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**The Proceedings of the International Plant Nutrition Colloquium
XVI**

Title

Development of leaf sampling and interpretation methods for Almond

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<https://escholarship.org/uc/item/8xt7q3jb>

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Publication Date

2009-07-28

Peer reviewed

Introduction

A recent focus group on Tree Nutrition, supported by the Fertilizer Research and Education Program (FREP) of the California Department of Food and Agriculture (CDFA), indicated that current nutrient management practices in tree crops are insufficient. Ninety percent of growers and consultants participating in this group and in subsequent surveys felt that the University of California's (UC) Critical Values (CVs) 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 CVs are limited in application and are possibly incorrect, or 2) there are systematic errors in the manner in which critical values are used. While it is not known if UC CVs 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 CVs have been used. Currently, standardized leaf samples from random trees scattered through an orchard are collected and analyzed for nutrients. The nutrient concentrations are then compared with established CVs, providing an estimate of the nutritional status of the orchard. If the resulting mean field nutrient concentration is equal or greater than the CV, then the nutrient supply for the whole field is deemed sufficient. In high value crops, however, this might not be a good approach, since it can 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 trees above the CV.

This research aims to develop 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 research will also offer the unique opportunity to verify current CVs and determine the utility of nutrient ratios as a diagnostic tool. Thus, the goals of this project are to 1) determine the degree to which leaf nutrient status varies across a range of representative orchards and environments, 2) determine the degree to which nutrient status varies within the canopy and throughout the year, 3) validate current CVs and determine if nutrient ratio analysis provides useful information to optimize fertility management, 4) develop and extend integrated Best Management Practices (BMP) for nutrient management in Almond.

Materials and Methods

All trials have been initiated in 8 to 10 year-old microsprinkler irrigated (one drip irrigated) almond orchards of good to excellent productivity planted to "Non-Pareil" (50% of all trees) almonds in soils representative of the region and a large percentage of almond acreage. At experiment completion, trees will have reached ages of 11 or 14 years (after 3 or 5 years), representing their most productive years.

All four study sites (at Arbuckle, Modesto, Madera and Lost Hills, California, USA) consist of contiguous blocks of 10-15 acres (4-6 ha). Leaf and nut samples are collected 5 times during the season over a period of 3-5 years. At each sites, 114 trees are sampled. Sample collection is spaced evenly over time from full leaf expansion to one month post-harvest. As phenological markers, days past full bloom and stage of nut development are recorded. Light interception, trunk diameter, and individual yields of these trees are also measured.

Using a standard leaf sampling protocol, samples are taken from exposed, non-fruiting spurs (NF), as well as from fruiting spurs with 1 (F1) and 2 fruits (F2) to determine the influence of the sampled plant part on accuracy of the sampling strategy. Composite nut samples are also collected from each site. Both leaf and nut samples are dried and ground prior to sending them to the DANR Analytical Laboratory located on the UC Davis campus.

Results and Discussion

This observational study illustrates nutrient dynamics throughout the season. Data from the first year of sample collection (2008 field season; Figure 1) suggest that nutrient concentrations and their variability depend on the nutrient sampled, sample type and sampling time.

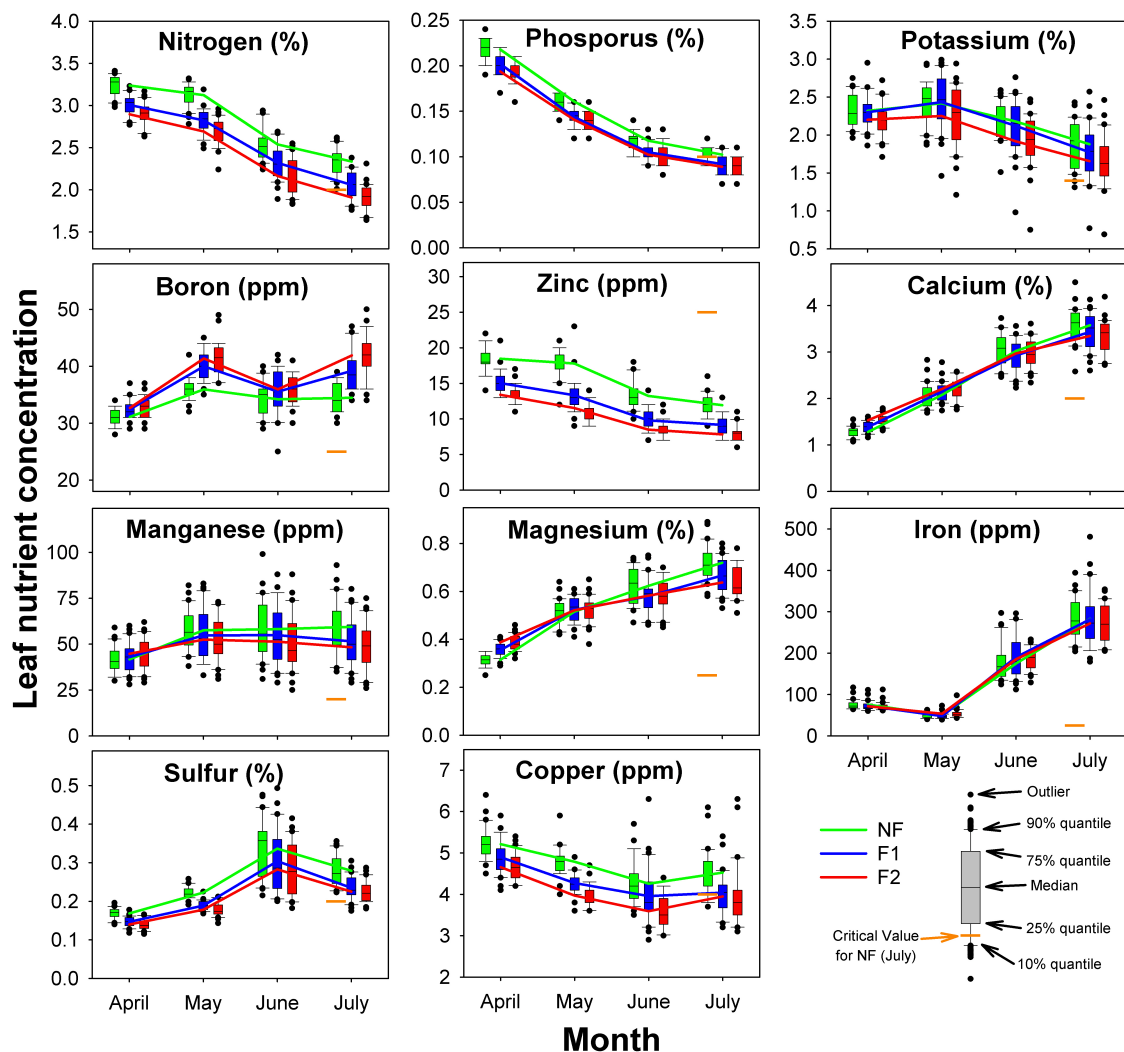


Figure 1. Nutrient behavior through the season in leaves from: non-fruiting spurs (NF), 1fruit spur (F1), and 2 fruiting spurs (F2). Data collected from one location (Arbuckle) during 2008 year.

Local fruit load, for example, appeared to significantly affect concentrations of N, P, K, B, Zn, S, and Cu. Other nutrients, such as Ca, Mg, Mn and Fe were much less affected by local fruit load. A clear effect of local competition between fruit and leaf can be observed for some nutrients. This competition may be critical for explaining nutrient mobilization from leaves to local nut load. Thus, there is preliminary evidence to postulate that the death of loaded spurs may be attributable to a local nutrient deficit throughout the season. The current sampling protocol, which only includes leaf samples from non-fruiting spurs, may not reflect true tree nutrient status. Values, which at present fall in the adequate range, don't express the real nutrient concentration in fruiting spurs. Assuming an adequate nutrient level based on this measure might fail to account for the requirements of plant structures that hold the yield of the season (spurs with fruit). These effects, clearly visible for Zn, are more significant when nutrient concentrations in NF samples are near or below critical values. On the other hand, B concentration throughout the season presents an opposite behavior from the other nutrients. The higher B values from F1 and F2 samples are surprising and may result from co-transport of B with sorbitol from source leaves to sink tissues

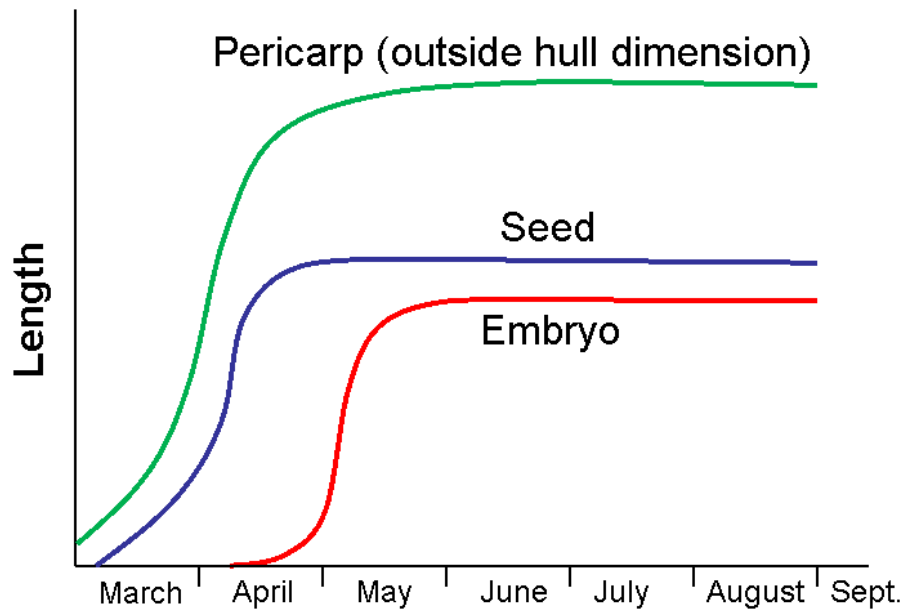


Figure 2. Conceptual representation of fruit development through out the season

Finally, the apparent changes in the increase/decrease rates of nutrient concentrations in May (30 days after flowering) and June (60 days after flowering) for almost all nutrients can be attributed to the exponential growth of the fruit during its phase I of the simple sigmoid curve (Figure 2), a common conceptual model of fruit development.