Managing Pistachio Nutrition

Patrick Brown
Muhammad Ismail Siddiqui
How Should I Fertigate?
Focus on N, K (and Mg)

- What tools (leaf, soil, water) should I be using, and how?
  - All of them, plus a little bit of plant nutrition understanding, and:
    - Fertilize according to yield potential of CURRENT year

- Are university guidelines for critical values still viable?
  - Yes for all elements except Mg which should be reduced to 0.4%.
  - However, doing leaf sampling right is really difficult
  - You cannot manage nutrition based on leaf analysis alone.
Principles of Nutrient Management- Optimizing Fertilization by Applying the 4 R’s

• Applying the **Right Rate**
  • Match demand with supply

• **At Right Time**
  • Determine when uptake from the soil occur
  • Maximize uptake minimize loss potential.

• **In the Right Place**
  • Ensure delivery to the active roots.
  • Managing variability across the orchard

• **Using the Right Source**
  • Maximize uptake minimize loss potential.

*Are our current guidelines for pistachio fertilization adequate to achieve this?*
Nutrients are obtained by living, active roots and growing plants
- Requires water for uptake
- No uptake during dormancy
- Soils must provide adequate water and oxygen for root growth.

Demand drives uptake. Yield potential determines your fertilizer rate, fertilizer rate does NOT determine yield.

There is an ‘optimal’ tissue nutrient concentration above which no benefit occurs—Critical Value.
Leaf Sampling and Critical Values

Still valid after all these years??
What do we know and how do we manage?
Leaf Sampling and Critical Value Analysis in Orchard crops
(based on Ulrich @ U Calif in 1950-70’s)

- Choosing the right leaf is difficult, sampling the field properly is very hard.
- CV’s only valid for July/August.
- Many CV’s are not yield based.
- Yield trials (N, K, B)
- Leaf symptoms (P, S, Mg, Ca, Mn, Zn, Fe)
- Unknown (Ni, Cl, Mo)
- Interpretation of results (NO R’S!)
- Leaf analysis can indicate a shortage but cannot define how to respond.
- No information on cause of deficiency.
- No guidance on Rate, Timing, Placement or Source.

*Critical values for boron deficiency and toxicity are currently being revised. Hull boron >300 ppm is excessive. Leaf sampling is not effective to determine excess boron.*
Shoot Zn Distribution Through A Dormant Tree (ppm)

Problem with leaf sampling: Sampling challenges.

- 16.3 ppm
- 19.1 ppm - sun exposed
- 28.5 ppm - sun exposed
- 47.9 ppm - shaded
- 39.7 ppm - sun exposed
- 70.3 ppm - shaded

Water sprout

Standard Sample: Fully Exposed non-fruiting leaves in late summer

Courtesy Scott Johnson
Nutrient Concentrations are strongly affected by Proximity to Fruit
Challenges of Sampling: Field Variability

(768 individual tree samples. High producing ‘uniform’ orchard)

Typical Sampling: 1 pooled sample per management unit
(Hypothetical) Field Mean 2.4% N (June): Critical Value 2.4% = OK?

No!: Full productivity can only be achieved when all individuals are above 2.4%
What is the right target mean? (variability:response:cost:returns:yield)
Summary: Tissue Testing for Pistachio

- **Challenges.**
  - Difficult to sample properly and hard to interpret. Sampling in the way most people currently do it, is a waste of money.
  - Are our UC critical values correct?
  - Tissue analysis does not inform management practice**

Do we have any Alternatives?
Leaf Sampling Alone Does not Address the 4 R’s

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*Are our current guidelines for pistachio fertilization adequate to achieve this?*
Ongoing Research to Improve Nutrient Management

- Improve Sampling Methodologies
- Quantify Nutrient use and Develop Nutrient Budget
- Validate Critical Values
- Investigate Nutrient Interactions and Ratios
Experimental Design

4 High Yielding Sites, 4 years
Leaf, Nut sample through year, individual tree yield
Nutrient Analysis

Plot Map (same for all sites)

All Sites: (54 trees)
• 5 in-season full nutrient analysis
• Yield (individual trees)
6 Almond and 5 Pistachio Orchard Sites

All Sites: (>100 trees)

• 5 in-season full nutrient analysis
• 5 in-season Spectral Analysis
• 5 in-season Plant Water Status
• Soil water and irrigation volume
• Yield (100 + individual trees)
• Nitrogen Use Efficiency (NUE)
• Aerial and satellite imagery

Two Sites:
• Gaseous nitrogen loss
• NUE

One Site: 50 x 2 acre, (drip/Fan Jet)
• Factorial 4N x 4K x source x Irrigation Trial
• 5 in-season full nutrient analysis, 5 in-season Stem WP, Soil water and irrigation volume, Yield (768 individual trees)
• NUE
• Canopy level imagery
• Aerial and satellite imagery
Challenges of Sampling: Field Variability
How do we sample properly?
Over what size orchard is this valid? Depends on field variability! If the variance is identical at all distances then the sample size is good for all field sizes.

This sampling protocol is valid for orchards of average variability. Growers must collect leaves from at least 17 trees each spaced at least 25 yards apart. To minimize cost, leaves of all trees can be pooled in one bag. If clear areas of differential tree behavior are known, these areas should be sampled and managed separately.

We estimated the number of samples needed for 90% confidence level for July leaf samples at four research sites.

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Madera (Madera County)
Alternate Approaches to Nutrient Management

Nutrient Budgeting

Replacing nutrients removed from the field

Essential Components and Challenges:

Right Rate

- Estimate demand (Last years yield, this years estimated yield, tree age, common sense)
- Measure and control inputs and losses (soil, fertilizer, irrigation, leaching, volatilization)
- Manage efficiencies and interactions
  - Right Place, Right Time, Right Source
  - Monitoring crop response

How?
Nutrient Budget Approach

- Mature pistachio tree is relatively determinate in growth pattern.
- Majority of nutrients are partitioned to fruit.

**Annual Distribution of Macronutrients: Pistachio**

![Graph showing nutrient distribution](image)
Can tree demand be synchronized with fertilizer application?

Nutrient removal
Per 1000 lbs (CPC yield)

- Valuable for estimating demand or replacing nutrient export
- Provides insight into efficiencies
  - N removal 28 lbs per 1000
  - K removal 25 lbs per 1000
  - P removal 3 lbs per 1000

Brown and Siddiqui-unpublished
Annual Distribution of Macronutrients: Pistachio

- **N** (Blue): Fruit + Leaves
- **P** (Blue): Leaves ‘Yielding’
- **K** (Red): Leaves ‘No yield’
- **Ca** (Green): Leaves ‘Yielding’
- **Mg** (Green): Leaves ‘No yield’

Total Removal (g/tree)
Variation in Yield over Time

Pistachio 4820 trees individually harvested.

Nitrogen export per tree (kgs):
- 1.0
- 0.8
- 0.6
- 0.4
- 0.2
- 0.0

6 year average N export (0.38 kg/tree)

Current annual Fertilizer N Rate (2 lb/tree)
Managing for Spatial Variability

Variability in Yield alters N demand?

>5,000 lbs yield

40 acre = 5,200 lb N
8,000 lb N supply

<2000 lbs yield

40 acre = 3,000 lb N
8,000 lb N supply

Difference in real N demand = 2,200 lb N
Difference in K demand = 1,900 lb K
Spatial distribution of N

Sites of Excess Fertilization have the highest potential for Nitrogen release

Leaf N (%)

Supra Optimal

Adequate

D. Smart et al
Environmental concerns

Nitrate concentrations in various California wells measured in 2007. Many exceed drinking standards

44 mg/L NO$_3$ = 10 mg/L NO$_3$-N

(much from animal manure)

(Ekdahl and others, 2009)
Survey of leaf N distributions in Californian Orchards
114 Orchards surveyed

![Graph showing July N concentration](image)

- **Percentage of trees**
- **July N concentration (%)**
- **Critical Value**
- **n=114**
Reducing Inputs without Considering Variability May Reduce Yield

**Graph Description:**
- The graph shows the percentage of trees across different July N concentration levels.
- The x-axis represents the July N concentration (%), ranging from 1.8 to 2.8.
- The y-axis represents the percentage of trees.
- A red area highlights trees with a lower yield and a green area indicates trees with more yield saved.
- The critical value for N concentration is marked.
- The number of trees (n=114) is noted on the graph.

**Key Points:**
- **Fertilizer saved:** Indicates the trees with the highest yield.
- **Yield lost:** Shows the trees with the lowest yield.
- The graph visually demonstrates the impact of N concentration on yield and fertilizer savings.
Managing Nutrition of High Value Crops

Avoid over fertilization without under-fertilizing any. How?

Correct deficiencies

Critical Value

Avoid over fertilization without under-fertilizing any. How?

n=114

Percentage of trees

July N concentration (%)
Are our Current CV’s Adequate?
### Current Critical Values for Pistachio

**July Sample**

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*ppm = parts per million or milligrams/kilogram dry weight.*

*% = parts per hundred or grams/kilogram dry weight.*
Validation of Existing Critical Values – (N)

Validation of Existing Critical Values – (K)

These analyses suggest that CV’s presented in the current Pistachio production manual, for Mg should be lowered from the current 0.6% to 0.45%.
Statistical and observational analysis suggested that the apparent negative effect of K on yield may be a consequence of an induced deficiency of Mg.
A magnesium project has been designed to further explore these important Mg * K interactions under field and greenhouse conditions.

Is it soil based or plant effect? We don’t Know!
Summary: How Should I Fertigate?

- What tools (leaf, soil, water) should I be using?
  - All of them, plus a little bit of plant nutrition understanding, and:
  - Fertilize according to yield potential of CURRENT year
  - Pay attention to field variability and year-year variability

- Are university guidelines for critical values still viable?
  - Yes for all elements except Mg which should be reduced to 0.4%.
  - Recognize that leaf sampling properly is really difficult to do well.
  - You cannot manage on leaf analysis alone, nutrient budgets must be incorporated,
Challenges of Sampling: Field Variability

How do we sample properly?
We estimated the number of samples needed for 90% confidence level for July leaf samples at four research sites.

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Thank you
How Widespread is this ‘Problem’?
Survey of leaf N distributions in Californian Orchards

The graph shows a histogram of July N concentration (%) with the critical value marked. The data set size is n=114.
Managing Nutrition of High Value Crops

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Critical Value

Percentage of trees

July N concentration (%)

n=114