Understanding soils for improved water and nutrient use efficiency

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Nitrogen Use Efficiency

**Highest** in spring
- (~30% = 15 kg N ha\(^{-1}\))

**Halved** in summer and 50-50 split
- (7.5 kg N ha\(^{-1}\))

**Spring** growth is more active, **fruit**, **leaf**, **shoot** are strong sinks

**Summer** has no **fruit**, less photosynthetic activity

Yield: ~ 27 t ha\(^{-1}\)  
Rate: 50 kg N ha\(^{-1}\)
Spring vs. summer fertigation

Fertilizer N partitioning spring

- 9.7 g N tree\(^{-1}\)
- 14.9% 1.8% 8.7%
- 14.7%
- 5.5%
- 2.7%

Fertilizer N partitioning summer

- 5.3 g N tree\(^{-1}\)
- 42.6%
- 14.7%
- 1.5%
- 13.7%
- 0.9%

Legend:
- First year wood
- Leaf foliage
- Fruit
- Old wood
- Root
- Spur & bud
- Trunk
Tree N status at dormancy

- **Summer and spring fertigation** makes similar contribution to storage

- Total N is the same, very small difference in fertiliser N

- Plant has other ways to acquire or accumulate storage N
Seasonal pattern of tree water use by 1-yr old Jazz apples (Tasmania)

- Measurements to define the water use over the whole growing season
Seasonal pattern of tree water use by 3-yr old Jazz apples (Tasmania)

- Quantify the link between climate and tree size/age using FAO-56 crop factor approach
https://www.applesoils.com/
Soil characterisation of SE Australian Apple growing regions

- Morphology
- Chemistry
- Hydrology
- Management
## Morphology

<table>
<thead>
<tr>
<th>Layer</th>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0-17 cm</td>
<td>Dark grey, 5YR 4/1; Coarse sandy clay loam; moderate 1-5 mm granular structure; no mottles; few 50-80 mm sub-rounded coarse fragments (Qtz); many very fine to fine pores; many very fine to fine roots; abrupt wavy boundary to</td>
</tr>
<tr>
<td>B21</td>
<td>17-27 cm</td>
<td>Reddish yellow; 7.5 YR 6/6; coarse sandy light clay; weak structure; many, fine to medium, faint orange, diffuse mottles (M); common, very fine pores; no roots; clear boundary to</td>
</tr>
<tr>
<td>B22</td>
<td>27-40 cm</td>
<td>Reddish yellow, 5YR 6/6; Heavy Clay; common, fine to medium distinct, red, sharp mottles (M) and many, fine to medium, distinct, diffuse, grey, mottles (M); few, very fine pores; few coarse roots and few very fine roots; gradual boundary to</td>
</tr>
<tr>
<td>B23</td>
<td>40-70 cm</td>
<td>Reddish Yellow, 7.5 YR 6/8; medium clay; many medium to coarse, reddish yellow mottles (M) and many medium distinct red clear mottles (M); few, very fine pores; few very fine roots.</td>
</tr>
</tbody>
</table>
## Chemistry

‘What is the resource beneath my feet?’

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Nitrate N mg/kg</th>
<th>Ammonia N mg/kg</th>
<th>Phosphorus Colwell mg/kg</th>
<th>Potassium Colwell mg/kg</th>
<th>Sulphur mg/kg</th>
<th>Organic Carbon %</th>
<th>Conductivity ds/m</th>
<th>pH Level (CaCl$_2$)</th>
<th>pH Level (H$_2$O)</th>
<th>Exchangeable Cations meq/100g</th>
<th>CEC meq/100g</th>
<th>ESP %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A11</td>
<td>4</td>
<td>3</td>
<td>295</td>
<td>170</td>
<td>7.2</td>
<td>2.48</td>
<td>0.052</td>
<td>5.7</td>
<td>6.5</td>
<td>2.58</td>
<td>4.07</td>
<td>2.46</td>
</tr>
<tr>
<td>A12</td>
<td>3</td>
<td>2</td>
<td>103</td>
<td>104</td>
<td>14</td>
<td>2.54</td>
<td>0.061</td>
<td>4.7</td>
<td>5.8</td>
<td>1.86</td>
<td>2.58</td>
<td>4.65</td>
</tr>
<tr>
<td>B1</td>
<td>2</td>
<td>1</td>
<td>13</td>
<td>81</td>
<td>21.2</td>
<td>1.22</td>
<td>0.073</td>
<td>4.5</td>
<td>5.4</td>
<td>1.11</td>
<td>1.58</td>
<td>6.33</td>
</tr>
<tr>
<td>B21</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>112</td>
<td>33.8</td>
<td>0.99</td>
<td>0.092</td>
<td>4.5</td>
<td>5.3</td>
<td>1.73</td>
<td>2.32</td>
<td>4.31</td>
</tr>
</tbody>
</table>

Values for Colwell P represent horizon based sampling and thus may differ to traditional Colwell P sampling at 0 - 100 mm or 0 - 75 mm depth.
Hydrology
# Hydrology

<table>
<thead>
<tr>
<th>Horizon (cm)</th>
<th>Bulk Density (g/cm³)</th>
<th>Hydraulic Conductivity (mm/hr)</th>
<th>% Moisture per Horizon</th>
<th>mm of Soil Water</th>
<th>Model parameters - van Genuchten</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Saturated water content 8s</td>
</tr>
<tr>
<td>A1</td>
<td>1.51</td>
<td>150</td>
<td>42.4</td>
<td>72.0</td>
<td>0.423</td>
</tr>
<tr>
<td>B21</td>
<td>1.94</td>
<td>Est 0.5</td>
<td>27.2</td>
<td>27.2</td>
<td>0.272</td>
</tr>
<tr>
<td>B22</td>
<td>1.40</td>
<td>Est 0.05</td>
<td>48.1</td>
<td>62.5</td>
<td>0.480</td>
</tr>
<tr>
<td>B23</td>
<td>1.41</td>
<td>0.005</td>
<td>47.4</td>
<td>151.7</td>
<td>0.474</td>
</tr>
</tbody>
</table>

Total soil moisture to 70 cm depth: 313 mm

% refers to per cent of total soil volume. RAW refers to readily available water between -10 and -50 kPa. PAWC refers to plant available water between field capacity -10 kPa and the permanent wilting point at -1500 kPa. Drainable porosity refers to moisture held between saturation and -10 kPa. EST. estimated value for hydraulic conductivity.
Hydrology

Total Soil Moisture: to 70 cm depth: Yellow Chromosol: Harcourt

- **Unavailable**
- **Available - Tightly Held**
- **Readily Available**
- **Drainable Porosity**

- ‘Drained’ ... Water that drains under gravity
- ‘Target’ .... Water that can be easily accessed from the soil
- ‘Backup’ .... Water that the plant can get but under stress
- ‘Dead’ .... Beyond what the tree can get
Hydrology
Strategic Irrigation and Nitrogen Assessment Tool for Apples

SOIL DATA
- Water content [L/L]
- Pressure head [cm]
- Sandy loam
- Coarse sand
- Saturation
- Field capacity
- Wilting point
- Air dry
- Refill point

CROP DATA
- Variety
- Training system
- Root stock
- Phenology
- Planting density
- Yield target

CLIMATE DATA
- Historical (BOM)
- Daily values
- Solar radiation
- Temp & RH%
- Wind speed
- Rainfall

MANAGEMENT
- Irrigation
- N Fertilizer
- Crop Load
- Timing
- Rates
- Strategies

SPASMO CORE

OUTCOMES
- Irrigation need
- Fertilizer need
- Yield & Response
- Benchmarking
- Planning
- What-if answers