Managing Nitrogen in Almond Orchards

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Fresno & Madera
Managing Nitrogen in Almond Orchards

- Nitrogen cycle, tree physiology
- Sources of nitrogen
- Nitrogen demand of almond
- Nitrogen rates for maximal almond production
- Nitrogen and hull rot
- Nitrogen needs of developing orchards

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Nitrogen Cycle within Orchard
Nitrogen Cycle within Orchard
N/Mineral Movement w/in Plants

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Nitrogen Sources:

- **Inorganic N fertilizers:**
  - Urea
  - Ammonium ($\text{NH}_4^+$)
  - Nitrate ($\text{NO}_3^-$)

- **Blends:**
  - Urea Ammonium Nitrate (UN-32) – liquid blend
  - Calcium Ammonium Nitrate (CAN-17) – liquid blend

- **Groundwater**
- **Manures/Compost**
- **Other sources:** Fulvic/Humic Acids, Compost teas
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.*
How do you calculate the right rate?

• First, you need to know the tree nitrogen demand based on predicted yield.

• Second, you need to calculate all the N credits.

• Third, you calculate the amount of nitrogen still needed.

• Fourth, you incorporate the fertilization efficiency.
The Right Rate Equation: “Avoid excess N, increase NUE, and increase profitability by accounting for all N inputs”
Optimizing N Use in CA Tree Crops.

Supply (Rate)  =  Demand (Amount and Timing)

Kathy Kelley-Anderson et al: ANR Pub # 21623
Almond Tree Nitrogen Demand

The graph shows the nitrogen demand of Almond Tree at different developmental stages and nitrogen demand at specific dates. The stages include:
- Dormant
- Bloom
- Fruit Set
- Fruit Enlargement
- Kernel Fill
- 10% Hull Split
- Harvest
- Leaf Fall

The nitrogen demand is measured in pounds per acre (lb ac⁻¹) and is represented by different colors for each component of the tree, including roots, trunk, scaffolds, canopy branches, small branches, leaves, blossoms, and fruits. The graph indicates that the nitrogen demand varies significantly throughout the developmental stages and between different dates.
Total and Annual Dynamics of N in Mature Almond Tree (data from 12 year old trees)
UC Nitrogen Rate Study

Methods:

• Trees were 8-10 years old, excellent productivity
• Each treatment had 15 trees, 6 blocks
• Nitrogen was sourced using CAN-17, UAN-32
• N applied in 4 fertigations – 20%, 30%, 30%, and 20% for February/March, April, June, and October, resp.
• Leaf samples were pulled at multiple times
• Trees were harvested, individual tree yields determined
• 4 lb sub-samples collected from two data trees/plot
• kernel weights determined
### UC Nitrogen Rate Study: Yield Effect

<table>
<thead>
<tr>
<th>Year</th>
<th>Irrigation</th>
<th>UAN 32</th>
<th>CAN 17</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>125 lbs</td>
<td>200 lbs</td>
</tr>
<tr>
<td>2009</td>
<td>Drip</td>
<td>2689 b</td>
<td>2977 b</td>
</tr>
<tr>
<td></td>
<td>Fanjet</td>
<td>2776 b</td>
<td>3111 ab</td>
</tr>
<tr>
<td>2010</td>
<td>Drip</td>
<td>2859 c</td>
<td>3426 bc</td>
</tr>
<tr>
<td></td>
<td>Fanjet</td>
<td>2872 b</td>
<td>3581 a</td>
</tr>
<tr>
<td>2011</td>
<td>Drip</td>
<td>3811 c</td>
<td>4272 b</td>
</tr>
<tr>
<td></td>
<td>Fanjet</td>
<td>3870 b</td>
<td>4014 b</td>
</tr>
</tbody>
</table>

*P* < 0.05, differing letters mean different statistical groupings

**Conclusions:**
- Maximal yields reached with 275 lb, no gain from 350 lb treatment;
- No difference between nitrogen source
- No difference between irrigation system
The proportion of annual N budget that goes to vegetation declines as the yield increases above 2,000 lb.
Applying more N than needed does not result in greater N uptake by fruit but does increase the potential for leaching loss.

There is less vegetative growth when yield is high even when N is applied in excess.

- Increasing N from 275 to 350 lbs N did not increase N removal by fruit.
- In plants receiving adequate N, 68 lbs of N is removed in 1000 lbs kernel yield.
- 80% of crop N is accumulated by 130 DAFB
Right Rate: Nitrogen Demand in Almonds

Nutrient removal Per 1000 lb Kernels

Nonpareil
  • N removal 68 lb per 1000

Monterey
  • N removal 65 lb per 1000

Growth Requirement
  • Yield 2,000 to 4,000 = 0 lb N
  • Yield 1,000 to 2,000 = 20 lb N
  • Yield <1,000 = 30 lb N
UC Davis Nitrogen Rate Study: Leaf Sampling
UC Davis Nitrogen Rate Study: Leaf Sampling

• Protocol:
  – Sample leaves from a single cultivar 43 days after bloom (+/- 6 days)
  – Collect leaves from 18-28 trees per orchard, combine leaves from area of concern
    • Each tree must be 30 yards apart
  – Collect leaves from 8 exposed spurs per tree between 5-7 feet off the ground for a total of 100-200 leaves
  – Send samples to the lab and request a full nutrient analysis. Data needs to be entered into model for correct June prediction.
Right Rate: Almonds

- **Extension Article:** “Almond Early-Season Sampling and In-Season Nitrogen Application Maximizes Productivity, Minimizes Losses” by **Sebastian Saa Silva, Saiful Muhammad, Blake Sanden, Emilio Laca, Patrick Brown** *(Google it)!*

- Includes Practical Examples

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3) If April tissue analysis predicts that your July tissue concentrations will be less than adequate, and if estimated yields ($Y_{est}$) differ substantially from preliminary predicted yields ($Y_{pred}$) as determined in (A) above, then **reduce or increase** N fertilization in subsequent fertilizations accordingly:

   a. Divide field estimated yields ($Y_{est}$) by preliminary predicted yields ($Y_{pred}$) = $Z$.
   b. Fruit Growth Application and Kernel Fill Application = $(1.7 \times Z)$ x Early-Spring Application Rate
   c. Fruit Maturity and Early Post-Harvest Applications = $(1.2 \times Z)$ x Early-Spring Application Rate. Note: In regions where significant rainfall may occur during this period, growers should consider use of a foliar application of N or supply N in a manner that minimizes loss potential.
Almond Nitrogen Timing

• Should be soil dependent
  – Sandier soils should wait until leaf out
  – Clay, Silt, Loam soils may apply earlier

• 80% should be delivered before hull-split, 20% in the post harvest
  – Majority should be prior to kernel fill

• Example program: 20% March, 30% April, 30% May, 20% August/September
Nitrogen Sources:

- **Urea** – converted to ammonium in a few days; must be converted to nitrate, can volatilize, water soluble, stable (~46% N)
- **Ammonium (NH₄⁺)** – Used by plants, positively charged, acidifying
  - In strongly acidic soils, conversion to nitrate may not occur for weeks
  - Ammonium Sulfate (Acidifying, source of sulfur)
- **Nitrate (NO₃⁻)** – Plant available form of nitrogen, negatively charged, easily leached
  - Calcium Nitrate (source of Calcium, creates a basic reaction)
  - Potassium Nitrate
- **Blends:**
  - Urea Ammonium Nitrate (UN-32) – liquid blend
  - Calcium Ammonium Nitrate (CAN-17) – liquid blend
Nitrogen Sources:

- **Groundwater** - sourced as nitrate, should be considered in budget,

- **Manures/Compost** – Percentage varies by source, age of compost, Food safety issues
  - Mineralizes most of N within first year (up to ~85%)

- **Fulvic/Humic Acids, Compost teas** – efficiencies relatively unknown, thought to be high
Supply Function
Nitrogen in the Water: Free source of N!

• Formula for Nitrate: Nitrate concentration (ppm) x inches irrigation applied x 0.052

• Formula for Nitrate-N: Nitrate-N concentration (ppm) x inches irrigation applied x 0.23

• Example: Lab reports 10 ppm Nitrate or 2.27 ppm Nitrate-N and you apply 48 inches of water
  Answer = 25lb
  Currently we estimate that only 70% of the N in the water will be available.
  Answer = 17.5 lb (25 x 0.7 = 17.5)
Why is there a difference between Nitrate-N and Nitrate?

- When the report is Nitrate, then the results are expressed as “NO₃”.
- When the report is Nitrate-N, then the results are expressed as nitrogen “N”.
- How much N is in a NO₃ ion?
  - Atomic Weight of N = 14
  - Atomic Weight of O = 16
  - 14+16*3 = 62. 14/62=0.22.
  - Therefore, only 22% of Nitrate is N.
Example

- Suppose the following:
  - Almond Demand Function: 2,500 kernel produced
    - \(2.5 \times 68 = 170\text{lbs of N}\)
  - Sum of N credits from N in the water = 17 lbs of N

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<tr>
<td>Monterrey</td>
</tr>
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<td>Growth Requirement</td>
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<td>- Yield &lt;1,000 = 30 lb N</td>
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170 lbs N yield demand
– 17 lbs N supply from irrigation

= 153 N lbs needed by the crop

Then, you incorporate the fertilizer efficiency.
Nitrogen Efficiency will likely be set at 70% by regulating agencies.

- This can be achieved in well-managed orchards, though it is easier in some than others.

\[
153 \text{ N lbs} / 0.7 = 218 \text{ lbs fertilizer N should be applied.}
\]

- However, if you do not manage N well this efficiency cannot be achieved:
- Efficiency can be reduced by:
  - Poor timing
  - Year to year yield variation (wrong rate)
  - Poor Irrigation uniformity (wrong place)
  - In field and between field variability (wrong rate, wrong place)
Almond Tree Demand, When to Apply, How efficient.

Tree Demand? = 68lbs of N for 1000lbs of kernel produced plus growth requirement (20-30 lbs) if yield is <2,000 lbs.

When to apply? = 80% during the first 4 months of growth, 20% post hull split – pre leaf senescence.

How efficient can we be if we do everything well? = 70% NUE
Bringing it All Together:

- Determining Total Crop Demand in lbs N
  - Expected yield divided by 1000 and multiplied by 62
- Subtract nitrogen applied through water
- Leaf Tissue Based Adjustment
  - If April N concentrations exceed 3.5%, it is likely that June fertilization can be omitted
- Determining N application rate
  - Subtract N applied through water from crop demand, multiply by 1.4 (assumes 70% efficiency factor)
- Timing of application should vary by soil type.
  - More “feeds,” the better
Nitrogen Prediction Models for Almond and Pistachio

These models are based on research conducted through Advanced Sensing and Management Technologies, a 4-year, multi-state project with goals to optimize resource use in deciduous tree crops. For project details, including investigative team, methodology and support, see project link.

Nitrogen Management Tools for Almond

1) Guidelines for Early Season Sampling and In-Season Nitrogen Budgeting (pdf)
2) Estimate almond tree demand: Almond Model for Calculating Nitrogen Demand
3) Interpret early season almond leaf samples: Download these spreadsheets: N-Prediction Model for Almond (22K) and N-Prediction Model for Almond: large datasets (317K) from this page: Crop Nutrient Status & Demand in Almond

N & K Prediction Model for Pistachio

1) Guidelines for Pistachio Early-Season Sampling and In-Season Nitrogen Application Maximizes Productivity, Minimizes Loss (pdf). By Muhammad Ismail Siddiqui and Patrick Brown
2) Estimate pistachio tree demand: Pistachio Model for Calculating Nitrogen Demand
3) Interpret early season pistachio leaf samples: Pistachio Prediction Model (PPM)
New Online and Tablet N Management Program

N Management Calculator available at the Almond Board Growers Website

Free and Anonymous (requires email address)

Or: Can be used as part of Californian Almond Sustainability Program (CASP)
Nitrogen Rate Study: Hull Rot

*Rhizopus stolonifer* - or - *Monilinia fructicola*
Nitrogen Rate Study: Hull Rot

Effect of Nitrogen Application on Hull Rot Incidence

Linear p<0.01

N rate (lb/acre)

- 0
- 125
- 250
- 500

Brent Holtz, UCCE San Joaquin

University of California
Agriculture and Natural Resources
Nitrogen Rate Study: Hull Rot

**Treatments**

- A = N 125 lb/ac
- B = N 200 lb/ac
- C = N 275 lb/ac
- D = N 350 lb/ac

*Green line represents mean*
Nitrogen Rates Study: Hull Rot

- N increases split timing by promoting vigor, thus increasing hull rot.
- Increasing hull rot as leaf N concentration exceeds 2.5% in mid-July
- N can be applied through July if:
  - supply do not surpass demand;
  - no new lush growth.
- Rate appears more important than timing.
Developing Almond Orchards

- Nitrogen needs look to be around 25-30 pounds for growth
- Needs to be added to crop requirements
- Be careful with the rate
Questions?

- Thanks to:
  - Sebastian Saa, Saiful Muhammad, Blake Sanden, and Patrick Brown, UC Davis/UCCE
  - David Doll, UCCE
  - Paramount Farming Company, The Almond Board of CA, USDA, CDFA
  - Brent Holtz, UCCE