University of California

Nitrogen Management Training
for Certified Crop Advisers

Nitrogen Management in
Citrus and Avocado
Efficient Nitrogen Management -the 4 R’s-

• Apply the **Right Rate**
  • Match supply with tree demand (all inputs- fertilizer, organic N, water, soil).

• Apply at the **Right Time**
  • Apply coincident with tree demand and root uptake.

• Apply in the **Right Place**
  • Ensure delivery to the active roots.
  • Minimize movement below root zone

• Using the **Right Source and Monitoring**
  • Maximize uptake, maximize response and minimize loss.

*The 4 R’s are specific to every orchard each year.*
Optimizing N Use in Tree Crops

Supply (Rate) = Demand (Amount and Timing)
The Right Rate Equation

Demand Function

Plant Nutrient Demand

Supply Function

N mineralized in the soil

N in the water

N in the fertilization

Efficiency Factor

Efficiency Factor

Efficiency Factor
N Demand Rates
Citrus
N Demand and Partitioning: Orange

1.3 lbs of N per 1,000 lbs of fresh weight produced. 20,000 lb yield

Diagram:
- Nitrogen
- Fruits: 26.7 lbs
- Woody organs: 22.3 lbs
- Tree: 25 lbs
- Leaves: 21.3 lbs
- Pruning material: 16 lbs
- Abscised leaves: 74 lbs

N Demand Timing: Orange

- Fruit and shoots account for majority of N used in a mature orchard.
- 38% of N is used in the leaves.
- Nitrogen uptake occurs from April to November.
- No uptake December to February.

N Demand in Relation to Tree Size: Citrus

Demand for growth – does not include the 1.3 lbs N per 1,000 lbs fresh weight that is required for fruit production.

• Young trees (1-5 years, canopy 0-250 ft³):
  – More leaves than stems or wood
  – Leaves have higher N concentration than stems
  – Trees N accumulates at rate of 0.07 lbs/yr per 50 ft³ increase in canopy volume
  – In most commercial orchards this represents 5-30 lbs N/acre/year

• Large trees (>8 years, canopy volume 1000-1500 ft³)
  – Most growth is in woody tissue (not leaves)
  – Trees accumulate N at lower rate of 0.04 lbs/year per 50 ft³ increase in canopy volume
  – About 5-20 lbs N N/acre/year

IFAS Fact Sheet SL-240, 2006
N Demand: Citrus Example

Example 1. Assume trees average 750 ft$^3$ in canopy volume (12 ft tall and 9 ft in diameter), 200 trees per acre and produce 300 boxes of fruit per acre. Assume a canopy increase of 100 ft$^3$ and a 70% N uptake efficiency.

<table>
<thead>
<tr>
<th>N Demand: Citrus Example</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit N accumulation</td>
<td>30 lbs of N per acre</td>
</tr>
<tr>
<td>Biomass N accumulation</td>
<td>0.15 lb of N per tree</td>
</tr>
<tr>
<td>X 200 trees per acre</td>
<td>30 lbs per acre</td>
</tr>
<tr>
<td>Total Fruit and Biomass N requirement</td>
<td>60 lbs per acre</td>
</tr>
<tr>
<td>50% maximum efficiency</td>
<td>60 lbs/0.5 = 120 lbs per acre</td>
</tr>
<tr>
<td>N requirement</td>
<td>60/0.7 = 86 lbs Fertilizer N</td>
</tr>
</tbody>
</table>

IFAS Fact Sheet SL-240, 2006
**N Demand: Citrus Example**

70%

**Example 2.** Assume trees average 1500 ft³ in canopy volume (16 ft tall and 11 ft in diameter), 200 trees per acre and produce 700 boxes of fruit per acre. Assume a 70% N uptake efficiency.

<table>
<thead>
<tr>
<th>Fruit N accumulation</th>
<th>70 lbs of N per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass N accumulation</td>
<td>0.10 lb of N per tree</td>
</tr>
<tr>
<td>(Figure 2)</td>
<td></td>
</tr>
<tr>
<td>X 200 trees per acre</td>
<td>20 lbs per acre</td>
</tr>
<tr>
<td>Total Fruit and Biomass N requirement</td>
<td>90 lbs per acre</td>
</tr>
</tbody>
</table>

50% maximum efficiency = 90 lbs/0.5 = 180 lbs per acre N requirement

90/0.7 = 128 lbs Fertilizer N
N Management Tools
Citrus
**Leaf Sampling: Citrus**

Leaf analysis guide for diagnosing nutrient status of mature Valencia and navel orange trees

<table>
<thead>
<tr>
<th>Interpretation</th>
<th>Nutrient (values in % dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Deficient</td>
<td>&lt; 2.2</td>
</tr>
<tr>
<td>Low</td>
<td>2.2 - 2.3</td>
</tr>
<tr>
<td>Optimum</td>
<td>2.4 - 2.6</td>
</tr>
<tr>
<td>High</td>
<td>2.7 - 2.8</td>
</tr>
<tr>
<td>Excess</td>
<td>&gt; 2.8</td>
</tr>
</tbody>
</table>


More information at [http://apps.cdfa.ca.gov/frep/docs/Citrus.html](http://apps.cdfa.ca.gov/frep/docs/Citrus.html)
N Demand Rates
Avocado
**N Demand and Partitioning: Hass Avocado**

- Fruit N removal = 2.2-4.3 lb N per 1000 lb fruit

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Fruit dry weight accumulation from a 4.5 ton/acre ‘Hass’ avocado crop

N accumulation in fruit from the same 4.5 ton/acre ‘Hass’ avocado crop

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N Demand and Partitioning: Hass Avocado

- 20-30% increase in vegetative growth occurs each year in a mature tree for a requirement of about 13-19 lbs N/acre/year
- Vegetative growth includes shoots, roots and build up for perennial wood for storage
- 3.5-6.8 lbs N/acre drop as leaves per year
- It’s unclear what role leaf litter plays in the N budget for subsequent cropping years

**N Demand Timing: Hass Avocado**

- Typical application timing: 6 split applications of about 25 lb/acre
- Jan, Feb, April, June, July, November
- Extra N in April (anthesis to early fruit set) and especially November (end of veg. shoot growth) improves yield, so these are likely the most critical periods of N uptake (Lovatt 2001)
- Extra N in Jan and Feb is most susceptible to leaching
- Extra N in June is allocated to leaves, not fruit
- Extra N in April reduced alternating bearing

Nutrient Management Tools
Avocado
Leaf N Analysis Standards: ‘Fuerte’ Avocado

N tissue values for ‘Hass’ should be slightly higher than ‘Fuerte’. Optimum leaf N for ‘Fuerte’ is 1.6 to 2%. Above this value there is a yield decline. ‘Hass’ value is set at a minimum of 2% with an unestablished upper range (probably around 2.3%).

Post-Harvest Response to N: Hass Avocado

Influence of N on the time to eating ripeness

Influence of N on the incidence of moderate/severe chilling injury after 6 weeks at 5°C.

N Management Tools: Hass Avocado

Total Fruit Nutrient Removal Calculator for Hass Avocado in California

Calculate the amount of nutrients that are removed when you harvest your crop. Enter your production below. No commas or periods please!

<table>
<thead>
<tr>
<th>Production Volume: 1000 lbs.</th>
<th>Arsenic: 0.0016 oz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen: 2.8045 lb.</td>
<td>Barium: 0.0288 oz.</td>
</tr>
<tr>
<td>Phosphorus: 1.0598 lb.</td>
<td>Cadmium: 0.0064 oz.</td>
</tr>
<tr>
<td>P₂O₅: 2.4269 lb.</td>
<td>Chromium: 0.0112 oz.</td>
</tr>
<tr>
<td>Potassium: 6.7151 lb.</td>
<td>Cobalt: 0.0016 oz.</td>
</tr>
<tr>
<td>K₂O: 8.1253 lb.</td>
<td>Lead: 0.0208 oz.</td>
</tr>
<tr>
<td>Iron: 0.1872 oz.</td>
<td>Lithium: 0.0256 oz.</td>
</tr>
<tr>
<td>Manganese: 0.0352 oz.</td>
<td>Mercury: 0 oz.</td>
</tr>
<tr>
<td>Zinc: 0.6176 oz.</td>
<td>Nickel: 0.0576 oz.</td>
</tr>
<tr>
<td>Copper: 0.2304 oz.</td>
<td>Selenium: 0.008 oz.</td>
</tr>
<tr>
<td>Boron: 1.5888 oz.</td>
<td>Silicon: 0.3792 oz.</td>
</tr>
<tr>
<td>Calcium: 0.5586 lb.</td>
<td>Silver: 0.0016 oz.</td>
</tr>
<tr>
<td>Magnesium: 1.1268 lb.</td>
<td>Strontium: 0.0704 oz.</td>
</tr>
<tr>
<td>Sodium: 1.0288 lb.</td>
<td>Tin: 0.0144 oz.</td>
</tr>
<tr>
<td>Sulfur: 2.0311 lb.</td>
<td>Titanium: 0 oz.</td>
</tr>
<tr>
<td>Molybdenum: 0 oz.</td>
<td>Vanadium: 0 oz.</td>
</tr>
<tr>
<td>Aluminum: 0.3744 oz.</td>
<td>Chloride: 1.1219 lb.</td>
</tr>
</tbody>
</table>

Created by Reuben Hofshi and Shanti Hofshi

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Data used in this calculator provided by M. L. Arpaia, University of California, Riverside (arpaia@uckac.edu). Fruit nutrient removal values are the averages of 4 grower lots (3 fruit per grower lot) harvested in June 1999. The peel, flesh and seed of individual fruit were analyzed.
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