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Root Tensile Strength in a Native and Non-Native Species of the Coastal Chaparral Community

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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 chafe 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 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.

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-preventive 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. Hydraulic loading 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. Further 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 light 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.

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 collected for 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.

Data/Results

![C. edulis Root Strength](image1)
![C. gigante Root Strength](image2)

![Table 1](table1)

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

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Transverse Area (mm²)</th>
<th>Modulus (Automatic) (N/mm²)</th>
<th>Modulus (Automatic Young’s) (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpobrotus edulis</td>
<td>10.586 ± 0.733</td>
<td>*5.583 ± 0.925</td>
<td>**7.736 ± 1.405</td>
</tr>
<tr>
<td>(Ice plant)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coreopsis gigante</td>
<td>9.222 ± 1.503</td>
<td>*2.444 ± 0.568</td>
<td>**3.148 ± 0.629</td>
</tr>
<tr>
<td>(Giant Coreopsis)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Acknowledgements

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Literature Cited