Development of Leaf Sampling and Interpretation Methods for Almond

Project No.: **08-HORT8-Brown**

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Objectives:

- Determine the degree to which leaf nutrient status varies across a range of representative orchards and environments
- Determine the degree to which nutrient status varies within the canopy and within the year.
- Validate current nutrient Critical Values and determine if nutrient ratio analysis provides useful information to optimize fertility management.
- Develop and extend an integrated nutrient BMP for almond.

Ninety percent of growers and consultants participating in the recent CDFA-FREP funded focus groups on Nutrition and subsequent surveys of growers, felt that UC Critical Values (CV's) were not appropriate for current yield levels, were not useful early in the season and did not provide sufficient guidance for nutrient management. Two explanations for this observation are possible, 1) the current CV's are limited in application and are possibly incorrect, or 2) that there are systematic errors in the manner in which critical values are used. While it is not known if UC CV's are incorrect (this will be verified), it is known that they have not been validated for early season use and it is clear that there has been a systematic error in the way leaf sampling and CV's have been used. Currently, standardized leaf samples from random trees scattered through the orchard are collected, analyzed for nutrients and compared with established CV's. If the resultant mean field nutrient concentration is equal or greater than the CV then the field is deemed to be sufficient. In high value crops, however, this is an invalid approach since it will result in half of the field being below the critical value. Growers, who have observed that a higher 'CV' is beneficial, are in effect, bringing a greater percentage of individual's trees above the CV.

We conclude that the 'problem' with current CV's is not that they are necessarily wrong, but that they do not account for within-field, within-canopy, between season or within-season variability. Preventing the occurrence of a deficiency in any part of an orchard or canopy, at any time of the year, is essential to high productivity and fertilizer use efficiency and is the goal of good growers. Unfortunately, the tools to achieve this economically and in an environmentally sound manner are not available and over-fertilization is currently the only tool growers have to ensure optimal field productivity. The recent CDFA-FREP nutrition focus group demonstrated that growers are aware of this problem and have a clear desire to find a better approach.

This project aims to correct this situation by developing new approaches and interpretation tools that better quantify field and temporal variability, are sensitive to yield and provide for in-season monitoring and fertilizer optimization in Almond and Pistachio. This project will also offer the unique opportunity to verify current CV's and determine the utility of nutrient ratios as a diagnostic tool.

All trials have been initiated in 8 to 10 year old (yo) microsprinkler irrigated (one drip irrigated) almond orchards of good to excellent productivity planted to Non-Pareil (50%) in soils representative of the region and a large percentage of almond acreage. At experiment completion, trees will have reached 11 or 14 yo (after 3 or 5 years) representing their most productive years. For each of 4 almond sites (Arbuckle, Salida, Madera, Bakersfield), plots are a 10-15 acre contiguous block. Both leaf and nut samples will be collected at 5 times during the season, selected from 114 trees in each plot for a period of 3-5 years. Sample collection will be spaced evenly over time from full leaf expansion to one month post-harvest. As a phenological marker, days past full bloom and stage of nut development will be noted. Light interception, trunk diameter, and individual yields of these trees will also be measured.

Standard leaf sampling protocol will be carried out on exposed, non-fruiting spurs (NF), as well as collecting leaves from fruiting spurs with 1 (F1) and multiple fruit (F2+) to explore different sampling methods. Composite nut (NUT) samples will be collected from each site. Both leaf and nut samples will be processed by researchers prior to being sent to the DANR Analytical Laboratory located on the UC Davis campus.

2008 Sampling Schedule for single site

	1*	2	3	4	5	6**	
Sample Type	6-Apr	12-May	16-Jun	26-Jul	15-Aug	17-Oct	Total
Non-fruiting spur leaves (NF)	30	114	114	30		30	318
Fruiting spur leaves - 1 nut (F1)	30	30	30	30		30	150
Fruiting spur leaves – 2+ nuts (F2+)	30	30	30	30		30	150
Nut sample	10	10	10	10	10		50
	100	184	184	100	10	90	668

*6-Aprsampling date based on estimated date of full leaf expansion.
**15-Sep sampling date 1 month post-harvest (harvest date estimated)

An extensive Grid-Sampling protocol has been established at each site using techniques developed for GIS (with Richard Plant, a leading agronomic statistician). At 54 grid points uniformly distributed across a 10-15 acre block of trees, May and July leaf nutrient status, light interception, trunk diameter and tree yield will be determined in each Nonpareil tree. At 30 of these grid points, the nutrient status and yield of 2 neighboring NP trees will also be collected as independent data points. Initially, non-fruiting spur leaves in exposed positions will be selected for these samples, however, depending on the early results, sampling protocols may be adjusted. Two statistical techniques ‘nugget sampling’ and ‘modified Mantel’ statistics will be used, this approach allows for partitioning of variance in nutrient status due to environment, due to genetic variability and 'random' variability and allows for determination of the interactions and dependencies between nutrition and yield and the nature of spatial variability within an orchard.

Overall this experiment will collect far more samples (2,672 samples from 456 individual trees), analyzed for more nutrients (N, K, P, S, Ca, Mg, B, Zn, Mn, Fe) than ever performed before and will collect the individual tree yields associated with each of these samples. This detailed approach is designed to provide the foundation statistical information needed to guide fertilizer practice for the forseable future.

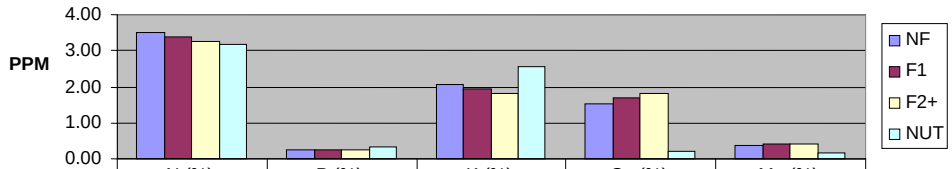
Interpretive Summary:

This experiment commenced in 2008 and results of only the first of the nutrient sampling dates and field yields have been determined. Full analysis of yield x nutrient status and within tree and between trees variability is not available at this time.

Results from the April round of leaf and nut sampling are given in Figures 1 and 2. Though statistical analysis has not yet been performed, it is apparent that there are differences between sampling type. As expected, non-fruiting spur leaf samples tend to have higher nutrient concentrations than fruiting spurs.

The fifth and final round of sampling will be conducted in mid-October. Lab analyses are being performed on the 2nd-4th rounds of sampling.

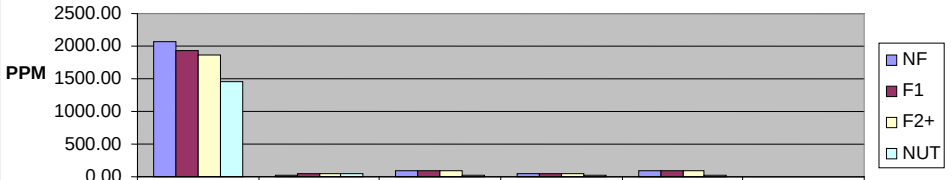
Figure 1. 4 Site Average from April Sampling for N, P, K, Ca, & Mg According to Sampling Type



	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
NF	3.50	0.26	2.04	1.54	0.35
F1	3.38	0.25	1.96	1.68	0.39
F2+	3.27	0.24	1.81	1.80	0.42
NUT	3.18	0.35	2.57	0.21	0.18

Nutrient

Figure 2. 4 Site Average from April Sampling for S, B, Zn, Mn, Fe, & Cu According to Sampling Type



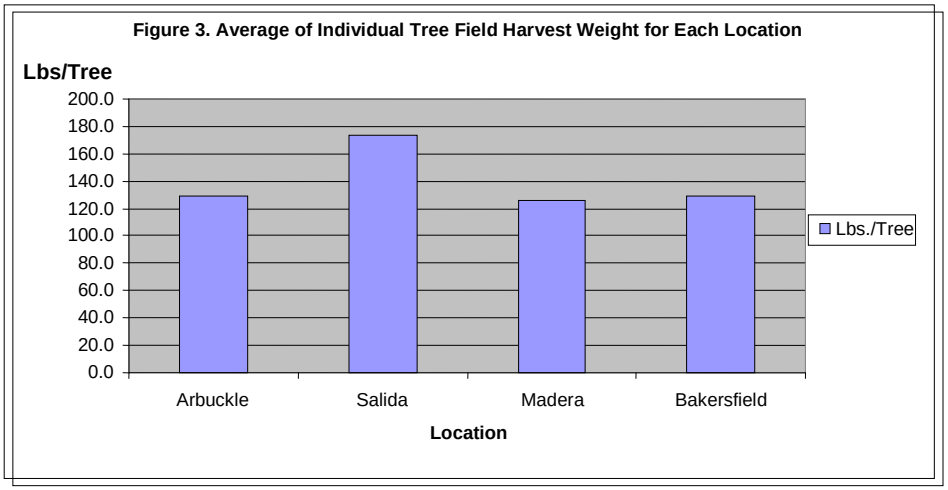
	S (ppm)	B (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)
NF	2066.58	32.97	93.08	39.12	84.46	6.25
F1	1927.67	34.36	98.23	40.95	86.46	6.05
F2+	1869.83	35.10	99.66	42.64	86.63	5.78
NUT	1460.00	55.68	29.13	12.38	32.98	7.94

Nutrient

Harvest field weights were obtained in August and the data are shown in Table 1 and Figure 3. Currently, 4 lb. samples from each individual tree at each location are being cracked out for additional yield data. Once more data from leaf/nut samples are available, statistical analyses will also be performed.

Table 1. Average Field Harvest Whole Fruit Weights (est 25% Kernel)

Location	Lbs./Tree	Lbs./Acre	Tons/Acre
Arbuckle	129.2	14215	7.11
Salida	173.1	17105	8.55
Madera	126.1	15387	7.69
Bakersfield	128.6	11458	5.73
All Sites	139.3	14541	7.27



This project will be continued 2009 - 2012.