Does ambient salinity in SUNY Oswego winter runoff impact Brassica rapa growth?

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ABSTRACT

Road salt runoff can be detrimental to flora growth, hindering normative physiological and biochemical processes within plants. We utilized water samples that approximated the typical salinity levels found in SUNY Oswego runoff to test *Brassica rapa* germination and growth responses by measuring plant height, leaf count, and cot count within 6 weeks. The conditions we set were 11 ppt (road salts), 2 ppt (sidewalk salts) and 0 ppt (grass / control salt levels); through our weekly sampling methods we noticed 11 ppt salinity caused withering within our plants, 2 ppt salinity reduced biomass growth, while control (0 ppt) plants thrived in non-saline induced conditions. Which confirmed our original hypothesis that high salinity stress negatively impacts *Brassica rapa* overall growth when exposed to increasing saline conditions found on SUNY Oswego's campus.

INTRODUCTION

Effects of road salt on plant growth

• Increasing winter applications of road salt negatively impacts roadside vegetation (Willmert et al. 2018).

• Plant organs and growth stages of varying species may respond differently to salinity (Schmidhalter et al. 2004).

• Long-term winter application of road salt increases annual mean concentrations of Cl in rivers and lakes, due to Cl entering groundwater (Szklarek et al. 2021).

• Chloride exposure decreases the biodiversity of aquatic animals and plants (Szklarek et al. 2021).

• Salt applied to paved surfaces in urban watersheds around Lake Ontario has significant and cumulative effects on groundwater quality (Meriano et al. 2009).

• Although some plants are *halophytes,* in which they're capable of being salt-tolerant and can help bolster plant biomass, most crop species are *nonhalophytes* including *Brassica rapa* (Schmidhalter et al. 2004).

• Salt deposition reduced plant density along roadsides (Willmert et al. 2018).

• Cl concentrations in Lake Ontario watersheds are projected to continue to rise each year due to an increased application of road salt in urbanized regions (Mackie et al. 2022).

Figure 1. Susan collecting road samples (11 ppt) used to replicate salt treatments (Early February)

Figure 2. Control Brassica Rapa Growth (3rd week / Late March)

Figure 3. Road *Brassica rapa* conditions resulted in withering and discoloration in plants (5th week / Late March)

Objective:

- Evaluate how salinity in SUNY Oswego winter runoff affects Brassica rapa germination and biomass.
- Simulate real-world conditions using water samples with typical runoff salinity levels.
- Identify the salinity threshold at which Brassica plants show reduced growth or stress.
- Contribute to understanding the environmental impact of road salt on plant growth.

Hypothesis:

When exposing *Brassica rapa* to salinity levels based upon averaged estimates found on Oswego's roads and sidewalks, overall biomass may effectively be reduced as salinity increases.

METHODS

• *Brassica rapa (Brassicaceae, Field mustard, Polycot genotype)*

• Salinity sampling site: SUNY Oswego Campus, Oswego County, NY

• 20 ppt salinity samples within snow collected across SUNY Oswego's campus (Figure 1) and averaged the condition samples to 11 ppt (road conditions) and 2 ppt (sidewalk conditions).

• 8 x 3 pots sample size (n=24) | 4 *Brassica* seeds within each pot (n=96)

• *Brassica* seeds planted in high salinity road conditions (11 ppt), and moderate salinity sidewalk conditions (2 ppt)

• 20 mL of conditions (road, sidewalk) allocated to each pot weekly, on the 2nd week dosage was increased to 50 mL to emulate oversalting

• *Brassica* leaf , cotyledon count & height were measured weekly over 35 days

• *Brassica* final biomass harvested at the 35th day of sample period (March 27th).

• *Brassica rapa* growth responses assessed using GraphPad Prism (La Jolla, CA)

RESULTS

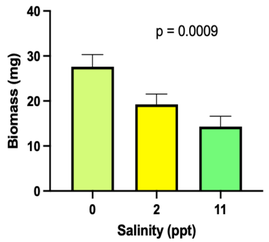

Figure 4: The control group showed significantly higher biomass compared to the 2 ppt and 11 ppt treatments (p = 0.0009, ANOVA) Error bars are standard error of the mean.

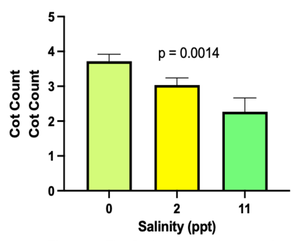

Figure 5: The final cot count decreased signifiacntly under the rising salinity treatments of 2 ppt and 11 ppt (p = 0.0014, ANOVA). Error bars are standard error of the mean.

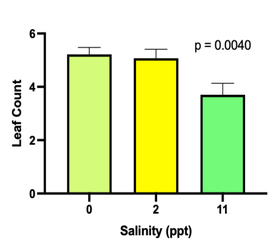

Figure 6: Final leaf count showed no difference between control and 2 ppt treatments, but a significant decrease at 11 ppt. (p = 0.0040, ANOVA). Error bars are standard error of the mean.

- Salinity treatments significantly impaired *Brassica rapa* growth across all measured parameters during the 5-week experiment. Plant height (Figure 7) declined ~1.5x with increasing salinity (control > 2 ppt > 11 ppt < 0.0001), time ($p < 0.0001$), and their interaction ($p = 0.0065$, two-way ANOVA).
- Similarly, cotyledon counts decrease 1.3x and leaf counts decrease 1.4x under elevated salinity (Figures 5–6), with the 11 ppt treatment showing the most severe reductions (cotyledon count: $p = 0.001$; leaf count: $p = 0.004$).
- Final biomass (Figure 4) was significantly lower, decreasing 1.4x in high-salinity groups ($p = 0.0009$), aligning with observed physiological stress symptoms, including leaf discoloration (healthy green to yellow/light purple) and leaves wilting.
- These findings support the hypothesis that salinity stress derived from road salt-associated salinity levels, particularly at 11 ppt, critically reduce *B. rapa* biomass and its developmental success.

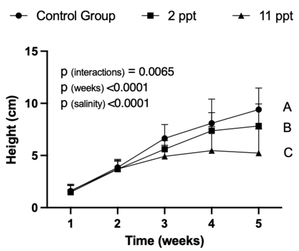

Figure 7: *Brassica's* plant height growth declined with increasing salinity (control > 2ppt > 11 ppt). Two-way ANOVA: significant effect of salinity (p < 0.0001), time (p < 0.0001), and interaction (p - 0.0065). Error bars are standard error of the mean. Capital letters indicate significant difference between the groups.

DISCUSSION

Brassica rapa Physiological response to Salt Conditions (NaCl)

(Figure 1) Collecting SUNY Oswego snow samples resulted in average salt conditions on campus roads (11 ppt) and sidewalks (2 ppt), we assessed whether salt applications were adversely affecting plant growth (Willmert et al) concluded soil degradation through deposition of road salt can impact plant survival rates and distribution.

Our control treatment *Brassica*'s growth remained unimpeded (Figure 2) , thriving in normative conditions, offering us a comparative analysis for our plants final Biomass (Figure 4) , weekly cotyledon and leaf count; physical features of a plant's growth are impeded by physiological and hormonal components of salt induced stress (Pavlović, I. et al).

Physical features of our road treatment group (Figure 3) showcased withering and discoloration of both leaves and stem height (Figure 7); which are traits observable in *nonhalophytes* that cannot utilize high salt conditions to aid germination and photosynthetic rates (Schmidhalter, U. et al. 2004).

(Ahmed et al. 2012) found that when exposed to extreme saline conditions *Brassica rapa* biomass, shoot and root lengths were found to significantly decrease in size, which confirms our reflected final biomass (Figure 4) as we saw a significant reduction in our 11ppt treatment (road conditions).

Vegetative yield performance within *Brassica* such as leaf gas exchange, cotyledon growth and count (Figure 5) within the Polycot genotype are biometrics shown to be impacted by salt conditions (Shahzad, B. et al.). Weekly conditions of high salinity resulted in final cot count decreasing as time persisted.

Observable height (Figure 7) within the 5-week survey showed inhibited stunted growth in our 2 ppt and 11 ppt treatment groups, (Jamil et al) found germination time increased as levels of salinity increased, utilizing three species of *Brassica;* resulting in shoot / root weight, leaf area and number of leaves being severely affected.

Due to the geographic location of SUNY Oswego's campus, much of the winter runoff (Figure 1) can directly degrade plant biodiversity and germination rates (Figure 7) within Lake Ontario due to high levels of Chloride & salt impeding plant growth. (Szklarek, S. et al. 2021)

Current winter applications of Sodium Chloride within Northeastern urbanized regions such as SUNY Oswego's campus are projected to raise chlorine levels within Lake Ontario (Mackie et al. 2022) and result in plants not being capable of photosynthesizing optimally (Figure 6) with reduced leaves.

Similarly in a study conducted within the Adirondack Watershed Institute Report, roadside soils with oversalted conditions (11 ppt) (SUNY Oswego road conditions) increased surface runoff, soil degradation and sedimentation of rivers and streams (Kelting, D. L. et al)

Urban runoff with high levels of Cl has the potential to transport high pollutants to groundwater reservoirs such as Lake Ontario and increases abiotic stressors onto both wetland and aquatic plant development (Figure 4) reduced habitat and physiological viability (Meriano et al. 2009)

CONCLUSION

- Evaluating how salinity in SUNY Oswego winter runoffs impacts plant growth can directly improve our campus plants and biodiversity.
- Annual winter monitoring of ambient salt conditions put onto SUNY Oswego's roads and sidewalks would directly allow us to monitor how much winter runoff is making its way to Lake Ontario and increasing Cl levels.
- Regulated salinity rates can define what constitutes a healthy level of ambient salt on our campus.

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