)

- The sex can be determined at seedling stage.

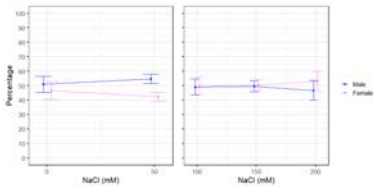


Fig 4: Percentage of male (blue) and female (pink) seedlings that germinated at various salt concentrations.

- The sex-ratio of germinated seedlings is largely unaffected by salt

Conclusions

- Little was known about effect of salinity on seed germination in several trees native to Canada [1,2]
- *P. deltoides* responds to salinity with delayed seed germination and reduced seedling growth at concentrations > 50mM (~ saline soils), indicating moderate tolerance [1,2].
- Variable effects of salinity on seed germination and seedling performance were observed, depending on the type of salinity and ions involved.
- Osmotic effects can be separated from ion toxicity. They can delay seed germination but did not induce lethal effects in our assays.
- Sex-typing can be performed successfully at the seedling stage.
- Sex of the seedlings has no influence on survival, which may differ depending on species & plant age[3].

References

1. Zhang et al. 2019. Transcriptomic analysis of seed germination under salt stress in two desert sister species (*Populus euphratica* and *P. pruinosa*). *Front Genet 10*, 1–16.
2. Zhang et al., 2004. From laboratory to field. Using information from Arabidopsis to engineer salt, cold, and drought tolerance in crops. *Plant Physiol 135*(2), 615-621.
3. Li et al., 2013. Sex-specific responses of *Populus yunnanensis* exposed to elevated CO_2 and salinity. *Physiol Plant* 147(4):477-88.

Acknowledgement

ON has been supported by a Mitacs RA. This research is generously funded by competitive grants awarded to KB from the Natural Science and Engineering Research Council, the Canada Foundation for Innovation, and the University of Toronto. The authors like to acknowledge all lab members for help with seed preparation.