

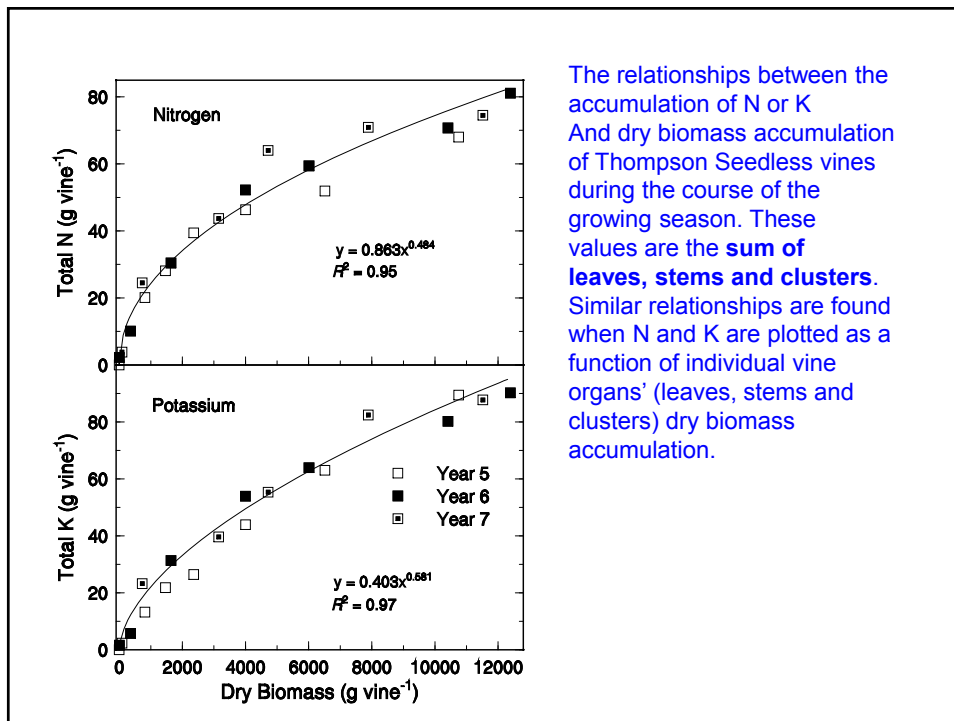
Mineral Nutrition of Grapevines: Nitrogen

Larry E. Williams

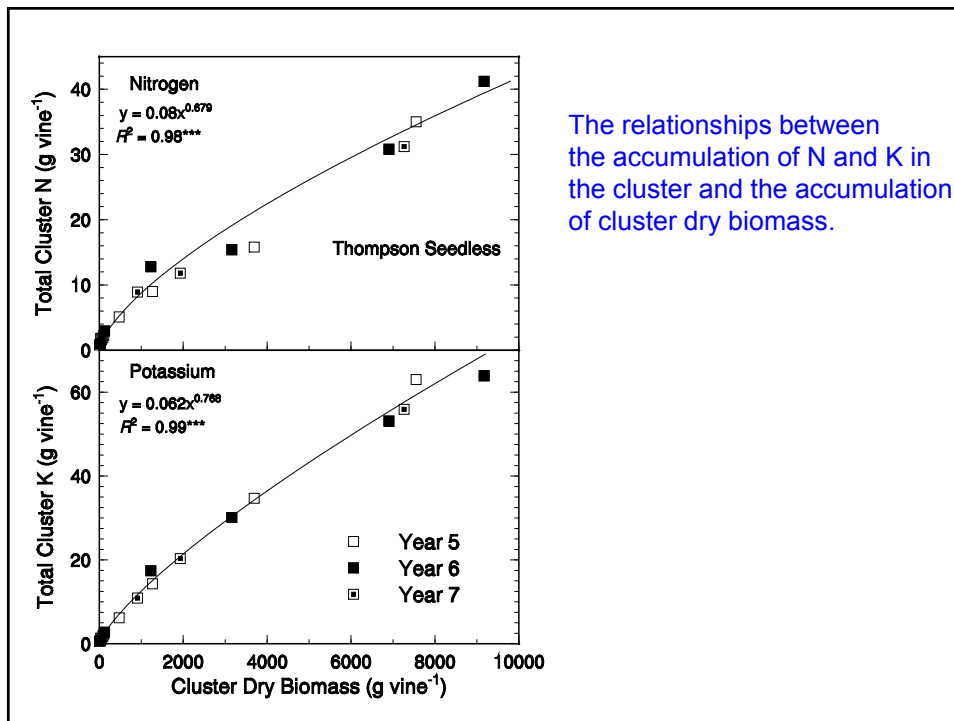
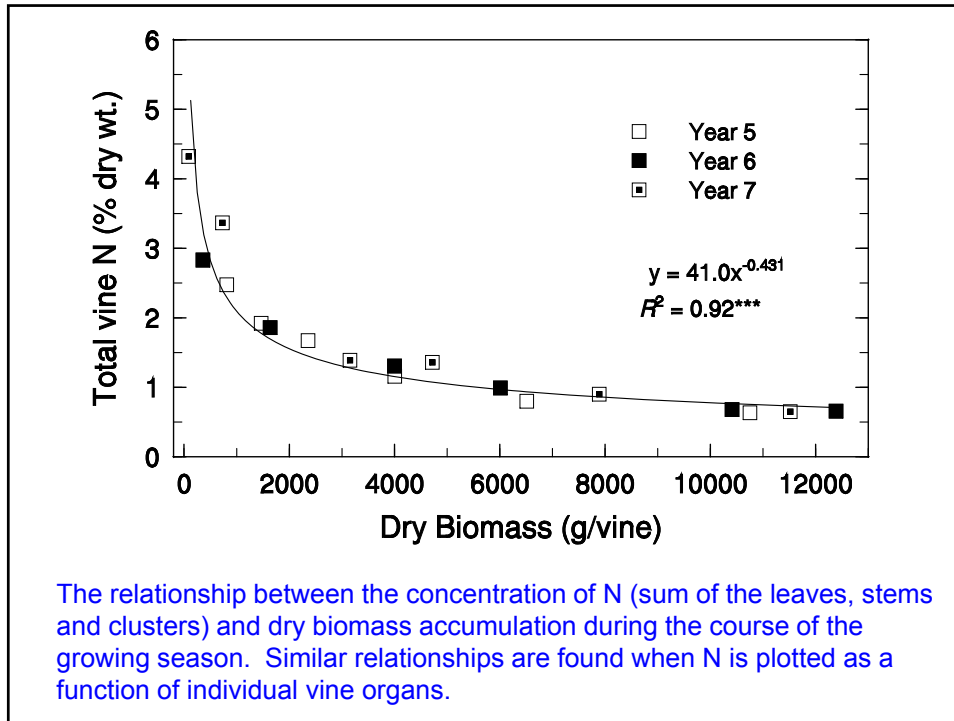
Department of Viticulture and Enology
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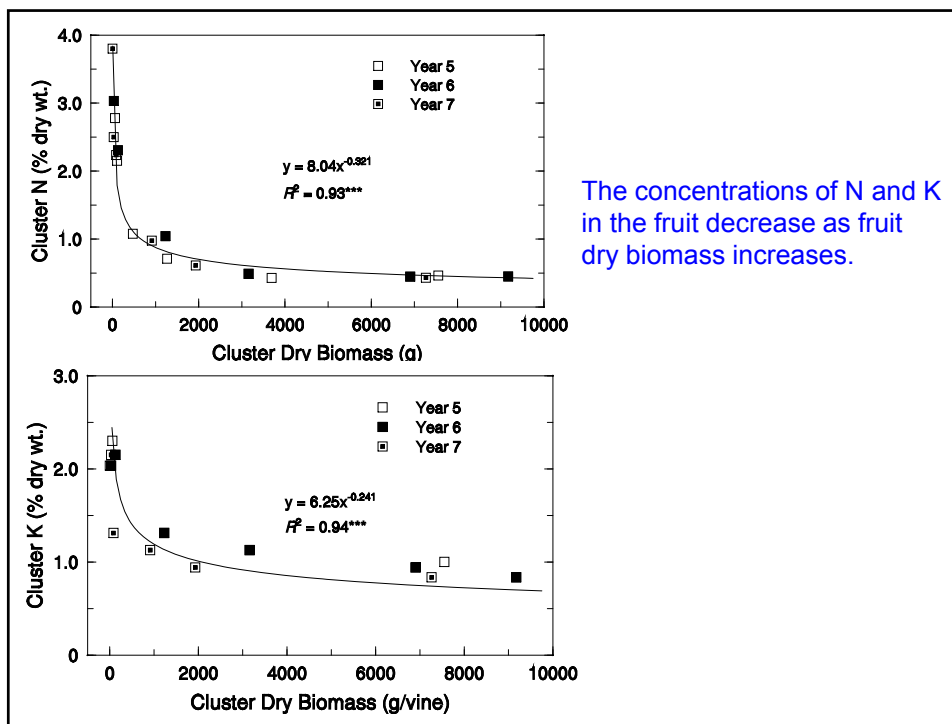
What drives the uptake
of mineral nutrients in
grapevines?

The uptake of mineral nutrients in plants is driven by growth (Ingestad, 1981) to include grapevines (Keller, 2005). Wermelinger et al. (1991) assumed that N demand was a linear function of dry biomass accumulation in their model of grapevine growth.

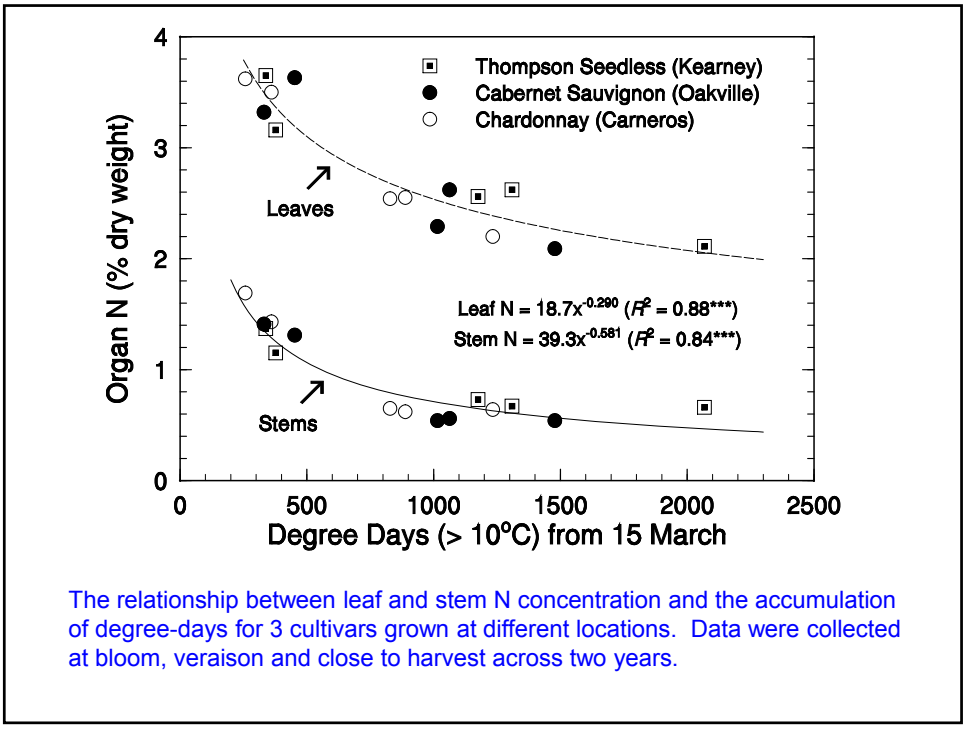


The relationships between the accumulation of N or K And dry biomass accumulation of Thompson Seedless vines during the course of the growing season. These values are the **sum of leaves, stems and clusters**. Similar relationships are found when N and K are plotted as a function of individual vine organs' (leaves, stems and clusters) dry biomass accumulation.

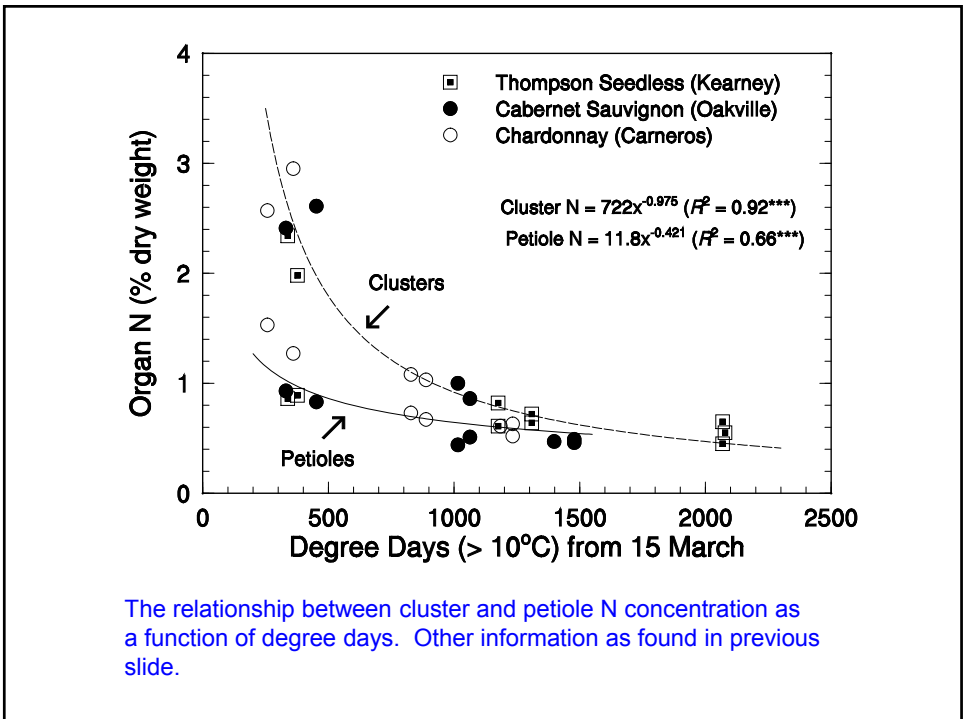




What happens to the concentration of N during the growing season?



The relationship between leaf and stem N concentration and the accumulation of degree-days for 3 cultivars grown at different locations. Data were collected at bloom, veraison and close to harvest across two years.



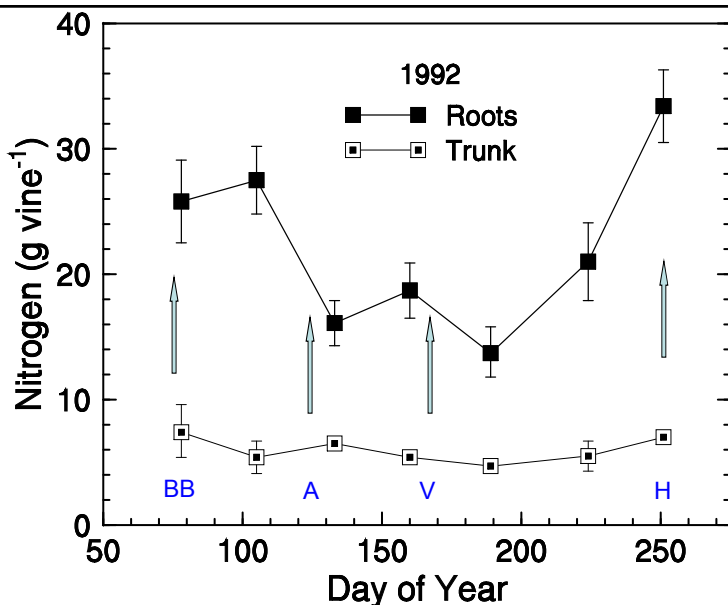
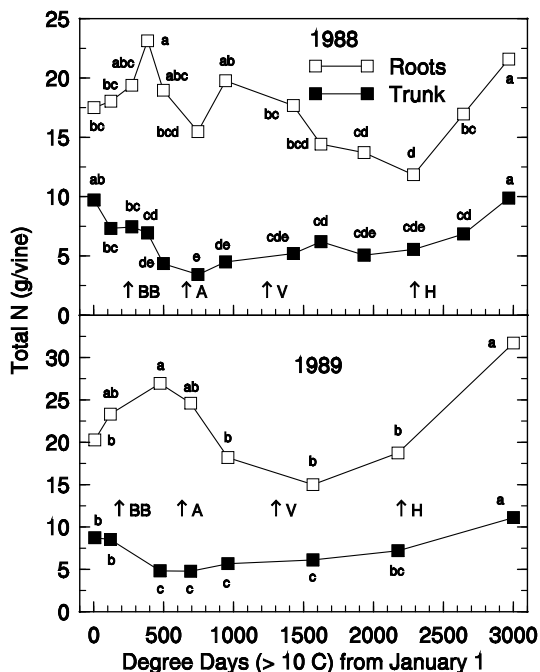
The relationship between cluster and petiole N concentration as a function of degree days. Other information as found in previous slide.

Summary:

- Nitrogen and K uptake are curvilinearly related to both seasonal vine water use and biomass accumulation of Thompson Seedless grapevines.
- The curvilinear relationship was more than likely due to the separation of vegetative and reproductive growth demands of N and K during the season.
- It is unknown whether the greater N and K uptake during the early portion of the growing season was due to an active uptake of both mineral nutrients or redistribution of N and K from the permanent structures of the vine.
- The concentration of N in the organs of grapevines decreases as the season progresses and is a function of the accumulation of degree days.

Dynamics of N Reserves in the Roots and Trunk and their utilization to support current season's growth of shoots (leaves, stems and clusters).
How important is the post-harvest period for the replenishment of N reserves?

Total N in the roots and trunk of Thompson Seedless grapevines across two seasons. BB, A, V and H refer to budbreak, anthesis (bloom), veraison and harvest, respectively. An increase in N indicates the accumulation of N while a decrease indicates the loss of N from the root or trunk. Vines were 4 and 5 years old in 1988 and 1989, respectively.



Total N in the trunk and roots of 6 year old Thompson Seedless grapevines from budbreak (BB), through anthesis (A), veraison (V) and harvest (H).

Metrics of the utilization of N reserves:

- N in the trunk is used to support root growth early on.
- Very little N reserves are used to support initial shoot growth (up to mid to late April)
- ~ 20% of the N reserves were used through fruit harvest one year, 17% used through July 24th another year and 28% through July 7th another year.
- If one calculates from budbreak to fruit harvest, reserves contributed 11 and 4% of shoot N requirements during two of the growing seasons.
- During the 6th growing season, N reserves in the roots and trunks had been completely replenished by fruit harvest.

The amount of N in the vine at harvest (9/5) and that at the end of the growing season (all leaves have fallen from the vine). The bottom row is the change in N from harvest to the end of the season. EOS stands for end of season.

Date	Clusters	Leaves	Stems	New Total	Fruiting canes	Trunk	Roots
	----- (g N / vine) -----						
9/5	32.0	30.0	11.1	73.1	2.2	7.0	18.8
EOS	<u>31.1</u>	<u>15.6</u>	<u>12.1</u>		<u>2.5</u>	<u>11.1</u>	<u>31.7</u>
Δ 9/5	---	-14.4	+1.0		+0.3	+4.1	+12.9

Values above are equivalent to lbs. per acre.

Approximately 50% of the N in the leaves at harvest will remain in the leaves that fall from the vine.

The loss of N from the leaves between harvest and EOS account for 85% of the N accumulated in the trunk and roots after harvest.

Comparison of 28 year-old Thompson Seedless grapevines that were fertilized with 34 g N per vine and those not fertilized and harvested at fruit maturity.

Treatment	Organ	Dry Bio. (g/vine)	N conc. (% dry wt.)	Total N (g/vine)	Woody N (g/vine)
'-N'	Leaves	1370	1.620	22.2	---
Current years	Fruit	6324	0.437	27.7	---
58.9 g/vine	Stems	1438	0.502	7.2	7.2
78.0 kg/ha	F.C.	411	0.448	1.8	1.8
69 lbs/acre	Trunk	8730	0.364	31.8	31.8
	Roots	<u>5240</u>	0.962	50.4	<u>50.4</u>
'+N'	Leaves	1592	1.746	27.8	---
Current years	Fruit	6175	0.550	34.0	---
73.5 g/vine	Stems	1623	0.604	9.8	9.8
97.3 kg/ha	F.C.	368	0.522	1.9	1.9
87 lbs/acre	Trunk	8650	0.394	34.1	34.1
	Roots	<u>5300</u>	1.318	69.8	<u>69.8</u>

Root N reserves (those found in the roots and trunk) can be refilled with N fertilizer applied during the growing season (fertilized 1 month after budbreak and after berry set).

Utilization of Nitrogenous and Potassium Reserves

- N may be translocated from the permanent structures of the vine (the trunk early on and roots later) to the shoots. The reserves may supply 10 to 25% of the total N needed for shoot/fruit growth at some point during the season.
- The vine's N reserves can be restored with N from the leaves as they senesce. This occurs from harvest through the end of leaf fall. They can also be restored with N taken up from the soil or fertilizer prior to or after harvest.
- Potassium is primarily derived from the soil with little coming from the permanent organs.

Uptake of ^{15}N labeled grapevine leaves and canes the year after incorporation into the vineyard's soil. Below data indicate that the N in the leaves and prunings can be taken up the following year.

Irrigation Treatment	Applied Tissue N (g vine ⁻¹)	Total Vine Biomass (kg vine ⁻¹)	Recovered ^{15}N labeled tissue (%) ^a
<u>Drip Irr.</u>			
Leaves	18.5 ± 1.6	14.1 ± 1.0	4.73 ± 0.92
Canes	18.9 ± 2.1	16.6 ± 1.1	1.46 ± 0.43
<u>Furrow Irr.</u>			
Leaves	18.1 ± 2.1	16.7 ± 0.9	4.95 ± 0.45
Canes	24.1 ± 2.3	16.7 ± 0.5	2.05 ± 0.92

^a The scientific literature values range from 6 to 29% (based mostly on agronomic crops) the year following incorporation into the soil.

N budget of vines across cultivars, grape production techniques and locations.

The average, high and low amounts of several mineral nutrients in one ton of fruit from grapevines (from Biology of the Grapevine).

Mineral Nutrient	Average	High	Low
	------(lbs. / t)-----		
N	2.92	4.12	1.80
P	0.56	0.78	0.44
K	4.94	7.38	3.18
Ca	1.00	1.86	1.08
Mg	0.20	0.32	0.10

N BUDGET OF THOMPSON SEEDLESS GRAPEVINES

Growth Period

Leaves	~35 g/vine
Shoots	~10 g/vine
Clusters	<u>~30 g/vine</u>
	75 g/vine

After Harvest

Fallen leaves	~10 -15 g/vine
Prunings	~15 g/vine
Remolilization	<u>~ 10 -15 g/vine</u>
	35 - 45 g/vine

g per vine are equivalent to lbs per acre with these vine and row spacings

Effects of Irrigation treatment on total vine % N and K and the amounts of those two nutrients per unit area at harvest of **5 year-old** Thompson Seedless vines.

Total vine	Irrigation treatment (fraction of applied H ₂ O amts)			
	0.2	0.6	1.0	1.4
N (% dry wt)	0.81 a	0.70 b	0.75 ab	0.73 ab
K (% dry wt)	0.72 bc	0.63 c	0.82 b	0.95 a
lbs. N/ ton	2.36	2.14	2.44	2.40
lbs. K/ ton	3.28	2.56	3.30	4.42
lbs. N/acre	52	79	95	97
lbs. K/acre	46	72	104	125

Comparison of **28 year-old** Thompson Seedless grapevines that were fertilized with 34 g N per vine and those not fertilized.

Treatment	Organ	Dry Bio. (g/vine)	N conc. (% dry wt.)	Total N (g/vine)	Woody N (g/vine)
'-N'	Leaves	1370	1.620	22.2	---
Current years	Fruit	6324	0.437	27.7	---
58.9 g/vine	Stems	1438	0.502	7.2	7.2
78.0 kg/ha	F.C.	411	0.448	1.8	1.8
69 lbs/acre	Trunk	8730	0.364	31.8	31.8
	Roots	<u>5240</u>	0.962	<u>50.4</u>	<u>50.4</u>
	Total	23,513		141.1	91.2
'+N'	Leaves	1592	1.746	27.8	---
Current years	Fruit	6175	0.550	34.0	---
73.5 g/vine	Stems	1623	0.604	9.8	9.8
97.3 kg/ha	F.C.	368	0.522	1.9	1.9
87 lbs/acre	Trunk	8650	0.394	34.1	34.1
	Roots	<u>5300</u>	1.318	<u>69.8</u>	<u>69.8</u>
	Total	23,708		177.4	115.6

Effect of vineyard location,
cultivar and year on the amount
of N found in the fruit and that
needed to produce a crop.

The amount of N per ton of fruit at four vineyard
locations across three years.

Location	Year	Total N		
		----- (pounds per ton of fruit) -----		
		<u>1997</u>	<u>1998</u>	<u>1999</u>
Carneros (Chardonnay)		2.68	2.50	2.58
Gonzales (Chardonnay)		2.48	2.56	2.88
Oakville (Cab. Sauvignon)		1.96	2.48	2.70
Paso Robles (C.S.)		3.16	3.02	2.76

The amount of N in the fruit at harvest, leaves as they fell from the vines and prunings taken during the winter at four locations and across years.

Location	Total N (clusters, leaves and prunings)		
	----- (pounds per acre) -----		
Year	<u>1997</u>	<u>1998</u>	<u>1999</u>
Carneros	52.2	37.9	42.5
Gonzales	42.0	23.5	36.7
Oakville	39.8	38.2	36.8
Paso Robles	38.9	41.0	32.6

Values would be greater if the N in leaves had been determined at harvest.

The effect of cultivar and year on total fruit fresh biomass at harvest, pounds of N in the fruit at harvest per acre and lbs. N per ton of fruit. Also included is the total N per vine in the leaves, stems and clusters at harvest and petiole NO₃-N at bloom and veraison.

Cultivar	Fruit metrics				Total Vine lbs. N/acre	NO ₃ -N bloom/veraison
	kg/vine	t/acre	lbs. N/acre	lbs. N/ton		
Traver/Laton						
Flame S.						
2014	31.0	24.7	69.9	2.82	181	2854 / 1635
2015	32.8	26.1	76.9	2.94	134	1645 / 2368
2016	34.8	27.8	89.5	3.22	182	1106 / 1344
Princess						
2015	24.4	21.9	57.7	2.63	160	1498 / 3020
2016	39.9	31.8	81.0	2.55	175	2532 / 406
A. King						
2015	43.1	34.4	128	3.71	211	1397 / 1022
2016	35.2	28.1	68.3	2.41	131	1528 / 842
Sheegene						
2016	30.1	24.0	61.6	<u>2.57</u>	165	2020 / 1747
				2.86		

The effect of N treatments on total fruit fresh biomass at harvest, pounds of N in the fruit at harvest per acre and lbs. N per ton of fruit of **Flame Seedless** and **Autumn King** (both Selma). Also included is the total N per vine in the leaves, stems and clusters at harvest and petiole NO₃-N at bloom and veraison.

Cultivar	Fruit metrics				Total Vine	NO ₃ -N
	kg/vine	t/acre	lbs. N/acre	lbs. N/ton (% dry wt.) ↓	lbs. N/acre	bloom/veraison
Flame S.						
0-s	13.6	9.1	9.4	1.03 (0.25)	45.1	< 5 / < 5
0-ma	17.0	11.3	12.6	1.12 (0.26)	46.1	78 / < 5
x-s	15.3	10.2	12.2	1.20 (0.30)	55.9	23 / < 5
x-ma	14.3	9.5	12.1	1.27 (0.30)	67.1	17 / < 5
2.5x-s	19.4	12.9	18.4	1.42 (0.34)	73.7	203 / < 5
2.5x-ma	18.0	12.0	19.7	1.64 (0.40)	92.3	90 / < 5
A. King						
0-s	31.8	21.2	53.2	2.50 (0.75)	141.1	1551 / 2026
x-s	25.9	17.2	42.2	2.45 (0.76)	137.5	2179 / 2407
2.5x-s	24.6	16.4	44.9	2.73 (0.91)	128.3	2959 / 3046

Table 9a. Total N (sum of the N in leaves, stems and clusters) of **Flame Seedless** as a function of N fertilizer treatment and growth stage (bloom, veraison and harvest). Values in the percent of N at harvest (% at hrvt) are the percentage of N accumulated at bloom and veraison compared to the accumulation of N at harvest.

N Trtmnt	Total N				
	(Bloom)	(Veraison)	(Harvest)	Harvest	Harvest
	(g/vine)			(kg/ha)	(lbs/acre)
0-s	49.4	102.1	109.4	196.0	174.6
0-ma	47.5	107.2	120.9	216.7	193.0
x-s	55.4	103.6	106.7	191.2	170.3
x-ma	53.6	102.3	102.8	184.2	164.1
2.5x-s	55.9	117.0	120.9	216.7	193.0
2.5x-ma	<u>54.3</u>	<u>109.1</u>	<u>119.1</u>	<u>213.4</u>	<u>190.1</u>
mean	52.7	106.9	113.3	203.0	180.8
% at hrvt	46.5	94.3	--	--	--

Leaf and stem biomass of FS is 60 and 90% greater than TS on a per acre basis.
Leaf and stem N concentration of FS much higher than TS at harvest (in July)

Grapevine N Fertilizer Program

- 1.) Assessing vineyard/vine N status
- 2.) Determination of N fertilizer amounts
- 3.) Kinds of N fertilizers
- 4.) Timing of fertilization events
- 5.) Effects of N on vegetative and reproductive growth

1.) Assessing vine nutrient status

- a.) deficiency symptoms
- b.) soil analysis
- c.) tissue analysis

1.) Assessing vine nutrient status

- a.) deficiency symptoms –
by the time this is observed
vine growth may already be
adversely affected.

1.) Assessing vine nutrient status

b) Soil analysis

“Soil Analysis is of no value in determining N needs. This is due to the transient nature of its main available form (NO_3) in the soil profile and the unavailability of organic-N fraction until it is mineralized.”

L.P. Christensen, UCCE Specialist
Raisin Production Manual

1.) Assessing vine nutrient status

c.) Tissue Analysis – criteria for usefulness

- The tissue used and the mineral nutrient measured should be related to the mineral nutrient status or its concentration in other organs of the vine.
- The tissue used and the mineral nutrient measured should be related to vegetative and reproductive growth of the vine.
- A critical value or its range for the mineral nutrient in the organ measured should be robust enough to cover a wide range of vineyard or grapevine situations.

1.) Assessing vine nutrient status

c.) Tissue Analysis

- Time of Sampling
- Type of Tissue Sampled
- Form of Nitrogen

Time of Sampling

Bloom and/or Veraison

- Definite Growth Stage
- Repeatable
- Convenient

Type of Tissue Sampled

- Petioles of mature leaves or those from opposite the cluster at bloom
- Petioles of mature leaves at veraison
- Leaf blades
- Fruit at harvest
- Canes during dormancy

Form of Nitrogen

Petioles – $\text{NO}_3\text{-N}$, $\text{NH}_4\text{-N}$, total N

Leaf Blades – total N

Fruit – total N, arginine, YANC

Canes – total N, arginine

NITRATE-NITROGEN Bloom Petiole Levels (ppm)

	Nitrate-Nitrogen (ppm)
Deficient	Less than 350
Questionable	350 - 500
Adequate	500 – 1,200
Excessive	Over 2,000
Possibly toxic	Over 3,000

The next slides show the relationships among petiole $\text{NO}_3\text{-N}$ and petiole and grapevine organ (leaves, stems and cluster) N concentrations, total vine N, cluster number per vine and yield.

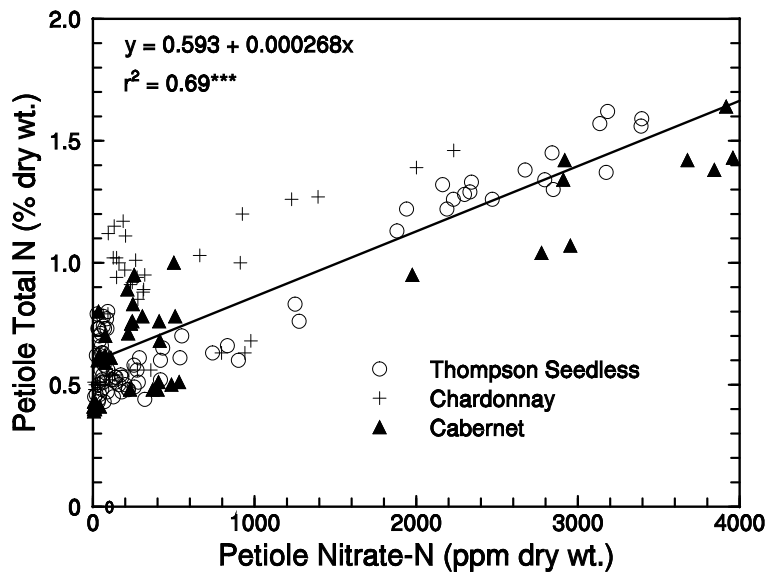
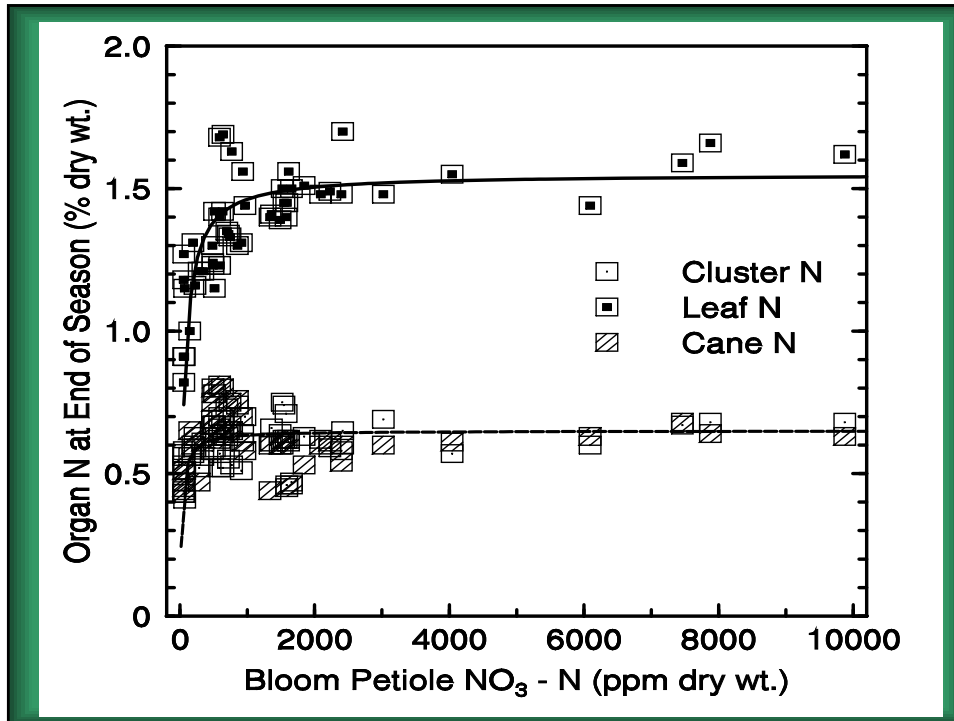
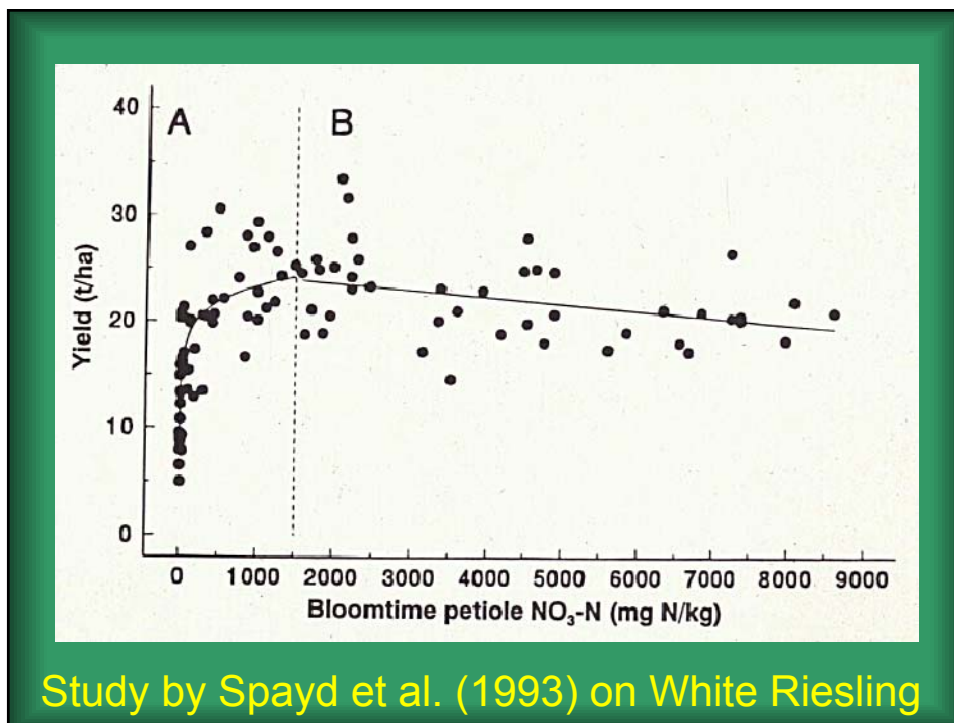
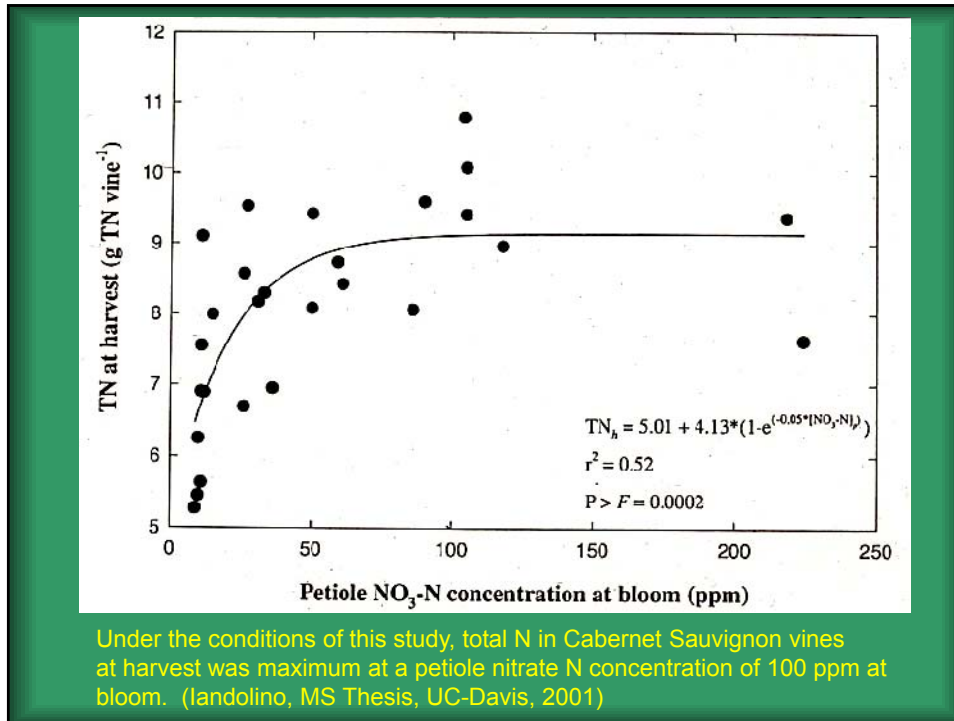


Figure 1. The relationship between petiole nitrate-N and petiole total N for three cultivars.



The previous slide shows that the concentration of N in the leaves, stems and clusters of Cabernet Sauvignon and Chardonnay on 5 different rootstocks does not decrease significantly until petiole NO₃-N decreases to very low values.



The study by Spayd et al. (1993) found that yield of White Riesling increased almost five-fold when petiole nitrate-N values increased from 7 to approximately 200 ppm and then leveled off after that.

The effect of different irrigation and applied N treatments on return bud fruitfulness of **Thompson Seedless** grapevines.

Treatment in 2001	Bloom 2001 Nitrate-N (ppm dry wt.)	Bloom 2001 Total N (% dry wt.)	Shoot # 2002 (# / 4 vines)	Cluster # 2002 (# / 4 vines)
No Irr./No N	64	0.72	365	159 b
Irrigated/No N	42	0.70	333	157 b
Irrigated/50 lbs. N	2450	1.33	359	200 a
Irrigated/100 lbs. N	2804	1.39	380	215 a

The effect of different irrigation and applied N treatments on return bud fruitfulness of **Chardonnay** and **Cabernet Sauvignon** grapevines.

Treatment in 2001	Bloom 2001 Nitrate-N (ppm dry wt.)	Bloom 2001 Total N (% dry wt.)	Cluster # 2002 (#/6 vines)
Chardonnay			
No Irr./No N	262	0.94	123
Irrigated/No N	152	1.02	171
Irrigated/80 lbs	1979	1.32	151
Cabernet Sauvignon			
No Irr./No N	145	0.73	144
Irrigated/No N	299	0.76	142
Irrigated/40 lbs	--	--	148
Irrigated/80 lbs	3215	1.30	144

The effect of three applied N treatments in 2014 on bloom petiole nitrate-N and total N of **Scarlett Royal** grapevines and return fruitfulness in 2015. Applied N is that removed in the crop the previous year.

Treatment in 2014	Bloom 2014 Nitrate-N (ppm dry wt.)	Bloom 2014 Total N (% dry wt.)	Cluster # 2015 (# / 4 vines)
No N	107 c	0.90 c	212 b
1.0 N	836 b	1.14 b	220 ab
2.5 N	1460 a	1.26 a	229 a

Effect of N fertilizer amounts and the timing of their application imposed in 2016 on return fruitfulness of three table grape cultivars in 2017. Data are expressed as cluster # per four vines.

(Values in parentheses are petiole NO₃-N from bloom in 2016)

Flame Seedless ----- N Fertilizer Amount -----				
Fertilizer Timing	0	1.0 x	2.5 x	Ave. Effect Timing
2 Slug Applications	162	193	202	185
10 Applications	<u>157</u>	<u>207</u>	<u>236</u>	200
Ave. Effect Amt.	159 b (42)	200 a (20)	219 a (146)	

Scarlet Royal ----- Fertilizer Amount -----				
Fertilizer Timing	0	1.0 x	2.5 x	Ave. Effect Timing
2 Slug Applications	213	226	220	220
10 Applications	<u>195</u>	<u>221</u>	<u>226</u>	214
Ave. Effect Amt.	204 (306)	223 (1072)	223 (1394)	

Crimson Seedless ----- Fertilizer Amount -----				
Fertilizer Timing	0	1.0 x	2.5 x	Ave. Effect Timing
2 Slug Applications	174	157	167	165
10 Applications	<u>153</u>	<u>157</u>	<u>169</u>	160
Ave. Effect Amt.	164 (151)	157 (644)	168 (838)	

Conclusions:

- The relationship between petiole nitrate-nitrogen and N concentration in the leaves, fruit and canes in several studies, total N in the vine at harvest and bud fruitfulness in response to N fertilizers indicates that a bloom-time petiole NO₃-N value of 200 ppm would be “adequate.” Nitrate values in the petioles at bloom below 100 ppm decreased percent N in those organs only slightly.
- A bloom-time petiole NO₃-N value less than 100 ppm one year may significantly reduce return fruitfulness the next. It is unsure whether it would adversely affect yields. If values less than 100 ppm occurred several years in a row one should assume its time to fertilize with N.

Grapevine Fertilization Program

2.) Determination of fertilizer amounts

It will depend upon whether it is a maintenance program or one to correct a deficiency

- a.) for a maintenance program one needs to determine how much of the mineral nutrient is removed from the vineyard (i.e. develop a N budget)
- b.) determine the efficiency with which fertilizer is taken up.

The average, high and low amounts of several mineral nutrients in one ton of fruit from grapevines.

Mineral Nutrient	Average	High	Low
	------(lbs. / t)-----		
N	2.92	4.12	1.80
P	0.56	0.78	0.44
K	4.94	7.38	3.18
Ca	1.00	1.86	1.08
Mg	0.20	0.32	0.10

Grapevine Fertilization Program

3.) Kinds of N fertilizers

“Generally the choice of the formulation of nitrogen can be based mostly upon cost.”

L.P. Christensen, UCCE Specialist

Applied water amounts (via drip or flood irrigation), nitrate N (NO₃-N) in the irrigation water (and equivalents) and applied N in the fertilizer treatments (x or 2.5x amounts) for the Scarlet Royal and Crimson Seedless vineyards during the 2015 growing season. No fertilizer N was applied to the Flame Seedless vines in 2015.

		Irrigation	Flame	Scarlet	Crimson
		Type	Seedless	Royal	Seedless
Applied water	L/vine	Drip	2279	4051	4327
		Flood	<u>2432</u>	<u>549</u>	<u>2472</u>
		Total	4711	4600	6799
	Gal./vine	Drip	603	1072	1145
		Flood	<u>643</u>	<u>145</u>	<u>654</u>
		Total	1246	1217	1799
	mm	Total	844	824	761
	inches	Total	33.2	32.4	30.0
NO ₃ -N	mean (ppm)	---	7.82 (8.11)	5.02 (4.39)	3.80 (3.78)
N equivalents	g N/vine		36.8	23.1	25.8
	kg N/ha		65.9	41.4	28.9
<u>N amount in the water</u> →		lbs. N/acre	58.7	36.9	25.8
Applied N	x treatment	g N/vine	---	31.3	42.3
	2.5x treatment	g N/vine	---	78.3	105.8

Grapevine Fertilization Program

4.) Timing of fertilization events

One must know when the N is being utilized by the vine to choose the appropriate date to apply the fertilizer.

L.E. Williams' recommendation for N fertilization application timing

Split applications^a

1st application – one month after BB
2nd application – just after berry set.

^a apply one half the total fertilizer to be used each time.

When do you not want to apply an inorganic nitrogen fertilizer?

- 1.) Avoid applying N in winter/early spring if the fertilizer is susceptible to leaching during this season.
- 2.) An application of N fertilizer just prior to or at bloom may increase the amount of berries that fail to set.
- 3.) A post-harvest application of an N fertilizer is probably not as efficient as some thought. For one to consider this time as appropriate, one needs to assess vine health, length of season remaining and soil type.

Values of fertilizer recovery efficiency (RE_N)

- 7 – 11% on Concord (dry-farmed in New York State (US)).
- 24 to 27% on Thompson Seedless (two fertilizer forms, nitrate and ammonia, drip irrigated)
- 4 – 11% Cabernet and Chardonnay drip irrigated vineyards (on different rootstocks)
- 24 – 29% using two amounts of ammonium nitrate fertilizer. Drip irrigated Cabernet Sauvignon.
- 70% on 50 year-old Sultana (Thompson Seedless) vines grown in Australia.

Effect of irrigation type and form of nitrogen on N fertilizer recovery efficiency (RE_N) and NDF.

Treatment	Recovery of ¹⁵ N Fertilizer (g ¹⁵ N fert. vine ⁻¹)	RE _N (g ¹⁵ N vine ⁻¹ /g ¹⁵ N fert.)*100	NDF (g ¹⁵ N vine ⁻¹ /g N vine ⁻¹)*100
<u>Drip Irr.</u>			
NO ₃	10.6	42.4%	10.4%
NH ₄	9.3	37.3%	8.2%
NO ₃ /Cont.	11.1	40.3%	11.4%
<u>Furrow Irr.</u>			
NO ₃	3.3 a	13.3% a	4.9% a
NH ₄	2.6 b	10.4% b	3.2% b

Petiole NO₃-N at bloom was 1011 ppm (dry weight basis)

Comparison of 28 year-old Thompson Seedless grapevines that were fertilized with 34 g N per vine and those not fertilized.

Bloom petiole NO₃-N for '-N' treatment was 94 ppm (dry wt. basis).

Treatment	Organ	Dry Bio. (g/vine)	N conc. (% dry wt.)	Total N (g/vine)	Woody N (g/vine)	
'-N' Current years 58.9 g/vine 78.0 kg/ha 69 lbs/acre	Leaves	1370	1.620	22.2	---	
	Fruit	6324	0.437	27.7	---	
	Stems	1438	0.502	7.2	7.2	
	F.C.	411	0.448	1.8	1.8	
	Trunk	8730	0.364	31.8	31.8	
	Petiole	Roots	<u>5240</u>	0.962	<u>50.4</u>	<u>50.4</u>
	Total		23,513		141.1	91.2
' +N' Current years 73.5 g/vine 97.3 kg/ha 87 lbs/acre	Leaves	1592	1.746	27.8	---	
	Fruit	6175	0.550	34.0	---	
	Stems	1623	0.604	9.8	9.8	
	F.C.	368	0.522	1.9	1.9	
	Trunk	8650	0.394	34.1	34.1	
	RE _N =	Roots	<u>5300</u>	1.318	<u>69.8</u>	<u>69.8</u>
	>100%	Total	23,708		177.4	115.6

The amount of N measured in the vine after leaf fall of 28 year-old Thompson Seedless grapevines as a function of three N fertilizer treatments and removing ½ of the leaves on the vine after fruit harvest ('PH Def'). The N treatments were no applied N (-N), the application of 34 g/vine (40 lbs N/acre) during the growing season in two slug applications (1/2 each time)(+N) and a post-harvest application of N (25 g N/vine; 30 lbs N/acre) after harvest (PH + N). The PH + N treatment received no applied N during the growing season.

N Trtmnt	Total N* (g/vine)	Δ N From Harvest** (g/vine)	Leaf N Remobilized (g/vine)	N Uptake (g/vine)	RE _N (%)
'-N'	128.2	37.0	11.0	26.0	---
'+N'	142.0	26.4	13.7	12.7	---
'PH + N'	134.0	42.8	9.7	33.1	28.4*
'PH Def'	111.2	20.0	6.8	13.2	---

*RE_N of 'PH + N' = (N uptake ('PH + N') – N uptake ('-N')/ 25.0) x 100

*Sum of N in the stems, fruiting canes, trunk and roots after leaf fall

**Δ N = N in stems, fruiting canes, trunk and roots at leaf fall minus N in those organs at harvest. Control for -N, PH+N and PH Def was the -N treatment at harvest.

The effect of cultivar (Scarlet Royal 'Old'), year and N treatment on total N at harvest. Total N is the sum of the N in the leaves, stems and clusters at fruit harvest. Delta (Δ) N refers to the total amount of N (summed across years) in the treatment vines minus the total N in the 0 controls. Applied N is the sum of N applied across the three years. N fertilizer use efficiency (RE_N) is ΔN / applied N x 100.

Cultivar/ Treatment	2014	2015	2016	Total	Δ 0 N trt.	Applied N	RE _N
SR 'Old'	----- g N/vine -----						
0	86.6	119.2	108.4	314.2	---	---	---
x	106.7	151.9	145.2	403.8	89.6	118.7	75.6%
2.5x	107.1	155.5	147.8	410.4	96.2	296.7	32.5%
0-s	85.2	130.7	102.4	mean ↓	---	---	---
0-ma	88.0	107.6	114.2	314.1	---	---	---
x-s	105.1	142.3	138.7	386.1	72.0	122.7	58.7%
x-ma	108.2	161.4	151.6	421.2	107.1	114.6	93.4%
2.5x-s	107.2	153.8	152.2	413.1	99.0	306.8	32.3%
2.5x-ma	107.1	157.2	143.3	407.6	93.5	286.5	32.6%

Vineyard predominately drip irrigated.

Total N per vine (sum of leaves, stems and clusters) of **Flame Seedless (Selma)** at **Harvest**, the difference (Δ) between the mean of the 0 N controls and the N treatments (Trtmnt.) at that stage, applied N up to that date and the N fertilizer recovery efficiency (RE_N). The RE_N was calculated by dividing the difference (Δ 0 control) by the amount of fertilizer applied up to the date data were collected. (2016 data)

N Trtmnt.	Total N (g/vine)	Δ 0 Control (g/vine)	Applied N (g/vine)	RE_N (%)
0	34.3	---	---	---
x	46.2	11.9	25.1	47.4
2.5x	62.4	28.1	62.8	44.7
0-s	33.9	---	0	---
0-ma	34.7	---	0	---
x-s	42.0	7.7	19.3	39.9
x-ma	50.4	16.1	30.8	52.3
2.5x-s	55.4	21.1	48.3	43.7
2.5x-ma	69.4	35.1	77.2	45.5

Total N per vine (sum of leaves, stems and clusters) of **Flame Seedless (Selma)** at **Harvest**, the difference (Δ) between the mean of the 0 N controls and the N treatments (Trtmnt.) at that stage, applied N up to that date and the N fertilizer recovery efficiency (RE_N). The RE_N was calculated by dividing the difference (Δ 0 control) by the amount of fertilizer applied up to the date data were collected. (2017 data)

N Trtmnt.	Total N (g/vine)	Δ 0 Control (g/vine)	Applied N (g/vine)	RE_N (%)
0	38.2	---	---	---
x	61.0	22.8	24.4	93
2.5x	72.5	34.3	61.0	56
0-s	37.1	---	0	---
0-ma	39.3	---	0	---
x-s	59.7	21.5	27.1	79
x-ma	62.3	24.1	21.7	111
2.5x-s	78.9	40.7	67.8	60
2.5x-ma	66.0	27.8	54.2	51

Recommendations:

- Take petiole samples every year at bloom and possibly at veraison.
- Set up procedure for their collection and location within each vineyard.
- Decide on form of N to analyze and repeat every year.
- Get reliable counts of clusters each year prior to any cluster removal procedures.
- Have must analyzed for N at the winery and relate to petiole values measured at bloom or veraison.
- Come up with value for the amount of N per ton of fruit removed from your vineyard.
- Analyze soil for nitrates at some point to determine background amount of N present.
- Monitor irrigation water for N.