Plant Nutrition and IPM –
Is Your IPM Program Truly Integrated?

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Potter Valley Tribe and US Environmental Agency

GY Territory

North Coast

- IPM 1973-1999
- Soil, Tissue Testing 1973 - Present
- Consulting 1973-Present
- Compost Production 1979-1993

  (New Era Farm Service, Y&B Ag Service)

Contra Costa Co.

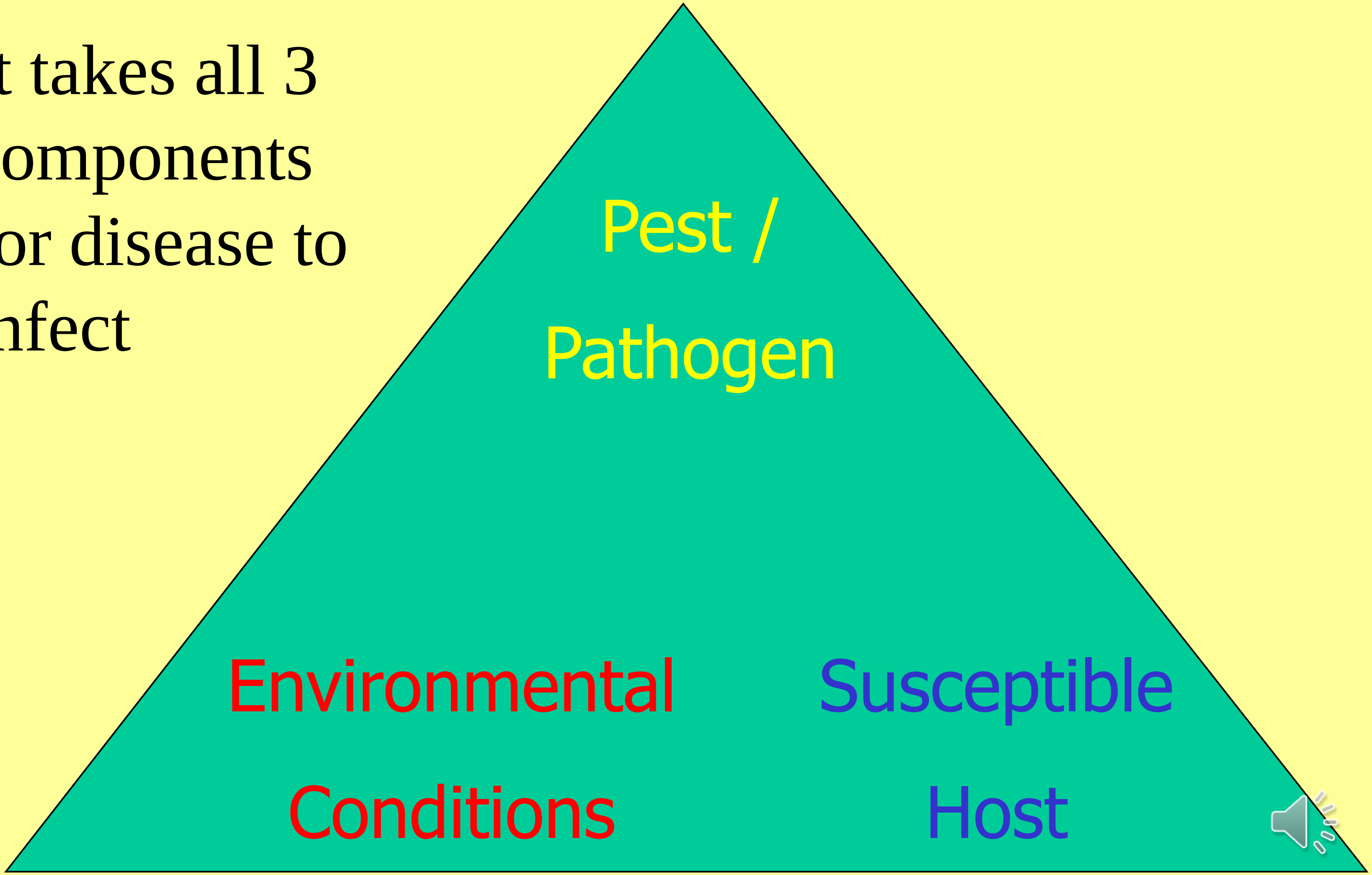
- All of the above: 1995 – Present

GY Territory

- Soil, Tissue Testing 2015 - Present
- Consulting 2015 - Present

The Disease Triangle

It takes all 3 components for disease to infect



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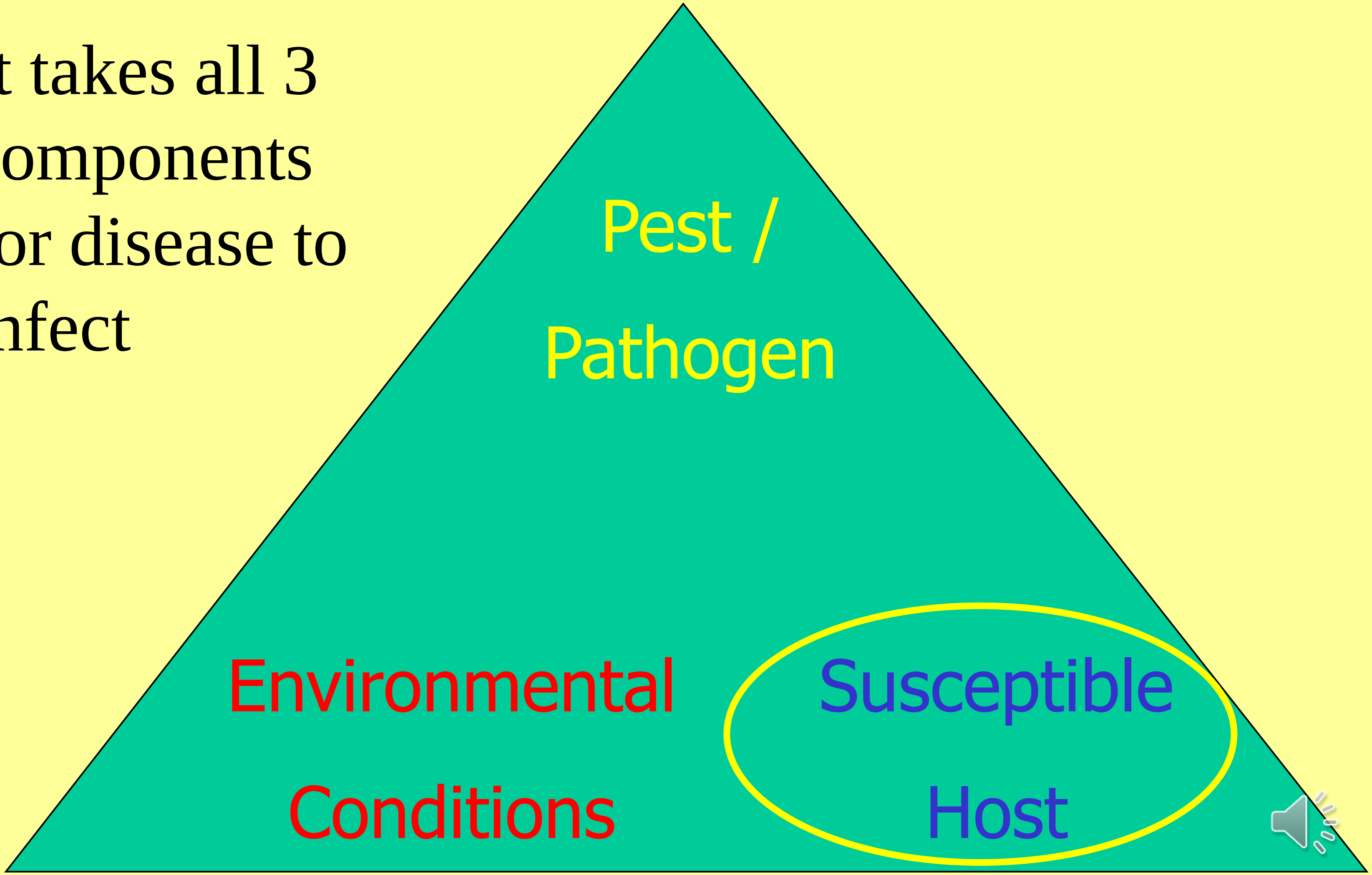
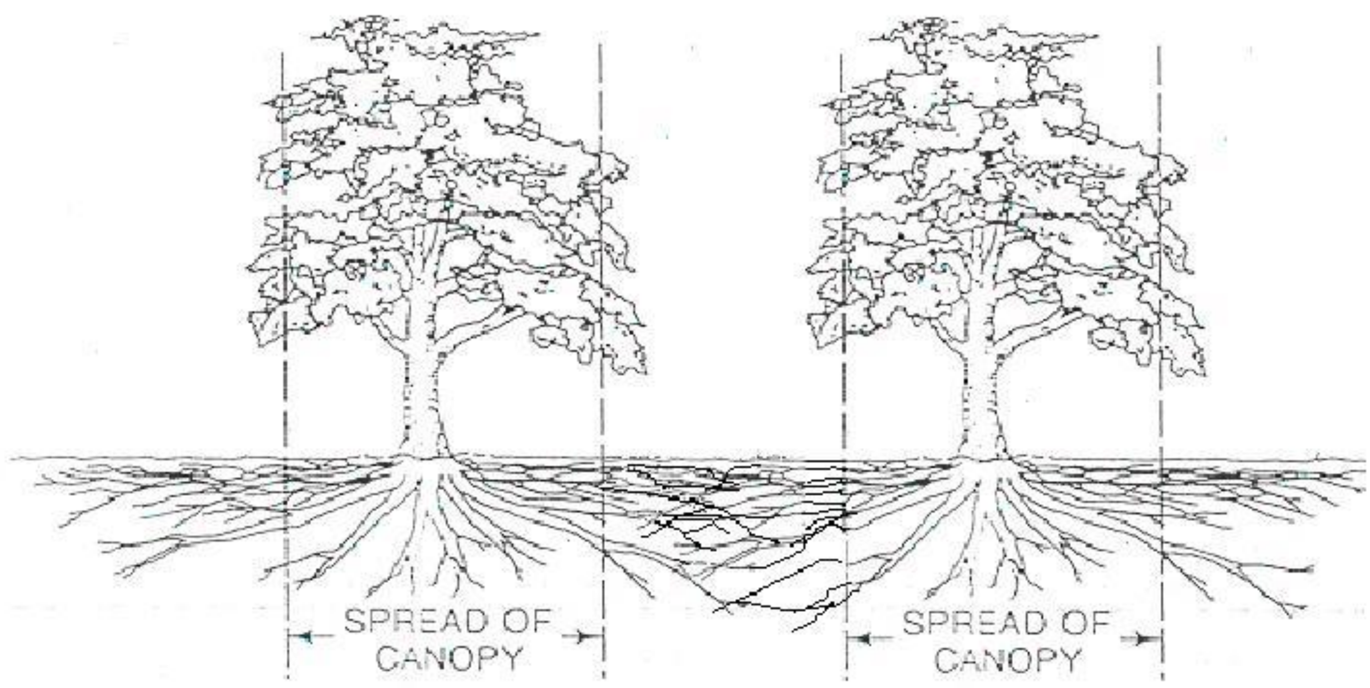


Often in IPM we spend our efforts monitoring the pest/disease and the environmental conditions

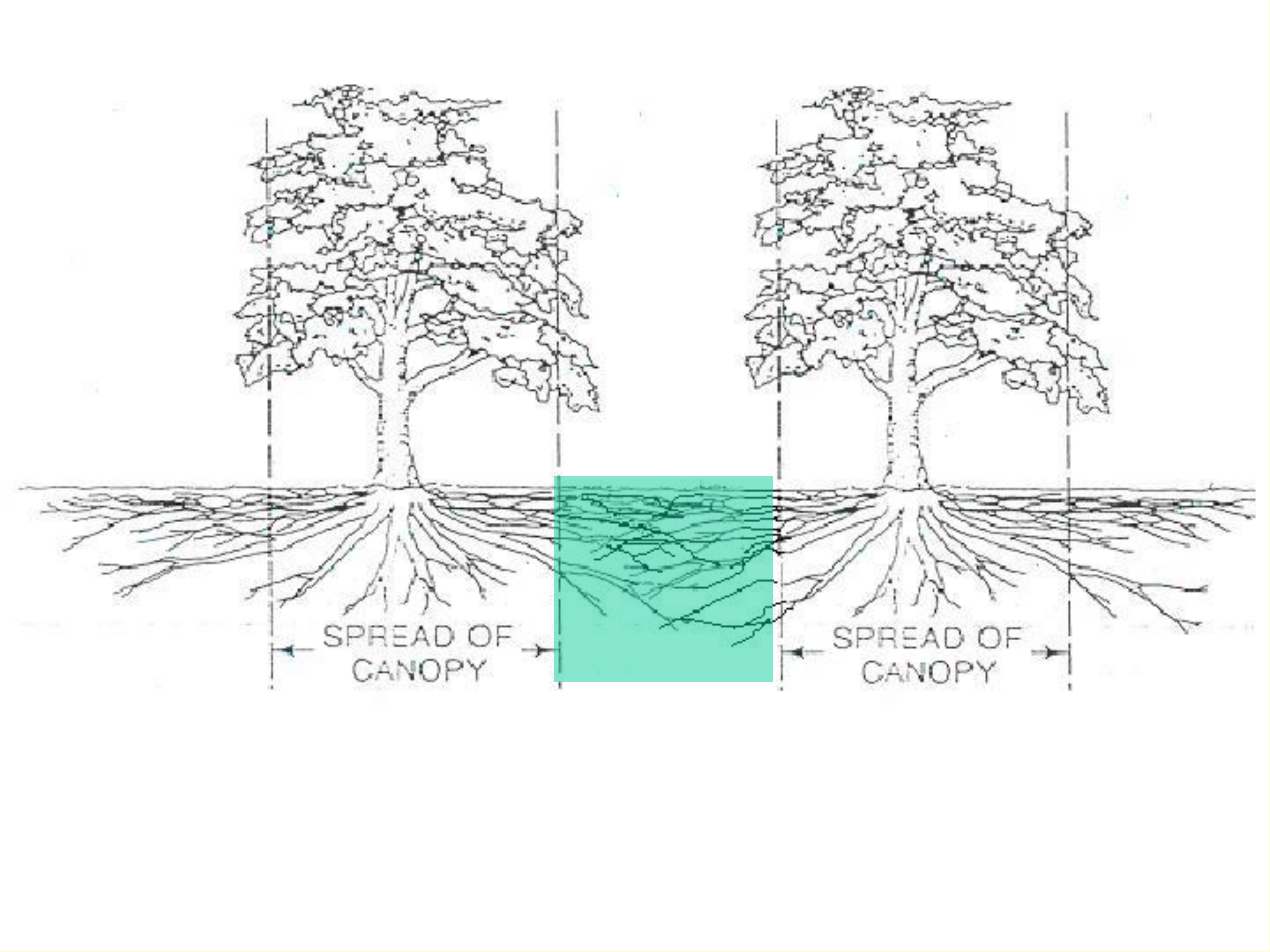
<u>All</u> of the biomass that makes up a mature tree or vine comes from the soil, water & air

Modern agriculture squeezes the most it can out of the agroecosystem

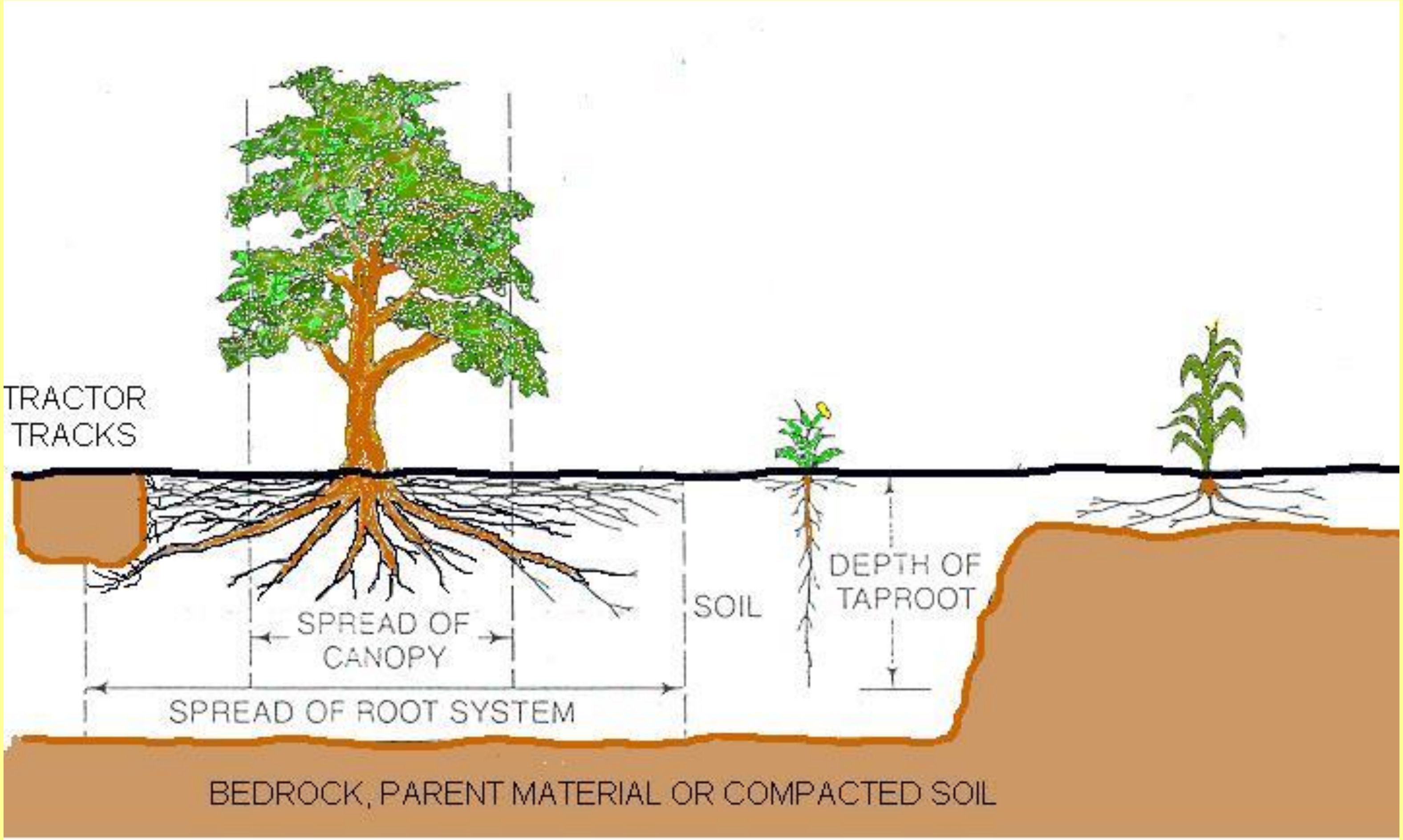


Pears, Apples: 20+ tons/ac Tomatoes: 50+ tons/ac
Grapes: 5-12 tons/ac Hay crops: 20+ tons/ac

Roots of healthy trees under irrigation will be competing with each other



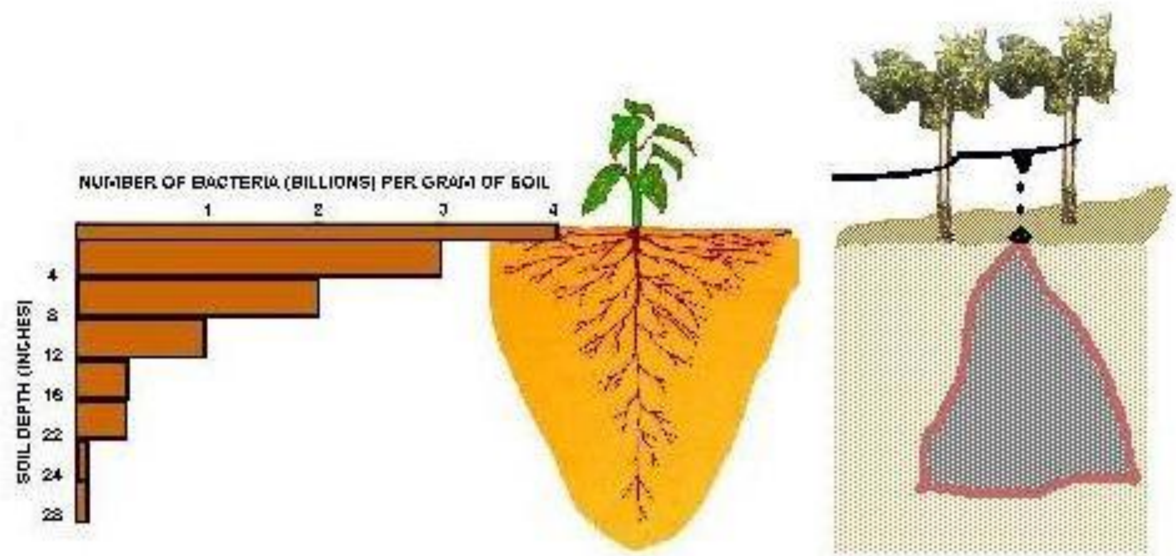
Crops need a biologically active, aerated root zone



Plant roots spread far from the plant seeking water and nutrients. Most roots spread laterally near the soil surface where the oxygen and carbon dioxide content is highest. Most of the biological activity and nutrient availability is at or just beneath the top foot of soil. Conditions that limit the spread of roots, like soil compaction, impervious layers, or saturated soil, also limit plant growth, yield, and health.

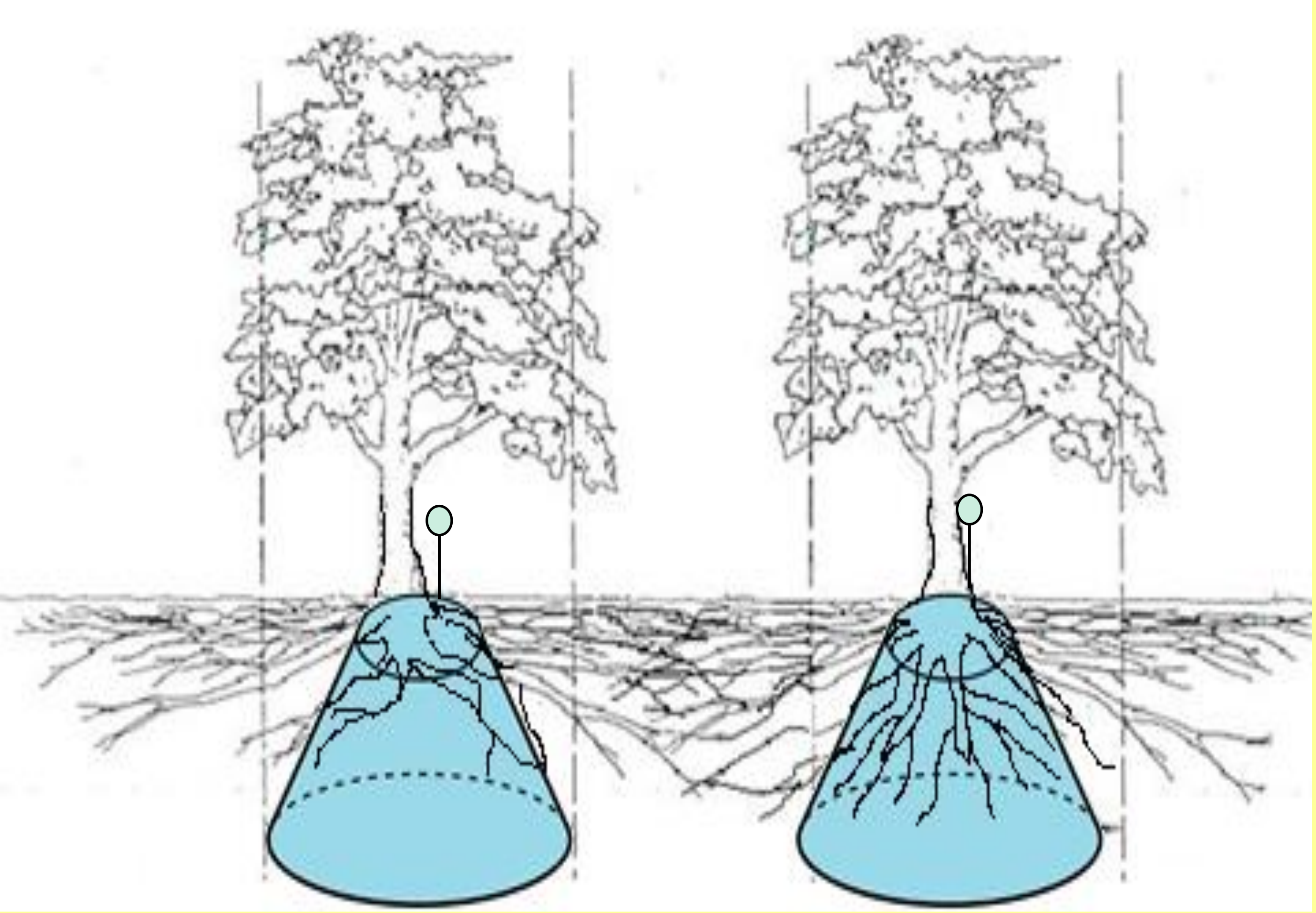
Drip irrigation – nutrient removal is from a smaller area; nutrient management is critical

DRIP IRRIGATION & ROOT FEEDING in TREES & VINES



DRIP IRRIGATION creates a wet zone in the form of an inverted pyramid. While this is very efficient in water delivery and use, it creates a zone that is opposite that of the optimum zone for the feeder roots of trees & vines. The most important soil reactions occur in the top 12 inches of soil: biological activity, nutrient transformations/availability and soil aeration are all optimum. Very careful attention to the fertilization program is needed to compensate for this situation. With intensive plantings, close spacing, or split-canopy systems, additional emitters may improve nutrient feeding in the top soil layer, and thus tree & vine performance, while using the same quantity of water.

Orchard irrigation emitters cover 1/3 to 1/2 of the orchard floor



Early pioneers who called for attention to soil fertility in managing pests & diseases:

- J.I. Rodale (1898-1971)

"Healthy Soil = Healthy Food = Healthy People"

- William Albrecht (1888-1974)

"Food is fabricated fertility"

Early Researchers: Nutrient-Pest & Disease Relations:

- We may also speculate on the possibility of influencing the population development of these mites by enhancing their food substrate through managing the fertilization of the host plant.
- Increases in mite population have commonly been associated with nitrogen fertilization or cultural conditions indicating such treatment.
  - van de Vrie (1972)

Early Researchers:

- Since the Ca demands of rapidly growing shoots supersede those of developing fruit, N-stimulated shoot growth, particularly during the early stage of fruit development, competes with the fruit for available Ca.

  -Shear (1975)

Early Researchers:

- Mineral nutrition of the plant (grapevines) is one of the several factors affecting the physiological behaviour of a genotype. It influences not only the balance of yield: quality, but it determines also in large measure the resistance or susceptibility to diseases, by controlling the plant's biochemical mechanisms which hasten or slow pathogenesis, and the virulence and ability of pathogens to survive.

  \- Huber (1980)

Importance of Nitrogen Management

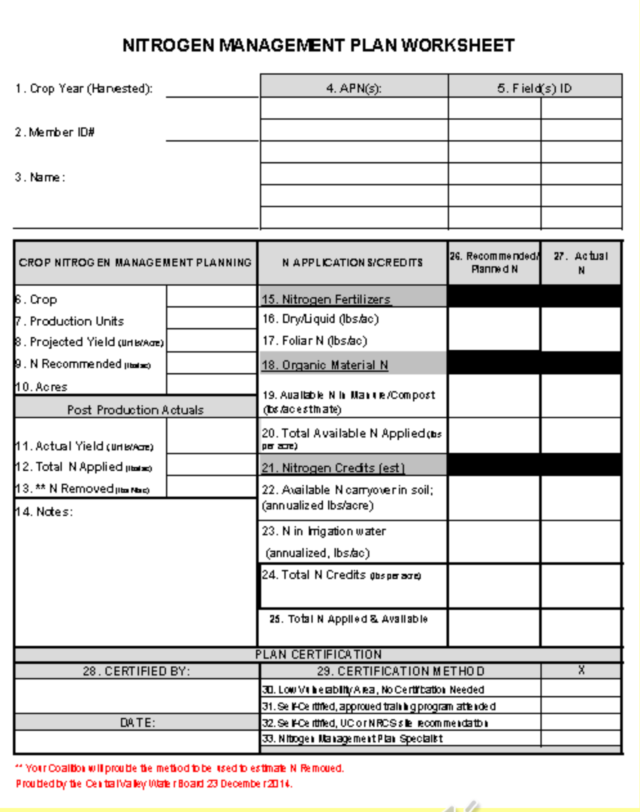
- Over-fertilization of orchard crops is widespread despite well-documented consequences to both the crop and the environment. Since the costs of over-fertilizing are small compared to the huge losses farmers could experience from yield reductions, there is little economic incentive to manage N more efficiently. Several fold more N than the total possible tree uptake is commonly applied. A clear economic incentive can be created if crop quality improves as excessive N use is reduced.

- Bacon (1996)

In some areas N management plans are now required to meet Regional Water Quality Control Board discharge requirements

Irrigated Lands Regulatory Program (ILRP)

The ILRP was initiated to prevent agricultural runoff from impairing surface waters, and later included the addition of groundwater regulations. Runoff from irrigated lands can contain pollutants, such as pesticides, fertilizers, salts, and sediment, which can harm aquatic life or make water unusable for drinking water or agricultural uses. Waste discharge requirements (WDRs) address irrigated agricultural discharges to protect water quality.



NITROGEN MANAGEMENT PLAN WORKSHEET

1. Crop Year (Harvested): ______
2. Member ID# ______
3. Name:

4. APN(s):	5. Field(s) ID	

CROP NITROGEN MANAGEMENT PLANNING		N APPLICATIONS/CREDITS	26. Recommended/ Planned N	27. Actual N
6. Crop		15. Nitrogen Fertilizers		
7. Production Units		16. Dry/Liquid (lbs/ac)		
8. Projected Yield (Units/Acre)		17. Foliar N (lbs/ac)		
9. N Recommended (lbs/ac)		18. Organic Material N		
10. Acres		19. Available N in Manure/Compost (lbs/ac estimate)		
Post Production Actuals				
11. Actual Yield (Units/Acre)		20. Total Available N Applied (lbs per acre)		
12. Total N Applied (lbs/ac)		21. Nitrogen Credits (est)		
13. ** N Removed (lbs N/ac)		22. Available N carryover in soil; (annualized lbs/acre)		
14. Notes:		23. N in Irrigation water (annualized, lbs/ac)		
		24. Total N Credits (lbs per acre)		
		25. Total N Applied & Available		

PLAN CERTIFICATION		
28. CERTIFIED BY:	29. CERTIFICATION METHOD	X
	30. Low Vulnerability Area, No Certification Needed	
	31. Self-Certified, approved training program attended	
DATE:	32. Self-Certified, UC or NRCS site recommendation	
	33. Nitrogen Management Plan Specialist	

** Your Coalition will provide the method to be used to estimate N Removed.
Provided by the Central Valley Water Board 23 December 2014.

CLIMATE and SOIL FORMATION

FOREST	PRAIRIE/GRASSLAND	DESERT
HIGH RAINFALL: 20+ "	MEDIUM RAINFALL: 10 - 15 "	LOW RAINFALL: 0 - 5 "
PRECIPITATION > EVAPORATION	BALANCED PRECIPITATION - EVAPORATION	EVAPORATION > PRECIPITATION
HI O.M. ACCUMULATION – Trees	HI O. M. ACCUMULATION – Roots	LOW O.M. ACCUMULATION
LEACHING OF MINERALS – Na, Ca, Mg, P_2O_5	NEAR OPTIMUM BALANCE OF MINERALS IN TOPSOIL	ABUNDANCE OF MINERALS – Ca, Mg, K, P_2O_5, excess salts
<<< INCREASING ACIDITY	MEDIUM RANGE pH 7-8	INCREASING pH >>>
BICARBONATE (HCO_3) PRODUCTION	LOW ACIDITY – DISSOLVES NUTRIENTS	CARBONATE (CO_3) ACCUMULATION
CARBOHYDRATES – Wood, fruits	PROTEIN – forages, grains, legumes	PROTEIN – w/ irrigation & leaching of salts
SUPPORTS FEWER ANIMALS	HIGH ANIMAL PRODUCTION	LOW NATIVE ANIMAL PRODUCTION
NEEDS: Limestone; often major nutrients	NEEDS: Maintain fertility & organic matter	NEEDS: Water, O.M., leaching of excess salts, often micronutrients
UNDER DESTRUCTION	**WELL DEVELOPED**	**UNDER CONSTRUCTION**

By Gregg Young, from Albrecht (1975)

Gregg A. Young, CP Ag

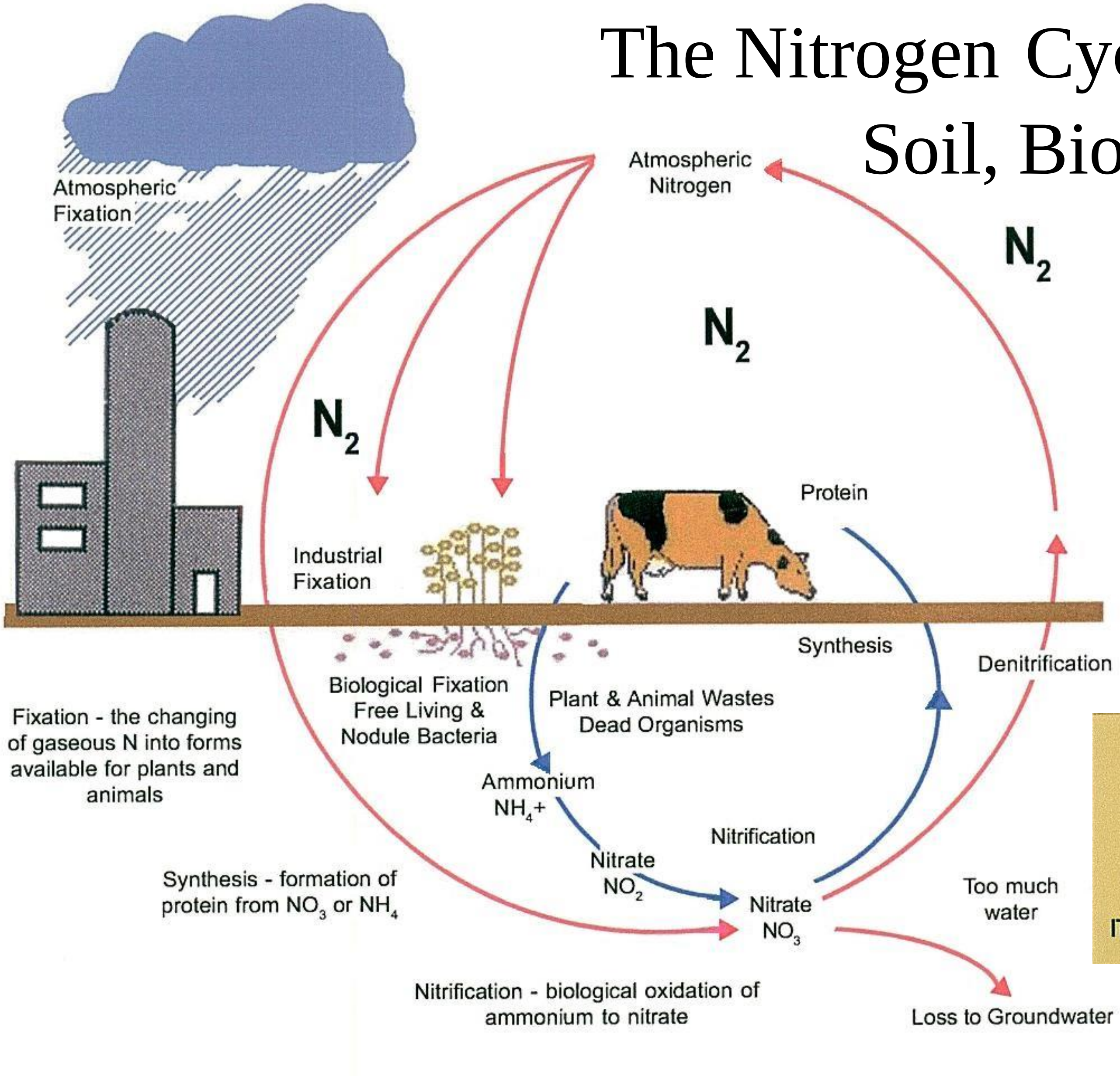
Soil Organic Matter is about 5% N

- **Soil N content ranges from 1700-6800 pounds per acre-foot (soil OM 1-4%)**
- **Generally, only 2% is considered available for crops = 34-136 pounds**
- **With thousands of pounds possible, achieving above-average (best) conditions for N availability should be a standard practice**
- **Since most crops only remove 100 – 300 pounds/ac of nitrogen, reductions in N use from 25-75% are possible if optimum conditions exist**

Potential for Improvement – N Use

POTENTIAL POUNDS of NITROGEN RELEASED by ORGANIC MATTER In the top foot of an agricultural soil				
% ORGANIC MATTER of SOIL	WEIGHT @ 3.4×10^6 pounds/ac	Pounds N @ 5 % of O.M.	To get closer to this ←	PLANT AVAILABLE @ 2 % per year
1 %	34,000 #	1700 #	You need:	34 #
2 %	68,000 #	3400 #	Abundant P, K, Ca, Mg, S & micronutrients Optimum cation balance	68 #
3 %	102,000 #	5100 #	Optimum soil aeration Optimum soil bio-activity	102 #
4 %	136,000 #	6800 #		136 #
Most crops only require between 50 and 250 pounds of nitrogen/acre per year				

The Nitrogen Cycle – Air, Water Soil, Biological Activity



THE NITROGEN CYCLE REQUIRES AIR

Organic matter breakdown needs O_2
Protein synthesis needs CO_2
Nitrification needs O_2 and CO_2

IT ALL WORKS BEST IN WELL AERATED SOILS

Most nutrients can be taken up and stored by trees for later use:

- Potassium is not stored in the plant; it is a necessary component of cell sap. Fruit becomes a ‘K sink’; needing a constant supply as fruit matures
- Calcium is needed in constant supply for root growth. If trees must search for Ca while blooming or developing fruit, supplies can be short

Importance of Potassium

- Potassium has long been known as the most important nutrient for reducing susceptibility to disease. High levels of potassium reduce the severity of more than 140 diseases caused by fungi, bacteria, viruses, and nematodes.

  - Bruulsema (1996)

Importance of Calcium

- Calcium has a number of vital roles in plant tissues, but for the purpose of this discussion two of these roles are of particular interest:

1. Calcium increases membrane stability
2. Calcium increases cell wall strength

- Tissues high in calcium have stronger cell walls, are firmer and resist infection more readily.

\- from South African Avocado Growers’ Association Yearbook 2000. 23:1-7

More on Calcium

- (Calcium disorders)…usually occur if the plant is undergoing rapid, active vegetative growth
- Rapid growth rate and ensuing calcium shortage are encouraged by environmental factors such as high temperatures and high soil nutrient levels (especially nitrogen)
- The tissues of affected plants are usually damaged and often become colonized by saprophytic microorganisms. In addition, commonly found plant pathogens also will attack and colonize such compromised tissues

More Calcium-Disease Relations

- If the physiological nature of the primary problem is not noted, a diagnosis error may occur because of the presence of the known pathogens which are only acting as secondary decay organisms
- In most instances application of calcium to soils already containing "abundant levels" of this element has little effect on the problem

- from Koike, S. California-Arizona Farm Press, November 19, 1994

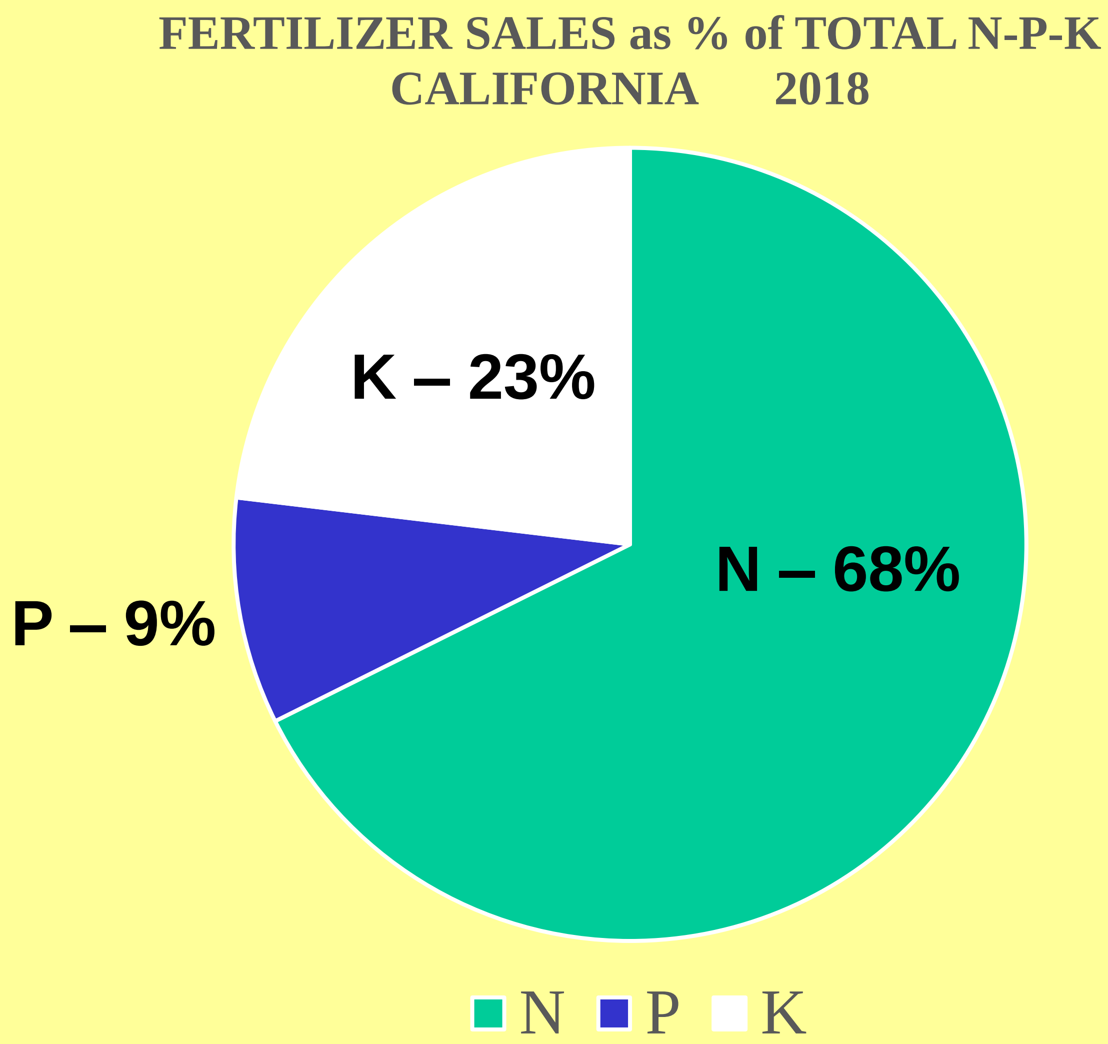
Quote Me on This:

There is no standard definition of "abundant soil calcium levels", so most fertilizer technicians, researchers & consultants do not know whether the soils they work with have optimum calcium level for best pest/disease resistance.

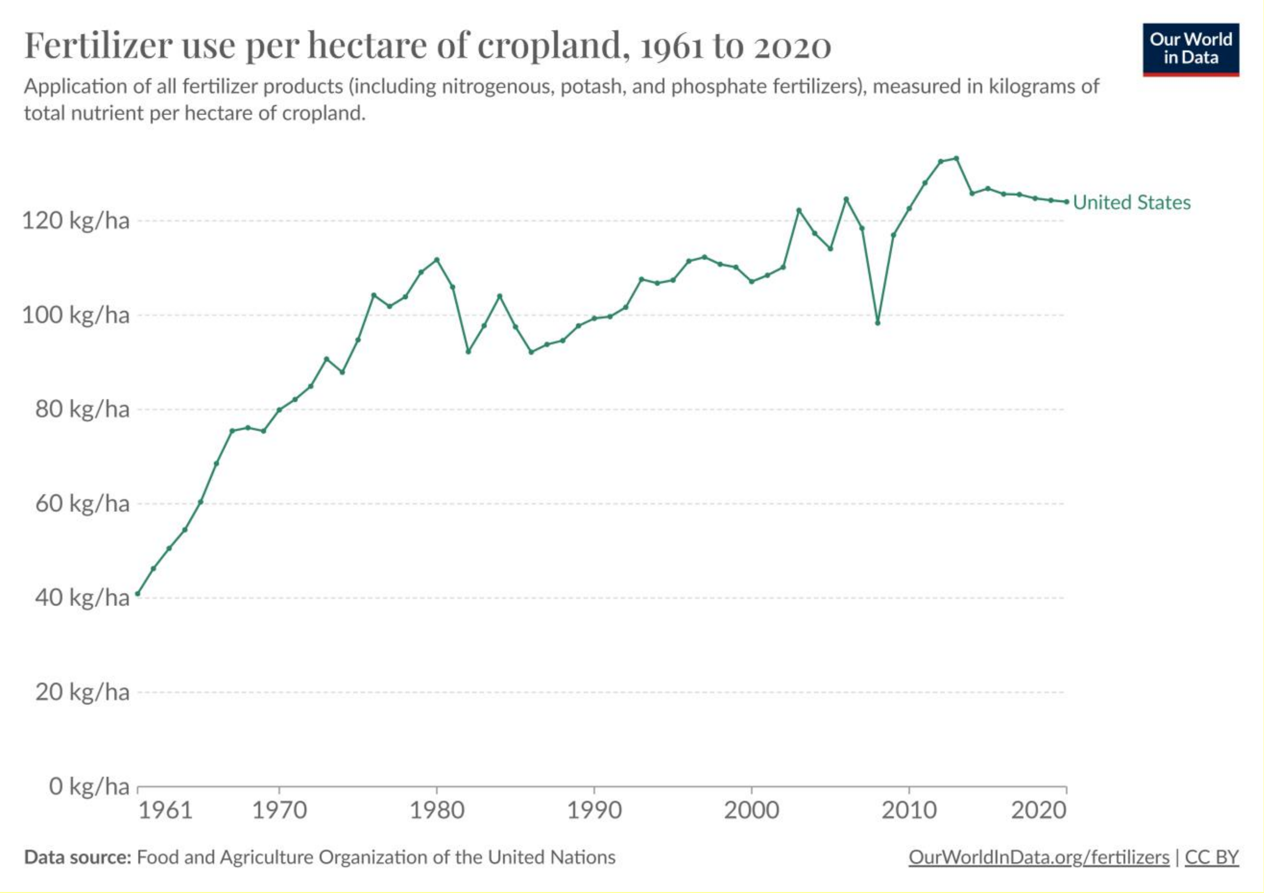
To be truly "Integrated", pest & disease management must consider soils & fertilization at the beginning. It should be backed up by data (soil and tissue tests)

G Young (since 1988)

California Fertilizer Use Trends



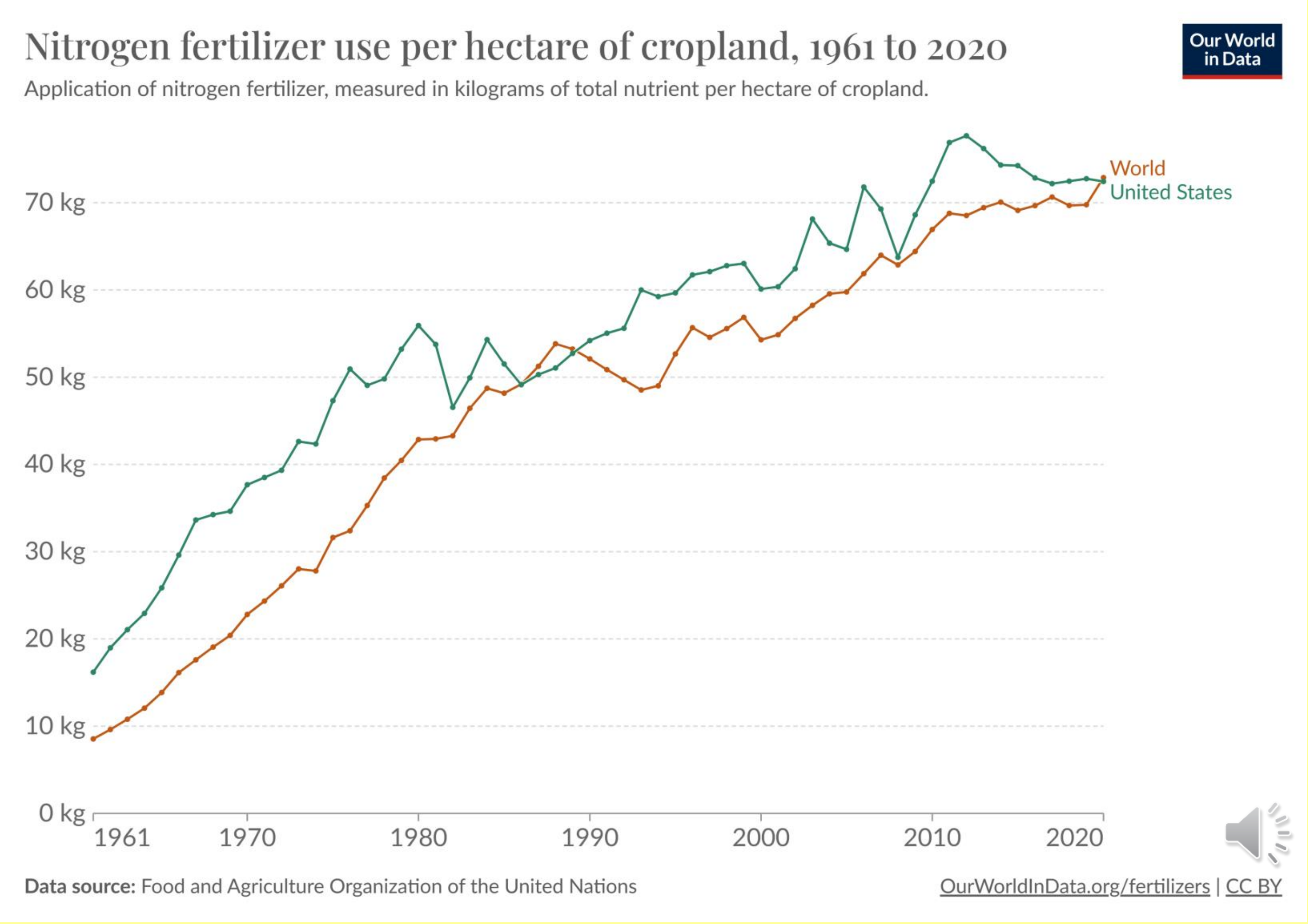
United States Agriculture Increasingly Relies on N for Crop Production (1960-2020)



from: https://ourworldindata.org/fertilizers

World Use of Nitrogen

from: https://ourworldindata.org/fertilizers



What Crops Really Need: Crop Nutrient Removal

Deciduous Trees & Vines

NUTRIENT UTILIZATION IN TREE FRUITS & VINES K > N > Ca						
CROP	YIELD/ACRE	N	P_2O_5	K	Ca	Mg
APPLE	20 tons	118	48	168	88	36
APRICOT	15 tons	129	42	172	114	24
CHERRY	12 tons	118	35	133	91	19
GRAPE	6 tons	59	17	92	46	13
PEACH	15 tons	116	30	125	101	24
PEAR	20 tons	120	40	145	102	28
PRUNE	12 tons	101	35	135	91	20
KIWIFRUIT	18 tons	149	50	208	144	40
NUTRIENTS CONTAINED IN FRUIT, SEEDS, SKINS, AND WOODY PARTS IN POUNDS PER ACRE PER YEAR						
* NOT INCLUDING WOODY PARTS						

What Crops Really Need: Crop Nutrient Removal

Citrus - Nuts

NUTRIENT UTILIZATION - CITRUS	Ca ≥ N ≥ K > P				
CROP	YIELD	N	P	K	Ca
ORANGE (fruit)	19 tons	166 #	13 #	179 #	61 #
ORANGE * (6 year old tree)	286/ac	59 #	7 #	47 #	71 #
CITRUS, (assorted)	30 tons	114 #	9 #	90 #	30 #
ORANGE, whole tree, 25 T/ac	25 tons	420 #	22 #	111 #	572 #
* Whole 6 year old trees = leaves, twigs, trunks, fruit			POUNDS PER ACRE PER YEAR		

NUTRIENT UTILIZATION – NUTS	N ≥ K > Ca				
CROP	N	P	K	Ca	Mg
PISTACHIO, nuts + leaves	122	16	118	78	35
ALMOND, fruit	234	23	198	29	16
ALMOND, average leaf %	3.0	0.2	2.2	3.3	0.6
ALMOND, #//1000 # kernal	75	9	85	8	5
WALNUT, nuts only	104	14	18	5	6
PECAN, nuts + shells %	2.0	0.2	1.2	0.8	0.2

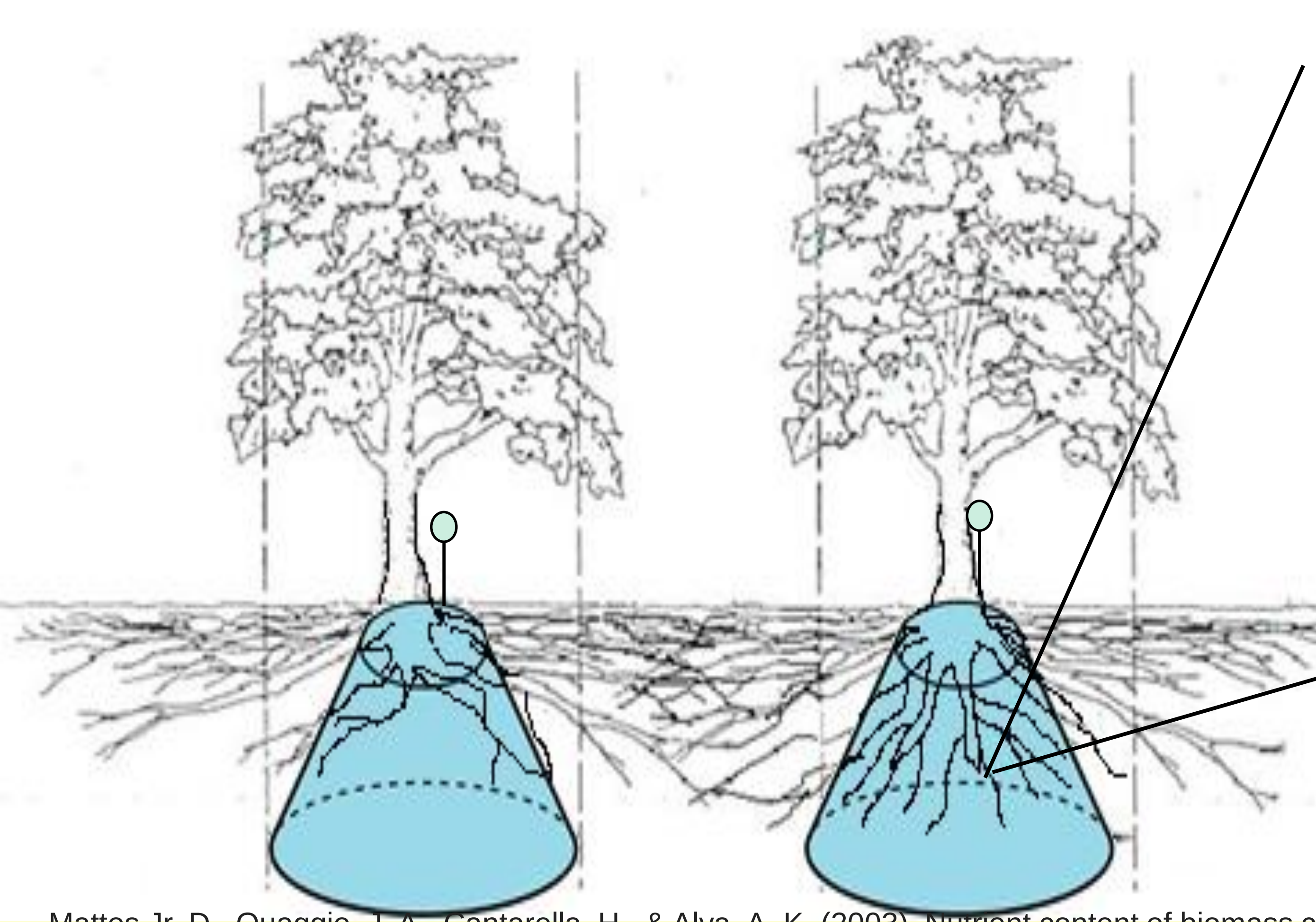
What Crops Really Need: Crop Nutrient Removal

Protein crops (nuts) tend to need more nitrogen than carbohydrates (fruits). Citrus and crops that have year-round leaves have more nitrogen tied up in the leaves. Calcium content of leaves and roots are near that of nitrogen, so seasonal tie ups of Ca can occur, even if crop removal is less. (G Young)

There is an agreement that calcium, nitrogen, and potassium are the dominant constituents of citrus tree biomass. Phosphorus, magnesium, and sulfur represent a smaller proportion (~10%)

From: Mattos Jr, D., Quaggio, J. A., Cantarella, H., & Alva, A. K. (2003). Nutrient content of biomass components of Hamlin sweet orange trees. *Scientia Agricola*, *60*(1), 155-160

Which means that in the summer nutrients come from either stored reserves or immediate uptake



Ca	213 #
N	177 #
K	141 #
Mg	26
P	7 #
Pounds/ac	

Oranges

Mattos Jr, D., Quaggio, J. A., Cantarella, H., & Alva, A. K. (2003). Nutrient content of biomass components of Hamlin sweet orange trees. *Scientia Agricola*, *60*(1), 155-160.

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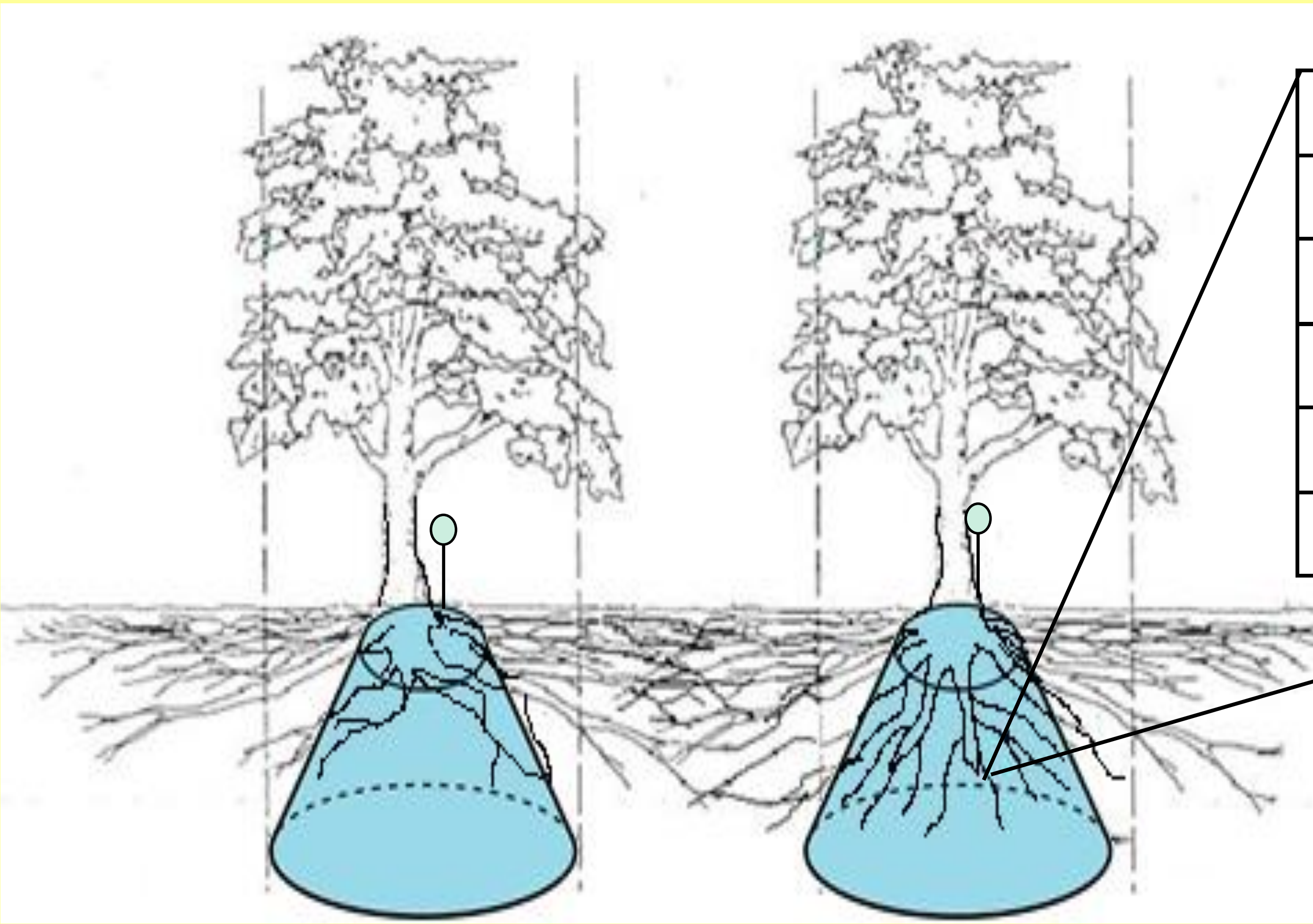
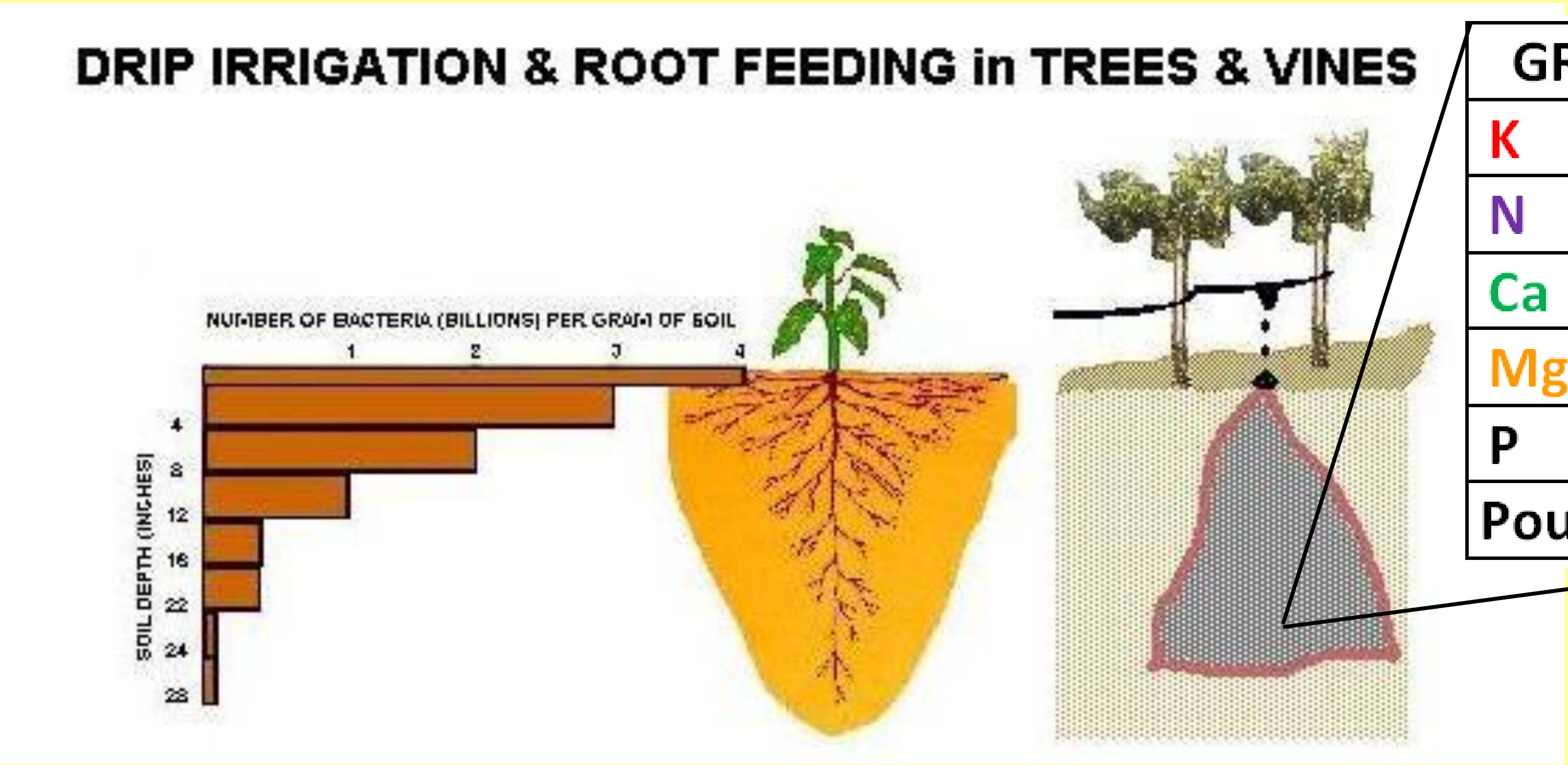


K	155 #
N	122 #
Ca	104 #
Mg	27 #
P	17 #
Pounds/ac	

Deciduous Tree Fruits

Vineyard nutrient removal is lower than most crops; however, it is from a much smaller root area.



GRAPES	
K	92 #
N	59 #
Ca	46 #
Mg	13 #
P	7 #
Pounds/ac	

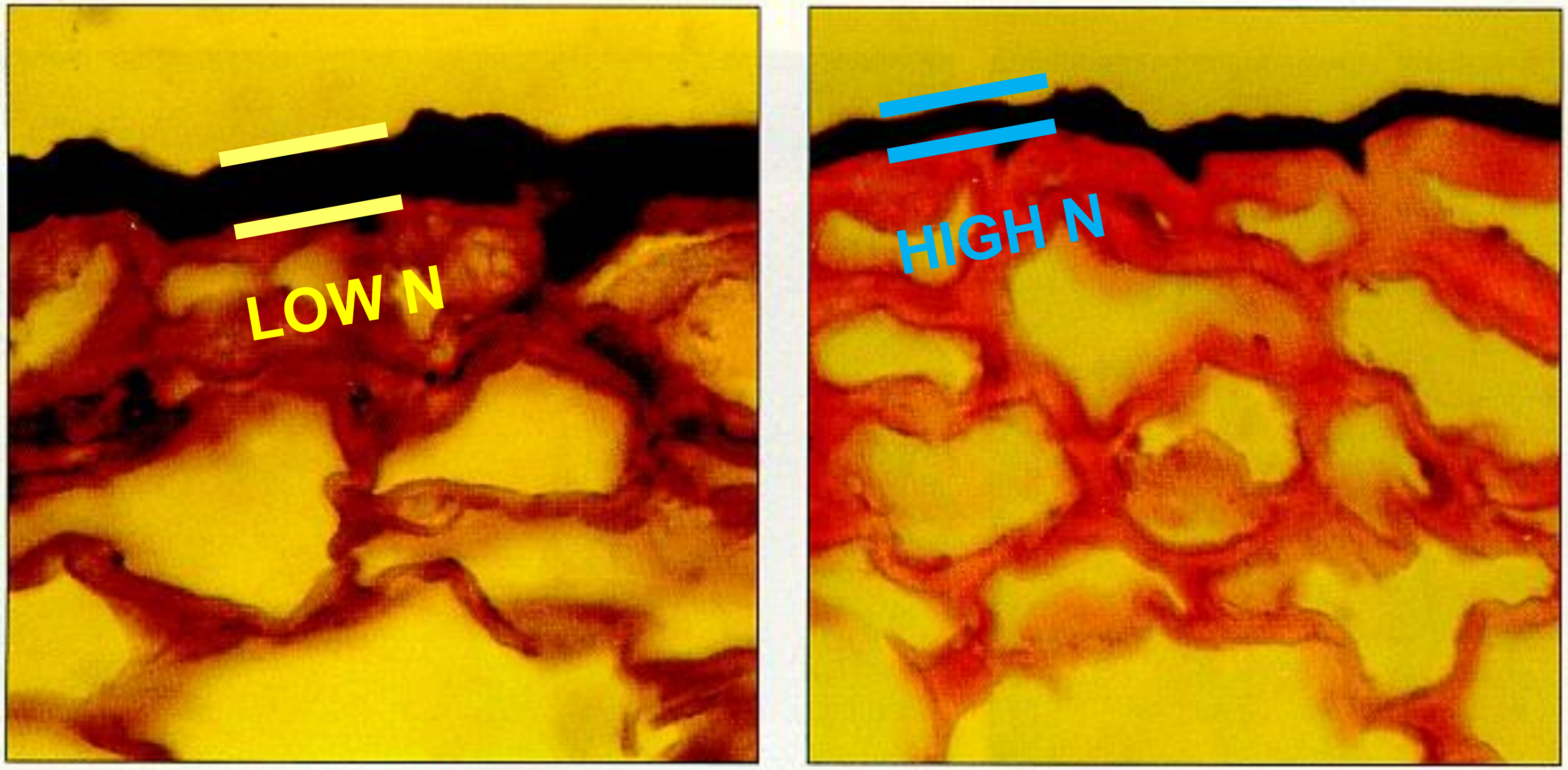
Effects of Excess Nitrogen

Fruit from trees fertilized with low rates of nitrogen (boxes on the left) ripened earlier and had redder color than fruit from trees fertilized with very high rates of nitrogen. *At right*, staff research associate Glenn Yokota searches for peach twig borer and oriental fruit moth damage on fruit.

Excess nitrogen raises nectarine susceptibility to disease and insects

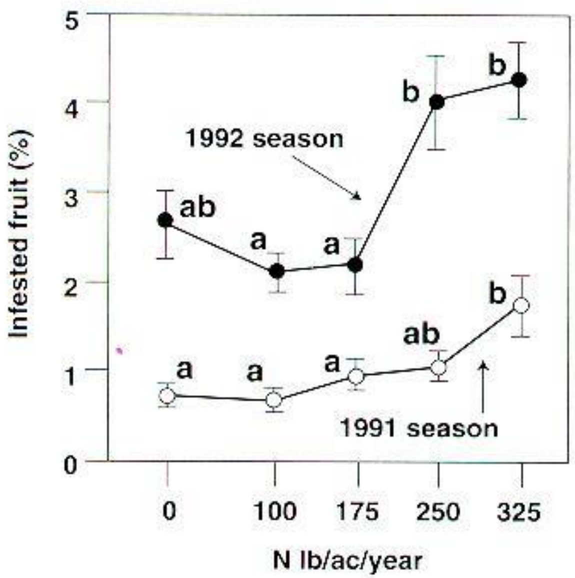
California Agriculture July-August 1995

Use of Excess Nitrogen Results in Plants with Elongated Cells with Thinner Walls



Cross sections of fruit cuticle show the fruit cuticle is thicker in fruit from low nitrogen fertilization treatments, *left*, than from the higher nitrogen treatments, *right*. A thicker cuticle may reduce infection of brown rot and improve postharvest characteristics.

1995 Breakthrough UC Research (demonstrating what many had already observed)



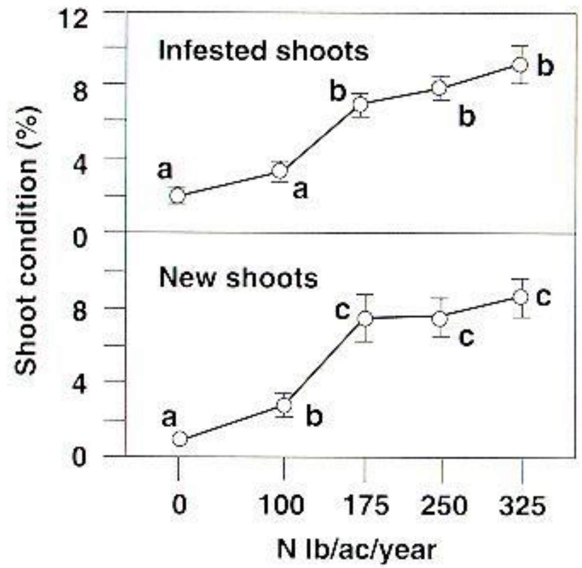


Fig. 5. Relationship between nitrogen (N) treatments and percent fruit infested with peach twig borer and oriental fruit moth for the 1991 and 1992 seasons. A positive correlation was found between increased N fertilization and infested fruit in 1991.

Fig. 6. Relationship between nitrogen (N) treatments and the number of infested and new shoots. A positive correlation was found between increased N fertilization and infested and new shoots.

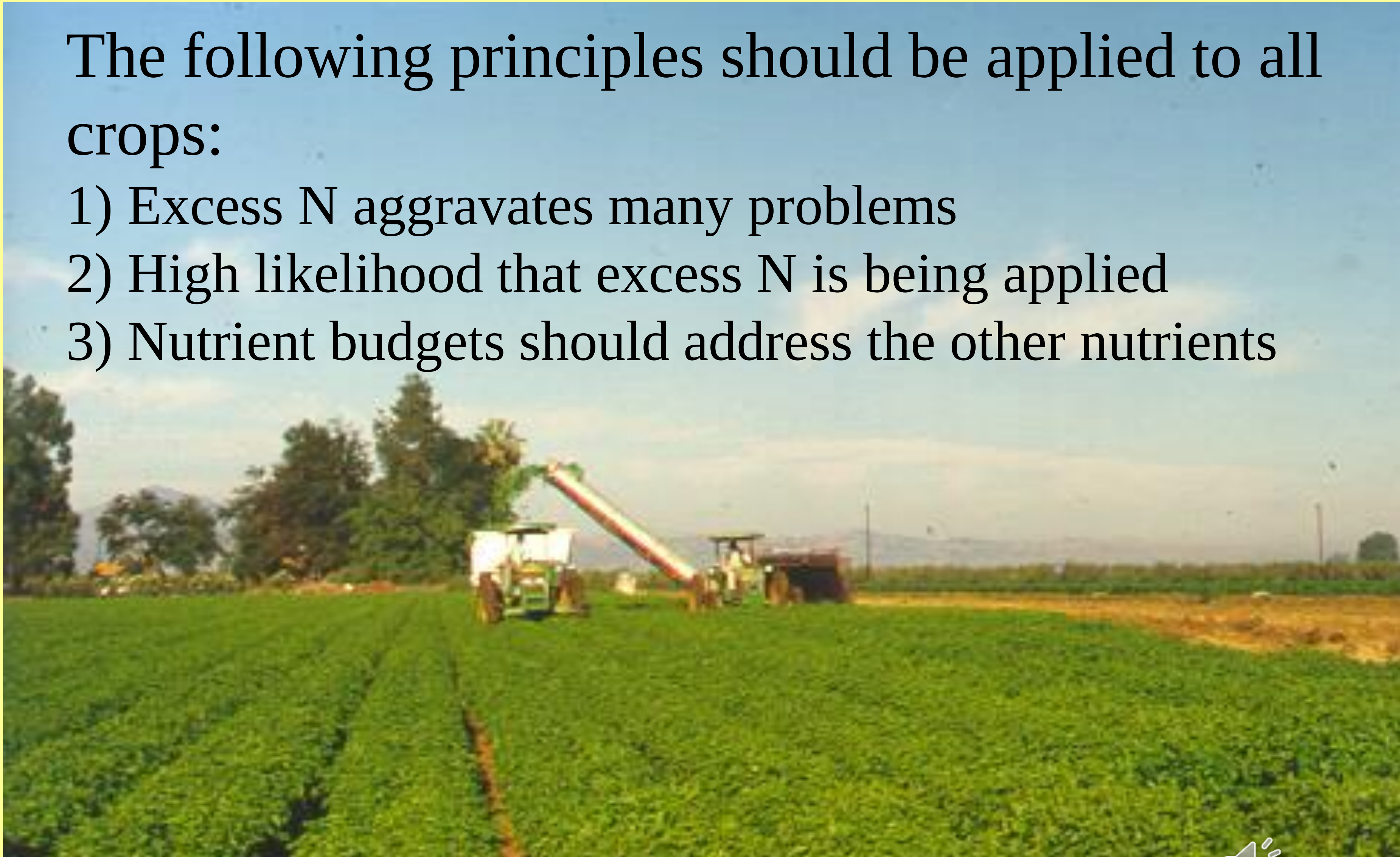
Most crops show thinner, more succulent growth with high N (which pests & diseases love)

PEST, DISEASE or CONDITION	CROP	NUTRIENT CONDITION	Effect On Problem	REFERENCE
VEGETATIVE GROWTH vs FLOWERING	CITRUS	Hi N	Worse	Omari, et al (2023)
GRAPE SKIN THICKNESS	GRAPE	Hi N	Worse	Keller, Arnink, Hrazdina (1998)
EXCESS SHOOT GROWTH	APPLE	Hi N	Worse	Pole, et al (2017)
FRUIT FIRMNESS *	APPLE	Hi N	Worse	3 studies
CELL WALL THICKNESS	APRICOT	Hi N	Worse	Jia, Mizuguchi, Hirano, Okamoto (2006)
THIN CUTICLES	FRUIT TREES	Hi N	Worse	Hanna, Zaher, & Ibrahim (1982)
CUTICLE DENSITY	NECTARINE	Hi N	Worse	Day (1997)

* There are numerous studies implicating high N with fruit firmness, bruising resistance, and storage quality.

The following principles should be applied to all crops:

1) Excess N aggravates many problems
2) High likelihood that excess N is being applied
3) Nutrient budgets should address the other nutrients



Common Pests, Diseases Affected by Excess N

List of Pest, Diseases Affected by Excess N:

Crop	Pests	Diseases
Tree fruits	2 Spot Mite, European Red Mite, Nematodes, Mealybugs, Leafhoppers, Psyllids, Oriental fruit moth, Peach twig borer	Scab, Fireblight, Powdery Mildew, Storage Rots, Bacterial Canker, *Botrytis*, Brown Rot, Shothole, Bacterial Rot
Nuts	Aphids, Navel Orangeworm, Mites	Rust, Scab, Bacterial Canker, Brown Rot, Hull Rot, Shot Hole, Kernal Necrosis
Grapes	2 Spot Mite, Mealybug, Pacific Mite, Vine Mealybug, *Phylloxera*, Grape Berry Moth, Leafhoppers	Bunch Rots, *Botrytis* (14), Powdery Mildew, Cane & Leaf Spot, *Phomopsis*, Downey Mildew (4), Grape Trunk Disease, Water Berry, Crown Gall
Citrus	Asian Citrus Psyllid, Aphids, Black Scale, Citrus Blackfly, Leafminer, Psyllid, Citrus Root Weevil, Whitefly, Glassy Wing Sharpshooter, Mealybugs, Citrus Red Mites, Nematode Populations, Purple Scale Lepidosaphes, Thrips, White Wax Scale, Gascardia, Woolly Whitefly	Citrus Canker, *Fusarium* Blight, Brown Spot, Dieback, Dry Root Rot, Exanthema Cu Deficiency, Key Lime Anthracnose, Lemon Gummosis, Mal Secco, Plenodomus, Scab

Research Related to Problems in the Industry

Verticillium wilt of pistachio

Proper nutrition reduces infection in low-inoculum soils and improves yields

Nutrients Help Citrus Survive Cold Snaps

Potassium Salt Reduces Celery Disease Losses

By Winston Goss

Fertilizers Can Affect Plant Diseases

By R. L. Luckhardt

How Calcium Nitrate fertilizer can increase potato yields, improve quality and reduce soft rot.

Practices to minimize postharvest decay of apples and pears

ORCHARD PRACTICES

• Use the minimum amount of nitrogen [N] fertilizer necessary to maintain plant vigor. High N fruit are more prone to various postharvest problems than lower N fruit.

Nutrient Balance Key to Success

Two Minerals Help Fight Plant Diseases

Phosphorus and potassium can reduce crop damage and disease

FINDING K'S ROLE IN ALLEVIATING STALK ROT

Ag authority reports on some interesting studies that correlate K deficiency with stalk rot in yield depression problem that continues to perplex agriculturists in Nebraska's irrigated sandhills

Wine Grape Production Costs – SJV 1980s

- Materials - Pesticides $149/ac per year
- Materials - Fertilizers $16/ac per year (N only)
- Sustained yields of 10 tons/ac per year ???

U.C. Cooperative Extension Costs Per Acre to Produce Wine Grape, San Joaquin Valley

Labor Rate: $8.71/hr. machine labor — Interest Rate: 10.00%
$7.71/hr. non-machine labor — Yield per acre: 10.0 Ton

OPERATION	Operation Time (Hrs/A)	Labor Cost	Fuel, Lube & Repairs	Material Cost	Custom/Total Rent	Your Cost	Cost
		Cash and Labor Costs per Acre					
Cultural:							
Prune & Tie	0.00	0	0	0	130	130	
Weed Control - Winter Strip	0.25	3	1	35	0	39	
Weed Control - Mow Middles 4X	1.72	18	10	0	0	28	
Weed Control - Disc Middles 1X	0.43	4	3	0	0	7	
Irrigate	5.00	39	0	169	01	207	
Pest Control - Vertebrate Pest	0.50	4	0	10	0	14	
Mildew Control - SI	1.15	12	7	37	0	56	
OLR & Mildew Control	0.38	4	2	15	0	21	
Mildew Control - Wettable Sulfur	0.38	4	2	2	0	8	
Fertilize	0.00	0	0	16	0	16	
Insect Control - Leafhopper	0.38	4	2	22	0	28	
Weed Control - Spot Spray	0.25	3	1	18	0	2	
Mildew Control - Dust Sulfur 4X	0.71	7	3	10	0	21	
Miscellaneous Costs	1.00	44	4	0	0	48	
Pickup Truck Use	2.38	25	9	0	0	34	
TOTAL CULTURAL COSTS	14.53	170	47	335	130	682	
Harvest:							
Harvest & Haul - Contract	0.00	0	0	0	450	450	
TOTAL HARVEST COSTS	0.00	0	0	0	450	450	
Interest on operating capital @ 10.00%					34		
TOTAL OPERATING COSTS/ACRE		170	47	335	580	1166	

A little more realistic now (2019):

- Materials - Pesticides $310/ac per year
- Materials - Fertilizers $345/ac per year (+K)
- Sustained yields of 10 tons/ac per year ???

UC COOPERATIVE EXTENSION – AGRICULTURAL AND RESOURCE ECONOMICS, UC DAVIS

TABLE 2. COSTS PER ACRE TO PRODUCE WINE GRAPES

SAN JOAQUIN VALLEY NORTH, Crush District 11 - 2021

60 # N, 144 # K per ac

Operation	Equipment Time (Hrs/A)	Labor Cost	Fuel	Lube & Repairs	Material Cost	Custom/ Rent	Total Cost	Your Cost
			Cash and Labor Costs per Acre					
Cultural:								
Well Test/Water Analysis	0.00	0	0	0	4	0	4	
Prune- Hand	0.00	670	0	0	0	0	670	
Prune- Chop Prunings	0.19	5	4	2	0	0	11	
Pests- Weeds/Disc 4X	1.72	48	35	12	0	0	94	
Winter Tie	0.00	61	0	0	15	0	76	
Trunk Suckering	0.00	102	0	0	0	0	102	
Petiole Tissue Sample/Analysis	0.00	0	0	0	0	6	6	
Pests- Disease/Mildew (Dust) 6X	1.20	33	8	4	21	0	66	
Irrigate	0.00	130	0	0	270	0	400	
Fertigate- 5-0-12 (4X)	0.00	0	0	0	345	0	345	
Shoot Removal/Positioning	0.00	305	0	0	0	0	305	
Chemigate- Mealybug & Leafhopper	0.00	0	0	0	30	0	30	
Trim Vines- Mechanical 2X	0.63	17	13	8	0	0	38	
Pests- Mildew, Leafhopper, & Mealybug	0.36	10	7	3	65	0	86	
Pests- Weeds/Summer Strip Spray	0.43	12	3	1	29	0	45	
Pests- Insects/Mites & Mildew	0.36	10	7	3	90	0	110	
Chemigate- N-pHuric Acid	0.00	0	0	0	6	0	6	
Pests- Weeds/Winter Strip Spray	0.43	12	3	1	75	0	91	
Pickup Truck Use	0.86	24	15	5	0	0	44	
ATV Use	0.86	24	1	1	0	0	26	
TOTAL CULTURAL COSTS	7.03	1,462	96	39	950	6	2,553	

Part of the Problem

2011

SAMPLE COSTS TO ESTABLISH AND PRODUCE

Processing Peaches

Cling and Freestone Late Harvested Varieties

SACRAMENTO VALLEY
and
SAN JOAQUIN VALLEY

UC COOPERATIVE EXTENSION

Table 2. COSTS PER ACRE TO PRODUCE CLING PEACHES

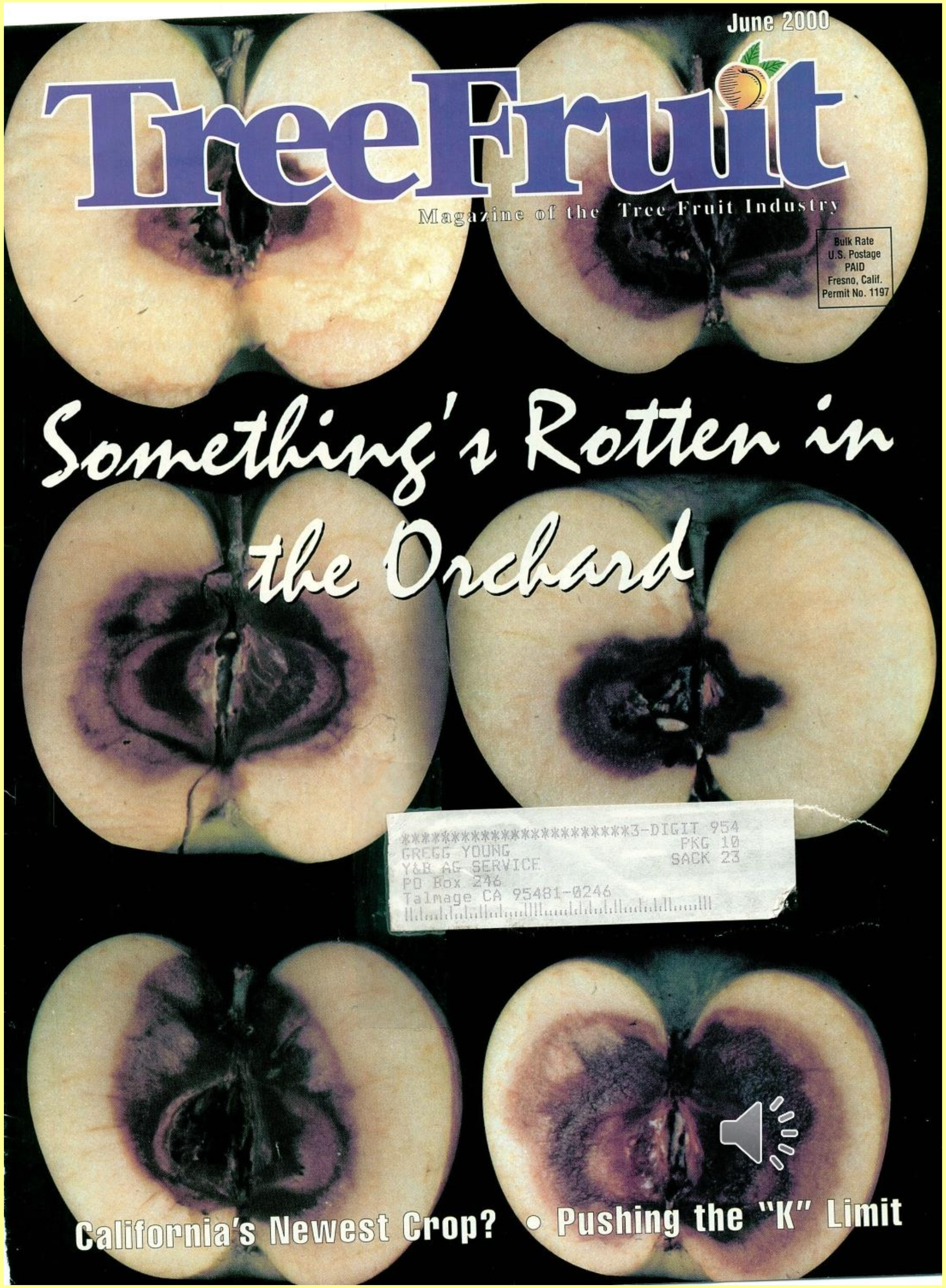
SACRAMENTO VALLEY and SAN JOAQUIN VALLEY 2011

	Operation	Cash and Labor Costs per Acre					
Operation	Time (Hrs/A)	Labor Cost	Fuel, Lube & Repairs	Material Cost	Custom/ Rent	Total Cost	Your Cost
Cultural:							
Prune: Hand Prune	34.50	378	0	0	0	378	
Tree: Wire Repair	1.50	16	0	25	0	41	
Disease/Insect: Dormant Spray (Oil, Kocide, Dimilin)	0.50	10	8	107	0	126	
Prune: Shred Prunings	0.40	8	7	0	0	15	
Disease: Brown Rot @ Partial Bloom (Pristine)	0.50	10	8	45	0	64	
Disease: Brown Rot @ Full Bloom (Indar)	0.50	10	8	21	0	40	
Disease: Mildew (Quintec)	0.50	10	8	36	0	55	
Irrigate: (water & labor)	2.56	28	0	115	0	143	
Weed: Spot Spray 2X (Roundup, 1X. Gramoxone 1X)	0.66	14	9	4	0	27	
Weed: Mow Middles 4X	1.60	33	27	0	0	60	
Fertilize: N (split application) (UN32)	0.00	0	0	42	0	42	
Disease: Mildew, Rust (Sulfur) 2X	1.00	21	16	7	0	44	
Insect: PTB, OFM (Asana, Checkmate) 2X	1.00	21	16	199	0	236	
Prune: Summer Prune	12.00	132	0	0	0	132	
Thin: Thin Fruit by hand	52.00	570	0	0	0	570	
Insect: PTB, OFM, Mite (Intrepid, Checkmate, AgriMek)	0.50	10	8	94	0	112	
Insect: PTB, OFM (Altacor, Checkmate)	0.50	10	8	85	0	104	
Prop Limbs & Remove Props	0.50	43	5	0	0	49	
Fertilize: Leaf Samples (nutrition analysis)	0.00	0	0	0	2	2	
Disease: Shothole, PLC (Ziram)	0.50	10	8	42	0	61	
Weed: Dormant Strip (Roundup, Matrix, Surfl	0.33	7	5	56	0	67	
Pickup: Farm Use	2.85	59	27	0	0	86	
ATV: Irrigation & General Field Use	2.85	59	8	0	0	68	
TOTAL CULTURAL COSTS	117.25	1,463	178	879	2	2,521	

FERTILIZERS 2%
PESTICIDES 27%
80 #/year N

An Industry-Wide Problem? The Evidence

- Reliance on soluble nitrogen
- N makes cells thinner & tissues softer
- Crops need K, Ca, P & other nutrients
- Many studies on this in trees & vines



I started writing about studies on nutrient-pest & disease relations in 1988 (15 insects, diseases, nematodes):

Table 1. Relationships Between Nutrients and Pest/Disease Resistance

Disease	Crop	Possible relationship	Definite relationship
Pythium	melons	NO_3†	soil O_2 deficiency†
Fusarium yellows	celery	ammonium N†	Ca; K; Cl*
Leaf blight	corn	high N; low P, K†	good N:K ratio*
Stalk rot	corn	--	high N; low K†
Stem rot	rice	high N; low K†	good N:K ratio*†
Stem soft rot	potatoes	Ca*	K; Cl*
Take all	wheat	ammonium N*; NO_3†	P; Cl*
Puccinia rust	wheat	P*	K*; high N†
Verticillium	pistachio	--	low P; K†
Powdery mildew	sugar beets, grapes	low Zn; high Ng	--
Decline	pear	low Ca†	--
Botrytis	grape	--	low K†
Erwinia fireblight	pear	low Zn†	high N; low K*
Mexican bean beetle	soybeans	air pollution; environment stress†	glutathione accumulation† --
Spider mites	various crops	high NO_3; low K†	--
Grasshoppers	sunflower	water; insect stress; fungus infection†	--
Pear psylla	pear	high NO_3†	--
Nematodes	various crops	nutritional stress† Low Ca†	soil antagonists*

* Increases disease resistance in plant; lowers susceptibility to disease.

† Decreases disease resistance; increases susceptibility to disease.

Data drawn from: Gross (1981); Laemmlen (1984); Redmond (1983); Agrichemical Age (1983); CDFA (1981); Luckhardt (1983); Lewis (1979); Ag Alert (1983); Hughes (1985); Olkowski (1982); Huber and Huber (1986); Pyror (1980); Ashworth, Morgan, and Surber (1986).

There are over 520 studies of relationships between nutrition and pest, disease & physiological disorders in the literature just on tree fruits & vines.

- 64% show high nitrogen aggravates the condition
- 28% show low calcium aggravates the condition
- 12% show relationships with potassium

Latest tally 11/2023 (520 studies in tree fruits & vines):

TOTAL	DATE	Hi N = Worse	% Hi N	Ca = Better	% Ca	K = Involved	% K	Nutrient Ratio/ Balance Involved
520	9/18/2023	332	64%	147	28%	65	12%	4%
		(or low N = Better)		(or low Ca = Worse)		(Hi or Low K)		(25 studies)

Interactions between Nutrients/Soil Conditions and Pests, Diseases & Physiological Disorders

PEST, DISEASE or CONDITION	CROP	SOIL or NUTRIENT CONDITION	EFFECT on PROBLEM	REFERENCE
HULL ROT	ALMOND	Hi N	Worse	Teviotdale (1996)
BROWN ROT, BLOSSOM	ALMOND	Hi N	Worse	Teviotdale (1996a)
SHOT HOLE	ALMOND	Hi N	Worse	Teviotdale (1996a)
BACTERIAL CANKER	ALMOND	Lo N	Worse	UC IPM (2005)
APHID	APPLE	Hi N	Worse	U Mass (2004)
BITTER PIT	APPLE	Hi N, Lo Ca	Worse	Bacon (1996)
BITTER PIT	APPLE	Hi N, Lo Ca	Worse	Shear (1975)
DELAYED MATURITY	APPLE	Hi N	Worse	Bacon (1996)
EUR[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
POST[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PREM[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
REPL[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TWO [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
EUR[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2 SPOT MITE	APPLE	Hi N	Worse	Rodriguez (1958)
FIREBLIGHT	APPLE	Hi N	Worse	Hildebrand, Heinicke (1937)
FIREBLIGHT	APPLE	Hi N	Worse	Fallahi, Mohan, (1991)
FIREBLIGHT	APPLE	Hi N	Worse	van der Zwet, Keil (1979)
FIREBLIGHT	APPLE	Hi N	Worse	Hildebrand, Heinicke (1937)
BROWN ROT	APRICOT	Lo K	Worse	Griffith (1975)
DELAYED MATURITY	APRICOT	Hi N	Worse	Bacon (1996)
PIT BURN	APRICOT	Hi N	Worse	Bacon (1996)
FRUIT CRACKING	CHERRY	Ca foliar	Better	Westwood (1978)
PHYTOPHTHORA	CHERRY	Poor drainage	Worse	Mircetich, Schreader, et al (1979)
SOFT FRUIT	CHERRY	Hi K, Lo Ca	Worse	Curwen, McArdle & Ritter (1966)
STECKLENBERG DISEASE	CHERRY	Lo P, Ca, & Mg	Worse	Baumann, von Olfers (1976)

Gregg Young, CPAg (1999, 2006)   www.qfirst.net   1

There are over 800 studies & articles on citrus, nuts, tree fruits & vines of links between nutrients and pests, diseases, and physiological problems (2023).

Gregg Young, CPAg 2014   www.qfirst.net

Deciduous Tree Fruits: Pests & Diseases

INTERACTIONS between NUTRIENTS/SOIL CONDITIONS and PESTS, DISEASES & PHYSIOLOGICAL DISORDERS

PEST, DISEASE or CONDITION	CROP	SOIL or NUTRIENT CONDITION	EFFECT on PROBLEM	REFERENCE
2 SPOT MITE	APPLE	Hi N	Worse	Wermelnger, Oertli, Baumgärtner (1991)
2 SPOT MITE	APPLE	Hi N	Worse	Suski, Badowska, (1975)
2 SPOT MITE	APPLE	Hi N	Worse	Jesiotr, Suski, Badowska-Czubik, (1979)
2 SPOT MITE	APPLE	Hi N	Worse	Wermelinger, Delucchi (1990)
2 SPOT MITE				...er, Oertli, Delucchi (1985)
2 SPOT MITE				...Volffgang, Reiss,Thiele (1980
ALFALFA GREENING				...0)
ANTIOXIDANT CONTENT				...007)
APHID				...04)
CALCIUM UPTAKE				...is, Cerny, Grassia (1970)
COLOR, FLAVOR				...nsson, Olsson (2007)
DELAYED MATURITY				...6)
E. RED MITE - egg production				...er, Haltrich. (2001)
EUROPEAN RED MITE				..., McMurty, Huffaker (1972)
EUROPEAN RED MITE				...st, (1959)
EUROPEAN RED MITE				..., Weires, (1989)
EUROPEAN RED MITE - egg...				...st (1959)
EXCESS ETHYLENE PRODUCTION	APPLE	Hi N	Worse	Fallahi, Conway, Hickey, Sams, (1997)
FIREBLIGHT	APPLE	Hi N	Worse	Hildebrand, Heinicke (1937)
FIREBLIGHT	APPLE	Hi N	Worse	Fallahi, Mohan (2000)
FIREBLIGHT	APPLE	Hi N	Worse	van der Zwet, Keil (1979)
FIREBLIGHT	APPLE	Hi N	Worse	Hildebrand, Heinicke (1937)
FIREBLIGHT	APPLE	Hi N	Worse	Pest Management Center (2013)
FIREBLIGHT	APPLE	Hi N	Worse	Fallahi, Mohan (2000)
FIREBLIGHT	APPLE	Hi N	Worse	van der Zwet, T. and S.V. Beer. (1991)
FLAVONOID CONTENT	APPLE	Hi N	Worse	Strissel, et al, (2005)

Hi N = Worse (number of studies)

Pests
81
Hi N = Worse

Diseases
116
Hi N = Worse

Citrus

INTERACTIONS between NUTRIENTS/SOIL CONDITIONS and PESTS, DISEASES & PHYSIOLOGICAL DISORDERS - CITRUS

PEST, DISEASE or CONDITION	CROP	SOIL or NUTRIENT CONDITION	EFFECT ON PROBLEM	REFERENCE
ACP, Development, Reproduction	CITRUS	Hi N & P	Worse	Telagamsetty, S. L. (2016).
APHIDS	CITRUS	Hi N	Worse	Braham, et al (2023)
ASIAN CITRUS CANKER	CITRUS	Hi N, Vigor	Worse	Krajewski & Krajewski, (2010)
ASIAN CITRUS PSYLLID	CITRUS	Hi N	Worse	Singh, Reddy, Deka (2020)
ASIAN CITRUS PSYLLID Feeding	CITRUS	Hi N	Worse	Serikawa, Backus, Rogers (2013)
ASIAN CITRUS PSYLLID Nymphal Mortality	CITRUS	Double N Rate	Better	Phillips, et al (2023)
ASIAN CITRUS PSYLLID Production	CITRUS	High N Rate	Better	Cantu, (2015)
BLACK SCALE				
BLACKFLY, *Aleu*				
BROWN SPOT				
BROWN SPOT,				
CITRUS LEAFM				
CITRUS BLACK				
CITRUS BLIGHT				
CITRUS BLIGHT, *Fusarium*	CITRUS	Hi NH3-nitrate	Worse	Burnett, Nemec, Patterson (1982)
CITRUS LEAF MINER	CITRUS	Hi K, Lo Ca	Worse	Mustaqeem, et al (2014)
CITRUS LEAFMINER	CITRUS	Hi N, Vigor	Worse	Krajewski & Krajewski, (2010)
CITRUS PSYLLA	CITRUS	Hi N	Worse	Catling (1969)
CITRUS PSYLLA	CITRUS	Hi N, Vigor	Worse	Krajewski & Krajewski, (2010)
CITRUS PSYLLA	CITRUS	Succulent Leaves	Worse	Pande (1972)

TOTAL	DATE	Hi N = Worse	% Hi N	Ca = Better	% Ca	K = Involved	% K	Nutrient Ratio/ Balance Involved
100	12/2023	87	87%	12	12%	11	11%	8%
		(or low N = Better)		(or low Ca = Worse)		(Hi or Low K)		(8 studies)

Deciduous Nut Crops

INTERACTIONS between NUTRIENTS/SOIL CONDITIONS and PESTS, DISEASES & PHYSIOLOGICAL DISORDERS

PEST, DISEASE or CONDITION	CROP	SOIL or NUTRIENT CONDITION	Effect On Problem	REFERENCE
ALMOND RUST	ALMOND	Hi N	Worse	Symmes, (2017)
ALMOND SCAB	ALMOND	Hi N	Worse	Johnson (2017)
APHID	ALMOND	Hi N	Worse	Vacante, Kreiter (2017)
BACTERIAL CANKER	ALMOND	Low N	Worse	UC IPM (2005)
BACTERIAL CANKER, *Pseudomonas*	ALMOND	Fall N spray	Better	Doll (2009)
BAND CANKER, *Botryosphaeria*	ALMOND	Hi N	Worse	Trouillas, F. (2017)
BROWN ROT, BLO				
DEFOLIATION				
HULL ROT				
HULL ROT				
HULL ROT				
HULL SPLIT, LEAF				
PREMATURE FRUI				
SHOT HOLE				
SPUR SURVIVAL	ALMOND	Low K	Worse	Lemons, (2001)
BACTERIAL CANKER	HAZELNUT	Low Ca, pH; Hi Al	Worse	Scortichini (2006)
BACTERIAL BLIGHT, *Xanthomonas*	HAZELNUT	Hi N, Lo Mg/K	Worse	Lamichhane, et al (2013)
INTERNAL BROWNING	HAZELNUT	Ca sprays	Better	Cacka, Sanguankeo (2012)
KERNEL MOLD	HAZELNUT	Ca sprays	Better	Cacka, Sanguankeo (2012)
MICRONUTRIENT CONTENT	HAZELNUT	Hi N	Worse	Özenç, et al (2014)
OIL CONTENT	HAZELNUT	Hi N	Worse	Özenç, et al (2014)
DISEASE RESISTANCE, HI VIGOR	NUTS	Hi N	Worse	Muhammad, Khalsa, Brown (2020)
BLACK PECAN APHID	PECAN	Hi N	Worse	Wood, Reilly (2000)
FALL FREEZE DAMAGE	PECAN	Hi N	Worse	Heerema, R. (2013).

TOTAL	DATE	Hi N = Worse	% Hi N	Ca = Better	% Ca	K = Involved	% K	Nutrient Ratio/ Balance Involved
50	4/2023	30	60%	12	24%	11	22%	14%
		(or low N = Better)		(or low Ca = Worse)		(Hi or Low K)		(7 studies)

Micronutrients can also be involved:

Micronutrients Involved
12%
Low or Hi = Better

Trees with leaves on all year require more nitrogen – and some studies show high N assists in pest & disease resistance (chemical salt forms of N also will knock down pests temporarily).

Citrus:

Hi N = Better	(or low N = Worse)
9	9%

104 references linking excess N to pest problems, and 256 to diseases (grapes, nuts, tree fruits)

Pests	TREES & VINES	Diseases
81		116
Hi N = Worse		Hi N = Worse

Pests	NUTS 50 refs	Diseases
9 = 18%		14 = 28%
Hi N = Worse		Hi N = Worse

Bunch Rots/*Botrytis*	GRAPES 130 refs	Hi Ca = Better
20		13
Hi N = Worse or Low N = Better		Hi Ca = Better or Low Ca = Worse
Insects & Mites		Powdery & Downey Mildew
14		6
Hi N = Worse		Hi N = Worse

Case Study - Fireblight of Apples & Pears

- Bacterial disease, infects blossoms/young fruit
- Infections require presence of bacteria in blossom, environmental conditions (warm & humid) and <u>susceptible</u> host
- Most sources caution that excess N aggravates this disease

Gre

Excess Vigor + Poor Mineral Balance

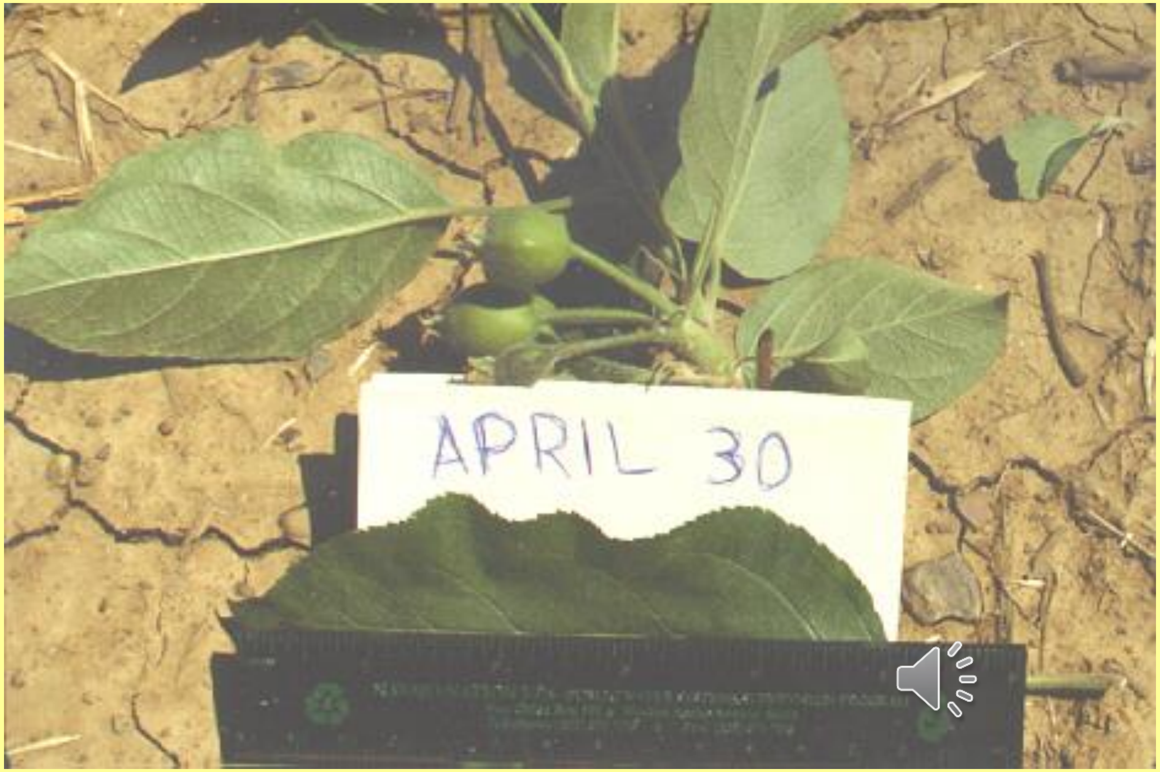
- 5" Apple leaf just after bloom
- Excess N in leaf analysis (16 refs show FB is worse)
- Deficient Ca & K in soil (6 refs show FB is worse)

Leaf N content =

2.5% (Optimum <2.2%)

Soil ratios Ca: Mg: K =

58%: 30%: 3% of CEC



Spring 2000 Fireblight Epidemic

- Weather & cultural conditions were just right for disease development
- Apple growers throughout central valley suffered severe economic losses
- Standard practice of over-fertilization with N to achieve large apples results in susceptible host


Shoot Growth in Orchards
Recommended: 12 - 24 inches
Actual: 24 - 48 inches +

2-foot growth, early June, apples (minimal N; trying to control vigor for fireblight management)

Others – *Botrytis*, *Monilinia*

Case Study – Brown Rot in Stone Fruits

- *Monilinia* brown rot infects blossoms, twigs, and fruit of stone fruit
- 12 refs show high N makes it worse
- 10 refs show high Ca makes it better

Organic Brown Rot Management

Using mineral and biological fungicides:

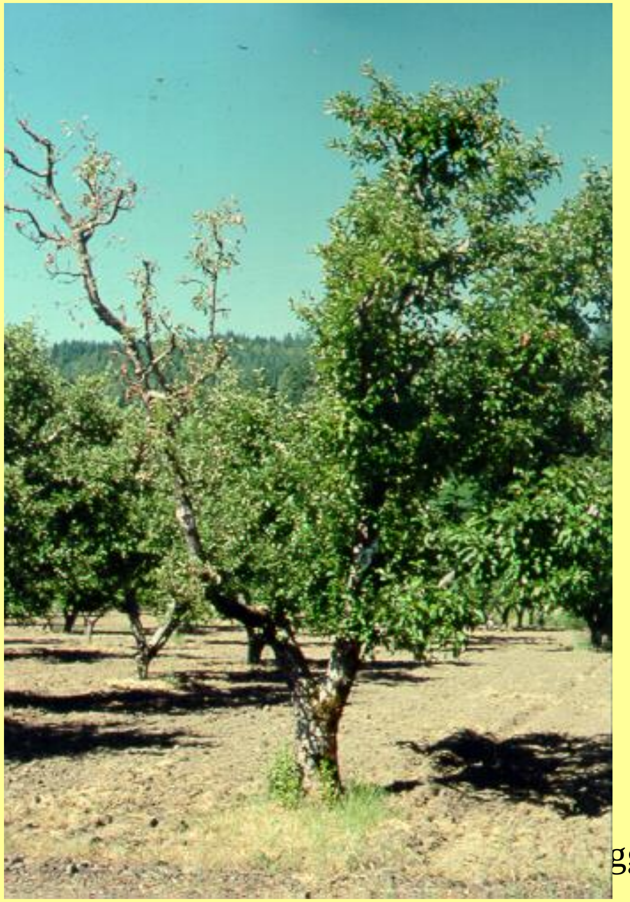
- We have gotten very good, consistent results in peaches, nectarines, plums and cherries by minimizing N and providing abundant Ca and K, even in very wet years
- Good, mixed, to poor results have been produced in apricots (which bloom much earlier)

Saturated soils, rather than light rain events aggravate brown rot blossom blight in early blooming varieties (2/25/23 in N. Calif.)

(Orchard that uses compost, mineral balancing, cover crops; down the street, same time

Die Back & Other Diseases & Maladies??

- Root rots, die back, decline, nematodes, etc.
- Multiple organisms involved: *Eutypa lata* causes a dieback condition; 11 different fungal species were isolated from grapevine cankers associated with *Eutypa*. Newsome, J. (2012). Grapevine Trunk Disease. *A review*..



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Insect, Mites, Nematodes Damage & Nutrition

- 104 references linking excess N to pest problems, and 256 to diseases (grapes, nuts, tree fruits)
- Note aphids building up around veins, sucking nutrients from plant sap

Quantifying Crop Fertilizer Needs:
Crop Nutrient Removal

- A good way to quantify minimum fertilizer needs
- Should consider all nutrients removed by crop: edible parts, seeds, skin, stems plus woody parts & roots of trees & vines
- Use crop removal with soil analysis results to figure likely limiting factor
- THE MINIMAL FERTILIZATION PROGRAM SHOULD REPLACE THE NUTRIENTS REMOVED ANNUALLY BY THE CROP
- Consideration of temporary, seasonal removal (leaves, roots) should also be considered

Newer biological materials can offer 80-90% control or more, but often not good enough - do we need a more integrated approach?

SERENADE® ASO

An Aqueous Suspension Biofungicide

CYD-X®

INSECTICIDAL VIRUS

GRANDEVO™

Active Ingredient: *Chromobacterium subtsugae* strain PRAA4-1[T] and spent fermentation media*.... .... 30.0%

ACTINOVATE® AG

Regalia®

Biofungicide Concentrate

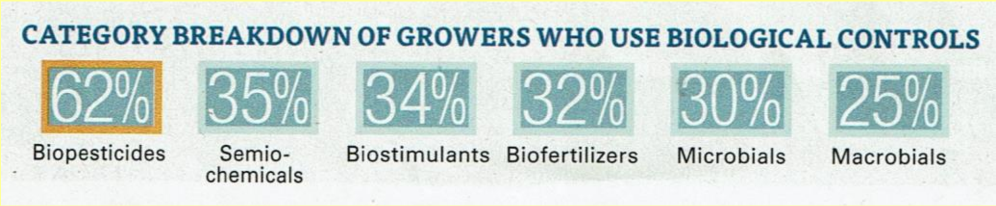
A plant extract to boost the plants' natural defense mechanisms against certain fungal and bacterial diseases.

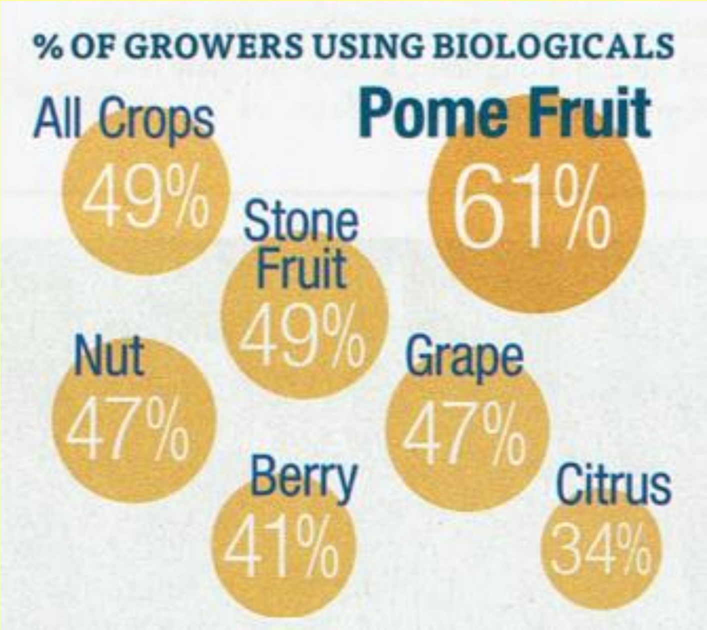
Active ingredient: Extract of *Reynoutria sachalinensis* .... 5 %

AzaSol

Water Soluble Bio Insecticide from Neem

Biological materials are the fastest growing sector in the pesticide industry (yea!)





Skernivitz, T. (2023). Money Well Spent – 2023 State of the Industry - Cover Story. American Fruit Grower. July, 2023. Vol 143 (7).

Will a healthier, less vigorous host allow better control with ‘soft’ materials?

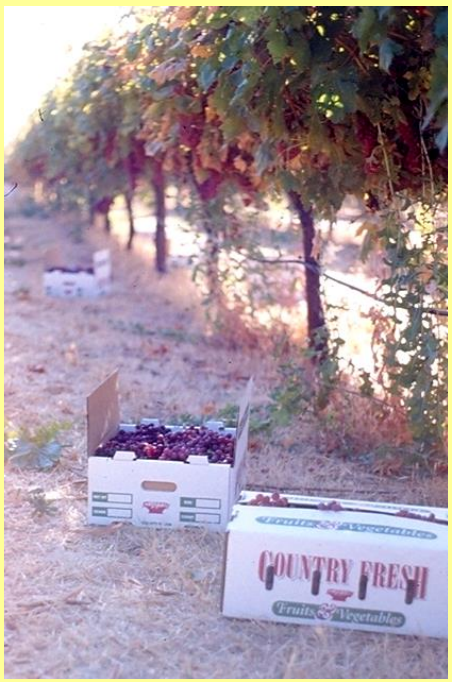
GRAPEVINE: FUNGICIDE EFFICACY – SOFT CHEMISTRY (BIOLOGICAL AND NATURAL PRODUCTS)

Fungicide	Resistance risk (FRAC#)[1]	Powdery mildew	Downy mildew	Bunch rot		Phomopsis cane and leaf spot	Eutypa dieback	Bot Cankerer	Dead Arm
				Botrytis	Summer				
Armicarb	low	+++	----	----	----	----	----	----	----
B-Lock**	low	----	---	----	-----	-----	++++	++	NR
Cinnacure	low	+++	----	----	----	----	----	----	----
Elexa**	low	+++	----	----	----	----	----	----	----
JMS Stylet oil4	low	+++	----	+++	++	----	NR	----	----
Kaligreen	low	+++	----	----	----	----	----	----	----
Milstop	low	+++	----	----	----	----	----	----	----
Sonata	low	+++	----	++	NR	----	----	----	----
Purespray	low	+++	----	----	----	----	----	----	----
Vintre*	low	+++	----	----	----	----	----	----	----
Actinovate	low	++	-----	----	----	----	-----	----	----
HiPeak*	low	++	----	----	-----	-----	-----	----	----
Messenger**	low	++	----	----	----	----	----	----	----
Prev-am [4]	low	++	----	----	----	----	++	----	----
Sporan	low	++	----	----	----	----	----	----	----
Timorex* [4]	low	++	----	----	----	----	----	----	----
VigorCal*[5]	low	++	----	----	----	----	----	----	----
VigorK*	low	++	----	----	----	----	----	----	----
Sporatec	low	+	----	----	----	----	----	----	----
Vitiseal	low	----	----	----	----	----	++++	----	----

FUNGICIDE EFFICACY – SOFT CHEMISTRY (BIOLOGICAL AND NATURAL PRODUCTS)

What to Do?

To minimize pesticide use, and ensure optimum quality, flavor & health (and good yields):



THE PROGRAM:

- **Balance soil exchangeable cations to 65-75% Ca; 10-15% Mg; 2-5% K; 0-5% Na (as % of total cation exchange capacity; maintaining cation balance with appropriate mineral amendments.**
- **Maintain P, K, S and micronutrients at generous levels**
- **Build and maintain OM through cover cropping, addition of composted organic matter and/or microbial soil inoculants, and promotion of healthy biological activity in soil**
- **Supply N in adequate amounts (for crop needs <u>only</u>) avoiding excess soluble N, applying N sparingly in split applications or via composted OM for activation of N cycle and slow release**
- **Foliar feeding of nutrients known to be deficient; applying during stressful times (bloom, maturity, adverse weather, pest/disease pressure, etc. (Young, 1988)**

Why not use the soil cation ratios that most major soil labs ~~show~~ on the soil analysis report form?

- 65-75% Calcium
- 10-15% Magnesium
- 2-5% Potassium
- 0-5% Sodium

Fine-tune and modify according to your specific crop and local conditions

Cation Balancing is Controversial

- **Not enough applied research**
- **Facts:**
  - Major soil cations (Ca, Mg, K, Na, H) all interact = when one is high, others are low or out of balance
  - The ratios affect soil pore space, drainage & tilth (especially low Ca with high Na or Mg)
  - Poor drainage & soil aeration adversely affect nitrogen, phosphorus, sulfur & potassium cycling
- All of these affect pest & disease resistance

From: Western Farm Press V 29 (3) January 20, 2007 (By Brent Rouppet)

- The higher the sodium content and lower the total salt content of irrigation water, the more likely soil particles will become separated and disorganized. This is caused by a chemical imbalance between calcium and sodium plus magnesium, both villains to good soil structure.

(In the past, and now, Ca and Mg are combined in water tests and calculating SAR. This article is suggesting combining Mg + Na. They should be analyzed separately) GY.

More Western Farm Press :

- Calcium is…essential for good soil structure; any calcium existing below the root zone or used by crops…is typically not being replaced in required quantities
- Balancing both the soil and irrigation water using additional calcium can correct nearly all water penetration problems… The chemical reaction and positive effective is immediate and dramatic, but not permanent.

More Western Farm Press:

- Less irrigation water is required to achieve the same results
- There is an improvement in water use efficiency. 25-100 percent more water is available in calcium treated soil vs. untreated
- There is increased oxygenation in the root zone
- Calcium is an essential plant nutrient, generally found in deficient quantities in most soils.

More Western Farm Press:

- Also, for optimum soil structure there should be approximately 16 times more calcium than sodium and 8 times more calcium than magnesium in the soil.

(this is based on ppm exchangeable Ca; as percent of CEC ratio of Ca:Mg should be about 6:1) GY

Cation ratios are valuable for:

- Fine tuning fertility programs
- Solving problem soils (poor structure, tilth, drainage)
- Developing programs with lower nitrogen inputs
- Producing quality (flavor, nutritional value), not just yields
- Improving organic matter management

Example: how Cation Balancing works

- **Soils with low clay content retain less K^+ in the exchangeable form, while soils with higher clay content retain K+ to a greater extent**
- **Application of winery wastewater with K+ and Na+ concentration resulted in accumulation of available K+**
- **The actual amounts and the ratios between the four dominant basic cations, namely Ca^{2+}, Mg^{2+}, K^+ and Na^+, adsorbed on the soil exchange complex, are important with regard to soil chemical and physical conditions, as well as plant nutrition**.

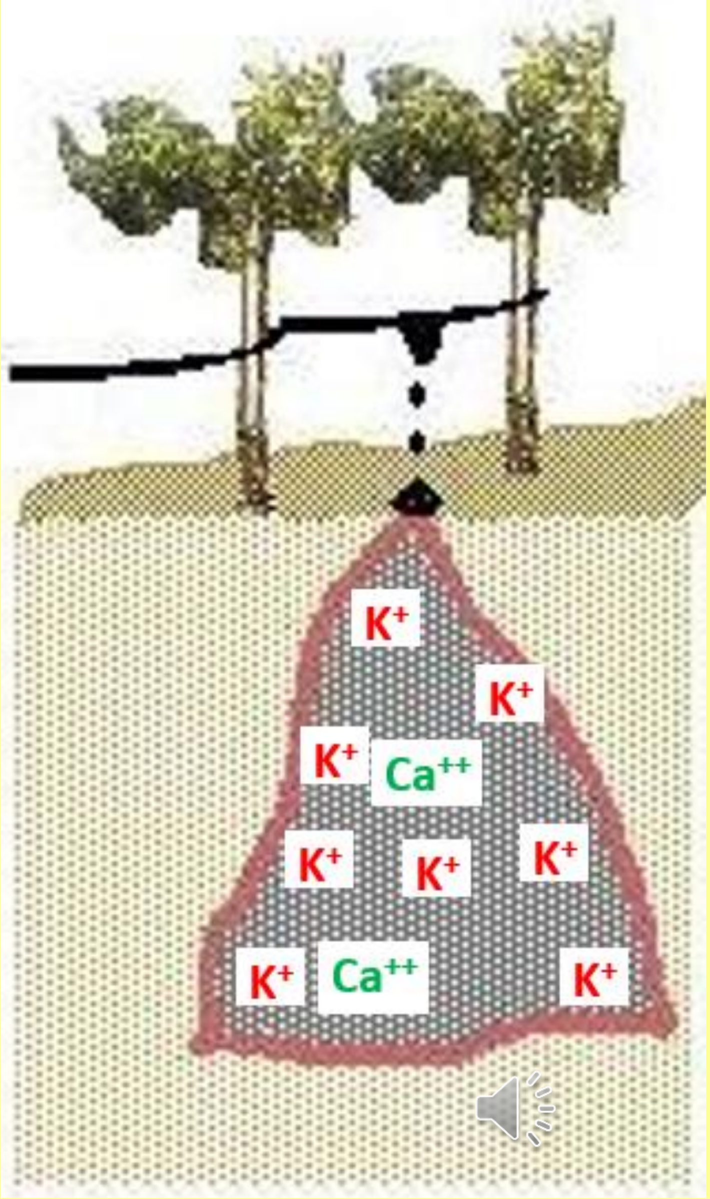
- From: Mulidzi, A. R., Clarke, C. E., & Myburgh, P. A. (2019). Response of soil chemical properties to irrigation with winery wastewater on a well-drained sandy soil. *South African Journal of Enology and Viticulture*, *40*(2), 1-1.

How Soil Balancing Works, cont.

- Adequate K^+ is… important for grapevine performance and K+ deficiencies will cause low yields... excessive K^+ levels can cause poor wine quality in terms of low acidity and poor colouring of red wines
- High levels of exchangeable K^+, similar to Na^+, can increase dispersion resulting in reduced soil hydraulic conductivity and water infiltration rate
- Dispersion leads to degradation of soil structure, which causes problems such as soil crusting (surface sealing) and slaking that can lead to low water infiltration rates, low hydraulic conductivity, poor aeration, poor root development and functioning Mulidzi, Clarke, & Myburgh, (2019)

How Soil Balancing Works, cont.

- If you are fertilizing/ watering with a typical low N, high K blend you will be overloading the soil colloid with K
- This creates conditions where vines have to exert energy to get needed calcium
- Vines will have reduced ability to resist *Botrytis*, stem necrosis, freeze damage, storage rot, cane dieback, nematodes



Applied Research focuses mostly on yields

- **Several researchers have tried to validate this theory with both greenhouse and field experiments but could not conclude that an ideal cation saturation ratio existed and found that CROP YIELDS were similar across a wide range of ratios.**
- **Some even argue that soil balancing improves nutritional quality of the harvested crop. However, contemporary research to objectively demonstrate such perceived benefits of practicing soil balancing is missing**

Chaganti, V.N. and Culman, S.W. (2017), Historical Perspective of Soil Balancing Theory and Identifying Knowledge Gaps: A Review. Crop, Forage & Turfgrass Management, 3: 1-7 cftm2016.10.0072

Using soil amendments to balance Ca: Mg: K: Na

Build and maintain OM - cover cropping, addition of composted organic matter and/or microbial soil inoculants, and promotion of healthy biological activity in soil

Nitrogen for crop needs *only*

- Develop well formulated N budgets, taking into account the enhanced ability of a soil balanced in minerals (best aeration) and high in bio-activity.

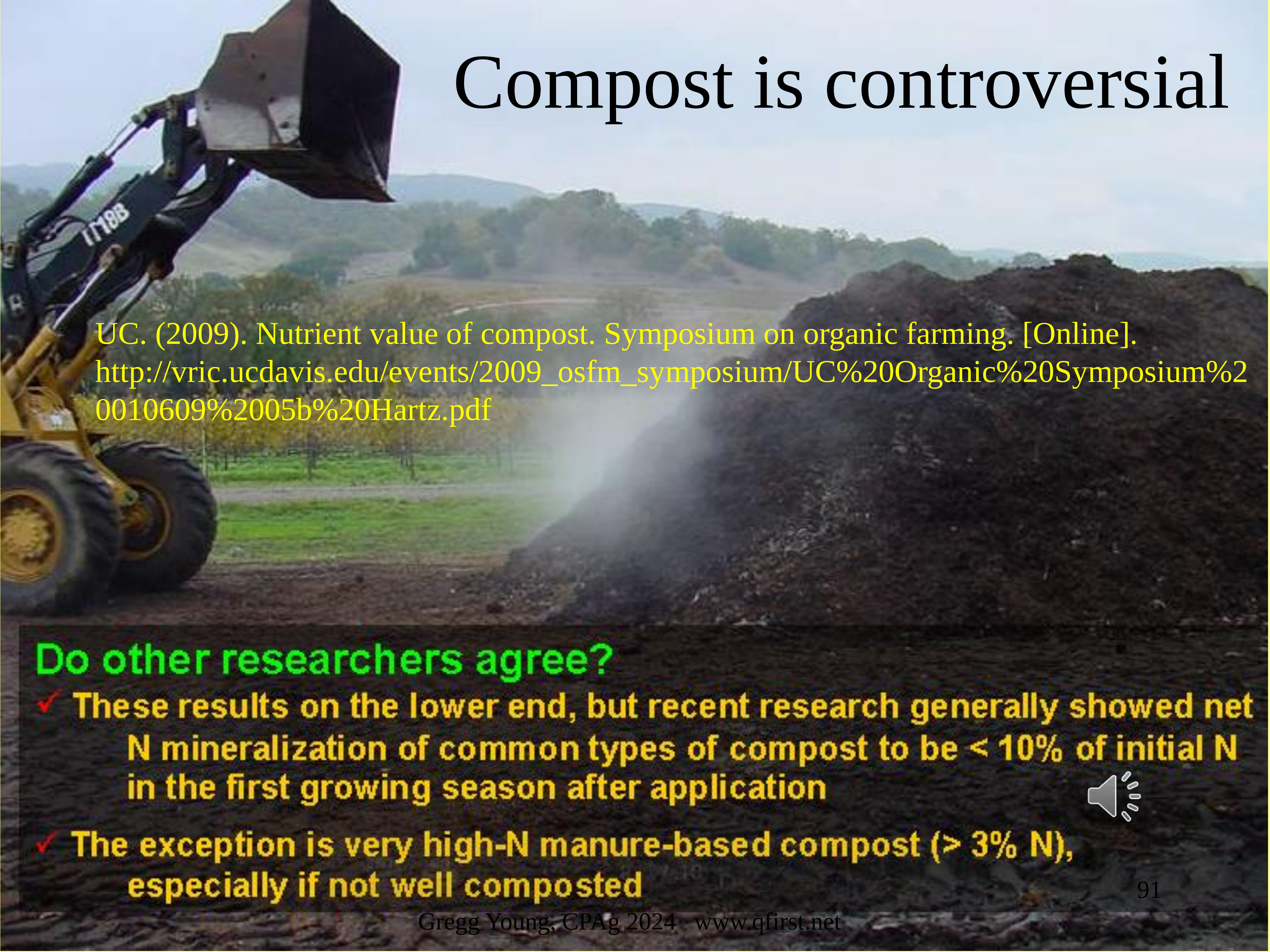
CROP	RECOMMENDED N RATE PER ACRE	SOURCE	WELL BALANCED, BIO-ACTIVE SOIL
ALMOND	100-200 #	(1)	
APPLE	72 – 200	(OSU)	25-50 (GY)
CHERRY	90-125	GFG	25-60 (GY)
GRAPE, raisin	20-60 #	(1)	
GRAPE, wine	20-80	(OSU, GFG)	0-25 (GY)
NECTARINE	100-150	(1)	25-60 (GY)
PEACH	50-100	(1)	25-60 (GY)
PISTACHIO	100-225	(1)	
PLUM	100-150	(1)	25-60 (GY)
WALNUT	150-200	(1)	25-50 (GY)

(1) Rosenstock, T., Liptzin, D., Six, J., & Tomich, T. (2013). Nitrogen fertilizer use in California: Assessing the data, trends and a way forward. *California agriculture*, *67*(1), 68-79
(OSU) Oregon State University (GFG) Good Fruit Grower Magazine

An alarming trend: Farming conventionally with organic-compliant materials

- Over-applying compost in the (mistaken) belief that a small % of N will be available for crop use
- Instead of using mineral sources, attempting to supply high amounts through compost (2-3% Ca, K)
- Fumigating (!) to knock down soil pathogens (a result of conventional practices), planting trees, and harvesting after legal period is past (in lieu of biological & mineral augmentation)

Compost is controversial

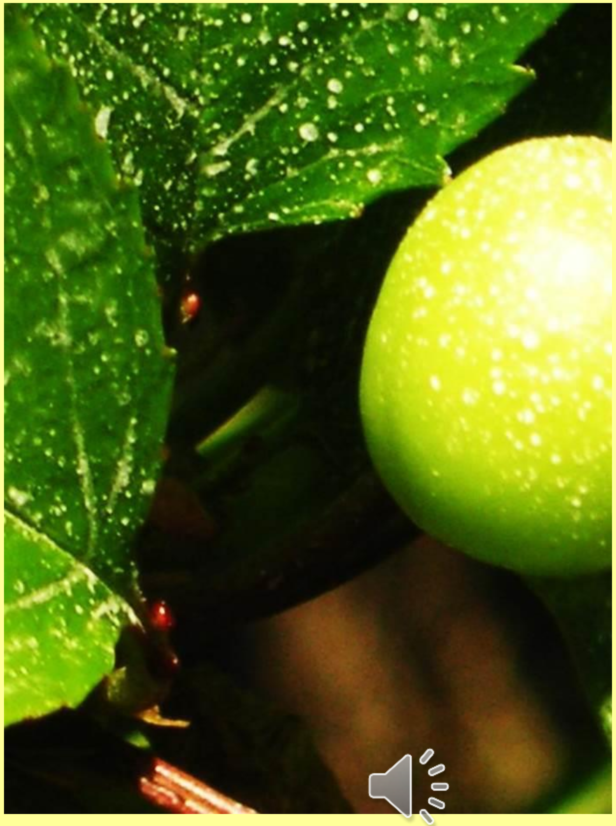


UC. (2009). Nutrient value of compost. Symposium on organic farming. [Online]. http://vric.ucdavis.edu/events/2009_osfm_symposium/UC%20Organic%20Symposium%20010609%2005b%20Hartz.pdf

Foliar Feeding - the application of essential plant nutrients to the above ground parts of plants

Main reasons for foliar feeding:

- Highly efficient & timely method of applying nutrients that could be limiting factors
- Can compensate for soil or environmentally induced deficiencies
- Can be used to augment resistance to pests & diseases when applied at stressful times



Calcium sprays are exploited as a main tool in integrated peach production leading to environmentally more friendly growing techniques, promptly by increasing tissue firmness and resistance to brown rot. Even in calcareous soils, pre-harvest calcium sprays have been proved beneficial.

Manganaris,G., Vasilakakis,M., Diamantidis, G. , Mignani, I. (2006).

Similar research suggests that foliar sprays of calcium be used in an integrated approach to post harvest disease management in stone fruit, strawberries, citrus, cherry, melons, & pomegranate

Madani, B., & Forney, C. F. (2015). Recent Research on Calcium and Postharvest Behavior. *Advances in Postharvest Fruit and Vegetable Technology*, 19.

What about Silicon?

Heat Stress | Drought Resistant | Thicker Leaf | Better Product

Silicon is an essential mineral element for some plants and is beneficial for all higher plants. It can function as an essential trace element in metabolic roles and also accumulate in large quantities in certain tissues, cells and cellular components to enhance physical attributes of plants. Silicon associates with calcium and pectin in the intercellular walls spaces in the roots providing rigidity of leaves improving photosynthetic activity. It reinforces the walls of the vessel cells in the xylem, preventing compression under conditions of high transpiration thus improving sap circulation. Silicon has important roles in the formation of new leaves, pollination, fruit formation and fruit storage.

"If we consider life on the earth in general the first thing we have to take into account is the very important part played by the what I might call the life of the siliceous substance in the world…"

"It is only through the balance of these two formative forces — as embodied in these two substances, silicon and limestone — that plant life can flourish in the form in which we know it to-day." Rudolph Steiner, (1924).

BD preparation 508 which is prepared from the silica-rich horsetail plant (*Equisetum arvense*) and used as a foliar spray to suppress fungal diseases in plants.

Si Protects Against Some Disease And Insect Pests

Studies show that adding silicon to the growing media significantly reduces the presence of powdery mildew in a variety of plants, including cucumber, tomatoes, strawberries, grapes, melons, and lettuce.

This nutrient also protects against bacterial and viral infections in certain plants.

Not only does silicon protect against disease, it also reduces the population of insects and mites feeding on silicon-treated plants.

K_2SiO_3 has potential as an alternative spray material to sulfur for powdery mildew control, because: *(1)* material cost is lower; *(2)* risk of H_2S in wines is reduced; and *(3)* it would potentially fall within guidelines for organic winegrowers as a natural substance.

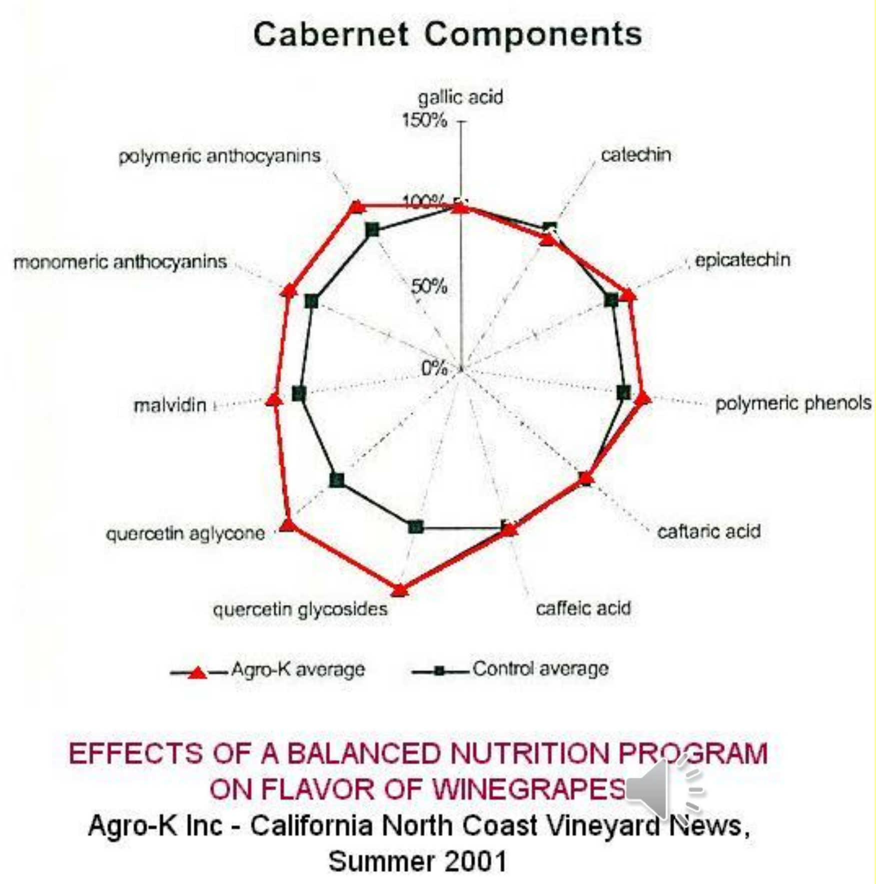
Reynolds, A., Veto, L., Sholberg,P., Wardle, D., Haag, P. (1996). Use of Potassium Silicate for the Control of Powdery Mildew [*Uncinula necator* (Schwein) Burrill] in *Vitis vinifera* L. Cultivar Bacchus. Am J Enol Vitic. January 1996 47: 421-428

For many years, it was thought that silicon provided a physical barrier associated with the plant cuticle, making it harder for insects to penetrate.

While this process is involved, **recent studies show that arthropods feeding on silicon-treated plants produce fewer offspring, suggesting that silicon is altering some aspect of the plant material ingested by these menaces**. Combining silicon with other biocontrol agents may lead to better protection and control over infestations.

Zellner, W. (2017). Silicon: a Biocontrol Agent that Boosts Plant Immunity. Growing Produce. September 1, 2017. [Online] http://www.growingproduce.com/vegetables/silicon-a-biocontrol-agent-that-boosts-plant-immunity/

Quality First – a movement to promote best fertilization for quality, flavor, and reduced pest & disease problems.



For a comprehensive analysis of this approach see A Training Manual for Soils and Fertilization in the North Coast of California at:

http://www.qfirst.net

- Review of work of Albrecht & other early soil scientists
- lessons for interpretation of soil analysis results
  - Balancing soil cations
  - Using composts & cover crops
  - Using foliar feeding to raise pest/disease resistance
  - Why you can cut nitrogen usage 25-75%

While it is not necessary for everyone to know the details of potash mining or the chemical reactions involved in phosphate fertilizer production, they should be able to understand that **you can't get something from nothing. Plants always require the basic components of growth from the soil in order to <u>thrive</u>**. The inescapable link between well-nourished plants and healthy food should be evident to everyone. (Emphasis added)

From: Robert L. Mikkelsen. (2015). Better Crops with Crop Food. Publication of the International Plant Nutrition Institute (IPNI) 2015 V 99 (4). Pg. 31.

References and more information are available at:
www.qfirst.net

Tables & References:
https://www.qfirst.net/sustainableOrganicAgriculture.html

Slide show w/ narration: TBD

Questions/Comments?
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THE END