Vineyard Nutrition

Petiole / Soil Sample Results Are Back, Now What?

Dr. Paul Domoto

Dept. of Horticulture

domoto@iastate.edu

Presented at the

Kansas Grape Growers & Winemakers Association

27th Annual Conference

January 11, 2013

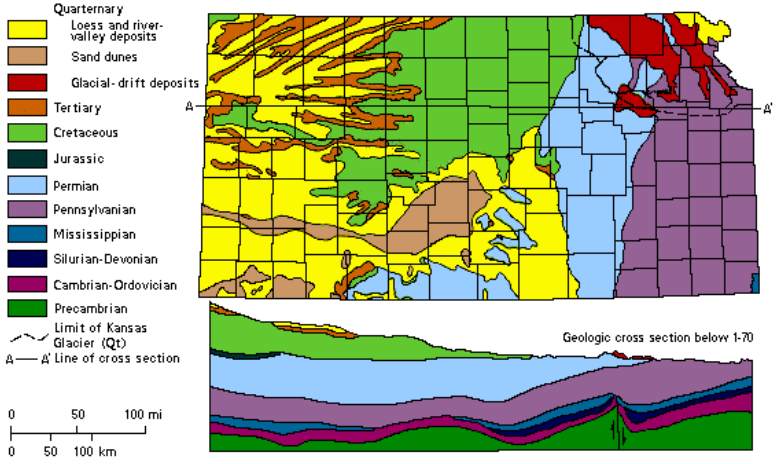
Developing a Fertilizer Program for a Vineyard

Need to know & understand your soil.

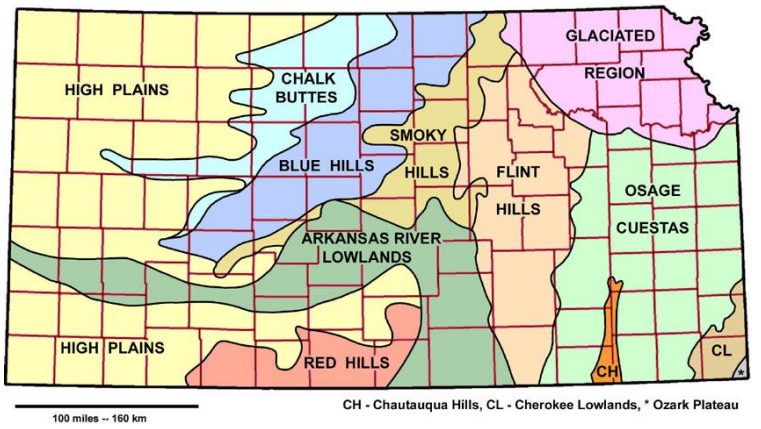
- **Begins before planting = Soil Sampling.**
  - Optimizing the soil pH for Grapes (5.5, 6.0, 6.5 or 7.0?).
  - Amending to optimize the level of major nutrients (P, K).
  - Understanding its internal drainage characteristic**.**
- **After planting = Petiole Analysis to adjust your fertilizer program based on:**
  - Soil's fertility level (O.M. content) & vineyard needs.
  - Variety characteristics (vigor, cold hardiness).
  - Cropping potential.

Availability of Essential Mineral Nutrients

- Composition of the soil parent material.
- Soil pH
- Soil Texture
  - Soil weathering / leaching
  - Internal drainage characteristics of the soil.
- Competition between nutrients for uptake by the plant.
- Soil organic matter content.
- Previous fertilizer history.



Bedrock Geology



Geologic Regions

Pre-plant Soil Testing

- Test for: **pH, Buffer pH, P, K, Mg, Zn, CEC, O.M.**
  maybe for: **S**
- Separate sample for each soil type.
- Separate samples for different cropping histories.
- Submit samples collected from 2 depths:
  - **0 to 8 inch** (0-6 inch) **depth.**
  - **8 or 16 inch** (6-12 inch)
    - To 24 inches for **S.**
- **K-State Agronomy Soil Testing Lab**
  - http://www.agronomy.ksu.edu/soiltesting/p.aspx?tabid=1
- **Commercial Laboratories**

Pre-Plant Soil Testing Sufficiency Ranges

Test	OSU*	ISU	U of MN	NRAES-145**
Soil pH	**5.5 - 6.5**	**6.0 - 6.5**	**6.0 to 7.0**	**
Phosphorous (P)	**20 - 50 ppm**	**> 30 ppm**	**> 25 ppm**	**20 - 50 ppm**
Potassium (K)	**125 - 150 ppm**	**> 150 ppm**	**> 150 ppm**	**75 - 100 ppm**
Magnesium (Mg)	**100 - 125 ppm**	**100 - 125 ppm**	**~ 100 ppm**	**100 - 250 ppm**
Zinc (Zn)	**4 - 5 ppm**	**3 - 4 ppm**	**> 1 ppm**	**2 ppm**
Organic matter	**2 - 3 %**	**2 - 3** (4) **%**	**- -**	**3 - 5 %**
Calcium (Ca)	- -	- -	> 600 ppm	500 - 2000 ppm
Boron (B)	.75 - 1.0 ppm	- -	> 1 ppm	0.2 - 2.0 ppm
Manganese (Mn)	- -	- -	> 6 ppm	20 ppm
Copper (Cu)	- -	- -	>0.2 ppm	0.5 ppm
Iron (Fe)	- -	- -	- -	20 ppm
Sulfur (S)	- -	> 7 ppm	- -	- -

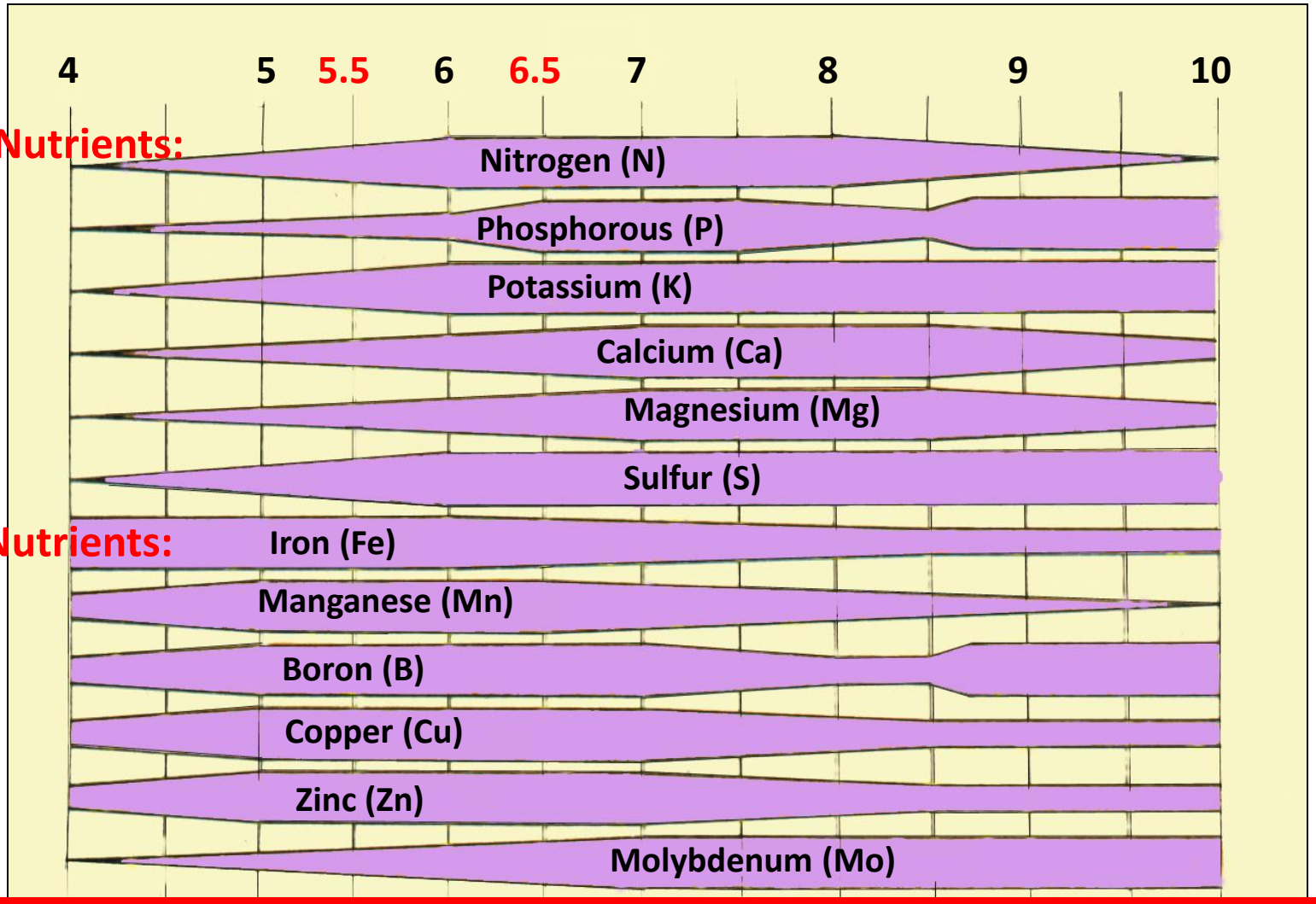
* **Midwest Small Fruit Pest Management Handbook** (OSU Ext. Bull. 861)
& **Midwest Grape Production Guide** (OSU Ext Bull. 919)

** **Wine Grape Production Guide for Eastern North America.**

Soil pH: **
5.0 *V. Labrusca*
6.0 hybrids
6.5 *V. vinifera*

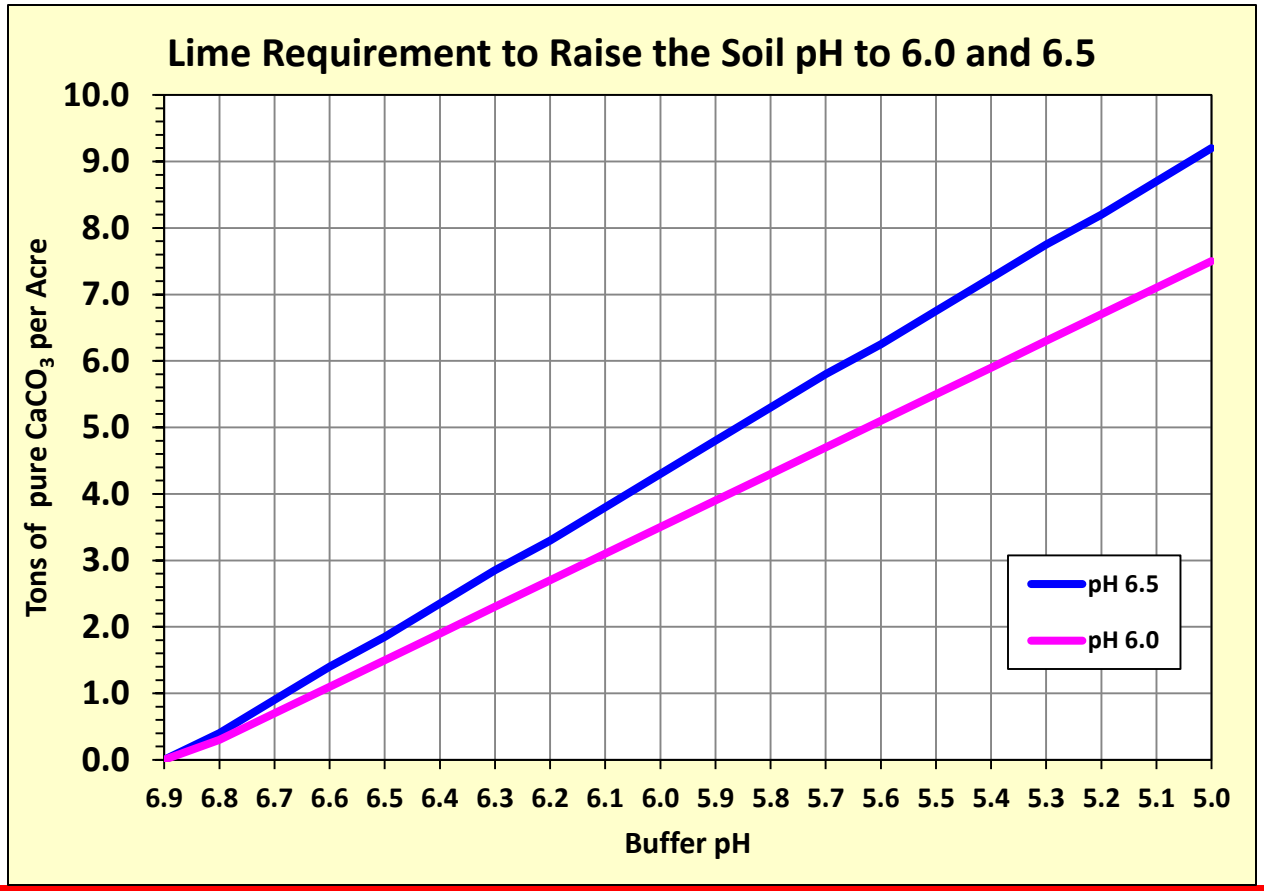
Soil pH

Affects the availability of the essential nutrients.



Adjusting the Soil pH Before Planting a Vineyard

- **Soil pH below 6.0**
  - Apply lime to bring the pH up to 6.0 or 6.5 based on the **Buffer pH**.
  - Limestone (Ca) or Dolomitic lime (Mg)?



Iron Chlorosis

Photographed by Eli Bergmeier

Adjusting the Soil pH Before Planting a Vineyard

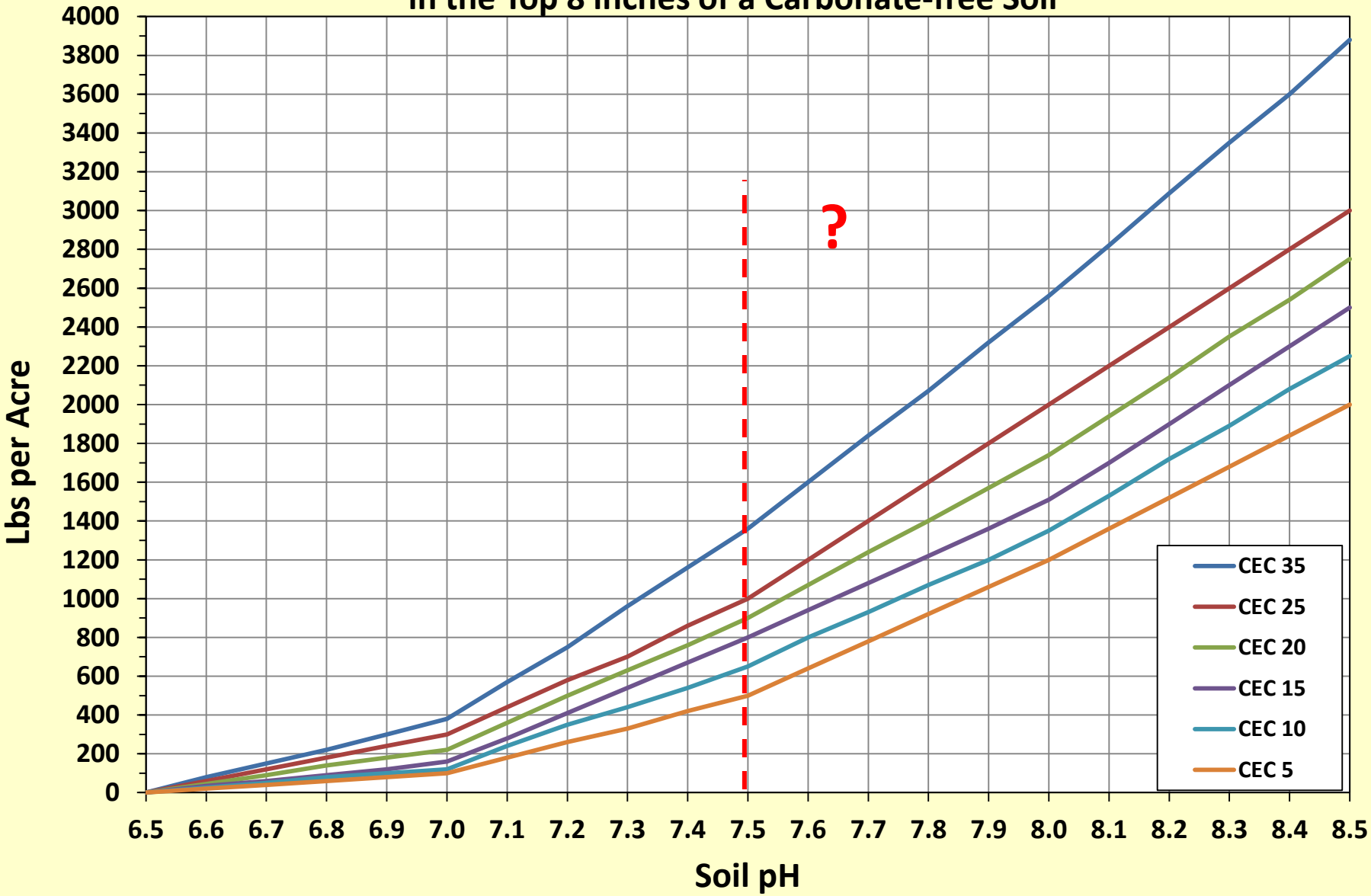
- **Soil pH between 6.5 to 7.0 ?**
  - Do nothing? (*V. labrusca* types **vs** *V. vinfera* & interspecific hybrids)
  - Apply sulfur to lower the pH to 6.5 or 6.0 ***or***
  - Take other measures to lower the soil pH
    - Acidifying forms of N fertilizer
- **Soil pH 7.0 to 7.5**
  - Apply sulfur to lower the pH to 6.5 or 6.0 ***and***
  - Take other measures to lower the soil pH
    - Acidifying forms of N fertilizer
- **Soil pH above 7.5**
  - Apply sulfur to lower the pH to 6.5 or 6.0**??**
    - Cost
    - Presences of free carbonates in the soil.

Forms of Sulfur:
Elemental (1x)
Aluminum sulfate (6x)
Ferrous sulfate (8x)

N Source (1 lb)	lbs of lime neutralized
Ammonium sulfate	5.4
Urea	1.8
Mono-ammonium phosphate	5.0
Manure, compost, etc	variable

Sulfur Required to Lower the Soil pH to 6.5

in the Top 8 inches of a Carbonate-free Soil



Fizz Test for Calcareous Soils*

Applying a few drops of household vinegar to a soil sample and listen and observe for bubbling.

Fizz test result	Estimated carbonates present (%)	Annual addition of elemental sulfur (ton/acre)	Duration (years)
None	0	none	None
Heard (barely audible)	0 – 1	.5 – 1	1
Slight (few bubbles)	1 – 2	1	1 – 2
Moderate (several bubbles)	2 – 3	1	2 – 3
Vigorous (many bubbles)	> 3	1	3 +

* From: *Acidifying Soil for Crop Production: Inland Pacific Northwest*. Pacific Northwest Ext. Publ. PNW 599-E

Optimizing Nutrients Before Planting

- **Phosphorous (P)**
  - Very immobile in the soil.
  - **Optimize to 30.5 ppm of P**
    - Equals **61** pp2m **= 61** lbs/A per plow slice of 8 inches.
  - **P fertilizer analysis** is measured as **% P_2O_5**
    - lbs of P / A **x 2.3 =** lbs of P_2O_5 / A
    - **61** lbs of P / A **x 2.3 = 140** lbs of P_2O_5 / A
  - **Amount of P_2O_5 to apply /A =** Optimum lbs of P_2O_5 /A **–** the exchangeable P_2O_5 /A from the soil test results.
    - If soil test shows **10** ppm exchangeable P **= 20** pp2m or **20** lbs of P /A **x 2.3 = 46** lbs of P_2O_5 /A
    - Amount of P_2O_5 to apply /A **= 140** lbs of P_2O_5 /A **– 46** lbs exchangeable P_2O_5 /A from the soil test results **= 94** lbs of P_2O_5 /A is required.
  - **The amount of fertilizer containing the P_2O_5 required /A =** lbs of P_2O_5 /A divided by the % analysis of the fertilizer product.
    - If **Ammonium monophosphate** (11-52-0) is applied:
    - Lbs 11-52-0 require /A **= 94** lbs P_2O_5 **/ 0.52 = 181** lbs/A

Optimizing Nutrients Before Planting

- **Potassium (K)**
  - Moves very slowly in the soil.
  - **Optimize to 150 ppm**
    - Equals **300** pp2m **= 300** lbs/A per plow slice of 8 inches
  - **K fertilizer analysis** is measured as **% K_2O**
    - Lbs of K / A **x 1.2 =** Lbs of K_2O / A
    - **300** lbs of K / A **x 1.2 = 360** lbs K_2O /A
  - **Amount of K_2O to apply /A =** Optimum lbs of K_2O /A **–** the exchangeable K_2O /A from the soil test results.
    - If soil test shows **50** ppm exchangeable K **= 100** pp2m or **100** lbs of K /A **x 1.2 = 120** lbs of K_2O /A
    - Amount of K_2O to apply /A **= 360** lbs of K_2O /A **– 120** lbs exchangeable K_2O /A from the soil test results **= 240** lbs of K_2O /A is required.
  - **The amount of fertilizer containing the K_2O required /A =** lbs of K_2O /A divided by the % analysis of the fertilizer product.
    - If **Potassium chloride** (0-0-62) is applied:
    - Lbs 0-0-62 require /A **= 240** lbs K_2O **/ 0.62 = 387** lbs/A

Optimizing Nutrients Before Planting

- **Potassium (K)**
  - **Inhibition of K uptake by excessive soil Mg.**
  - If the ratio of exchangeable K / Mg is equal to or less than 0.3
  - **Optimize K at 40% of the exchangeable Mg content.**
    - If a soil test shows **120** ppm K and **500** ppm Mg.
    - Ratio of exchangeable K / Mg = 120 / 500 = **.24**
  - **Optimizing K at 40% of the exchangeable Mg.**
    - **500** ppm Mg x **.4** = **200** ppm K.
  - **Amount of K (ppm) required = Optimum K** (40% exchangeable Mg) **– exchangeable K from soil test.**
    - **200** ppm optimum K **– 120** ppm exchangeable K = **80** ppm K required.
    - Equals **160** pp2m or **160** lbs/A per plow slice of 8 inches.
    - **Lbs/A of K_2O require = 160 lbs K/A x 1.2 = 192 lbs of K_2O /A**
  - **The amount of fertilizer containing the K_2O required /A =** lbs of K_2O /A divided by the % analysis of the fertilizer product.
    - If **Potassium chloride** (0-0-62) is applied:
    - Lbs 0-0-62 require /A **= 192** lbs K_2O **/ 0.62 = 310** lbs/A

After Planting: Soil vs Petiole Analysis

Soil Analysis:

- **2nd year & beyond:**
  - Monitor the soil pH.
  - Basis for K rate if petiole analysis indicates a short supply.

Petiole Analysis:

- **1st year:**
  - Not accurate
  - Reflects growing conditions in the nursery.
- **2nd year & beyond (*begin when vines come into production*):**
  - Measures the amount of nutrients the vines are able to take up from the soil.
  - Sampling time is important.
  - Annual analysis allows for fine-tuning of the fertilizer program, & correcting shortages before they become a problem.

Normal Nutrient Ranges for Grapes

Based on Petiole Analysis

Nutrient	At Bloom (*for* American hybrids) *	Mid-July to Mid-Aug.** (*Fertilizing Fruit Crops*. OSU Bull. 458)
Nitrogen (N)	1.6 to 2.8 %	0.9 to 1.3 %
Phosphorous (P)	0.20 to 0.60 % ?	0.16 to 0.29 %
Potassium (K)	? 1.50 to 5.00 % ?	1.50 to 2.50 % ?
Calcium (Ca)	0.40 to 2.50 % ?	1.20 to 1.80 %
Magnesium (Mg)	0.13 to 0.40 %	0.26 to 0.45 %
Sulfur (S)	*No data (>0.1%)*	*No data (>0.1%)*
Manganese (Mn)	18 to 100 ppm	31 to 150 ppm
Iron (Fe)	40 to 180 ppm	31 to 50 (200) ppm
Boron (B)	25 to 50 ppm	25 to 50 ppm
Copper (Cu)	5 to 10 ppm	5 to 15 ppm
Zinc (Zn)	20 to 100 ppm	30 to 50 ppm
Molybdenum (Mo)	0.2 to 0.4 ppm	0.3 to 1.5 ppm

* Mills, H.A. and J.B. Jones. 1996. **Plant Analysis Handbook II**. MicroMacro Publishing

** With exception of Mo, ranges are published in the *Midwest Grape Production Guide*, OSU Bull. 919, & the *Midwest Small Fruit Pest Management Handbook*, OSU Bull. 861.

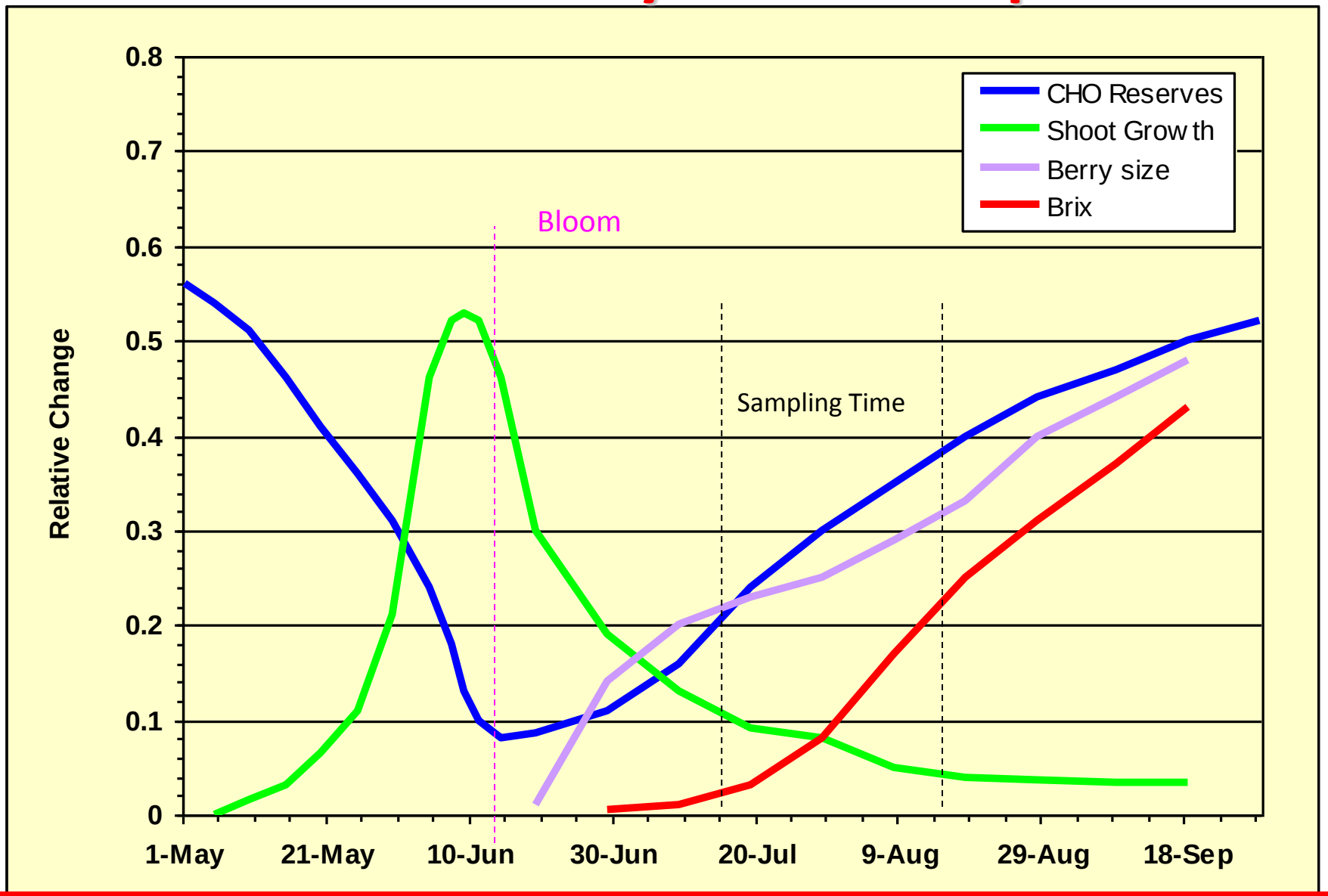
Normal Nutrient Ranges for Grapes

Based on Petiole Analysis

Nutrient	NRAES 145*	
	At Bloom	70-100 Days After Bloom
Nitrogen (N)	1.2 to 2.2 %	0.8 to 1.2 %
Phosphorous (P)	0.17 to 0.30 %	0.14 to 0.30 %
Potassium (K)	1.5 to 2.5 %	1.20 to 2.00 %
Calcium (Ca)	1.0 to 3.0 % ?	1.0 to 2.0 %
Magnesium (Mg)	0.3 to 0.5 %	0.35 to 0.75 % ?
Sulfur (S)	*No data*	*No data*
Manganese (Mn)	25 to 1,000 ppm ?	25 to 1,500 ppm ?
Iron (Fe)	20 ppm	30 to 100 ppm
Boron (B)	25 to 50 ppm	25 to 50 ppm
Copper (Cu)	5 to 15 ppm	5 to 15 ppm
Zinc (Zn)	30 to 60 ppm	30 to 60 ppm
Molybdenum (Mo)	.5 ppm	.5 ppm

* Wine Grape Production Guide for Eastern North America.

Annual Growth Cycle of a Grapevine



From: Winkler, General Viticulture

Changes in Nutrient Concentrations during the Growing Season

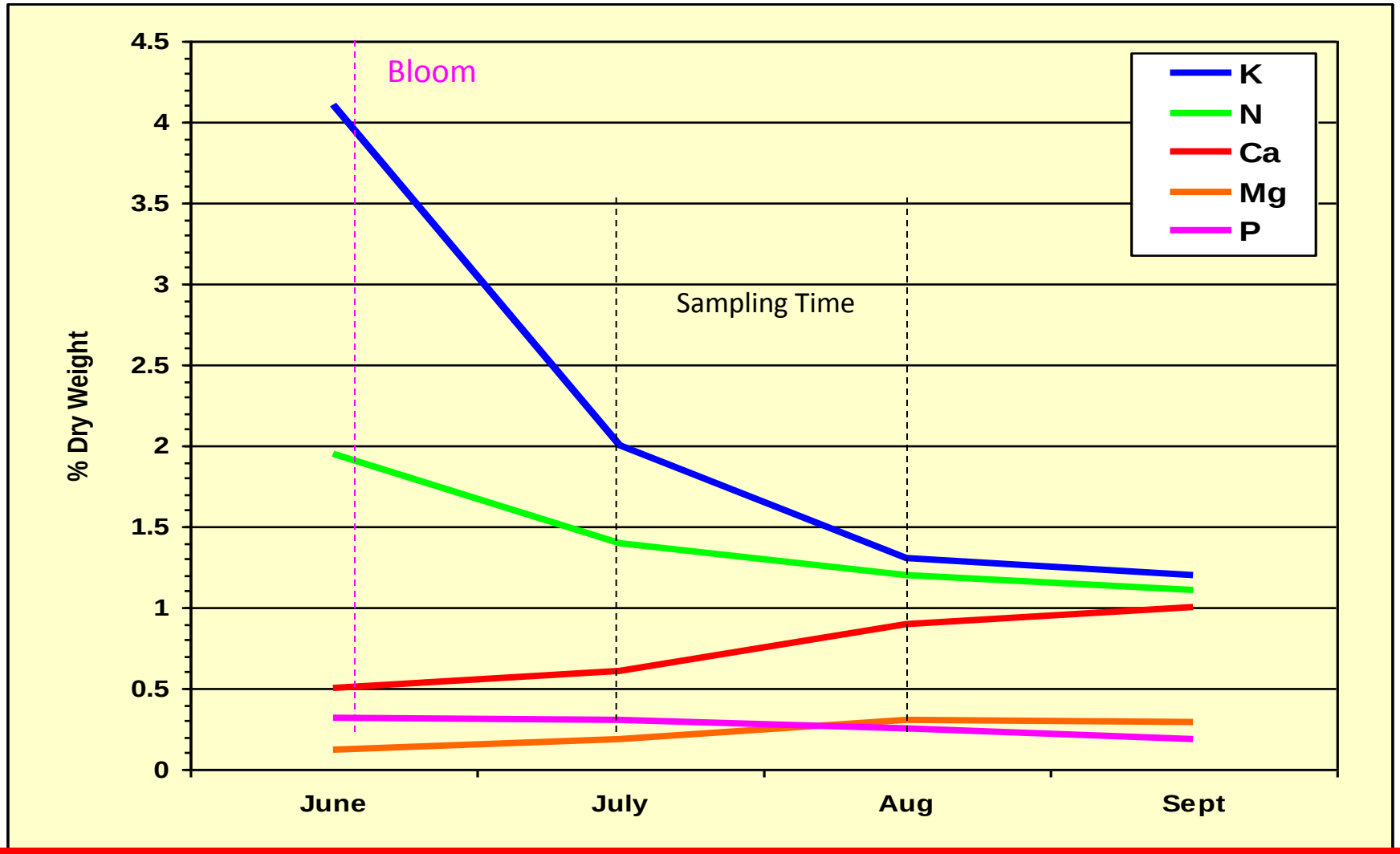
Increase

- Calcium (Ca)
- Magnesium (Mg)
- Boron (B)
- Iron (Fe)
- Manganese (Mn)

Decrease

- **Nitrogen (N)**
- Phosphorous (P)
- **Potassium (K)**
- Sulfur (S)
- Copper (Cu)
- Zinc (Zn)

Changes in Nutrient Concentrations during the Growing Season

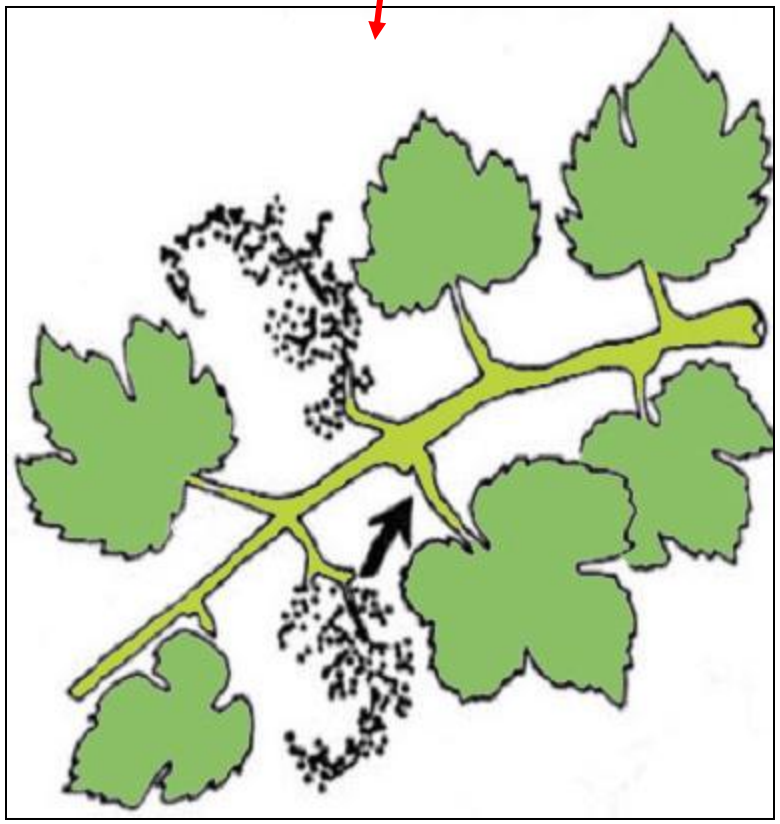


Smith, C.B, *et. Al.* 1957. The nutritional status of Concord grape vines in Erie county, Pennsylvania as indicated by petiole and soil analysis. Proc. ASHS 70:189-196.

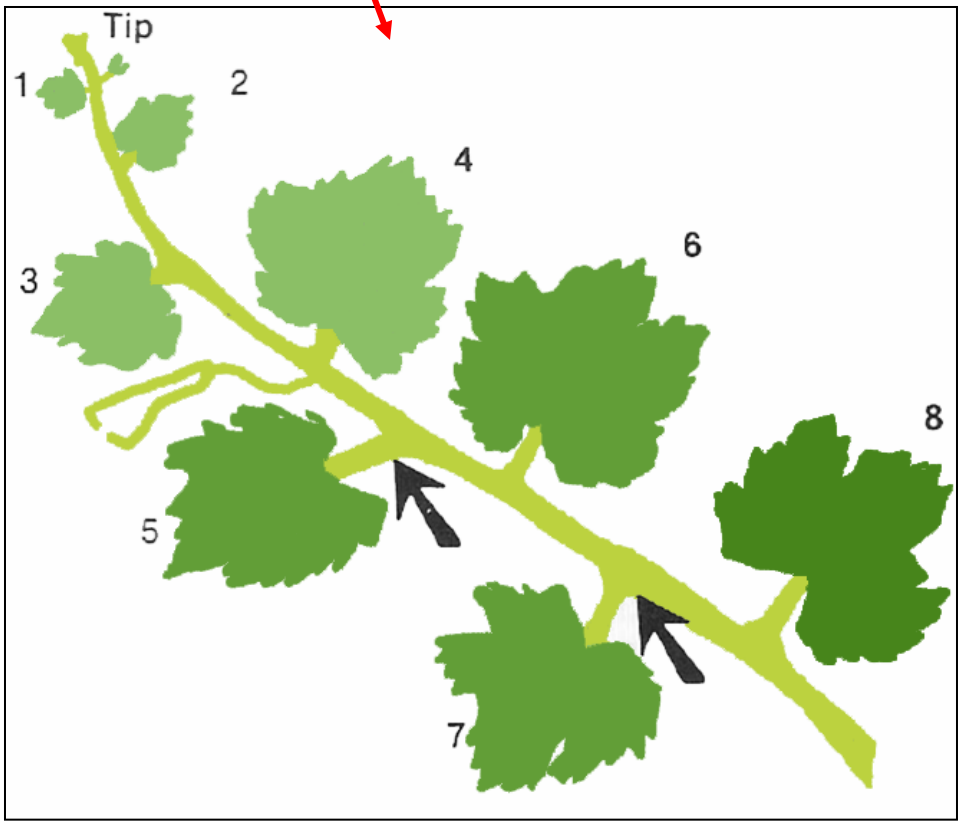
Collecting a Petiole Sample

- **Collect at the same time each year!**
- Do not mix varieties into one sample!
- If a planting is located on more than one soil type, collect separate samples for each soil type.
- If a planting received different fertilizer applications, separate samples should be collected.
- A sample should consist of 100 petioles, or 150-200 for varieties with small petioles.

Full Bloom vs Mid-Summer



Opposite of the first cluster.



Most recently fully expanded leaf.

Figures adapted from: *Grapevine Nutrition and Fertilization in the San Joaquin Valley*. 1978 Univ. of California publ. 4087

Interpreting a Petiole Analysis

Petiole analysis is not an exact science.

- Can tell if you need to apply more or less of a nutrient.
- The more information available, the better.
- Annual testing allows you to fine-tune your fertilizer program.

To assist, additional information suggested:

- The vigor & health of the vines.
- Soil type, texture and internal drainage classification.
- Soil moisture conditions (excess, drought?)
- Previous soil test results.
- Production potential for current and previous season.
- Current and past fertilizer program.
- Spray materials applied prior to collecting the sample.
  - Micro-nutrient containing fungicides
  - Foliar nutrient sprays

Normal Nutrient Ranges for Grape Petioles

Mid-July to Mid-August (early veraison) Sampling

Nutrient	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	0.30 - 0.70	0.70 - 0.90	0.90 - 1.30	1.40 - 2.00	>2.10
P (%)	≥0.12	0.13 - 0.15	0.16 - 0.29	0.30 - 0.50	>0.51
K (%)	0.50 - 1.00	1.10 - 1.40	1.50 - 2.50	2.60 - 4.50	>4.60
Ca (%)	0.50 - 0.80	0.80 - 1.10	1.20 - 1.80	1.90 - 3.00	>3.10
Mg (%)	≥0.14	0.15-0.25	0.26-0.45	0.46-0.80	>0.81
S (%)	*No data*	*No data*	>0.10	*No data*	*No data*
Mn (ppm)	10 - 24	25 - 30	31 - 150	150 - 700	>700
Fe (ppm)	10 - 20	21 - 30	31 - 100	101 - 200	>200
B (ppm)	14 - 19	20 - 25	25 - 50	51 - 100	>100
Cu (ppm)	0 - 2	3 - 4	5 - 15	15 - 30	>31
Zn (ppm)	0 - 15	16 - 29	30 - 50	51 - 80	>80
Mo (ppm)			0.3 - 1.5		

From: Fertilizing Fruit Crops. Ohio Coop. Ext. Ser. Bull. 458.
Reprinted in: Midwest Grape Production Guide. OSU Ext. Bull. 919.

What if petiole analysis shows a need for a nutrient?

How much should be applied?

When should it be applied?

How often should it be applied?

How should it be applied? (soil vs foliar)

Factors that need to be considered:

- Mobility of the nutrient.
- Soil texture / cation exchange capacity.
- Soil pH as it affects nutrient availability/solubility.
- Soil organic matter content.

Nitrogen (N)

(OSU: 0.9 – 1.3 %)

(NRAES: 0.8 – 1.2%)

Source	Fate
• Fertilizer • Legumes (Fix up to 300 lb / A / yr) • Soil organic matter (Releases ~20 lb / A / % OM / yr) • Lightning (Fix ~10 lb / A / yr)	**Lost from Soil:** • Leaching • De-nitrification **Taken up by Plants:** • Recycled: Leaves & Prunings • Removed: Fruit • Tied up: Old wood

How Much Nitrogen is Needed?

Mid-Atlantic Wine Grapegrower's Guide:

- **Grapes ~ 0.18% N, Canes ~ 0.25% N**
- **Nitrogen removed:**
  - **Grapes: 3.6 lb / A / ton**
  - **Canes: 1.7 lb / A / lb of prunings / vine**
- **For a 5 ton crop & 3 lb prunings / vine:**
  - **Grapes: 18 lb / A + prunings 5.1 lb / A = 23.1 lb/A total**

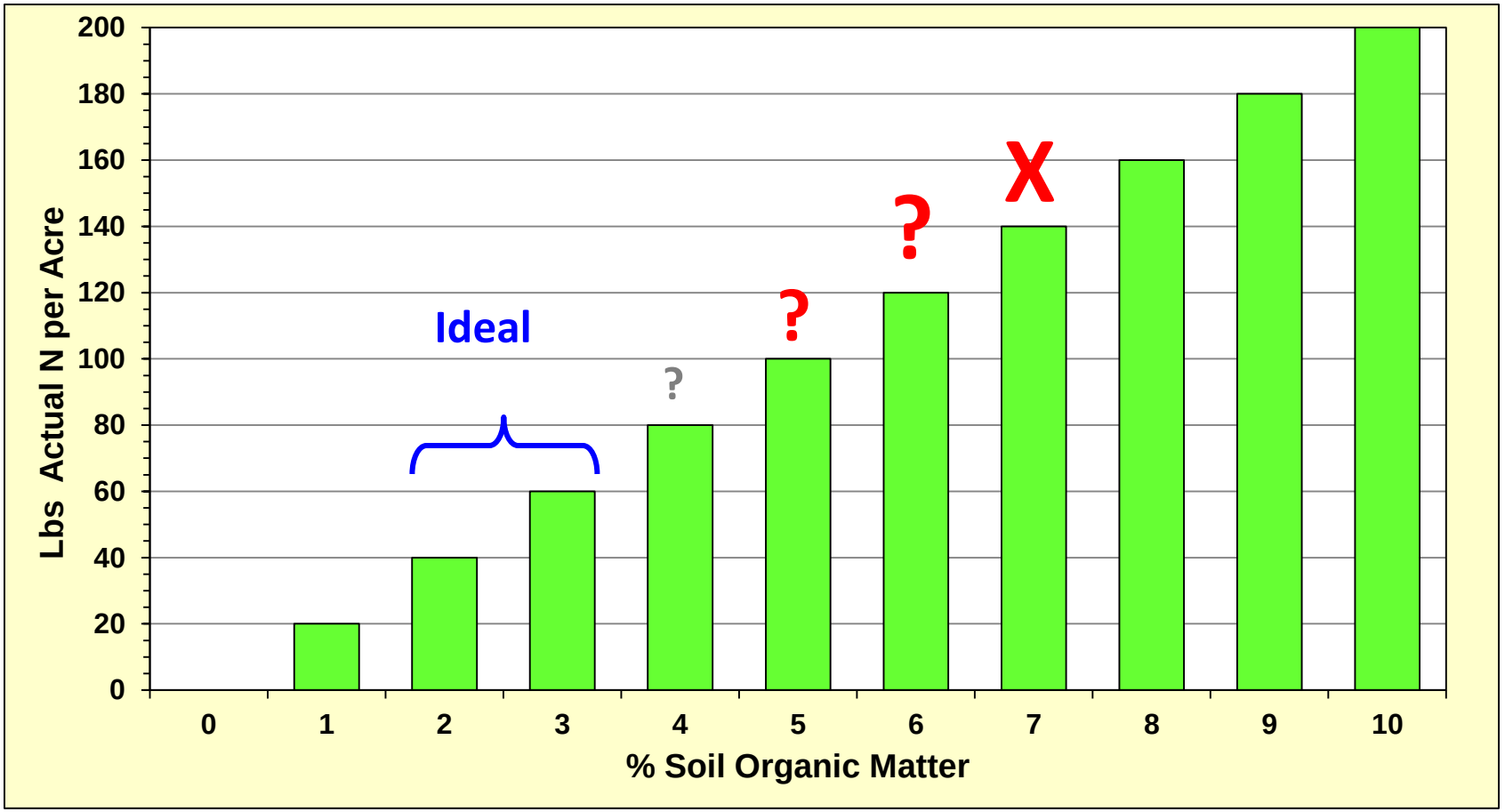
From: Midwest Grape Production Guide. Ohio State Univ. Ext. Bul. 919

"Need between 40 and 80 pounds of actual N / acre per year."

- Sod occupies 2/3's of the land and requires ~ 1 lb N / 1000 sq ft (~30 lb / A).
- Grapes are receiving from 10 to 50 lb of N per acre.

Soil organic matter content:

Nitrogen Released from Organic Matter



Need to adjust N fertilization practices based on the organic matter content of the soil.

How Much Nitrogen is Needed?

1. **Have to consider the N released for the soil organic matter** (~20 lb /A / % OM/yr) **& vine vigor.**
   - Less than 2% OM: Consider increasing the N rate by 10-20%
   - 2 to 3 % OM: 40 to 30 lb actual N/acre is probably adequate.
   - > 3%: Consider reducing the N rate/acre by the amount of N derived from the OM.
   - Adjust up or down based on vine vigor & experience.
2. **How much could be leached out of the root zone?**
   - Sandy soils are more prone to leaching.
     - Consider split N applications – half pre-bud break & the other half ~ 4-6 weeks after bud break.
   - With trickle irrigation, apply multiple applications spread out from bud break to about early-July.

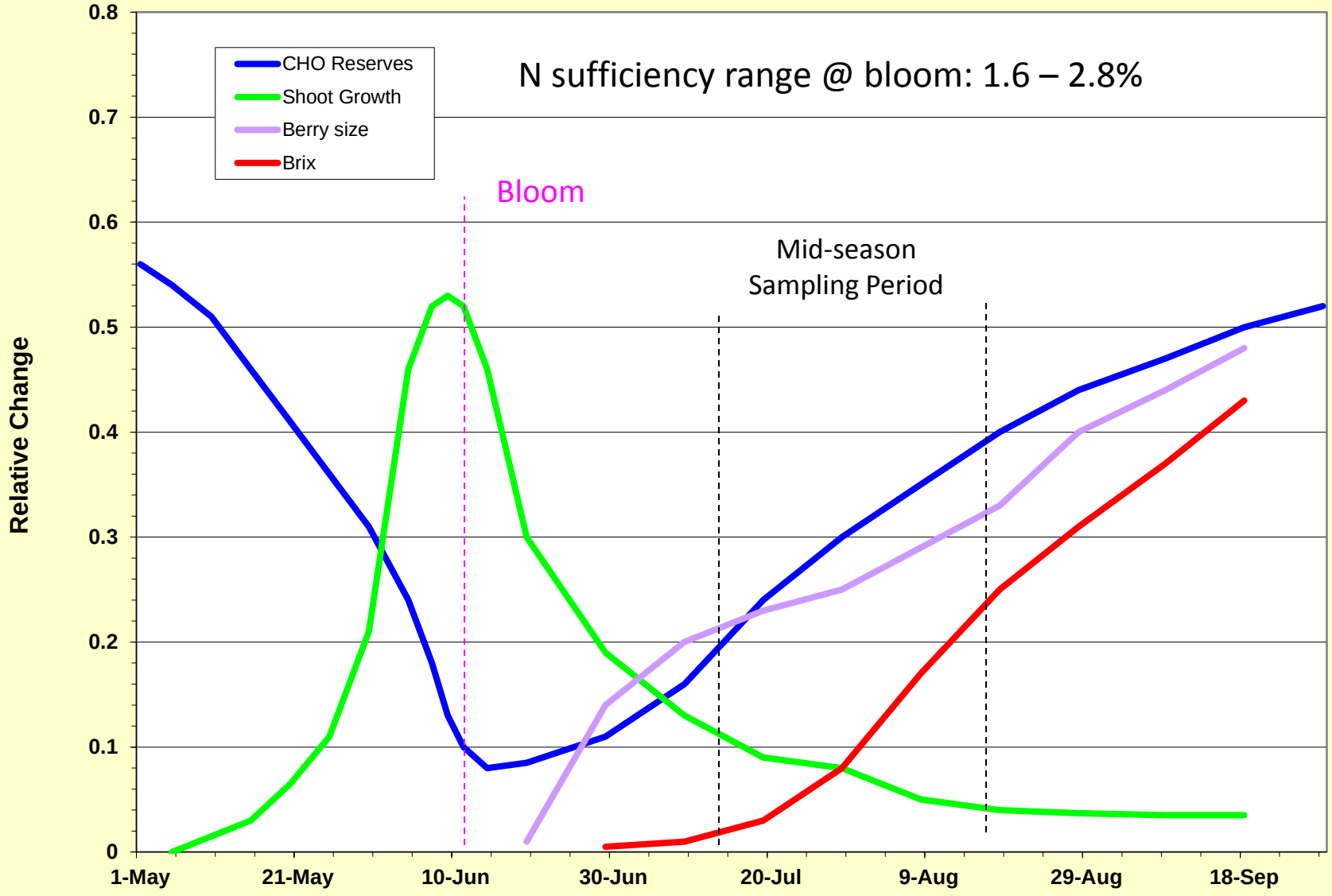
Nitrogen Management

Dr. Carl Rosen, Univ. of Minnesota

Nitrogen Fertilizer Recommendations Based on Petiole Analysis (mid-July to mid-August)	
Petiole N (0.9 – 1.3%)	**N Fertilizer to Apply (lb N / A)**
> 1.5	**0**
1.3 – 1.5	**20**
0.9 – 1.3	**30**
< 0.9	**40 - 50**

Other concerns: petiole K & Zn content

Annual Growth Cycle of a Grapevine



What form of nitrogen should be used?

Soil pH:

- Acid soils (pH < 6.0): nitrate forms to raise the pH.
- Optimal soil pH (6.0 to 6.5 or 7.0): urea (46-0-0)
- Alkaline soils (pH> 6.5 or 7.0): ammonia forms to lower the pH.

The associated element if there is a need.

- **Cations:** calcium nitrate, potassium nitrate
- **Anions:** ammonium mono phosphate, ammonium sulfate

Complete fertilizers (13-13-13):

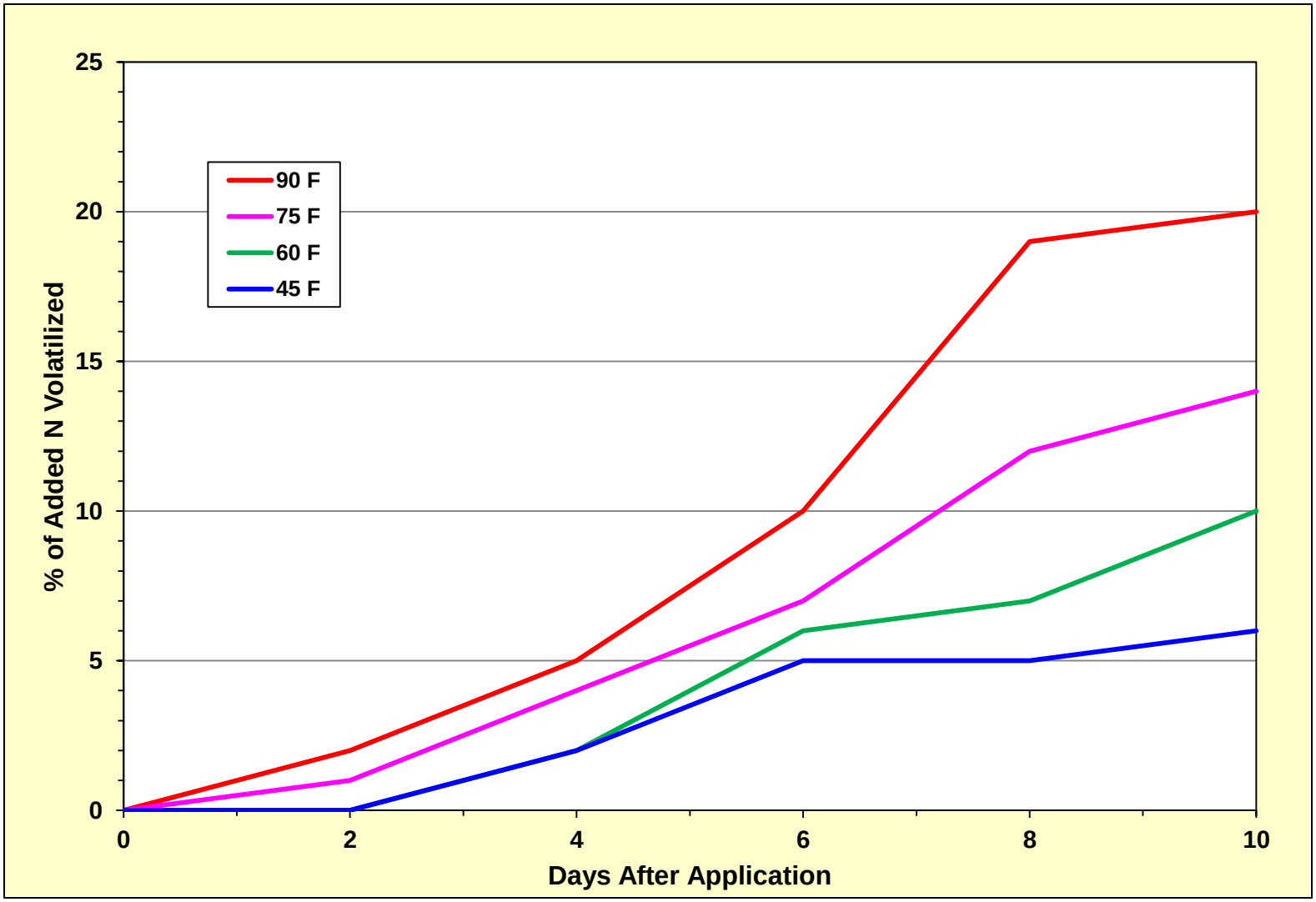
- Only if there is a need for each of the nutrients.
  - Expensive
  - Immobility of P and K.
  - Risk of K-induced Mg deficiency on sandy soils.

What form of nitrogen should be used?

Nitrogen availability:

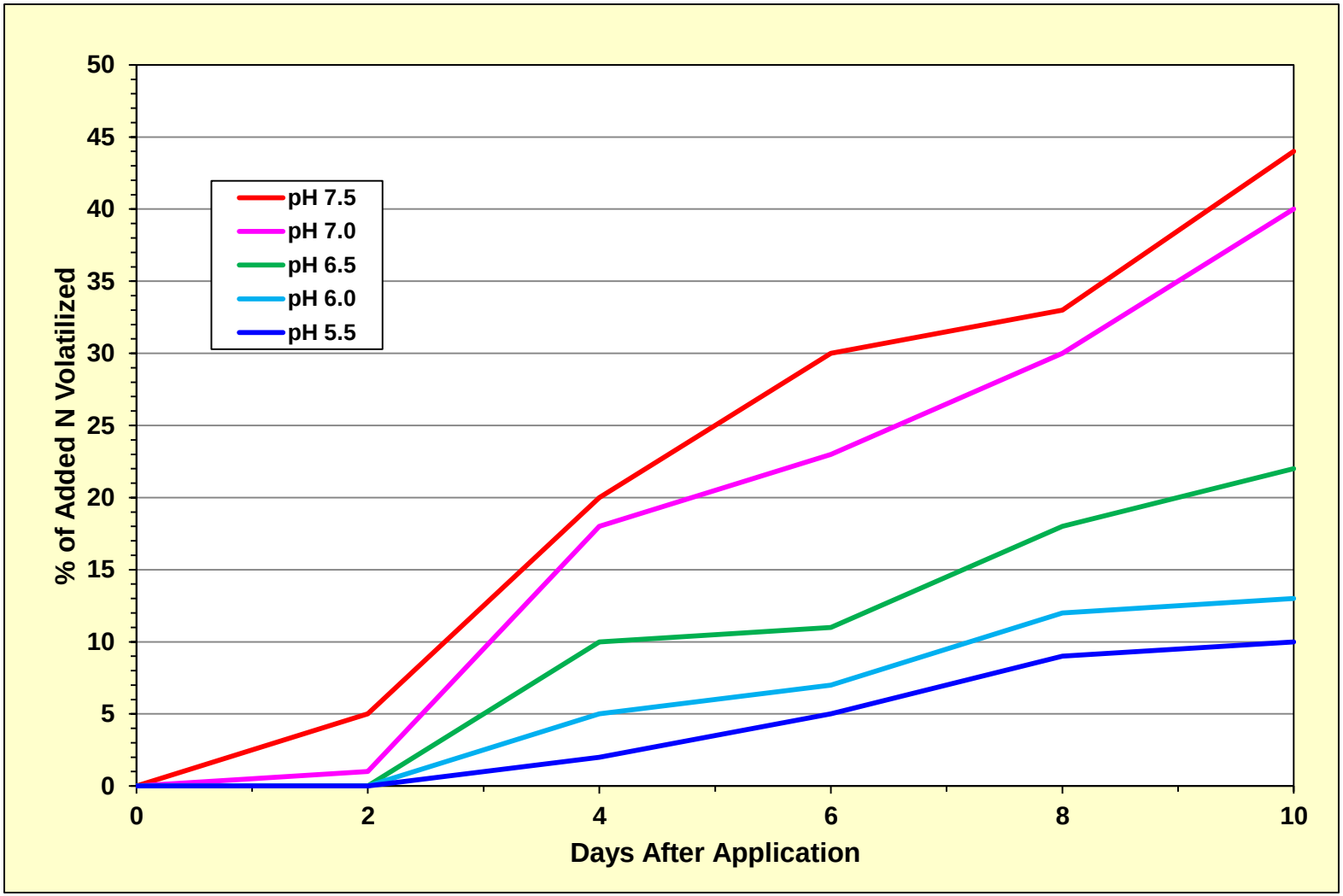
- **Nitrate forms - NO_3 :**
  - Readily available to plants.
  - Very subject to leaching.
- **Urea - $CO(NH_2)_2$:**
  - Can be taken up by plants as urea, or converted to ammonia (NH_4) then to NO_3-N.
  - Will volatilize under warming temperatures when surface applied.
  - Will volatilize when surface applied on higher pH soils.
- **Ammonia forms – NH_4 :**
  - Slowly available, must convert to NO_3-N before it can be taken up by plants.
  - Requires soil temperatures above 50^o F to convert to NO_3-N.
  - Can be tied up on soil particles.
    - Less prone to leaching.

Effect of Temperature on the Volatilization of Surface Applied Urea



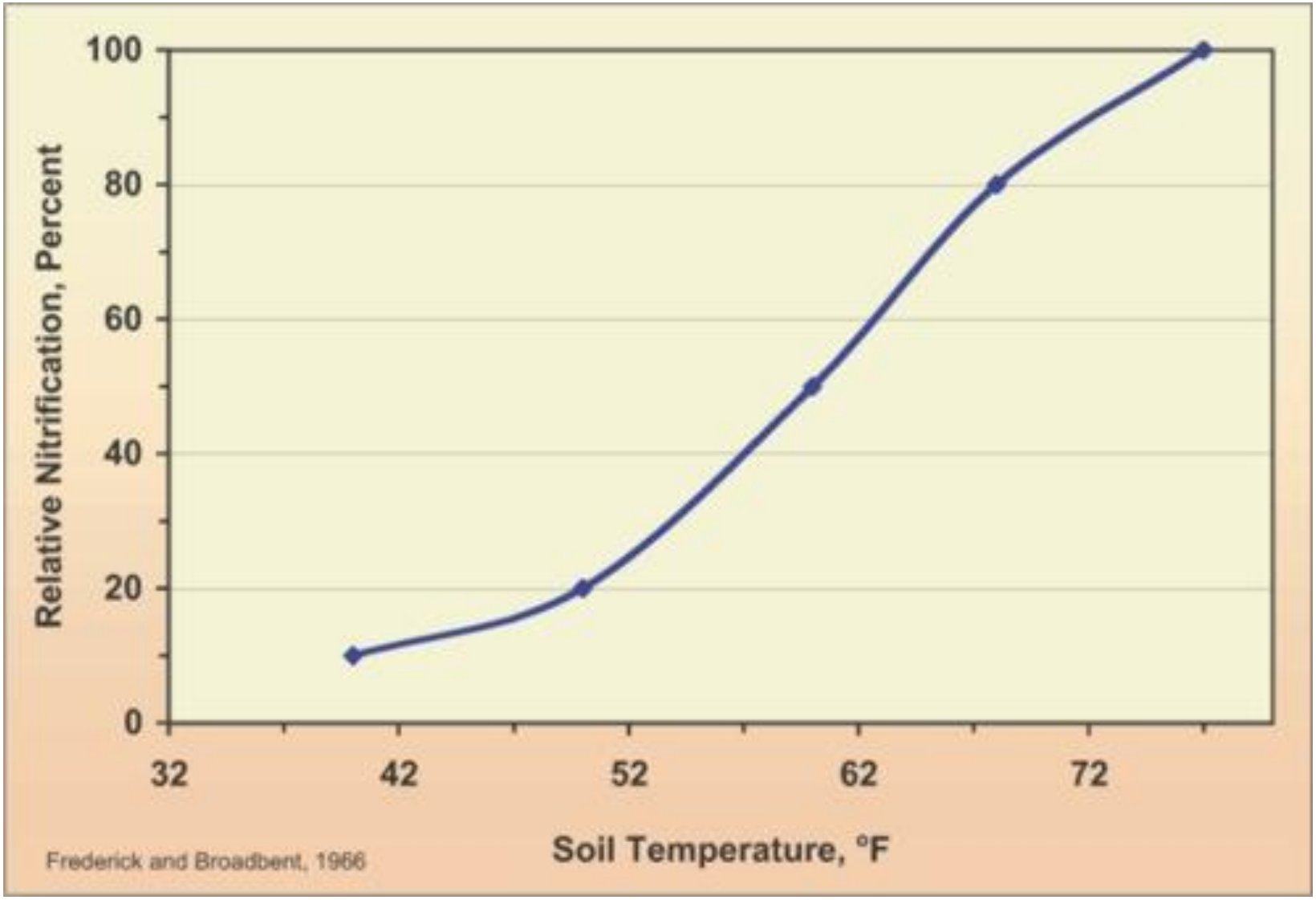
From: Volatilization of Urea Affected by Temperature and Soil pH.
http://www.ag.ndsu.edu/procrop/fer/ureavo05.htm

Effect of Soil pH on the Volatilization of Surface Applied Urea



From: Volatilization of Urea Affected by Temperature and Soil pH.
http://www.ag.ndsu.edu/procrop/fer/ureavo05.htm

Effect of Soil Temperature on the Nitrification of Ammonia



***From*: Why 50 degrees Fahrenheit? http://www.ipm.iastate.edu/ipm/icm/2001/10-22-2001/why50.html**

When Should Nitrogen be Applied?

Most needed at bloom.

- **Nitrate forms - NO_3 :**
  - **Closer to the time of bloom.**
    - Readily available to plants.
    - Very subject to leaching.
- **Urea - $CO(NH_2)_2$:**
  - **Early spring or in the fall when growth stops.**
    - Can be taken up by plants as urea, or converted to NH_4-N then to NO_3-N.
    - Volatile under warming temperatures when surface applied.
- **Ammonia forms – NH_4 :**
  - **Early spring or in the fall when growth stops.**
    - Slowly available, must convert to NO_3-N before it can be taken up by plants.
    - Requires soil temperatures above 50^o F to convert to NO_3-N.
    - Can be tied up on soil particles.
    - Less prone to leaching.
- **Manure (NH_4):**
  - **In the fall, after harvest and growth has stopped.**
    - Food safety issue

Phosphorous (P)

(OSU: 0.16 – 0.29 %)

(NRAES: 0.14 – 0.30%)

- **Practically immobile in the soil.**
  - Pre-plant soil analysis & amend before planting.
- **Generally not a problem.**
  - Plants often do well on low P soils.
    - **Unavailable ⇆ Exchangeable ⇆ Available P in the soil.**
    - **Soil mycorrhizal organisms aid in making P available.**
- **Can be a problem on sandy, low CEC soils.**
  - Apply manure in the fall as an N source.
    - **N (1-3%), P (0.3-3.2%), K (.5-2.9%); OM (30-74%)**
  - Winery pomace (dried).
    - **N (1-2%), P (~1.5%), K (.5-1.0%); OM (80%)**
  - Apply ammonium mono phosphate (11-52-0) as a N source.
  - Apply P as a foliar application (refer to labels).

Potassium (K)

(OSU: 1.50 – 2.50 %)

(NRAES: 1.20 – 2.00%)

Moves very slowly in the soil.

- For perennial crops, high rates of K are needed to move the K down into the root zone.
- **If petiole analysis shows a need for K.**
  - Conduct a soil test to determine how much K is need to optimized soil K and apply as a band application.
  - Test magnesium (Mg) to make sure that:
    - Excessive Mg is not inhibiting the uptake of K.
    - Additional K will not affect the uptake of Mg.

Potassium Management

Dr. Carl Rosen, Univ. of Minnesota

Potassium Fertilizer Recommendations Based on Petiole Analysis (mid-July to mid-August)	
Petiole K (1.5 – 2.5%)	**K Fertilizer to Apply (lb K_20 / A)**
> 2.0	**0**
1.5 – 2.0	**100 – 200**
1.0 – 1.5	**200 – 300**
< 1.0	**300 - 400**

Potassium Management

Potassium (K) soil applications:

- **Apply when the need has been identified:**
  - Potassium chloride (0-0-62)
  - Potassium sulfate (0-0-50)
  - Potassium magnesium sulfate, Sul-Po-Mag (0-0-22 + 22% S, 11% Mg)
- **Apply in the spring:**
  - Potassium nitrate (13-0-44)

Foliar K applications:

- Often needed in addition to soil applications to correct deficiencies for the first year or two.
- **Begin applying early in the season:**
  - Potassium nitrate (44% K, 13% N)
  - Potassium sulfate (53% K, 18% S)
    - Apply at 6 to 10 lb / 100 gallons (1 to 3 applications/season).
  - Vigor-K™ (20% K) *follow label directions*
  - Nutri-K® (15% K) *follow label directions*

Apply a straw mulch under the vines.

Calcium (Ca)

(OSU: 1.20 – 1.80 %)

(NRAES: 1.0 – 2.0 %)

Generally not considered a problem in grapes.

Could become a problem on sandy soils.

- If the soil pH is low (acid), apply lime to raise the pH.
- If the soil pH is in the optimal range, apply Ca as gypsum (calcium sulfate).
- Use calcium nitrate as your N source
  - 15.5% N, 21% Ca

Magnesium (Mg)

(OSU: 0.26 – 0.45 %)

(NRAES: 0.35 – 0.75 %)

Can be a problem on sandy soils, particularly when K has been over applied.

- If the soil pH is low (acid), apply dolomitic lime to raise the pH to 6.0 or 6.5.
- If the soil pH is in the optimal range, apply:
  - 50 to 100 lb magnesium oxide (MgO) /A.
  - 300 to 600 lb Epson salt ($MgSO_4$) /A.
- Foliar applications of Epson salt at 10 lb/100 gal.
  - Apply as 2 post-bloom applications.

Excessive Mg can be a problem on some calcareous and glaciated soils.

- Inhibits K uptake.

Sulfur (S)
(> 0.10 %)

- **No reliable data on a sufficiency level for grapes.**
  - Sulfur has often been included in spray programs.
  - Sulfur has historically been an air pollutant.
- If petiole S is > 0.10 %, considered adequate.
- If petiole S drops < 0.10 %:
  - Check the soil pH and take measures to acidify if necessary.
  - Use S-containing forms of fertilizer in your fertility program.
  - Apply liquid lime sulfur in the dormant for anthracnose control.
  - Use S-containing fungicides in your disease control program if the varieties are not S-sensitive.

Boron (B)
(25 – 50 ppm)

Can be low in many Midwest & high pH soils

- B is involve in fruit set.
  - Improves the rate of pollen tube growth and thereby improves fertilization of the flowers.
- If there is a need for B.
  - 4 to 6 lbs B / A as a soil application.
  - Pre- and post-bloom foliar applications of Solubor (20% B) at a rate of 2 to 4 lbs/A per application.
    - First application at about the 3-inch stage of shoot growth.
    - Post bloom application, if needed.
    - Tight vs loose clustered variety?

Copper (Cu)
(5 – 15 ppm)

Michigan St. Univ.

Can be low on sandy or high pH soils.

- If Cu is low.
  - Include a few applications of Bordeaux (copper sulfate + hydrated lime) *or* a fixed copper + hydrated lime in the disease control program.
  - Avoid applying during or just following cool, wet weather.
    - Greater absorption & risk of phytotoxicity.
    - Can begin at about the 10-inch growth stage.
  - If it is a Cu-sensitive variety, apply a dormant application of Cu.
    - It has some benefit in controlling grape anthracnose.

Manganese (Mn)

(OSU: 31 – 150 ppm)

(NRAES: 25 – 1,500 ppm)

Can be low on sandy and high pH soils.

- If Mn is low.
  - **Include a Mn-containing fungicide in your early season disease control program.**
    - **mancozeb** (Dithane M-45, Maneb, Penncozeb)
      - **Contains 16% Mn.**
      - **66 day pre-harvest interval.**
  - Apply a chelated form of Mn as a foliar spray (*refer to label*).

Can be excessive (> 700 ppm) on low pH soils.

- Apply lime to raise the soil pH.

Zinc (Zn)

(OSU: 30 – 50 ppm)

(NRAES: 30 – 60 ppm)

Can be low on sandy, high pH, eroded, terraced or leveled soils.

- **If Zn is low:**
  - **Soil application of zinc sulfate (36% Zn) to bring the available Zn up to 6-8 lb/A.**
  - **Include a Zn-containing fungicide in your early season disease control program.**
    - **mancozeb (Dithane M-45, Maneb, Penncozeb)**
      - **Contains 2% Zn.**
      - **66 day pre-harvest interval.**
    - **Ziram**
      - **Contains 16% Zn.**
      - **21 day pre-harvest interval.**
  - **Apply a chelated form of Zn as a foliar spray** (*refer to label*)**.**

Iron (Fe)

(OSU: 31 – 50 (*200*) ppm)

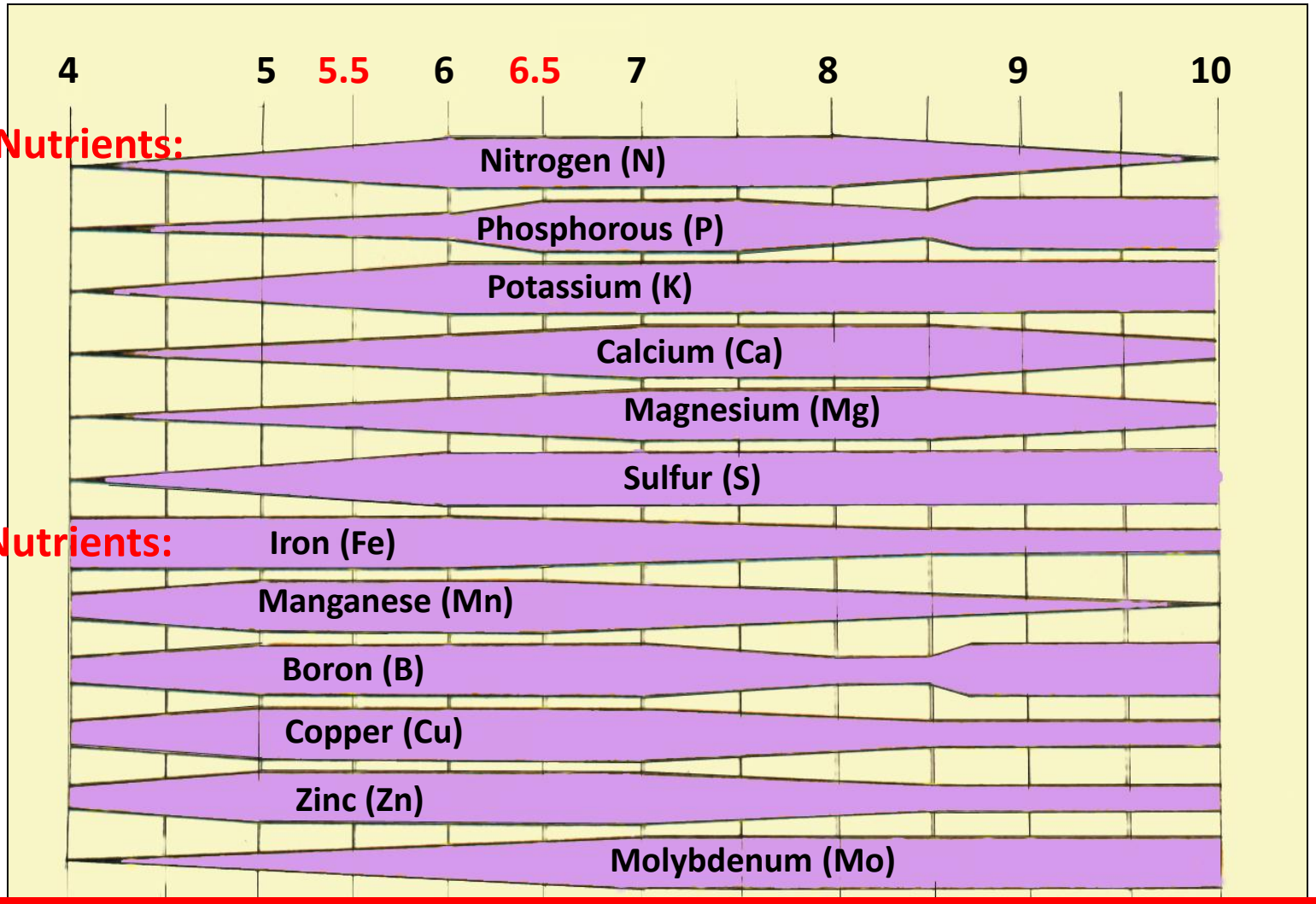
(NRAES: 30 – 100 ppm)

Can be low on high pH soils (> 7.4) and some sandy soils.

- If Fe is low.
  - Apply Fe chelate as a foliar spray at a rate of 1-2 lb/A. per application.
    - Start early and repeat every 10-20 days (*refer to label*).
  - Take measures to lower the soil pH.

High pH Soils

Can go to foliar applications of the micro nutrients.



Summary of Grape Fertilizer Management

- **Pre-plant:**
  - Soil Test: **pH, P, K, Mg, Zn, CEC, O.M.**
  - Amend soil as needed and incorporate.
- **First year:** Apply some N after planting (~.5 oz actual N/vine) , to get vines off to a good start.
- **Second year:** Apply 30-40 lbs actual N/acre, adjusted based on the soil organic matter content.
- **When production begins:**
  - Begin petiole analysis on an annual basis.
  - Adjust N fertilizer rates based on test results and vine vigor.
  - Apply other nutrients as needed based on petiole analysis results.
- **DO NOT apply any nutrients unless there is a need!**