Nitrogen Management for Almonds

David Doll

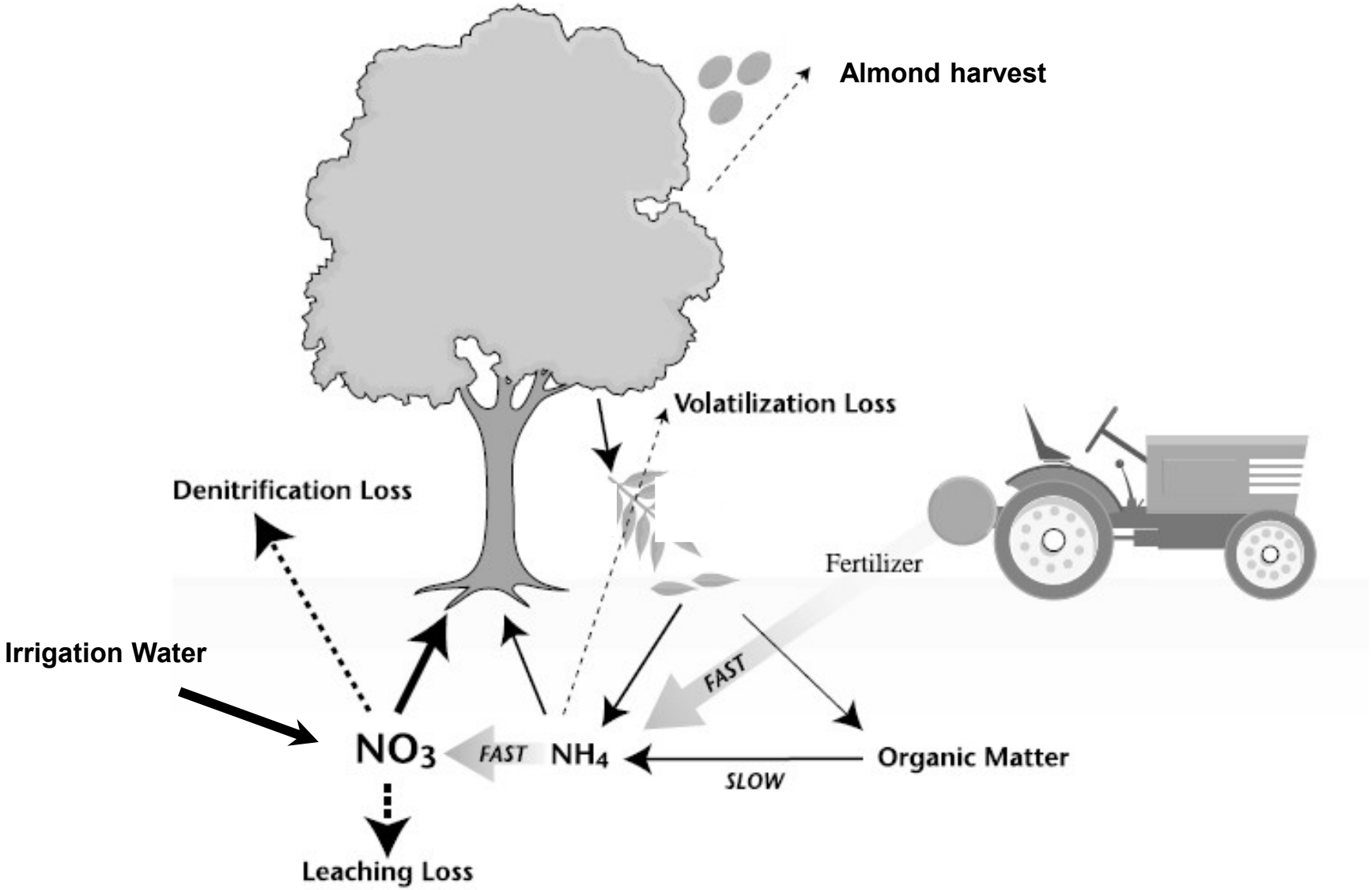
Rota Unica

6/3/2020

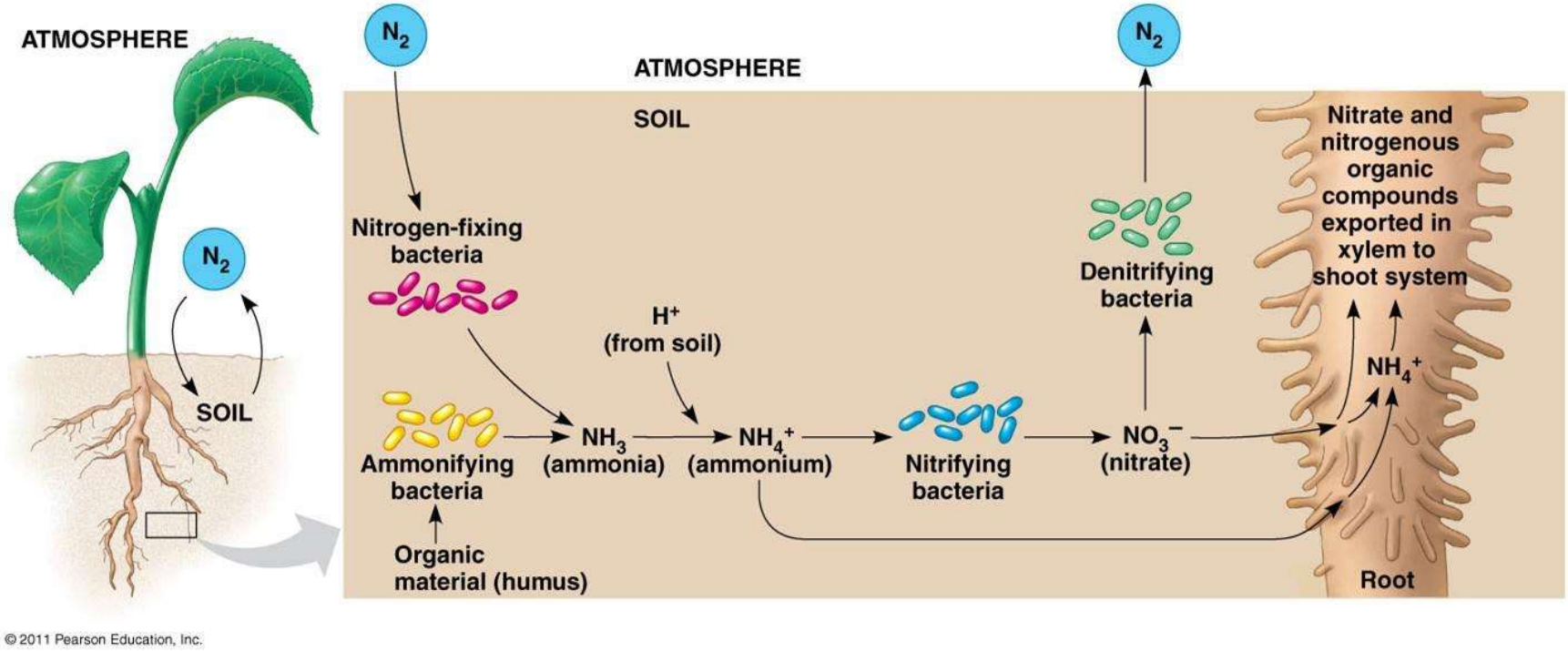
Overview

1. Basics of Nitrogen Management within Almonds
2. Management for Mature Orchards
3. Management for Developing Orchards
4. System feedback and examples

Nitrogen Cycle w/in Orchard



Nitrogen Cycle w/in Orchard



The plant can use two types of nitrogen:
Nitrogen can be actively “pumped” into the plant as ammonium (NH4)
Moves with the water via mass flow as nitrate (NO3)

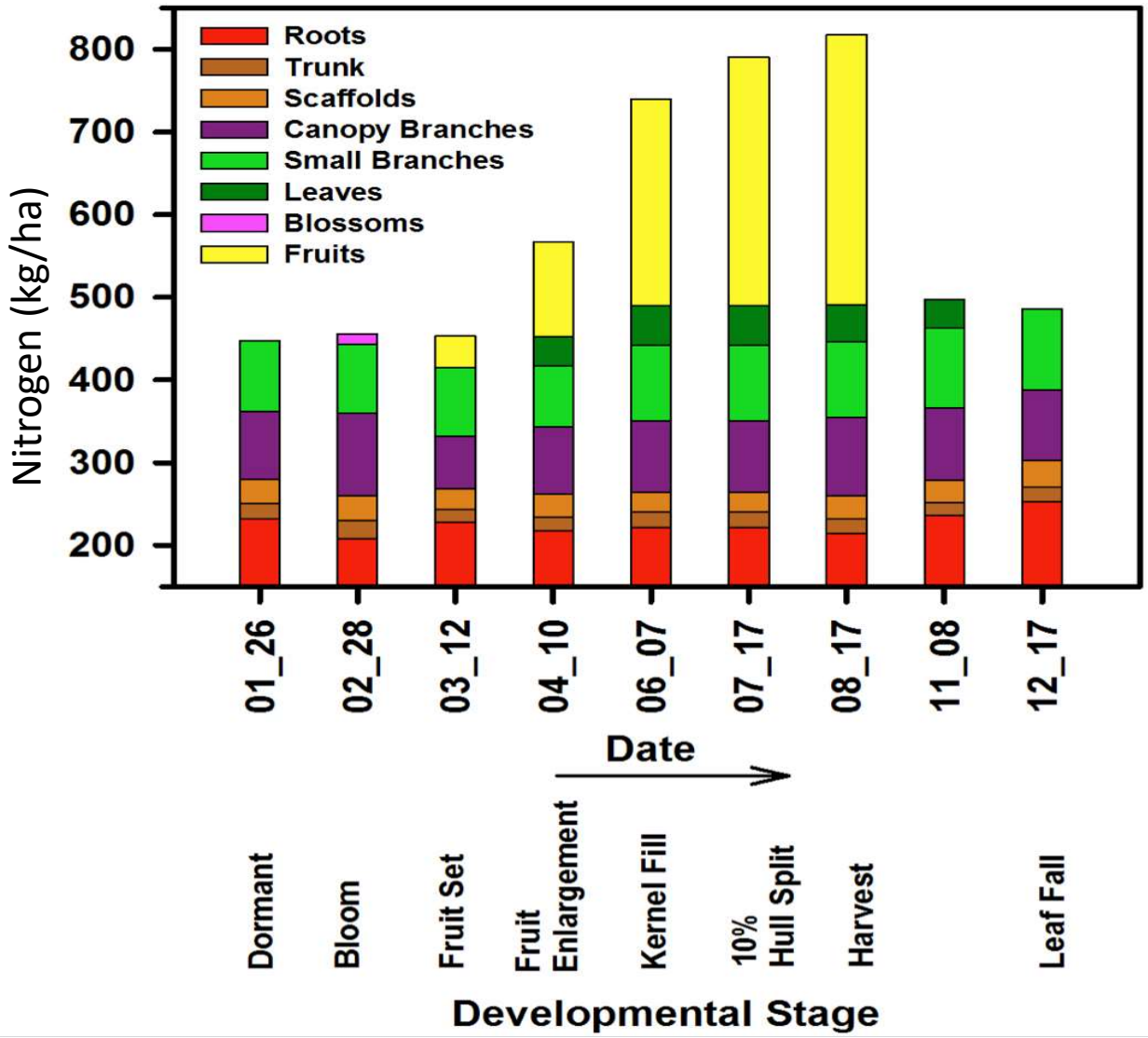
Sources of Nitrogen

- **Urea** – produced through Haber-Bosch process, must be converted to nitrate, can volatilize, water soluble, stable (~46% N)
- **Ammonium (NH_4^+)** – Can be used by plants in anaerobic conditions, positively charged in neutral, acidic soils
  - Ammonium Sulfate
- **Nitrate (NO_3^-)** – Plant available form of nitrogen, negatively charged, easily leached
  - Calcium Nitrate
  - Potassium Nitrate
- Blends:
  - Urea Ammonium Nitrate (UN-32) – liquid blend
  - Calcium Ammonium Nitrate (CAN-17) – liquid blend

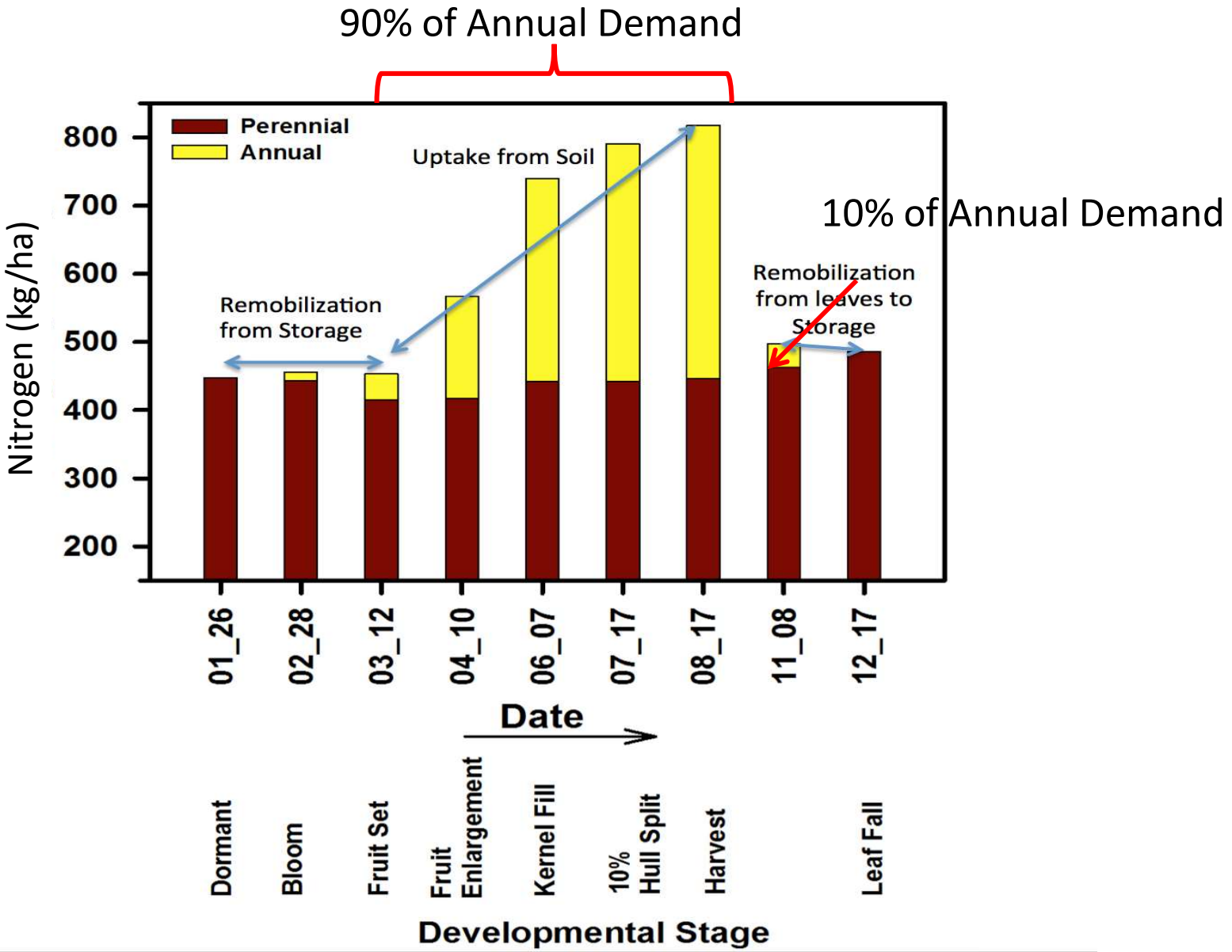
Source of Nitrogen

- **Groundwater-** sourced as nitrate, usually a contaminant, should be determined by testing
- **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

Almond Tree Nitrogen Demand



Almond Tree Nitrogen Demand



Nitrogen Management For Mature Trees

- Nutrient management plans should be based on nutrient removal
- Rates of macro and micro-nutrients take into account soil characteristics, cropping history, tissue analysis and field observations

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, April, June, and October, respectively
- Leaf samples were pulled at multiple times
- Trees were harvested, and individual tree yields were determined for all data trees, 2 kg sub-samples were collected from two data trees/plot and cracked out to determine kernel weights from field weights

UC Nitrogen Rate Study:
Yield effect different N sources

		UAN 32				CAN 17			
Year	Irrigation	125 lbs	200 lbs	275 lbs	350 lbs	125 lbs	200 lbs	275 lbs	350 lbs
2009	Drip	2689 b	2977 b	3327 ab	3507 a	2512 b	2634 b	3064 b	3605 a
	Fanjet	2776 b	3111 ab	3263 ab	3380 a	3143	3130	3248	3216
2010	Drip	2859 c	3426 bc	3909 ab	4332 a	2624 c	3191 bc	3967 ab	3995 a
	Fanjet	2872 b	3581 a	3810 a	3776 a	3030 b	3410 ab	3993 a	3898 a
2011	Drip	3811 c	4272 b	4643 a	4735 a	3640 c	4336 b	4864 a	4852 a
	Fanjet	3870 b	4014 b	4480 a	4425 a	3803 c	4159 b	4452 a	4398 a

P<0.05, differing letters mean different statistical groupings

Conclusions:

Maximal yields reached with 275 lb/acre (310 kg/ha), no gain from 350 lb/acre (390 kg/ha) treatment;

No difference between nitrogen source

No difference between irrigation system

This was a high-yielding orchard – 5 tons kernel/ha.

Big crops require more nitrogen!

UC Davis Nitrogen Removal Study

Site	Variety	Year	N Removed/1000 kernel kg
Modesto (185 lbs/acre)	Nonpareil	2009	67
		2010	63
Madera (250 lbs/acre)	Nonpareil	2009	75
		2010	82
Arbuckle (190 lbs/acre)	Nonpreil	2009	*
		2010	56
Belridge 2 (275 lbs/acre)	Nonpareil	2009	67
		2010	67

Average N removed/1000 kernel kg – 68 kg (assume ~70kg)

CITA Nitrogen Removal Study - Spain

Variety	Nitrogen exported per kernel ton (kg)
Guara	58
Masbovera	60
Cambra	61
Antoneta	65
Lauranne	68
Ferragnes	74
Moncayo	74
Marta	74
Marcona	79
Nonpareil	87
Desmayo Largueta	82

- Nitrogen export rates varies by variety;
- If variety isn't listed, might be best to utilize the average – 71 kg/kernel ton;
- Reduce rates if soil and leaf levels are increasing.

Source: Espada, et al, 2010

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

Average Crop Requirement

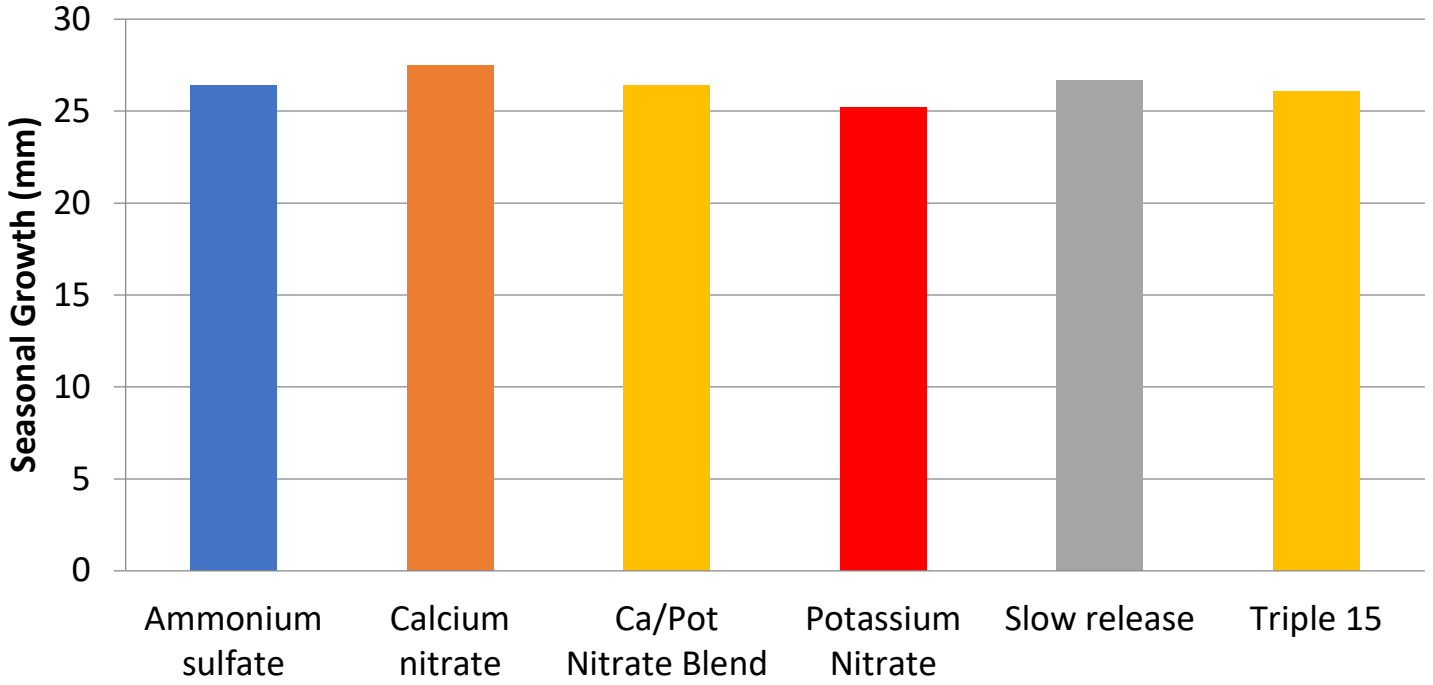
~71 kgs of N exported for every 1000 kgs of kernel crop

- Nitrogen rate should be based on demand and crop removal;
- Conduct a preseason (March) estimate of expected yield; based upon historic yield trends for each orchard, last year's yield, and grower experience;
- If yielding under 2 ton/ha, need to add an additional 25 kg of nitrogen (e.g. 1.5 ton/ha crop = 130 units of N/ha);
- Account for other sources of nitrogen and nitrogen use efficiency.

Nitrogen for Developing Orchards

First Year Fertilizer Studies: Merced County

Sandy loam soil, irrigated with micro-sprinklers, acidic soils, medium cation exchange capacity – 150 grams/tree total N, 6 applications of 25 grams /tree



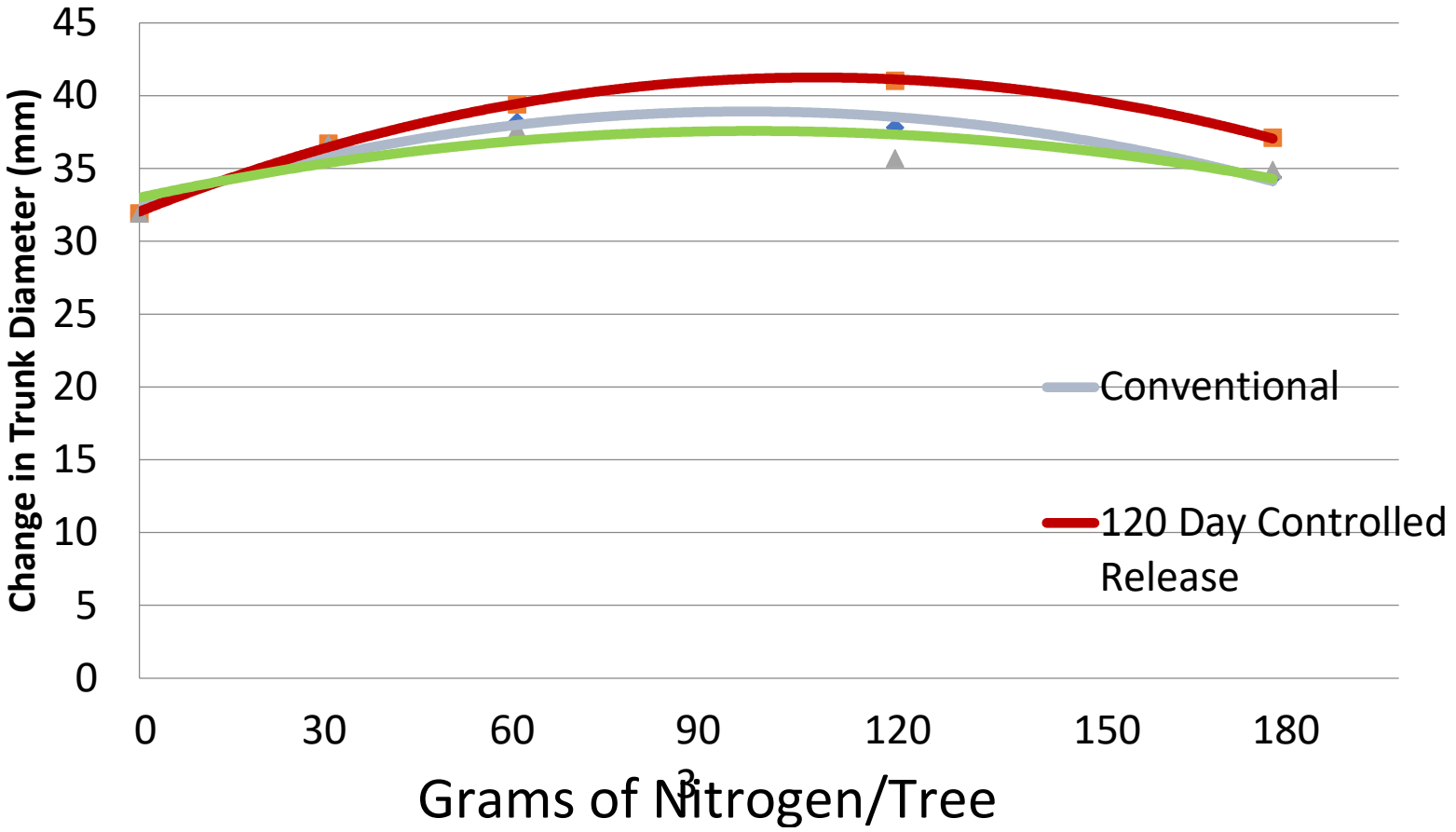
Nitrogen source did not influence trunk caliper change.

Fertilizing Young Almond Orchards: What Rate?

Fertilizer Rate Trials

- Sand soil
- Nitrogen was sourced using blended triple 15 granular, controlled release
- Applied at variable rates with 0, 25, 50, 100, 150 grams of N/tree with split applications
- Tree growth and tissue (tissue not shown)

Merced Trials – First Year Almond Fertilization Rate



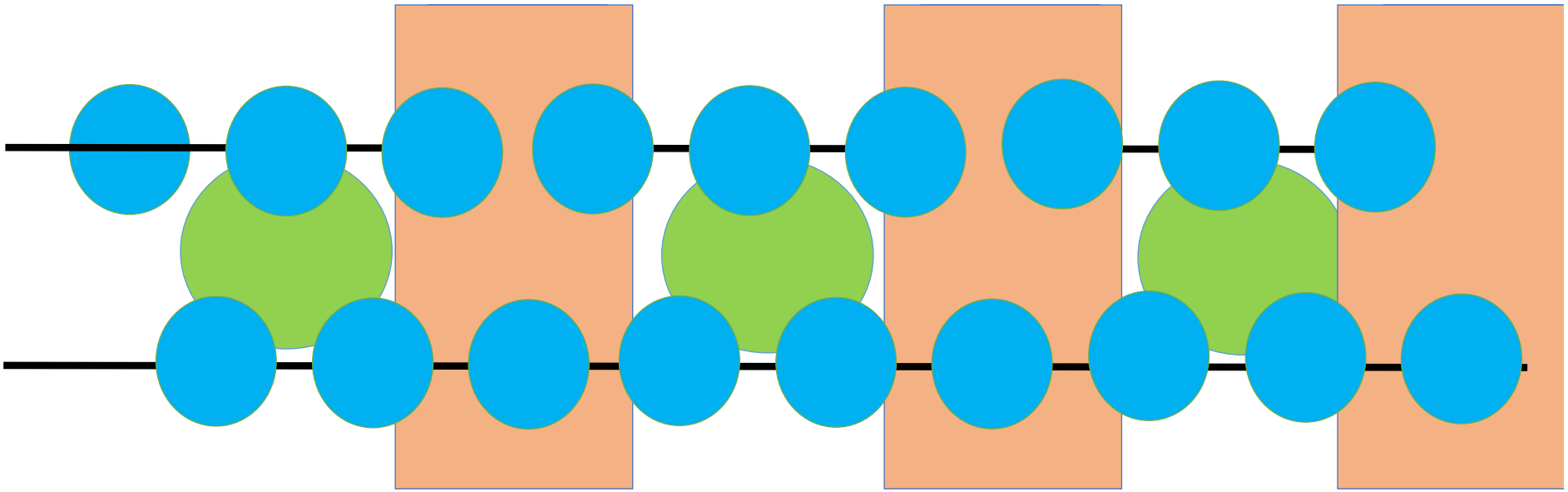
Fertilizing Young Almond Orchards: What rate?

- Study suggest somewhere between 120-150 grams of Nitrogen per tree
  - Supported earlier work of John Edstrom
  - Supports Patrick Brown's work of 25-35 kg/ha of vegetative growth requirement

Rate/Tree	4.5x6.7 (331)	4 x 6.7(373)	4 x 6 (415)
120 grams	40 kg/ha N	45 kg/ha N	50 kg/ha N
150 grams	50 kg/ha N	55 kg/ha N	62.5 kg/ha N

Growing young trees is more than just nitrogen: Proper irrigation practices must be used in order to maximize growth. Irrigation is 80%, nutrition is 10%!

Fertilizing Young Almond Orchards: Efficiency Considerations



Application Efficiency of systems for young trees is dependent upon delivery to development root system.

To account for this, more nitrogen might be needed to maximize growth.

Fertilizing Young Almond Orchards: How much?

For 2nd leaf or older:

- Nitrogen needs apear to be the same as first year trees.
- Needs to be added to crop requirements if yielding under 2000 kgs/ha
  - E.g. if trees are producing 500 kg/ha, an additional 40 kg/ha will be needed.
- Once the crop is greater than 2 ton/ha, the nitrogen removal method provides sufficient nitrogen for growth

Fertilizing Young Almond Orchards: How much?

BE CONSERVATIVE: Many little feeds are better than one “slug.”

No More than 25 grams of N per tree’s age for any application

1 year old: 25 grams of N per fertilization

2 year old: 50 grams of N per fertilization

WHY?

Fertilizing Young Almond Orchards: How much?

Lanky Growth

Nitrogen Burn

Fertilizing Young Almond Orchards: Other Considerations?

When to start:

- Wait until at least 6-12 inches of new growth
- Hold off irrigation until soil begins to dry down
- Make sure there is adequate phosphorous, potassium, zinc, boron, and copper.

Nitrogen Feedback Measurements

- Mature Trees:
  - Leaf samples
  - Soil Samples
- Developing Orchards:
  - Soil Samples

Almond Tissue Sampling Recommendations

- Tissues should be sampled to determine sufficiency levels
  - Almond: Mid-July and Hull analysis for boron
  - Needs to follow a specific protocol (2-3 non fruiting spurs from 20 trees, 30 meters apart)

Determining Rates/Needs

Proper Leaf Sampling Methods

- Sample trees in late July;
- Collect fully expanded leaves from non fruiting branches
- Collect one to two average looking leaflets from 25-50 trees within the area of interest, 30meters apart
- Submit for testing within 24 hours or dry as soon as possible
- Be cautious of nutrient sprays shifting results

Determining Rates/Needs - Almonds

Mid Summer Leaf Nutrient Analysis (Mid-June)

Element	Critical Value	Suggested Range
Nitrogen (N)	1.8%	2.2-2.5%
Phosphorous (P)	0.10%	0.15-0.3%
Potassium (K)	0.8%	1.2-1.5%
Calcium (Ca)	-	2.0%
Magnesium (Mg)	0.25%	-
Boron (B)	30 ppm	30-65 ppm
Zinc (Zn)	15 ppm	20-25 ppm
Copper (Cu)	4 ppm	6-10 ppm
Sodium (Na)	Not established	<0.25%
Chlorine (Cl)	Not established	<0.3%

Determining Rates and Needs

Soil Sampling

- Should be conducted regularly
- 3-10 sub-samples from the sampling depths for each block
- Generally value to sample active irrigation zone more frequently, deeper depths occasionally
- Be aware of different soil types within fields and sample differently.
- Salinity sampling should be in the fall after irrigation is complete, nutrient sampling for nitrate in the spring

Determining Rates and Needs

Soil Sampling

Nitrate:

- Generally, sampling the top 3 feet is sufficient
- Will account for available nitrogen and can be subtracted from nitrogen budget
- Quick estimation of plant available nitrogen:

$$N\ (kg/ha) = \frac{NO^3\text{-}N \text{ concentration } (mg/kg) * 100\ m^3 * \text{soil sample thickness } (cm) * 1.2\ tons/m3}{1000}$$

Developing a Nitrogen Plan:

- Determining Total Crop Demand in lbs N
  - Almond: Expected yield divided by 1000 and multiplied by 68
- Subtract nitrogen present within soil
- Determining N application rate
  - Subtract N from soil and applied through water from crop demand, multiply by 1.25 (assumes 80% efficiency factor)
- Timing of application should vary by soil type.
  - More “feeds,” the better

Scenario: Almond

- Mature, 7 year almond orchard, Belona
- Expected yield: 2.2 ton/ha kernel
- Double drip line irrigation, 7500 m3 of water use
- Soil test reveals 5 ppm nitrate in top 30 cm

Fertilizing Almond Orchards: N Credits

Nitrate-nitrogen (NO^3-N) in the Soil:

$$N\ (kgs/ha) = \frac{NO^3\text{-N concentration (mg/kg)} * 100\ m^3 * \text{soil sample thickness (cm)} * 1.2\ tons/m3}{1000}$$

Depth	5 PPM	10 PPM	15 PPM	20 PPM
0-15 cm	9	18	27	36
0-30 cm	18	36	54	72

UC Nitrogen Rate Study: Nitrogen Use Coefficient

$$NUE = \frac{\text{Nitrogen Removed}}{\text{Nitrogen Applied}}$$

N Rate (lb/ac)	Drip	Fan Jet
125	1.43	1.30
200	1.03	1.03
275	0.93	0.88
350	0.82	0.70

Almond NUE ~80% using drip irrigation

Nitrogen Budget: Almond

N source	N budget for 2500 kg/ha Cropload
Crop N removed	2.2*71=**156**
N credits from soil	-18
Net Crop N requirement after credits	138 kg/ha
Total fertilizer N for the season to apply (70% NUE)	**172 kg/ha=(138/0.8)**
Amount of additional nitrogen due to inefficiency	34 kg

Application timings for Almond

Using example from before: 190 kgs/ha of nitrogen needed to be applied

Date	% of Total	kg of N
Early Spring	**20**	**35**
Fruit Growth	**30**	**52**
Kernel Fill	**30**	**52**
Fruit Maturity or Early Post-Harvest	**20**	**34**

+ 172 kgs of N

Questions?