Updating Nutritional Strategies for Today's California European Pear Industry

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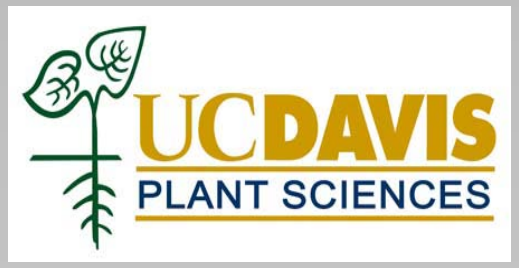


Updates to UC recommendations have changed over time, reflecting the changes in the industry – 1991, 2007

Why look again at nutritional recommendations?

- The sustainable pear growing program -- preliminary survey results from the Soil and Nutrient Management indicated research targets and benchmarking practices as a focus
- Current recommendations can be expanded to recognize
  - site-specific differences – grower surveys in Delta and North Coast
  - Growers' strategy differences = no 'one size fits all' approach to inputs and cropping goals

What Questions are we asking?

- What is the seasonal pattern of N partitioning
- What are the 'Best Practices'
  - When to apply
  - What form to apply
  - How much to apply
- How much Nitrogen is enough? Too little? Too much?
- How to measure Nitrogen? What tissue? When to sample?
- What plant growth responses are affected?
- How does N:K:Ca balance affect cropping and quality?

Delta Grower Survey 2008
Chuck Ingels, CPAB-funded
4300 acres, 11 growers surveyed

- Typical use ~120 #N_{act}/A/yr (Range = ~60-280 #N_{act}/A/yr)
- Some growers use vegetative vigor and cropping to adjust up or down, as well as current fertilizer pricing – including NO nitrogen in some years
- Average yields vary widely, ~20-34 tons/A, by orchard

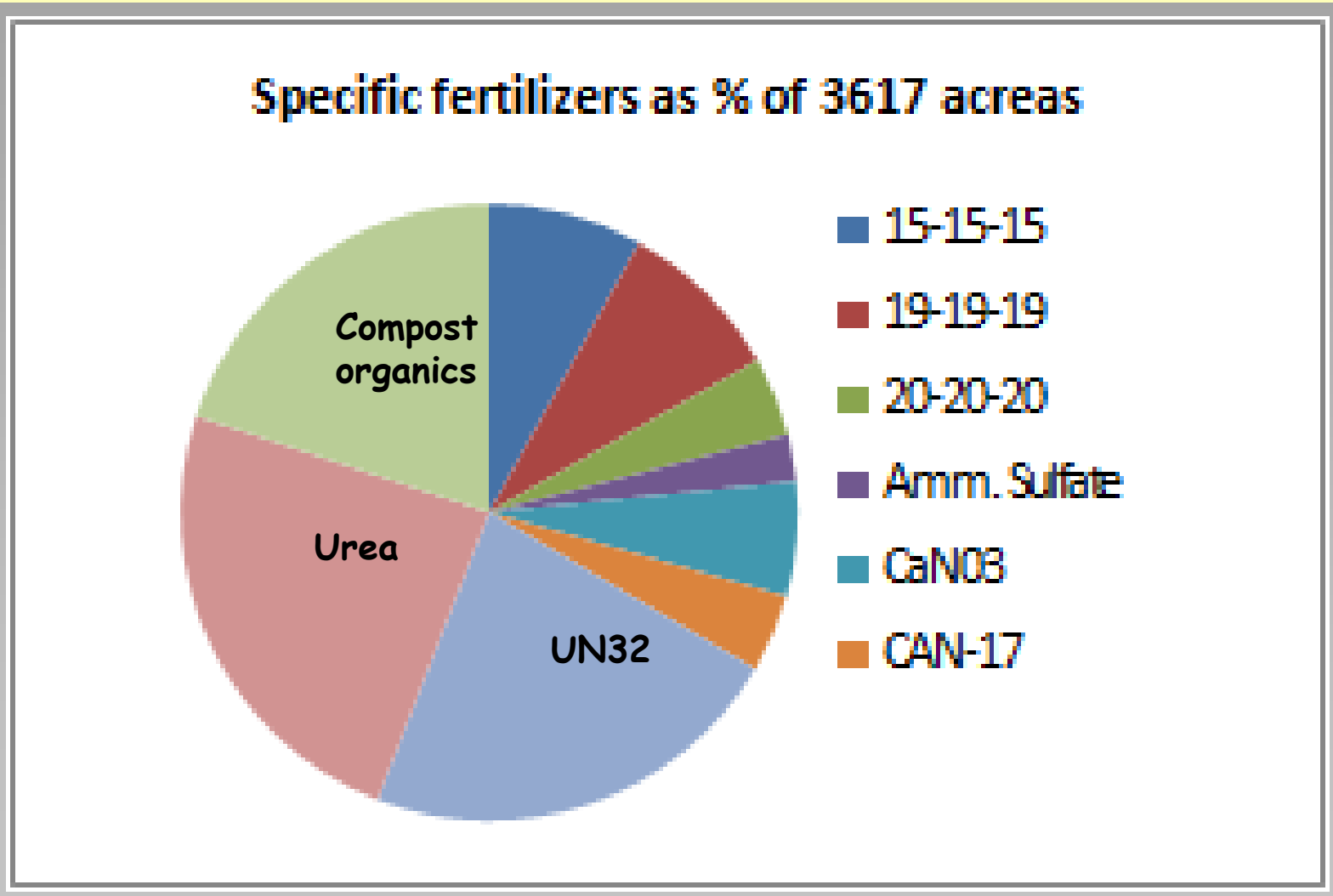
Grower	Frequency	Timing	Products	Quantity (lbs./acre)			Fertilization method
				Per timing	Total/yr	Based in part on	
1	2x/yr.	May, June	CAN-17	30 each	60		Injection
2	2x/mo.	through harvest	$CaNO_3$		60	Vigor	Injection
3	1x	$CaNO_3$	KNO_3	100	175	Vigor, crop load	Broadcast
	3x	Spring	$CaNO_3$	25 each			Broadcast
	2x/mo.	May, June	CAN-17		175		Injection
4	1x/yr.	PH	NH_4NO_3	100	150	Crop load	Broadcast
	2x/yr.	Spring	$CaNO_3$	25 each			
5	3x	Apr, June, PH	$CaNO_3$ or CAN-17		120-140		Broadcast Injection
6	2x/yr.	June, PH	UN-32	20 each	40	Vigor	Injection
7	2x/yr.	Apr, June	NH_4NO_3	30 each	120	Crop load, vigor	Broadcast
	1x/yr.	PH	NH_4NO_3	60			Broadcast
8	3-4x/yr.	Apr, May, June	UN-32 UN-32	100 50	150		Injection Injection
9	1x/yr.	June	$CaNO_3$		200		Broadcast
10	3x/yr.	Apr, May, June	$CaNO_3$		120		Broadcast
	1x/yr.	PH	$CaNO_3$	20			Broadcast
11	1x/yr.	Spring	$CaNO_3$	40-100	100-160	Crop load	Broadcast
	1x/yr.	PH	Urea	60			Broadcast

[1]PH = postharvest.

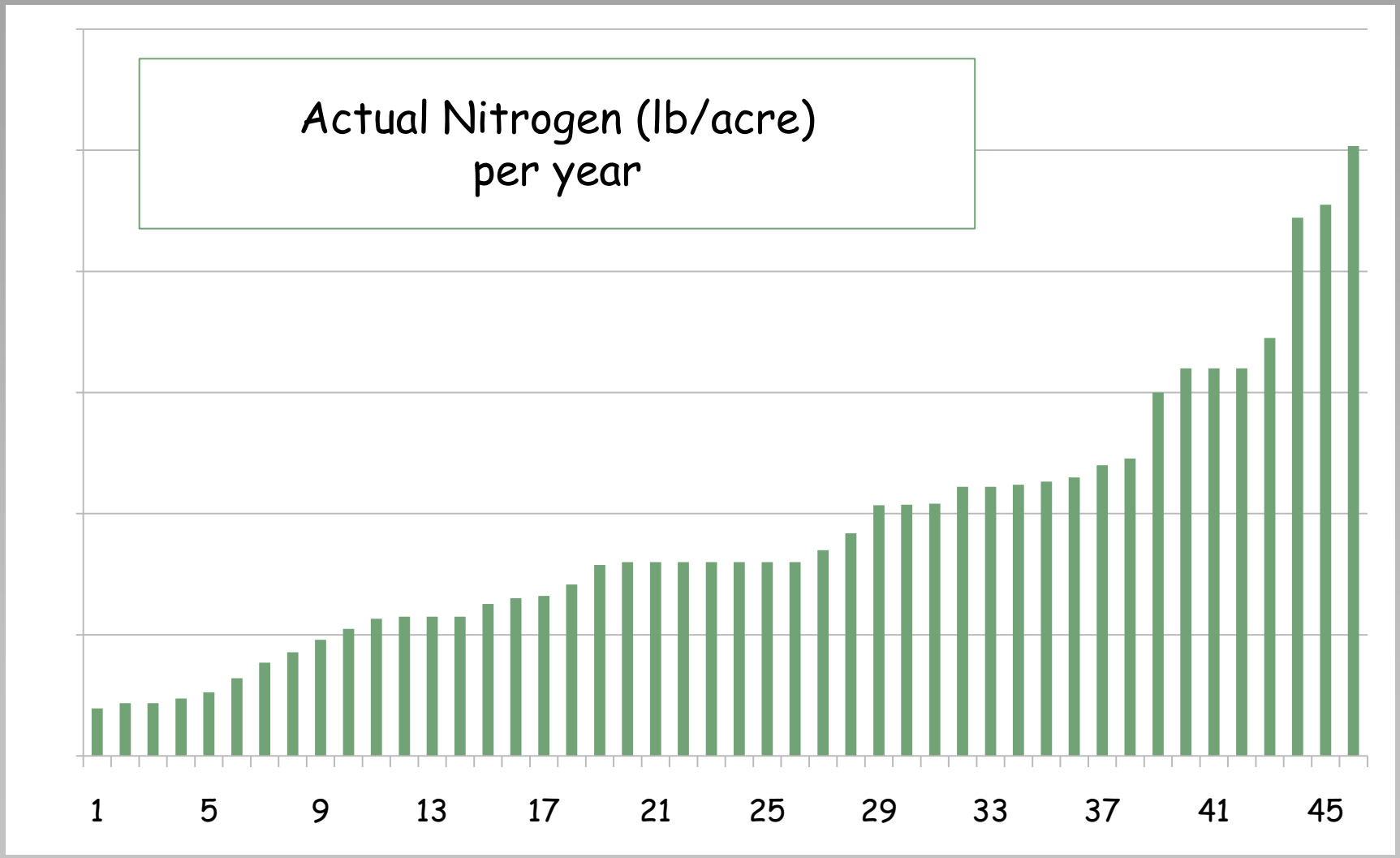
NORTH COAST SURVEY, 2010

RACHEL ELKINS, CPAB-funded

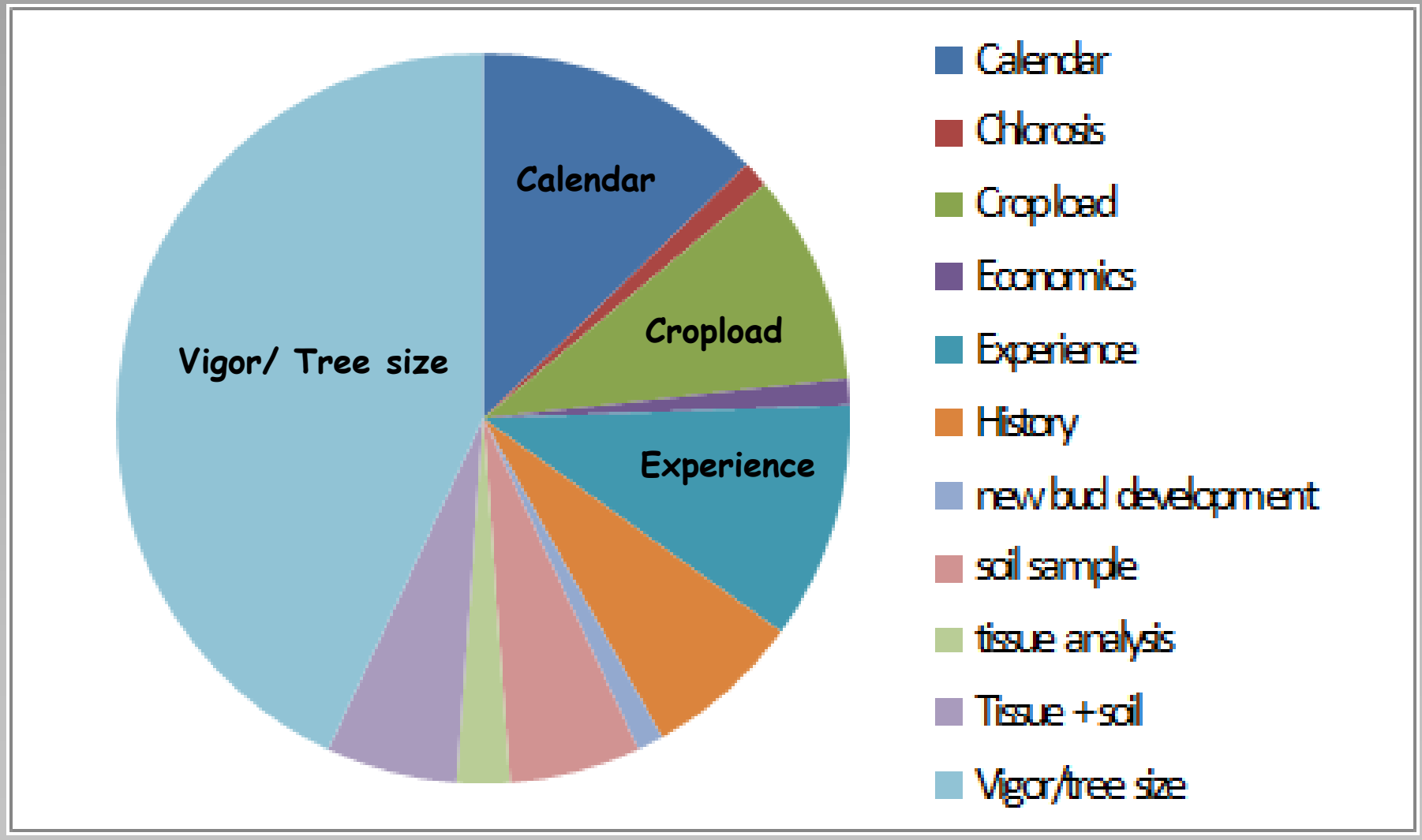
3617 acres -- 53 orchards -- 30 growers



Range of Annual Total N Usage in 53 orchards, 30 growers



Fertilizer Amount based on:



2009 Preliminary Study (CPAB)

- 'High N' orchard (120 lb N) vs 'Low N' orchard (60 lb N; Elliot 1)
- Measured %N content of tissues @ 3 timings, vegetative vs reproductive tissues
- March and July – no differences in %N between orchards; October – small difference between orchards
- Differences in N were 'between tissue types' (shoot vs spur, bud vs leaf) – and there was **little to no difference between orchards**
- Half-rate N usage for 2 years did not significantly reduce tissue levels (based on our comparisons and 'Low N' grower's recollection of his leaf sampling)
- Is the additional applied N at the 'High N' orchard resulting in an economic benefit? **Both orchards reported similar yields and no problems with fruit quality**

FREP Project 2010-2012

- 3 orchards, each with different trial based on orchard conditions and grower objectives/practices
- Each addresses some component of N management for vigor control, maximizing yield and fruit quality
- All are in the Sacramento Delta, 'Bartlett' trees that are 60-100+ years old

'Elliot 1' = 'Low N' from 2009 project

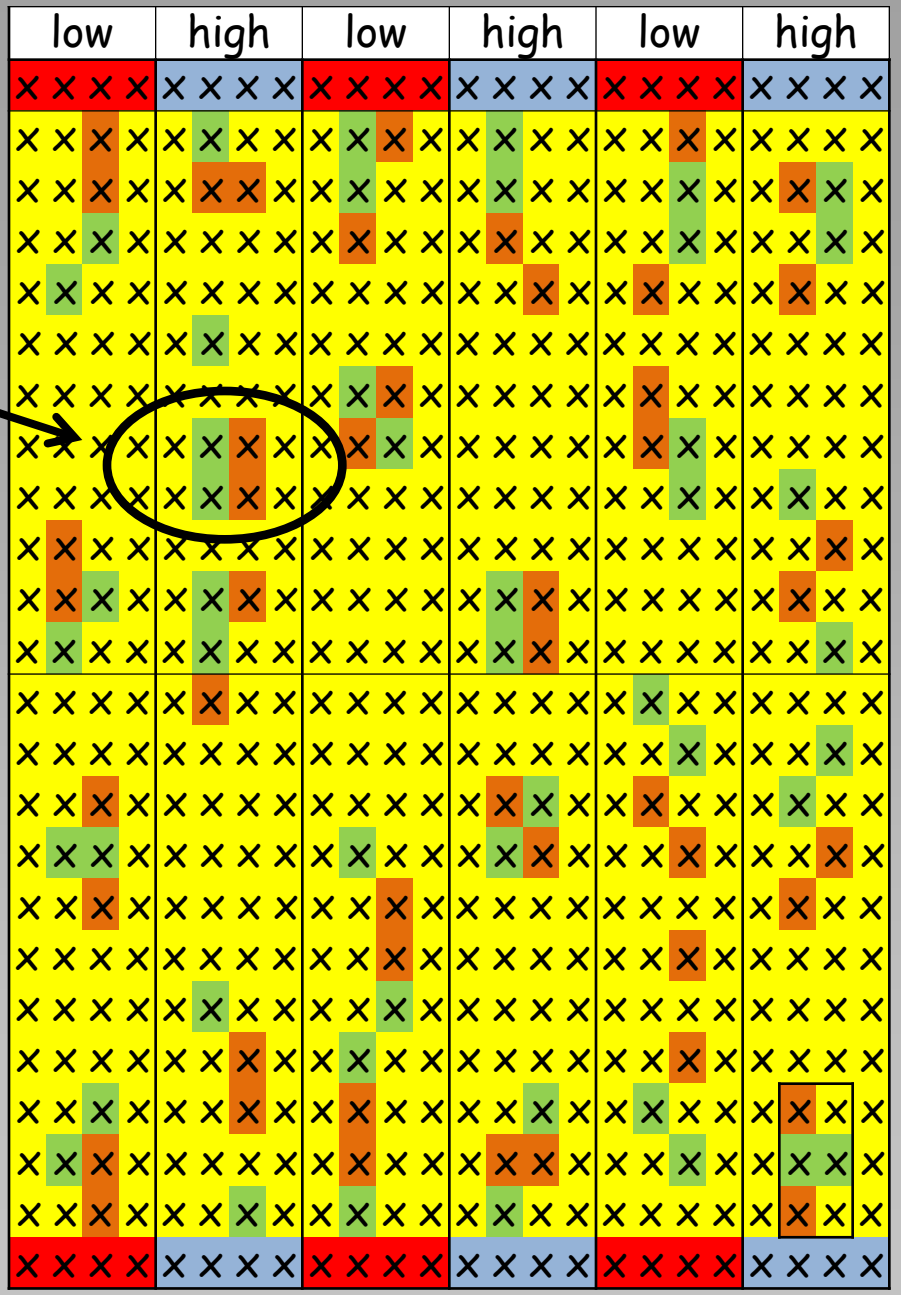
- N application level adjusted annually based on vigor and cropping
- Typical yield 20-25 tons/A -- Yield in 2009 = 25 tons/A
- Interplanted to 8' x 17' , 320 trees/A, Rows 70 trees long
- Elliot 1 will be used to compare 'standard' N use to BMP, using annual yield to adjust close to UC recommendation of 2lb N/ton/A

Elliot 1

	Lb Nitrogen (actual)/Acre/Year				Forms N	
	Spring		Fall	total	Spring	Fall
2007	63		60	123	$Ca(NO_3)_2$	$(NH_4)_2SO_4$
2008	63		0	63	$Ca(NO_3)_2$	
2009	63		60	123	$KNO_3 + Ca(NO_3)_2$	$(NH_4)_2SO_4$
	63		0	63	$KNO_3 + Ca(NO_3)_2$	
2010	High N	0	60	60	No spring N in 2010 due to hail damage	$(NH_4)_2SO_4$
	Low N	0	0	0		

Elliot 1

- 3 blocks (4 rows each) per N level with 4 – four tree plots per block for sampling
- Yields adjusted for tree number by rating tree size and productivity



Elliot 1

July, 2008 analyses (grower's)

- Water pH 6.33
- Leaf: **only 3.04% N was excessive by UC standards.**
- Soil: pH 6.33, nitrates 10.9ppm, ammonium 1 ppm, and of other nutrients tested, **only Mg exchangeable appeared excessive at 588ppm. 'Low' to 'very low' soil nutrients included: soluble K, Ca, Mg, and boron.** The soil is a mixture of sandy and silty clay-loam
- **Fertilizers applied budget-dependent with idea of 'as needed' with respect to yield and fireblight-sensitive vegetative vigor**

	Shoot leaf	Non-bearing	Bearing
July 2009	2.75	2.48	2.09
Oct 2009	1.89		
April, 2010 - no N yet	Shoot leaf	Non-bearing	Bearing
High N	2.64	2.89	2.66
Low N	2.85	2.84	2.54
July, 2010 - No N yet	Shoot leaf	Non-bearing	Bearing
High N	2.99		2.80
Low N	2.84		2.72

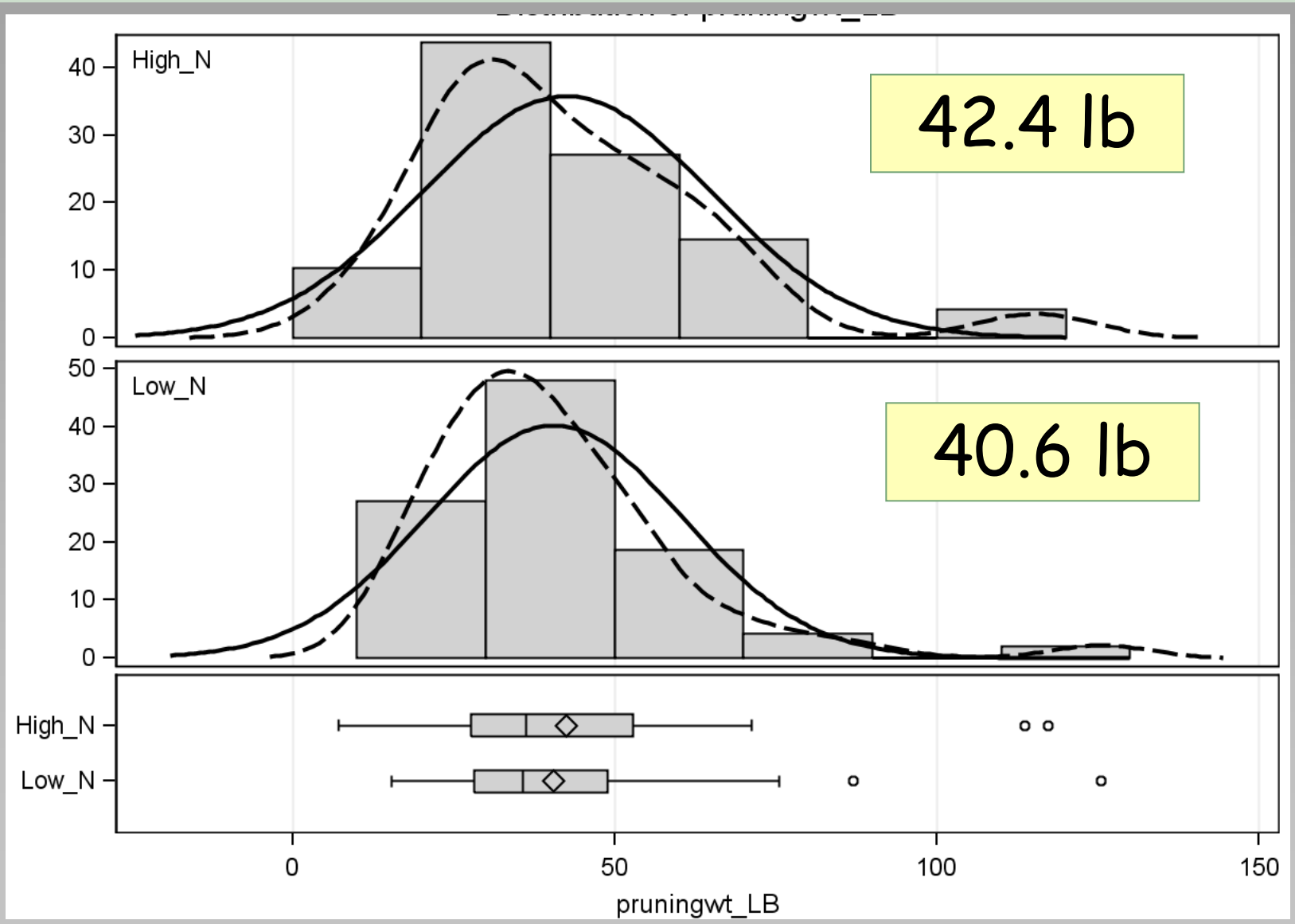
No statistical differences yet; also no deficiences.

Elliot 1, Harvest – No fertilizer applied since Fall, 2009

N level	Fruit weight (oz) for #1 fruit	Count/lb	%Soluble solids	Firmness (lb)	% #1 Fruit	Yield (lb per tree)
High N	7.8 a	2.03 a	11.7 a	30.0 a	79.0 a	210.6 a
Low N	7.8 a	2.07 a	11.6 a	29.8 a	68.9 b***	177.0 a

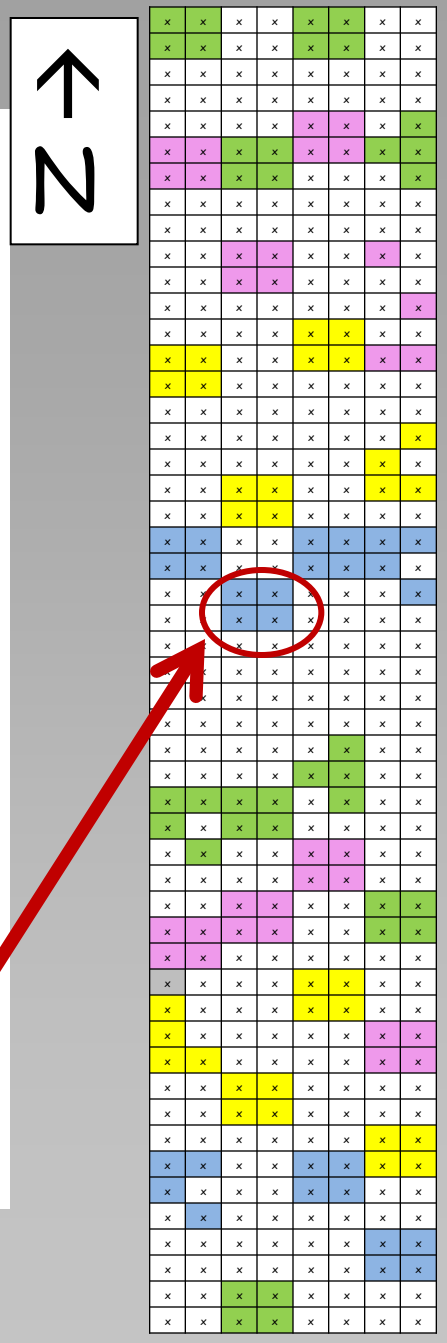
Means separation within columns by Student's ttest, 5% level. Where letters differ significant differences are indicated (***, ** * = 0.01, 0.1, 0.5, respectively).

Pruning Weights (Lb) – No difference



McCormack

- 10' x 20' spacing, 218 trees/A
- **North half of orchard is low vigor, lower yields, smaller fruit and later harvest**
- **South half has better soil and a higher water table**
- **2009 N/A/yr = 152# throughout orchard**
- **Recent management changes (flood changed to solid set sprinkler irrigation, running E-W; better pruning) have increased yields from 20-23 t/A/yr to 30-32 t/A/yr**
- McCormack will be used to compare 'optimized' and 'reduced' N to test customizing BMP
- 4 blocks/treatment, 4-four tree plots per block



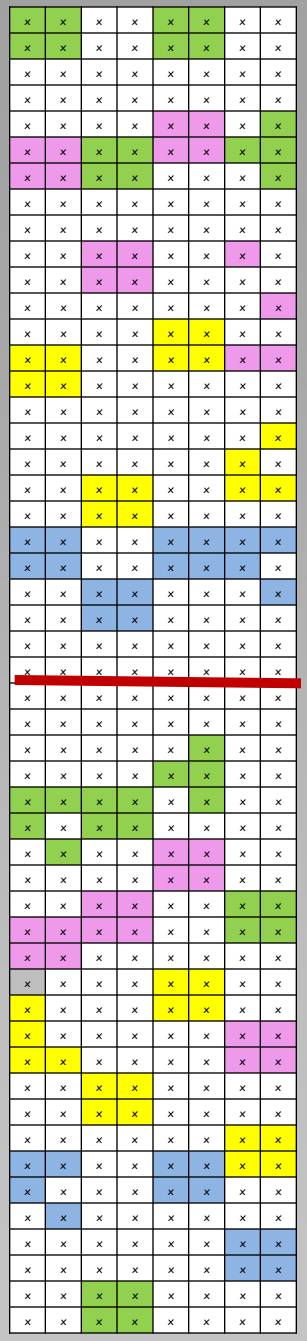
North ‘weak’ half

South ‘strong’ half

McCormack

N applied prior to harvest 2010

N



Treatment 1 (N half)	**282#N/A**	Fertigation 6x May-June = 129 #N from CAN17 **222#N** 2x May and June $Ca(NO_3)_2$ @ 300 lbs/acre ea. = 93# N/acre MOP (0-0-62): 322 lbs./acre = 200 lbs. K2O/acre = 166 lbs. K/acre + Urea: 130 lbs./acre = 60 lbs. N/acre
Treatment 2 (S half)	**129 #N/A**	Fertigation 6x May-June = 1[illegible] **129#N** from CAN17

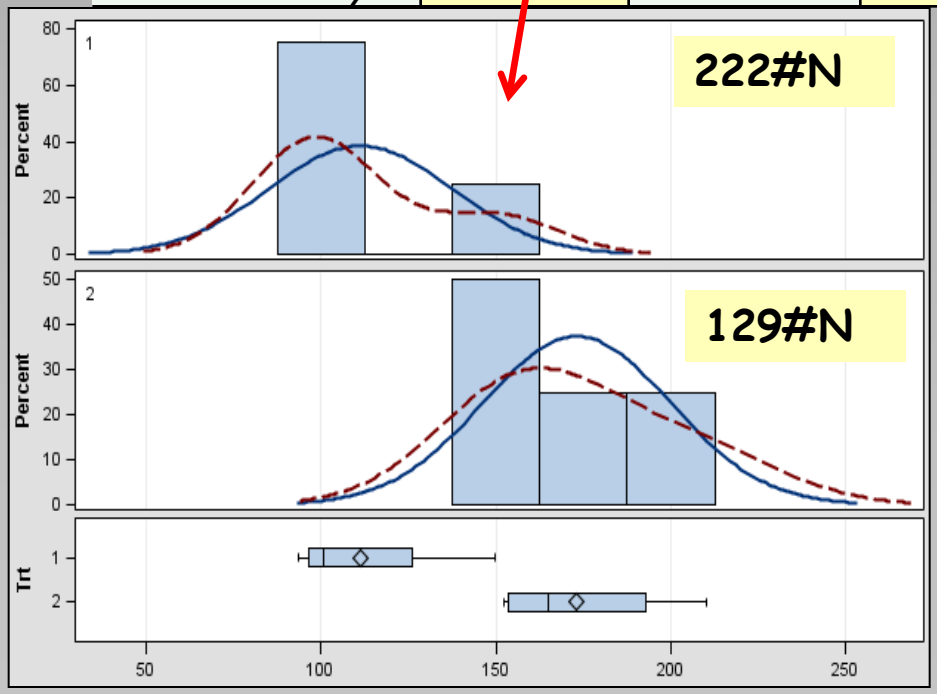
McCormack N analyses

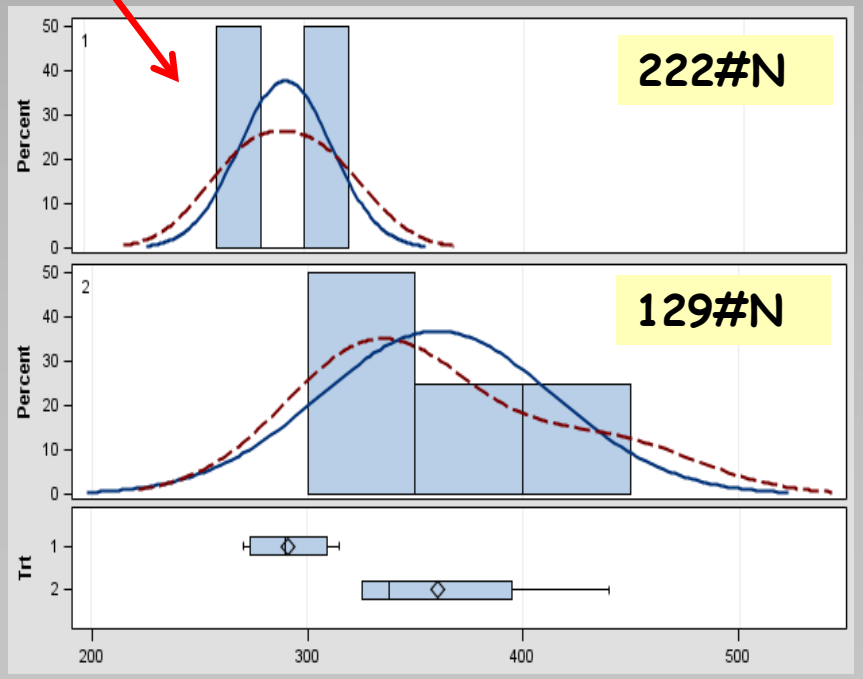
April, 2010	Shoot leaf	Non-bearing	Bearing
282 lb N (North)	3.05 a	2.94	2.67 a
129 lb N, (South)	2.95 b	2.93	2.54 b
July, 2010	Shoot leaf		Bearing
282 lb N (North)	2.80 a		2.09
129 lb N, (South)	2.72 b		2.05

- No difference in N fertilizer before April, but significant differences in leaf levels found in shoot and bearing spur leaves
- North half trees much smaller with lower vigor, less crop, so less N may be 'lost' to crop and shed leaves. N reserves may stay higher.

McCormack Harvest

'Treatment groups'	Yield/tree (lb)			#1 fruit/tree (lb) 2nd harvest	%Yield as 1st harvest	%Yield of 2nd harvest as #1 fruit
	1st harvest	2nd harvest	total			
Low vigor trees 282# N/A/yr	111.2 b *	180.2 a	291.4 a	128.4 a	37.9 b *	71.2 a
High vigor trees 129# N/A/yr	173.1 a	187.1 a	360.2 a	142.4 a	48.1 a	76.2 a





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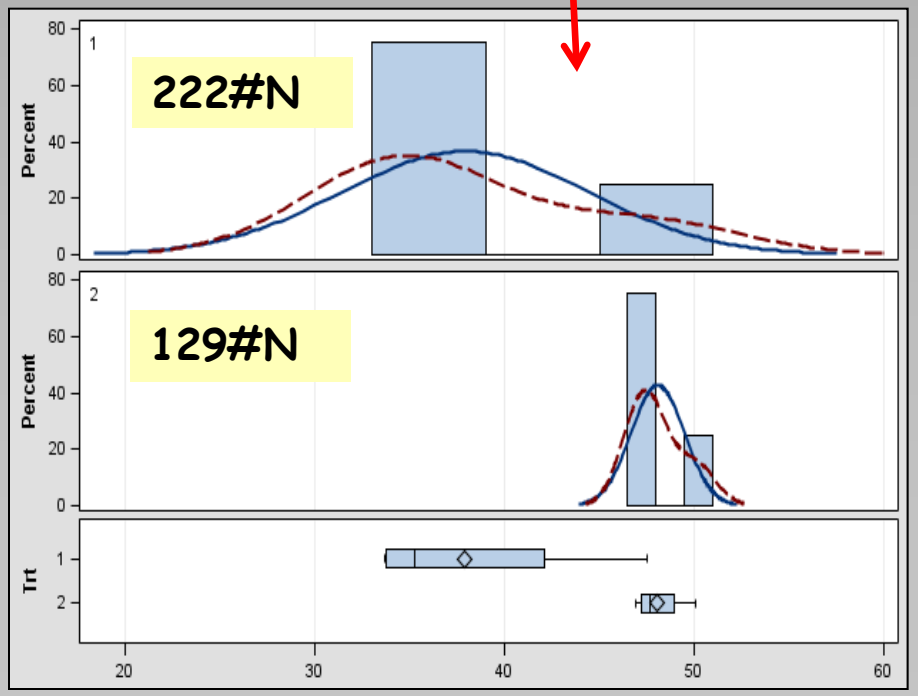
High vigor trees 129# N/A/yr	173.1 a	187.1 a	360.2 a	142.4 a	48.1 a	76.2 a

- Yield in first harvest much higher in high vigor trees – 56% higher than in low vigor trees
- Total yield not <u>statistically</u> different, but only because of the spread in the data
- %Yield as the first harvest 26% increase from the low vigor trees
- No differences in fruit size



Elliot 2

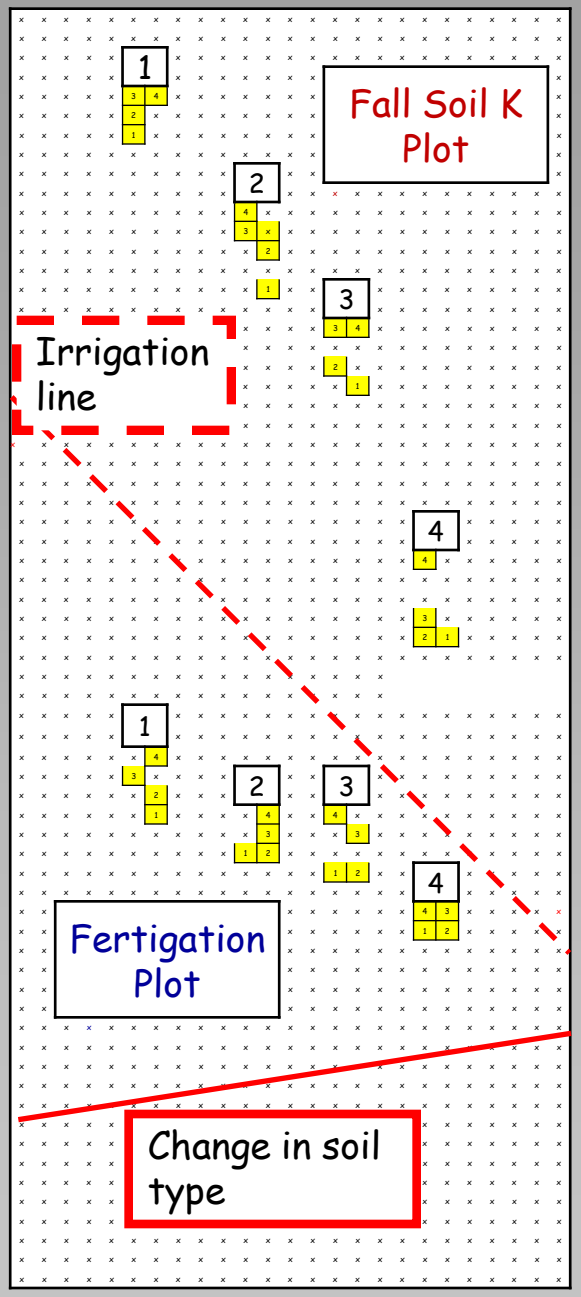
- Elliot 2 is a test orchard for **N:K:Ca effects on fruit quality and cropping, comparing grower's 'traditional' K application (500# K_2O=150 #K_{act}/A/yr applied to soil in fall) to K fertigation ($K_2S_2O_3$=28 #Kact/A/yr, 3 equal applications during fruit development)**.
- Urea (1#/100 gallons/acre) is applied in each fireblight spray for 'fruit finish', for a total of 0.7-2.76 #N/acre.
- **Total N usage for 2010 will be 61-63 lb/A**
- Ca total will be 47 lb/
- K (as potash or Kmend) will be 26% by weight
- Treatment effects postharvest evaluated with funding by California Pear Advisory Board

Elliot 2

- Interplanted to 11' x 22', 180 trees/A

<u>2 treatments (by Fall, 2010):</u>

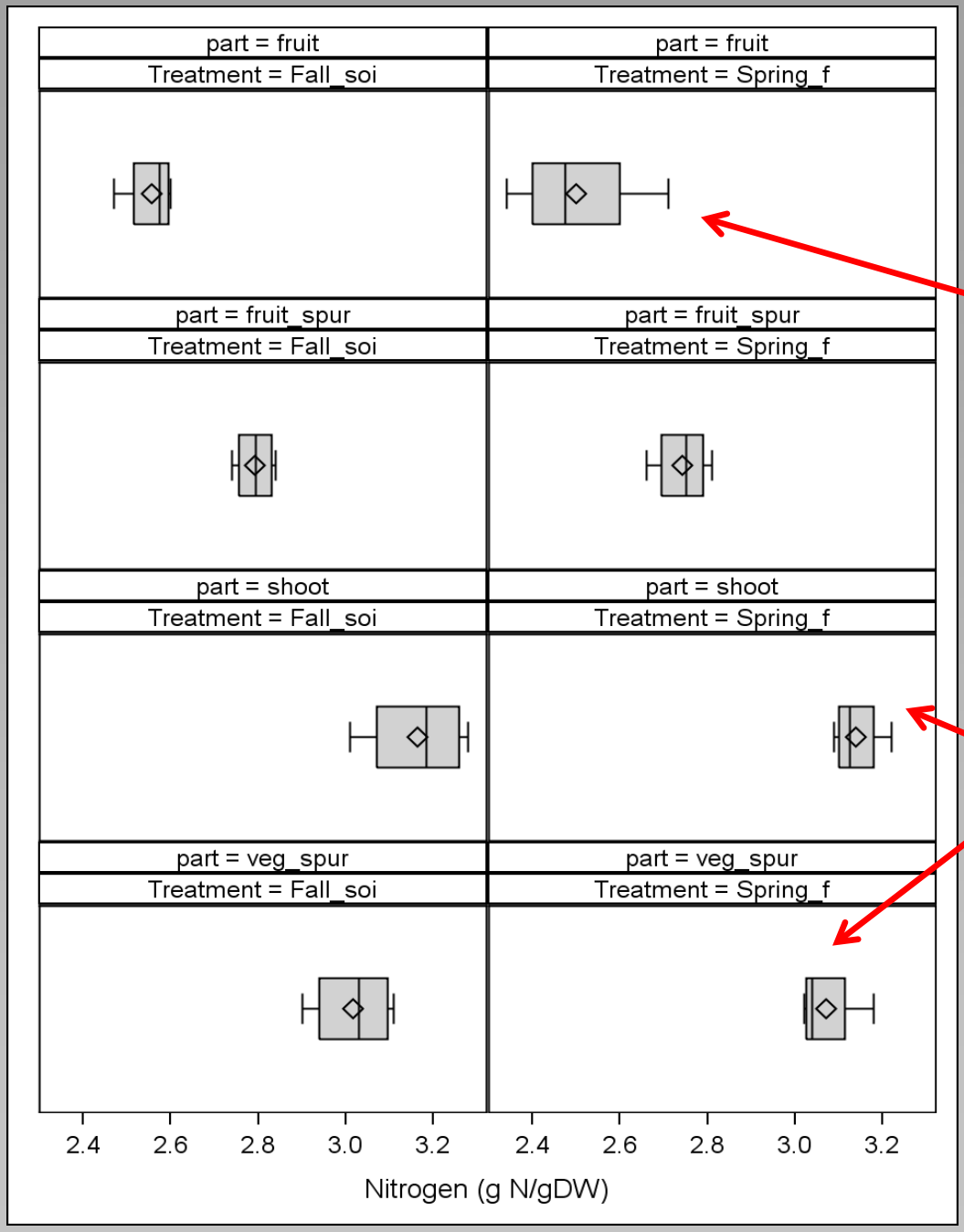
- Fall soil-applied K (potash)
- Spring fertigated KTS (Kmend)
- In April, 2010, both plots had only 2009 fertigation
- By harvest, the 'Fertigation Plot' had 2009+2010 fertigation
- Orchard had NO fertilizer in 2007, 2008 with no apparent ill effects
- Typical yield is 25 tons/A , with the yield varying year-to-year by no more than 1-2 tons. Fruit quality has been consistent and without disorders. The fruit has not been 'hard to size' and is picked twice for size.



Elliot 2

Elliot 2: Harvests July 20 and August 2. First harvest was a 'size' pick of all fruit ≥ 2 5/8" diameter. **No significant differences were found between fertilizer treatments. Samples of fruit from Harvest 1 → Postharvest study**

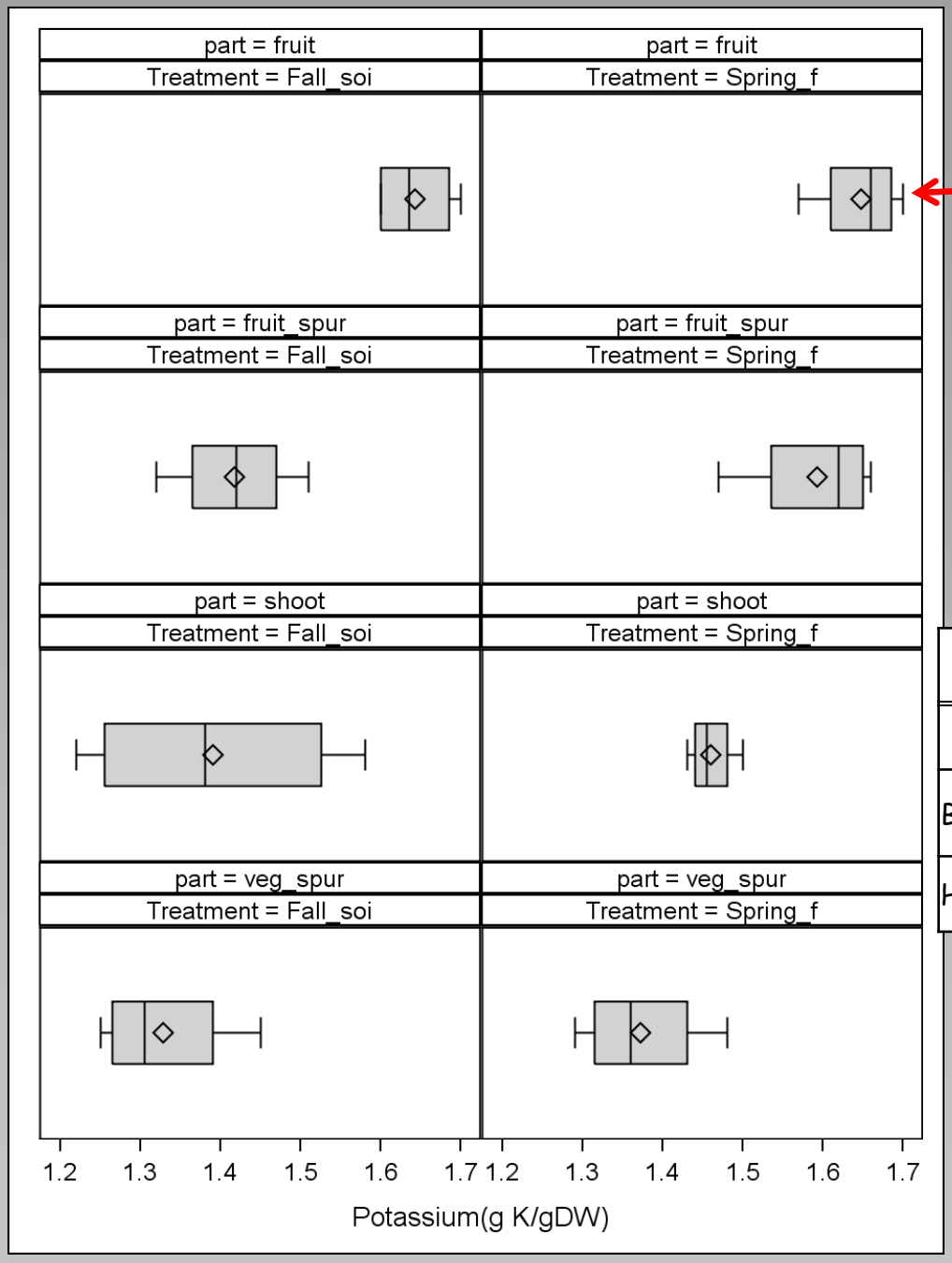
Treatment	Second harvest			% #1 Fruit total	%Fruit in 1st harvest
	Fruit weight (oz)	#Fruit/lb	% #1 Fruit		
Spring fertigation (K thiosulfate)	6.3	2.5	61.5	76.2	41.6
Fall soil application (K potash) –not by harvest	6.5	2.5	65.4	78.8	44.9



Elliot 2: Nitrogen content of plant parts in April, 2010.

Fruit show lowest N content

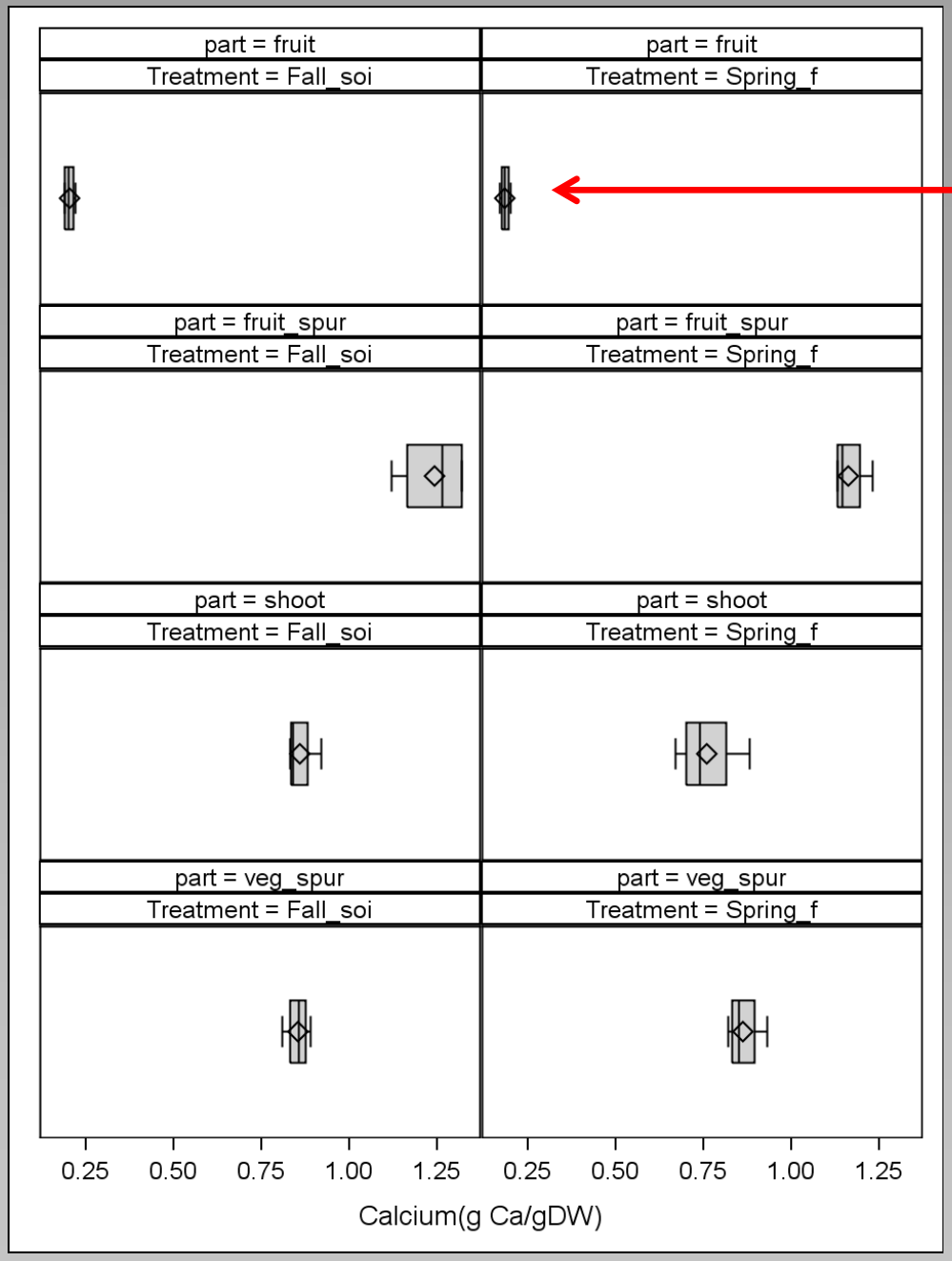
Differences in N content are found among different plant parts; highest N in vegetative tissues



Elliot 2: Fruit show high potassium content.

In a recent study on 'black end' disorder in pear, Ingels (2005 CPAB Report) found that pears with the disorder exhibited peel levels of potassium far greater, and calcium levels lower, than in healthy fruit

	K		Ca		K/Ca Ratio	
	Peel	Flesh	Peel	Flesh	Peel	Flesh
Black end	3690	5640	740	430	5.0	13.1
Healthy	741	4290	1050	360	0.7	11.9

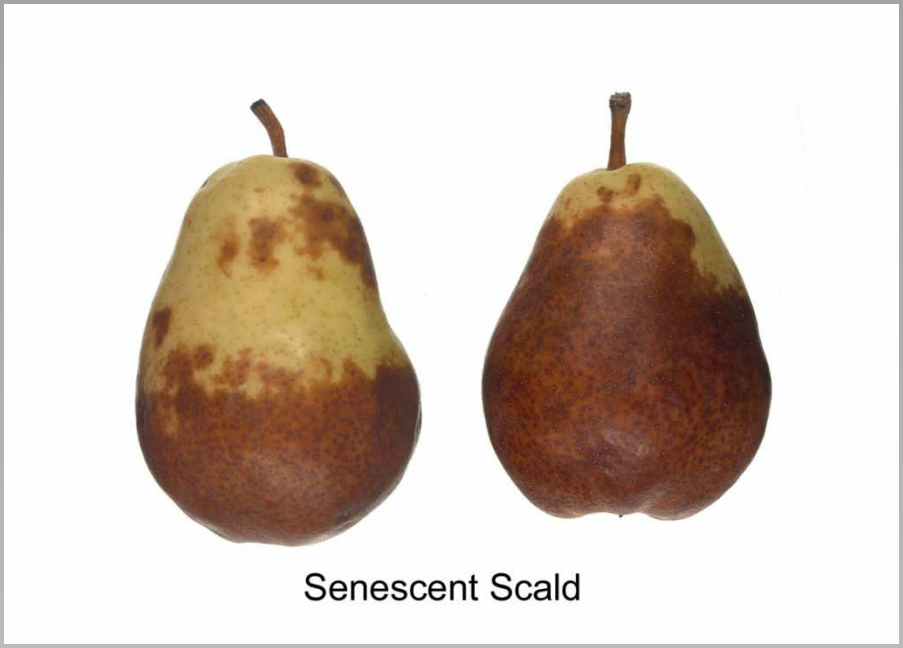


Elliot 2: Calcium content

Fruit show low calcium content.

The original rootstock in this orchard, *P. calleryana,* is known for 'black end'.

Postharvest Study -- Mitcham and Biasi



Senescence and Superficial Scalds

2009 Fertigation throughout orchard; by harvest only the spring-fertigated half had applied K in 2010

	K applied	*Firmness (lb)*[x]	*Soluble solids(%)*	*Titratable acidity(meq)*	*Color*[y]	
					Ground	*H□*
Harvest+6 days	*Spring*	2.5***	13.9	0.37***	2.7***	104
	----	2.3	13.7	0.34	3.0	102

No differences at harvest

Fruit ripening was greater in the fruit from the fall K treatment (no K in 2010 until after these fruit were harvested), and the ripening was more uniform.

Fruit with spring K ripened more during 3 months CA storage.
But, after storage + 4 days at ambient temperatures, the maturity indices were not different, or only slightly different between the treatments.

	K applied	Firmness (lb)[x]	Soluble solids(%)	Titratable acidity(meq)	Color[y]	
					Ground	H□
3 months storage	Spring	14.0***	13.3*	0.19	2.4*	103***
	----	15.9	12.8	0.20	1.9	106
3 months + 4 days	Spring	2.6***	13.4	0.22	3.9***	91.6***
	----	2.3	13.4	0.22	3.8	92.4

Spring K fertigation treatment (vs no K after spring 2009 and until fall 2010) accelerated ripening and storage defect development during the 3 month storage period. These results are consistent with high K and low Ca found in leaf and fruit tissue samples and previous research on 'black end' in pear (Ingels, 2005 CPAB report).

K fertilizer	*Decay*	*Internal browning*	*Superficial scald*		*Senescent scald*	
			Score	*%Surface affected*	*Score*	*%Surface affected*
Spring fertigation	0.03	0.7***	0.07	0.8	0.1***	2***
____	0.06	0.1	0.04	0.5	0.0	0

Defect scoring for decay, internal browning and types of scald: 0 = none; 1 = slight; 2 = moderate; 3 = severe.

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California Pear Advisory Board

Thom Wiseman, PCA

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Jeff McCormack