Optimum Fertilization for Tree Plantations

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Optimum Fertilization

- Biological
- Economical
- Environmental
Basic Tree Crop Nutrition

Rapid Growth = High Demand

Nutrient Depletion = Low Yields

Depends on Stage of Stand Development
Three General Nutritional Stages

Establishment  Rapid Growth  Maintenance
Two Growth Phases

Before Canopy Closure

After Canopy Closure
General Pattern of Tree Growth

The diagram illustrates the growth pattern of trees over a period of years. The x-axis represents the plantation age in years, ranging from 0 to 10. The y-axis on the left represents stem mass in kg C m⁻², ranging from 0 to 7. The y-axis on the right represents stem increment in g C m⁻² yr⁻², ranging from 0 to 1.2.

- **Stem Mass**: The line shows the steady increase in stem mass over time, reaching a peak around the 4th year and then stabilizing.
- **Stem Increment**: The dashed line indicates the initial rapid increment in stem mass, followed by a peak around the 1st year and a subsequent decline.
Key is Canopy Closure
Before Canopy Closure

- **Establishment Stage**
  - little nutrient accumulation
  - split applications N,P,K 4 oz or 100g/tree
    - planting
    - repeat w/in 6 months

- Little effect on long term fertility
- Good root zone development
Before Canopy Closure

*Eucalyptus N demand during Rapid Growth Stage in Hawaiʻi*

<table>
<thead>
<tr>
<th>Soil Nitrogen Content</th>
<th>570 kg/ha</th>
<th>350 kg/ha</th>
<th>260 kg/ha</th>
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</thead>
<tbody>
<tr>
<td>&lt;0.45%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.45% to 0.60%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0.60%</td>
<td></td>
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</tbody>
</table>
High Nitrogen = High Photosynthesis

![Bar chart showing the effect of nitrogen on photosynthetic capacity. The chart compares the photosynthetic capacity of control and fertilized plants, with fertilized plants showing a higher capacity.]
High Photosynthesis = High Production
High Leaf Area = High Production
Poor nutrition = Low leaf area = low production
After Canopy Closure

- Nutrient accumulation greatest in stem
- Leaf biomass reaches equilibrium
- Large proportion of nutrient requirement met by recycling
Nutrients in a *Eucalyptus saligna* Plantation

% of Total

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trunk</td>
<td>12</td>
<td>49</td>
<td>24</td>
<td>08</td>
<td>14</td>
</tr>
<tr>
<td>Bark</td>
<td>08</td>
<td>09</td>
<td>15</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>Branches</td>
<td>17</td>
<td>14</td>
<td>26</td>
<td>34</td>
<td>17</td>
</tr>
<tr>
<td>Leaves</td>
<td>63</td>
<td>28</td>
<td>35</td>
<td>31</td>
<td>39</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Choice of Fertilization

- Mineral Applications
  - correction of known deficiencies
  - establishment on poor soil conditions
  - stimulating growth
  - timing
Choice of Fertilization

- Intercropping with Nitrogen Fixing Trees
  - $N$ availability limits growth
  - $N$ fixation rates substantial
  - little competition to crop tree
Crop Tree Height Effects

**Pure stands**

**Mixed stands**

![Graphs showing tree height growth for pure stands and mixed stands with Albizia and Eucalyptus species.](image-url)
Crop Tree Biomass Effects

![Graph showing the effects of crop tree biomass with different percentages of Albizia in the stand. The graph compares Eucalyptus and Albizia in terms of tree biomass (Mg/ha).]

- Eucalyptus
- Albizia
Site I Eucalyptus Soil

+P

Control

+N

+N+P
Greenhouse Soil Bioassay Trails
Biological Nitrogen Fixation

Atmospheric Nitrogen $N_2$

to

Ammonia $NH_3$
N Fixation vs Mineral N

- Continuous moderation
- Organic
- Long term effects

- Single large pulse
- Inorganic
- Short term effects

Problem: Trees that fix N (for example Acacia, Albizia, or Casuarina) are very often invasive weeds
Take home lessons

- Fast-growing trees demand nutrients.
- There are stages in a tree’s growth, and fertilizing while the canopy develops is critical.
- Leaves demand more nutrients to develop than wood does. Low fertility can lead to sparse crowns and low production.
- Look into organic sources that may be available.
- Integrating N-fixers into the system can have long-term benefits.