Precision fertigation for improved apple orchard productivity

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Project Overview

Current situation: Guidelines for fertigation are generic and don’t fully consider total N flux and impacts of rates and timing of application

Aim: Optimal N nutrition in apple orchards through fertigation

Major outcome: Protocols for precision fertigation in apple orchards that account for tree uptake, utilisation and fruit quality, crop, leaf and pruning removal and nutrient flux
Trial Establishment

‘Galaxy’ at Lucaston Park Orchards, Tasmania

![Image of orchard with irrigation equipment and people working]

- Delivering N
- Fluxmeters for N leachate
- TDR probes for soil moisture
- Sap Flow for tree water use

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Experimental Design

-Irrigation treatments applied when grower irrigates: high (3.9L/hr), medium (2.3L/hr) and low (1.6L/hr)

-Split N treatments applied as Ca(NO$_3$)$_2$ (4 reps per treatment)
-ON
-25%N Pre harvest and 25%N Post harvest
-50% N Pre harvest and 50% N Post Harvest
-50% N Post harvest
-100%N Post harvest.

-Ratios are based on a percentage of annual N application of 60kg/N/ha.

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Monthly leaf N sampling

Irrigation starts
Irrigation stops
2015
2014
Post-harvest fertigation
Pruning wood N sampling
Pre-harvest fertigation
Post-harvest fertigation
Harvest

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Pre-harvest fertigation significantly increased leaf and fruit N content.
Fruit Quality

• Pre-harvest N fertigation significantly influenced fruit colour (3 indices)
• No significant influence of fertigation on firmness
Orchard water use efficiency

Yearly tree water use
Cumulative water use over a season
Seasonal drainage
‘Eco-efficiency’ of apple orcharding

‘activities that create economic value while reducing ecological impact and resource use’

Average inputs and outputs of apple growing at Lucaston

<table>
<thead>
<tr>
<th>Growing season</th>
<th>Irrigation (L per tree)</th>
<th>Fertigation N (kg/tree)</th>
<th>Yield (kg/tree)</th>
<th>Drainage loss (L/tree)</th>
<th>Nitrate loss (kg-N/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-14</td>
<td>1335</td>
<td>0.014</td>
<td>39</td>
<td>424.35</td>
<td>0.015</td>
</tr>
<tr>
<td>2014-15</td>
<td>567</td>
<td>0.014</td>
<td>33</td>
<td>447.75</td>
<td>0.016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Growing season</th>
<th>Water Inputs $\varepsilon_1$ (L/kg fruit)</th>
<th>Water Outputs $\varepsilon_2$ (L/kg fruit)</th>
<th>Nitrogen Inputs $\varepsilon_3$ (kg fruit/kg N)</th>
<th>Nitrogen Outputs $\varepsilon_4$ (kg fruit/kg N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-14</td>
<td>34.2</td>
<td>10.9</td>
<td>2820</td>
<td>2543</td>
</tr>
<tr>
<td>2014-15</td>
<td>17.2</td>
<td>13.6</td>
<td>2386</td>
<td>2056</td>
</tr>
</tbody>
</table>

These simple metrics, on a year by year basis, will enable us to assess the impact of different irrigation and fertigation strategies on the eco-efficiency of orchard production.

Additional factors to consider: season N recycling, crop removal, mineralised N etc.
N$^{15}$ Trial: Nitrogen recycling

Questions

• What is the importance of N remobilisation versus N uptake by roots for new shoot growth and when does this occur?
• Can the quantity of N stored be influenced by timing and application rate of N fertigation?
• When is uptake most efficient?

Treatments:

• Zero N$^{15}$ control
• Pre-harvest N$^{15}$ (60g/tree) only
• Pre-harvest N$^{15}$ (60g/tree) plus post-harvest N$^{15}$ (60g/tree)
• Post-harvest N$^{15}$ (60g/tree) only.
PIPS II: Building on fertigation research

- **Sub-project 1: Building a multi-season N budget for optimised fertiliser management**
  - Use $^{15}$N to trace the fate of N over multiple seasons
  - Quantify the relative contributions and timing of all N sources
  - Quantify total N loss above and below ground
  - Determine the uptake of N, P and K under foliar and fertigation treatments and influence on fruit quality

- **Sub-project 2: A nationwide decision support tool to guide on-farm irrigation and nutrient management**
  - Develop a grower/adviser focused decision support tool for irrigation and nutrient management – using SPASMO
  - Will include: point-source application of water and nutrients via a line of drippers or sprinklers, 3D tree-canopy module with leaf processes linked to local microclimate and orchard specifics
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