The roots of Blue Carbon: Effects of soil properties on stilt root development in Rhizophora stylosa

Anne Ola & Catherine E. Lovelock
Blue Carbon

- Mangroves have large carbon (C) stocks in sediments, 5 - 10.4 Pg (Atwood et al. 2017)

Climate change mitigation

- Root biomass is a major contributor to these C sinks (McKee et al. 2007)
Plasticity and soil bulk density

- Plasticity of root development in response to environmental conditions (Zolla et al. 2010)

- Soil Bulk Density (BD): g soil per cm³ volume

Alameda and Villar, 2012
Mangrove soil bulk density

- Large range of soil BD in mangroves
- For example, 0.12 g cm$^{-3}$ in the US (Genthner et al. 2013) to 1.37 g cm$^{-3}$ in Australia (Lovelock et al. 2014)

High BD mineral soil
Low BD organic soil
Schematic drawing of the effect of soil bulk density (BD) on soil properties.
Schematic drawing of the effect of BD on root growth.

- **Shoot growth**
  - Biomass ↓
  - Number of leaves ↓
  - Height ↓
  - Stem volume ↑

- **Root traits**
  - Length ↓
  - Diameter ↑
  - Density:
    - Surface rooting
    - Lateral root proliferation
  - Anatomy
  - C:N ratio

Alameda and Villar (2012)
Contrasting responses - field and lab
Aim and Hypothesis

Aim:
To assess the morphological and anatomical response of R. stylosa stilt roots upon exposure to soils of different BDs.

Hypothesis:
1) BD has an effect on root traits.
2) The effect of soil BD on root growth is also reflected on anatomical features.

Gill and Thomlinson, 1977
Burial: 6 month

Root traits:
- C & N
- Diameter
- Volume
- Biomass
- Tissue density
- Length (total, primary, lower order)

<table>
<thead>
<tr>
<th>BD (g cm⁻³)</th>
<th>Peat (g)</th>
<th>Perlite (g)</th>
<th>Sand (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>10.6</td>
<td>14.3</td>
<td>156.6</td>
</tr>
<tr>
<td>0.8</td>
<td>10.6</td>
<td>7.3</td>
<td>345.6</td>
</tr>
<tr>
<td>1.2</td>
<td>10.6</td>
<td>0.4</td>
<td>529.2</td>
</tr>
</tbody>
</table>
Results

Loose soil (0.4 g cm⁻³)

Dense soil (1.2 g cm⁻³)

Soil BD affects primary root length and diameter, as well as root biomass of R. stylosa stilt roots.
Stepwise linear regression analysis suggests root C % is influenced by log(tissue density) (p=0.03). C:N is not only influenced by log(tissue density) (p=0.007) and primary root diameter (p=0.025).
↑ Fibrous strand size/phloem area (µm²)
← Cortex thickness (mm)
← Aerenchyma lacunae (% area)
← Vascular tissue cell wall (% area)
← Vascular cylinder (mm²)
Soil BD affects anatomical features (aerenchyma, fibrous strands) of stilt roots, features important in root aeration and structural support, respectively; and influence tissue density and composition.
Conclusion

• Stilt roots of *R. stylosa* are strongly influenced by variation in soil BD.

• Soil BD also affects root anatomical features such as aerenchyma and fibrous strands found within the vascular circle.

• Tissue density influences root C %, and together with primary root diameter the C:N ratio.

Variations in soil type and stilt root traits are likely to influence C cycling in Rhizophora forests.