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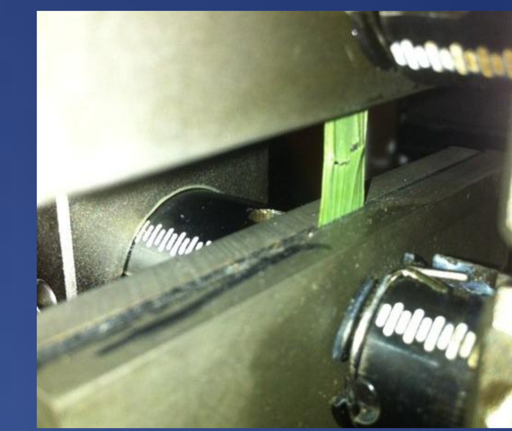

Introduction

The physical strength of a leaf, or leaf tensile strength, involves the amount of force that can be applied to a leaf before causing physical damage or breakage of the leaf. High tensile strength can be beneficial to the survival of a leaf by ensuring resistance to environmental factors and stress. In this study, the correlation between the hydration and the tensile strength of a leaf was examined. Researchers had observed monocot plants and wondered if the more hydrated plants would have greater tensile strength and therefore a greater chance of survival. This experiment was not intended to address the whole question, but to begin to decipher the complexity of the problem. As a model organism, *Elymus Glaucus,* also known as the blue wildrye, was chosen. *E. Glaucus* is a monocot and a perennial herb native to North America and a common grass found in California. Its invasive nature suggests that when under stress, it exhibits characteristics unique to monocots. Procedures and results are presented as a model for comparing the tensile strength of the leaves' hydration status.

Materials and Methods

Samples of leaves from *Elymus Glaucus* were collected from the sample site near the top of the Firestone Steps of Pepperdine University's campus. Ten samples were collected; five of which were immediately placed in a sealed icebox to maintain hydration status and five of which were left exposed to the atmosphere to dry for approximately two hours. Leaves were then individually placed in a Scholander-Hammel Pressure Chamber to measure the leaf water potential. Each of the sample's widths and thicknesses were measured along, on and off of the mid-rib of the leaf. After this data was recorded, the leaves' tensile strength was measured using the Instron. The Instron applied force to the leaf and recorded the force at the point where the tissues were compromised and at the point where the tissues physically broke. An initial slope representing the amount of stress that could be handled by the leaves without breakage, the Young's Modulus, was calculated by the machine. Data was examined in order to draw conclusions about the value of leaf hydration status.

Acknowledgements

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Abstract

Tensile strength and water potential are both factors that are essential to thelife and survival of a plant. Tensile strength is a measure of the amount of force that a plant can undergo before tissue damage and breakage occur. The primary objective of this study was to examine the correlation between tensile strength and leaf hydration status, or water potential. The water potential of leaves of a monocot grass native to North America, *Elymus Glaucus*, commonly known as blue wildrye, was measured using the Scholander-Hammel Pressure Chamber. The tensile strength of hydrated and of dehydrated leaves was measured using an Instron. Results showed that there was no strong correlation between the leaves of *Elymus Glaucus*'s water potential and tensile strength. However, the data showed a pattern that suggested that dehydrated leaves, which have a lower water potential, tend to have a higher tensile strength than that of hydrated leaves.

Results

Data collected in this experiment did not support our hypothesis that *Elymus Glaucus* leaves would have a greater tensile strength when hydrated. Although results contained were not statistically significant, data suggested that dehydrated monocot leaves may actually have a greater tensile strength than they did at hydration. The mean modulus of the five hydrated leaves was 181.257 N/mm^2. The mean modulus of the five dehydrated leaves was much higher, 600.068 N/mm^2. The larger number is greatly due to an outlier in the data. During one dehydrated leaf trial, the Instron slipped and the leaf was reported to have broken at a much higher point than it would have reported otherwise. We see in the graph of tensile stress vs strain in dehydrated leafs the difference of this outlier. Although the outlier may skew the mean, the maximum tensile strain and strain at break for hydrated leaves were 7.64582 N/mm^2 and 7.17617 N/mm^2, respectively. These were much lower than the means for the dehydrated leaves, 12.784 N/mm^2 and 12.684 N/mm^2, respectively. The two tailed p value was 0.074508; results were not significant.

Dehydrated Blade Strength

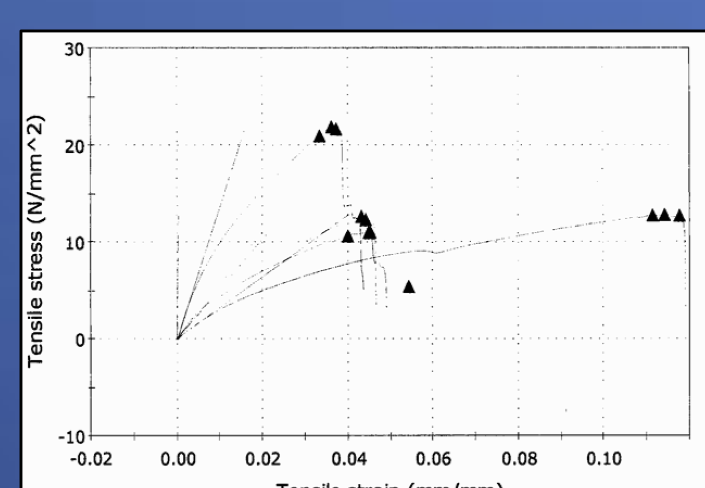

Fig. 1.

Hydrated Blade Strength

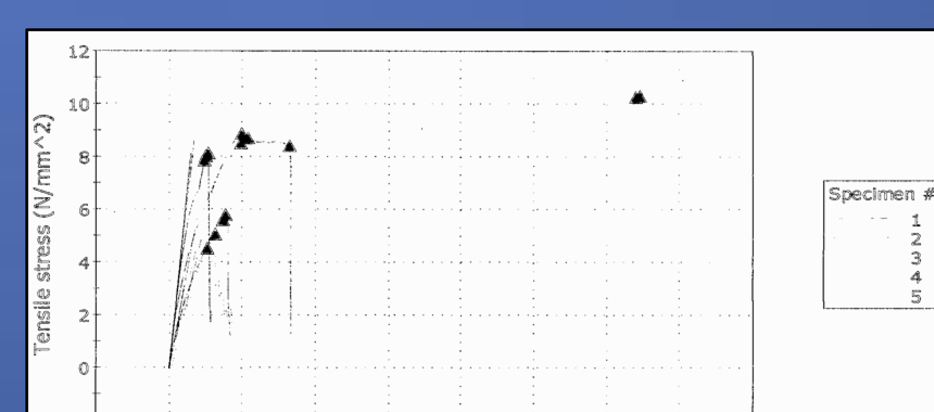

Fig. 2.

Status of *Elymus Glaucus*	Average Pressure (Bars)	Tensile Strain at Maximum (N/mm^2)	Tensile Strain at Break (N/mm^2)	Young's Modulus (automated) (N/mm^2)
Hydrated	-22.8	7.645	7.176	181.257
Dehydrated	-31.4	12.784	12.684	600.068

Table 1.

Table 1. A student t test was run to confirm the distinction between the "hydrated" and "dehydrated" hydration statuses. The Tensile Strain at Maximum describes the maximum amount of force placed upon each leaf before its tissues were comprised. The tensile strain at break describes the amount of force necessary to physically break the leaf. A larger force per unit of area was necessary to break the dehydrated leaf.

Discussion and Conclusions

Although the Instron's flat plates make it ideal for working with leaves, there was experimental error due to plate slippage. In future experiments, using a much larger sample size could help to negate such an error and could also possibly increase significance of the data. Although no definitive conclusions were able to be drawn, the data found was important to the scientific community as well as to the community at large. *E. Glaucus* is commonly used by the United States Soil Conservation Service to rehabilitate vegetation. Knowledge of this plant and the effects of hydration status on its strength is important to understanding its viability in various climates. In choosing where *E. Glaucus* would be of use, the USSCS would benefit to know that a plant in dry conditions might not necessarily be more weak than a plant in dry conditions. The greater tensile strength of dehydrated leaves suggests that the *E. Glaucus* could survive in conditions where water was scarce. More tests must be done in order to understand the full range of the plant's viability; beyond tests examining maximum conditions that the plant could withstand, the relationship between hydration status and tensile strength is complex and its mechanisms should be further examined in future experiments.

Literature Cited

- Balasmo, R.A., C.Vander Willigen, A.M.Bauer, J. Farrant. 2006. Drought Tolerance of Selected *Eragrostis* Species Correlates with Leaf Tensile Properties. Annals of Botany Company 97(6): 985–991.
- Snyder, Leon A, 1950. Morphological Variability and Hybrid Development in Elymus Glaucus. American Journal of Botany 37:628-636.
- Erickson, Vicky J., Nancy L. Mandel, and Frank C. Sorensen. 2004. Landscape Patterns of Phenotypic Variation and Population Structuring in a Selfing Grass, Elymus glaucus (blue wildrye). Can. J. Bot. Vol. 82