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Abstract

Non-native species are regularly introduced into environments in which they replace existing native species and drastically influence the ecological characteristics of the area and the habitat of the living organisms surrounding them. In the botanical field of study, invasive plant species can choke out native species thus making them endangered or extinct. Specifically in the Santa Monica Mountains of Southern California, there are over 300 non-native species of plants, each the source of its own repercussions and having both positive and negative effects on the environment. One specific non-native species, *Carpobrotus edulis* (ice plant) replaces the native *Coreopsis gigante* (giant coreopsis) and grows along the windy, sandy coast near the Santa Monica Mountains, supposedly better anchoring the soil and preventing wind erosion. This study attempted to examine one factor affecting soil retention abilities of plants: root tensile and elastic strength of the lateral roots of giant coreopsis as compared to the fibrous roots of ice plant. Our data showed that ice plant had a significantly stronger initial tensile strain per unit area as well as elastic resistance (stress/strain) despite not having significantly larger roots than those of giant coreopsis.

Introduction

The Santa Monica Mountain range houses a diverse range of plant species highly adapted to the Mediterranean climate. The native chaparral, making up the smallest biome in five isolated location across the globe, have mechanisms for surviving the arid atmosphere and sandy soil. However, the sustainability of the local vegetation has been put to the test with the introduction of hardy groundcover species like *Carpobrotus edulis*. Commonly known as ice plant in the United States, *C. edulis* is an evergreen succulent from South Africa that is wind- and drought-resistant, forming a dense mat of horizontal growth[1]. It has been introduced to many locations worldwide to prevent soil erosion with its fibrous root system, but quickly overruns this purpose and becomes invasive by taking up available resources and changing soil nutrient composition and pH[2]. The California Invasive Plant Council ranks *C. edulis* a "high" threat[1] to local vegetation like *Coreopsis gigante*, a perennial shrub of the *Asteraceae* found only in Southern California within the United States[3]. The initial justification for introduction of ice plant to the western United States was soil retention. Therefore, mechanical root strength of both the native and non-native species *C. edulis* and *C. gigante* was compared using an Instron. It was hypothesized the difference in the MOR (modulus of rupture) and MOE (modulus of elasticity) of both would not be great enough to justify ice plant's introduction and potential choking-out of native species. The assumption was made that tensile strength of individual roots directly correlates to soil-retention ability.

Materials & Methods

Sample fibrous roots of *C. edulis* and lateral roots of *C. gigante* were collected from the sample site located along Malibu Road, Malibu, CA. Roots were checked for no outer cortex breaks, then measured and placed in the Instron. The machine applied stress to the root and calculated an initial slope representing the amount of stress handled by the root without causing damage (Figs. 1, 2). The amount of force a lateral root could stand was compared between the two species.

Acknowledgements

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Data/Results

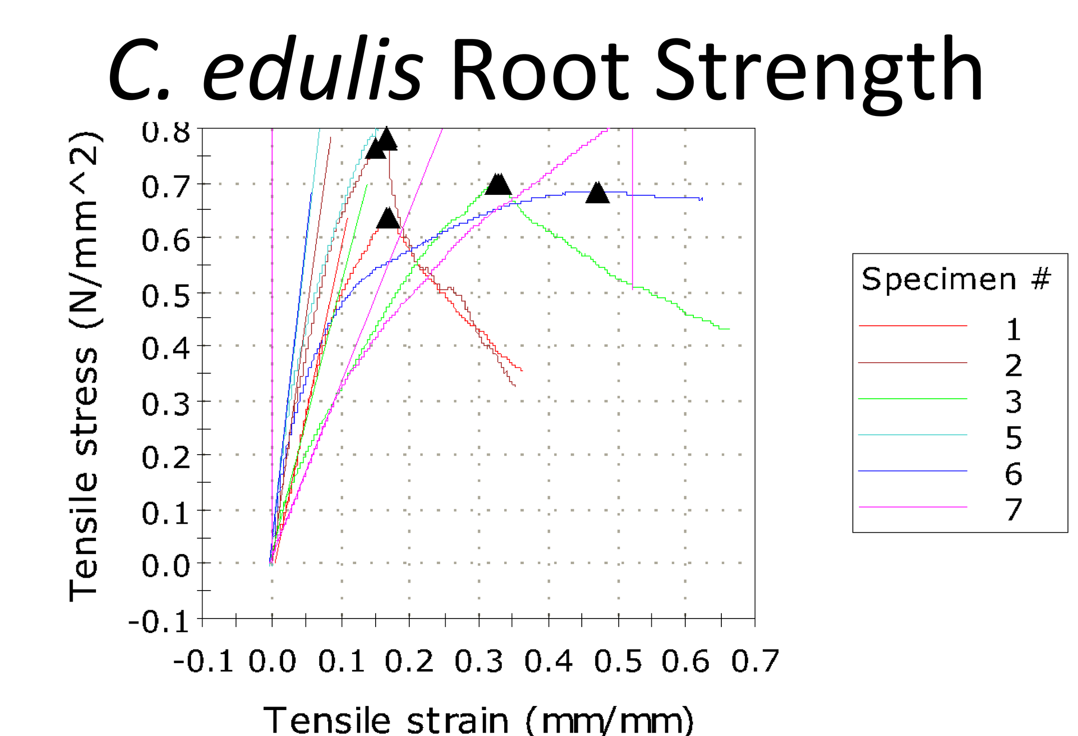

Fig. 1

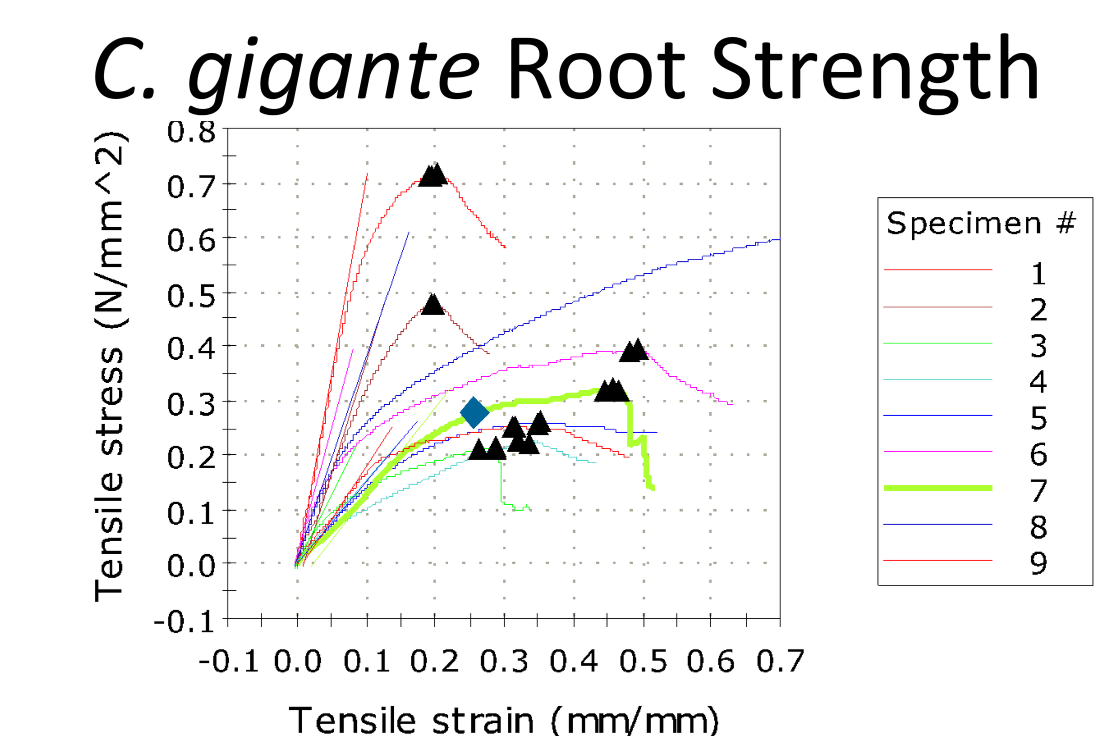

Fig. 2

Taxon	Transverse Area (mm^2)	Modulus (Automatic) (N/mm^2)	Modulus (Automatic Young's) (N/mm^2)
Carpobrotus edulis (Ice plant)	10.586 ± 0.733	*5.583 ± 0.925	**7.736 ± 1.405
Coreopsis gigante (Giant Coreopsis)	9.222 ± 1.503	*2.444 ± 0.568	**3.148 ± 0.629

Table 1. Leaf Morphology and Tensile Strength Properties. *C. edulis* n = 6; *C. gigante* n= 9. Asterisk denotes significant difference ($P < 0.05$).

There was no significant difference between the transverse area of *C. edulis* and *C. gigante* ($P = 0.432$), indicating a similarity in morphology of the species. The modulus (automatic), however, a measure of initial slope to determine the maximum initial strain, showed significant difference between the two species ($P = 0.0184$), with *C. edulis* exhibiting greater initial strain than *C. gigante*. Similarly, a measure of Young's Modulus (stress/strain), determine elastic resistance to an outside force, yielded a significant difference between the native and non-native plant species ($P = 0.0204$), again the elastic strength of *C. edulis* exceeding that of *C. gigante*.

Discussion

Data supported the hypothesis that *C. edulis* root tensile strength would exceed that of *C. gigante*. Thus, on the basis of pure root strength, *C. edulis* has better erosion-preventative properties than the native *C. gigante*. However, the protection of rare native species may supersede the erosion-prevention superiority of an invasive nonnative species.

Although a significant result was obtained, there are multiple avenues for procedural refinement. (1) The Instron is not optimized for roots -- data was collected using a manual modification to an existing program for measuring leaf tensile strength. A program specific to the non-uniform, tapered shape of roots should be written for future experiments. (2) Looking at individual root strength does not account for the overall size of plant root systems, which must be considered when making generalizations about soil erosion prevention efficiency. (3) A difference was observed between the tensile strength of dry and hydrated roots in *C. gigante*. Hydration level must be controlled in comparative studies, however this does provide an interesting direction for future experiments. Hydration has been hypothesized as a factor in plant tissue strength. It has been shown not to hold in stem tissues, but our observations suggest that the hypothesis may hold for roots. (4) Roots broke inconsistently, but when they did break the stele and cortex often broke separately -- indicating that each root has two separate tensile strengths, which may or may not sum to be equivalent to the initial slope recorded in this experiment. Future research could account for this by measuring the tensile strength of the root sections separately or by focusing on the stele tensile strength through the use of tight rubber grommets on the Instron. (As opposed to the flat metal clamps used in this experiment.) It is possible that any difference between stele and cortex tensile strength is related to root contractility. This would add another parameter to the understanding of erosion prevention, as a contractile root might have greater soil stabilizing capabilities than a non-contractile root.

The greater tensile strength of individual *C. edulis* roots suggests that it has greater ability to thrive in erosion-prone areas, indicating that *C. edulis* has a clear advantage over *C. gigante* in its [*C. gigante*] preferred habitat. This may be one of the advantages that has made *C. edulis* such an efficient invasive species. As such, it would be worthwhile to compare the root tensile strength of *C. edulis* growing in regions in which it is invasive to that of *C. edulis* growing in its native environment. There is little knowledge of how invasive plant species behave in their native environments and a comparison between native and invasive *C. edulis* root tensile strengths could shed light on the modifications -- or lack of modifications -- that allow the plant to become invasive in alien environments.

Conclusions

- The morphology, namely, the cross-sectional area of the lateral roots of *Coreopsis gigante* as compared to the fibrous roots of *Carpobrotus edulis,* was not significantly different.
- The initial tensile strain of the *Carpobrotus edulis* roots was significantly greater than that of the *Coreopsis gigante* roots.
- The elastic resistance of the *Carpobrotus edulis* roots was also significantly greater than that of the *Coreopsis gigante* roots.

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