# Exploratory Study to Evaluate the Feasibility of Measuring Leaf Nitrogen Using Silicon-Sensor-Based Near Infrared Spectroscopy for Future Low-Cost Sensor Development

**Project No.:** **08-HORT10-Slaughter**

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**Objectives:**

This project will evaluate the feasibility of measuring the leaf nitrogen content in leaves using optical measurements in the silicon region of the visible (VIS) and near infrared (NIR) spectrum. The development of a silicon-detector-based VIS-NIR leaf nitrogen measurement technique would allow the future development of low-cost sensor technology for plant nitrogen management programs in almond. This sensing technology would be one critical component of an overall plant nutrition and irrigation management program.

The project will also explore the feasibility of using multi-spectral techniques to determine leaf nitrogen content and leaf phenology simultaneously. Simultaneous determination of nitrogen and phenology will allow growers to determine the optimum leaf nitrogen content required for full leaf productivity adjusted for the percentage of non-living leaf cell wall material that increases as the leaves mature, which cannot currently be done with other rapid methods. Together these techniques would provide a fully integrated sensing system that could be used at any time in any almond leaf.

**Research Plans:**

Fully exposed, Southwest-facing leaves from non-fruiting branches will be harvested every month in spring and summer from trees at various sites in collaborative projects.

Leaves covering a range of leaf age will be harvested and only undamaged leaves will be used in the study. Leaf age determination at the time of leaf collection will be carefully monitored through knowledge of tree phenology conducted in the collaborative projects. The study will be designed to obtain a set of leaves with a range of nitrogen content and leaf age. SPAD (Minolta instrument Co) leaf chlorophyll measurements will be made on each leaf in the field. At collection, the leaves will be placed in sealed plastic bags and stored on ice in an ice chest in the field.

The leaves will be transported to the laboratory the day of harvest and allowed to warm to room temperature. The fresh weight of each leaf will be measured. Both the transmission and reflectance of each fresh leaf will be measured using a laboratory spectrophotometer from 400 nm to 2500 nm. After the optical measurements are completed leaf area will be determined, each leaf will be dried, and the dry weight recorded. The dried leaves will be individually ground into a fine powder and sealed in foil pouches for nitrogen analysis at the UC Davis Stable Isotope facility. We will record N on the basis of mass N per dry weight of leaf (%N - the standard) as well as N per unit leaf area. We will also measure a range of leaf 'signals' to be used in the determination of age specific leaf nutrient recommendations. In addition to this specific single leaf determination conducted here (which is essential for instrument calibration), we will be determining leaf nutrient concentrations and yields in 100 individual trees using standard sampling techniques in the collaborative projects. The collection of these additional leaf samples from the same experimental trees in addition to others from within the same field will help us model the results of the single leaf NIR determination to whole field relevance. All of this data will be integrated to provide the necessary regression curves for instrument calibration, interpretation and management decisions.

A multivariate spectral analysis of the data will be conducted using the SAS statistical software package for model development and evaluation. Internal cross-validation techniques and the Press statistic will be used to determine the correct number of wavebands or full-spectrum factors to use in the calibration models. A separate set of leaf data will be used for independent model validation.

### Interpretive Summary:

This project will collect the basic background information needed to explore the feasibility of the future development of a low-cost near infrared-based optical sensor that can replace the standard leaf sampling and analysis protocol, which is expensive and time consuming and hence limits replications and the speed with which management responses can be made. The specific challenge is to develop an instrument that is low-cost, fast and sensitive. The second objective is to optimize this device so that N determinations can be meaningfully made and interpreted at any time during the growing season. This is not possible with current methodologies since leaf N concentration changes so rapidly as leaves develop that the resulting data are difficult to interpret.