Grapevine Mineral Nutrition

Peter Christensen
Viticulture Specialist, Emeritus
Department of Viticulture and Enology
University of California, Davis

UC Kearney Agricultural Center
Parlier, CA

Vineyard Mineral Nutrient Deficiencies and Excesses

Macronutrients

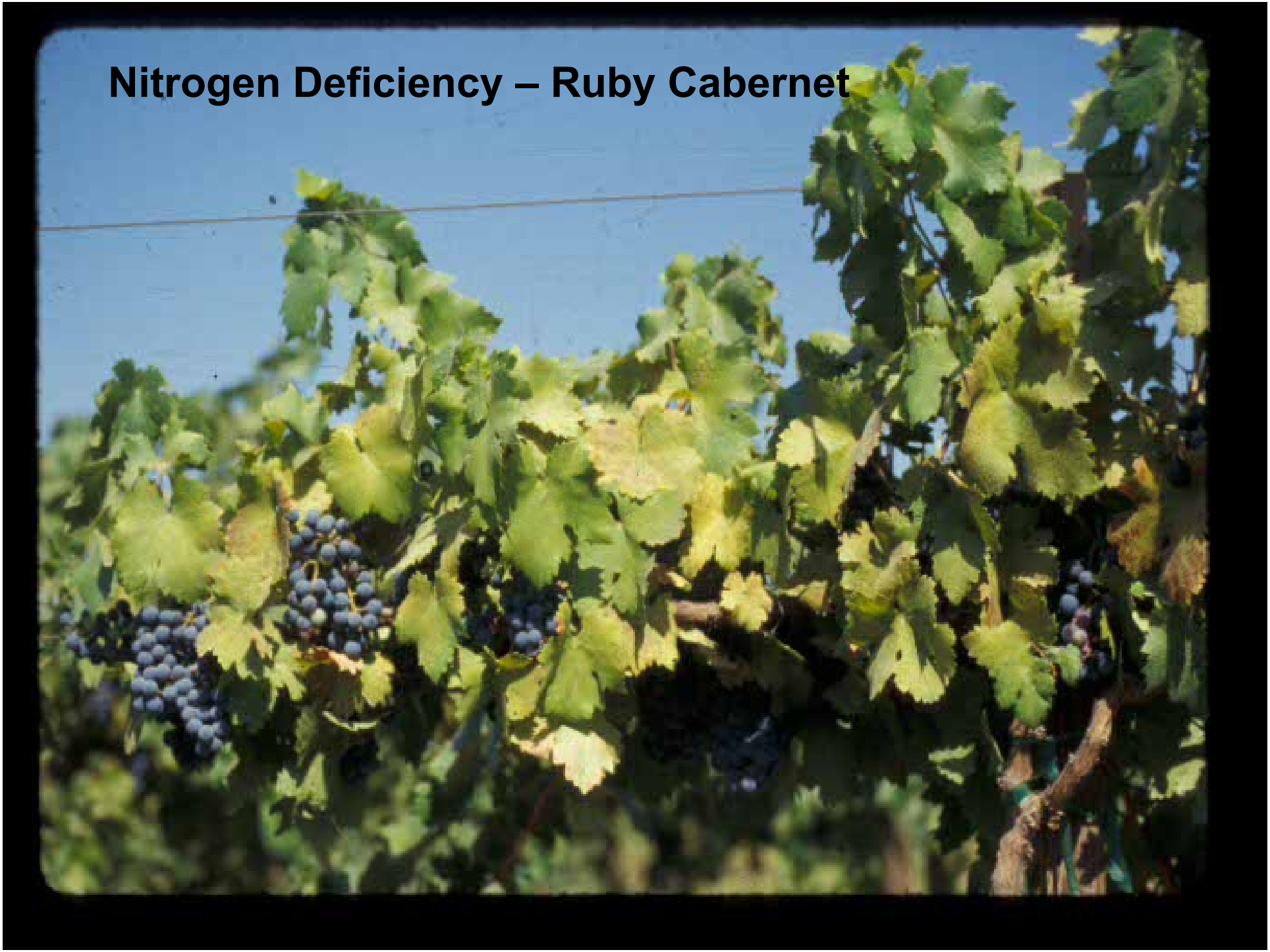
Nitrogen
Potassium
Phosphorus
Magnesium
Calcium
Sulfur

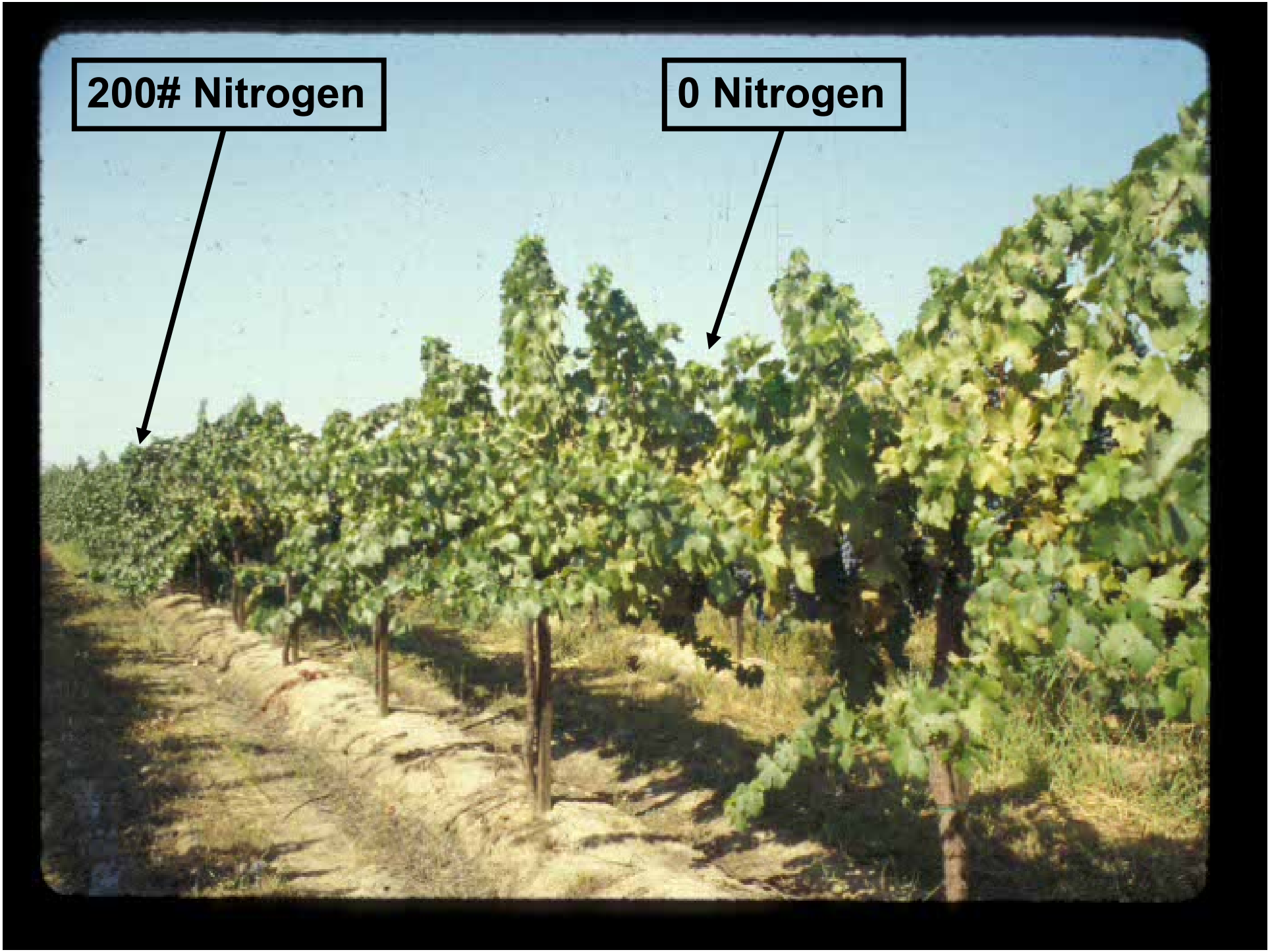
Micronutrients

Zinc
Boron
Iron
Manganese
Copper
Molybdenum

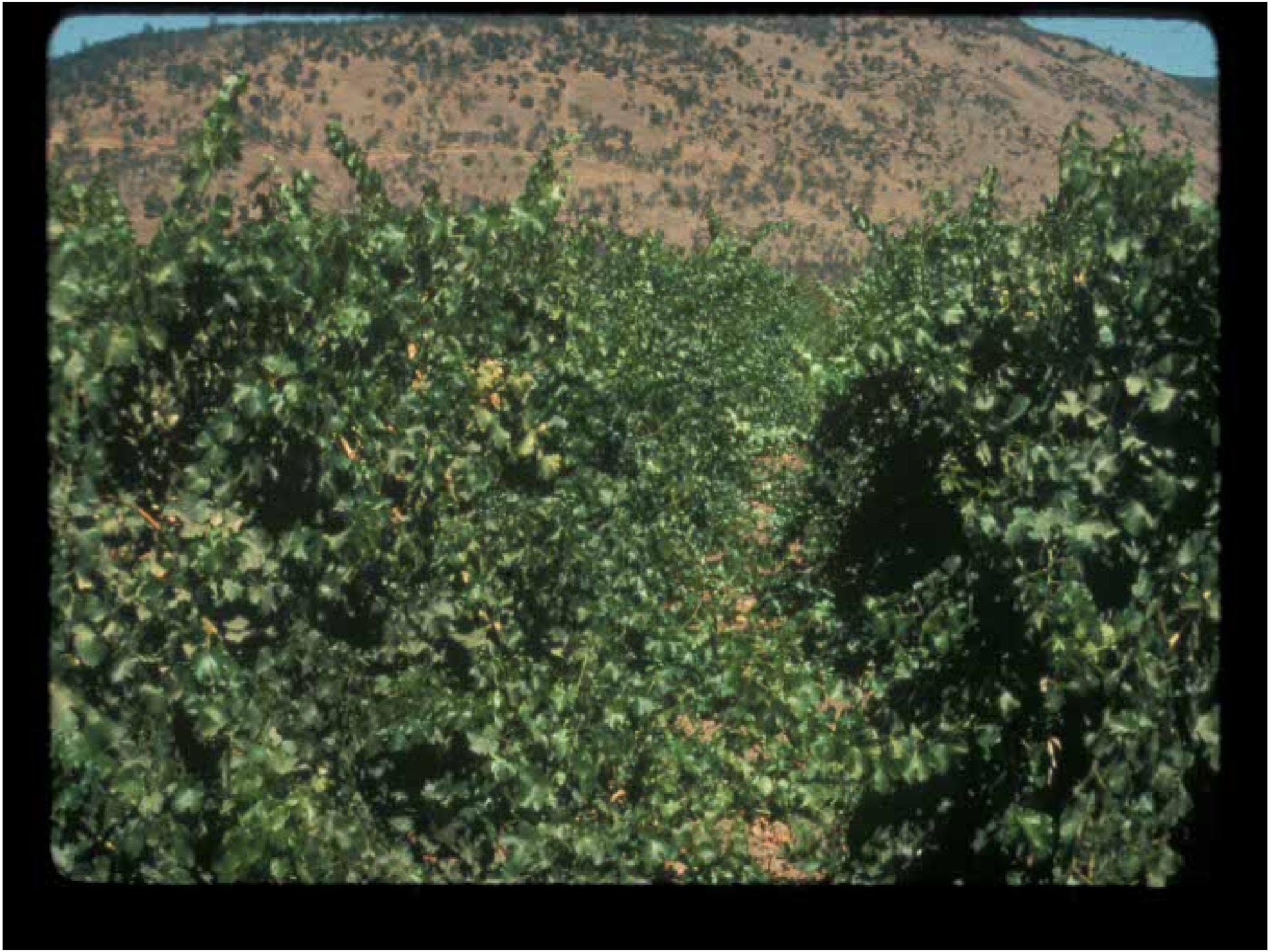
NITROGEN (N)

Nitrogen Deficiency – Ruby Cabernet




200# Nitrogen
0 Nitrogen


Sand Streak with N Deficiency



Excess Nitrogen & Low Fruitfulness

Excess Nitrogen Effects

- Lower bud fruitfulness
- Lower fruit set
- Delayed fruit ripening
- Lower raisin grades
- Reduced anthocyanins
- Higher malate & pH
- Susceptibility to fungal diseases
- Higher pruning and cultural costs


Chardonnay – Anderson Valley

Assessment of N Need

- Vine vigor
- Canopy density
- Fertilizer history and N inputs
- Soil and root conditions
- Laboratory analysis

Nitrogen Fertilizer Timing

Nitrogen Utilization is Dynamic

- Vines store and remobilize N
- Stored N contributes 30% N utilized between bud break and bloom
- Spring levels are strongly influenced by N status in previous summer and fall
- Post harvest applications provide the most stored N at bud break

Anhydrous Ammonia Application – 1970s

Nitrogen Timing

- Spring to early summer
  - Apply in increments over time
  - Irrigate at ≤ ET to avoid leaching
- Post harvest
  - Intact, healthy leaf area
  - > 3 weeks before leaf fall

Fall Canopy

Vine Nitrogen Demand

- Vine Recycled ~ 40 lbs. per acre

- Crop Removal ~ 30 lbs. per acre
  10 ton crop per acre

L. Williams

Nitrogen Fertilization – Drip Irrigation

Timing: Spring to early summer and/or Post-harvest

Rates, lbs N/acre:

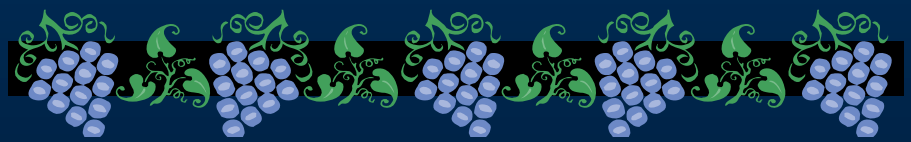
0	High to excess vigor
10-20	High to medium
20-30	Medium
30-40	Medium-low to low

***Apply in increments over time**

Reduced Nitrogen Leaching

- Cover crops
- Fertilizer Timing
  - choose periods of utilization
  - split applications
- Placement
  - side dress – furrow irrigation
  - drip
- Irrigate at 70-80% ET

PHOSPHORUS (P)



Phosphorus Deficiency in California

- New viticulture areas and soil sites
  - Enabled by drip irrigation

- Mostly hillsides of north coast and Sierra Nevada
- Low pH
- High iron


Phosphorus Deficiency
Cabernet Sauvignon


Willamette Mite - Merlot

Phosphorus Critical Values

	Petiole Levels (% P)	
	Bloom	Veraison
Deficient	<0.10	<0.08
Questionable	0.10-0.15	0.08-0.12
Adequate	>0.15	>0.12
Cushion	>0.20	>0.15

Phosphorus Deficiency Correction

Rates:

- 0.33 lb. P/vine under drippers, 3 years
- 0.66 lb. P/vine unnecessary

Materials:

- Single or Treble superphosphate
- Ammonium phosphate

POTASSIUM (K)

Potassium Deficiency – Cut Area

Potassium Deficiency

- **True Deficiency**
  - Soil low availability
  - Shallow soils
- **Induced Deficiency**
  - Root problems – pests, drainage, compaction
  - Water stress
  - Heavy crop

Induced Potassium Deficiency

Nutrients Removed in 1 Ton of Grapes

Averages in Literature

Nutrient		Lb/Ton
Potassium	K	4.94
Nitrogen	N	2.92
Phosphorus	P	0.56
Calcium	Ca	1.0
Magnesium	Mg	0.2
Iron	Fe	0.01050
Zinc	Zn	0.00065
Copper	Cu	0.00115
Boron	B	0.00110

Potassium Deficiency Thompson Seedless


Potassium Deficiency
Chardonnay

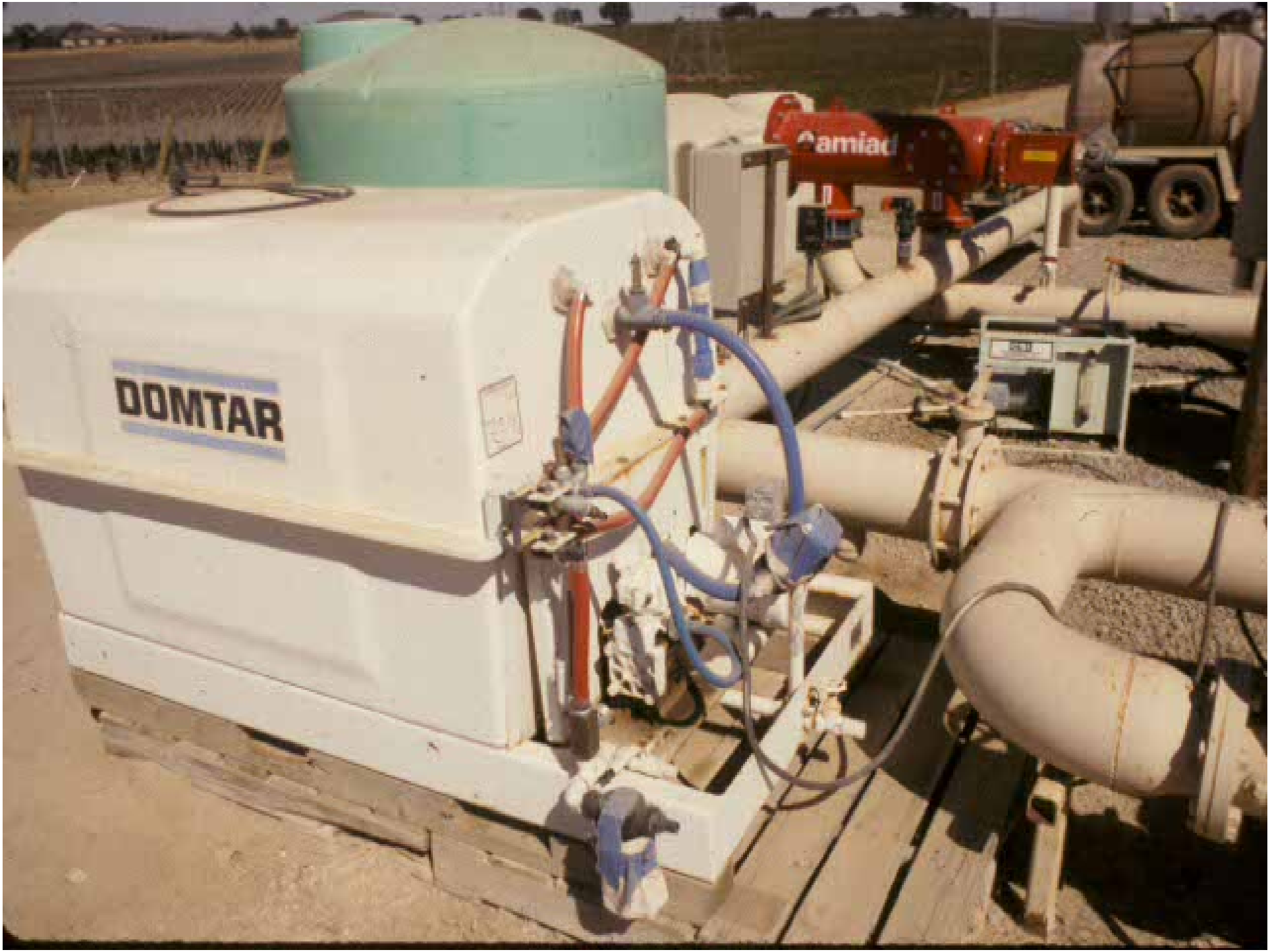

Potassium Deficiency
Cabernet franc

Potassium Critical Values

	Petiole Levels (% K)	
	Bloom	Veraison
Deficient	<1.0	<0.5
Questionable	1.0-1.5	0.5-1.0
Adequate	>1.5	>1.0
Cushion	1.5-2.5	1.0-2.0


Magnesium Deficiency
Zinfandel

Potassium Sulfate Slug Treatment


DOMTAR

Potassium Fertilization – Drip Irrigation

Deficiency	Lbs Potassium Sulfate (44% K)	
	Per vine	Per acre*
Mild	1/2	250
Moderate	1	500
Severe	2	1000

- **Incremental or slug application.**
- **3x rate for furrow application.**

*519 vines per acre

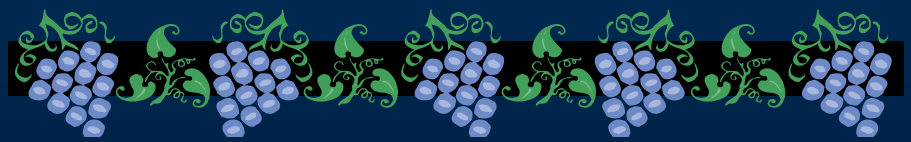
Potassium Status and Rootstocks

HIGH	MEDIUM	LOW
Freedom	SO4	1103P
St. George	5C	110R
Schwarzmann	5BB	140Ru
44-53M	Ramsey	420A
1616	3309C	5A
Harmony		
039-16		
101-14Mgt		

Rootstock Potassium Ranking

1. Freedom 4.05%
2. Harmony
3. 039-16
4. 101-14Mgt
5. 5BB
6. 5C
7. 3309C
8. 1103-P
9. Ramsey (Salt Creek)
10. Own Root 2.10%

ZINC (Zn)



Zinc Deficiency

- **Low soil zinc**
  - sands
  - cut areas
- **Lowered availability**
  - calcareous soils
  - high pH
  - high P – manure, corrals, poultry yards
- **Cool temperatures**
- **High N and vigor**
- **Rootstocks (American *Vitis species*)**


Research with Zinc Foliar Sprays

ZINC FOLIAR SPRAY

2 weeks pre-bloom to bloom

Dilute application

2 to 3 lbs zinc/acre

Neutral zinc (50-52%)	4 to 6 lbs/ac
Zinc oxide (75-80%)	2.5 to 4 lbs/ac

BORON (B)

Boron in Vineyard Soils

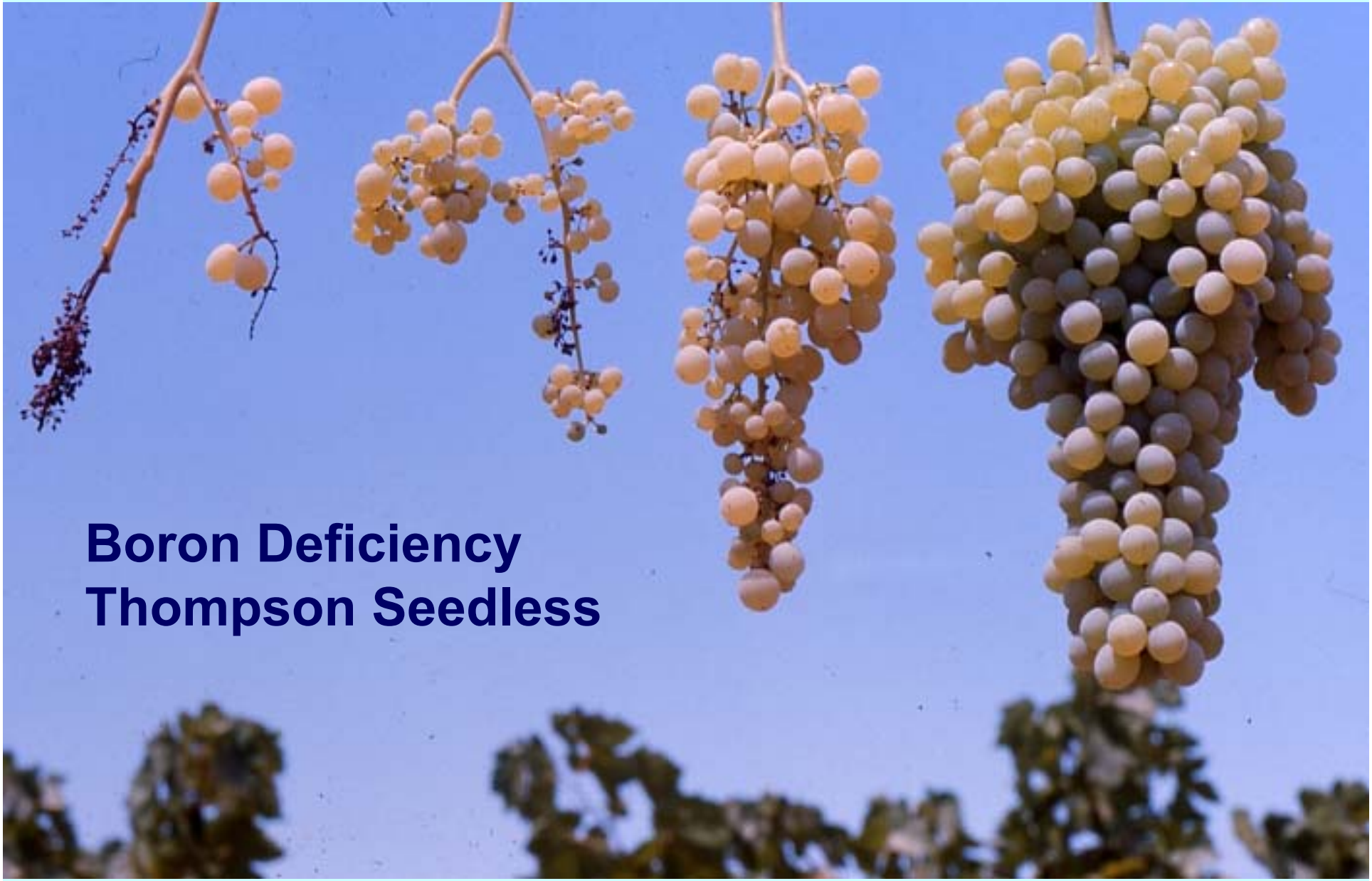
Deficiency		**<0.2 ppm**
Toxicity	**Beginning symptoms**	**0.6 - 0.75 ppm**
	Increasing severity	**>1 ppm**
	Severe	**>2 ppm**

Boron Excess Potential – Marine Sedimentary Soils

Boron Deficiency Potential – Sierra Nevada Alluvial Plains

Sierra Nevada Foothills

North Coast


Boron Deficiency
Thompson Seedless

Boron Deficiency – White Riesling

Boron Transport Is Important to Deficiency

- **Xylem transported**
  - constant supply needed
- **Limited phloem mobility**
  - localized, temporary deficiencies
- **Availability reduced in dry soil**
  - drought-induced deficiency


Drought-induced
B Deficiency
Pinot noir

Boron Deficiency

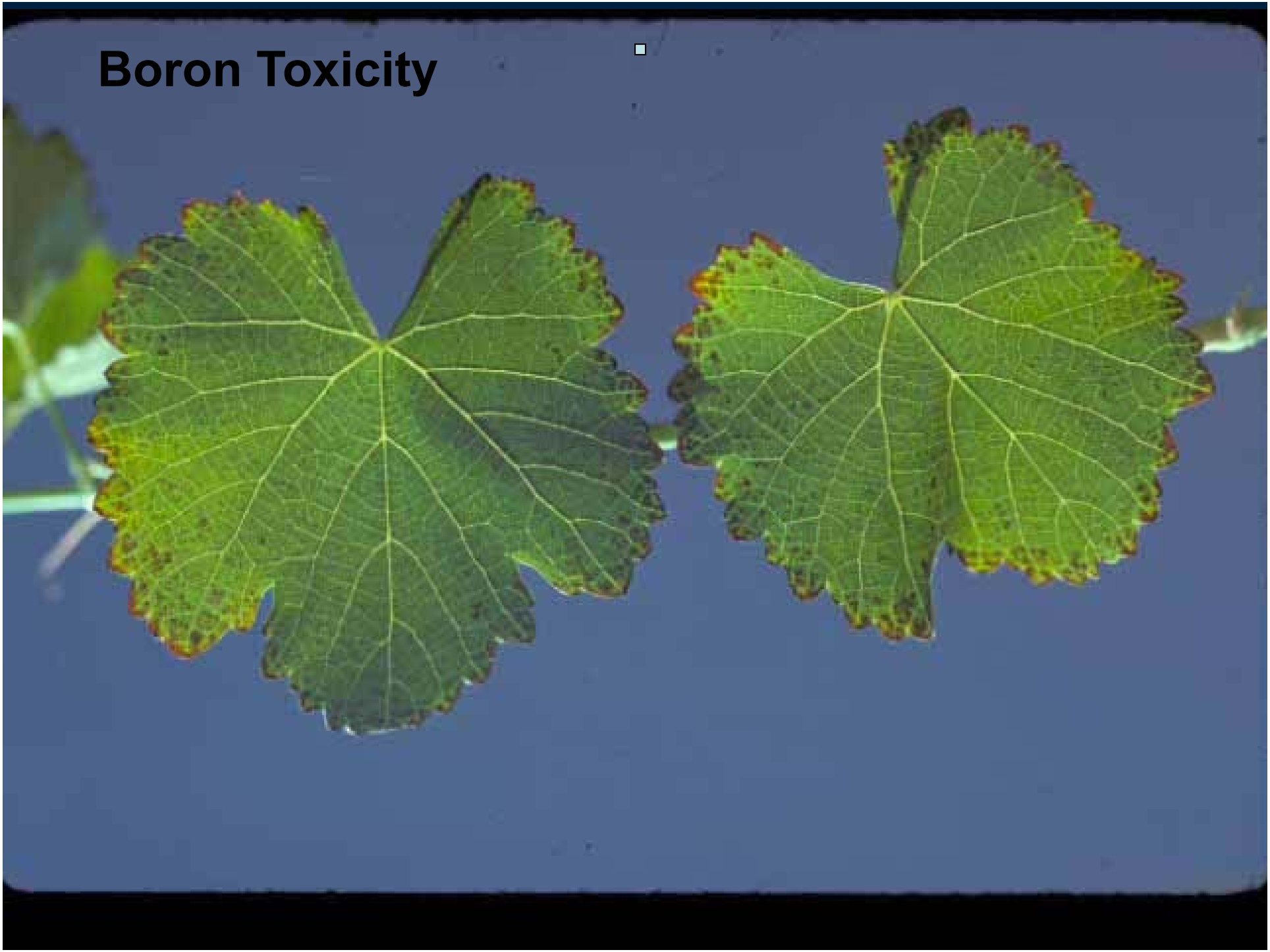
- ***Early Season, Temporary "Barnes Effect"***
  Drought-induced in previous fall and winter
- ***Spring to Early Summer***
  Naturally low soil and plant status
- ***Mid to Late Summer***
  Low soil water status

BORON APPLICATION

BROADCAST or HERBICIDE BAND	**4 lb B/acre** • **3-4 years**
FOLIAR	**½ to 1 lb B/acre** • **Annual (Fall)**
DRIP	**1 lb B/acre** • **Initial** **1/3-½ lb** • **Annual**

•Monitor with tissue analysis

Boron Toxicity



Always Monitor Boron Fertilization with Tissue Analysis

- Leaf Petiole or Blade samples can be used

Iron Chlorosis Lime-induced

Foliar or Drip=

Partial & Temporary

Lime-induced Chlorosis – Rootstock Tolerance

Rootstock	% $CaCO_3$
140Ru	20-30
5BB	20
5C	17
1103P	17
110R	17
3309C, 101-14Mgt	11

Manganese Deficiency

Monitoring Mineral Nutrition

Knowledge of:

- Site/Soil characteristics and chemistry
- Vineyard design requirements
- Fertilizer inputs
- Cultural practices
- Tissue analysis
- Observation and judgment

Vineyard Soil Analysis

Nutrient Status Limitations:

- Rootstock
- Variety
- Soil depth
- Root distribution
- Irrigation patterns
- Crop load
- Soil pests
- Soil Chemistry / nutrient availability

Soil Analysis

Chemistry

- pH
- Salinity
- Lime presence
- Permeability
- Toxicity
- Cation exchange
- Saturation %

Nutrient Baseline

- NO_3-N
- PO_4-P
- Ca, Mg, K
- Zn, Mn, Fe, Cu, B
- SO_4-S

Petiole Sampling

- Ease of sampling
- More representative
- Clean surface
- Easily washed and dried
- More experience and data
- More effective for:

NO_3-N Total-N

P K Mg Zn

Opposite Cluster Petiole Sample

Bloom

Sampling Stages

Bloom

- Survey sampling
- Early information
- Ease of sampling
- Useful for micronutrients and macronutrients

Veraison (ripening)

- Follow-up sampling
- More stable for some nutrients
- Accuracy for K

Harvest

- Problem solving

Tissue Analysis Limitations

Nitrate-N	Differs by cultivar, region, and weather
Phosphorus Potassium Magnesium Zinc Boron Manganese	Critical levels are more consistent
Iron	Lack of relationship to symptoms Easy contamination