Avocado Fertilization

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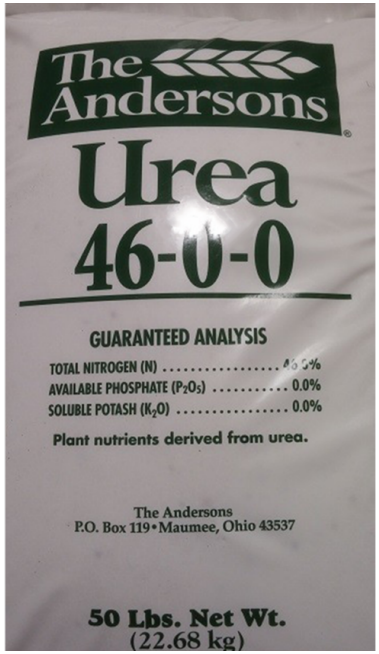
Introduction

- Avocados have few mineral deficiencies
- Surface feeder roots are efficient at recycling nutrients back into the tree

- Nitrogen should be applied every year, occasionally zinc and sometimes phosphorus, potassium and calcium (maybe)
- Calcium may be beneficial especially on acid soils and it may provide a degree of resistance to avocado root rot fungus



- Leaf analysis is normally used to determine mineral deficiency or excess
  - Samples (usually 40 leaves per block) are taken from late August-Oct from 5-7 month-old spring-flush leaves. These are the leaves about 5-6 from the end of the flush

- Liquid fertilizer injection is the normal way to apply fertilizers
  - Ease of application, much less labor costs, application is on the roots in the irrigated zone, very efficient on slopes

A New Grower's Quick Guide

- Hass avocados usually require 1.5 – 2.0 lbs actual nitrogen per tree per year
- Usually applied as a liquid fertilizer divided between 6 to 9 applications per year
- A hand-applied suggestion would be
  - 6 lbs triple 15 per tree in late February or early March (= 0.90 lbs actual N)
  - 3 lbs calcium nitrate (15.5-0-0) in June (= 0.47 lbs actual N)
  - 3 lbs calcium nitrate (15.5-0-0) in June (= 0.47 lbs actual N)
  - Total 1.83 lbs actual N/tree/year

Zinc

- Leaves are mottled, showing yellowing between the veins
- Small leaves
- Zinc sulfate can be
  - Applied by helicopter in May, 8 lbs/acre in 20 gallons water
  - Or, through the irrigation system
  - Or, hand applied around each tree every 3-5 years

Zinc Deficiency

Chloride Tip-Burn

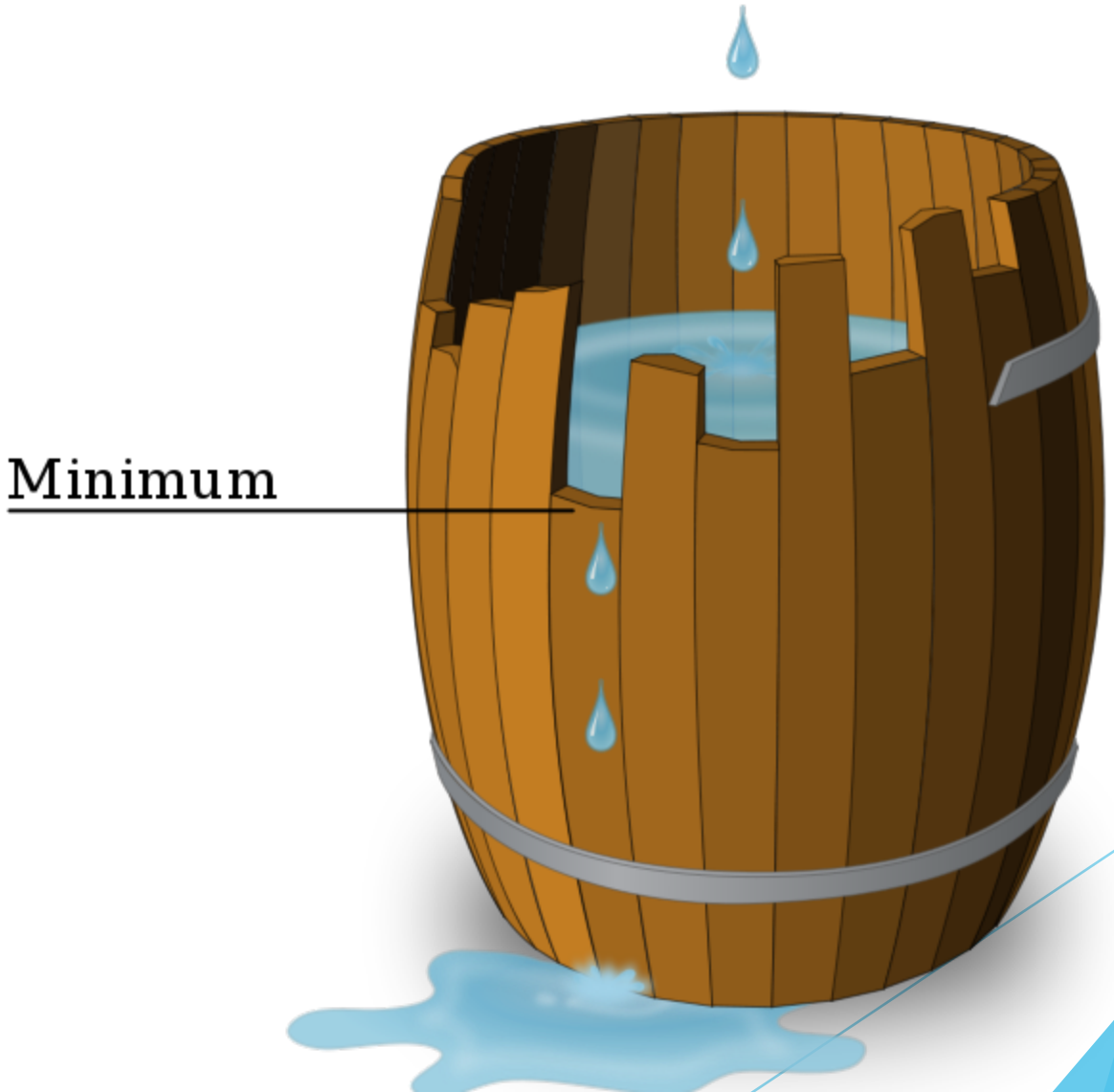
- Not a mineral deficiency, but an excess of salinity due to
  - Saline irrigation water (wells or reclaimed water)
  - Poorly leached soils (salt accumulates in the root-zone)
  - Under-irrigation
  - Over application of manures and fertilizers
  - Water turned off during escrow! (a big problem)

Chloride Tip Burn-Avocado

Required Mineral Nutrients

- 16 mineral nutrients
- C, H, O from air and water
- N, P, K (primary macro-nutrients)
- Ca, Mg, S (secondary macro-nutrients)
- Micro-nutrients….Zn, Fe, Mn, Cu, B, Mo, Cl

Law of the Minimum



Wt.(lbs) Mineral Nutrients Removed in 10,000 lbs Avocados/Acre (Cutting, New Zealand, 2000)

- N 35.6
- P 5.4
- K 60.4
- Ca 0.8
- Mg 3.3
- S 3.5
- B 0.04
- Fe 0.09
- Zn 0.04
- Mn 0.02
- Cu 0.01

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

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

http://www.avocadosource.com/

Leaf Analysis

- Sampling
  - Leaves taken in August-October period
  - 5-7 month-old leaves sampled
  - Non-fruiting branches
  - Sample good blocks vs. poor blocks in separate samples

- In California, despite 4 decades of research, only a limited number of experiments have been conducted to determine optimal rates of soil applied fertilizers - N, P, K, Fe, and Zn.

- All other fertilizer recommendations are based on leaf analyses using optimum ranges borrowed from citrus & though modified over the years, are not related to any avocado yield parameter.

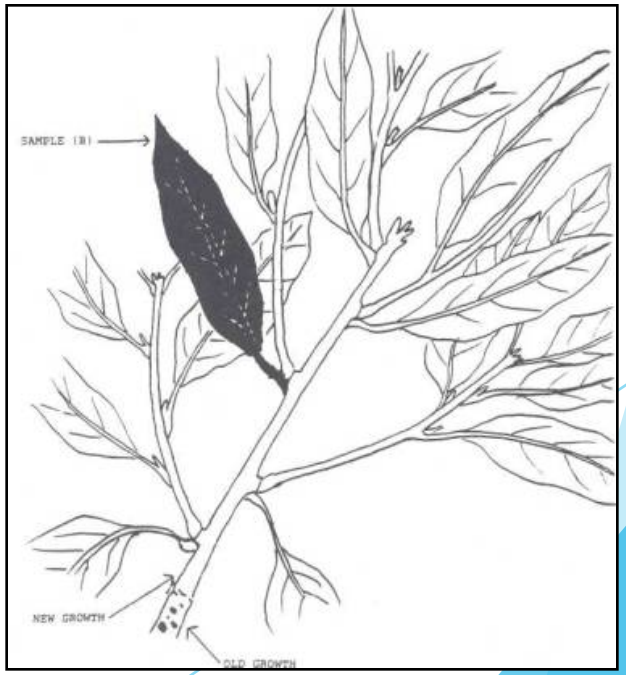


Table 2. Ranges of Elements for Interpretation of Leaf Tissue Analyses for Avocado

		Ranges for Mature Trees		
Element	**Unit**	**Low**	**Sufficient**	**High**
Nitrogen (N)				
Hass	%	<1.8	2.0 - 2.2	>2.2
Fuerte	%	<1.6	1.6 - 2.0	>2.0
Phosphorus (P)				
Fuerte	%	0.05 - 0.07	0.08 - 0.25	0.26 - 0.3
All Others	%	0.05 - 0.09	0.10 - 0.25	0.26 - 0.3
Potassium (K)	%	0.35 - 0.74	0.75 - 2.0	2.1 - 2.9
Calcium (Ca)	%	0.50 - 0.99	1.00 - 3.00	3.1 - 4.0
Magnesium (Mg)	%	0.15 - 0.24	0.25 - 0.80	0.9 - 1.0
Sulfur (S)	%	0.05 - 0.19	0.20 - 0.60	0.7 - 1.0
Boron (B)	Ppm	20 - 49	50 - 100	>100
Iron (Fe)	Ppm	20 - 49	50 - 200	>200
Manganese (Mn)	Ppm	15 - 29	30 - 500	>500
Zinc (Zn)	Ppm	<20	30 - 150	>150

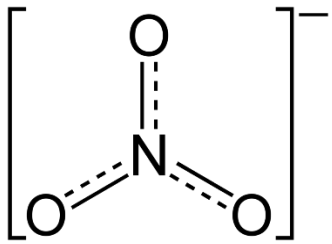
The Essential Elements (Australia)

- Primary Elements Required for Growth
  - Carbon, Hydrogen and Oxygen
    - Supplied from carbon dioxide and water, essential for photosynthesis
  - Nitrogen
  - Phosphorous
  - Potassium

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

Nitrogen

- Nitrate is mobile in the soil and is absorbed readily into roots, leaches readily

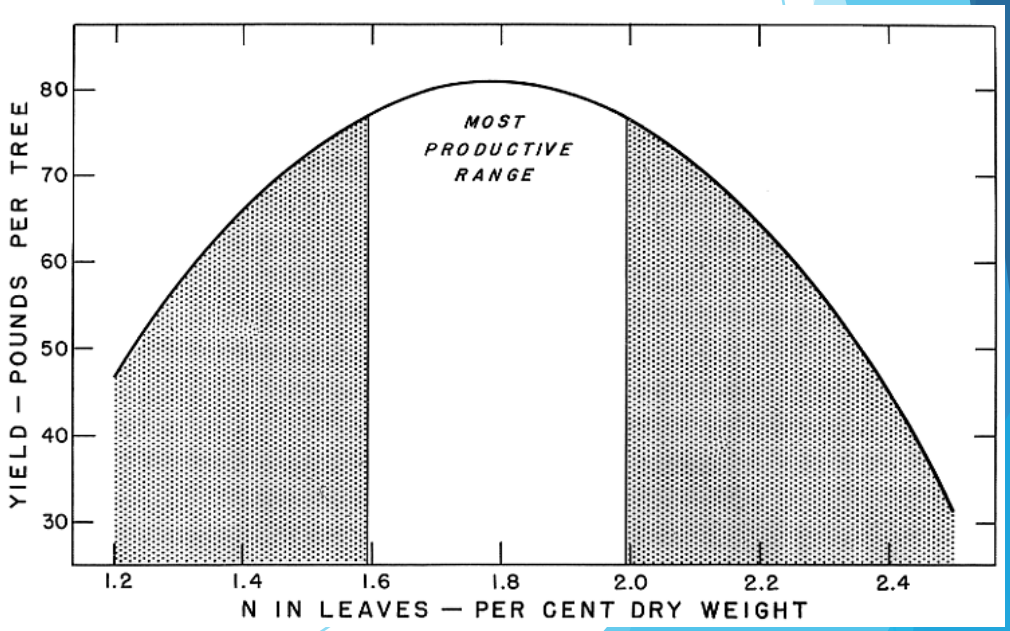


- Ammonium is bound to the surfaces of soil particles and is not leached readily, slowly converts to nitrate

$$NH_4^+$$

- Most fertilizers are a combination of nitrate and ammonium

Nitrogen Deficiency – General Yellowing of leaf and Reduction in Yield of Fuerte



Nitrogen Deficiency

Slow growth, stunting, reduced yields

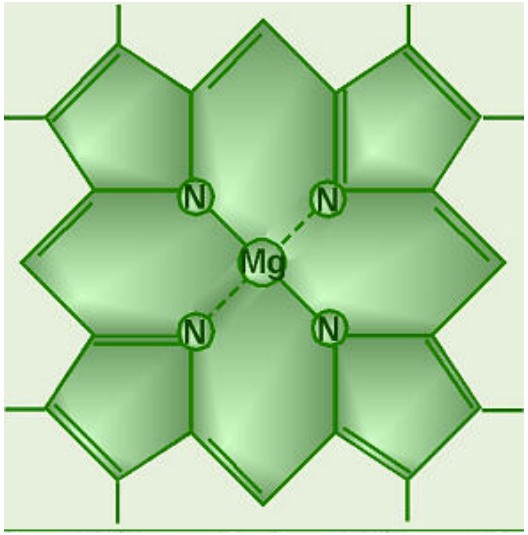
Yellow-green color to leaves (a general yellowing)

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

Don't confuse with root rot and gopher damage

Functions of Essential Elements

- Nitrogen (N)
  - Nitrogen is utilized by plants to make amino acids, which in turn form proteins, found in protoplasm of all living cells. Also, N is required for chlorophyll, nucleic acids and enzymes



Nitrogen Application Timing research from Dr Carol Lovatt, UC Riverside – Phenological Stages

- Control trees: nitrogen was applied at 1.50 lb/tree/year, divided into 0.25 lbs in January, February, April, June, July, Nov.
- Treatments: the same but there was an extra 0.25 lb applied in each of these months
- The best yield occurred when the extra N was applied in April or in November (next slide for data)

Four-year trial by Lovatt

	N applied	cumulative yield, average wt/tree of fruit
Control trees	(1.50 lbs/year)	128.7lb
Jan	extra 0.25 lb	123.4
Feb	extra 0.25 lb	123.4
April	extra 0.25 lb	158.0
June	extra 0.25 lb	117.0
Nov	extra 0.25 lb	168.3

Phenological Stages in the Lovatt Trial

- January – budbreak and ovule initiation
- February – beginning of the cauliflower stage of bloom, pollen formation
- April – anthesis (flowering period), fruit set and initiation of the spring vegetative flush
- June – Stage 1 of the fruit development and end of the June drop period
- July
- November – end of the fall vegetative flush and beginning of flower initiation within the buds

Table 3 Amount of Actual Nitrogen per Tree per Year (Mature Grove)

Spacing	# Trees/	Actual N/acre (lbs)	Actual N/tree (lbs)	Amount of Fertilizer to Apply per Tree		
				Triple 15	Ammonium Nitrate	Urea
				15-15-15	34-0-0	46-0-0
15' x 20'	145	200	1.4	9.3	4.1	3.0
20' x 20'	109	200	1.8	12.0	5.3	3.9
20' x 40'	54	200	3.7	24.7	10.9	8.0

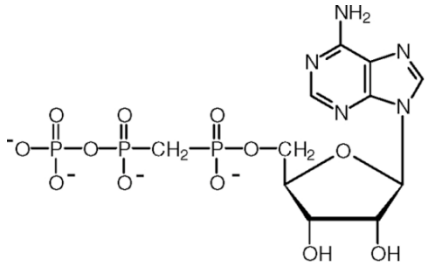
Nitrogen Deficiency

- Lack of vegetative vigor
- Pale, green small leaves
- Reduced yields
- Premature defoliation
- Leaves with yellow veins (severe deficiency)

- Root rot has the same symptoms, how can you tell the difference?

Functions of Essential Elements

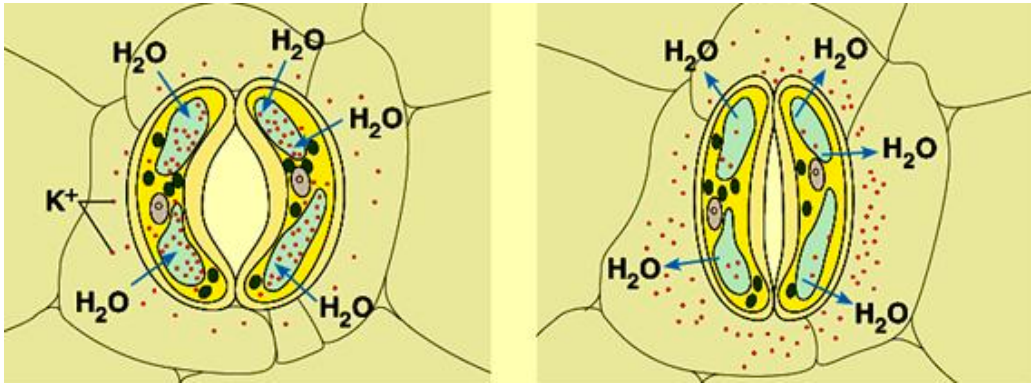
- Phosphorus (P)
  - Phosphorus is used to form nucleic acids (RNA and DNA), it is used in storage and transfer of energy (ATP and ADP)



  - P fertilizer stimulates early growth and root formation, used to drive nutrient uptake, cell division, metabolism
  - Generally sufficient in most California soils. Least response by plants in summer with extensive root systems (tree crops). Mainly taken up by mycorrhizae

Functions of Essential Elements

- Potassium (K)
  - Potassium is required by plants for translocation of sugars, starch formation, opening and closing of guard cells around stomata (needed for efficient water use)



  - Increases plant resistance to disease
  - Increases size and quality of fruit
  - Increases winter hardiness

Potassium Suggestion

- Potassium sulfate KTS (0-0-25) 13 gal/ac applied during each month of June, August, October through irrigation system

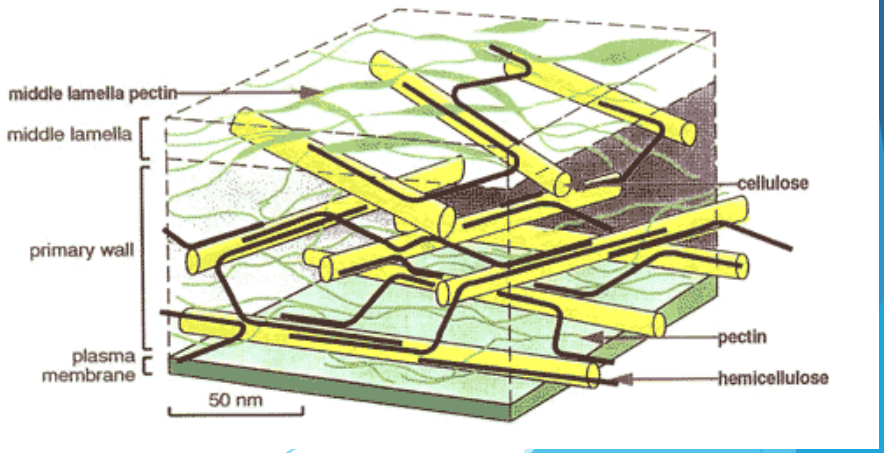
- Or, granular Potassium sulfate (0-0-53) 200 lbs/ac applied in June and 200 lbs/ac applied in October

Functions of Essential Elements

- Calcium
  - Essential part of cell walls and membranes, must be present for formation of new cells
  - Has been shown to make avocado root tips less leaky, therefore less attractive to Phytophthora zoospores

Deficiencies:

poor root development
leaf necrosis and curling,
bitter pit, fruit cracking,
poor fruit storage
water soaking



What about Organic?

- If the grove is under good biological control and free from root rot, the only change is to give trees an organic fertilizer
- If the certifying agency requires compost or mulches be applied around trees, this can be cost prohibitive
- Fruit prices usually 10%-40% higher than conventional prices

Simple Fertilizer Plan

- ½ bag EZ Green per tree in Feb, ½ bag in June

A Little More Complicated: One Grove Manager's Organic Fertilization Program

- EZ Green 50 lb/tree every other year in October
- BioFlora Crumbles 6-5-5, 5 lb/tree in Feb
- Inject Phytamin 6-0-0 (?) 40 lb/ac May and Aug
- In the off year apply Nature Safe 8-5-5 (every other year) 5 lb/tree

Mulches and Manures

- High carbon mulches (wood chips and straw) decompose slowly, bacteria in the soil tie up nitrogen in order to decompose the mulches, these may require a nitrogen soil application to offset this problem
- Manures are sources of nitrogen, but they vary from 1% N (horse manure) to 3% N (composted chicken manure)

Cover Crops for Organic Production

- Should be a legume that can fix N from the air
- Can they contribute in avocado production?
  - Should be turned under, but this can't be done in avocado culture due to the shallowness of the roots
  - Too much shading on the ground to grow cover crops

Description	Total N	Ammonium N	P_2O_5	K_2O	S
			Lbs. per ton		
Non-composted poultry					
Turkey/rice hull litter	35	4	53	37	6
Fresh broiler/rice hull	78	6	51	53	9
Fresh layer	79	8	125	67	16
Aged layer	43	9	164	79	14
Non-composted dairy/steer					
Fresh dairy separator solids	43	1	17	12	10
Fresh dairy corral scrapings	47	2	26	141	12
Aged dairy separator solids	41	1	13	8	9
Aged steer corral scrapings	26	5	31	66	8
Composts					
Broiler/rice hull compost	38	2	86	50	11
Dairy	27	1	27	57	9
Dairy/gin trash	31	1	22	57	14
Dairy/steer	33	0	17	51	9
Dairy/poultry	34	2	39	66	10
Gin trash	47	0	18	75	29

Some factors to think about if you want be organic

If 100 lbs of aged chicken manure is applied to 1 mature tree:

- 43 lbs N/2000 lbs of manure x 100 lbs applied to 1 tree = 2.15 lbs actual N is applied to 1 tree
- If we assume a mineralization rate of 50%, then 1.08 lb of actual N is available to the tree that year (from proteins to ammonium and nitrate)
- But since manure is applied to the surface, and if we have a 30% loss due to mineralization and ammonia gas is lost to the atmosphere, we actually have 0.76 lb N available to the tree this year

What is Mineralization?

- Process by which organic N from manures and other waste is converted to plant-available inorganic forms of nitrogen.
- *Mineralization* is done by soil microbes. They convert organic N into ammonium (NH_4^+) and nitrate (NO_3^-)

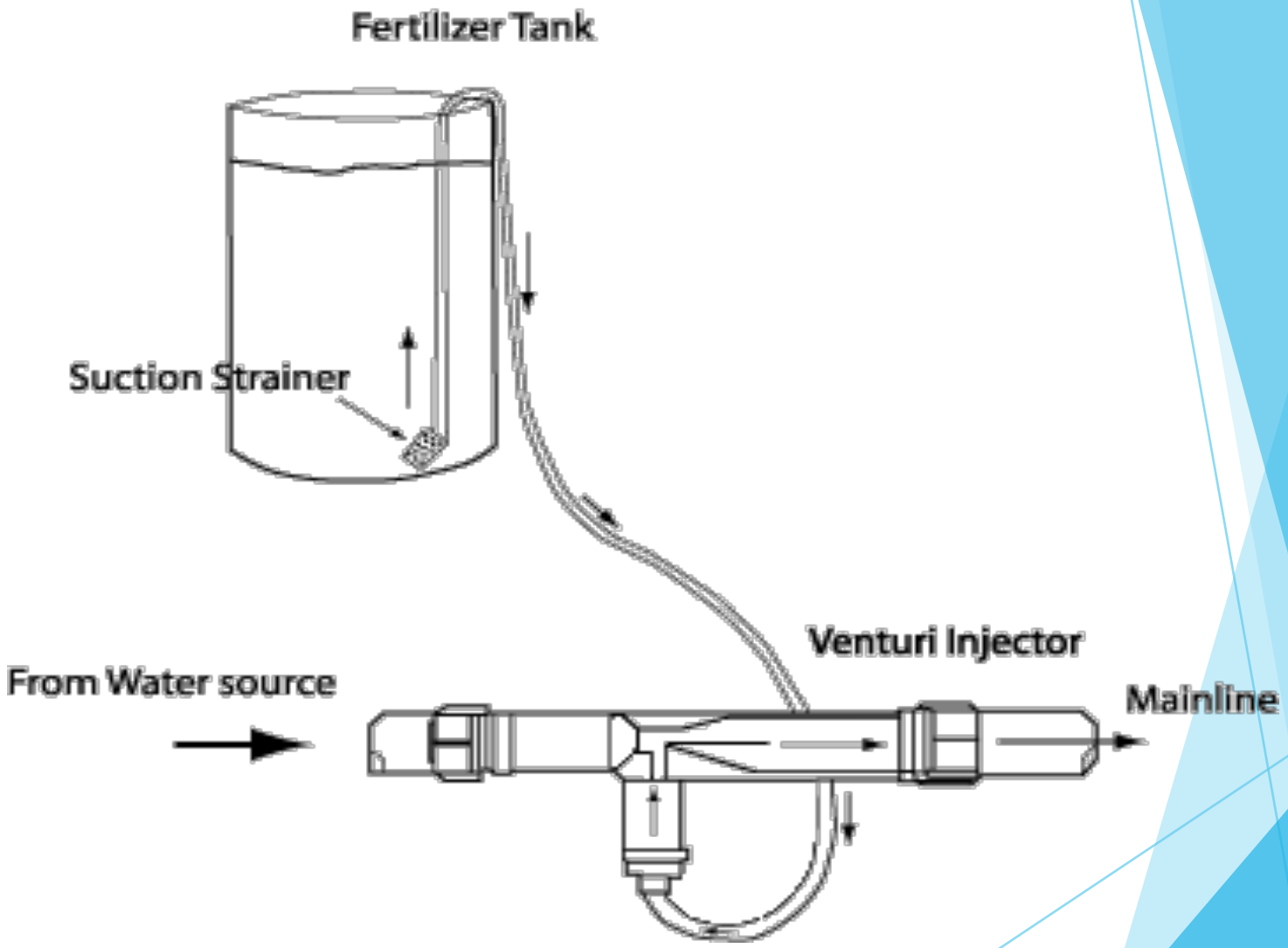
Advantages of Fertigation

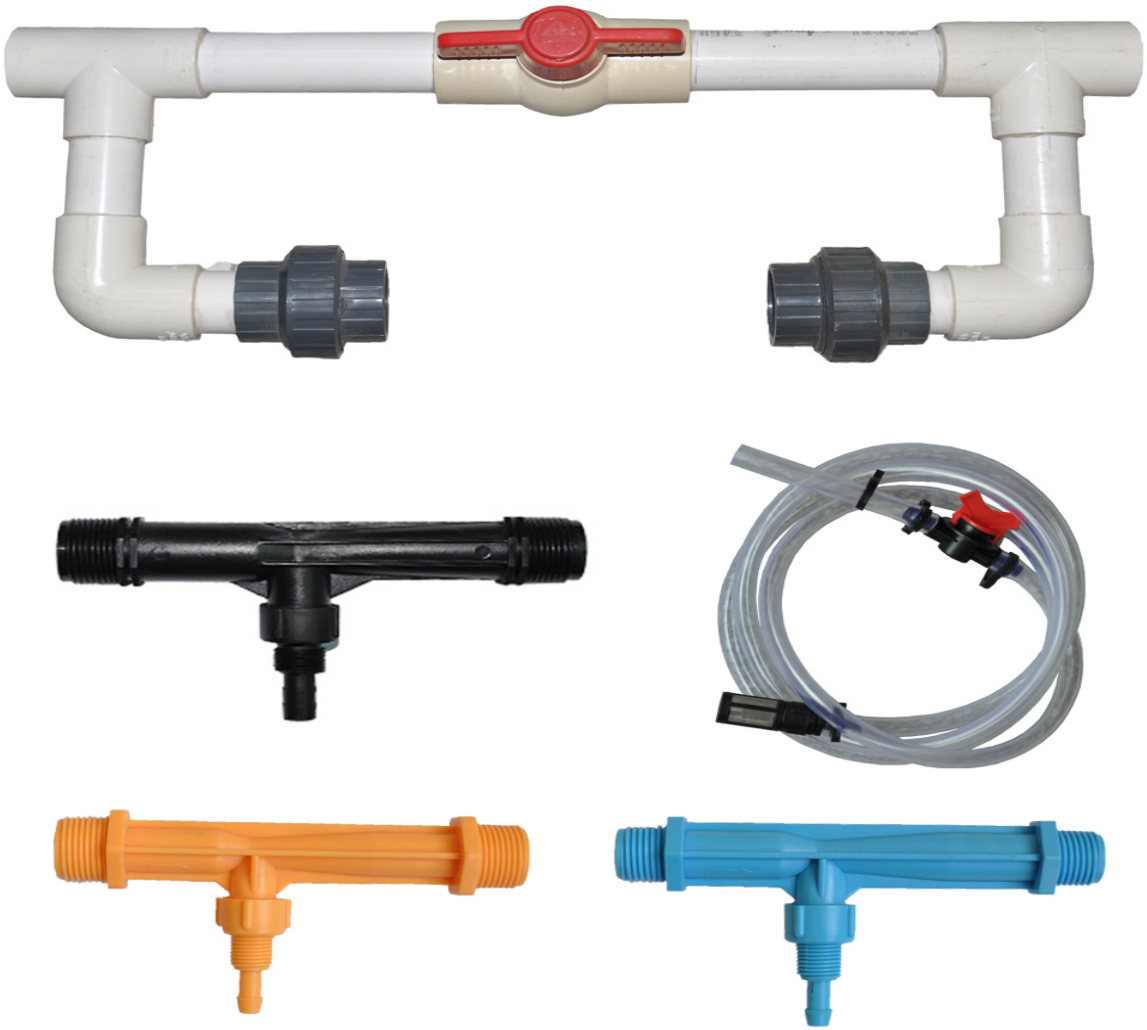
- Most groves have low volume irrigation systems
- Water is distributed uniformly, good fertilizer distribution
- Manager has flexibility in timing applications
- Less fertilizer needed because all of the fertilizer is applied to the wetted area, where the roots are located
- Labor costs are lowered
- On steep slopes, this is the only practical method of fertilizer application

Injection Equipment

- Differential pressure tanks (Batch Tanks)
- Venturi devices
- Positive displacement pumps

- Also needed:
  - Backflow prevention device
  - Tanks that can hold chemical fertilizers


Fertilizer Tank
Suction Strainer
Venturi Injector
From Water source
Mainline



Water Powered Positive Displacement Pump

Zinc

- Avocado has a small but essential requirement for zinc
- Leaf mottling between veins, small rounded fruit, shortened internodes
- Zinc deficiency can be a chronic problem in organic groves where high phosphorous manures are used

Zinc Suggestion

- Zinc foliar spray in May when leaves are most absorbent
- Or 12% zinc sulfate applied through the irrigation system in June, August and October at the rate of 6 gal/ac each time

Zinc Deficiency

Zinc Deficiency

Boron Deficiency

Boron Deficiency

One Last Thought

- There is a yield loss of 12% for every 35.5 ppm chloride in irrigation water
- All growers, especially organic growers, should be leaching!
- And, measure your chloride levels in well water (often)