Updating Nutritional Strategies for Today's California European Pear Industry

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Objectives 2010-2012

- Seasonal tissue N (where, when, how much) vs tree productivity and growth (reassess CV's and tissue measurement).
- 'Typical' vs reduced N (compare standard and 'customized' BMP)
- Effects on crop load and fruit quality due to nutrient 'balances'
- Refine BMP to maintain productivity and fruit quality and reduce excessive N use
- Assess irrigation management to reduce nitrate leaching
  - All sites used high irrigation efficiency

Historic Research and Recommendation Development

- Shoot leaves are the most commonly used tissue worldwide
  - Only in California are non-bearing spur leaves used
  - This has been the UC recommendation since 1983 lumping pear with all other spur-borne fruits, but no published data from historic studies used these leaves
  - Leaves are sampled in mid-summer before harvest
- Calif research 1940's-50's – basal shoot leaves all season
  - leaf analyses poorly correlated to N fertilization
  - Response to applied N only when leaf N < 1.7%
  - 1.7% - 2.2%, local influences might cause a response
  - Above 2.2% *any response to applied N would be unlikely*

- 1965-1966 -- only fruit set was highly correlated with CV's in June (2-2.3) or September (1.7-2)
- Inadequacy was demonstrated by reduced yields due to poor fruit set
- But adequacy due to applied N amount difficult to measure, since tissue N levels didn't show applied N uptake.
- 1994, 1997-2000 studies confirmed pear's N insensitivity (no reduced vigor with 0 N applied)

UC Recommendations 'Then and Now'

- 1991 -- 75 to 125 lb N per acre per year
  - 'High' yields were 20 tons/A
  - Labor and fertilizer were cheap
- 2007 – BMP based on use efficiency for N and vegetative vigor control
  - 2 lb N per ton of crop/A/yr (which would be ~40-64 lb/A/yr for current yields)
  - Excessive N if current season shoot growth > 12" (in the Delta, with high water tables, shoots grow up to 5' per year)
  - CV = 2.2%, adequate 2.3-2.6%

Elliot 1 (60 or 120 #N vs 0 N): Results

- Fall N ⟶ higher N in spring
- Spring N ⟶ higher N in summer
  - shoot and bearing spur leaves
  - range of tissue levels was very small; none inadequate
- No difference in vigor (pruning weights)
- 0N for 3 years did not reduce yields or fruit quality, indicating that tissue N levels were adequate

Elliot 1 (60 or 120 #N vs 0 N): Results

- 'High N' treatment slightly increased fruit size by decreasing overall yields.
- Cumulative tonnage per acre for 2010-2012 was 63.7 ('High N') vs 67.6 ('Low N').
- Yield efficiency (yield on a per tree basis)
  - High N yield efficiency averaged 0.077
  - 0N yield efficiency averaged 0.079
  - This is the comparison that seems to make the best sense – no applied N paid off for this grower these years.

Elliot 1: BMP Recommendations

- Yield efficiency better indicator of N response than either tissue analyses or vegetative growth responses.
- Leaf analyses important if N < 1.7%; use mid-shoot or basal shoot leaves in spring
- Applied N should be managed on a 'as needed only' basis (reduction in fruit set) with 2 lb N/ton/A.
- Variable bearing capacity of this orchard is due more to environmental conditions (bloom weather, preharvest crop loss) and tree variability than N level.

McCormack: Customized N level

- North half of orchard is low vigor, lower yields, smaller fruit and later harvest
- South half has better soil and a higher water table

The grower's goals:

- Increase reproductive and vegetative vigor in North half
- Advance maturity in North half so more fruit are ready at the 'first pick'

McCormack: Results

Actual N/A/yr:	High N, Low vigor	Low N, High vigor
2009	159	159
2010	282	129
2011	313.5	150.5
2012	255	107.5

Leaf sampling results overall:

- Differences between leaf types was greater than that between orchard halves
- Differences between replicates within orchard half similar to between orchard halves
- No inadequacy regardless of cropping in South half
- Leaf analysis not applicable

Pruning weights only reflected inherent difference in vigor between orchard halves.

McCormack Yield Results

2010-2012:

- No difference: Fruit sizes within size grade, % of the crop that were #1 fruit in total yield
- Consistently good fruit size, regardless of heavy cropping in S half

2010: % of the crop that were #1 fruit in the 2nd harvest were not different (but not in the 1st harvest)

2011 and 2012: %Yield in the first harvest was not different by treatment – **maturity was advanced in 'first pick' for N half**

		$\#N_{act}/A$	Total tons/A
High N, low vigor	2010	282	19.8
	2011	313.5	28.6
	2012	255	20.5
	cumulative		68.9
Low N, high vigor	2010	129	26
	2011	150.5	33.9
	2012	107.5	29.9
	cumulative		89.8

High N, low vigor as % of Low N, high vigor	Total tonnage	#1 tonnage
2010	81	73
2011	75	85
2012	68.5	71

McCormack: Conclusions and BMP Recommendations

- Leaf N analysis not as useful as N by cropping level.
- Yield increase or decrease in response to nutrient management of each half should be measured independently.
- High vigor half has had less N since 2009. Low vigor half has had more N.
- High percentages of #1 fruits with good yields indicate a strong nutritional program appropriate for this situation.
- Historic yields were 20-23 ton/A/yr; a range of management strategies have increased yields to 30-32 ton/A/yr in the S half, 26.5 tons averaged over 3 years, both halves.

Elliot 2: Nutrient balance effects on fruit quality and yield

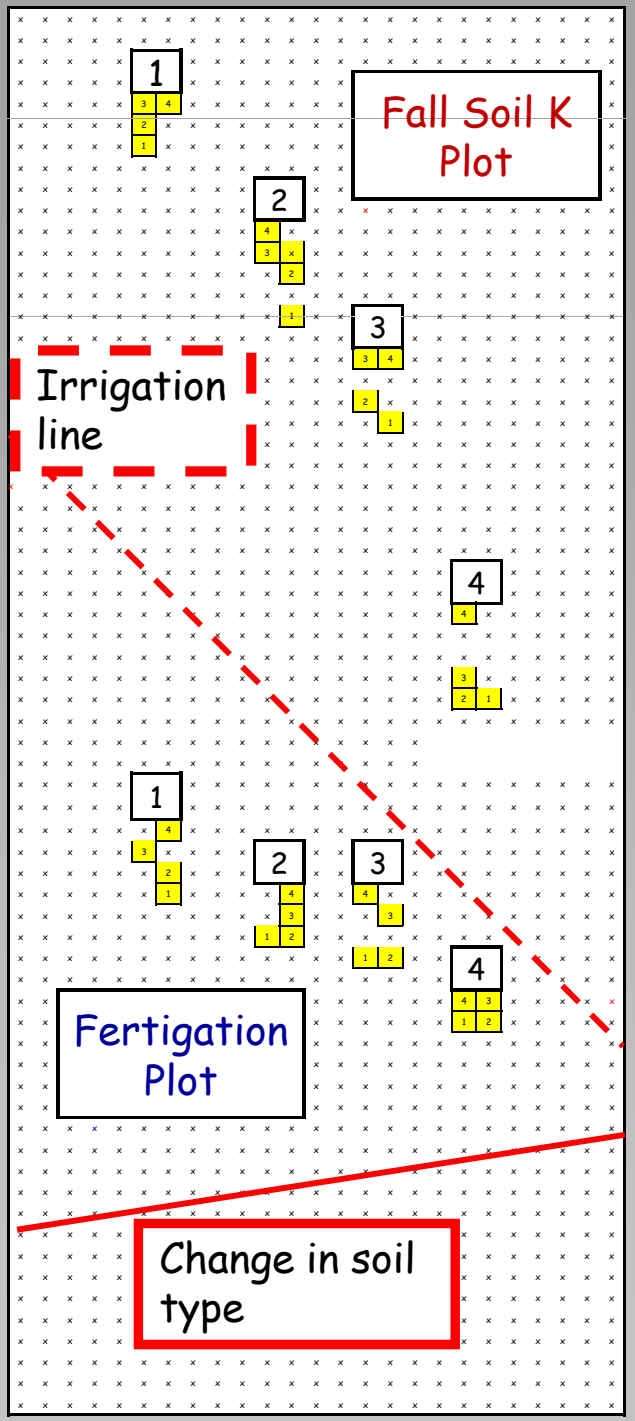
Differential treatments are K form, timing and amount

500# K_2O (muriate of potash) = 150 #K /A/yr applied to soil in fall

versus

K fertigation $K_2S_2O_3$ (Kmend) =28 #K/A/yr, 3 X in spring (84 #K/A/yr)

- NO fertilizer in 2007-2008 with no apparent ill effects
- Typical yield = 25 tons/A
- 2009-2012 ~64 #N/A in spring
- **Tissue analyses spring, 2010** – N adequate
- Within **leaf** type and **fruit**, some nutrients were higher in Fertigation plot (**before differential treatment**)
- **Bearing spur leaves** – higher levels in Fertigation plot for K, (K+Mg)/Ca, K/Ca and N/Ca; higher level in Soil plot for Mg.
- Fruit had the highest number of nutrient extremes for both locations combined, and several extremes for each location.



Postharvest Fruit Quality, 2010

- Spring Fertigation treatment reduced firmness before and after storage and increased fruit disorders after storage (internal browning and senescent scald).
- Firmness was correlated with April nutrient levels:
  - higher levels in (K+Mg)/Ca, K/Ca and Fe in bearing spur leaves
  - lower Ca and higher K in bearing spur and shoot leaves
  - April 2010 K/Ca and N/Ca in fruit was high – predictive of potential fruit quality problems
- July tissue analyses were similar

Nutrients and Postharvest Fruit Quality, 2010

- Spring 2010 Fertigation had not occurred by the April sample timing
- Tree uptake of nutrients already influenced by soil textural differences for soil type transition from Scribner clay loam to Egbert clay loam.
- Spring fertigation with $CaNO_3$ and K increased the N/Ca and K/Ca imbalances during fruit development.
- N is highly mobile, Ca is not (to get it into fruit it must be applied to the fruit itself).
- Leaf Ca does not = fruit Ca
- Ca moves in the water stream and not from leaves to fruit

Nutrient ratios July 2010, predictive of fruit quality problems

		%Dry wt		$\frac{(K+Mg)}{Ca}$				
		N	Ca	N/K	$\frac{(K+Mg)}{Ca}$	K/Ca	Mg/Ca	N/Ca
Shoot	Fertig	2.7***	1.0***	2.9*	1.3***	1.0***	0.43***	2.6***
	Soil	2.1	1.6	2.3	1.0	0.7	0.31	1.3
Bearing spur	Fertig	2.6***	1.0***	3.1	1.4***	1.0***	0.36*	2.7***
	Soil	2.1	1.6	2.5	1.0	0.7	0.29	1.3

Elliot 2: Harvest and Fruit Quality

2010-2011:

- Fruit size slightly better with Spring fertigation, but more #1 fruit with Fall K
- Firmness after storage reduced ~1 lb by Spring fertigation

2012:

- No differences in yields or fruit quality by K treatment in 2012.

Cumulative: The %change in yield over time from the same limbs and trees—none

Elliot 2: Nutrient sampling and levels for fruit quality

- Fall K soil application 'equalized' some of the early differences with K spring fertigation
- Soil type appeared to be most influential in affecting trees' ability to take up individual nutrients
- Single nutrient levels were not as important to fruit quality as nutrient balances
- Sampling in early spring (small fruit) and mid-season (shoot and bearing spur leaves), provided good prediction of potential for fruit disorders
- Tissue analyses should be interpreted with caution with respect to applying nutrients, (especially N and K), that can exacerbate potential for disorders.
- Nutrient balances should be calculated and used to assess need for fertilizers before application.

Conclusions and BMP Recommendations

- This orchard was adequately fertilized—leaf 'inadequate' analyses did not correlate with yield or fruit quality.
- In order to avoid potential for fruit quality disorders Fall application of K is advised and applications of Ca in Spring should be considered as a foliar application.
- N is probably not needed unless fruit set is reduced.
- Any N application should be considered for fall, to reduce the likelihood of nutrient imbalances for fruit quality when those are indicated by early season tissue analyses.

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