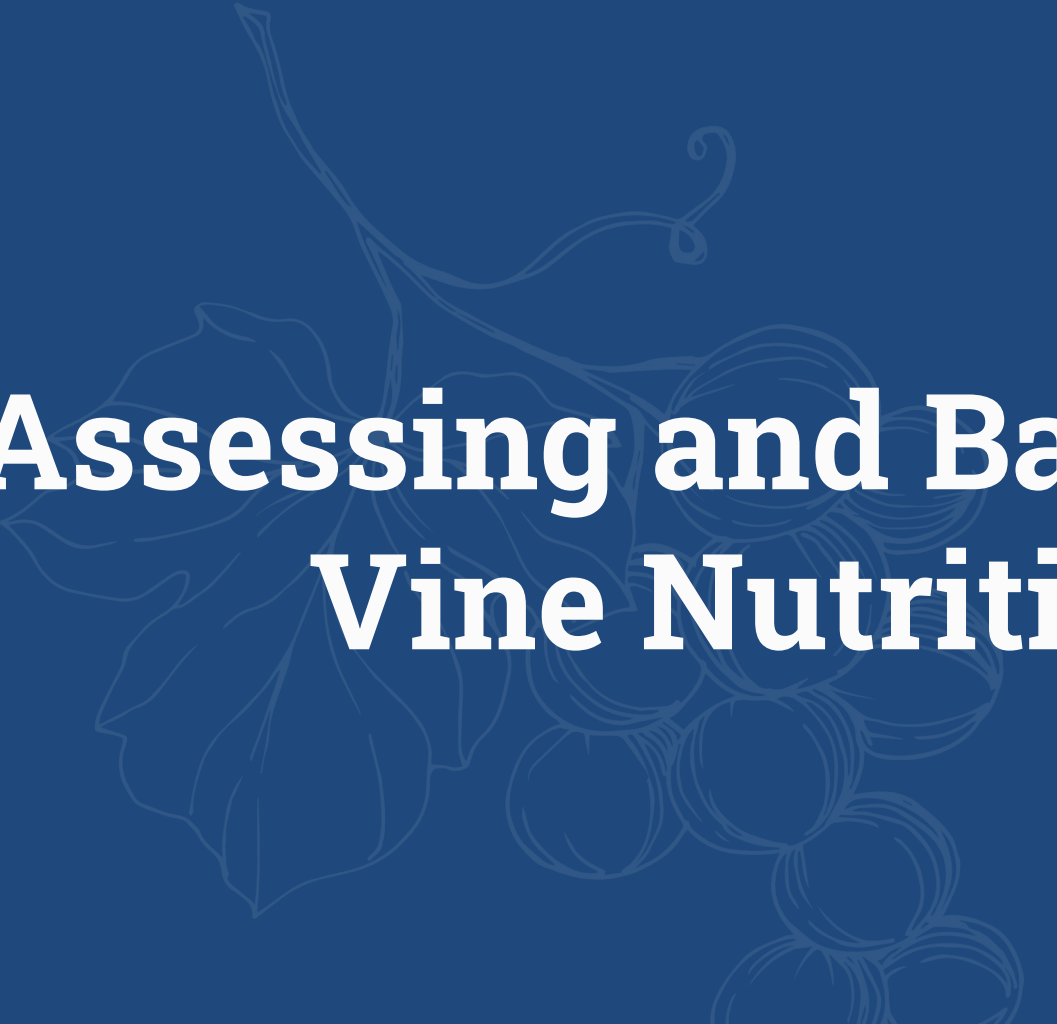




Assessing and Balancing Vine Nutrition

Fritz Westover | Viticulturist

Virtual Viticulture Academy and Westover Vineyard Advising





PennState



VINEYARD TEAM

Promoting Sustainable Winegrowing



TEXAS A&M
UNIVERSITY



WESTOVER

vineyard advising



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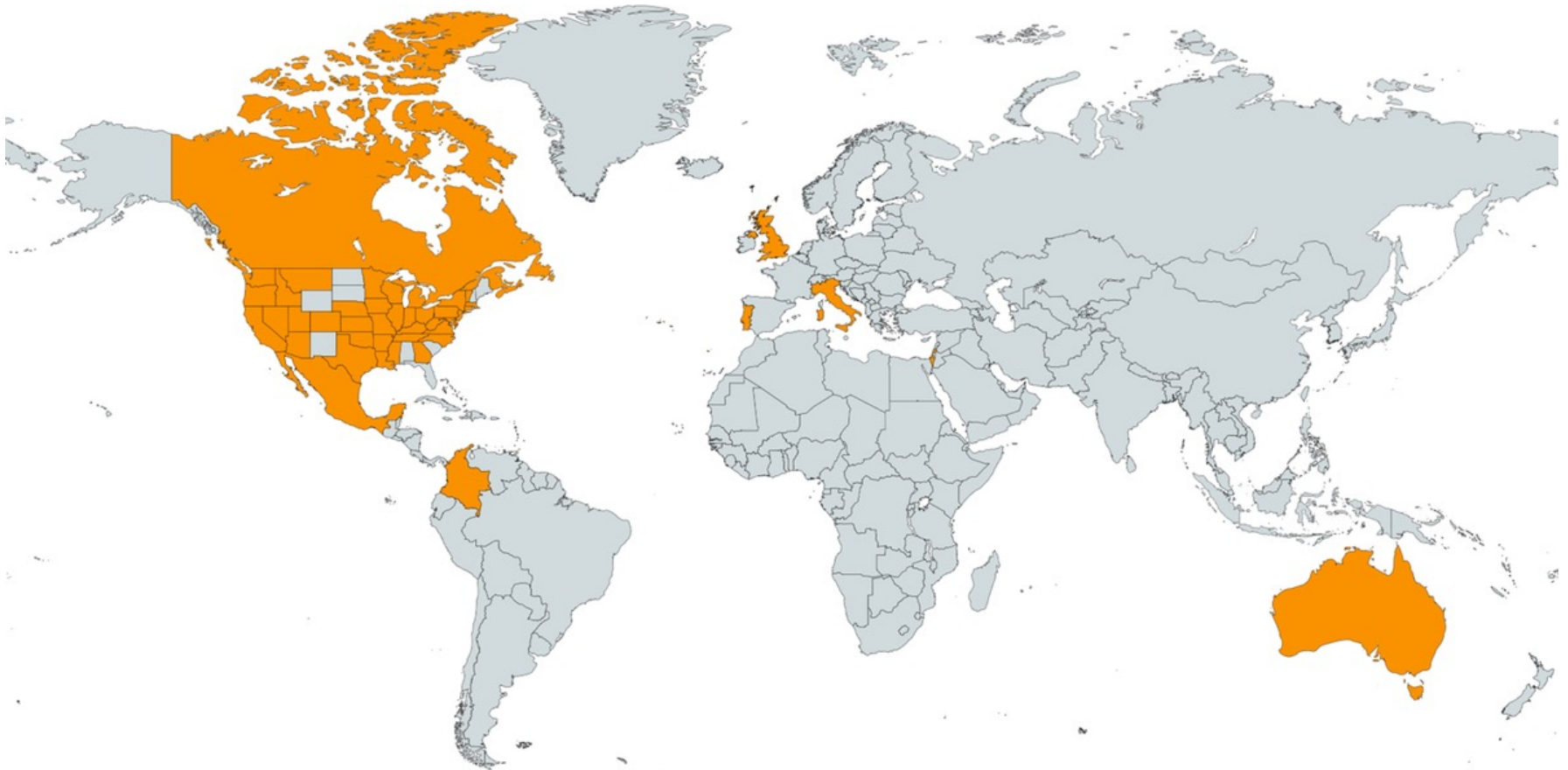
VINEYARD
UNDERGROUND

“Who’s your
Viticulturist?”



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Members of Virtual Viticulture Academy Span the Globe





Sampling for Nutrient Management

Petiole or Whole-Leaf analysis tells us what the vine has taken up from the soil.

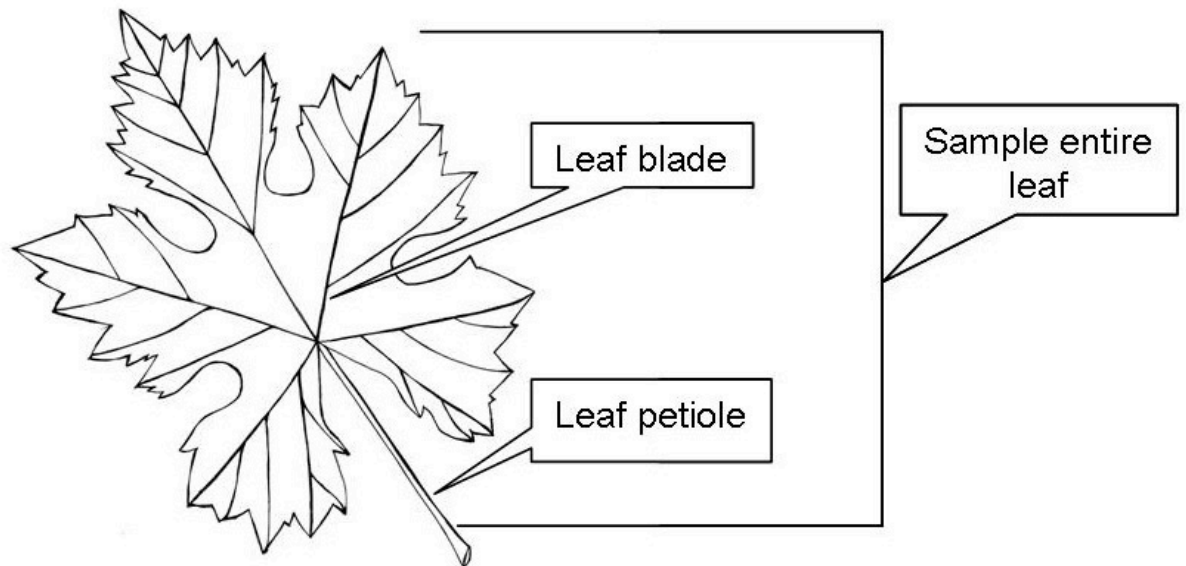


Soil analysis tells us what mineral nutrients are available in the soil for vines to access.



Petioles or Leaf Blades

- Much historical data with petioles
- Leaves are storage organ
- Methods and timing arguably more important than organ



When and Where

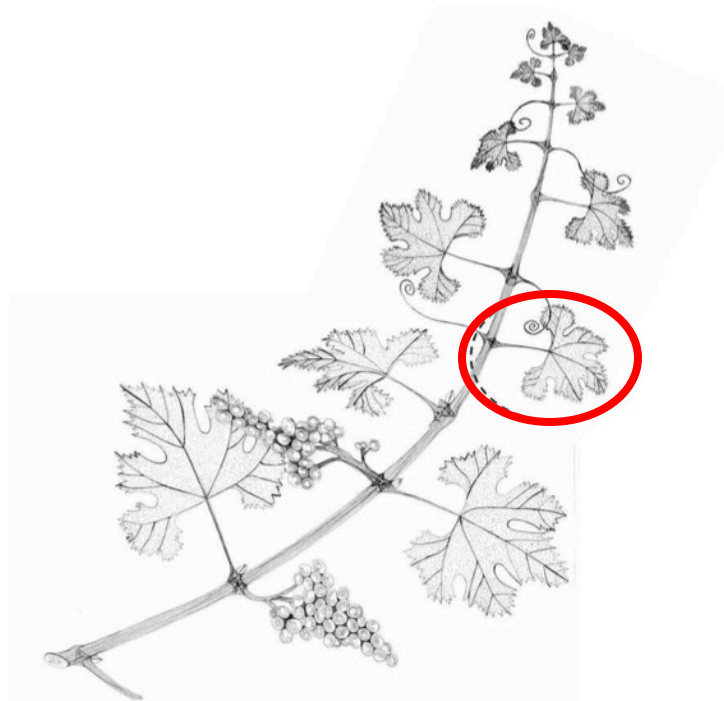
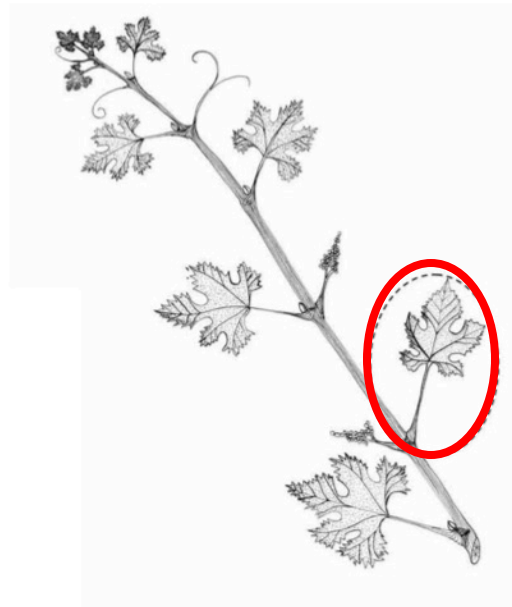


Figure 3. Grape vine shoot at bloom (left) and veraison (right) with appropriate leaf for sampling circled. (Please note that the three smallest leaves appear flat in this illustration, whereas on the actual shoot they would be curled in towards the shoot tip.)

Table 1. When, where, and how to extract grape leaves for nutrient analysis.

Sampling Time	Leaf Position (Figure 3)	Method
Bloom (30–60%)	Leaf opposite basal cluster of a primary shoot	• 50–100 leaves (target of 25 leaves per acre) • Random collection from both canopy and sides
Veraison (40–60%)	Fifth leaf (If the vineyard has been hedged, use untrimmed canes.)	



Target Values – Whole Leaf

Nutrient	Bloom	Veraison
Nitrogen (N, %)	2.5 - 3.5	2.25 - 3.25
Phosphorus (P, %)	0.15 - 0.45	0.12 - 0.30
Potassium (K, %)	0.75 - 1.50	0.50 - 1.00
Magnesium (Mg, %)	0.25 - 0.50	0.25 - 0.50
Calcium (Ca, %)	1 - 3	1 - 3
Boron (B, ppm)	30 - 100	30 - 100
Zinc (Zn, ppm)	25 - 100	15 - 50
Manganese (Mn, ppm)	30 - 100	30 - 100
Iron (Fe, ppm)	>75	>75
Copper (Cu, ppm)	6 - 20	6 - 20

Source: Pacific Northwest Extension Publication PNW622. Sampling Guide for the Nutrient Assessment of Irrigated Vineyards in the Inland Pacific Northwest. 2011 Washington State University.



Target Values - Petioles

Nutrient	Bloom	Veraison
Nitrogen (N, %)	1.2 - 2.2	0.8 - 1.2
Phosphorus (P, %)	0.17 - 0.30	0.14 - 0.30
Potassium (K, %)	1.5 - 2.5	1.2 - 2.0
Magnesium (Mg, %)	0.3 - 0.5	0.35 - 0.75
Calcium (Ca, %)	1.0 - 3.0	1.0 - 2.0
Boron (B, ppm)	25 - 50	25 - 50
Zinc (Zn, ppm)	30 - 60	30 - 60
Manganese (Mn, ppm)	25 - 1000	100 - 1500
Iron (Fe, ppm)	25 - 100	30 - 100
Copper (Cu, ppm)	5 - 15	5 - 15

Source: Wolf, T.K. (Ed.). 2008. Wine Grape Production Guide for Eastern North America. Natural Resource, Agriculture, and Engineering Service (NRAES), Ithaca, NY.



Nutrient Demand - Timing



- Majority of nutrient demand is from **bud burst to bloom** when shoot growth is most rapid... But most growers do not sample tissue until bloom!
- Late season sampling can tell the grower what is needed to meet demands **from bud burst to bloom in following season**. Fertilizer can be added at veraison, post-harvest, and again between bud burst and bloom the following year.



If you can only sample one time...

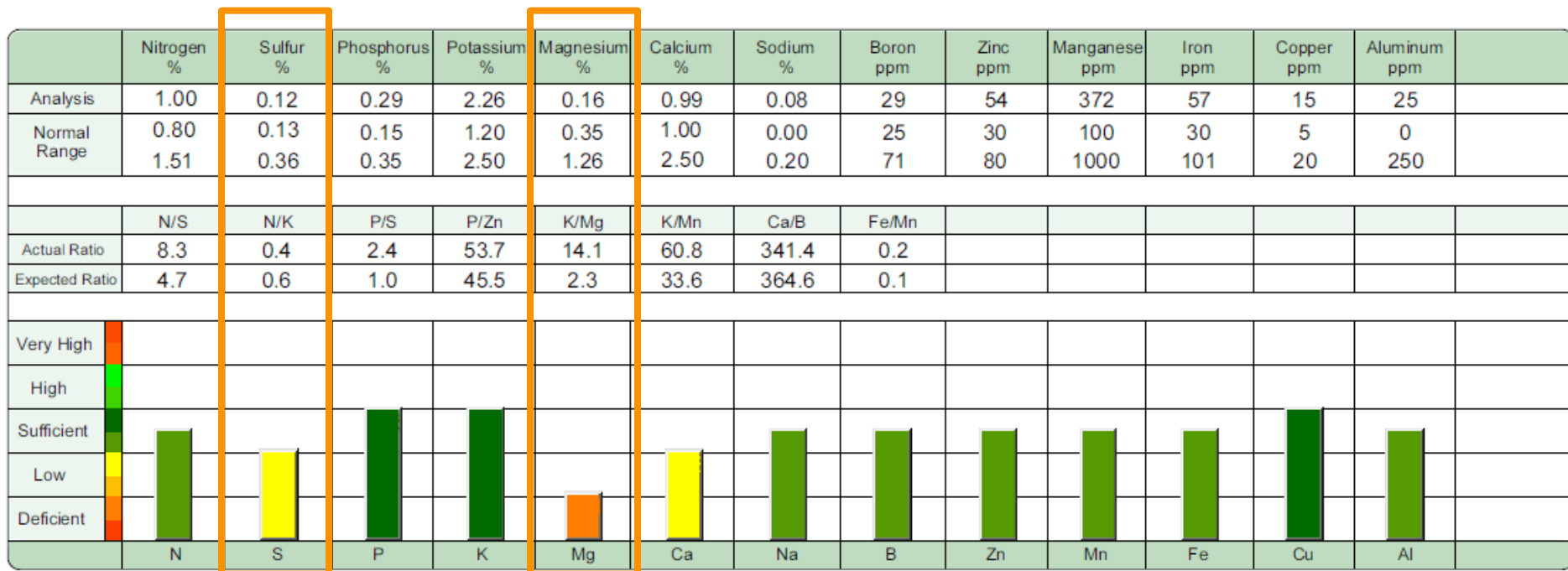
Sample at Veraison

- Nutrient sample more representative of season-long nutrient status and uptake efficiency
- Adjustment made for current and following season



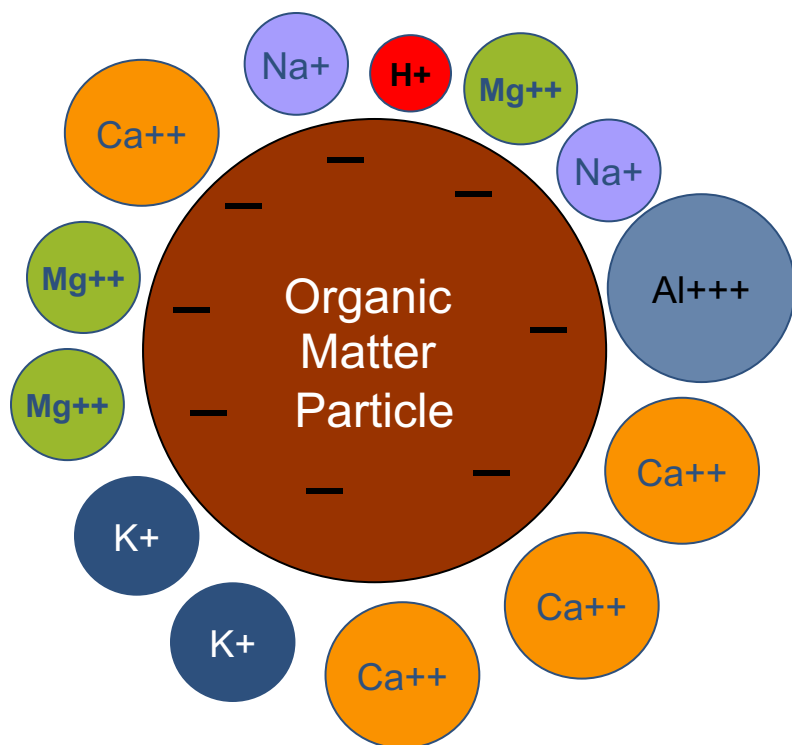


Example Laboratory Report





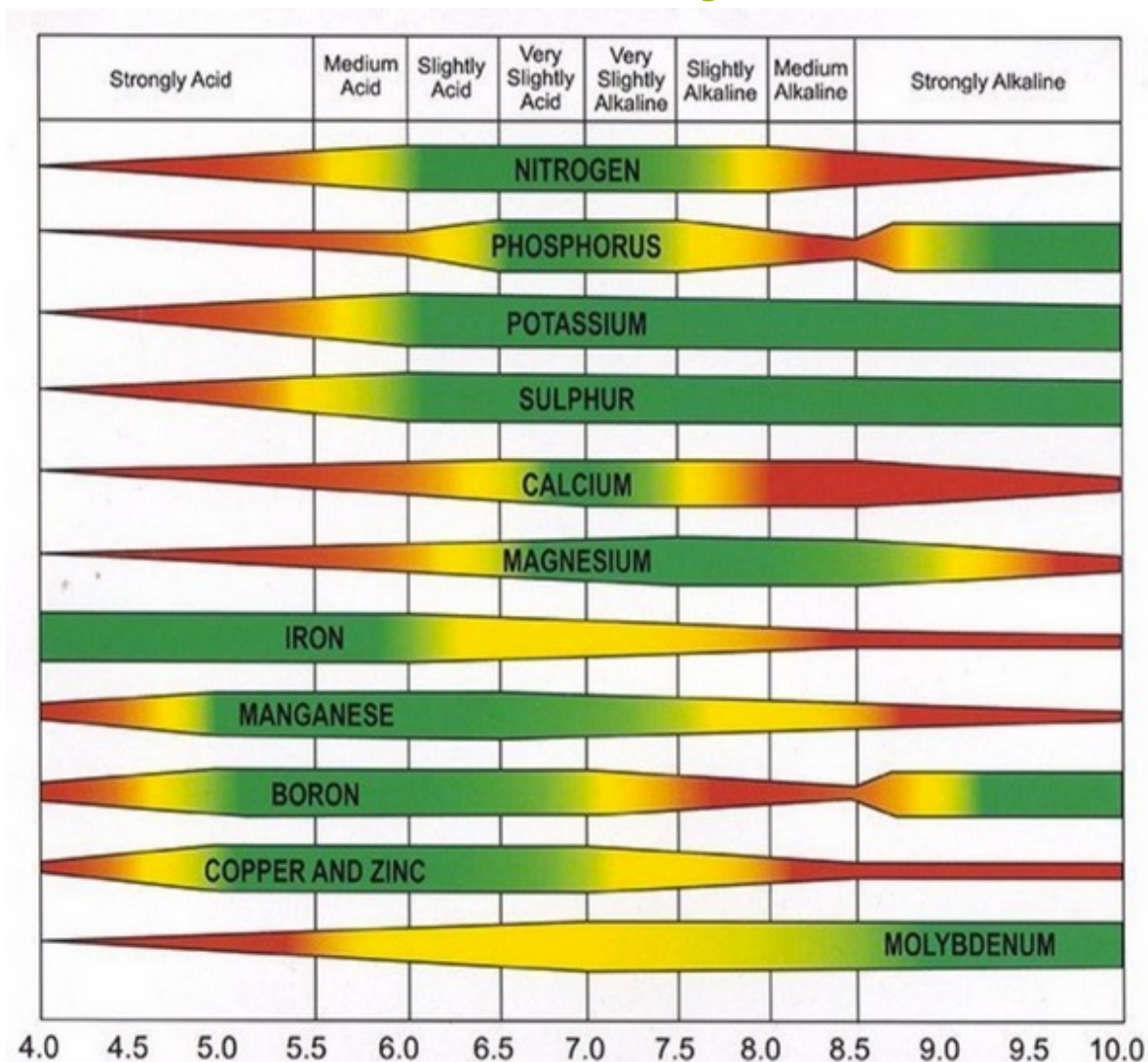
Know the commonly deficient nutrients in your site/region



Soil test will show Base Saturation (% Ca, K, Mg, Na, H)



Soil pH Affects Availability of Plant Nutrients



Spreading Lime



Healthy Young Vines



Chardonnay, K = 0.71%

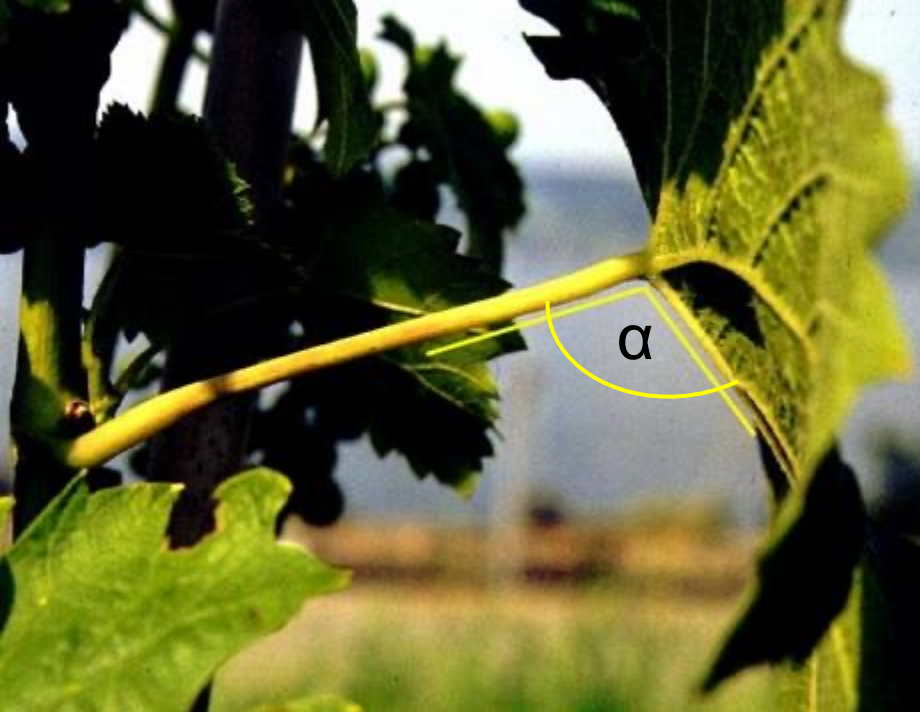


NITROGEN



N Deficit – Visual

- Shoot growth ⇨⇨
- Leaf photosynthesis ⇨
 - Chlorophyll ⇨
 - Anthocyanins ⇨
- Leaf senescence
 - Nutrient recycling to sinks (young leaves...)







Sources of Nitrogen

**Release of N
from soil
Organic Matter**

Slow

**0.5% OM = approx. 20 units
N over season**

**Release of N
from compost**

Slow

**30% of total N
(20% Yr. 1 + 10% Yrs. 2-3)**

**Input of N
fertilizers &
irrigation water**

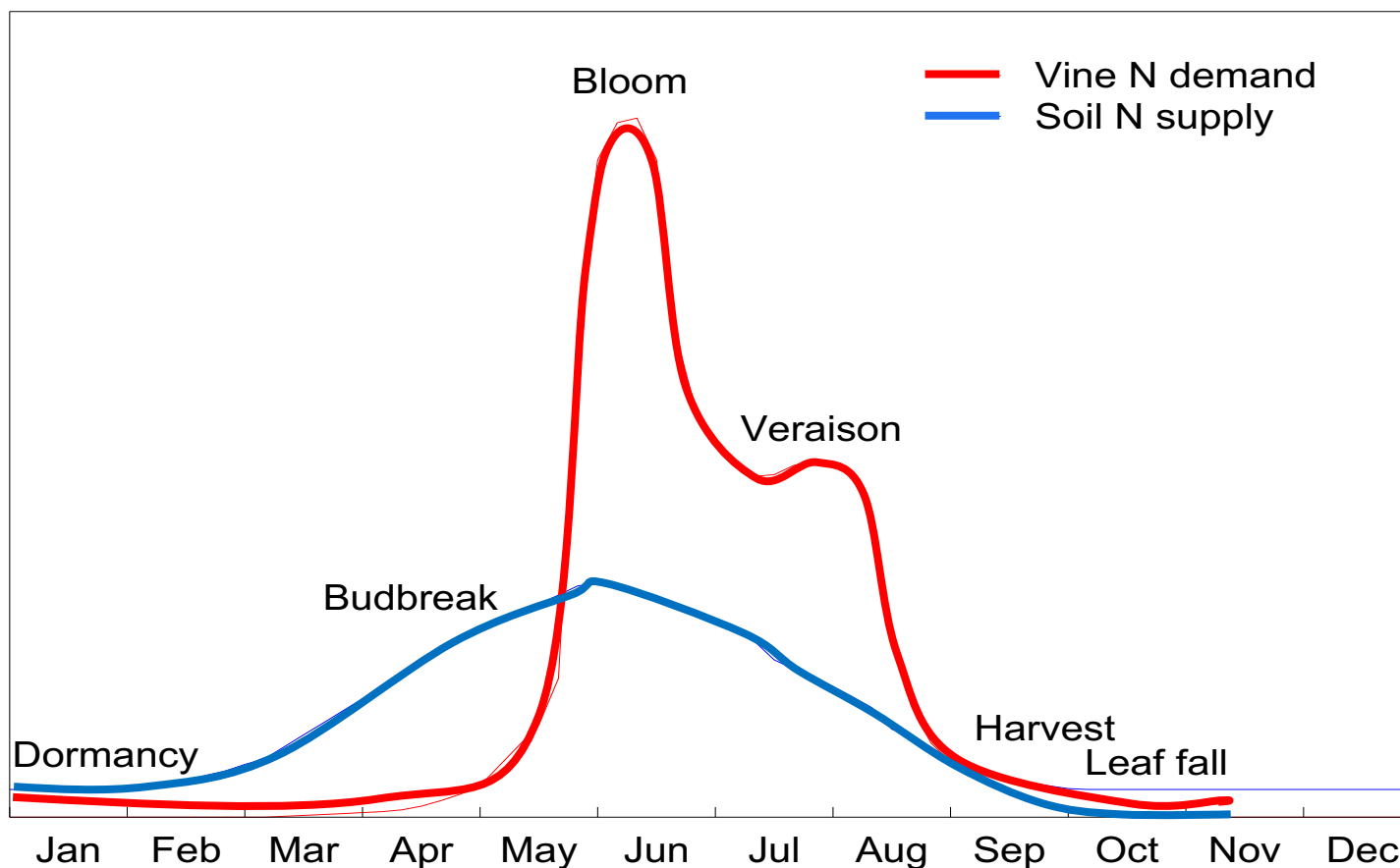
Fast

**Efficiency varies from
ground/drip/foliar**



Timing N Fertilizer Application

- Storage reserves for budbreak (through bloom)
- Uptake mostly during rapid growth (>6-leaf stage)





Nitrogen Fertilization

Drip

- 32-0-0
- CAN

Broadcast

- Ammonium Sulfate
- DAP/MAP
- Urea
- Calcium Nitrate

Foliar Spray

- Slow-release N
- Urea (low biuret)

Natural Sources

- Compost
- Liquid compost
- Fish emulsion
- Feather meal
- Pelletized manures
- Organic matter



Foliar Nitrogen Fertilization

N-PACT
26-0-0

MEGAFOL

F002574

2.5 GAL

(9.5 L) NET VOLUME – 25.5 lbs (11.6 kg) NET WEIGHT

3-0-8 PLANT NUTRIENT FOR FRUITS,
VEGETABLES AND FIELD CROPS.

GENERAL INFORMATION

MEGAFOL is a liquid foliar fertilizer specially formulated to improve the vigor of vegetables, fruits, and field crops. MEGAFOL is intended to supplement standard fertility programs and it is a readily available source of nitrogen and potassium.

SHAKE WELL BEFORE USING

GUARANTEED ANALYSIS

Total Nitrogen (N).....3%
2%..... Urea Nitrogen
1%..... Other Water Soluble Nitrogen
Soluble Potash (K₂O)..... 8%
DERIVED FROM: urea; Kelp extract, Sugar
Beet Vinasse; potassium acetate.



Foliar Nitrogen Fertilization



ORBIX™

8-5-3

Ammonia Free Foliar Nutrient Solution

GUARANTEED ANALYSIS:

Total Nitrogen (N)	8.0%
7.5% Urea Nitrogen	
0.5% Other Water Soluble Nitrogen	
Available Phosphate (P ₂ O ₅)	5.0%
Soluble Potash (K ₂ O)	3.0%
Boron (B)	0.02%
Cobalt (Co)	0.0005%
Copper (Cu)	0.05%
0.05% Chelated Copper (Cu)	
Iron (Fe)	0.10%
0.10% Chelated Iron (Fe)	
Manganese (Mn)	0.05%
0.05% Chelated Manganese (Mn)	
Molybdenum (Mo)	0.0005%
Zinc (Zn)	0.05%
0.05% Chelated Zinc (Zn)	

AWAKEN®

16-0-2



**MICRONUTRIENT PREMIX MULTI-PURPOSE
FERTILIZER ADDITIVE FOR USE ON MANY CROPS**

GUARANTEED ANALYSIS:

Total Nitrogen (N)	16.00%
5.70% Ammoniacal Nitrogen	
3.40% Nitrate Nitrogen	
6.90% Urea Nitrogen	
Soluble Potash (K ₂ O)	2.00%
Boron (B)	0.02%
Copper (Cu)	0.15%
0.15% Chelated Copper	
Iron (Fe)	0.15%
0.15% Chelated Iron	
Manganese (Mn)	0.15%
0.15% Chelated Manganese	
Molybdenum (Mo)	0.0006%
Zinc (Zn)	2.70%
0.15% Chelated Zinc	



Deficiency Symptoms

Magnesium

- Symptoms typically on basal to mid-shoot leaves
- More common with low soil pH (< 5.5)
- Impact on fruit yield and quality not well quantified.





Magnesium Fertilization

Broadcast

- Magnesium Sulfate (10%)
- Dolomitic Lime (10%)
- Kieserite (15%)

Foliar Spray

- Chelated Magnesium (4-6%)
- Magnesium Sulfate (10%)
- Magnesium complexes

NutriSync
Magnesium



MAGNESIUM 4%

CHELATED MICRONUTRIENT
FOR CORRECTION OF MAGNESIUM MICRONUTRIENT
DEFICIENCY IN CROPS

GUARANTEED ANALYSIS

Sulfur (S).....	6.00%
6.00% Combined Sulfur (S)	
Magnesium	
(Mg).....	4.00%
4.00% Chelated Magnesium (Mg)	

Spreading Dolomitic Lime or Kieserite





Tempranillo

Potassium



Chardonnay (0.71% K)



Cabernet Franc



Potassium Fertilization

Drip

- Potassium thiosulfate

Broadcast

- Potassium Sulfate (0-0-50) “Potash”
- K-Mag

Foliar Spray

- Soluble potash
- Potassium hydroxide (neutralized)





Phosphorus



Merlot





Phosphorous Fertilization

Broadcast

- Diammonium Phosphate (DAP) (18-46-0)
- Monoammonium Phosphate (11-52-0)

Foliar Spray

- Diammonium Phosphate (DAP) (18-46-0)
- Monoammonium Phosphate (11-52-0)



8-24-0

GUARANTEED ANALYSIS:

Total Nitrogen (N)	8.00%
8.00% Ammoniacal Nitrogen	
Available Phosphate (P ₂ O ₅)	24.00%
Iron (Fe)	0.10%
0.10% Chelated Iron (Fe)	



HI-PHOS LC

8-30-2

GUARANTEED ANALYSIS

Total Nitrogen (N)	8.00%
8.00% Ammoniacal Nitrogen	
Available Phosphate (P ₂ O ₅)	30.00%
Soluble Potash (K ₂ O)	2.00%
Boron (B)	0.02%
Copper (Cu)	0.05%
0.05% Chelated Copper (Cu)	
Iron (Fe)	0.10%
0.10% Chelated Iron (Fe)	
Manganese (Mn)	0.05%
0.05% Chelated Manganese (Mn)	
Zinc (Zn)	0.05%
0.05% Chelated Zinc (Zn)	



Micronutrients

Very small concentrations needed by the plant for normal growth and development

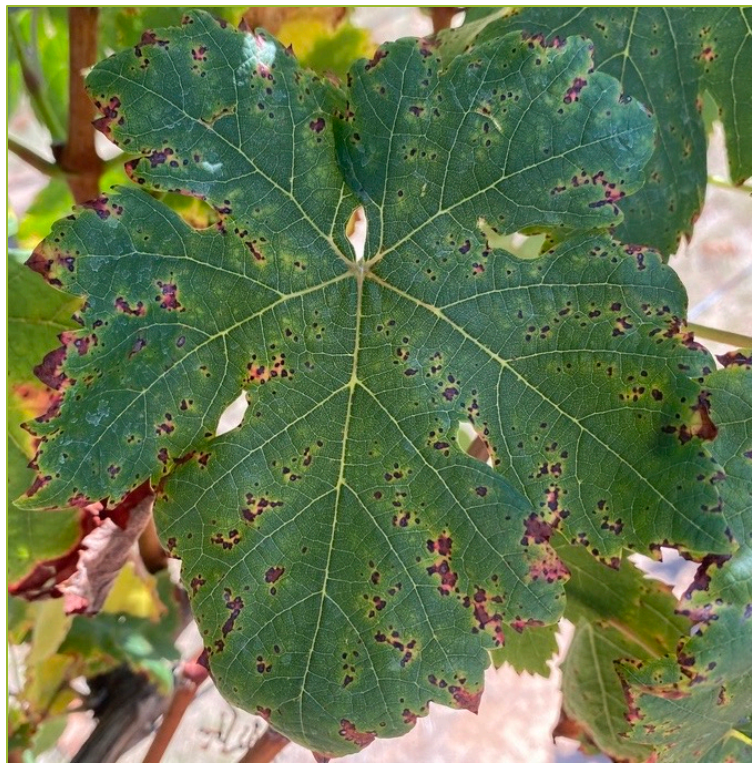
- **Iron**
- **Zinc**
- **Boron**
- **Manganese**
- **Copper**
- **Molybdenum**





Boron Toxicity

- Cupped leaves with rounded edges (soil toxicity)
- Leaf scorch or necrosis (spray toxicity)



‘Uptake’



Spray toxicity



Iron Deficiency and Toxicity



Deficiency



Spray toxicity



Micronutrient Fertilization - Boron

Broadcast / Drip

- Boric acid

Foliar Spray

- Borosol or Solubor
- Blends with Zinc etc.



BOROSOL® 10

**A Soluble Polyborate Liquid
For the Prevention and Correction of
Boron Deficiencies in Crops**

GUARANTEED ANALYSIS
Boron (B) 10%
Derived from: Boric Acid
Contains 1.1 pounds of Boron per Gallon

20.5% BORON



SOLUBOR®

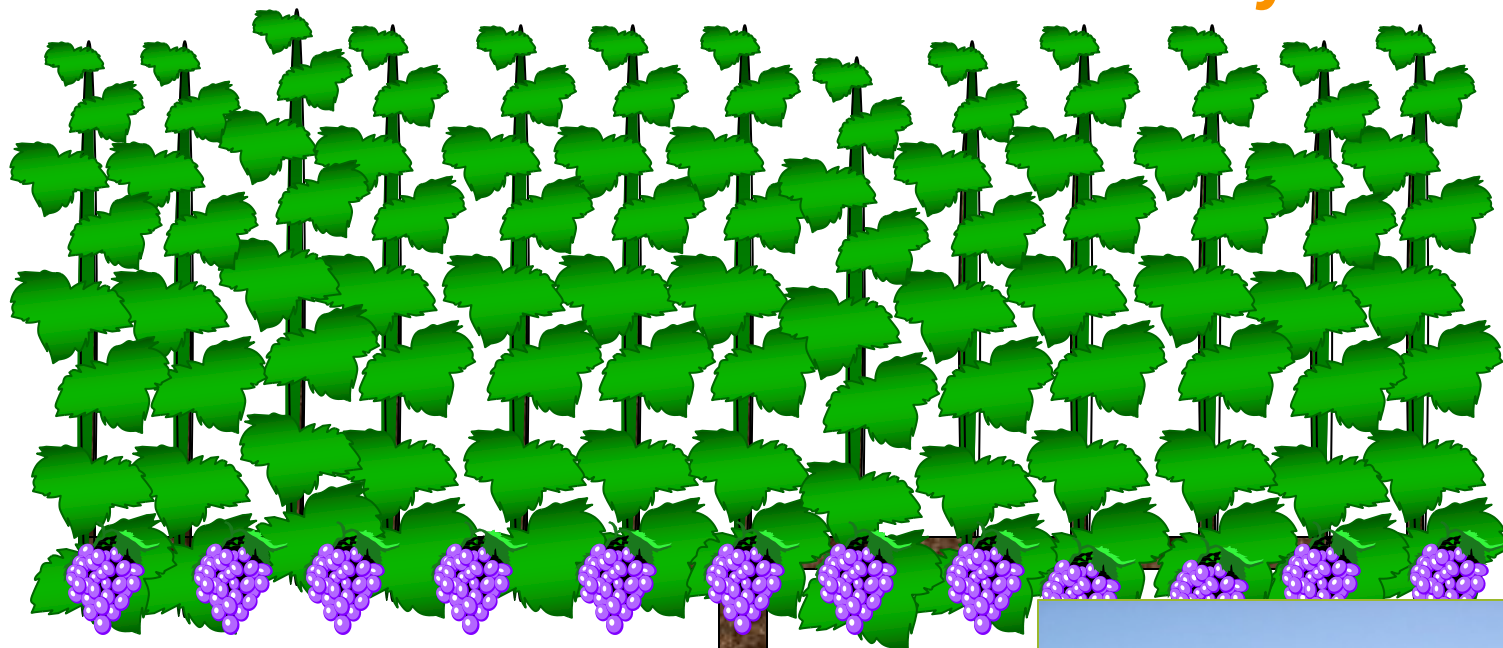


Building and Effective and Relevant Nutrient Budget

- Budget Template
- Crop Yield/Estimated Yield
- Nutrient Removal Data
- Soil Sample Report
- Water Sample Report
- Plant Tissue Results



How do nutrients leave the vineyard?



Nutrients Removed by Crop (pounds/ton)

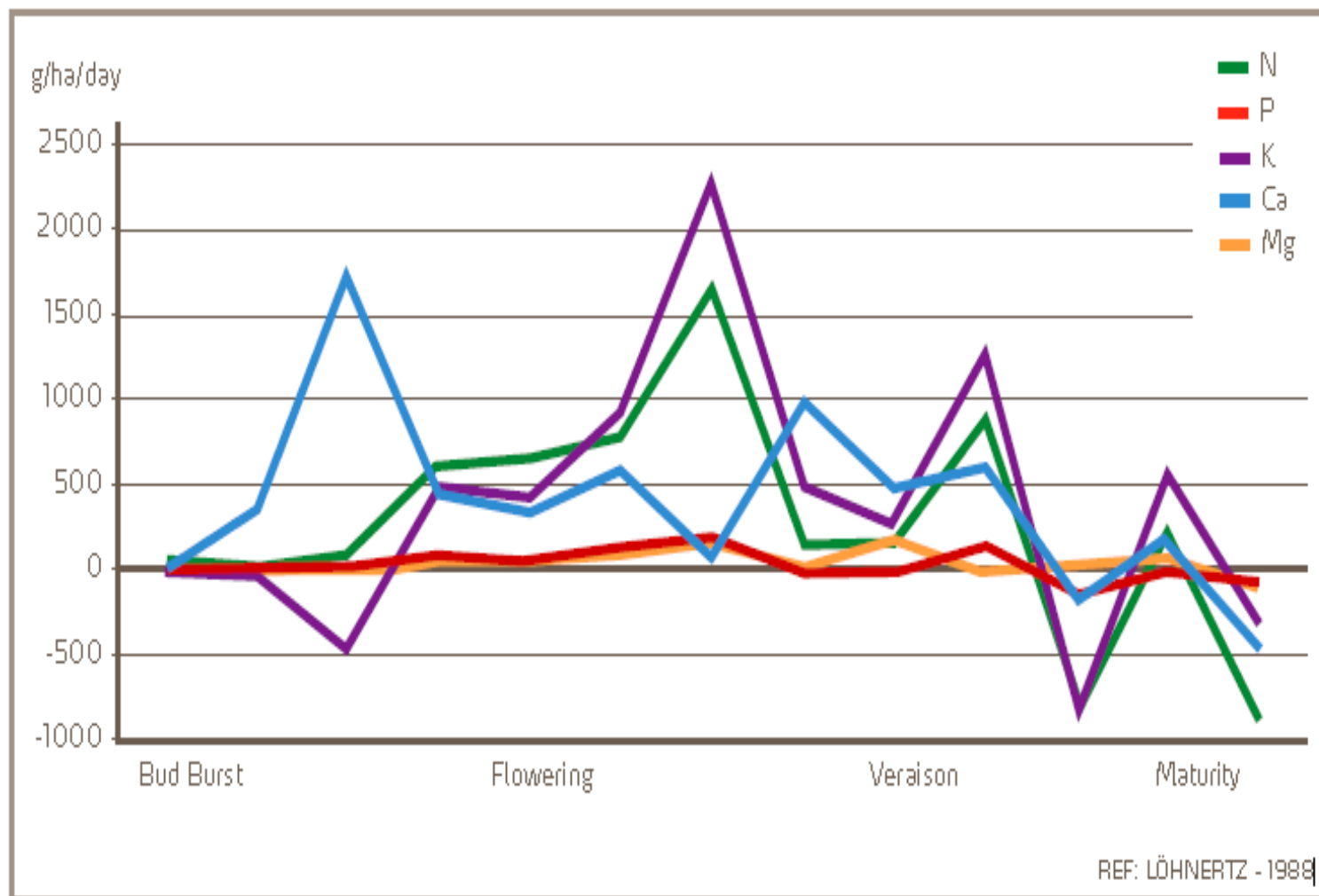
Nutrient	Min	Max	Avg
N	2.0	6.0	4.0
P	0.4	0.8	0.6
K	3.0	8.0	5.5
Ca	0.4	2.0	1.2
Mg	0.1	0.4	0.3





Fertilizer Application Timing

Major Nutrient Uptake from a study on Riesling in Germany





Understand how Nutrients are Taken Up by Roots

Nutrients that move with water solution (mass flow)

→ Rapid transpiration enhances nutrient uptake



NO_3^-

Nutrients that are adsorbed by contact of growing root (diffusion)

→ Dominant form of uptake for most nutrients



**K^+
 $\text{P}(\text{H}_2\text{PO}_4^-)$**



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Fertilization Philosophy

Only apply:

...what is needed

...when it is needed

...in the correct formulation



Fertilizer Calculations

Example for Solid Fertilizer: Ammonium sulfate $[(\text{NH}_4)_2\text{SO}_4]$ fertilizer contains 21%N of 0.21 lbs N/lb of fertilizer. If 100 lbs of ammonium sulfate are applied per acre, the total N application is 21 lbs/a.

$\frac{100 \text{ lbs } (\text{NH}_4)_2\text{SO}_4}{\text{ac}}$	$\times$	$\frac{0.21 \text{ lbs N}}{1.0 \text{ lb } (\text{NH}_4)_2\text{SO}_4}$	$=$	$\frac{21 \text{ lbs N}}{\text{ac}}$
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Example for Liquid Fertilizer: Ammonium nitrate (AN20) has a density of 10.76 lbs/gal, and 21% nitrogen.

$\frac{10.76 \text{ lbs}}{\text{Gal of Fertilizer}}$	$\times$	$\frac{0.21 \text{ lbs N}}{\text{lb of Fertilizer}}$	$\times$	$\frac{5 \text{ gal applied Fertilizer}}{\text{ac}}$	$=$	$\frac{11.3 \text{ lbs N}}{\text{ac}}$
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Uptake of Fertilizers Based on Application Methods

Application Method	N	K	Mg	Fe	B	Mn	Zn
Soil surface	mod	slow	mod	slow	mod	slow	Slow
Drip irrigation	fast	mod	fast	mod	fast	mod	Mod
Foliar spray	fast	mod	mod	mod	fast	mod	mod

Slow:

Apply well before peak demand and not when deficiency is present. Rain or irrigation may facilitate movement of mobile nutrients (N, Mg, B).

Moderate:

Apply 2 or 3 weeks before peak demand.

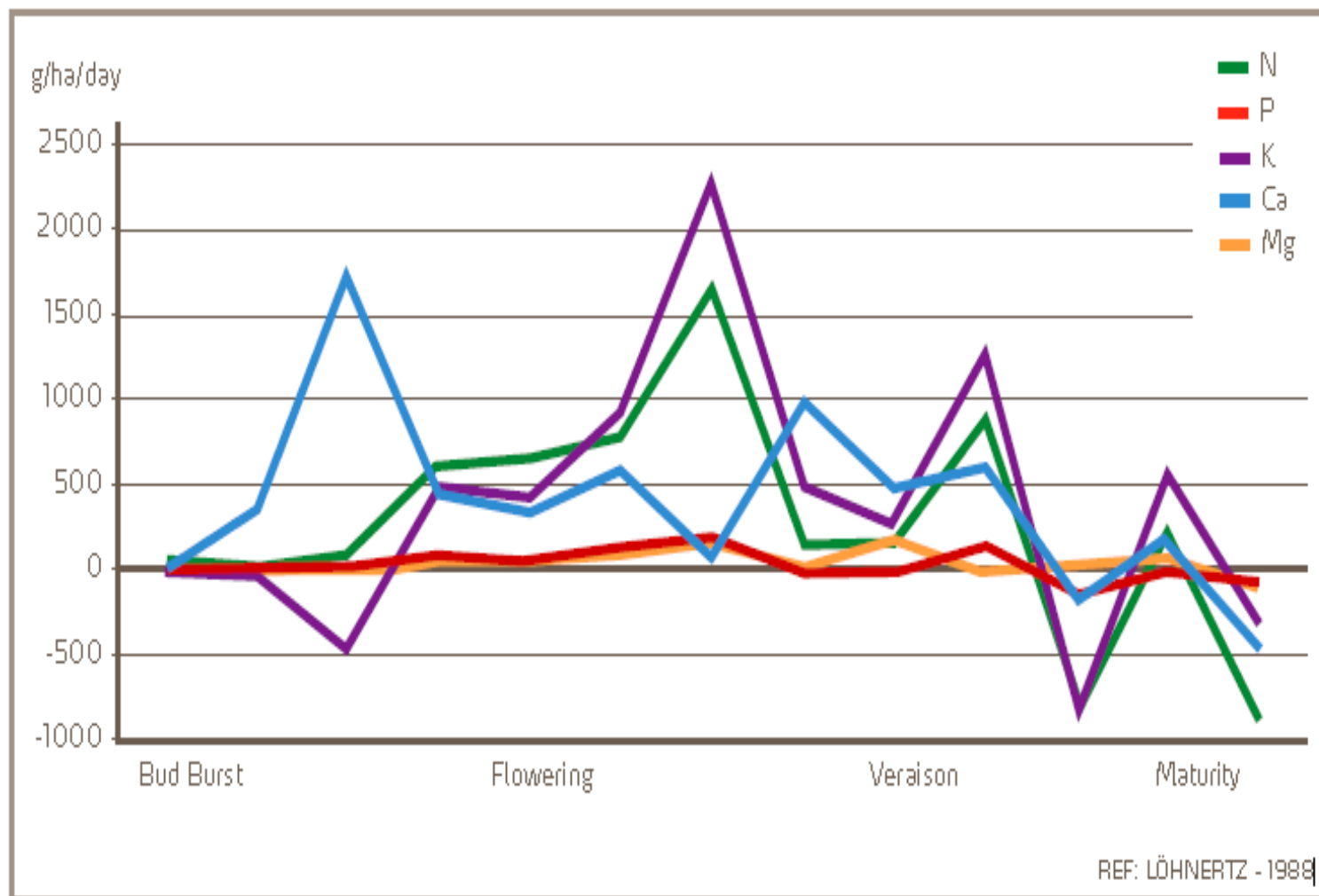
Fast:

Apply just before peak demand or if deficiency symptoms present.



Fertilizer Application Timing

Major Nutrient Uptake from a study on Riesling in Germany





Irrigation Water Analysis Report

LAB NO.	Sodium meq/liter Na	Calcium meq/liter Ca	Magnesium meq/liter Mg	Carbonate meq/liter CO ₃	Bicarbonate meq/liter HCO ₃	Chloride meq/liter Cl	(E.C.) Conductivity mmhos/cm	pH	Copper ppm Cu	Iron ppm Fe	Manganese ppm Mn	Zinc ppm Zn
51970	19.4	2.4	7.5	<1	5.0	25.7	1.78	7.5				
51971	6.5	1.0	2.9	<1	7.8	0.8	0.80	7.6				
	Na ppm	Ca ppm	Mg ppm	CO ₃ ppm	HCO ₃ ppm	Cl ppm						
51970	447	48	91	<1	305	910						
51971	150	20	35	<1	476	28						

Phosphorus ppm P	Potassium ppm K	Nitrate ppm NO ₃	Sulfate ppm SO ₄	Boron ppm B	TOTAL Dissolved Solids ppm	adj. S.A.R.	Comments:
<.01	31	39.03	1125	0.62	1139	8.75	
<.01	10	37.10	193	0.58	518	4.69	



Fertilizer Calculations for Irrigation Water

Example for a lab report of ppm NO3: The report from the lab shows 45ppm NO3 and a total of 0.89-acre-feet (ac-ft) of irrigation water was applied.

Step 1: Convert ppm NO3 to lbs N/acre foot (ac-ft) of irrigation water applied.

$$45 \text{ ppm NO3} \times 0.62 = 27.9 \text{ lbs N/ac-ft}$$

Step 2: Multiply lbs N/ac-ft by total irrigation water applied per acre.

$\frac{27.9 \text{ lbs N}}{\text{Ac-ft}}$	$\times$	$\frac{0.89 \text{ ac-ft irrigation water}}{\text{ac}}$	$=$	$\frac{24.8 \text{ lbs N}}{\text{ac}}$
---	----------	---	-----	--

Compost as a fertilizer



Photo: Doug Beck

Application Methods & Timing



Photo: Doug Beck



Compost Rate Worksheet - Vineyard Application

Date:

Vineyard Block:

Compost Source:

Compost Type:

Method 1: Determine the rate of compost to apply based on desired available nitrogen in year one.

Fill in the green boxes based on the analysis results from the lab or suggested default.

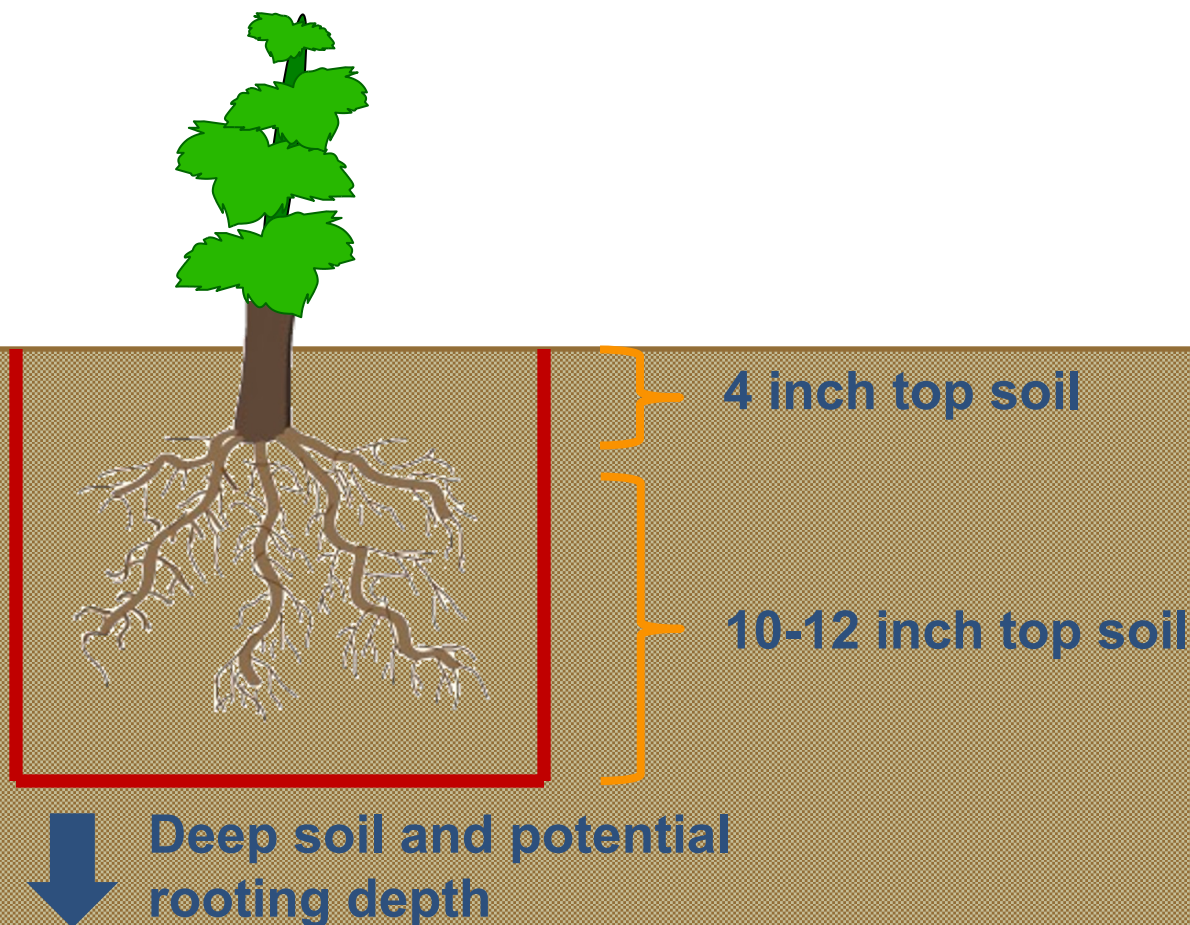
Fill in the yellow boxes with your desired criteria.

Results for estimated nitrogen from compost and application/order rates appear in the red box.

Analysis Numbers from Lab				Estimated Nitrogen Available Year 1	Estimated Release lbs/Ton Compost	Desired Nitrogen Per Acre (lbs)	Compost Rate Tons/Acre	Total Acres	Total Compost Order (tons)	Total Compost Order (yd ³)
				Default 0.20						
N	% wet	lb/yd ³	lb/ton	0.20	10.5	30	2.9	5	14.3	31.8
	2.62	23.6	52.4	0.20	10.5	30	2.9	5	14.3	31.8
Wt/Vol	lb/yd ³	→ Range is 800 to 1000 lbs								
	900									



Root Size and Nutrient Availability





Advice

- **Before planting your vineyard:**
 - Add needed fertilizer and amendments before planting and incorporate to rooting depth (based on soil tests)
- **After your vineyard is planted:**
 - Make a plan and be flexible with season
 - Add only the fertilizers that are needed, and at only the rates needed (based on plant tests and visual observation)
- **Fertilize at the time & with method for optimal uptake**
 - Based on fertilizer source and application method

What's Next?





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THE PODCAST

Be a Better Grape Grower

Learn the art and science of growing
exceptional wine grapes in a way that
fits your life and vineyard.

GET STARTED





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NEW

Prioritized Pruning: What You and Your Crew Mus...

Video Course

Member Content



NEW

Cut with Confidence, Not Consequence

Video Course

Member Content



NEW

Pruning Field Course 2026 - TX

Video Course

Member Content

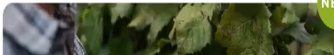


NEW

Retraining Trunks and Cordons

When permanent line structures (trunks or cordons) become damaged due to cold or certain diseases, there are several different ways to retrain these structures. When only one side is damaged, keeping one side of the vine in production while retraining the other side may be possible.

Retraining Whole Vines Requirements



NEW



NEW



Recommended Resources



Nutrients Commonly Low in Vineyards

How-To-Guide

Member Content



Target Values - Soil

Nutrient	Parts per Million (ppm)	Pounds per Acre (lb/a)
Phosphorus (P)	20 - 50	40 - 100
Potassium (K)	75 - 100	150 - 200
Calcium (Ca)	500 - 2000	1000 - 4000
Magnesium (Mg)	100 - 250	200 - 500
Boron (B)	0.3 - 2.0	0.6 - 4.0
Copper (Cu)	0.5	1
Iron (Fe)	20	40
Manganese (Mn)	20	40
Zinc (Zn)	2	4

Target Nutrient Values in Soil

Vineyard Tool

Free Content



Target Values - Petioles

Nutrient	Bloom	Veraison
Nitrogen (N, %)	1.2 - 2.2	0.8 - 1.2
Phosphorus (P, %)	0.17 - 0.30	0.14 - 0.30
Potassium (K, %)	1.5 - 2.5	1.2 - 2.0
Magnesium (Mg, %)	0.3 - 0.5	0.35 - 0.75
Calcium (Ca, %)	1.0 - 3.0	1.0 - 2.0
Boron (B, ppm)	25 - 50	25 - 50
Zinc (Zn, ppm)	30 - 60	30 - 60
Manganese (Mn, ppm)	25 - 1000	100 - 1500

Target Nutrient Values – Petioles

Vineyard Tool

Free Content



Target Values – Whole Leaf

Nutrient	Bloom	Veraison
Nitrogen (N, %)	2.5 - 3.5	2.25 - 3.25
Phosphorus (P, %)	0.15 - 0.45	0.12 - 0.30
Potassium (K, %)	0.75 - 1.50	0.50 - 1.00
Magnesium (Mg, %)	0.25 - 0.50	0.25 - 0.50
Calcium (Ca, %)	1 - 3	1 - 3
Boron (B, ppm)	30 - 100	30 - 100
Zinc (Zn, ppm)	25 - 100	15 - 50
Manganese (Mn, ppm)	30 - 100	30 - 100

Target Nutrient Values – Whole Leaves

Vineyard Tool

Free Content



Notes on Composting Grape Pomace

How-To-Guide

Member Content



Using Compost in the Vineyard

How-To-Guide

Member Content

VINEYARD UNDERGROUND

TUNE
INTO THE
PODCAST





Presentation PDF



- ✓ Assessing and Balancing Vine Nutrition – [Download PDF](#)
- ✓ Notes from the Site Visits – [Download PDF](#)

Related Grower Guides

- ✓ [Young Vine Care – Dormancy Preparation](#) – How-To Guide
- ✓ [Essentials of Young Vineyard Management](#) – Video Course
- ✓ [Crop Estimation Tips](#) – How-To Guide
- ✓ [End of Season Vineyard Checklist](#) – Vineyard Tool
- ✓ [Understanding Seasonal Nutritional Requirements – Tips & Tricks](#) – How-To Guide

Related Vineyard Underground Episodes

- ✓ Baby Steps Towards Biodynamics and Organic Growing Practices with Thijs Verschuuren – [Part 1](#) | [Part 2](#)
- ✓ [Vineyard Nutrient Essentials – Nitrogen Fundamentals](#) with Dr. Markus Keller
- ✓ [Vineyard Nutrient Essentials – Phosphorus Fundamentals](#) with Dr. Terry Bates
- ✓ [Soil-Nutrient Interactions and the Role of Potassium in Eastern Vineyards](#) with Dr. Jaclyn Fiola

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