Fertilizer Management for Avocado Production

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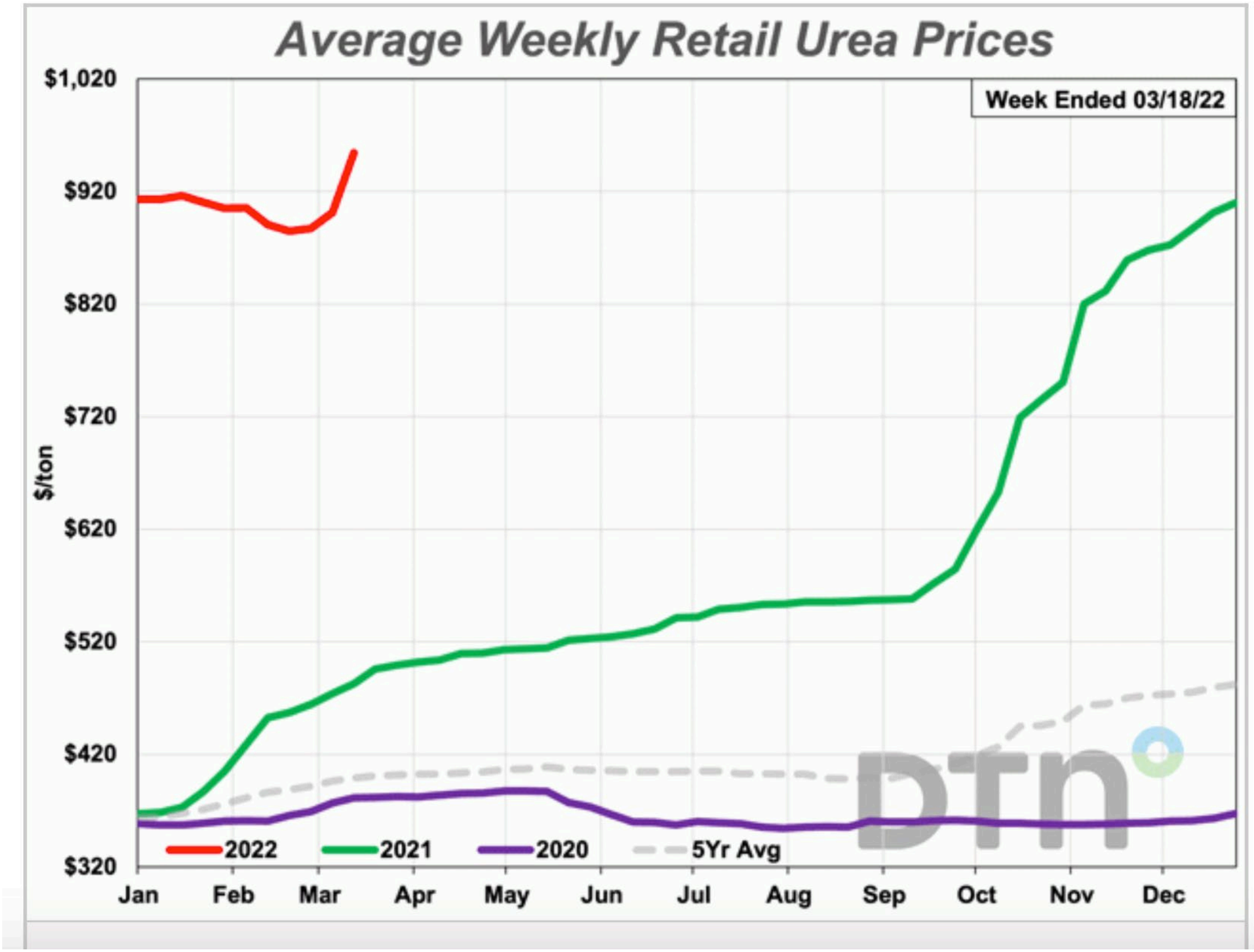
Fertilizers are getting more expensive!



California Avocado Association 1933 Yearbook 18: 39-49

Fertilizing Avocado Groves

(With especial reference to the use of and the supplementing of manure)

L. D. Batchelor
University of California, Citrus Experiment Station

California Avocado Society 1952 Yearbook 37: 201-209

NUTRIENT COMPOSITION AND SEASONAL LOSSES OF AVOCADO TREES

S. H. Cameron, R. T. Mueller, and A. Wallace

http://www.avocadosource.com/

Plant Essential Elements

Macronutrients

Nitrogen - Low response

Fixed Program 40-125 lbs

Timing – Phenology 2X-5X

Phosphorus
Potassium
Sulfur
Calcium
Magnesium

Infrequent applications
Guided by leaf analysis
and soil test reports

Micronutrients

Zinc
Iron
Manganese
Copper

Controlled by soil pH
Guided by leaf analysis
Supplied as trace elements
or as metal chelates Boron

Nutrient	Units	Range
Nitrogen	% N	2.2 - 2.6
Phosphorous	% P	0.08 - 0.25
Potassium	% K	0.75 - 2.0
Sulphur	% S	0.2 - 0.6
Calcium	% Ca	1.0 - 3.0
Magnesium	% Mg	0.25 - 0.8
Zinc	ppm Zn	40 - 80
Copper	ppm Cu	5.0 - 15
Sodium	% Na	less than 0.25
Chloride	% Cl	less than 0.25
Iron	ppm Fe	50 - 200
Boron	ppm B	40 - 60
Manganese	ppm Mn	30 - 500

AVOCADOSOURCE.COM

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Total Fruit Nutrient Removal Calculator for Hass Avocado in California

Calculate the amount of nutrients that are removed when you harvest your crop. Enter your production below. **No commas or periods please!**

Production Volume: 6000 lbs.

Calculate

		Arsenic:	0.0096 oz.
Nitrogen:	16.827 lb.	Barium:	0.1728 oz.
Phosphorus:	6.3588 lb.	Cadmium:	0.0384 oz.
P_2O_5:	14.5617 lb.	Chromium:	0.0672 oz.
Potassium:	40.2906 lb.	Cobalt:	0.0096 oz.
K_2O:	48.7516 lb.	Lead:	0.1248 oz.
Iron:	1.1232 oz.	Lithium:	0.1536 oz.
Manganese:	0.2112 oz.	Mercury:	0 oz.
Zinc:	3.7056 oz.	Nickel:	0.3456 oz.
Copper:	1.3824 oz.	Selenium:	0.048 oz.
Boron:	9.5328 oz.	Silicon:	2.2752 oz.
Calcium:	3.3516 lb.	Silver:	0.0096 oz.
Magnesium:	6.7608 lb.	Strontium:	0.4224 oz.
Sodium:	6.1728 lb.	Tin:	0.0864 oz.
Sulfur:	12.1866 lb.	Titanium:	0 oz.
Molybdenum:	0 oz.	Vanadium:	0 oz.
Aluminum:	2.2464 oz.	Chloride:	6.7314 lb.

http://www.avocadosource.com/

Fertilizer Calculator

English Units Metric Units Calculate

Primary Nutrient: Nitrogen (N) **Nutrient Information**

Amount of Primary Nutrient: 165 lbs.

Fertilizer: Ammonium Nitrate **Fertilizer Information and MSDS**

Price of Fertilizer: 1 / lb.

Fertilizer Formula: NH_4NO_3

Amount of Fertilizer: 471.43 lbs.

Price of Primary Nutrient: 2.86 / lb.

Secondary Nutrient:

Amount of Secondary Nutrient: lbs.

Price of Secondary Nutrient: / lb.

Using the Fertilizer Calculator
Sources of Fertilizer Calculator
Nutrient Removal Calculator
Scientific Calculator

Chart of the Effect of Soil pH on Nutrient Availability
Country Specific Normal Leaf Level Ranges
Soil Levels
Nutrient Interaction Chart
Law of the Minimum - Liebig's Law

Plant Stress by S. Kant and U. Kafkafi - Hebrew University

Created by Reuben Hofshi and Shanti Hofshi

/

https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Avocado.html

A collaboration between

cdfa

FERTILIZER RESEARCH AND EDUCATION PROGRAM FREP

UC DAVIS
UNIVERSITY OF CALIFORNIA

- **Guidelines Home**
- Acknowledgments

Additional Information:

- **Avocado Nitrogen Uptake and Partitioning**
- Avocado Production in California
- FREP Database

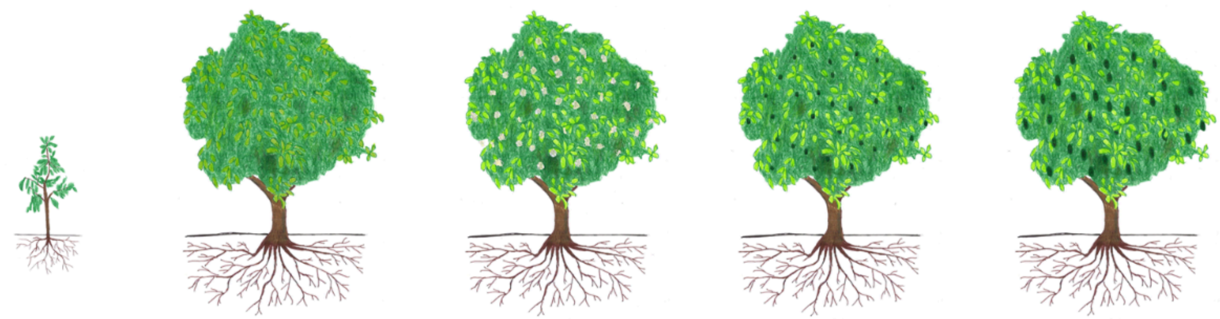
Links:

- UC Fruit & Nut Research and Information Center
- UC Integrated Pest Management
- California Avocado Society
- California Avocado Commission
- UC ANR Avocado Nutrient Management
- Subtropical Fruits of San Diego County
- Avocado Source (Extensive avocado information library)

PNK

California Fertilization Guidelines

Avocado



	Young Trees	Winter	Spring Flush; Bloom	Fruit Development	Harvest
Nitrogen (N)	Soil Test / N		Foliar N	Leaf Analysis / Soil Applied N	
Phosphorus (P_2O_5)	Soil Test / P		Foliar P	Leaf Analysis / Soil Applied P	
Potassium (K_2O)	Soil Test / K		Foliar K	Leaf Analysis / Soil Applied K	
Zinc (Zn)	Soil Test / Zn		Soil Applied Zn	Leaf Analysis / Foliar Zn	

Nitrogen Deficiency

Slow growth, stunting, reduced yields

Yellow-green color to leaves
(a general yellowing)

More pronounced in older leaves since N is a mobile element that will move to younger leaves

Nitrogen Fertilization Strategies for the 'Hass' Avocado that Increase Total Yield Without Reducing Fruit Size

Jaime E. Salvo[1] and Carol J. Lovatt[2]

Table 1. Annual nitrogen (N) fertilizer application times and rates for 'Hass' avocado trees for the four crop years of the research (one crop year is 16 months).

			N application (lb/acre)					
No.	N Treatment[z]		January	April	July	August	November	Annual total
1	1x N January, April, July, August + November (control)	Soil	25	25	25	25	25	125
2	2x N April	Soil	18.75	50	18.75	18.75	18.75	125
3	2x N April + November	Soil	8.3	50	8.3	8.3	50	125
4	2x N August	Soil	18.75	18.75	18.75	50	18.75	125
5	2x N November	Soil	18.75	18.75	18.75	18.75	50	125
6	3x N April	Soil	12.5	75	12.5	12.5	12.5	125
7	3x N April	Foliar	12.5	75	12.5	12.5	12.5	125
8	0.8x N July + August	Soil	—	—	20	20	—	40

[z]Soil = soil-applied N was ammonium nitrate (NH_4NO_3). Foliar = foliar-applied N was low-biuret urea (granules, 46% N, ≤0.25% biuret) at 75 lb/acre in 200 gal/acre (1,870.8 $L \cdot ha^{-1}$) of water (pH 5.5) applied with a 400-psi (2757.9 kPa) handgun sprayer; 1 lb/acre = 1.1209 $kg \cdot ha^{-1}$.

Nitrogen Fertilization Strategies for the 'Hass' Avocado that Increase Total Yield Without Reducing Fruit Size

Jaime E. Salvo[1] and Carol J. Lovatt[2]

Table 2. Effects of nitrogen (N) fertilizer application times and rates on 'Hass' avocado 4-year cumulative total yield and yield of commercially valuable size (CVS) fruit (178–325 g/fruit FW) and small fruit (99–177 g/fruit FW) as kilograms and number per tree.[z]

			4-yr cumulative yield[z]					
			Total		CVS fruit		Small fruit	
No.	N Treatment[y]		(kg/tree)	(no./tree)	(kg/tree)	(no./tree)	(kg/tree)	(no./tree)
1	1x N January, April, July, August + November (control)	Soil	243.2 a[x]	1,241 ab	158.0 a	695 a	77.7 ab	525 ab
2	2x N April	Soil	249.9 a	1,338 a	144.2 a	646 a	99.8 a	675 a
3	2x N April + November	Soil	208.0 b	1,062 bc	134.9 a	595 a	65.6 b	446 b
4	2x N August	Soil	220.2 ab	1,163 ab	134.4 a	596 a	79.3 ab	548 ab
5	2x N November	Soil	220.1 ab	1,094 bc	152.7 a	671 a	59.5 b	400 bc
6	3x N April	Soil	235.2 ab	1,196 ab	151.2 a	666 a	74.5 ab	503 ab
7	3x N April	Foliar	208.1 b	946 c	160.2 a	682 a	33.5 c	223 c
8	0.8x N July + August	Soil	241.6 a	1,181 ab	173.6 a	764 a	58.6 bc	390 bc
P value			0.0362	0.0026	0.1451	0.1465	0.0003	0.0004

[z] 1 g = 0.0353 oz, 1 kg = 2.2046 lb, 1 lb = 0.4536 kg; commercially valuable size fruit and small fruit correspond to packing carton sizes 60 + 48 + 40 and 84 + 70, respectively; packing carton size is based on the number of fruit per 25-lb box within a tolerance of 0.5 lb.
[y] Refer to Table 1.

Table 3. Effects of nitrogen (N) fertilizer application times and rates on 'Hass' avocado leaf N concentrations in year 4 and averaged across the four crop years of the research; one crop year is 16 months.

No.	N Treatment[z]		Leaf N concn (g/100 g leaf tissue DW)[y] Yr 4	Leaf N concn (g/100 g leaf tissue DW)[y] 4-yr avg
1	1x N January, April, July, August + November (control)	Soil	2.37 abc[x]	2.56 ab
2	2x N April	Soil	2.32 bc	2.55 ab
3	2x N April + November	Soil	2.33 bc	2.53 bc
4	2x N August	Soil	2.31 bc	2.57 ab
5	2x N November	Soil	2.37 abc	2.58 ab
6	3x N April	Soil	2.45 a	2.62 a
7	3x N April	Foliar	2.38 ab	2.59 ab
8	0.8x N July + August	Soil	2.28 c	2.46 c
P value			0.0270	0.0284

[z]Refer to Table 1.

[y]1 g/100 g = 1%.

[x]Means in a vertical column followed by different letters are significantly different by Fisher's protected least significant difference test at $P \leq 0.05$.

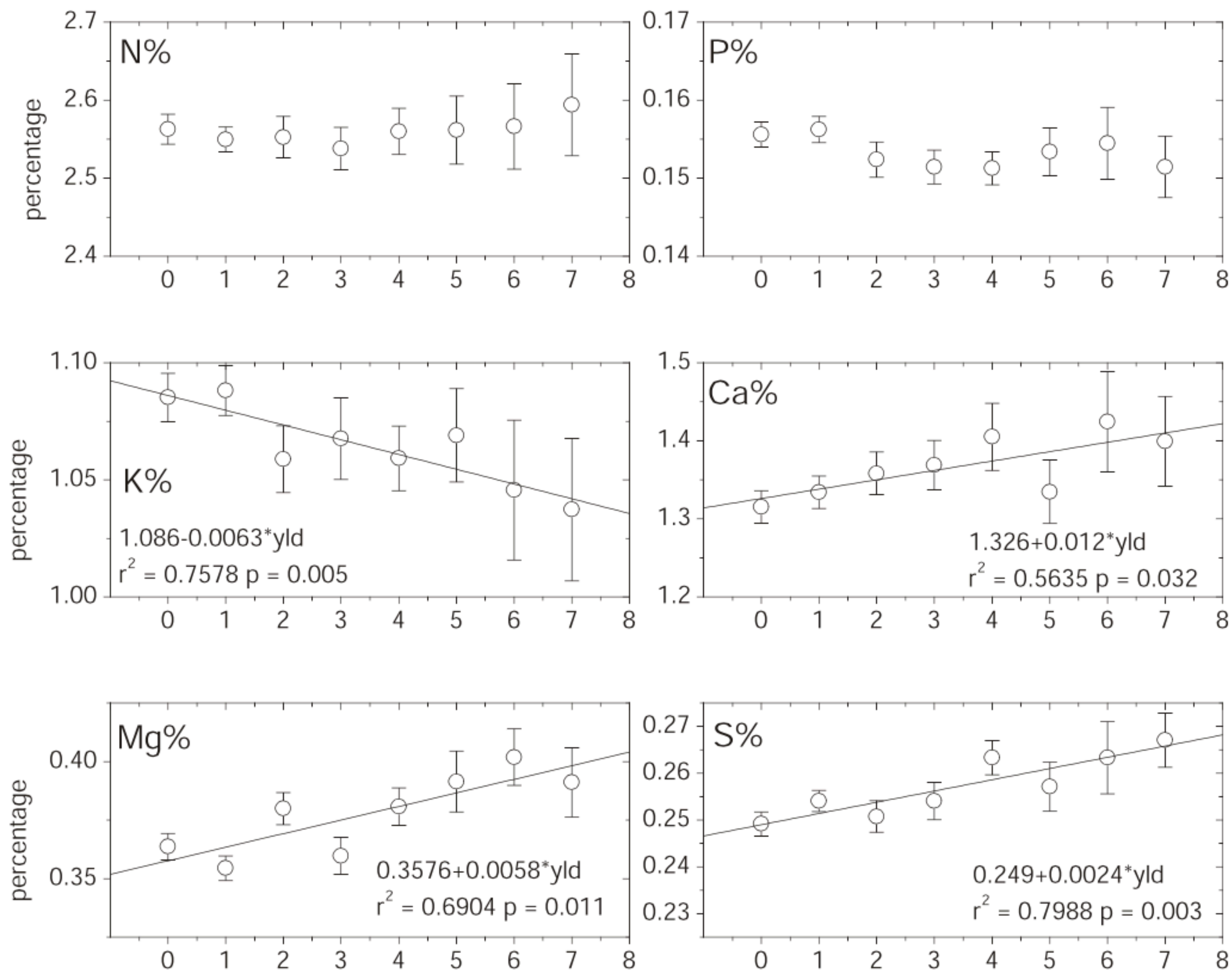
LEAF MINERAL NORMS OF 'HASS' AVOCADO TREES FROM THE WESTERN BAY OF PLENTY OF NEW ZEALAND

J. Dixor
Avocad
Tauran
Corres
jonatha

Table 1. Hass leaf target levels from various sources

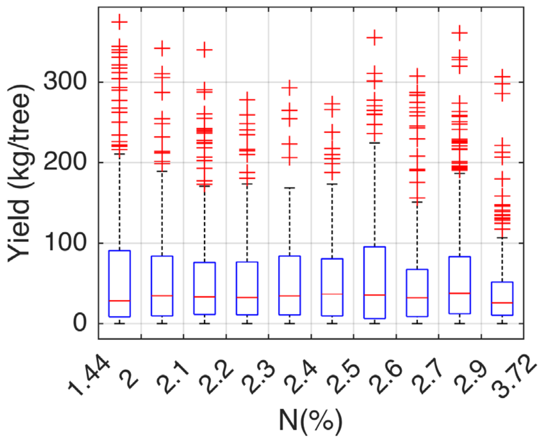
Mineral	NZ Grower Manual	Agrilink Australia[2]	Avocado Book[3]			Mexico[4]
			Deficient	Range	Excess	
N%	2.5-2.9	2.2-2.6	1.6	1.6-2.8	3.0	2.2-2.6
P%	0.16-0.22	0.08-0.25	0.14	0.14-0.25	0.3	0.08-0.25
K%	1.0-1.2	0.75-2.0	0.9	0.9-2.0	3.0	0.7-2.0
Ca%	1.8-2.5	1.0-3.0	0.5	1.0-3.0	4.0	1.0-3.0
Mg%	0.5-0.7	0.25-0.8	0.15	0.25-0.8	1.0	0.25-0.8
S%	0.3-0.4	0.2-0.6	0.05	0.2-0.6	1.0	0.2-0.3
Fe ppm[1]	50-200	50-200	20-40	50-200		50-200
Mn ppm[1]	100-500	30-500	10-15	30-500	1000	30-500
Zn ppm[1]	60-100	40-80	10-20	40-80	100	30-150
B ppm[1]	40-60	40-60	10-20	40-80	100	50-100

[1]Minimum values; [2]Vock 2001, [3]The Avocado Botany, Production and Uses, [4]Salazar-Garcia 2002

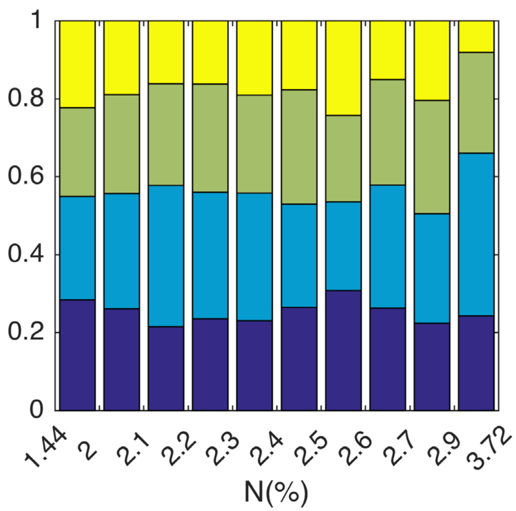


N%
P%
K%
1.086-0.0063*yld
r^2 = 0.7578 p = 0.005
Ca%
1.326+0.012*yld
r^2 = 0.5635 p = 0.032
Mg%
0.3576+0.0058*yld
r^2 = 0.6904 p = 0.011
S%
0.249+0.0024*yld
r^2 = 0.7988 p = 0.003
percentage

Leaf Nitrogen and Avocado Yield Potentials



Nitrogen has little apparent influence on fruit yields but levels above 2.6% are associated with decreasing numbers of high yielding trees producing more than 100 kg fruit. Lower yields are also noted for trees with >2.9% N, however, there are relatively few trees having this much leaf nitrogen.



The lowest number of low-yielding trees (dark blue) occur for trees having 2.2% N. Across the industry, most trees fall in range from 2.2 - 2.8 N. Overall optimum for maximum orchard yield identified here is 2.4%.

Law of the Minimum - Liebig's Law

Justus von Liebig, generally credited as the "father of the fertilizer industry", formulated the law of the minimum: if one crop nutrient is missing or deficient, plant growth will be poor, even if the other elements are abundant.

Liebig likens the potential of a crop to a barrel with staves of unequal length. The capacity of this barrel is limited by the length of the shortest stave (in this case, phosphorus) and can only be increased by lengthening that stave. When that stave is lengthened, another one becomes the limiting factor.

Research Questions

- ✧ Can we model the relationships between avocado yield potential and the levels of different elements that occur in plant leaf tissues?

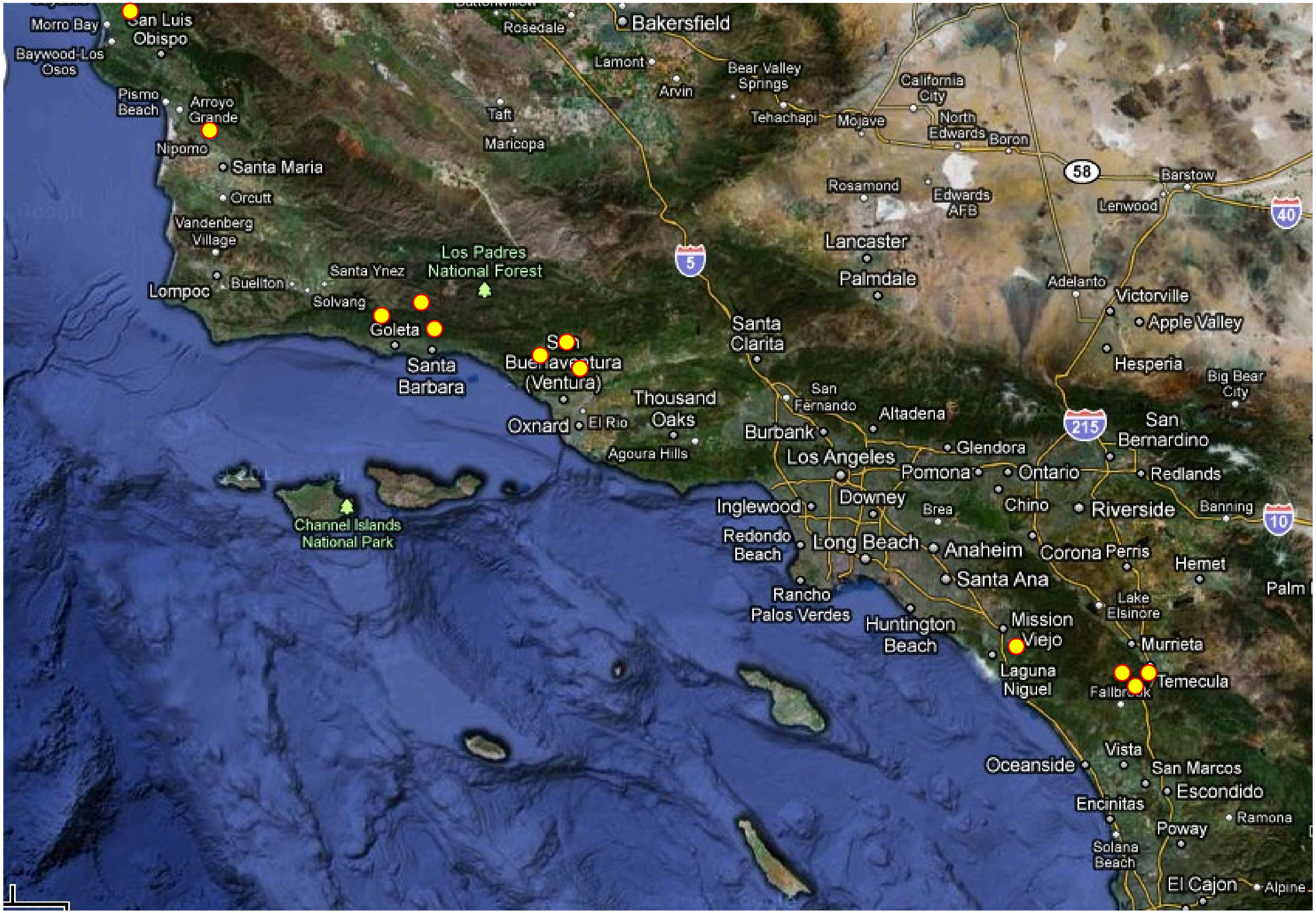
N, P, K, S, Ca, Mg, Fe, Zn, Mn, B, Cu (Si, Ni)

- ✧ What are the optimum levels of nutrients that are associated with achieving the highest possible yields of avocados? What about nutrient interactions?

- ✧ When should fertilizers be applied to achieve optimum fertilizer use efficiency and environmental safety?

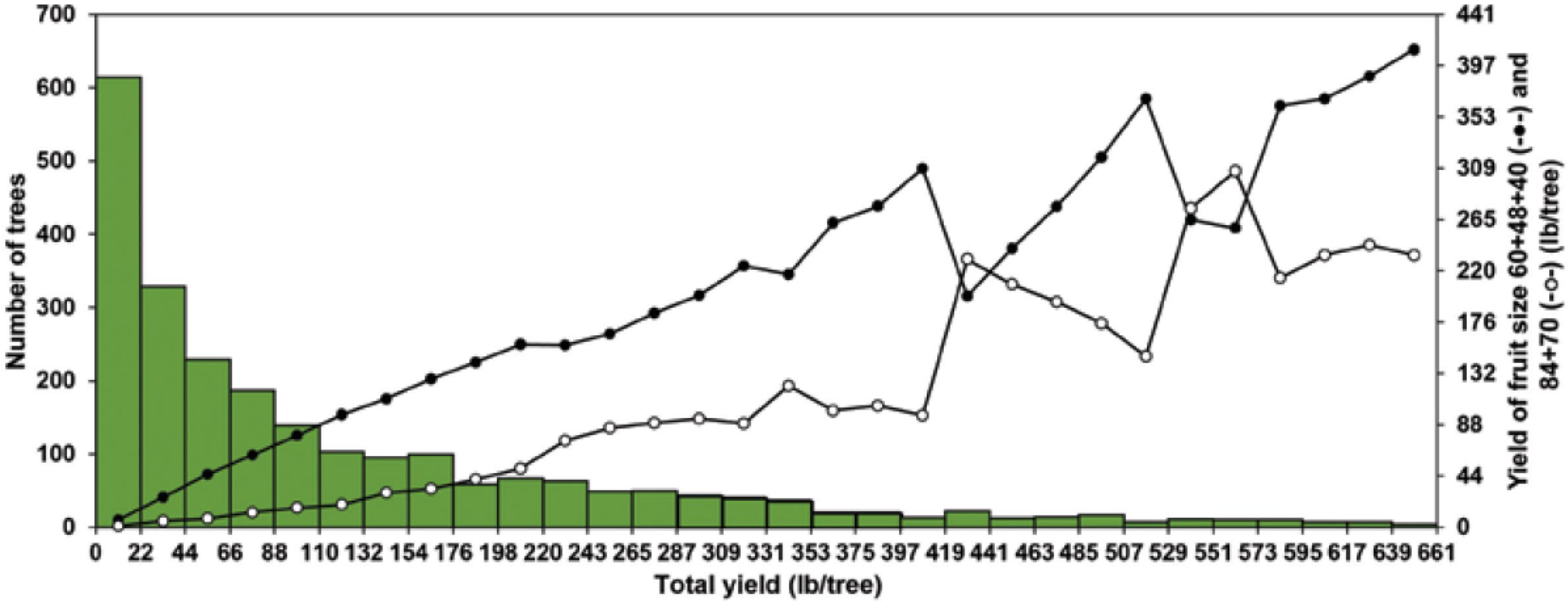
Avocado Production Transect Network

12 Locations
450 Total trees



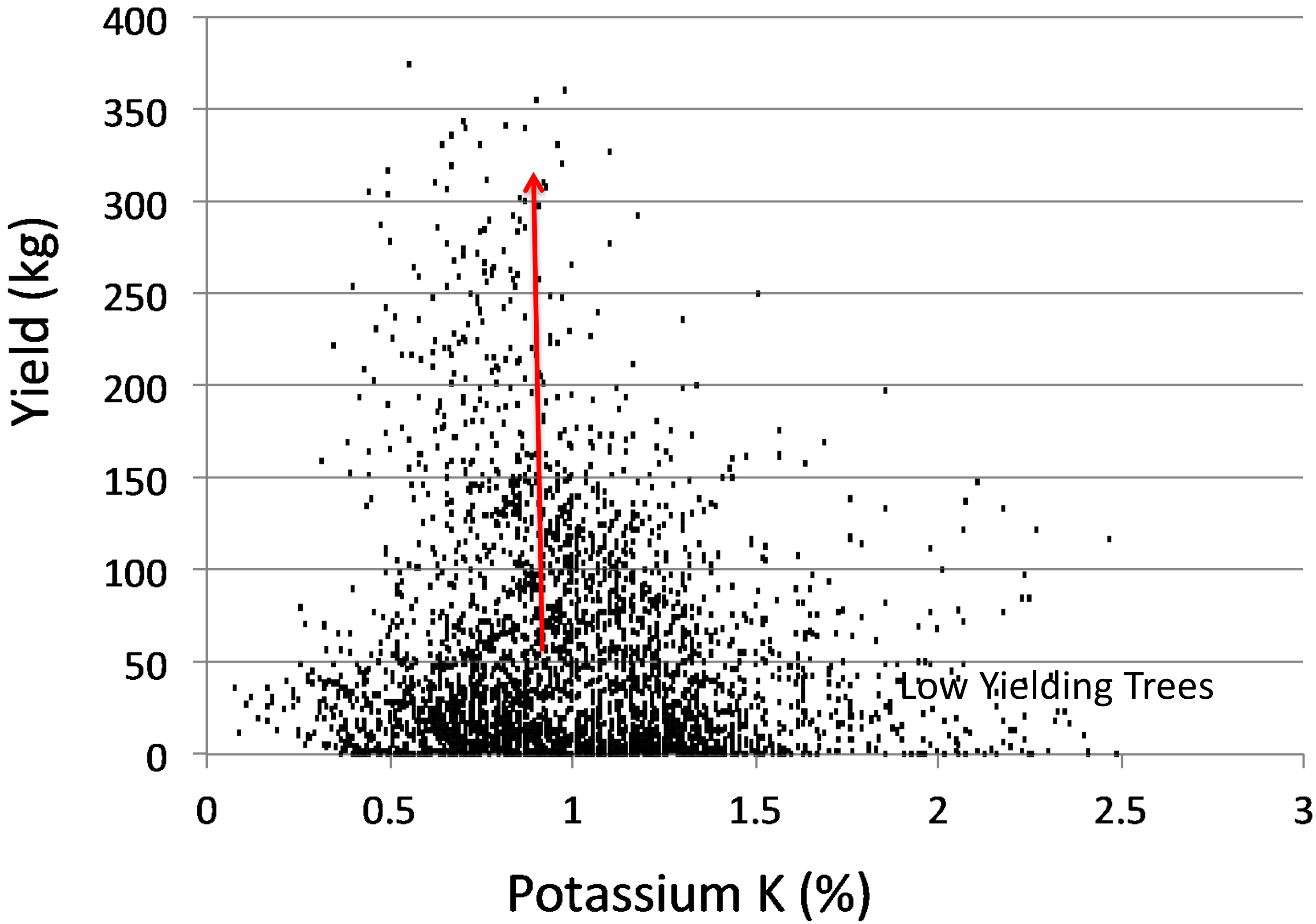
Rootstocks: Duke 7, Toro Canyon, Dusa, Thomas, Mexican

Yield Characteristics of California 'Hass' Avocado Trees

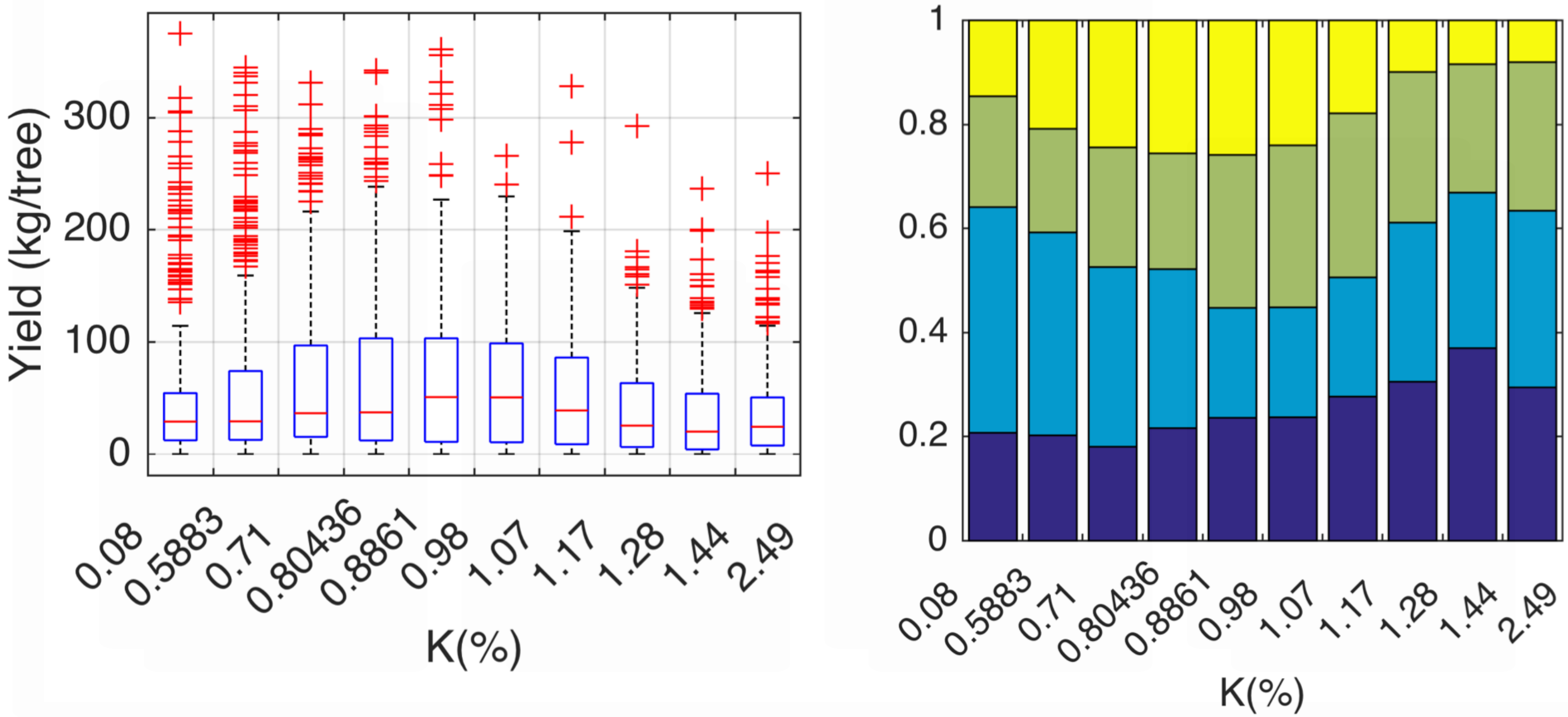


From the Grove. Fall 2017
Carol Lovatt, Yusheng Zheng, Toan Khuong, Salvatore Campisi-Pinto, David Crowley, and Philippe Rolshausen

Yield of avocado in relation to leaf potassium concentrations.

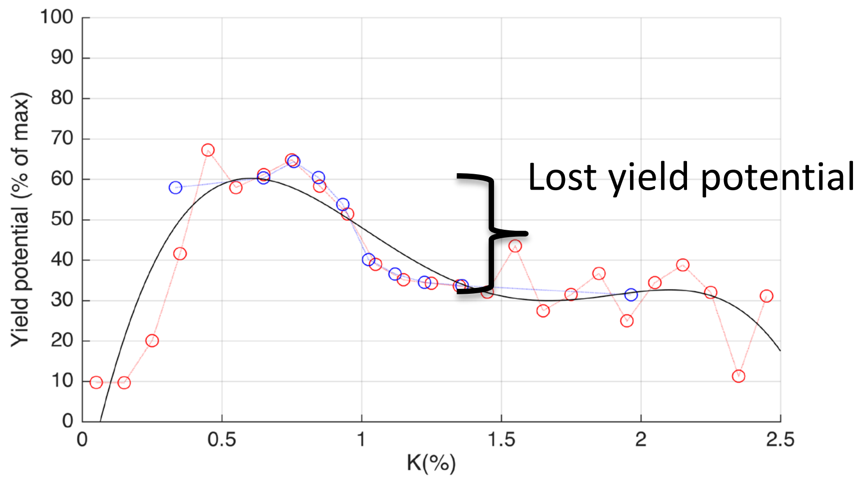


Leaf Potassium Relationship to Yield Potential

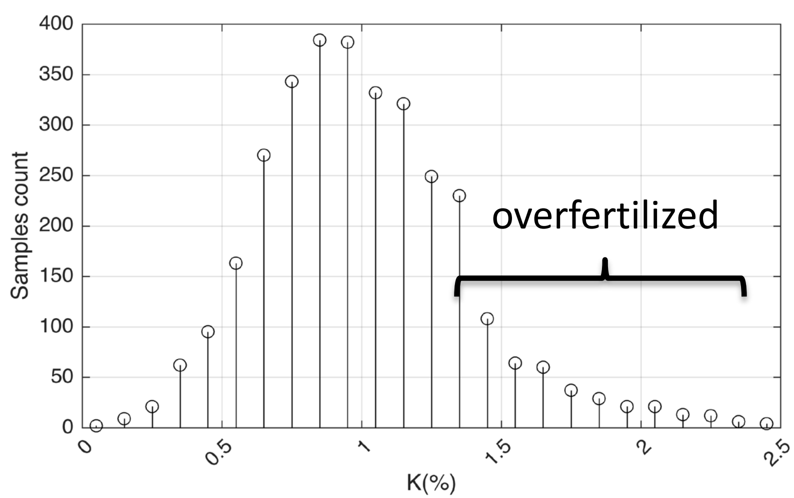


Avocado fruit yields in relation to leaf potassium content for trees sorted into bins corresponding to different nutrient range categories. Left, blue boxes represent range of yield values observed for 95% of trees in that nutrient category, red horizontal line inside each box is the yield for the median tree. The upper 1 percent of trees with highest yields are shown as the red cross data points above boxes for each nutrient range category.

Where is the avocado industry currently poised with respect to potassium?



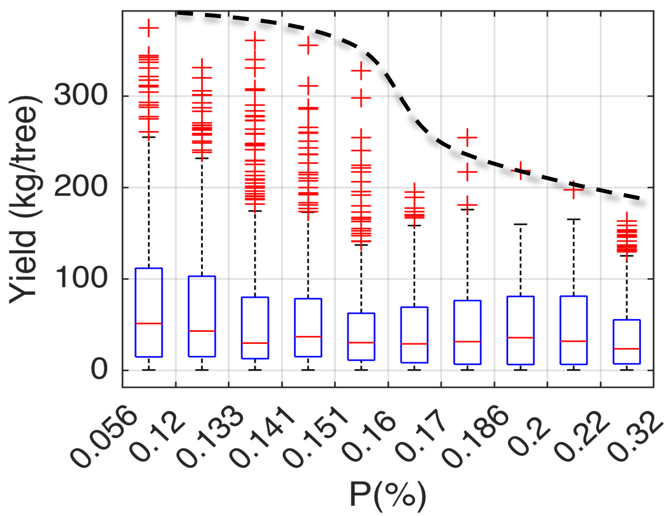
~ 20% of trees are in the optimum range of 0.8% K. Another 20% of trees are low in K, and 60% of the trees have K levels that may be excessive for obtaining the maximum yield potential.



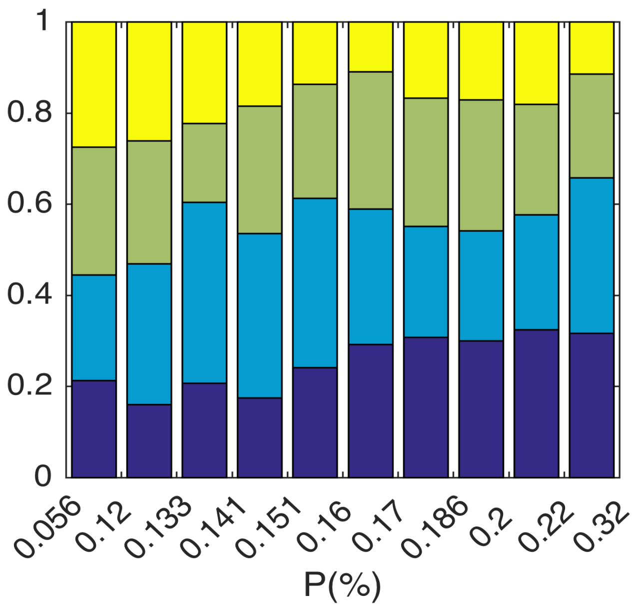
At leaf K levels of 0.8%, 18% of the trees are nonbearing. The number of nonbearing trees in an orchard increases to 36% when leaf K levels are above 1.4%. Overall about 20% of trees in the industry are being overfertilized for potassium.

Avocado Fruit Yield - Phosphorus Response Model

(Lovatt Crowley combined data sets, n = 3500 observations)



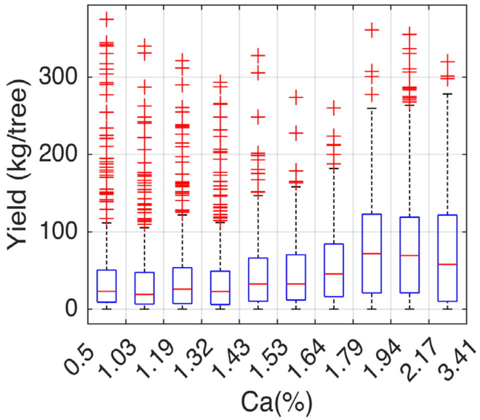
The frontier of production for the highest yielding trees follows a downward curve, with sharply at levels above 0.16% P. The yield response category for the majority of the trees (95% represented by the blue boxes) shows a relatively flat response to P, but that the highest median production is at 0.15%.

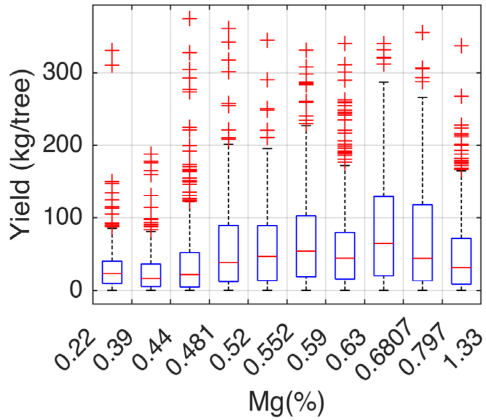


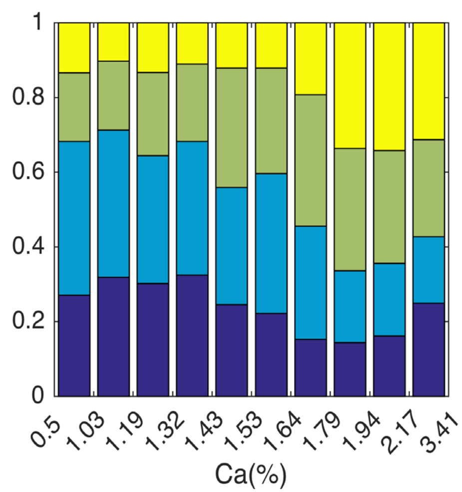
The numbers of high yielding trees (yellow) decrease with increasing P values.

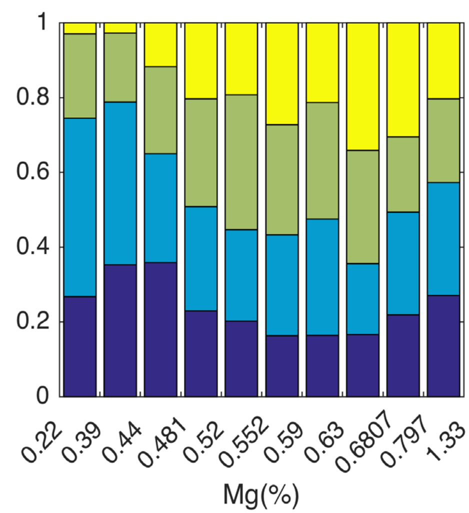
The lowest number of low yielding trees (purple) are those having between 0.12 to 0.15% leaf P concentrations, which is identified as the optimum range.

Avocado Yield Response Functions for Calcium and Magnesium







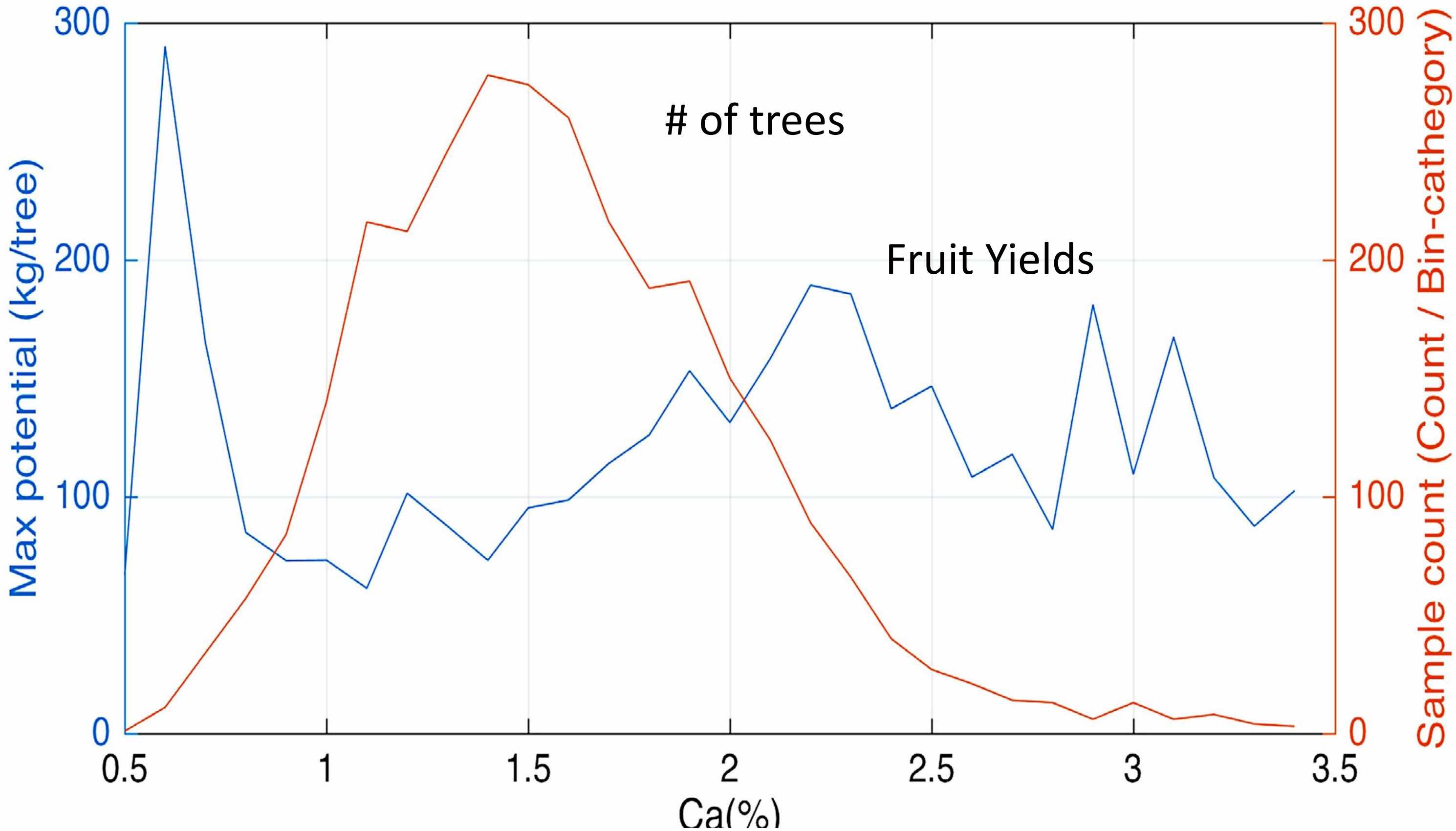


High yields are consistently associated with increased concentrations of Ca and Mg. High yielding trees may have up to 3.4% Ca.

Likewise, the numbers of low yielding trees (dark blue) decrease to a minimum for trees having from 1.6 to 1.94% Ca.

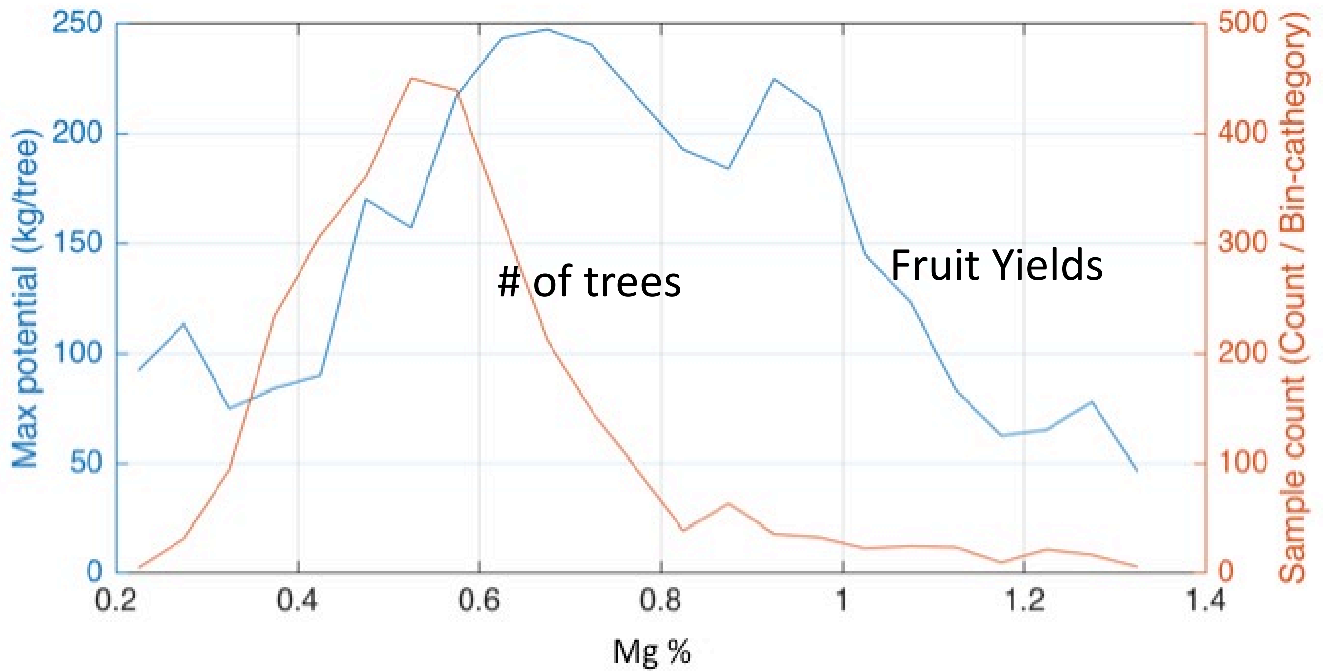
A nearly identical pattern is observed for magnesium, optimum magnesium levels are targeted at .0.6 – 0.68%

Calcium Levels and Yield Potential



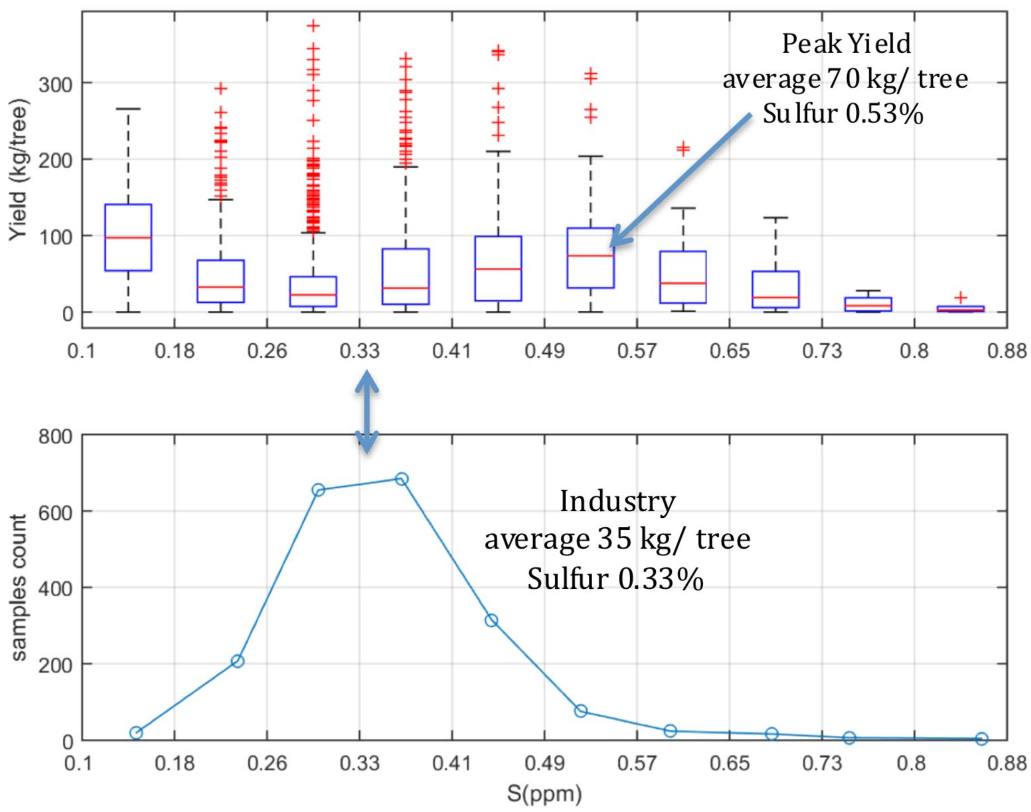
Calcium response curve for the top 5% producing trees (blue line) versus the number of individual trees having different levels of Ca (red line). Data suggest that the industry is poised too low on Ca.

Magnesium Relationship to Yield Potential



Magnesium response curve for the top 5% producing trees (blue line) versus the frequency for all trees having different levels of Mg (red line). Data suggest that the industry is poised too low on Mg.

Sulfur: The missing element in avocado nutrition?



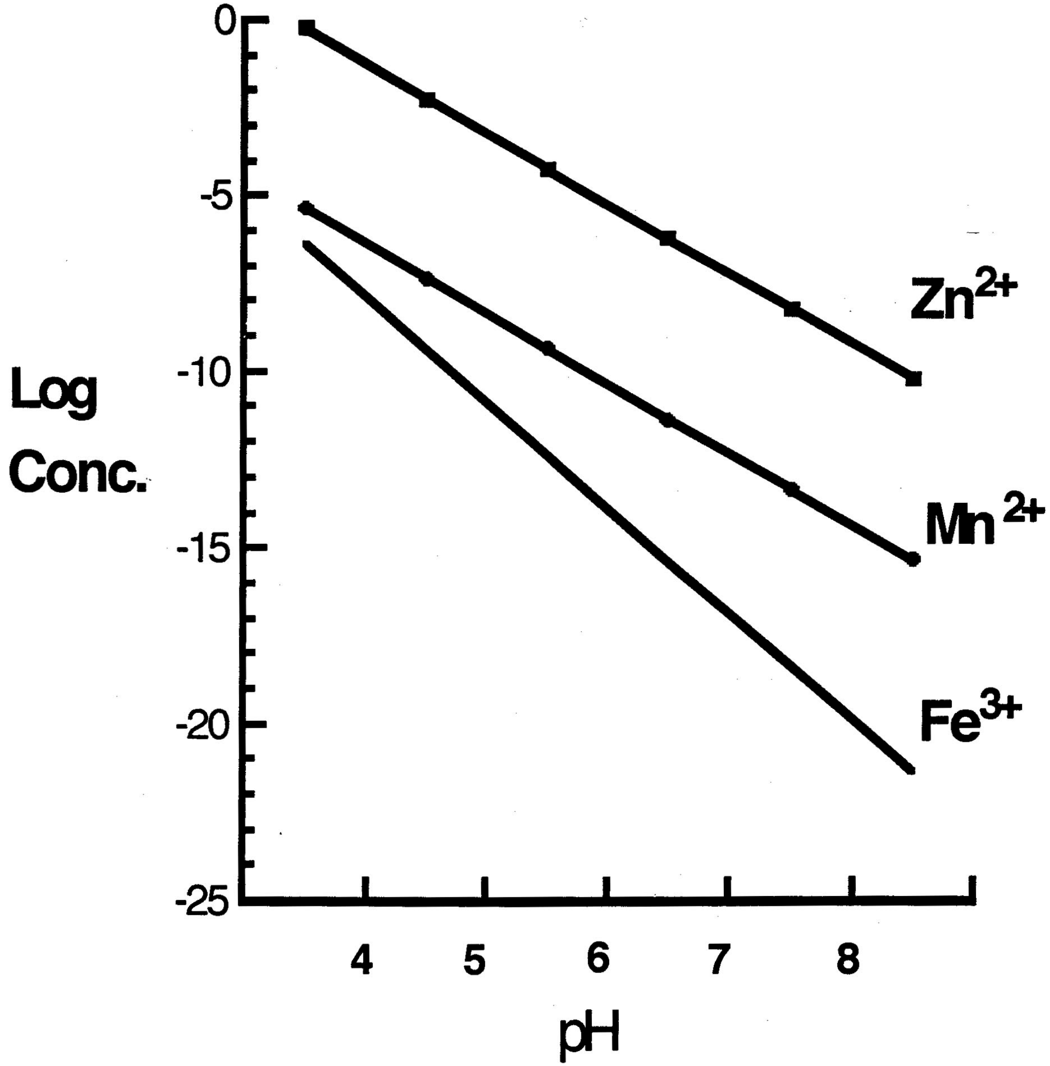
Frontier analysis showing box plots of yield for trees having different levels of leaf sulfur, median yield indicated as red line centered in each box. Bottom plot shows frequency of trees in each sulfur level category. As shown in the sample counts associated with each box plot, the majority of trees in the study had ~0.33% leaf sulfur, versus trees with peak yield occurring less frequently, and having 0.53% leaf sulfur. The data suggest S is limiting for most trees in this study and probably also for the avocado industry in general.

Zinc, Iron, and Manganese

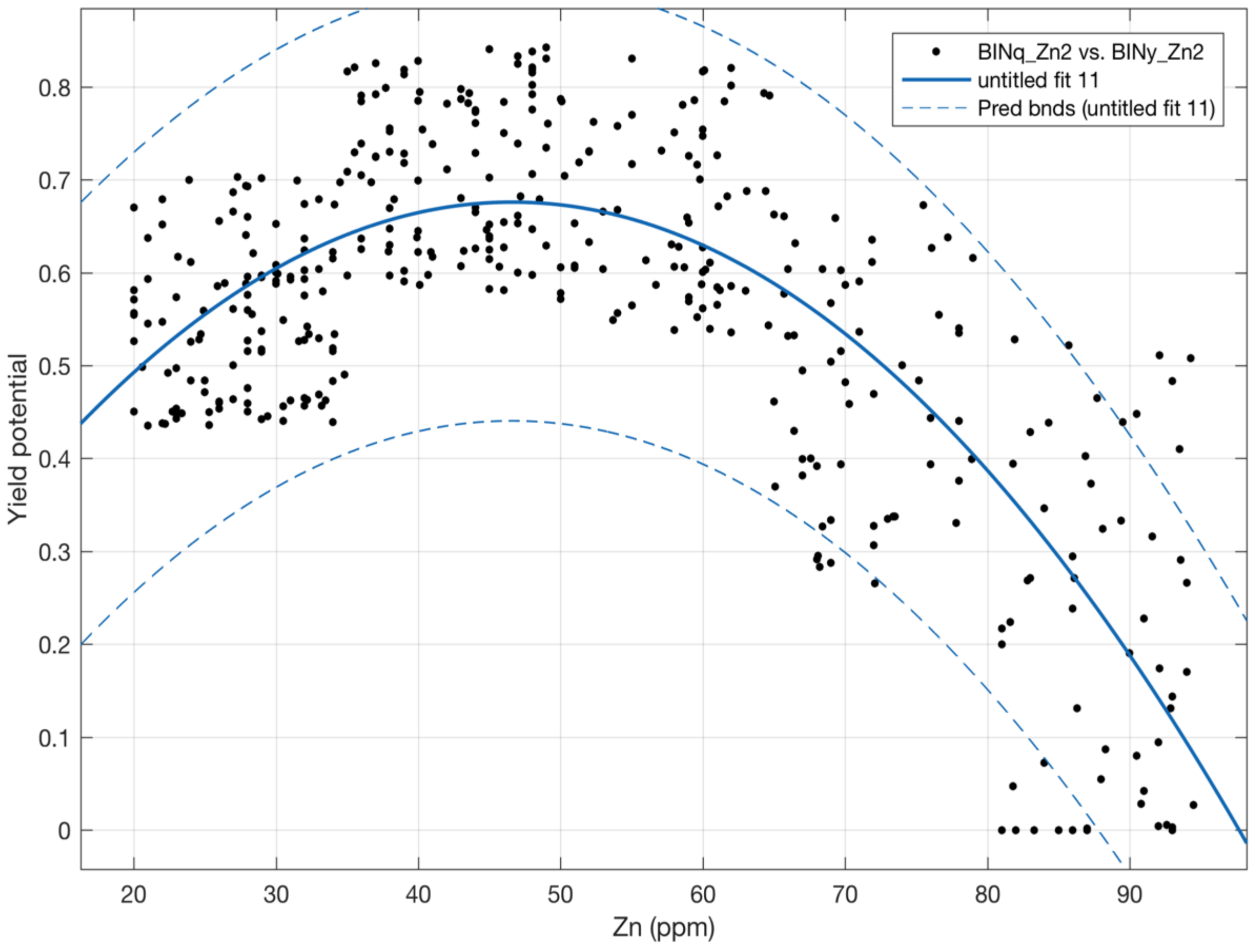
Deficiencies all look similar

Interveinal mottling and chlorosis.

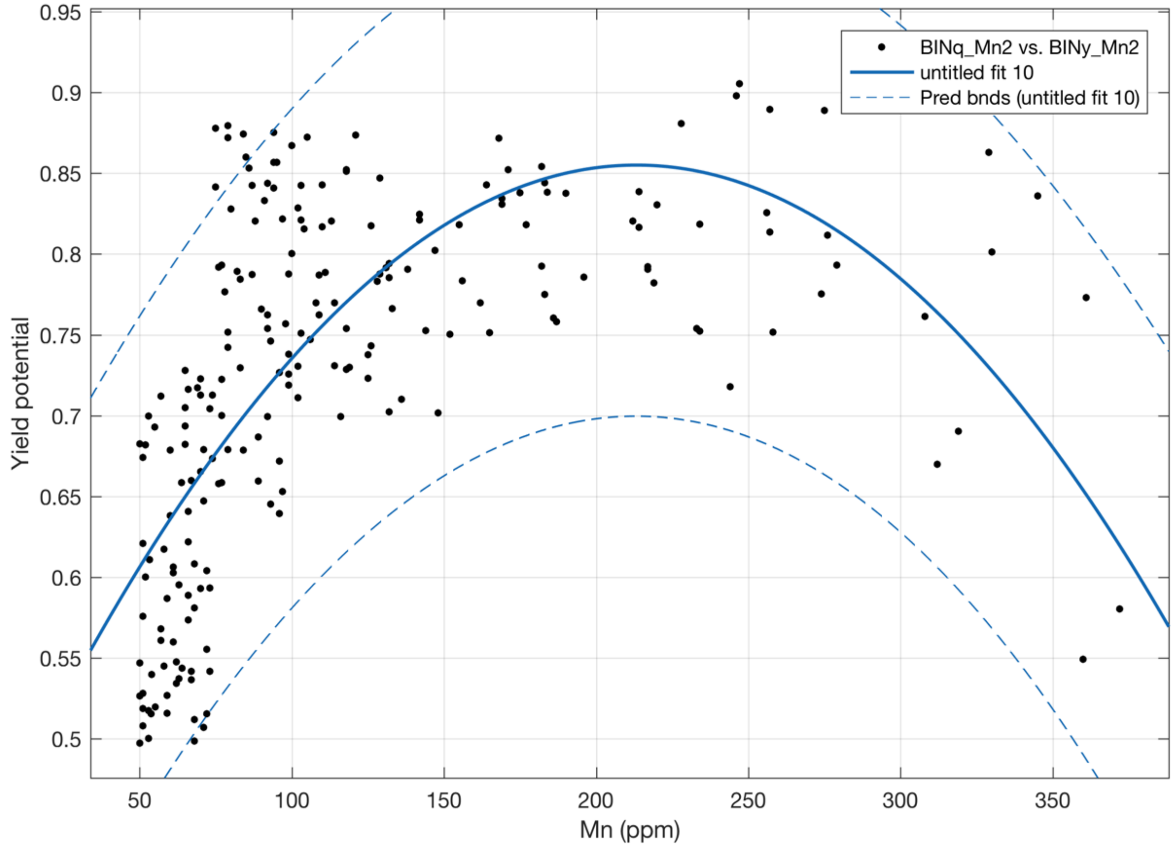
Soil pH effects on metal solubility



Zinc Relationship to Yield Potential



Manganese (Mn) Relationship to Yield Potential

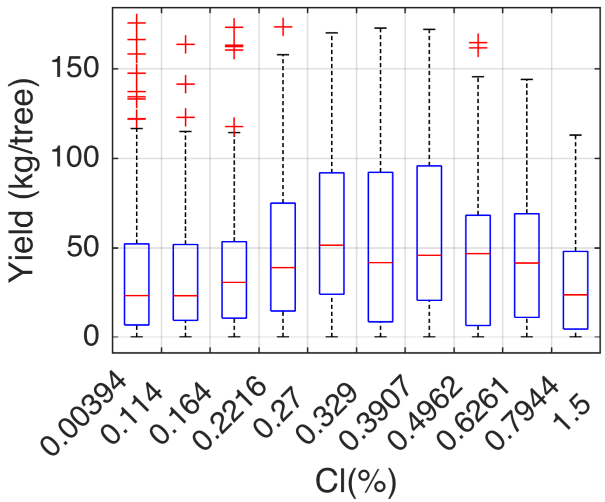


Sulfur Burners for Acidification of Soils

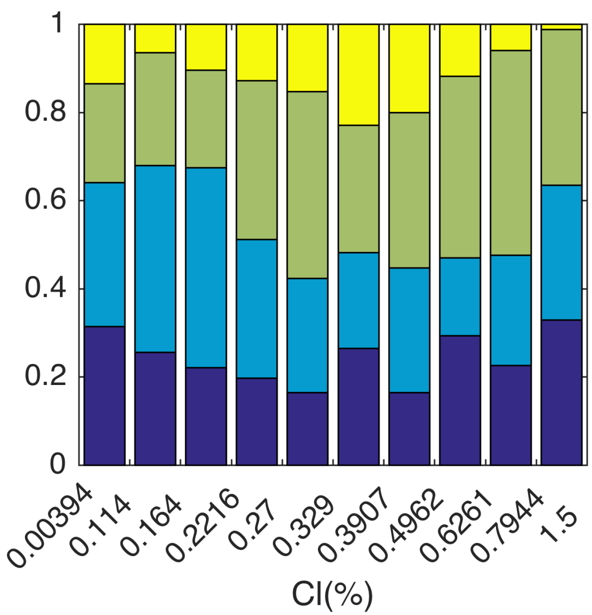
Produce sulfurous acid (safer than sulfuric acid)
Dissolves calcium carbonate lime to produce gypsum $CaSO_4$

Salt Burn: Chloride Toxicity

Chloride Effects on Avocado Yields



The frontier of production for the highest yielding trees decreases for trees having above 0.6% leaf Cl. Interestingly, trees with the lowest chloride levels (below 0.2% Cl) had lower yields. However, there are relatively few trees in the data set in this category. The majority of trees in the data set have leaf Cl levels from 0.2-0.5%.



The greatest number of high yielding trees have between 0.3 to 0.5 leaf Cl. At leaf concentrations above 0.6%, the number of high yielding trees decreases sharply, with approximately 30% of the trees becoming low or non-bearing.

Sample Report for DST Analysis of Leaf Tissue Data

Leaf Tissue Concentrations

	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu	B	Cl
Site 1	2.25	0.164	1.01	1.66	0.638	48.2	65	66	5	21.1	1.14
Site 2	2.1	0.179	1.62	1.17	0.483	25.4	31	54	5	26.8	1.18
Target	1.9-2.6	0.19-0.21	0.95-1.1	2.2-2.4	0.6-0.7	45-55	180-250	>80	7.0-9.0	40-60	<0.5

Rank of Most Limiting Elements and effect on % Yield Potential (YP)

Element	% YP		Element	% YP
Cu	84		Zn	71
B	85		Mn	82
Mg	85		Cu	84
Mn	88		Ca	87
Ca	89		Fe	88
Zn	94		P	89
K	95		K	95
Fe	97		B	97
P	98		Mg	97
N	100		Cl	100
Cl	100		N	100

Sample Report for DST Analysis of Leaf Tissue Data

	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu	B	Cl
Site 1	2.25	0.164	1.01	1.66	0.638	48.2	65	66	5	21.1	1.14
Site 2	2.1	0.179	1.62	1.17	0.483	25.4	31	54	5	26.8	1.18
Target	1.9-2.6	0.19-0.21	0.95-1.1	2.2-2.4	0.6-0.7	45-55	180-250	>80	7.0-9.0	40-60	<0.5

Element	% YP	
Cl	44	Excess
Mn	75	
B	84	
Ca	87	
Cu	91	
P	91	
Fe	92	
K	99	
Zn	99	
Mg	100	
N	100	

Element	% YP	
Cl	36	Excess
K	43	Excess
Mn	63	
Ca	63	
Zn	82	
Fe	87	
Mg	88	
Cu	91	
B	91	
P	96	
N	100	

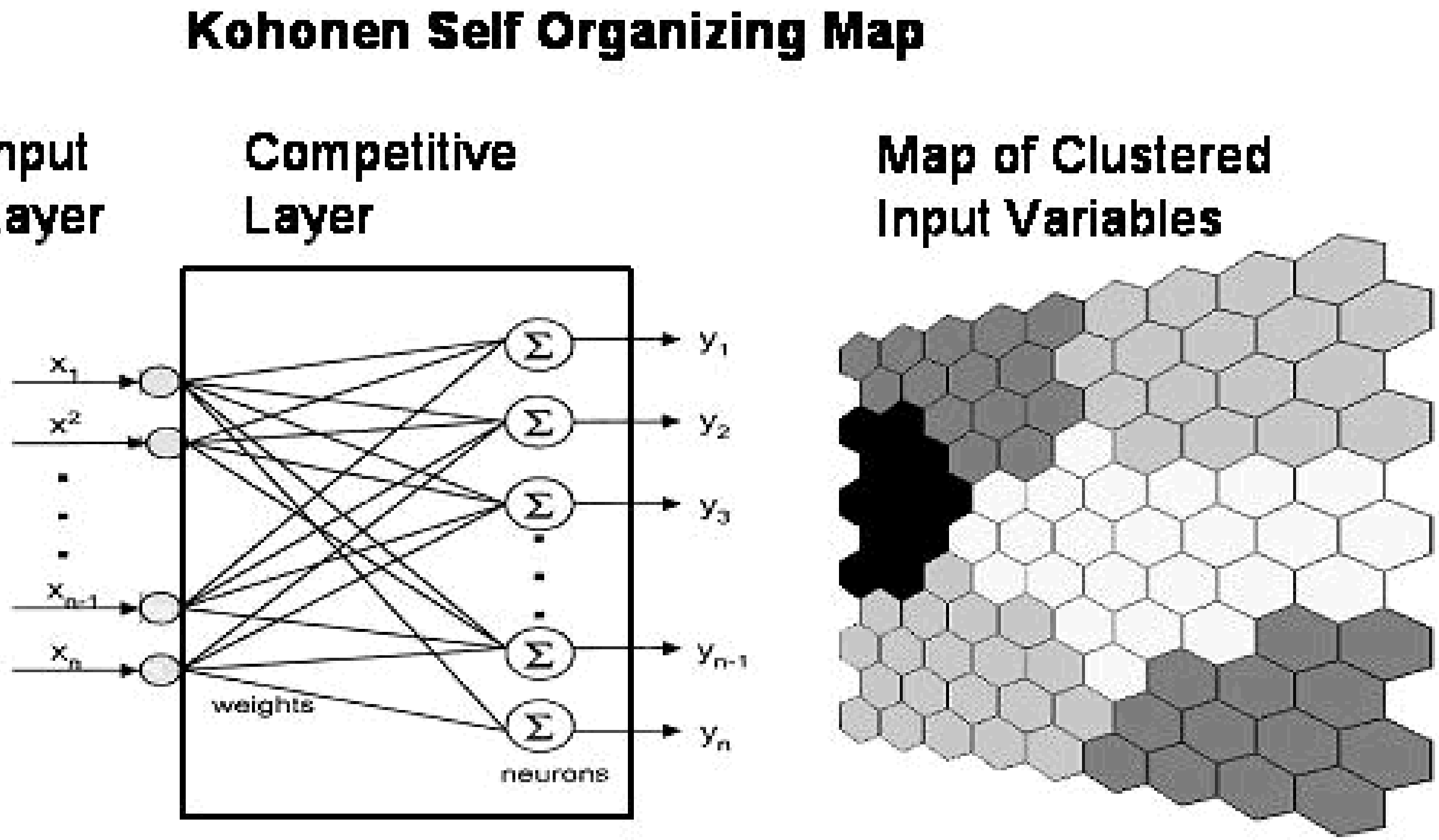
Most Limiting Elements At Each Location

	Location 1		Location 2		Location 3		Location 4
S	72	S	63	S	70	S	62
Mn	81	Mn	69	Mn	72	Mn	65
Fe	83	Fe	84	Fe	90	Ca	82
Ca	91	Cu	84	Ca	91	Cu	84
Cu	95	Ca	91	Cu	95	Fe	87
B	97	Cl	94	Mg	95	Cl	94
P	98	B	94	B	96	B	94
N	98	Zn	97	Cl	96	P	96
Zn	99	P	98	P	98	Zn	96
K	99	K	99	K	99	K	99
Cl	99	Mg	100	Zn	99	Mg	99
Mg	100	N	100	N	100	N	100

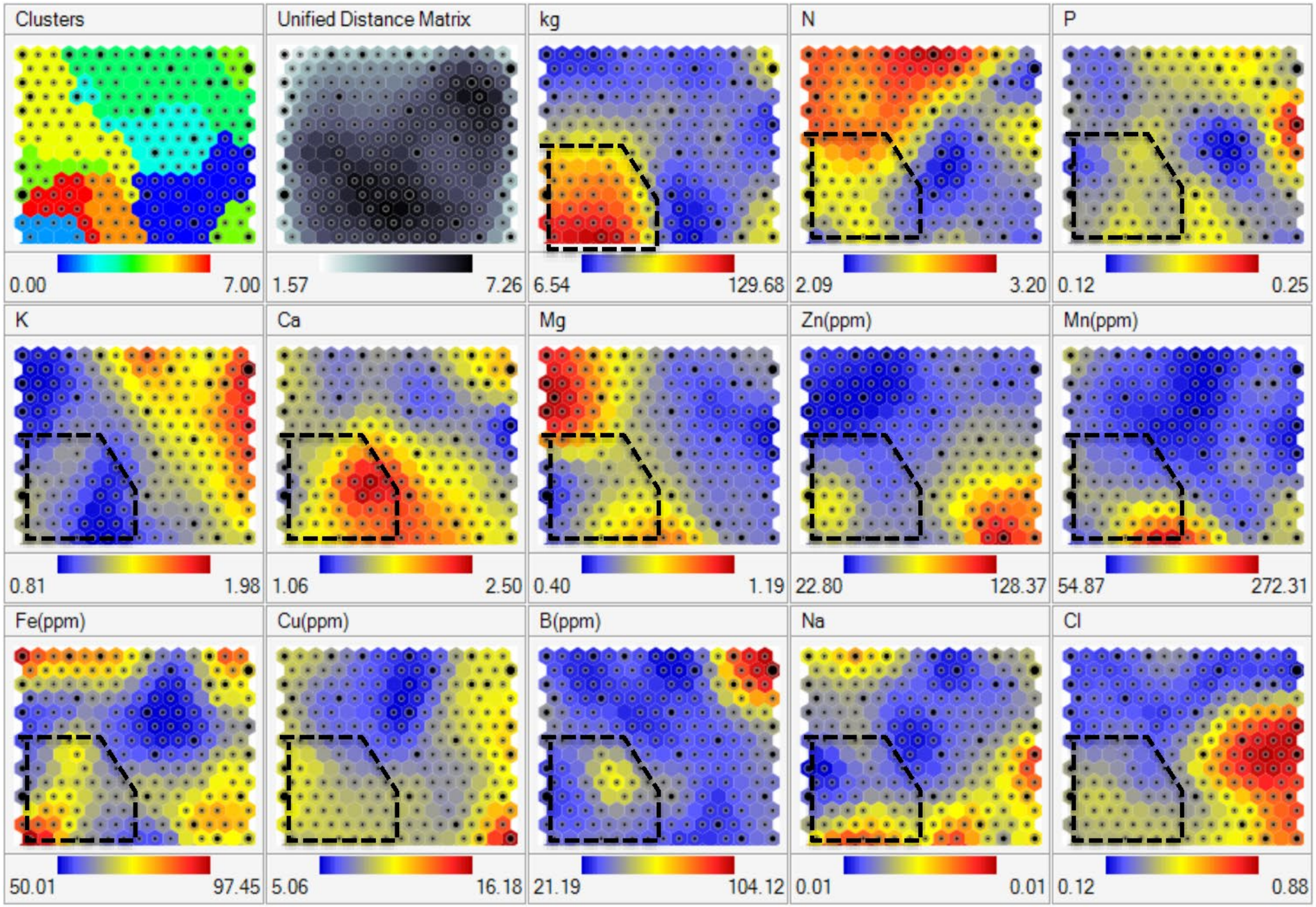
	Location 5		Location 6			Location 7			Location 8
Mn	79	S	67		Mn	76		S	76
S	85	Mn	68		K	79	excess	Zn	76
P	86	K	77	excess	Zn	80		Mn	83
Ca	86	Ca	80		Fe	86		Cl	88
Cl	87	Fe	81		S	91		Fe	89
Fe	88	Cu	84		Ca	97		Ca	91
K	92	Mg	92		Cl	98		Mg	96
Zn	99	Zn	94		P	98		P	98
Cu	99	P	95		N	98		Cu	98
Mg	99	B	99		Cu	98		B	98
B	100	Cl	100		Mg	99		N	99
N	100	N	100		B	99		K	99

Visualization of Nutrient Yield Relationships Using Artificial Neural Networks for Pattern Recognition

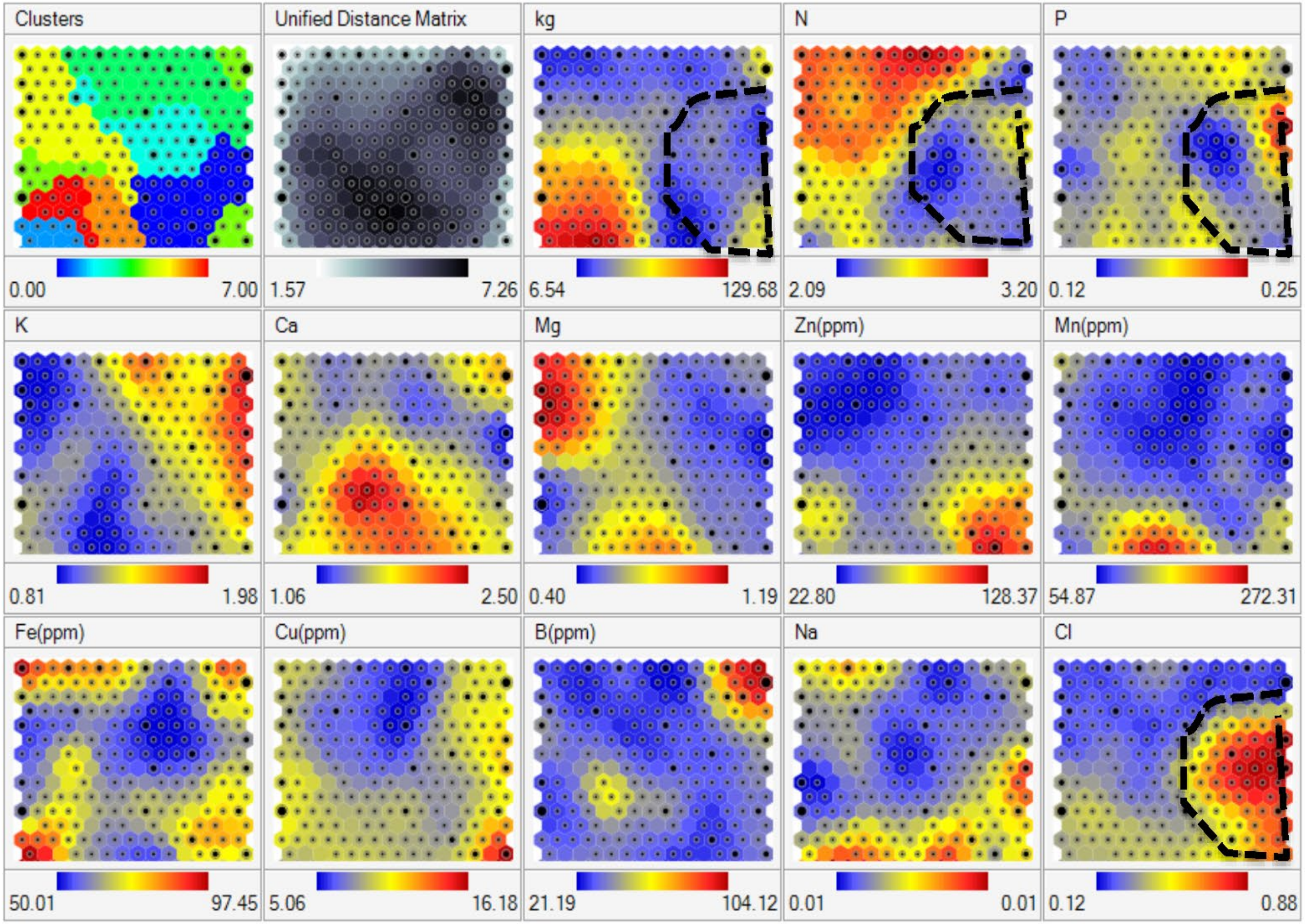
Yield (kg)
Nitrogen
Phosphorus
Potassium
Calcium
Magnesium
Zinc
Boron



Kohonen Self Organizing Map of Yield - Nutrient Relationships



Relationships between leaf chloride, mineral nutrient concentrations and yields in avocado



Summary

Nitrogen is the most dynamic of the managed elements and is continually lost from soils by denitrification and leaching. N is best supplied in the spring (April) and early summer with multiple applications matching tree phenology and N demand. Empirical field studies indicate 40-125 lbs per acre per year are sufficient.

Leaf tissue analysis and soil reports are used to guide fertilization with other elements that are supplied as needed. Leaf tissue concentrations that support rapid tree growth and strong canopy development are different from those that are associated with high fruit yields.

Excess nutrients as well as nutrient deficiencies are associated with lowered yield potentials. Across the industry, several elements are out of alignment with nutrient concentrations that affect yield potentials. These include calcium, sulfur, and zinc deficiencies, and excess of potassium

Summary

Uptake of nutrients and fertilizer use efficiency are dependent on healthy roots and mycorrhizae that depend in turn on soil organic matter and soil physical and chemical properties.

Good irrigation and leaching practices are central to managing soil salinity and soil fertility. Chloride toxicity affects root growth, lowers leaf nutrient uptake, and causes crop loss.

Artificial neural network models and quantile regression methods reveal with statistical confidence the optimal levels for nutrients that are associated with the fruit yield potentials of avocado.

Decision support tools have been developed to predict avocado fruit yield potentials with respect to leaf analyses. The output from the DST model ranks all of the elements according to priority for correction and can thus guide tree fertilization. This information is in the public domain, and is available commercially as a custom report (iwanngagrow.com).

Disclaimer

Many factors affect avocado yields, including soil type, climate, and weather as well as irrigation water quality which will vary between locations and over time. Yields are further affected by management practices including pruning, use of mulches, disease control, pollination, and salinity. Given, we do not make any claims that the decision support tools can predict actual yields that can be achieved, but instead refer only to % yield potentials with respect to tree nutrition.

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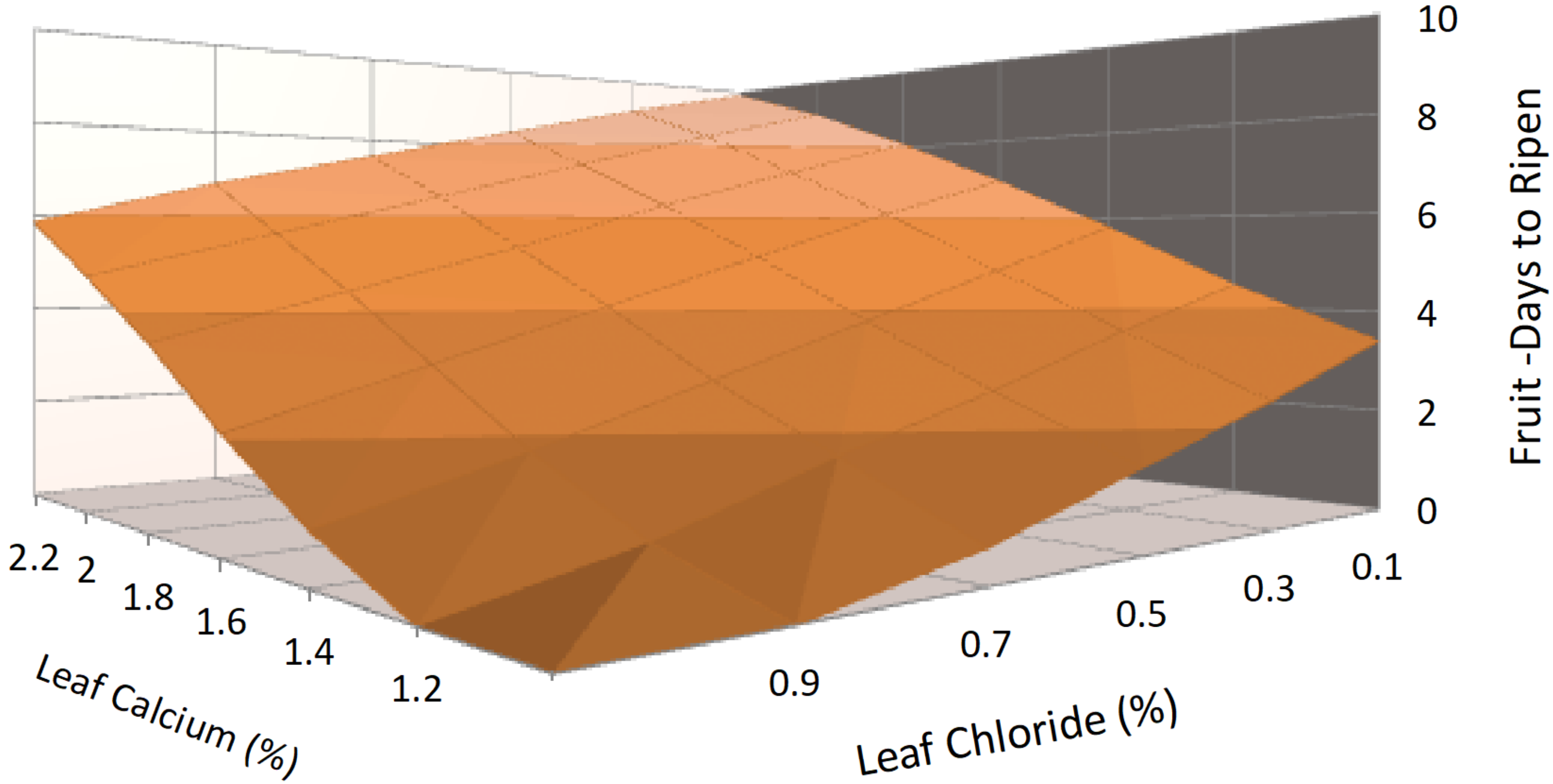
Interactions of Leaf Chloride and Calcium Contents on Fruit Time to Ripening for Hass Avocado



Nutrient concentrations in leaves of various fruit tree species

Nutrient	Unit DW	Apple[a,c,d,e]	Pear[a,c,d,e]	Cherry[b]	Peach[b]	Apricots[a,b]
Nitrogen (N)	%	1.7 – 2.5	1.8 – 2.6	2.00 – 3.03	2.7 – 3.5	2.4 – 3.3
Phosphorous (P)	%	0.15 – 0.3	0.12 – 0.25	0.10 – 0.27	0.1 – 0.30	0.1 – 0.3
Potassium (K)	%	1.2 – 1.9	1.0 – 2.0	1.20 – 3.3	1.2 – 3.0	2.0 – 3.5
Calcium (Ca)	%	1.5 – 2.0	1.0 – 3.7	1.20 – 2.37	1.0 – 2.5	1.10 – 4.00
Magnesium (Mg)	%	0.25 – 0.35	0.25 – 0.90	0.30 – 0.77	0.25 – 0.50	0.25 – 0.80
Sulfur (S)	%	0.01 – 0.10	0.01 – 0.03	0.20 – 0.40	0.2 – 0.4	0.20 – 0.40
Copper (Cu)	mg/Kg	5 – 12	6 – 20	0 – 16	4 – 16	4 – 16
Zinc (Zn)	mg/Kg	15 – 200	20 – 60	12 – 50	20 – 50	16 – 50
Manganese (Mn)	mg/Kg	25 – 150	20 – 170	17 – 160	20 – 200	20 – 160
Iron (Fe)	mg/Kg	60 – 120	100 – 800	57 – 250	120 – 200	60 – 250
Boron (B)	mg/Kg	20 – 60	20 – 60	17 – 60	20 – 80	20 – 70

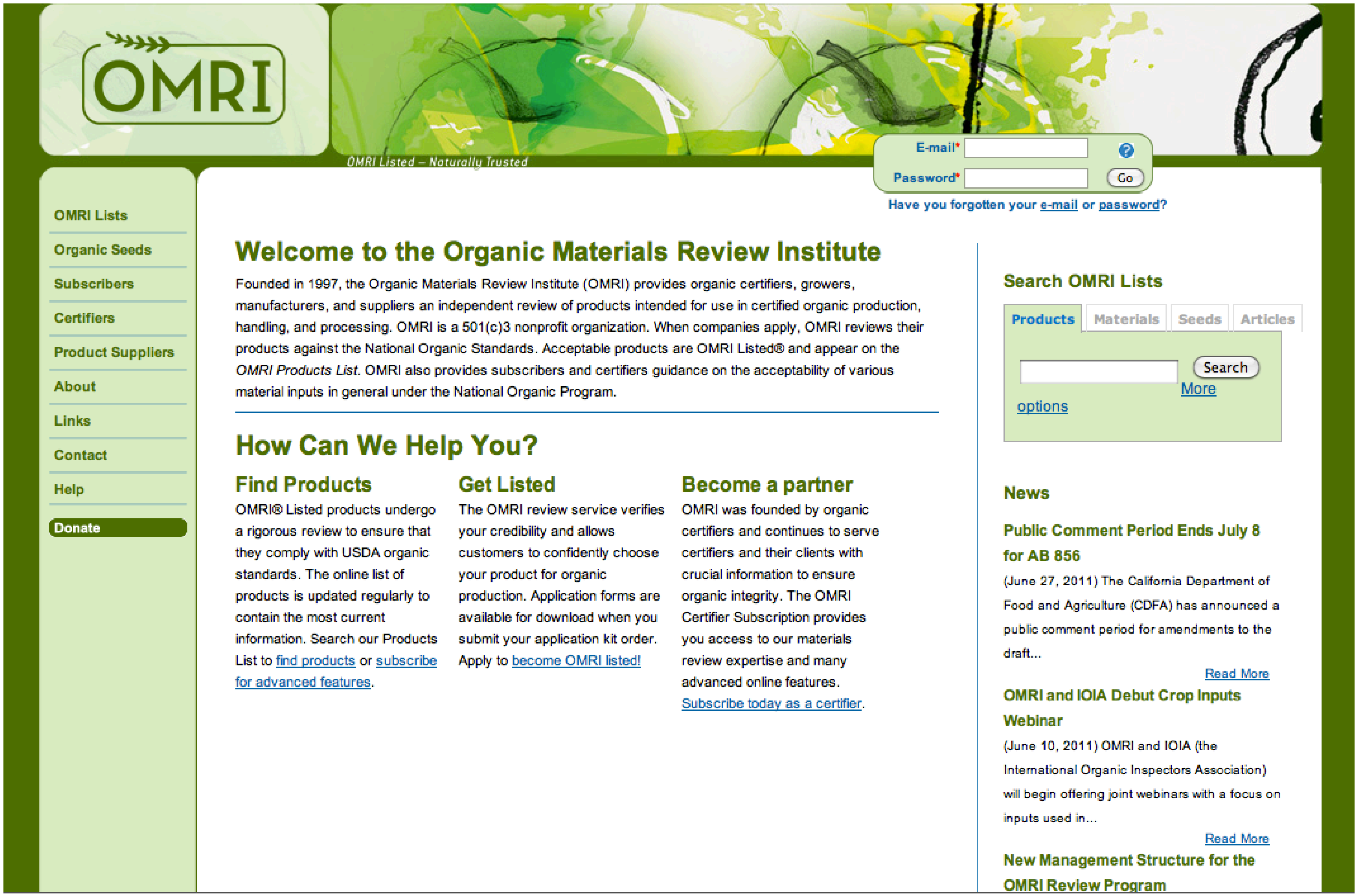
Adapted from:

[a] Shear and Faust, 1980;

[b] Reuter and Robinson, 1997;

[c] Righetti et al., 1990;

What about organic fertilizers?



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Decision Tree for Calculation of Nitrogen Application Requirements

N Replacement Calculations		**Adjustment factor to achieve target Leaf N**		**N Use Efficiency Adjustment (%)**
Yield (lbs acre)		Leaf N Content Prior Fall		Soil Texture (Leaching Potential)
↓		↓		↓
N Removed in Fruit (2.8 lbs /1000 lbs fruit)		Target/measured (2.2% target/Leaf N%)		Denitrification Potential)
↓		↓		↓
Nitrogen Requirement (lbs acre)	X	Leaf Target Level Adjustment	/	N Use Efficiency Adjustment (%)
				↓
				Total N to be Applied

- N Retained in Leaf Litter Layer +/- 5lbs
- Adjust for N content of irrigation water

Calculations for Fertilization Program

Nitrogen Replacement X Nitrogen Use Efficiency X Target Adjustment Factor = Fertilizer Requirement

Nitrogen Replacement
- Fertilizer
- N Content Irrig Water
- Org Matter Decomp

Nitrogen Use Efficiency
- N Losses
- Leaching
- Denitrification
- Soil Properties
- Application Frequency

Target Adjustment Factor
- Leaf Analysis
- Historical Records
- Aerial Image Analyses
- Petiole Analyses

Fertilizer Requirement
- % N Formula
- Application Schedule

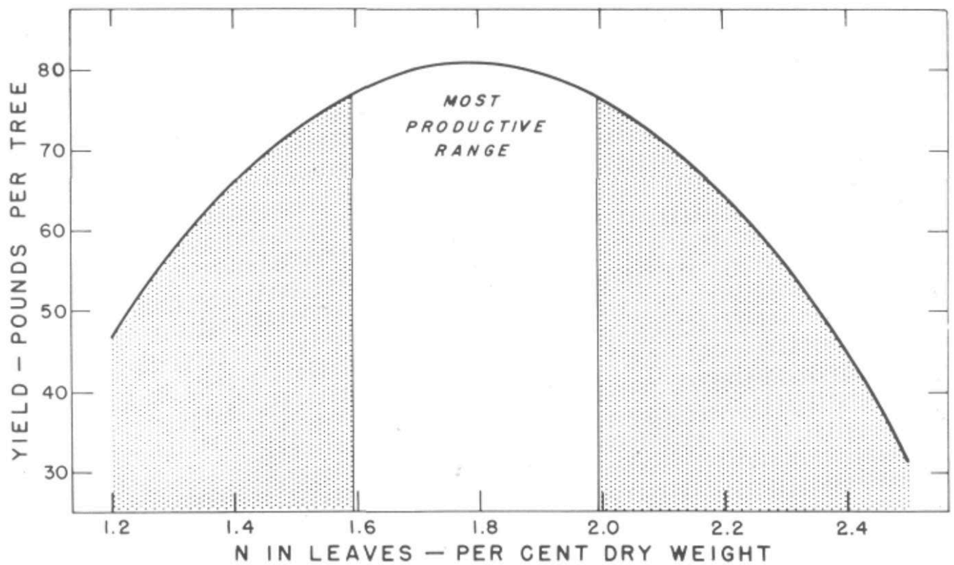
California Agriculture. 1960. 14(1):12.

Fertilization of the Avocado
Leaf analysis as a guide to nitrogen

T. W. EMBLETON, W. W. JONES and M. J. GARBER

Recent reports indicate that applications of too little or too much nitrogen to avocado trees result in reduced yields.

Fuerte avocado yield as related to the percentage of nitrogen in the youngest, fully expanded and mature leaves sampled in the August–October period.



Undoubtedly, soil types, rootstock, climate, soil salinity, variations in irrigation water and other less obvious factors influence the efficiency of a given rate of nitrogen as related to the nitrogen nutrition in the tree.