Development of Leaf Sampling Methods and Nutrient-budget fertilization

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Methods

Observational trial

- Four Representative CA almond orchards.
- Three different leaf samples (NF/F1/F2)
- Modeling prediction and spatial analysis.
- Individual tree yield.

Fertigation trial (Kern County)

- Two N and three K sources .
- Four N and three K rates.
- Two irrigation Systems: Fan Jet and Drip.
- Leaf and nut samples collected five times during the season.

Observational trial

Model 1
Develop a prediction model.

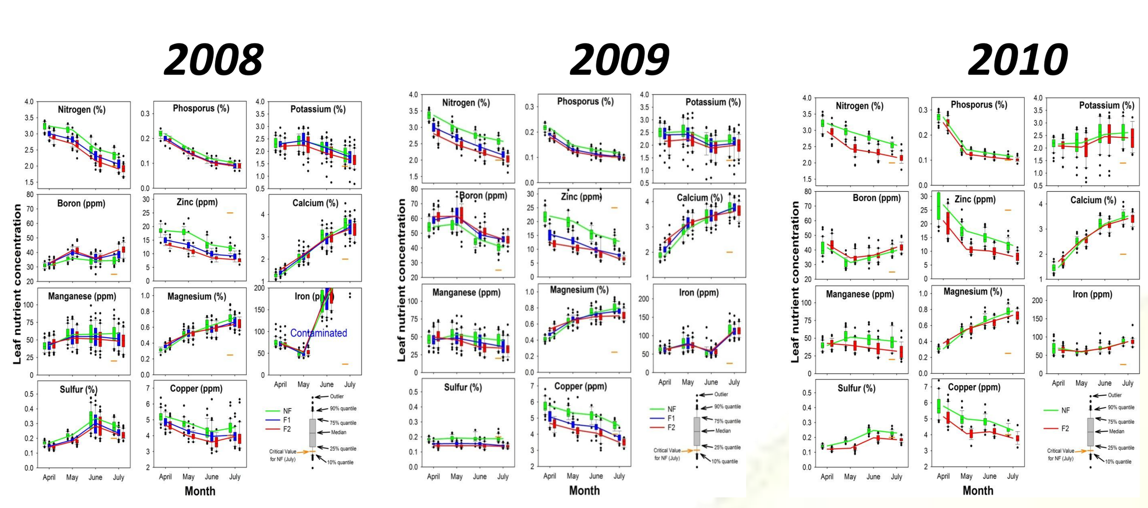


Figure 1. Nutrient behavior throughout 2008, 2009, and 2010 season in leaves from non-fruiting spurs (NF), spurs with 1 fruit (F1), and spurs with 2 fruits (F2). The graphs show data collected from the Arbuckle orchard.

Can we sample in April and Predict July?

Approach: Multi site, multi year, multi tissue and multi element analysis.

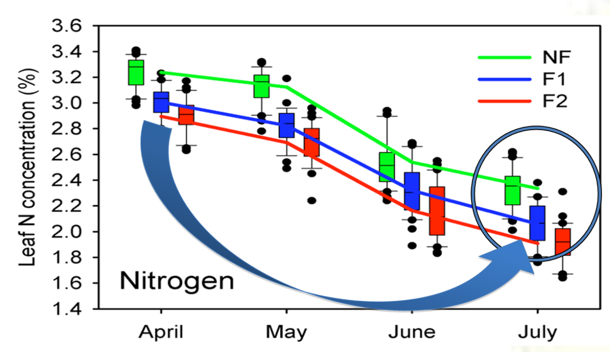


Figure 2. nitrogen behavior through the season n leaves from non-fruiting spurs (NF), spurs with 1 fruit (F1), and spurs with 2 fruits (F2)

Site	Year	July Nitrogen Predicted	July Nitrogen Observed	Predicted Percentage of Trees below 2.2 % at July	Observed Percentage of Trees below 2.2 % at July
Arbuckle	8	2.4	2.3	15%	23%
Belridge	8	2.4	2.4	3%	0%
Madera	8	2.5	2.4	4%	10%
Modesto	8	2.4	2.4	9%	17%
Arbuckle	9	2.4	2.6	10%	0%
Belridge	9	2.4	2.4	11%	3%
Madera	9	2.6	2.4	2%	3%
Modesto	9	2.6	2.7	1%	0%
Arbuckle	10	2.4	2.5	14%	0%
Belridge	10	2.3	2.7	10%	0%
Madera	10	2.3	2.3	12%	21%
Modesto	10	2.4	2.5	7%	0%

Figure 3. Site cross-validation of Model 1 results.

Model 2
Develop prediction model.

Model Output

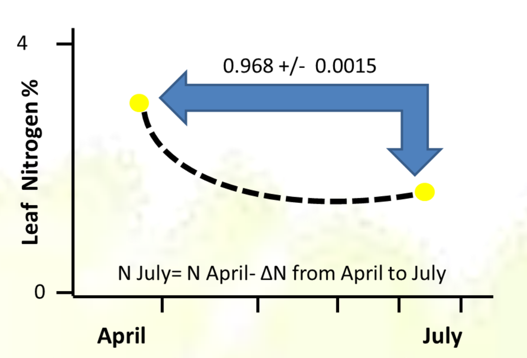


Figure 1. Predicted nitrogen change from April to July

Sampling Output

Number of Acres	Trees needed at 95% Confident	Trees needed at 90% Confident
2	25	18
5	27	19
10	28	19
50	28	20
100	28	20

Note: 1 acre is assumed to be 100 trees

Figure 2. Number of trees needed in April to predict July-Nitrogen-Concentration

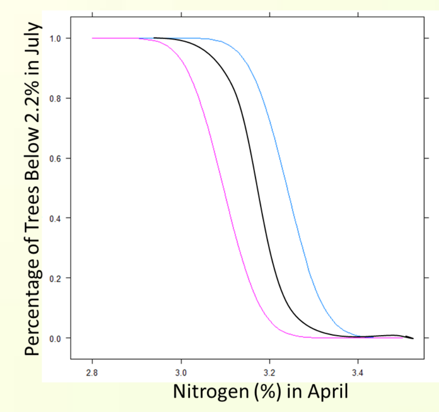


Figure 3. Expected % of trees below 2.2% in July

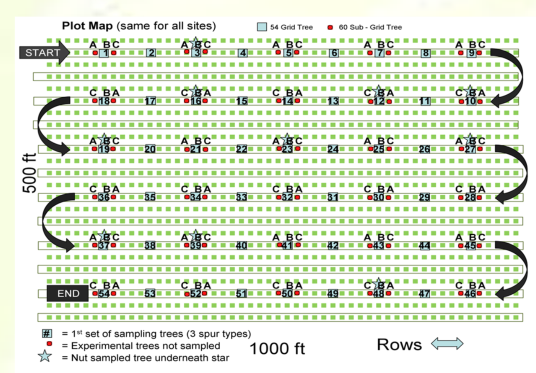


Figure 4. Cluster grid design to calculate the correct sampling protocol.

Preliminary Sampling Criteria

Collect leaves from 18 to 28 trees in one bag.

Each tree sampled at least 30 meters apart.

In each tree collect leaves around the canopy from at least eight well exposed spurs located between 5 and 7 feet from the ground.

In April, collect samples 43 days afer full bloom +/- 6 days)

Preliminary Conclusions

- Two models to predict July nitrogen content and the percentage of trees below the July critical value have been generated.
- The first model is potentially more robust, uses fruiting spur information and has less assumptions than model 2.
- The second model has more assumptions than model 1, must use non fruiting spurs to predict non fruiting spurs, and is potentially more precise than model 1.
- Model 2 suggest that a nitrogen content above 3.3 % in April will result in >95% of all trees being above 2.2% in July.
- These models will be further validated with information collected in 2012.

Fertigation trial

Nutrient response curves

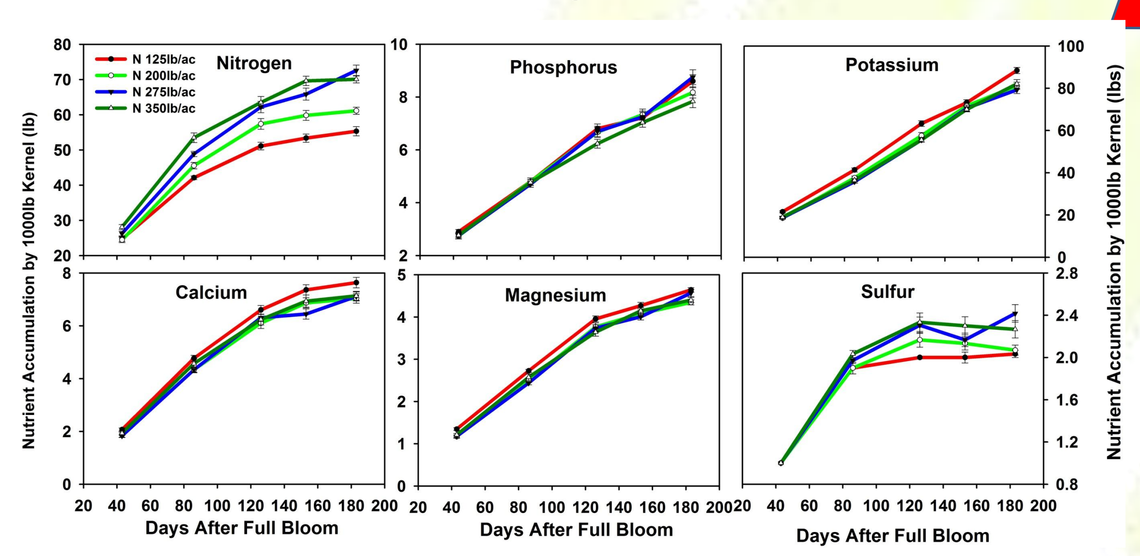


Figure 5. Nutrient accumulation by 1000lb kernel yield for nitrogen rate treatment. Each point represents mean and standard error

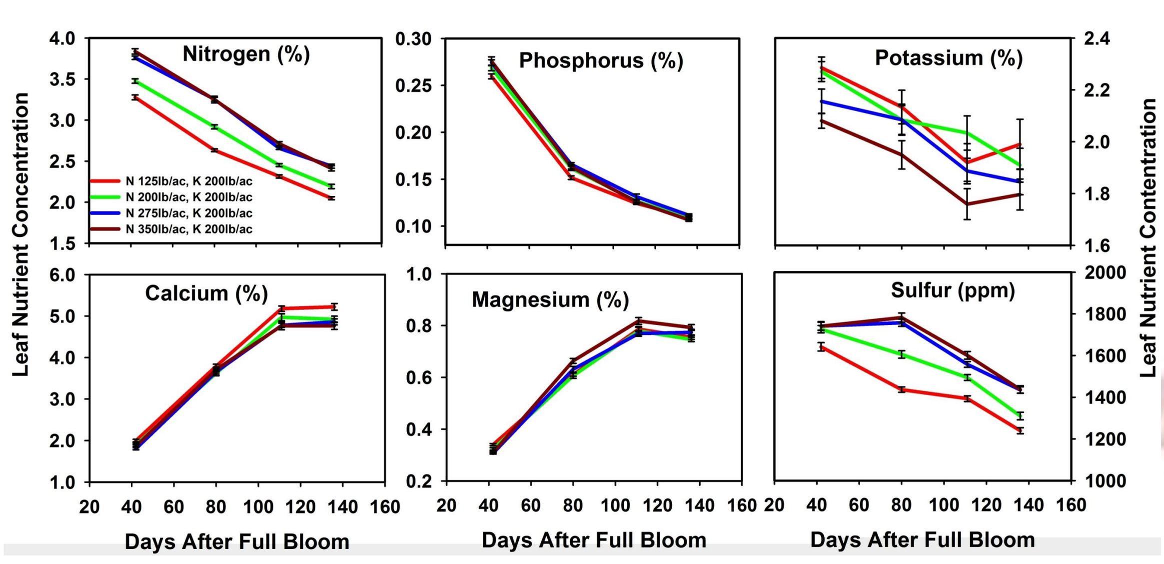


Figure 6. Leaf Nutrient concentration for nitrogen rate treatments. Each point represents mean and standard error

Nutrient use efficiencies

Table 1. Mean kernel yield 2010 and 2011 from nitrogen rate treatment (lb/ac)

Mean Kernel Yield 2010 (lb/ac)

Irrigation	N UAN 32				N CAN 17			
	125	200	275	350	125	200	275	350
Drip	2,865	3,453	3,765	4,064	2,622	3,313	3,960	3,728
	c	b	ab	a	c	bc	ab	a
Fan Jet	2,584	3,109	3,481	3,583	2,730	3,046	3,810	3,530
	c	b	b	a	d	c	a	b

Mean Kernel Yield 2011 (lb/ac)

Irrigation	N UAN 32				N CAN 17			
	125	200	275	350	125	200	275	350
Drip	3,732	4,229	4,696	4,775	3,564	4,365	4,833	4,969
	c	b	a	a	c	b	a	a
Fan Jet	3,744	4,048	4,480	4,406	3,746	4,161	4,420	4,361
	c	b	a	a	c	b	a	a

Means in same irrigation type not followed by the same letter are significantly different at 10%. Statistics are only within irrigation type and not between irrigation types.

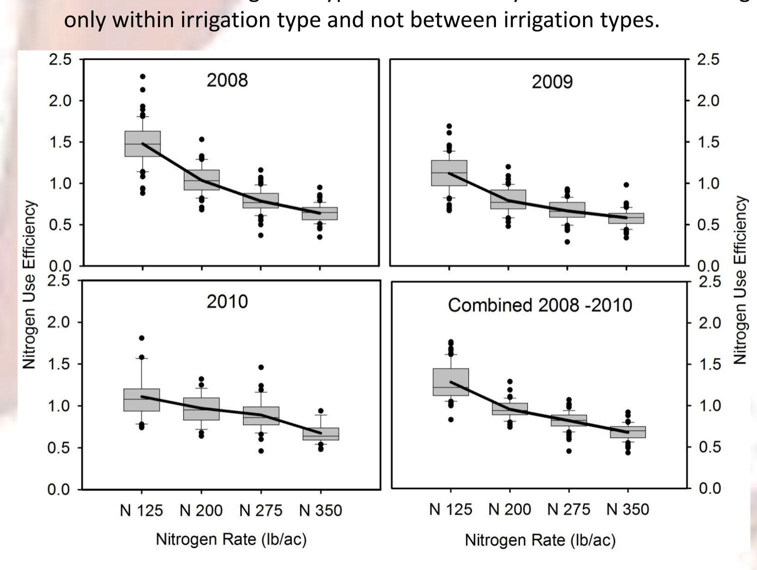
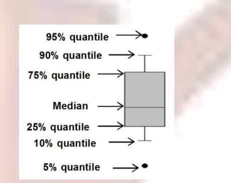


Figure 7. Nitrogen Use Efficiency as ratio of N exported in fruit and N applied, for N rate. Bold line represents the mean.

Legend



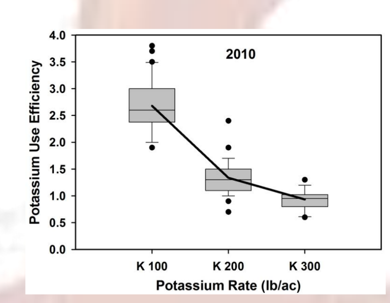


Figure 8. Potassium Use Efficiency for K rate

Preliminary Conclusions

- 1000lb kernel removes from 55 (at a leaf N of 2.0 in July)-70lb N (at a leaf N of 2.4 in July), 8lb P and 80lb K.
- 80% of N, 75% of P and K accumulates in the fruit before 120 DAFB (mid June in 2010).
- K concentration in leaves is highly variable and hence leaf sampling is difficult to interpret.
- In this trial a N rate of 275lb/ac maximized yield (4,700 lb acre) and there was no benefit from N application in excess of this value.
- A Nutrient Use Efficiency (N removed in harvest/N applied) of 75% was observed for N rate 275lb/ac rate.
- Although significant differences in leaf K status were observed; no statistically significant differences in yield have been observed (table 2 and 3)

California almonds AlmondBoard.com | cdfa California Department of Food and Agriculture | USDA United States Department of Agriculture National Institute of Food and Agriculture Specialty Crop Research Initiative Project | Tessenderlo Kerley | YARA

Table 2. Mean Leaf Potassium content (%) in July 2010 for K rate.

Mean Leaf Potassium in July 2010 (%)

Irrigation	K Rate (lb/ac)		
	100	200	300
Drip	1.9	2.0	2.2
	b	ab	a
Fan Jet	1.43	1.81	2.23
	c	b	a

Means in same irrigation type not followed by the same letter are significantly different at 10%. Statistics are only within irrigation type and not between irrigation types.

Table 3. Mean kernel yield 2010 and 2011 from Potassium rate and Source treatment (lb/ac).

Mean Kernel Yield 2010 (lb/ac)

Irrigation	K Rate (lb/ac)			K Source @200lb/ac		
	100	200	300	SOP+KTS	SOP	KCL
Drip	3,829	3,765	3,844	3,659	3,649	3,583
Fan Jet	3,501	3,481	3,475	3,496	3,431	3,080
				a	a	b

Mean Kernel Yield 2011 (lb/ac)

Irrigation	K Rate			K Source @200lb/ac		
	100	200	300	SOP+KTS	SOP	KCL
Drip	4,733	4,696	4,807	4,783	4,839	4,874
Fan Jet	4,379	4,480	4,525	4,498	4,345	4,407

Means in same irrigation type not followed by the same letter are significantly different at 10%. Statistics are only within irrigation type and not between irrigation types. K rate treatments were applied as 60% SOP and 40% KTS