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Management Tools for Fertilization of the 'Hass' Avocado

PROJECT LEADER
Richard Rosecrance
Associate Professor
Plant Sciences, College of Agriculture
California State University
Chico, CA 95926
(530) 898-5699
rrosecrance@csuchico.edu

PROJECT LEADER
Carol J. Lovatt
Professor
Department of Botany and Plant Sciences
University of California
2150 Batchelor Hall
Riverside, CA 92521
(951) 827-4663
carol.lovatt@ucr.edu

COOPERATOR
Ben Faber
Farm Advisor
UC Cooperative Extension, Ventura County
669 County Square Drive, #100
Ventura CA, 93003-5401
(805) 645-1451
bafaber@ucdavis.edu

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.

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

1. Develop user-friendly phenological timelines reporting biomass accumulation and total nutrient uptake for specific reproductive structures and vegetative components.
2. 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.
3. 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 includes 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 during the current year
- Crop load or yield during the previous year
- Canopy size
- Leaf nitrogen, potassium, and zinc
- Soil texture
- Irrigation rate

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:

1. Inclusion of the developing fruitlets and the maturing crop in the avocado nutrient model (Figure 1). Mature avocados can be harvested over an extended period of time. Therefore, the harvest date was also included in the model
2. 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 1).

Study Avoman computer model (developed by Australian researchers) and OVERSEER (developed by New Zealand researchers) to determine if their approach is feasible in California.

We evaluated the phenology models from an avocado nutrient budget model from Australia entitled ‘Avoman’. Some aspects of the model have been incorporated into the California model. For example, we have incorporated data from this model concerning the relationship between canopy size and nutrient content. Avocado trees store most of their nutrients in leaves, thus an estimate of canopy size is critical in developing a nutrient fertilizer budget. The avocado phenology models in ‘Avoman’, however, were evaluated and rejected because of the large climatic and tree phenological differences between Australia and California.

Currently, we are evaluating a new nutrient fertility model (OVERSEER) recently published from New Zealand (2009) to see if information from this model can be adapted to California conditions. The OVERSEER nutrient budget model calculates average annual flows in N, P, K, and S in avocado orchards. The model contains a database with information on nutrient concentrations of fertilizers and crop residues. The equations within the model are based on studies carried out in New Zealand and are currently being evaluated for California conditions. We analyzed nitrogen and potassium requirements using both programs at different yield levels (Table 2). Nitrogen requirements at the same yield level were similar in both programs; however potassium requirements were about 20% greater in Avomodel compared to OVERSEER. A possible cause for this difference is that in the Avomodel potassium requirements are based

Figure 1: Nitrogen and potassium fertilizer model for the ‘Hass’ avocado in California, input (left) and output (right)

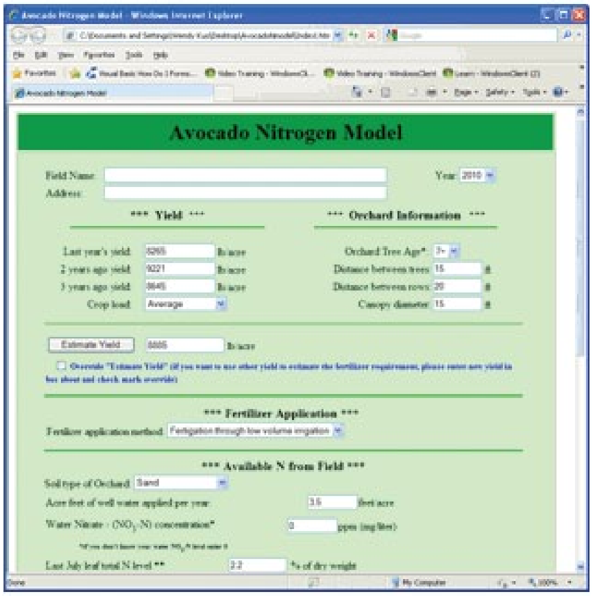


Table 1: Nitrogen leaching factor based on irrigation water applied (percent acre-feet of water applied above required amount) and soil type.

Percent of Acre-Feet of Irrigation Water Applied Above Required Amount	Percent of Leaching Fertile Loam	Percent of Leaching Sandy Loam	Percent of Leaching Sand
0	0	0	0
15	0	0	10
30	10	20	35
45	25	35	50
60	35	50	65
75	55	65	80
100+	65	80	100

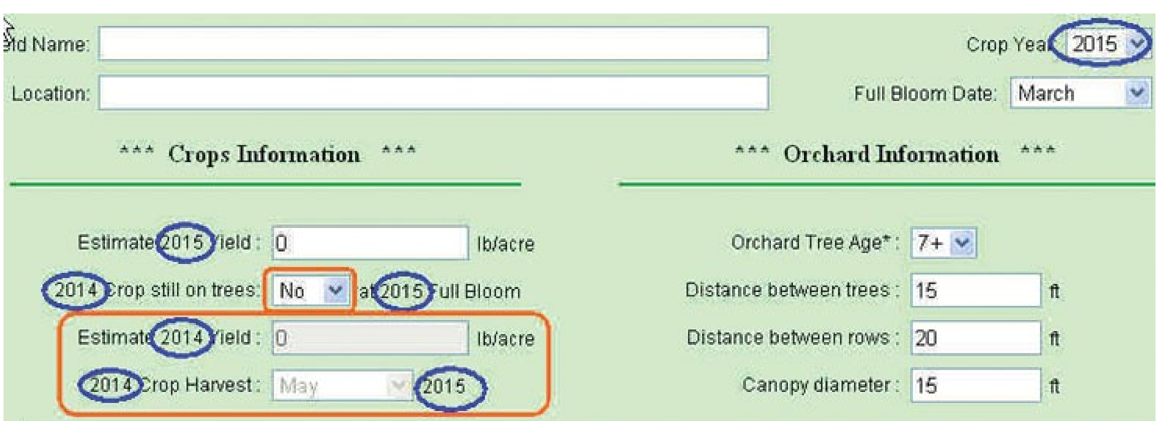
Table 2: Comparison of nitrogen and potassium requirements based on the avocado nutrient model currently under construction (Avomodel) and a nutrient model developed in New Zealand (Overseer) under different yield scenarios.

Program	Yield (lb/acre)	Nitrogen Requirement (lb/acre)	Potassium Requirement (lb/acre)
Avomodel	15000	49	121
Avomodel	12000	41	97
Avomodel	9000	32	73
Avomodel	6000	29	55
Overseer	15000	53	101
Overseer	12000	42	80
Overseer	9000	32	60
Overseer	6000	21	40

entirely on what is removed in the crop and prunings. In contrast, OVERSEER subtracts exchangeable soil potassium from what K is required in the crop and prunings. The soil potassium levels are not considered in the Avomodel recommendation.

These factors above are used as inputs into our model (Figure 1). Currently we are trouble shooting the model. In the future we will be adding zinc fertilization to the model. An important factor to take into account to determine zinc recommendations is root health of the orchard – is the problem lack of zinc or lack of roots? Avocados have a relatively shallow root system, which is highly susceptible to Phytophthora root rot. This disease will degrade the root system of avocado trees and will strongly decrease zinc uptake. Thus, a query will be included in the model to evaluate if roots are present in the leaf litter or mulch.

Figure 2: Model modifications that include nitrogen requirements from this year's crop and last year's fruit.



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. The field testing of the model is currently underway.

LITERATURE CITED

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