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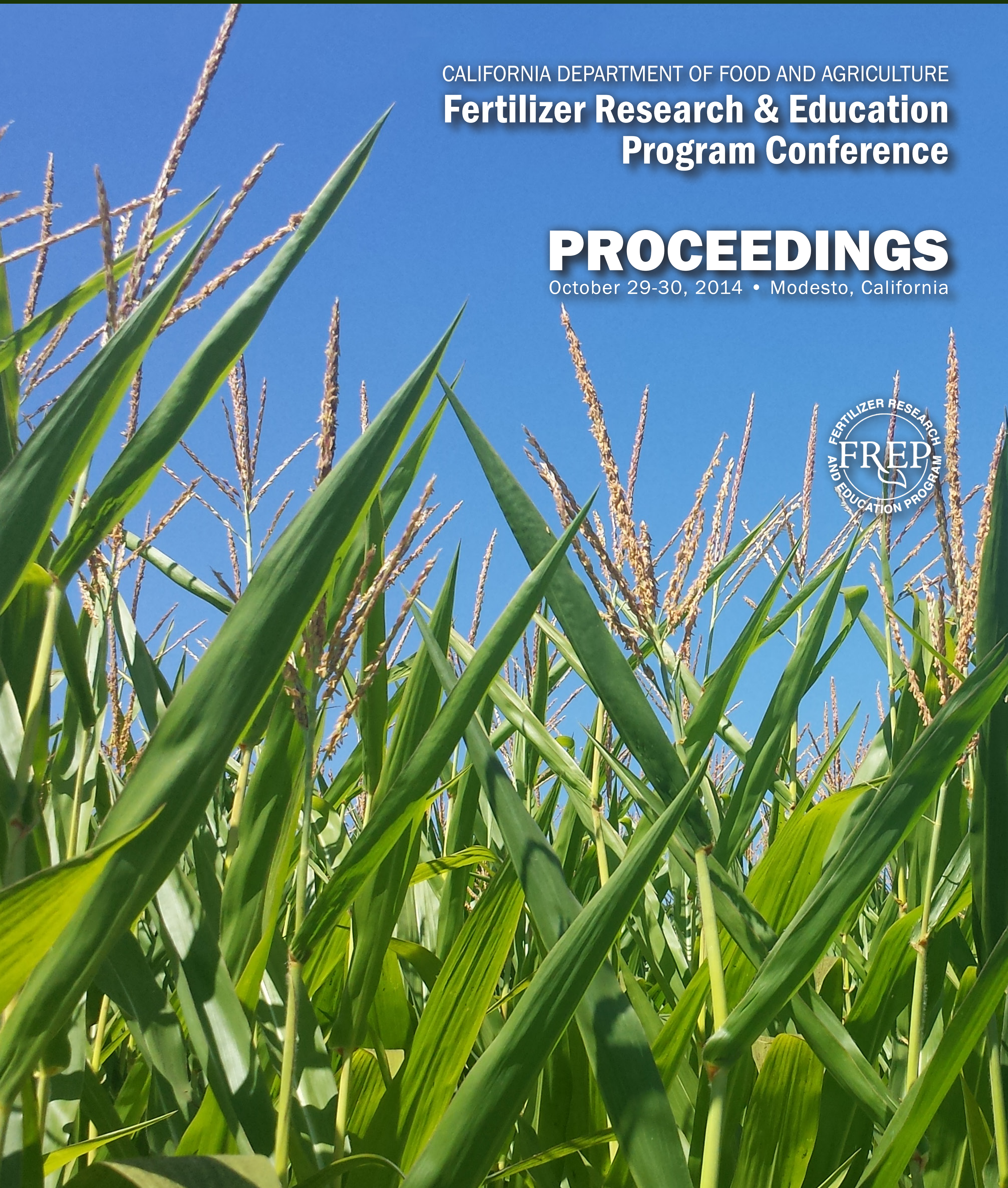

FERTILIZER RESEARCH AND EDUCATION PROGRAM
FREP

Management Tools for Fertilization of the ‘Hass’ Avocado

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INTRODUCTION

This project focuses on developing best management fertilizer practices to improve nutrient use efficiency (yield per unit input of fertilizer) and reduce environmental pollution related to excessive fertilizer applications. For the ‘Hass’ avocado (*Persea americana* L.) industry of California, fertilization rates and optimal leaf nutrient ranges have been borrowed from citrus for all nutrients except nitrogen (N), zinc (Zn) and iron (Fe). Competition from Mexico, Dominican Republic, Chile, Australia, Peru, and South Africa requires the California avocado industry to increase production per acre to remain profitable. Optimizing fertilization is essential to achieve this goal.

The development of best management fertilizer practices is particularly important for alternate bearing avocado trees, for which most growers use the results of their August-September leaf analyses to replace nutrients used by the current crop. If not managed correctly, trees that are setting fruit in an off year receive more fertilizer than is needed (Lovatt, 2001). Over fertilization with nitrogen can significantly decrease avocado fruit size (Arpaia et al., 1996). Properly timing soil-applied nitrogen can increase yield and fruit size and reduce alternate bearing of the ‘Hass’ avocado.

Included in the model is links to an irrigation scheduling model. Recent water shortages have highlighted the need to improve plant water use efficiency. Maximizing fertilizer uptake in plants produces a crop with roots that explore more soil volume for water and nutrients in less time. This results in a healthier crop that can more easily withstand seasonal stresses.

We believe that the deliverables of this project will increase yield, fruit size and profitability for California’s 6,000 avocado growers, while protecting the groundwater. Information on best management fertilizer practices will be supplied in two formats: 1) graphically – plots will be developed documenting the stage-to-stage (month-to-month) changes in the concentrations of each essential mineral nutrient in vegetative and reproductive organs for both on- and off-crop trees, and 2) Dynamically – A computer-based fertilizer model will be developed. Computer-based fertilizer recommendations have been successfully adopted by growers for other crops (almond, pistachio, walnut, macadamia, etc.) and should be developed for avocado.

OBJECTIVES

Develop user-friendly phenological timelines reporting biomass accumulation and total nutrient uptake for specific reproductive structures and vegetative components.

Develop a computer program that growers can easily use to calculate their own fertilizer recommendations (nutrient, application time and rate) based on tree phenology, crop load, and vegetative growth calculations.

Trouble-shoot, and finalize the computer program and make it available on the web. Our computer-based approach involves mathematical data mining, graphic representation of results for ease of use, and development of the computer program.

DESCRIPTION

The PIs completed the difficult task of quantifying nutrient partitioning during all stages of tree phenology by excavating on- and off-crop avocado trees every two months over two years at Somis Pacific in Moorpark, California. At excavation, trees were dissected into inflorescences, fruit, leaves, green shoots (<½ inches), small branches (½-2 inches), mid-size branches (2-4 inches), scaffolding branches (4-6 inches), wood (> 6 inches), scion trunk, rootstock trunk, scaffolding roots, small roots and new roots. Total weight of each component was recorded. Sub-samples were washed, dried, ground, weighed and analyzed for nutrient content of 12 essential elements.

A basic phenology and yield-based nutrient model has been developed for avocado using these tree nutrient partitioning data (called Avomodel). Currently, we are expanding the model parameters to produce a more comprehensive model that include factors such as crop load in the current and previous year and nitrogen leaching based on irrigation practices.

RESULTS AND DISCUSSION

Development of avocado nutrient fertilization model

Calculating the appropriate rate of fertilizer to apply is a complex process that involves interpretation of leaf and soil analyses, and a range of orchard and site condition factors.

In a typical well-managed orchard with reasonably fertile soil, nitrogen, potassium and zinc are likely to be the only nutrients that need to be applied regularly. Thus, the fertility model developed for this project will include these nutrients. Factors to consider when developing a nutrient fertilization model include:

- crop load or yield in the current year;
- crop load or yield in the previous year;
- canopy size;
- leaf nitrogen, potassium and zinc levels;
- soil texture.

Nitrogen and potassium fertilizer model for the 'Hass' avocado in California, input and output is shown in Figure 1. The model is simple to use with minimal inputs required.

The relationship between avocado yield and nutrient removal in the crop must be determined in order to develop a fertilizer recommendation model. Crop nutrient removal values of important macro- and micro-nutrients is presented in Table 1.

It is a common practice in avocado orchards to apply N fertilizer at rates that exceed those required for maximum yield and sustainable production. Over-irrigation, due to a poor irrigation plan can increase the risk of nitrate leaching. Therefore, updated nitrogen leaching factors were recently included in the model. The factor was based on irrigation water applied (percent acre-feet of water applied above required amount) soil type, and the amount of N applied (Table 2).

We have an adapted the California almond nitrogen model to avocado. The model can be seen at the website: http://www.csuchico.edu/~rr19 and is being linked to the UC Davis Fruit and Nut Center web page.

New additions to the model

Tree phenology and soil type

Avocado trees are unique because the fruits can remain on the tree for 15 to 18 months after full bloom (two growing seasons). The tree must support the growing fruitlets and the maturing fruit from the previous growing season. Moreover, both developing and maturing fruit are strong sink for nutrients. Recent modifications to the avocado nutrient fertilization model include:

Inclusion of the developing fruitlets and the maturing crop in the avocado nutrient model. Mature avocados can be harvested over an extended period of time. Therefore, the harvest date was also included in the model

Addition of a nitrogen leaching factor into the model based on irrigation water applied (Percent acre-feet of water applied above required amount) and soil type (Table 3).

Climate Regime

We are evaluating an irrigation module in the program. Avocados are grown in three main areas in the state: San Diego, Ventura, and San Luis Obispo. The climate is very different between San Luis Obispo and San Diego. We developed irrigation requirements for these three main growing regions (Table 2). These irrigation requirement values were determined using the CIMMIS weather station data and crop coefficients from the Wateright program <http://www.wateright.org>.

Macro- and Micro-Nutrient Removal in the Crop

The output results for a 10,000 pound per acre avocado crop yield are presented in Figure 1. In the soil potassium section of the Avomodel we have included common potassium fertilizers for growers to select. This model will do all the calculations converting pounds of elemental K to pounds of fertilizer. This feature should facilitate the use of this model.

Macro- and micro-nutrients removed in the avocado crop were included in the output of the model (Table 1.) Thus, growers will be able to determine nutrient removal values and in coordination with tissue and soil analyses assess if fertilization is required. Finally the output of the model was changed to allow for it to be downloaded into Excel and saved. This enables growers to run the program, save it to Excel, and refer back to the results at some later date.

CONCLUSIONS

The main contribution of the presented fertilization model is the application of mathematical functions in the calculation of the amounts of plant-available nutrients in avocado orchards. In the calculation of fertilization rates, the model includes factors such as crop load (current and previous year), canopy size, leaf nutrient levels, soil texture, and irrigation rate. The model is adjustable for different agro-ecological conditions and crop requirements.

LITERATURE CITED

Arpaia, M. L., J. L. Meyer, G. W. Witney, G. S. Bender, D. S. Stottlemyer, P. R. Robinson. 1996. The Cashin Creek nitrogen fertilizer trial - what did we learn? California Avocado Society 1996 Yearbook, 80: 85-98.

Lovatt, C. J. 2001. Properly timed soil-applied nitrogen fertilizer increases yield and fruit size of ‘Hass’ avocado. Journal of the American Society for Horticultural Science, 126(5): 555-559.

Other Nutrients Removed in the Crop		
Phosphorus	12.08	lbs/acre
P_2O_5	27.67	lbs/acre
Sulfur	21.73	lbs/acre
Boron	14.78	oz/acre
Calcium	6.09	lbs/acre
Magnesium	11.72	lbs/acre
Zinc	7.23	oz/acre
Manganese	4.05	oz/acre
Iron	2.15	oz/acre
Copper	2.65	oz/acre

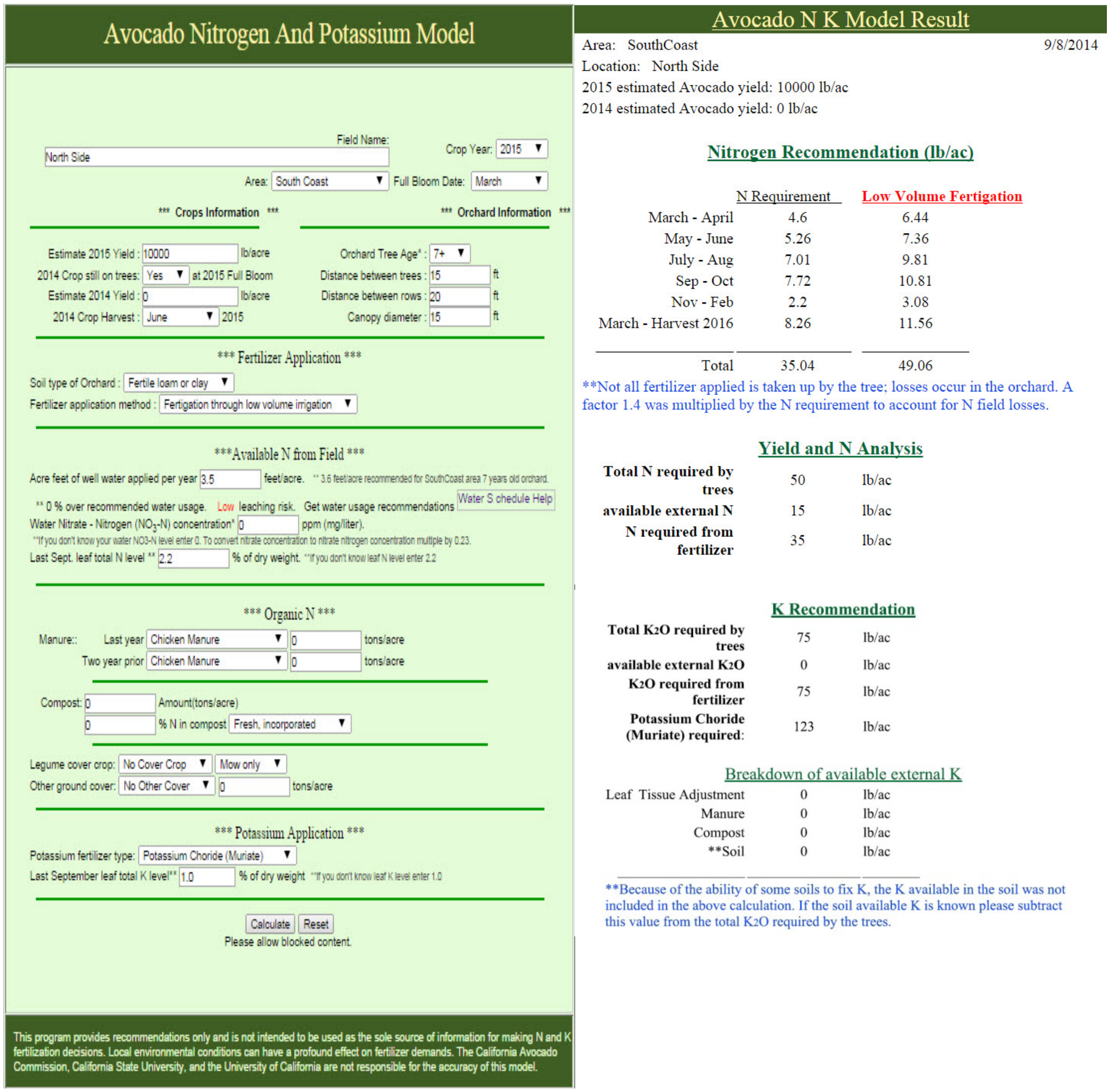
Table 1. Nutrient removal in the avocado crop based on a 10,000 pound per acre yield.

% of acre-feet of irrigation water applied above required amount	% of leaching Fertile Loam	% of leaching Sandy loam	% of leaching Sand
0	0	0	0
15	0	0	45
30	15	30	60
45	30	45	75
60	45	60	100
75	60	75	100
100+	85	90	100

Table 2. Nitrogen leaching factor in three soil types based on excess irrigation water applied (percent acre-feet of water applied above required amount).

Tree Age	Tree Age vs Water Needed (feet per acre)		
	Ventura	San Diego	San Luis Obispo
1	0.4	0.5	0.5
2	0.7	0.9	0.9
3	1	1.5	1.3
4	1.2	2.2	1.8
5	1.4	2.5	2.2
6	1.6	3.2	2.4
7+	1.6	3.6	2.8

Table 3. Avocado water requirement as a function of tree age for the three major avocado growing regions in California.


Avocado Nitrogen And Potassium Model

Field Name: North Side
Crop Year: 2015
Area: South Coast
Full Bloom Date: March

*** Crops Information ***
Estimate 2015 Yield : 10000 lb/acre
2014 Crop still on trees: Yes at 2015 Full Bloom
Estimate 2014 Yield : 0 lb/acre
2014 Crop Harvest : June 2015

*** Orchard Information ***
Orchard Tree Age* : 7+
Distance between trees : 15 ft
Distance between rows : 20 ft
Canopy diameter : 15 ft

*** Fertilizer Application ***
Soil type of Orchard : Fertile loam or clay
Fertilizer application method : Fertigation through low volume irrigation

***Available N from Field ***
Acre feet of well water applied per year 3.5 feet/acre. ** 3.6 feet/acre recommended for SouthCoast area 7 years old orchard.
** 0 % over recommended water usage. Low leaching risk. Get water usage recommendations Water Schedule Help
Water Nitrate - Nitrogen (NO_3-N) concentration* 0 ppm (mg/liter).
**If you don't know your water NO3-N level enter 0. To convert nitrate concentration to nitrate nitrogen concentration multiple by 0.23.
Last Sept. leaf total N level ** 2.2 % of dry weight. **If you don't know leaf N level enter 2.2

*** Organic N ***
Manure:: Last year Chicken Manure 0 tons/acre
Two year prior Chicken Manure 0 tons/acre
Compost: 0 Amount(tons/acre)
0 % N in compost Fresh, incorporated
Legume cover crop: No Cover Crop Mow only
Other ground cover: No Other Cover 0 tons/acre

*** Potassium Application ***
Potassium fertilizer type: Potassium Choride (Muriate)
Last September leaf total K level** 1.0 % of dry weight **If you don't know leaf K level enter 1.0

Calculate Reset
Please allow blocked content.

This program provides recommendations only and is not intended to be used as the sole source of information for making N and K fertilization decisions. Local environmental conditions can have a profound effect on fertilizer demands. The California Avocado Commission, California State University, and the University of California are not responsible for the accuracy of this model.

Avocado N K Model Result

Area: SouthCoast 9/8/2014
Location: North Side
2015 estimated Avocado yield: 10000 lb/ac
2014 estimated Avocado yield: 0 lb/ac

Nitrogen Recommendation (lb/ac)

	N Requirement	Low Volume Fertigation
March - April	4.6	6.44
May - June	5.26	7.36
July - Aug	7.01	9.81
Sep - Oct	7.72	10.81
Nov - Feb	2.2	3.08
March - Harvest 2016	8.26	11.56
Total	35.04	49.06

**Not all fertilizer applied is taken up by the tree; losses occur in the orchard. A factor 1.4 was multiplied by the N requirement to account for N field losses.

Yield and N Analysis

Total N required by trees	50	lb/ac
available external N	15	lb/ac
N required from fertilizer	35	lb/ac

K Recommendation

Total K2O required by trees	75	lb/ac
available external K2O	0	lb/ac
K2O required from fertilizer	75	lb/ac
Potassium Choride (Muriate) required:	123	lb/ac

Breakdown of available external K

Leaf Tissue Adjustment	0	lb/ac
Manure	0	lb/ac
Compost	0	lb/ac
**Soil	0	lb/ac

**Because of the ability of some soils to fix K, the K available in the soil was not included in the above calculation. If the soil available K is known please subtract this value from the total K2O required by the trees.

Figure 1. Nitrogen and potassium fertilizer model for the 'Hass' avocado in California, input (left) and output (right) based on 10,000 pounds per acre avocado crop yield.

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