East San Joaquin Water Quality Coalition

Workshops for Almond Growers with Outlier Parcels

1

First Year of Identifying Outliers

- Why does the Coalition identify outliers?
- How are outliers identified?
- I'm an outlier – what now?
- What if my data are wrong?
- Long-term nitrogen management activities

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Why Identify Outliers?

State Water Board Requirement

The Coalition must identify outliers annually based on the INMP Summary Report data submitted, using:

-- ranges for multi-year A/R ratio and

-- A-R difference target values developed by the Coalition

- ✓ The terms for developing target values is not specifically defined
- ✓ The Regional Water Board approved the Coalition's IQR method for calculating outliers
- ✓ A new approach can be submitted each year, if necessary

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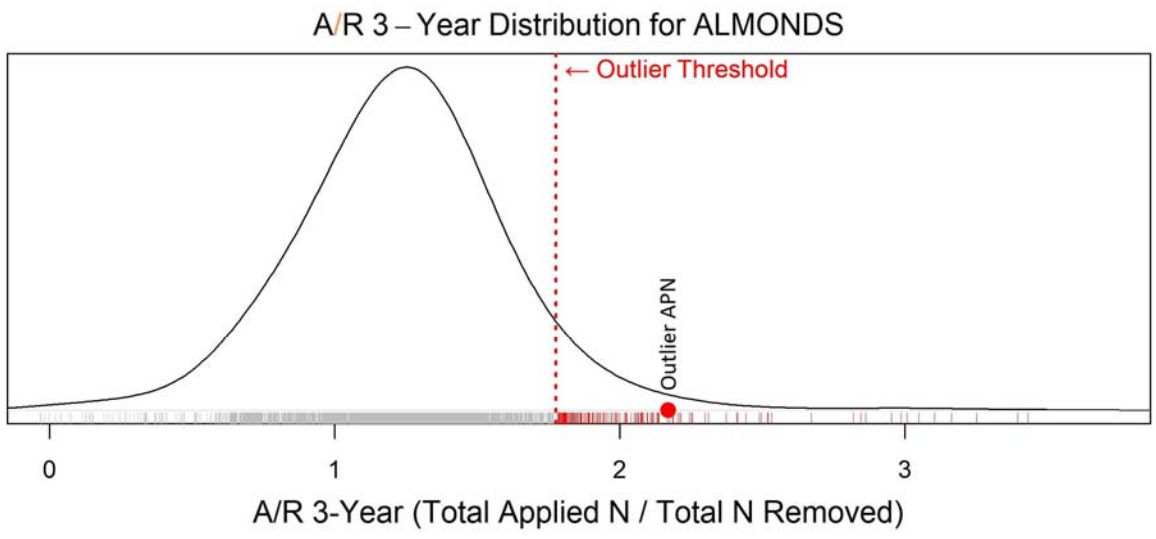

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Crop Coefficients: "The Number"

Indicates amount of nitrogen to efficiently grow a crop
- Little to no excess for leaching to groundwater

Some crops have "Good Numbers" i.e. research supports number

Some crop coefficient need more studies

See Annual Report
Pgs 15-17

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Metric for Grower Performance – A/R (Applied N divided by Removed N)

Used to determine outliers

Accumulate A/R values for crops across coalition region

Outlier identification method
- Calculate the Interquartile Range
  - *Box and whisker plot*

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What if parcel data is incorrect?

•If data used to calculate outlier parcels are incorrect:

✓ Contact the Coalition
✓ Complete and sign a Data Change Form
✓ Provide original INMP worksheet from corrected crop year

• A/R will be recalculated and reassessed against the original threshold:

✓ If the new ratio is below the threshold, outlier status will be updated

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Why Identify Outliers?

ESJWQC required to develop a Comprehensive Groundwater Quality Management Plan for High Vulnerability Areas to:

✓ Address exceedances of the nitrate Maximum Contaminant Level (MCL)

✓ Provide education and outreach to members identified as outliers

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Comprehensive Groundwater Quality Management Plan

Enables the Coalition to develop an approach to reduce and/or eliminate impairments to the beneficial use of groundwater: nitrate focus

If the Coalition didn't develop a comprehensive management plan, each grower would be required to demonstrate that they do not impair groundwater

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Priority Crops for Targeted Outliers

- Previous years' priority crops will be evaluated along with new crops each year
- Parcels already in the Outlier/Management Practice Implementation Report (MPIR) process will be exempt

2018	2019	2020	2021	2022
Almonds	Wine Grapes	Sweet Potatoes	Figs	Peaches
	Pistachios	Corn, Silage	Alfalfa	Prunes
	Walnuts	Processing Tomatoes		

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Groundwater Quality Management Plan Approach

Five Main Steps

1. Identify potential sources of nitrate discharges (starting with outlier parcels)
2. Provide education to growers regarding management practices to minimize discharges
3. Encourage growers to adopt practices
4. Evaluate multi-year A/R ratios
5. Provide feedback to growers on progress

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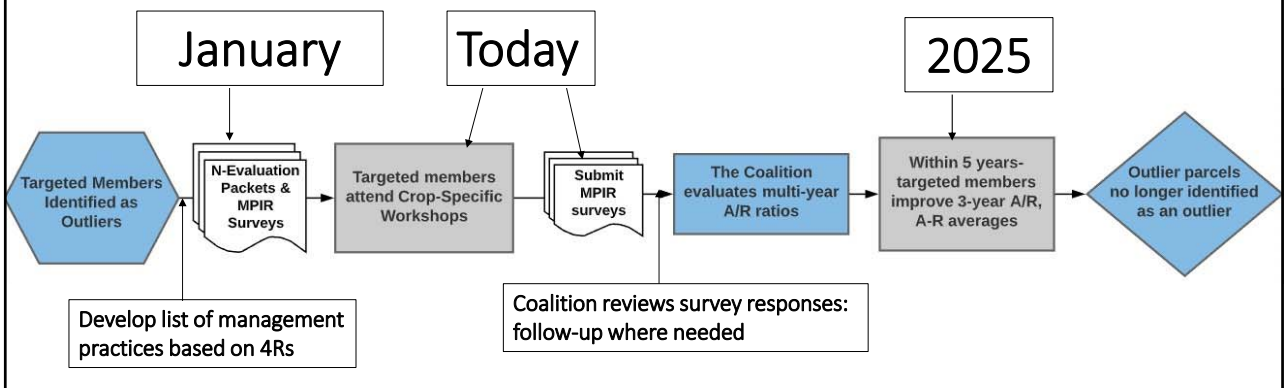
Groundwater Management Plan Approach



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How Are Outlier Parcels Identified?

- 3 year running totals of A/R ratios:
  2016
  2017
  2018
- Specific to parcel, crop and member:
  Requires that the same member farm the same crop on the same parcel for 3 years (e.g. mature almonds)
- Outliers determined using the Interquartile Range (IQR)

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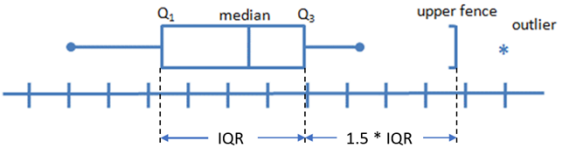

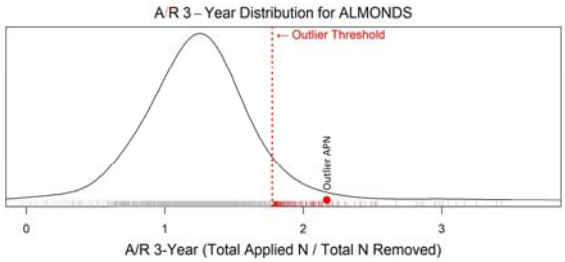

IQR = Interquartile Range

Outlier Threshold Calculations

Outlier threshold calculated for each individual crop

[Q1 – (1.5e-4MC) * IQR; Q3 + (1.5e3MN) * IQR] Eq. 1

And for distributions skewed to the left (MC < 0), outliers are data points outside of the interval

$[Q_1 - (1.5e^{-3MC}) * IQR; Q_3 + (1.5e^{4MN}) * IQR]$ Eq. 2

Where Q1 and Q3 are the 25th and 75th percentiles of the data respectively, and e is the natural exponential function. When the distribution of data is perfectly symmetrical, MC = 0 and the range becomes exactly the standard (non-modified) IQR outlier method. However, the A/R data for each crop are generally skewed to the right, therefore the data range specified in Eq. 1 is more likely to be the expression used to determine the number of outliers. The focus of the ESJWQC will be those outliers that are above the 75th percentile of the IQR.

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Nitrogen in Irrigation Water

"PUMP AND FERTILIZE"

Nitrate-N (NO_3-N) in well water is **"useful" source** of nitrogen for crop production.

Determine the concentration of nitrogen in your irrigation water source (well, etc).

Example:

well water = 35 ppm nitrate-N (NO_3-N).

apply 30 ac/inches water per acre per season

*35 ppm nitrate-N x **0.225** = 7.875 lbs N/acre inch x 30 inches = **236.25 lbs N per acre.***

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I Have Outlier Parcel(s) – Now What?

Member Responsibilities

- Submit Crop Year A/R INMP Summary Report (annually)
- Attend Crop-Specific Workshop
- Complete MPIR Survey (Management Practice Implementation Report)
  - *Initial MPIR survey*
  - *Follow –up MPIR survey (if needed)*
- Implement management practices, demonstrating actions taken to improve water quality

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I have Outlier Parcel(s) – Now What?

ESJWQC Responsibilities

Reporting

✓ Summary of surveys sent and received reported in ESJWQC Annual Reports to Regional Water Board.

Tracking

✓ Coalition will track changes in management practices and monitor improvements over the next five years.

Evaluate

✓ In year five (2025), the Coalition compares current 2016-18 crop year A/R to 2022-24 calculated 3-year A/R

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Overview on Upcoming Nitrogen Management Activities

A/R acceptable ranges

✓ Acceptable maximum ratio values to be developed for each crop

✓ Starting with almonds in 2020

Crop nitrogen removed coefficients

✓ Coalition is refining coefficients for crops with missing or poor values

✓ Must have coefficients to cover 95% of acreage by March 2021; 99% by March 2023

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Overview on Upcoming Nitrogen Management Activities

MPEP: Management Practice Evaluation Program

✓ Effectiveness of Practices: identify if existing management practices are protective of groundwater quality

GW Protection Formulas, Values, and Targets

✓ Total nitrogen loading estimates will be reported for an entire township

✓ Proposed formula currently in development - due July 1

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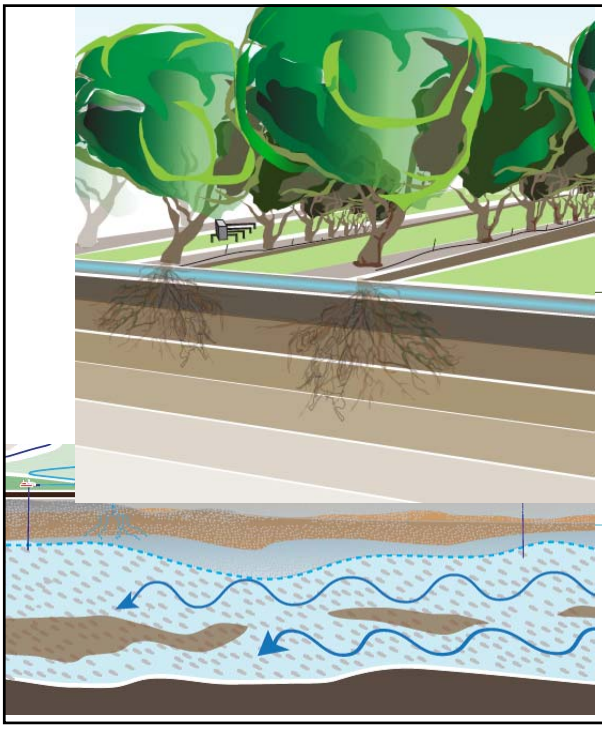

(A-R) + other variables = GWP Value < GWP Target

GWP Formula

Work towards goal of value being less than target on a Township level

Ground Surface

GWP Formula

GWP Value

GWP Target

Groundwater (ambient water quality)

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East San Joaquin Water Quality Coalition

Questions?

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Nitrogen Management in Almonds

ESJ

Sebastian Saa, Sr. Manager Agricultural Research

February 2020

Essential Nutrients

(Lifecycle cannot be completed in their absence)

Photosynthesis	Macro Nutrients	Micro Nutrients
Carbon	Nitrogen	Zinc
Oxygen	Phosphorus	Iron
Hydrogen	Potassium	Boron
	Calcium	Manganese
	Magnesium	Copper
	Sulfur	Chlorine
		Nickel
		Molybdenum

- Always Manage
- Monitor and Manage, Prevent/React
- Isolated occurrence (Monitor)
- Unknown

Source: Dr. Brown's lab from UC-Davis

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.

Together we develop valuable tools and resources for our growers and processors

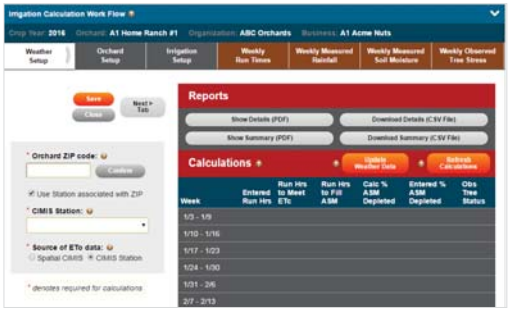
CASP Online: SustainableAlmondGrowing.org

Self-Assessment Modules

- Assess your practices while learning about alternative + best practices
- Contribute to telling the almond sustainability story

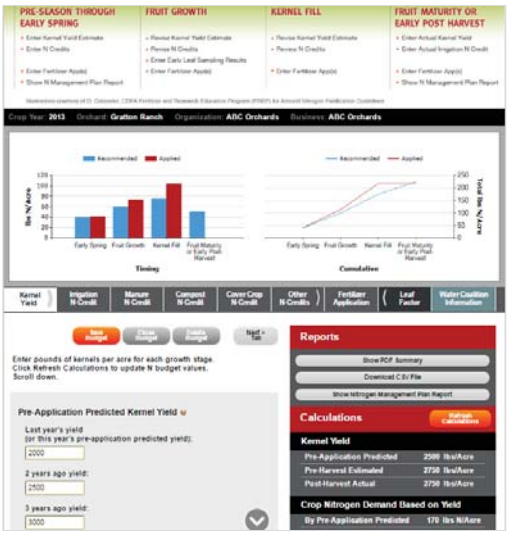
Irrigation Calculator

- Performs basic water demand calculations with user-submitted system information and auto-updates from CIMIS
- Provides irrigation schedule and run time



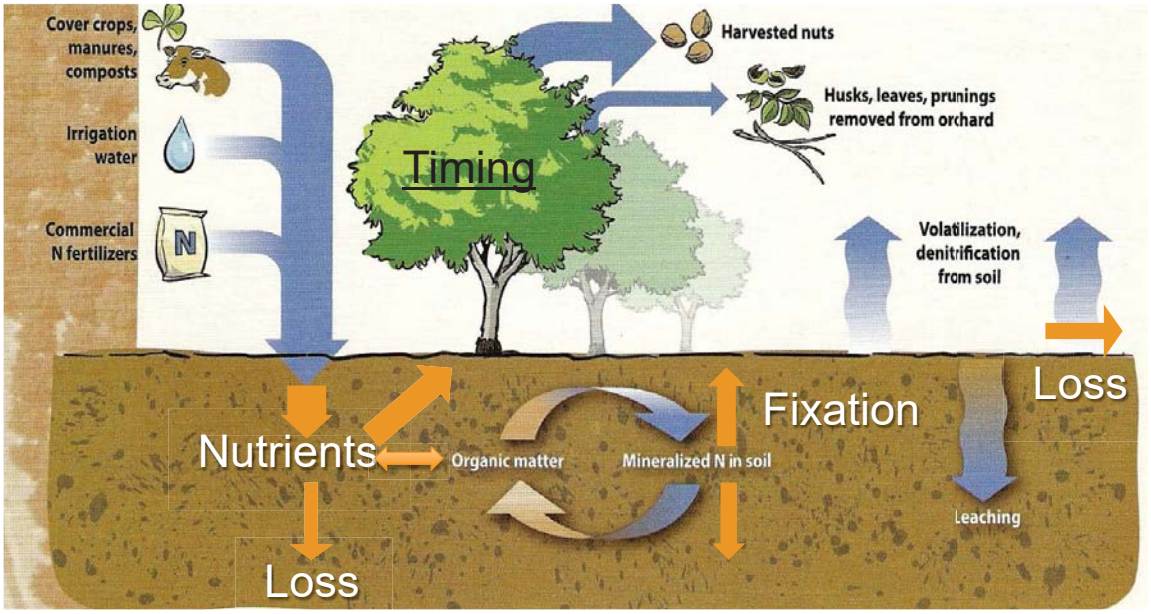
Nitrogen Calculator

- Estimates N need + timing of applications based on yield estimates
- Provides ILRP required N Management Plan



Optimizing N Use in CA Tree Crops.

Supply (Rate) = Demand (Amount and Timing)

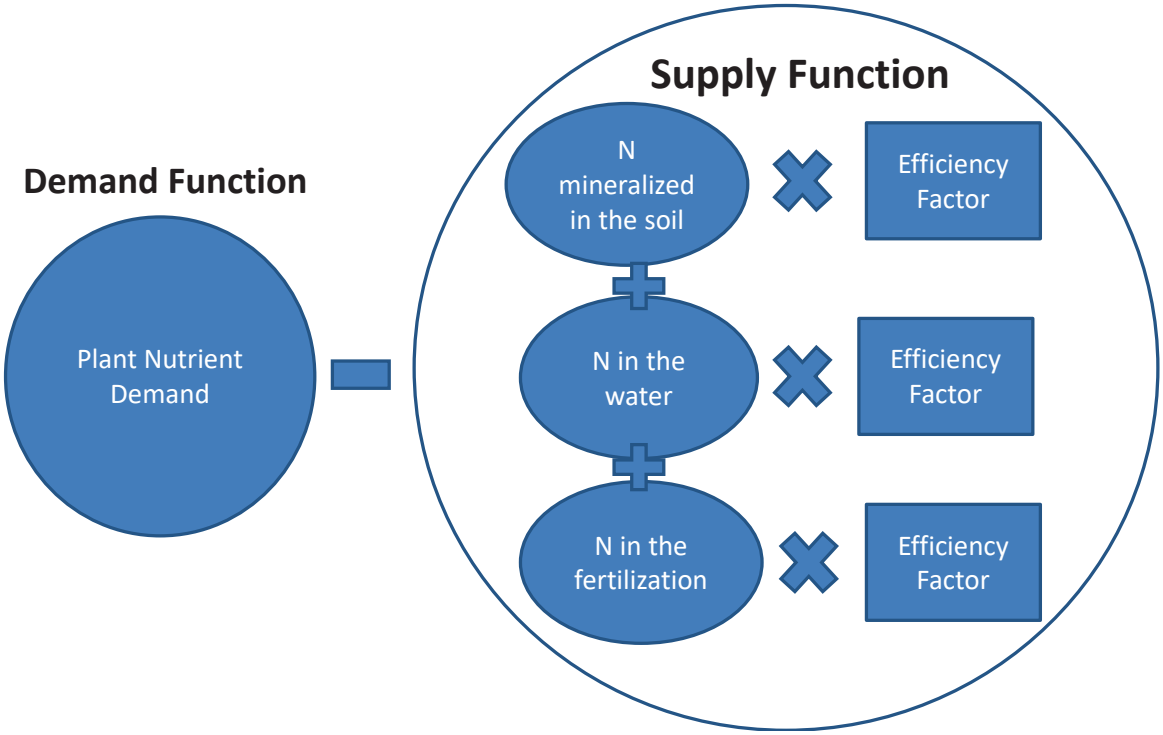


Kathy Kelley-Anderson et al: ANR Pub # 21623

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 fertilizer 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"



Determining the Demand Function

Nutrient Budget Approach

- **What is the total annual tree demand?**
- **When during growth and development does uptake occur?**

Approach:

- **Whole tree excavation, trunk coring, sequential nut collection and analysis, yield measurements- 1000's of individual trees at multiple sites and years**

Source: Dr. Brown's lab from UC-Davis

Right Rate: Plant Nutrient Demand

Source: Dr. Brown's lab from UC-Davis

Right Rate = (Tree Nutrient Demand – Nitrogen Credits)

Tree Nutrient Demand

Nutrient removal Per 1000 lb Kernels

Nonpareil

- N removal 68 lb per 1000
- K_2O removal 96 lb per 1000
- P_2O_5 removal 18 lb per 1000

Monterrey

- N removal 65 lb per 1000
- K_2O removal 91 lb per 1000
- P_2O_5 removal 16 lb per 1000

Nitrogen Credits

- Compost
- Cover crops
- Irrigation water
- Manure
- Others

Source: Dr. Brown's lab from UC-Davis

Third, you calculate the amount of fertilizer needed.

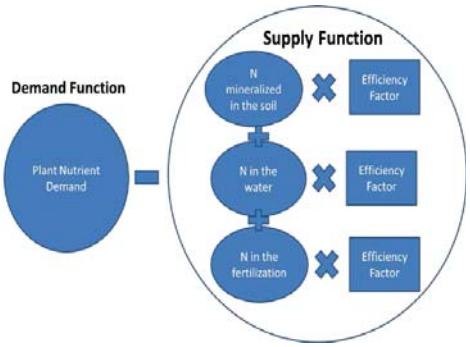
- Let's use a conceptual example to understand how much N needs to be applied per acre:
- Suppose the following:
  - Almond Demand Function: 2,500 kernel produced per acre
    - 2.5 X 68 = 170lbs of N per acre
  - Sum of N credits from soil (i.e. compost and cover crop), and N in the water = 22 lbs of N per acre

Nutrient removal Per 1000 lb Kernels

Nonpareil
- N removal 68 lb per 1000

Monterrey
- 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



Third, you calculate the amount of fertilizer needed.

170 from yield N demand/ac – 22 from N credit/ac= 148 N lbs/ac needed

Fourth, you incorporate the N efficiency.

?

Nitrogen Efficiency in almonds is 70%

- This can be achieved if you follow the 4 Rs.

148 N lbs/acre needed /0.7 = 211 lbs/acre should be applied*

*to support 2,500 lb/acre of projected yield given 22 lb/acre of N credits

- However, if you do not manage N well this efficiency cannot be achieved:
- Four Examples where efficiency can go down:
  - Application errors
  - Year to year yield variation
  - In field variability
  - Between field variability

Nutrient Use Efficiency Declines if N Rate is > Demand.

Table 27.4 Influence of nitrogen (N) application on yield of Nonpareil almond and amount of N removed.

N in fertilizer (lb N/acre)	Kernel N (% dry weight)	Yield (kernel lb/acre)	N removed (lb/acre) Crop*	Prunings
0	3.0	2,290	89	3.3
56	3.2	3,158	133	3.9
112	3.6	3,651	170	
225	3.8	3,830	194	4.9
450	3.9	3,679	198	6.2

>80 % $NUE_{(PNB)}$

<45% $NUE_{(PNB)}$

Source: K. Uriu and W. C. Micke, unpublished data.

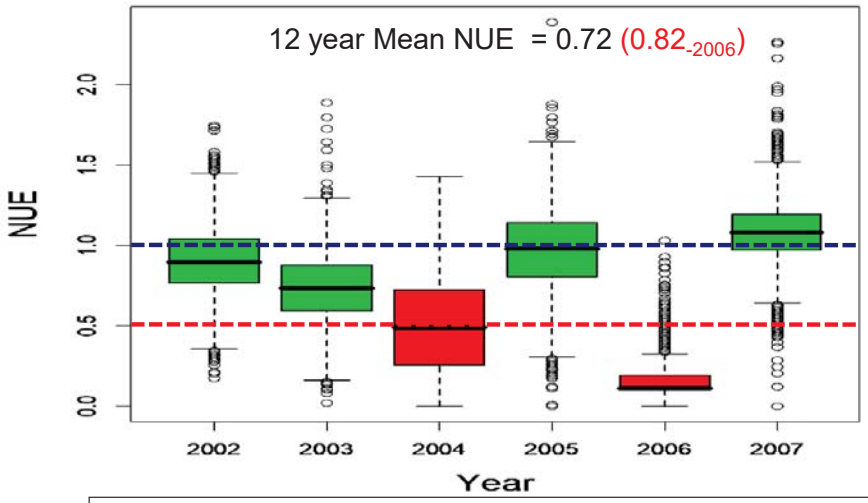
Matching supply (fertilizer) with demand (yield) is the best way to enhance efficiency.

How does yield vary across a field and between years?

Source: Dr. Brown's lab from UC-Davis

Nutrient Use Efficiency and Variability in Pistachio.

4850-9650 individual Tree NUE estimations
(N removed in harvested fruit / applied)

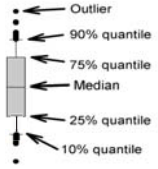


60,000 lb total 6yr N application (40 ac).

41,000 lb exported in yield.

$7{,}000_{est}$ lb pruning, leaf loss and growth

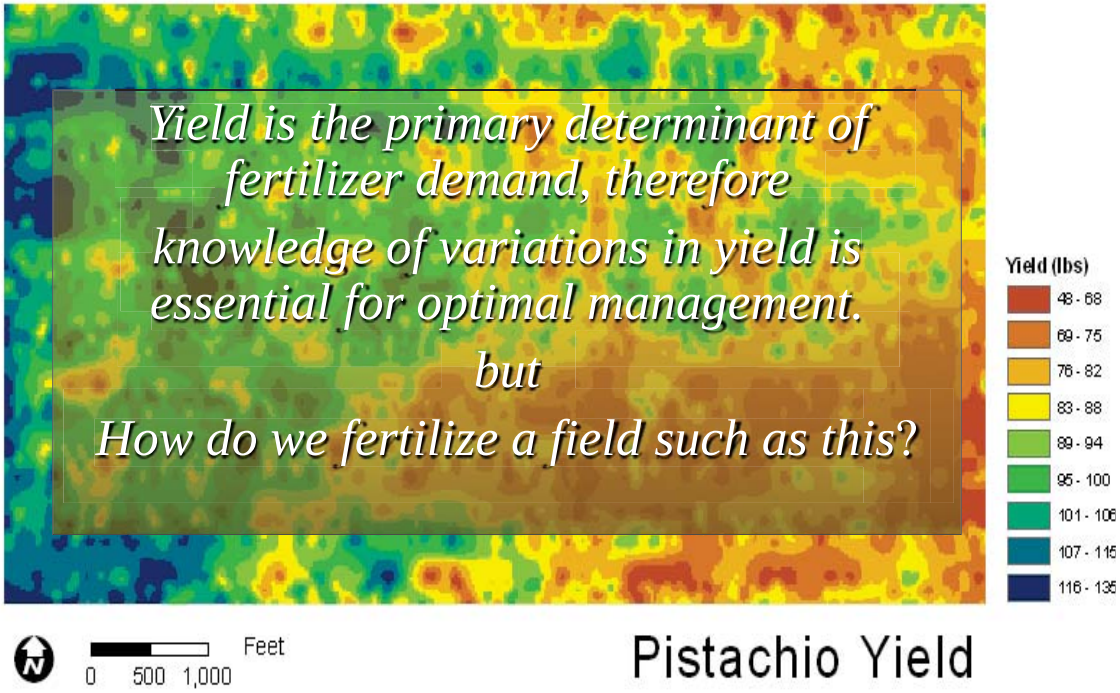
12,000 lb 'lost'
50 lb ha^{-1} yr^{-1}



24 yo Pistachio, 5 inch rainfall zone, no deep percolation.
Silt loam, pH 6.7-7.0, OM 0.6%, 2 ppm NO_3N (100cm). Fertigated with five in-seasons split apps.
10 yr ave yield = 4,000 lb ac= 180 lb N ac in exported fruit
Mean N application 250.

Source: Dr. Brown's lab from UC-Davis

Yield is not uniform in any field.
Yield of 16040 trees Pistachio trees (80 acre)



Source: Dr. Brown's lab from UC-Davis

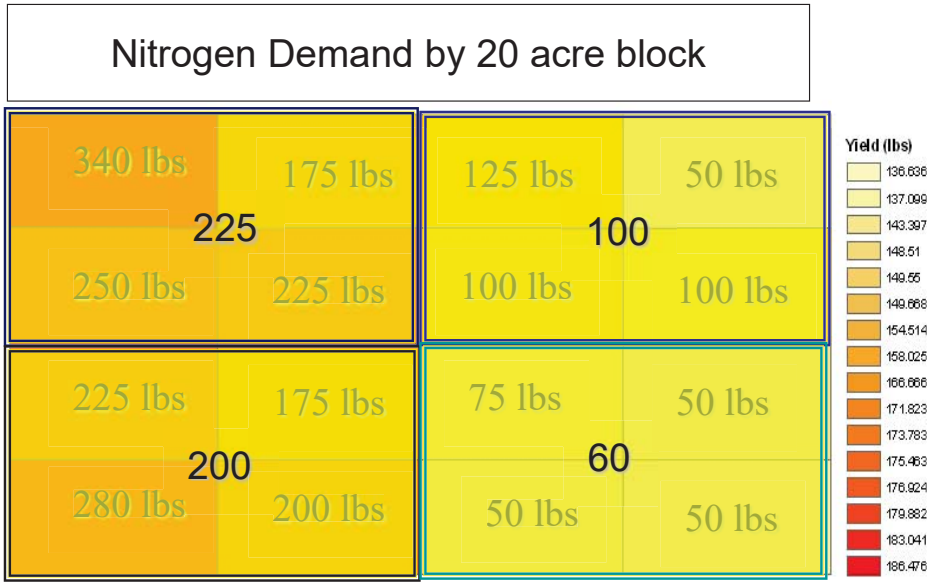
Individually controlled microsprinkler system.

Robert Coates, Mchael Delwiche, Patrick Brown

Individual microsprinkler with sensor would allow for site specific fertigation.

We are not at this stage yet but growers can still make substantial improvements by separating irrigation systems by cultivar or by portions of the field.

Source: Dr. Brown's lab from UC-Davis



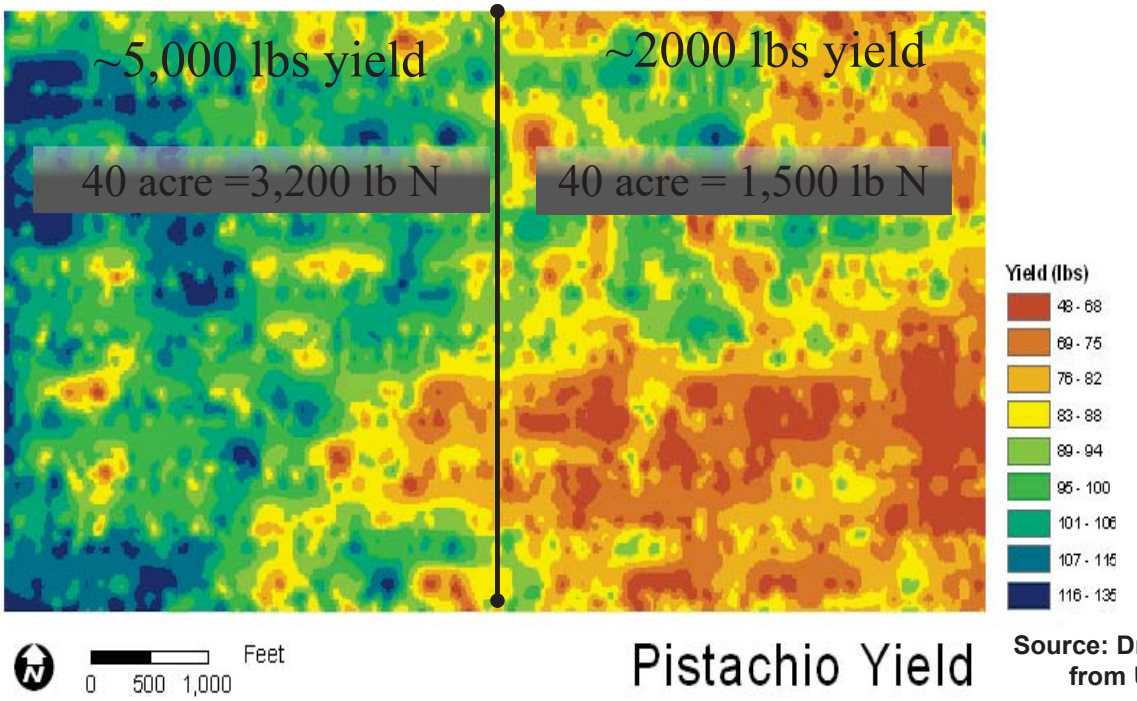
Whole Field Average N demand = 150 lbs N

Source: Dr. Brown's lab from UC-Davis

Managing for Spatial Variability

Introduces greater complexity in management

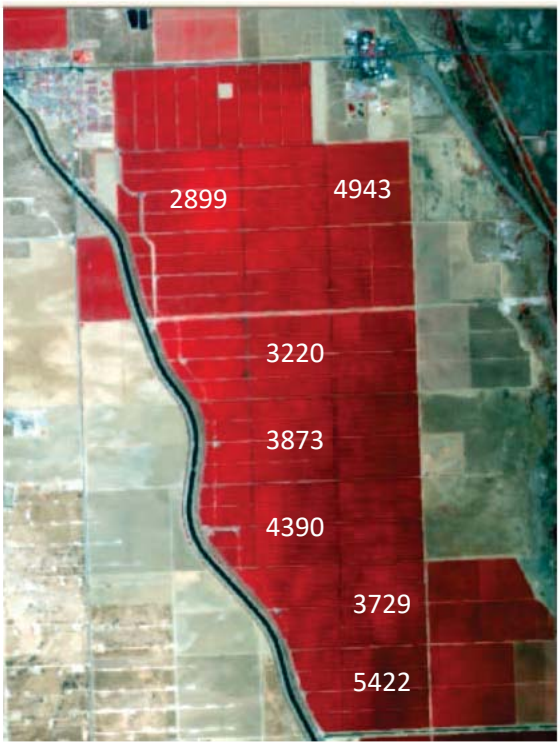
Is it worth it?



Pistachio Yield

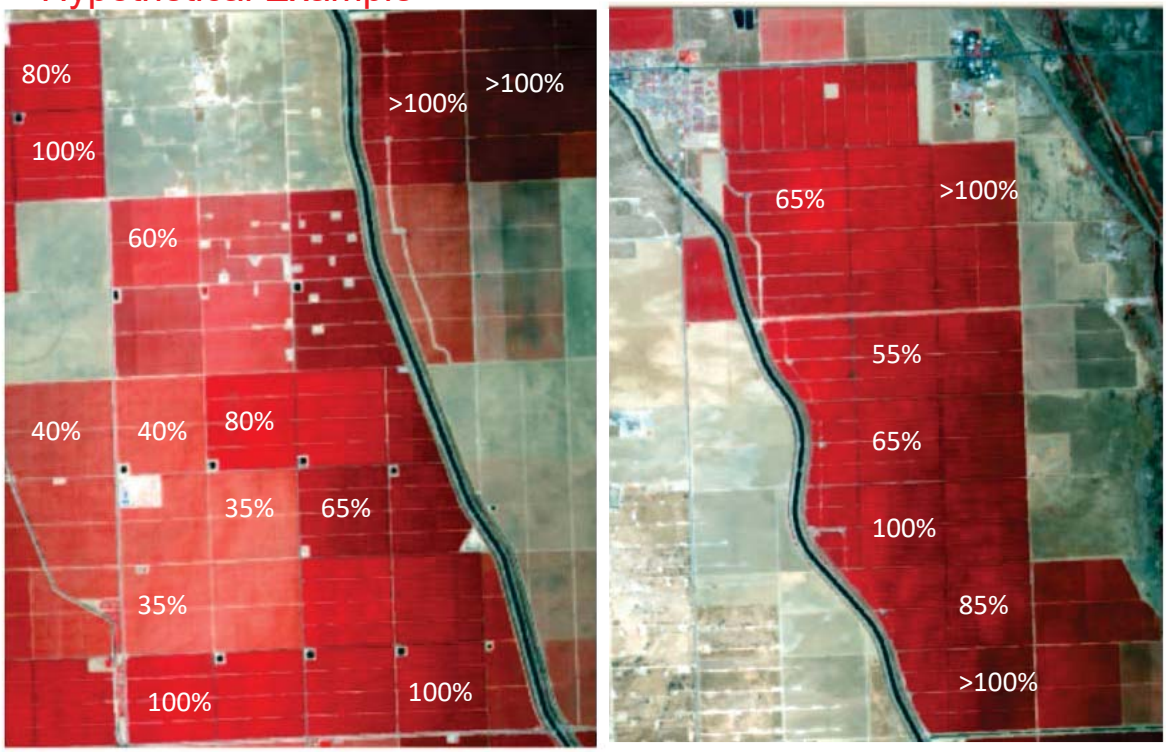
Source: Dr. Brown's lab from UC-Davis

Yield and Final Nutrient Use Efficiency: 275 Lbs N Applied Hypothetical Example

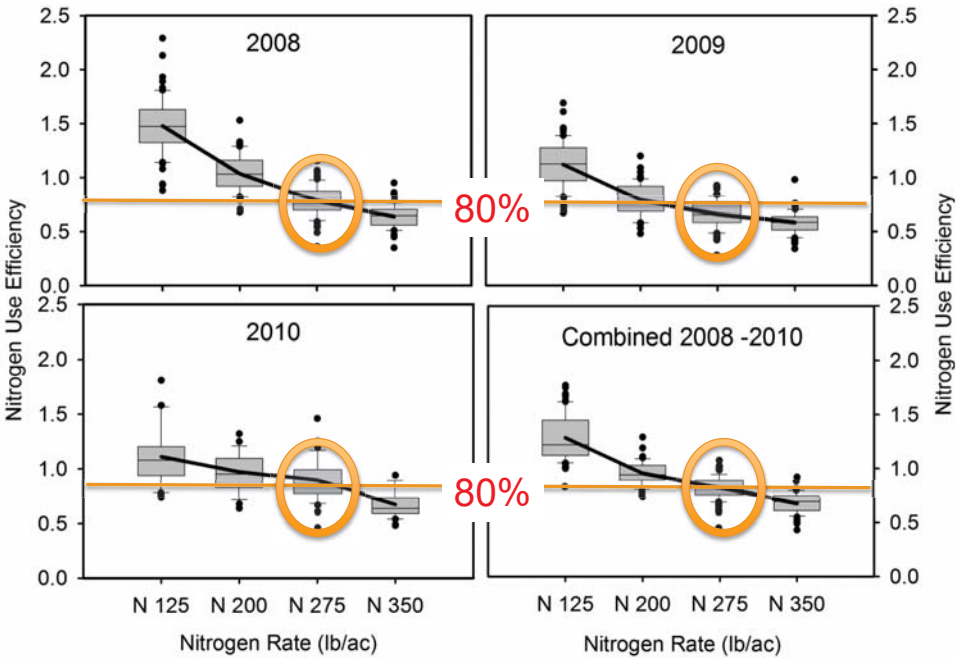


Yield and Final Nutrient Use Efficiency: 275 Lbs N Applied

Hypothetical Example



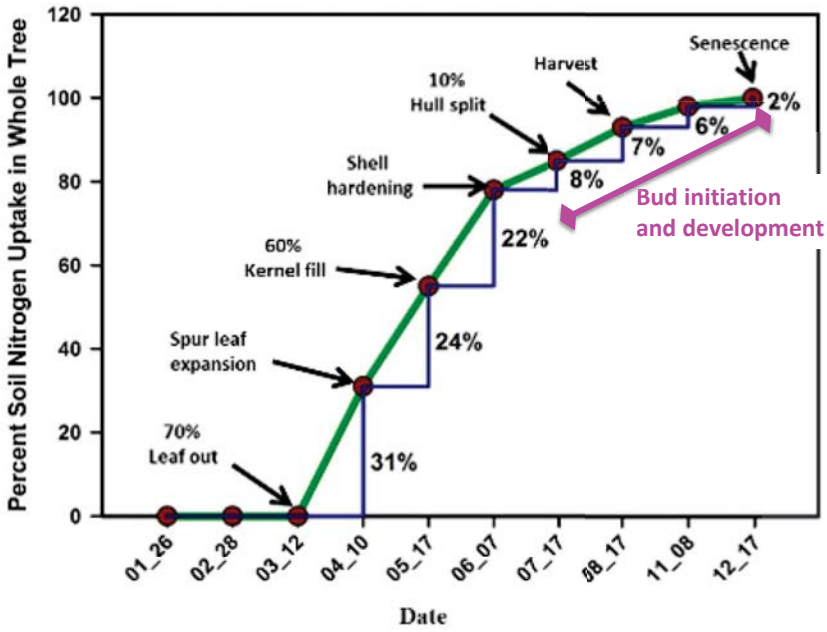
Nitrogen Use efficiency 2008 – 2010 under optimum treatment (N 275) was >80%.



NUE = N Export in Fruit/N Applied

Source: Dr. Brown's lab from UC-Davis

Right Time: From 70% leaf out to Harvest = 92% of uptake



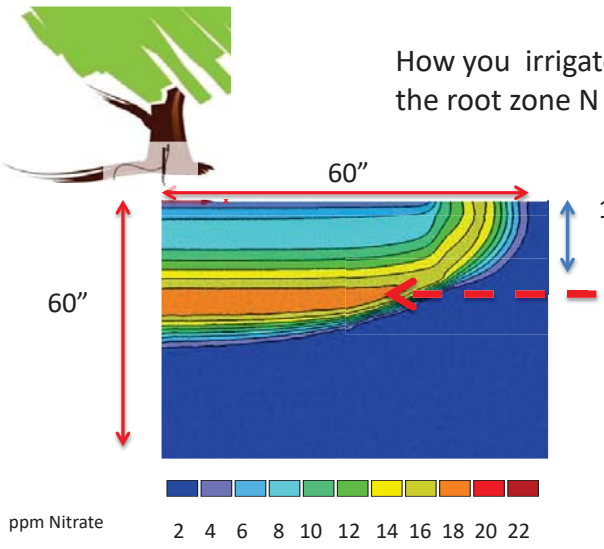
- Ideal Fertilization: Multiple Applications in season timed with demand
- Demand driven by yield (every orchard and cultivar may be different)
- No significant uptake prior to leaf out
- Minimal uptake after harvest (8% or 10-20 lbs).
- Applications managed to keep N in the irrigated root zone
- To optimize N use, all inputs must be optimized

Source: Dr. Brown's lab from UC-Davis

Right Place: Apply during the last third of your irrigation event

Right Place: Impact of Fertigation Timing on Nitrate Uptake by the Tree

Bad Example: N injected in first 3 hours of 12 hour irrigation.



How you irrigate and fertigate determines where in the root zone N is deposited.

Kandelous, Unpublished

Right Place: Where does N uptake occur?

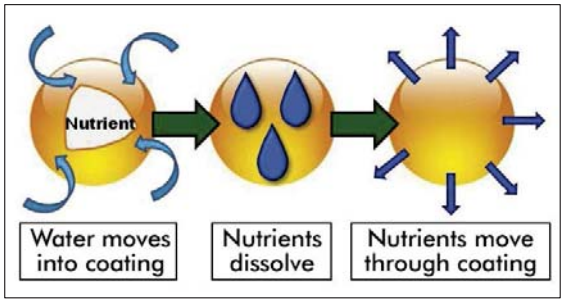
Soil and Irrigation Practices will Influence this Greatly.

Specie	Depth of Main Root Feeding Zone (inches)	Reference
Almond	3-18	Olivos et al (2013)
Apricot	3-12	Ghena and Tercel 1962
Cherry	3-15	Tamasi 1975
Peach	0-25	Dziljanov and Penkov 1964b
Plum	1-20	Tamasi 1973
Walnut	0-20	Kairov et al. 1977

Adapted from: Atkinson, 1980. The Distribution and Effectiveness of the Roots of Tree Crops. Horticultural Reviews.

Right Source: Forms of fertilizer: Enhanced efficiency

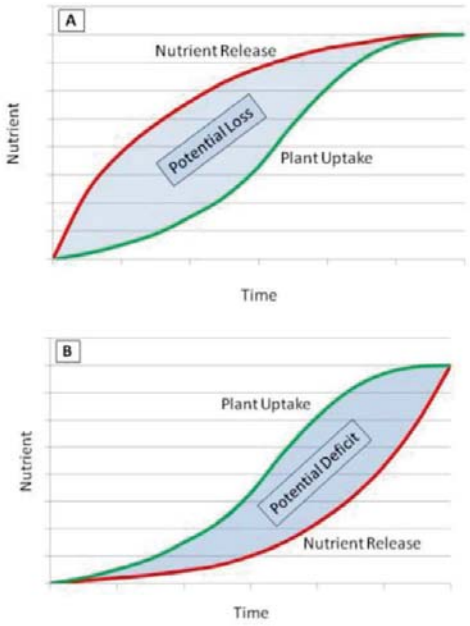
- New technologies have been developed to improve nutrient stewardship
- Some of the important categories include:
  - Coated fertilizers
  - Slowly soluble fertilizers
  - Inhibitors of biological processes
  - Other nutrient enhancing materials



Source: 4R Plant Nutrition: A Manual for Improving the Management of Plant Nutrition, 2012 IPNI

Right Source: Forms of fertilizer: Enhanced efficiency

- Synchronizing nutrient release with plant demand is a challenge with enhanced efficiency fertilizers.
- The same challenge is valid for organic fertilizers.



Source: 4R Plant Nutrition: A Manual for Improving the Management of Plant Nutrition, 2012 IPNI

Right Monitoring: Be Proactive - April Leaf Sampling

- Collect leaves from 18 to 28 trees in one bag (depending of the confidence level and on the number of acres).
- Each tree sampled at least 30 yards apart.
- In each tree collect leaves around the canopy from at least 8 well exposed nonfruiting spurs located between 5-7 feet from the ground.
- In April, collect samples at 8121 GDH +/- 1403 (43 days after full bloom (DAFB) +/- 6 days).
- If you would like to collect samples in July, then collect samples at 143 DAFB +/- 4 days. SAME RULES!

Source: Dr. Brown's lab from UC-Davis

Conclusions: Managing Nitrogen in Almond

Base your fertilization rate on realistic, orchard specific yield, account for all N inputs and adjust in response to spring nutrient and yield estimates.

- **Make a preseason fertilizer plan based on expected yield LESS the N in irrigation and other inputs.**
  - **1000lb kernel removes from 68lb N, 8lb P and 80lb K.**
- **Conduct (properly!) a leaf analysis following full leaf expansion ~ Mid of April.**

Conclusions: Managing Nitrogen in Almond

- **In May, review your leaf analysis results and your updated yield estimate, then adjust fertilization for remainder of season.**
- **At harvest review yields and adjust post harvest fertilization accordingly**
- **Time application to match demand in as many split applications as feasible**
  - **80% N uptake occurs from full leaf out to kernel fill.**
  - **Apply up to 20% hull split to immediately post harvest, corrected for actual yield - but only if trees are healthy.**
  - **Optimize everything!**
- **Every field, every year, is a unique decision**

Together we develop valuable tools and resources for our growers and processors

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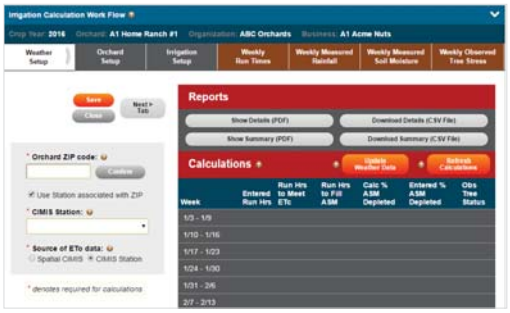

Nitrogen Calculator

- Estimates N need + timing of applications based on yield estimates
- Provides ILRP required N Management Plan