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NZ Spinach Productivity under Salt Stress in different Pedoclimatic Conditions

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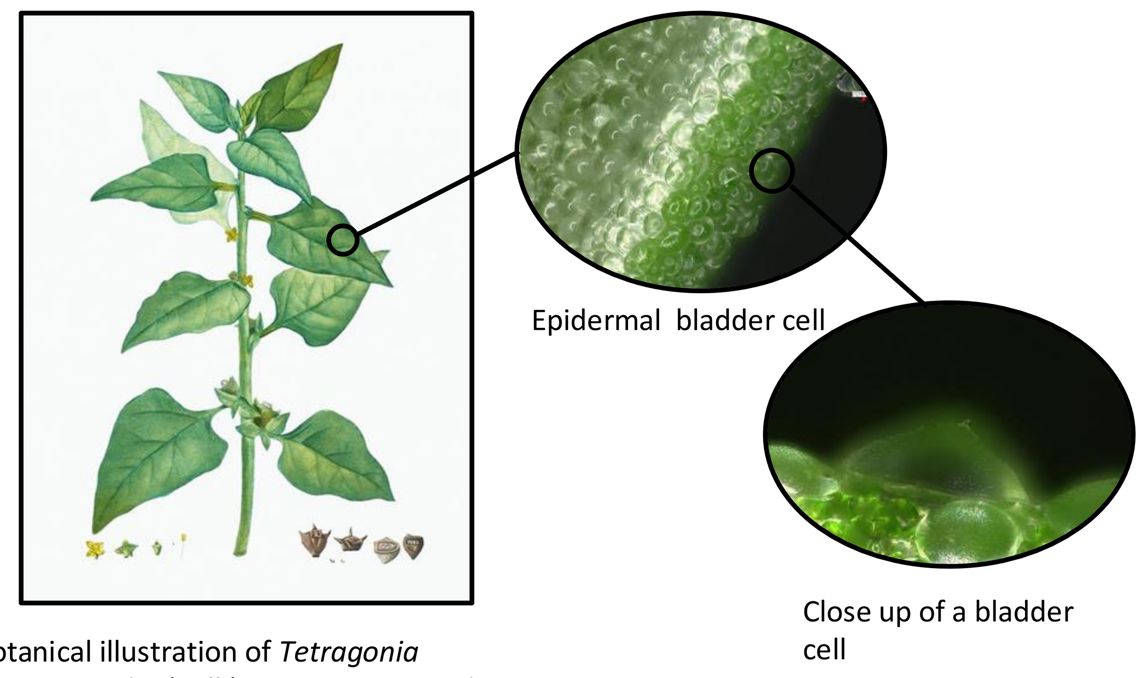
Introduction

Salinity affects about 1100 million hectares of land, primarily due to coastal proximity or improper irrigation. Tetragonia tetragonioides, commonly known as New Zealand spinach, is a halophyte that shows potential to be used a a crop in such environments due to its salinity tolerance.

A notable feature of T. tetragonioides is the "epidermal bladder cell" or "salt bladder," which serves as repository for salt, effectively diverting the harmful substance away from the leaf's primary tissues. This adaptation enables the plant to sustain essential metabolic activities like photosynthesis, which would typically be impeded by salt exposure. These cells can expand to accommodate increasing amounts of accumulated salt as the plant matures.



Botanical illustration of *Tetragonia tetragonioides* (Pall.) Kuntze. Histoire des Plantes Grasses (1799) by Pierre-Joseph Redouté.

Figure 1: Epidermal salt bladders of T. tetragonioides

Objective

We studied how soil, climate, and salinity affect T. tetragonioides' growth and productivity, alongside investigating ion accumulation in plant tissues to understand its nutritional value and salt stress adaptations.

Methods

Greenhouse pot trials were conducted at the University of Florence in autumn 2022 and spring 2023 growing T. tetragonioides in two different soils (i.e., sandy and clay soil) with increasing salinity levels in the irrigation solution: Control (0 mM NaCl), medium salinity (100 mM NaCl), high salinity (200 mM NaCl). Soil electrical conductivity, water requirements and plant physiological parameters were monitored over six weeks, after which the plant growth, the yield as well as the leaf mineral element concentrations were determined.

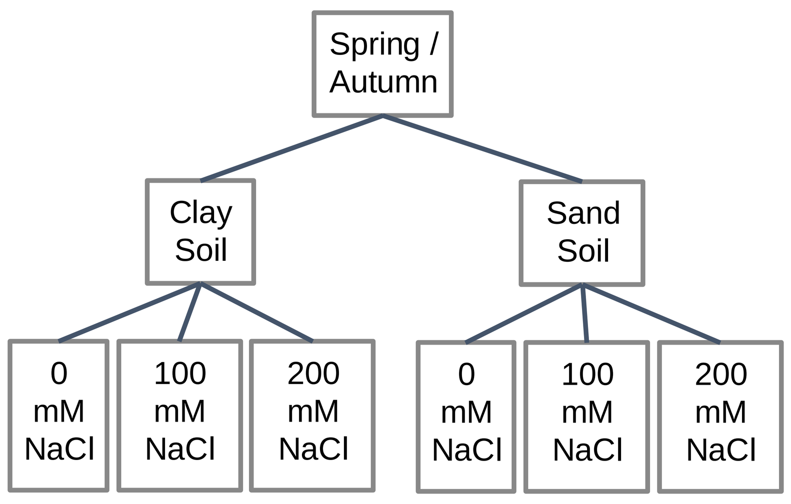


Figure 2: Experimental design

Figure 3: Experimental set-up

Results and Discussion

The results on plants growth indicated significant interactions between the independent variables: season, soil type and salinity of irrigation water. The yield of T. tetragonioides was higher when grown in spring compared to autumn and with sandy soil compared to the clay soil. Yield and leaf area cover exhibited a linear relationship, suggesting that leaf area cover shall be preferred over plant height as the phenological attribute that best predicts yield in crop modelling

T. tetragonioides showed an includer behavior, accumulating salt mainly in the leaves. This accumulation was observed both at the plant and at the soil level, where the electrical conductivity of soil samples collected in the rhizosphere zone was lower compared to that collected from soil far from the root zone.

The salt stocking limit of the leaves was found to be of about 80000 ppm Na and was reached at a soil ECe of 10 dS/m; this can be useful information for possible phytodesalinization projects.

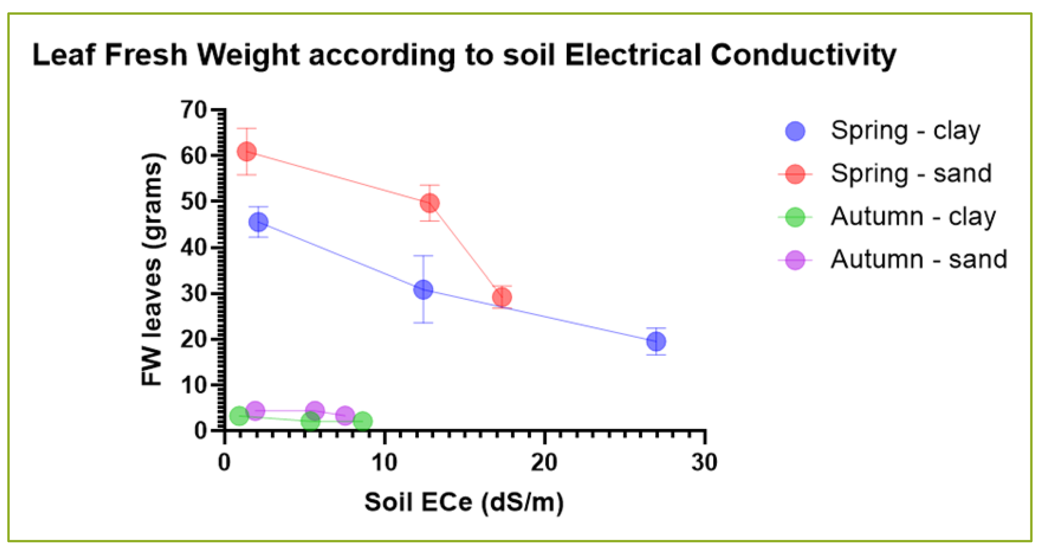


Figure 4: Yield according to ECe

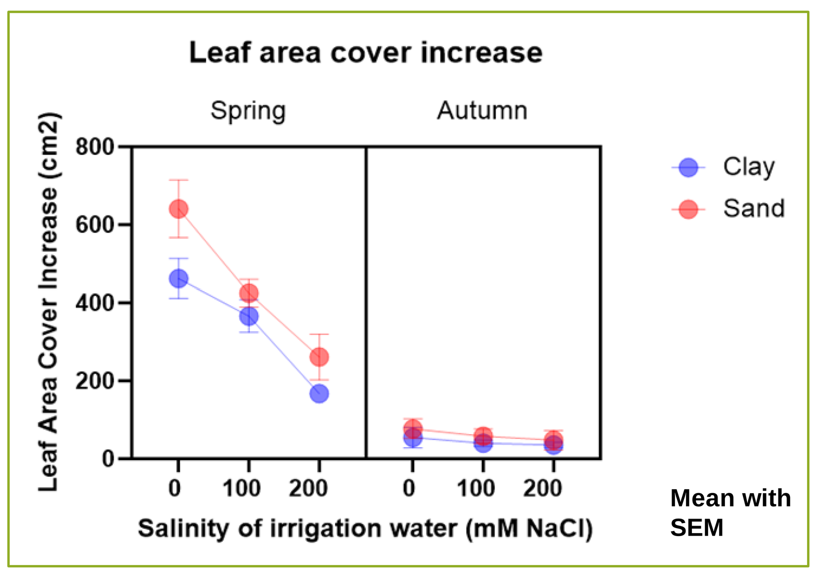


Figure 5: Leaf area cover increase

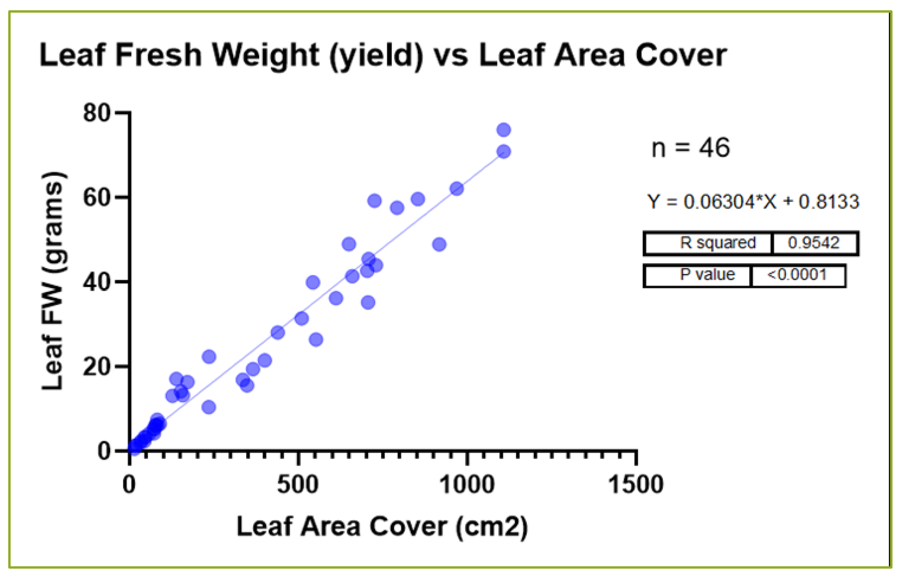
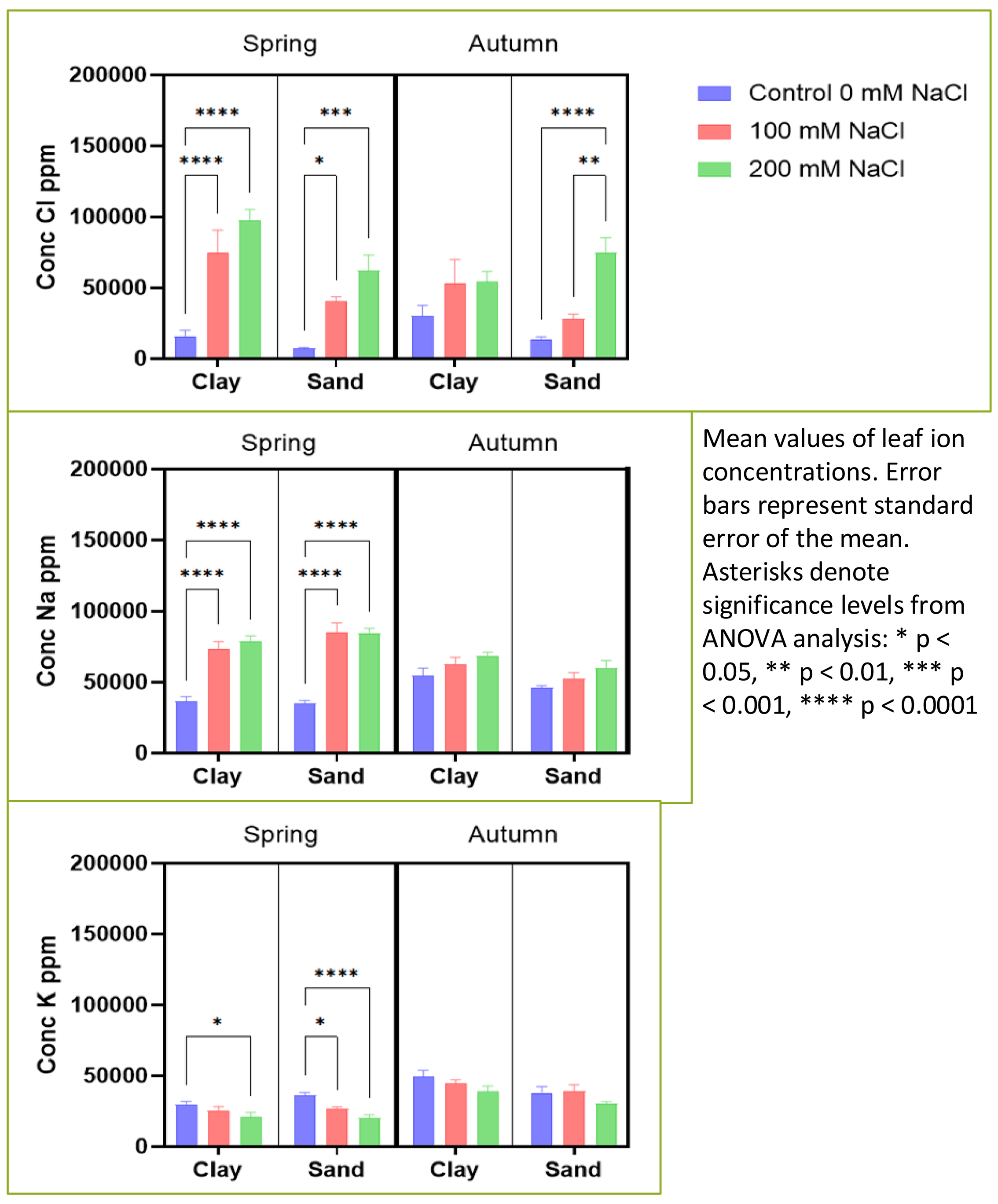
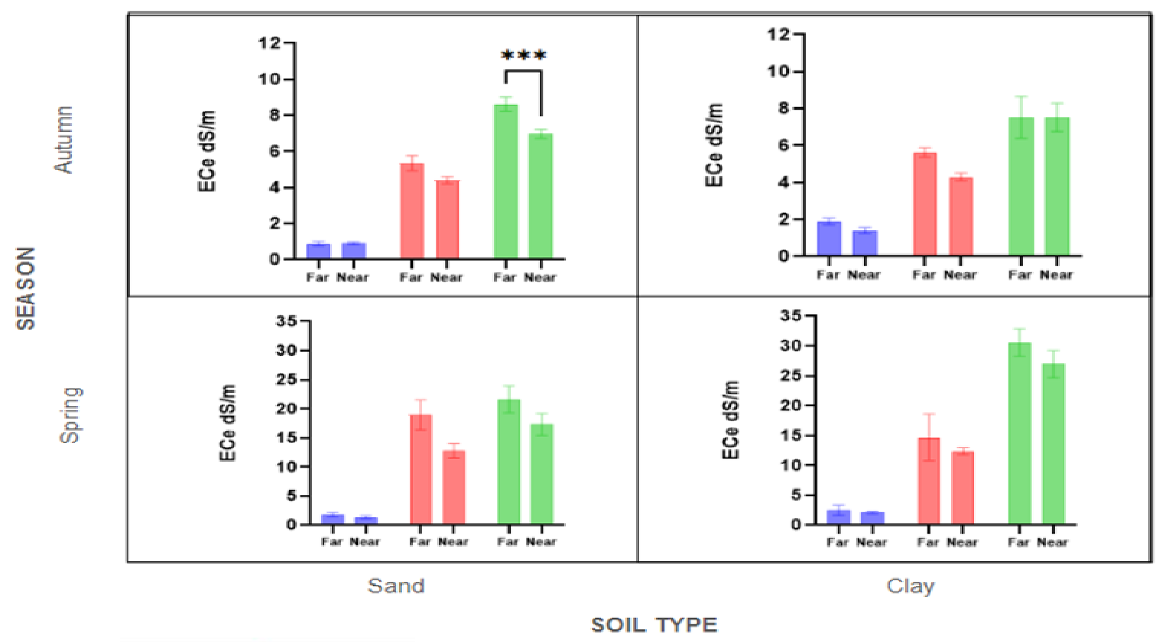


Figure 6: Linear regression yield vs final leaf area cover



Mean values of leaf ion concentrations. Error bars represent standard error of the mean. Asterisks denote significance levels from ANOVA analysis: * p < 0.05, ** p < 0.01, *** p < 0.001, **** p < 0.0001

Figure 7: Leaf ion concentration in leaves



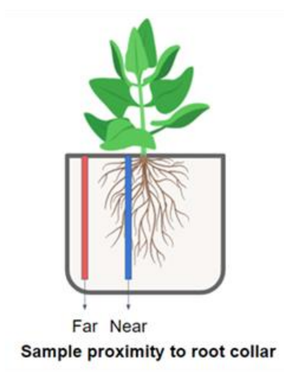


Figure 8: Soil ECe according to proximity to root collar.
Mean values of leaf ion concentrations. Error bars represent standard error of the mean. Asterisks denote significance levels from ANOVA analysis: * p < 0.05, ** p < 0.01, *** p < 0.001, **** p < 0.0001

Conclusions

Ultimately, this study highlights the need to consider season and soil type in designing halophyte cultivation systems. Our findings provide valuable insights into the growth patterns and phytodesalination potential of T. tetragonioides, aiding in crop modeling and agricultural production in salt-affected lands.