Improving Fruit Yield and Quality in Southern California Organic Mango Production

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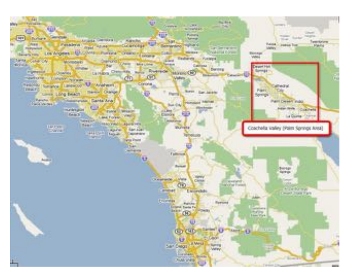
Introduction

Mango (*Mangifera indica*) is major fruit tree crop of the tropics and subtropics, particularly in Asia, where it is among most economically important fruit crops. Mango has very limited production in temperate Mediterranean climates and currently the only US states producing the fruit are California, Florida, and Hawaii. This study focuses on the improvement of organic mango production in the Coachella Valley of Southern California, where the dry/hot desert climate presents a significant challenges for producers. These challenges include sandy, alkaline soil and alkaline irrigation water which cause nutrient imbalance. Additionally, weed proliferation is a limiting factor to crop production.[1] Recent reviews on mango crop management and physiology indicate that the best prospect for improving mango production must involve a holistic approach that considers the specific climate and edaphic environment.[3]

Left: A young mango in the Coachella Valley, CA study site.
Right: A butterfly attracted by Alfalfa cover crops.



The Coachella Valley in Southern California.

Objectives

The overall goal of this study is to improve crop productivity. In order to do so, we will evaluate the benefits of the following cultural practices:

1) Use acidified irrigation water to decrease soil pH and correct plant nutrient deficiencies.

2) Use cover crops and soil amendments for weed control and improved soil fertility.

Methods

1) A sulfur burner was installed in the orchard reservoir that is used for irrigation. We recorded water quality, soil nutrient composition, and plant nutrient profiles before the installation of the sulfur burner. These measurements will be recorded at same time every year for 3 consecutive years.

2) Eight cover crop and soil amendment treatments are being evaluated for weed control, soil nutrient composition, plant nutrient profile, fruit yield and quality. Each treatment will be repeated 5 times with 1 row (60 trees) = 1 replication. Thus, 40 rows will be needed for this experiment. Treatments will include:

a. Untreated control
b. Cowpea cover crop
c. Sudan grass cover crop
d. Alfalfa cover crop
e. Biochar with no cover crop
f. Biochar with cowpea cover crop
g. Biochar with sudan grass cover crop
h. Biochar with alfalfa cover crop

Biochar is a type of charcoal made from carbon-rich waste products (wood pallets, tree trimmings, municipal waste), and can increase organic mango production's water/nutrient use efficiency and yield as well as increase soil populations of beneficial microorganisms.[2]

Clockwise from top-left: Mango with Alfalfa (left) and Untreated control (right) cover crops. Mango with Sudan grass (left) and Cowpea (right) cover crops. Sulfur burner installed at the water reservoir. Close-up of sulfur burner.

Results

MANGO SOIL ANALYSIS

Test Description	Result	Units	Optimum Range	Graphical Results Presentation
Primary Nutrients				
Nitrate-Nitrogen	12.8	Lbs/AF	31 - 71	🟦
Phosphorus-P_2O_5	92	Lbs/AF	140 - 280	🟧
Potassium-K_2O (Exch)	364	Lbs/AF	350 - 2100	🟩
Potassium-K_2O (Sol)	78.9	Lbs/AF	83 - 460	🟩 4%
Secondary Nutrients				
Calcium (Exch)	13400	Lbs/AF	8900 - 12000	🟨
Calcium (Sol)	247	Lbs/AF	140 - 620	🟩 30%
Magnesium (Exch)	681	Lbs/AF	900 - 1800	🟩
Magnesium (Sol)	76.3	Lbs/AF	62 - 210	🟩 15%
Sodium (Exch)	200	Lbs/AF	0.0 - 850	🟩
Sodium (Sol)	474	Lbs/AF	0.0 - 840	🟩 50%
Sulfate	909	Lbs/AF	87 - 3800	🟩
Micro Nutrients				
Zinc	18.8	Lbs/AF	3.8 - 170	🟩
Manganese	13.6	Lbs/AF	5.3 - 260	🟩
Iron	41.6	Lbs/AF	38 - 210	🟩
Copper	2.40	Lbs/AF	1.1 - 45	🟩
Boron	0.920	Lbs/AF	1.1 - 8.3	🟩
Chloride	370	Lbs/AF	11 - 660	🟩
CEC	18.5	meq/100g	14 - 35	🟦
% Base Saturation				
CEC - Calcium	90.3	%	60 - 80	🟨
CEC - Magnesium	7.57	%	10 - 20	🟩
CEC - Potassium	1.04	%	1.0 - 6.0	🟩
CEC - Sodium	1.17	%	0.0 - 5.0	🟩
CEC - Hydrogen	< 1.00	%	0.0 - 3.0	🟩
				Strongly Acidic / Moderately Acidic / Near Neutral / Moderately Alkaline / Strongly Alkaline
pH	7.86	---	4.5 - 5.8	🟥

Very Low / Moderately Low / Optimum / Moderately High / Very High

Good – Problem. 🟦 Indicates physical conditions and/or phenological and amendment requirements.

'Fruit Growers Lab' soil analysis report: Initial soil analysis from untreated control plots on year 1 of the study reveal low levels of Nitrogen (NO_3) and Phosphorus (P_2O_5) and high levels of Calcium. Of particular interest is the high alkalinity of the soil, which has a pH of 7.86

MANGO PLANT TISSUE ANALYSIS - FRUIT BEARING

Test Description	Result	Units	Optimum Range	Graphical Results Presentation (Deficient / Low / Ample / High / Excessive)
Macro Nutrients				
Total Nitrogen (Leaf)	1.64	%	1.0 - 1.5	🟩
Phosphorus (Leaf)	0.095	%	0.080 - 0.18	🟩
Potassium (Leaf)	0.554	%	0.30 - 1.2	🟩
Calcium (Leaf)	2.20	%	2.0 - 5.0	🟩
Magnesium (Leaf)	0.20	%	0.20 - 0.40	🟩
Micro Nutrients				
Zinc (Leaf)	14.4	ppm	20 - 150	🟧
Manganese (Leaf)	13	ppm	60 - 500	🟥
Iron (Leaf)	31	ppm	70 - 200	🟧
Copper (Leaf)	4	ppm	10 - 20	🟧
Boron (Leaf)	108	ppm	50 - 100	🟩
Sodium (Leaf)	0.017	%	0.0 - 0.20	🟩

Good – Problem
Note: Color coded bar graphs have been used to provide you with 'AT-A-GLANCE' interpretations.

'Fruit Growers Lab' tissue analysis report: Leaf tissue analysis of fruit bearing trees that trees are deficient in the Micronutrients Zinc, Manganese, Iron, and Copper.

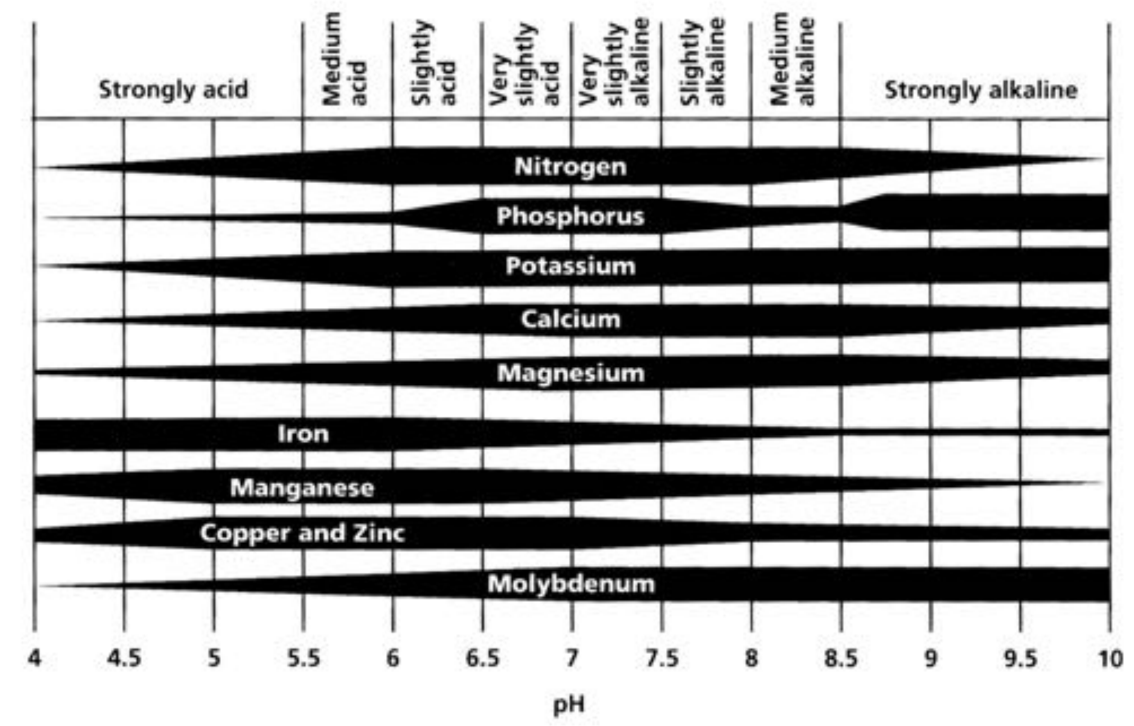
Fruit Tree Irrigation Suitability Analysis

Test Description	Result mg/L	Meq/L	% Meq	Lbs/AF	Graphical Results Presentation (Good / Possible Problem / Moderate Problem / Increasing Problem / Severe Problem)
Cations					
Calcium	79	3.9	37	210	**
Magnesium	27	2.2	21	73	**
Potassium	5	0.13	1	14	**
Sodium	103	4.5	42	280	🟩
Anions					
Carbonate	< 10	0	0	0	🟩
Bicarbonate	160	2.6	25	440	**
Sulfate	249	5.2	49	680	**
Chloride	96	2.7	26	260	🟩
Nitrate	0.9	0.015	0	2	🟩
Fluoride	0.3	0.016	0	0.8	🟩
Minor Elements					
Boron	0.20			0.54	🟩
Copper	< 0.01			0.00	🟩
Iron	0.26			0.71	🟩
Manganese	0.010			0.027	🟩
Zinc	0.040			0.11	🟩
TDS by Summation	720			2000	🟩
Other					
pH	8.0			units	🟧
E. C.	1.05			dS/m	🟩
SAR	2.6				🟩
Crop Suitability					
No Amendments	Fairly		Poor		🟩
With Amendments	Good				🟩
Amendments					
Gypsum Requirement	0.1			Tons/AF	
Sulfuric Acid (98%)	9.1			oz/1000Gal	Or 22 oz/1000Gal of urea Sulfuric Acid (15/49).
Leaching Requirement	8.1			%	

Good – Problem
Note: Color coded bar graphs have been used to provide you with 'AT-A-GLANCE' interpretations.

'Fruit Growers Lab' irrigation water analysis report: The water currently being used to irrigate Mangoes has a high pH of 8.0

Conclusions & Future Directions



Nutrient uptake of plants in relation to soil pH.[4]

As shown in the figure above, soil pH directly affects the nutrient uptake ability of plants. The alkaline soils of the Coachella Valley are likely the reason for the Micronutrient deficiencies observed in the Mango leaf tissue analyses. The sulfur burners installed for this study should gradually alleviate these problems as it acidifies the irrigation water. The nutrient uptake of plants is directly affected by the pH of the soil, and as the soil lowers in pH, certain nutrients such as Iron, Manganese, Copper, and Zinc, will become more available to the plants (see above figure).[4]

Concurrently, the aim for cover crop and biochar treatments is to reduce overall inputs and weed management efforts while enhancing soil nutrient profile, plant nutrient status, and overall crop yield and quality. Cover crops can increase soil organic matter and nitrogen, use any excess nutrients, and prevent weed growth through out-competition and/or allelopathy.[1]

References

1. Hartwig, NL, et al. (2002) *Cover crops and living mulches.* Weed Science 50(6): 688-699.

2. Lehmann, J, et al. (2011) *Biochar effects on soil biota – A review.* Soil Biology and Biochemistry 43(9): 1812-1836

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