Characterizing Urban Plant Tolerance to Salt

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Background

Human activities heavily alter the environments in which plants and animals live – and these effects are highly evident when comparing cities to surrounding rural areas (Galpaz et. al, 2010). An important question to ask is how plant species have responded to these human caused environmental changes and in particular whether they have adapted to these new environments. One of the components defining an urban environment in cities with high snowfall is the practice of using salt (i.e. NaCl) de-icers. In the Twin Cities an average of 230,000 tons of salt are used each winter (Sander et.al, 2007).

Have plant populations growing in urban environments, with heavy use of salt, adapted higher salinity tolerance than populations in rural environments?

Materials & Methods

Seeds (n=600) were sampled from habitats (urban, rural) in two different states (Minnesota, New York) from two species (Fig 1). Field collected seeds were used in a greenhouse study (Fig 2), where they were grown in a randomized setting in two different salt treatments (25 mM NaCl, 75 mM NaCl) and control.

Figure 1: The studied plant species: *L.virginicum* & *B. incana*

***Lepidium virginicum*, self-fertilizing annual**

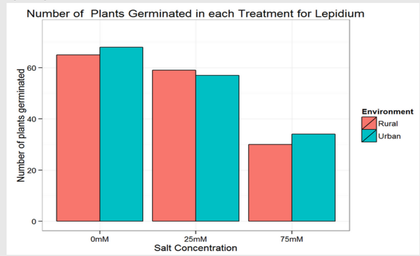
***Berteroa incana*, outcrossing perennial**

Data collected include date of germination, rosette diameter and number of leaves. The data were analyzed by an analysis of variance with species and sampling locations as main effects using R. Pairwise comparison was performed for each pair of treatment in both species.

Figure 2: The randomized greenhouse setting with two salt treatments (25mM NaCl = pink, 75mM NaCl = blue) and control (0mM NaCL = yellow)

Results & Discussion

- **Salt stress has a detrimental effect on germination**- Overall, both salt treatments had negative effects on the proportion of plants that germinated (less seeds germinated compared to control), however the germination proportions did not differ between urban and rural populations (Fig 3).



- *Figure 3*: Number of seeds (*L. virginicum*) that germinated out of total 75 in each treatment (0mM, 25mM and 75mM NaCl) for each population (urban and rural). Least seeds (avg n=32) germinated in the highest salt treatment (75mM), compared to control (avg. n=67). There was no significant difference between the proportions of viable plants in the urban and rural populations. Similar results were obtained for *B. incana*.

Salt has a detrimental effect on fitness- in bot urban and rural populations control seeds germinated significantly earlier and were on average larger, with more leaves when compared to each of the salt treatments. Figure 4 shows the rosette diameter differences in *B. incana*. Similar results were obtained in both plant species.

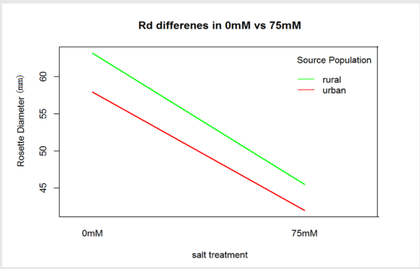


Figure 4: Rosette diameter of B. incana in no salt treatment versus 75mM salt treatment. Rural plants are represented by the green line and urban plants by red line. There was no difference between these populations. Plants subjected to salt stress were on average 2 cm smaller compared to control (p=0.0005).

Urban plants respond differently to salt stress than rural- comparing control treatment to 25mM salt solution treatment, seed collected from urban sites in New York germinated significantly earlier than seeds form rural sites in New York (p=0.029) and they also had bigger rosette diameter (p=0.007, Fig 5) and higher leaf count (p=0.017). While the urban plants from New York had greater overall fitness than rural New York plants, there was no significant difference between urban and rural populations of Minnesota.

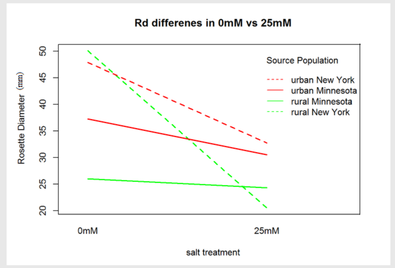


Figure 5: Rosette diameter of L.virginicum in no salt treatment versus 25mM salt treatment. Rural plants subjected to salt stress were on average smaller compared to urban stressed (p=0.007).

Urban plants respond differently to salt stress than rural- When comparing control treatment to 75mM salt solution treatment, seeds from Minnesota that were collected in urban sites started germinating significantly earlier (6 days on average, p=0.057, Fig 6) than seeds from rural sites in MN and they also had on average larger rosette diameter (p=0.01). Interestingly, there was no difference between urban and rural populations in New York.

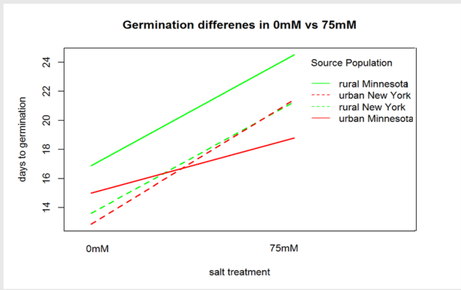


Figure 6: Time (in days) from planting to germination of the seeds of *L.virginicum* in no salt treatment versus 75mM salt treatment. The plants from urban populations in Minnesota germinated on average 6 days earlier (p=0.057) than the rural Minnesota plants. There was no significant difference between the urban and rural populations in New York.

-No significant differences were observed between the urban and rural *B. incana* plants in response to either salt treatment.

Conclusion

- The results from this study suggest that exposure to salt stress generally reduces fitness in all studied plants (*L.virginicum & B.incana*) and populations when compared to plants grown under control conditions.
- Plants were smaller and had reduced numbers of leaves in both species. Additionally, salt stress has detrimental effect on proportions of seeds that germinate and causes delay in germination in comparison to control plants.
- The results also suggest that urban plants under certain conditions respond differently to salt stress than rural populations. Plant collected from urban sites in New York had higher overall fitness than the corresponding rural plants in 25mM salt treatment when compared to control. Interestingly, in 75mM salt treatment, difference between rural and urban populations could be seen in plants collected in Minnesota, but not New York. This contradictory nature of the results might reflect differences in salt de-icer usage in Minnesota versus New York and further research is required.
- In conclusion, salt stress is an important environmental factor that limits the germination of seeds and plant fitness. Continuous exposure to increased salt levels, such as in cities where the use of road salt is common, might lead to heritable adaptations in plants growing in this environment.

Works Cited

- Galpaz N, Reymond M (2010) Natural Variation in Arabidopsis thaliana Revealed a Genetic Network Controlling Germination Under Salt Stress. PLoSONE 5(12): e15198. doi:10.1371/journal.pone.0015198
- Sander A; Novotny E; Mohseni; Stefan H; (2007) Inventory of Road Salt Use in the Minneapolis/St.Paul Metropolitan Area. *Minnesota Department of Transportation*, Local Roads Research Board (LRRB)

- The project was performed under Tiffin Lab, University of Minnesota