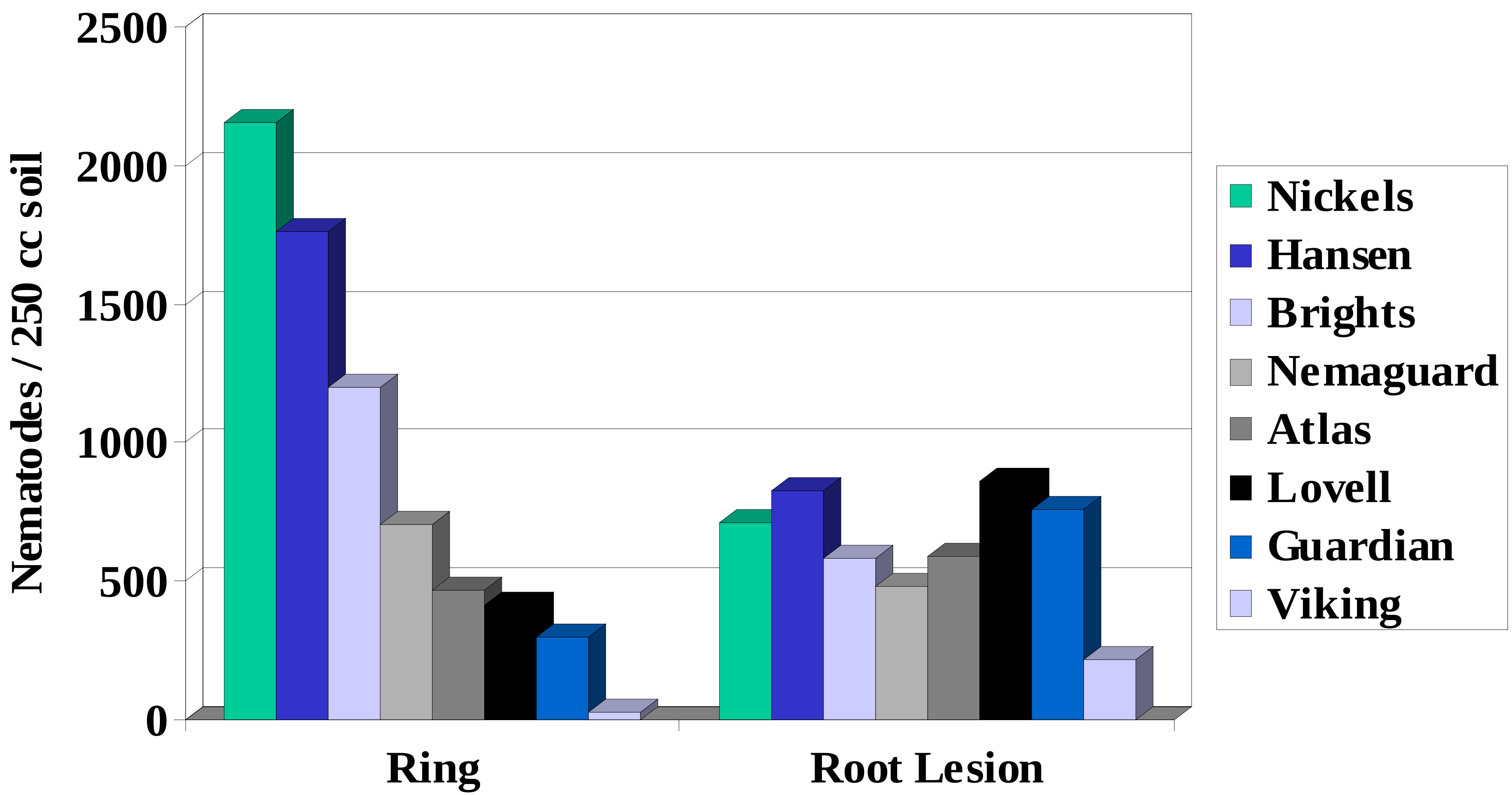
Table 2. Leaf Tissue Nutrient Levels of Nonpareil Almond on Eight Different Rootstocks. July, 2004. Escalon CA

	N (%)	K (%)	B (ppm)	Ca (%)	Mg (%)	Na (ppm)	Cl (%)	Zn[2] (ppm)	Mn (ppm)
Nemaguard	2.30 a[1]	2.76 abc	47 a	3.84 de	0.61 d	74 abc	0.09 a	101 a	64 cd
Lovell	2.28 a	2.92 ab	47 a	3.56 e	0.61 d	75 ab	0.08 b	112 a	69 cd
Guardian	2.32 a	2.57 cd	47 a	3.73 e	0.70 b	69 bcde	0.08 b	96 a	57 d
Atlas	2.27 a	2.70 bc	49 a	4.23 bc	0.67 bc	66 cde	0.04 c	100 a	77 c
Viking	2.26 a	2.99 a	45 ab	4.11 cd	0.47 e	73 abcd	0.04 c	106 a	94 b
Nickels	2.13 b	2.27 e	42 bc	4.78 a	0.69 b	65 de	0.03 c	108 a	102 b
Brights'	2.09 b	2.40 de	42 bc	4.44 b	0.64 cd	80 a	0.03 c	114 a	102 b
Hansen	2.08 b	2.00 f	40 c	5.03 a	0.75 a	61 e	0.03 c	112 a	132 a

Fig. 2. Soil Numbers of Pathogenic Nematodes as Influenced by Rootstock

May, 2004



Potassium Needs and Current Approaches in Almond Production

Roger Duncan

UCCE Pomology & Viticulture Advisor

Stanislaus County

Potassium Nutrition

- Essential for formation of starch
- Essential for translocation of sugars
- Regulates opening and closing of stomata
  - K+ is pumped into guard cells
  - water moves into guard cells in response to osmotic gradient
  - guard cells swell, open stomata

Potassium Nutrition

- Promotes root growth
  - produces large, uniformly distributed xylem vessels in root system
- Increases size and quality of fruits and nuts*

Potassium Deficiency Symptoms Include...

- Slow growth
  - leaves become pale
  - leaf size and shoot growth are reduced
- The tip and subterminal margins of leaves become necrotic
  - leaf tip sometimes curls upward
  - Vikings "prow"

Severe K^+ Deficiency in Almond

How do we know if we need to apply potassium fertilizer?

LEAF ANALYSES!

The University "Party Line"

- Deficient: below 1% K
- Adequate: over 1.4% K

- *based on leaves sampled from non-fruiting spurs in July
- **What???
- ***Numbers were developed many decades ago based on foliar symptoms - not yield
- ****Growers are no longer satisfied with yields less than 2000 lb per acre

- Word on the street says K^+ values should be 2% or higher

- **IS THIS TRUE???**

Comparison of Leaf Potassium Values vs. Nonpareil Yield

A survey of 10 Stanislaus County orchards, 1997

- Survey of 10 “comparable” orchards
  - Nonpareil variety
  - Similar age (not too old, not too young, not too sick)

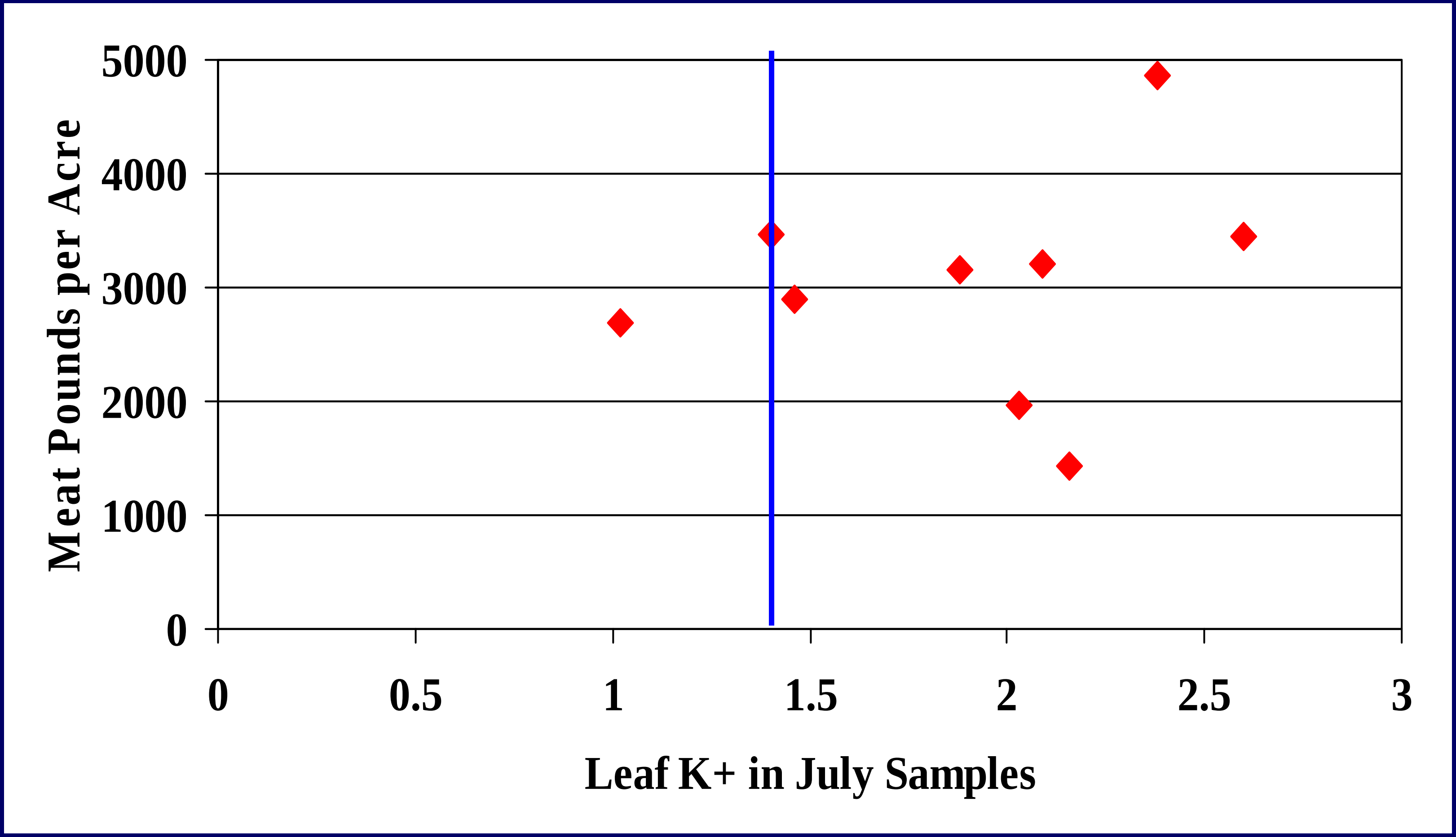
Comparison of Leaf Potassium Values vs. Nonpareil Yield

A survey of 10 Stanislaus County orchards

- Leaves sampled from 15-18 consecutive, “representative” trees in each orchard on July 25, 1997
- Submitted to A & L Labs for analyses
- Harvested and determined yield for same 15-18 trees in each orchard.

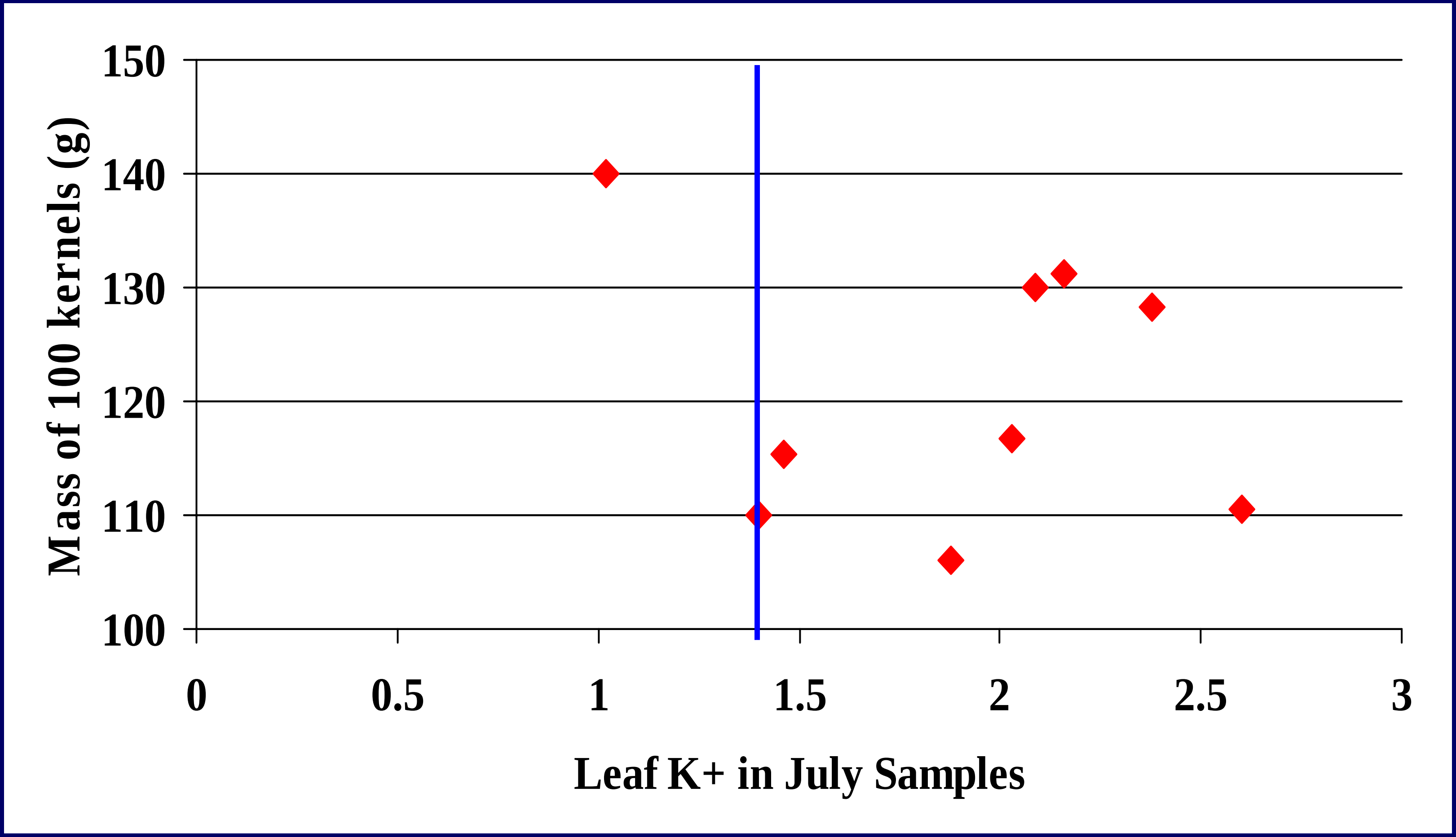
Comparison of Leaf Potassium Values vs. Nonpareil Yield

A survey of 10 Stanislaus County orchards, 1997



Comparison of Leaf Potassium Values vs. Kernel size

A survey of 10 Stanislaus County orchards, 1997



Summary

- Almost all orchards above published 1.4% K
- No apparent relationship between leaf K values and yield
- No relationship between leaf K and kernel size
- Differences may be masked by differences in other cultural practices

Potassium Trial 1998-2002

Salida, CA

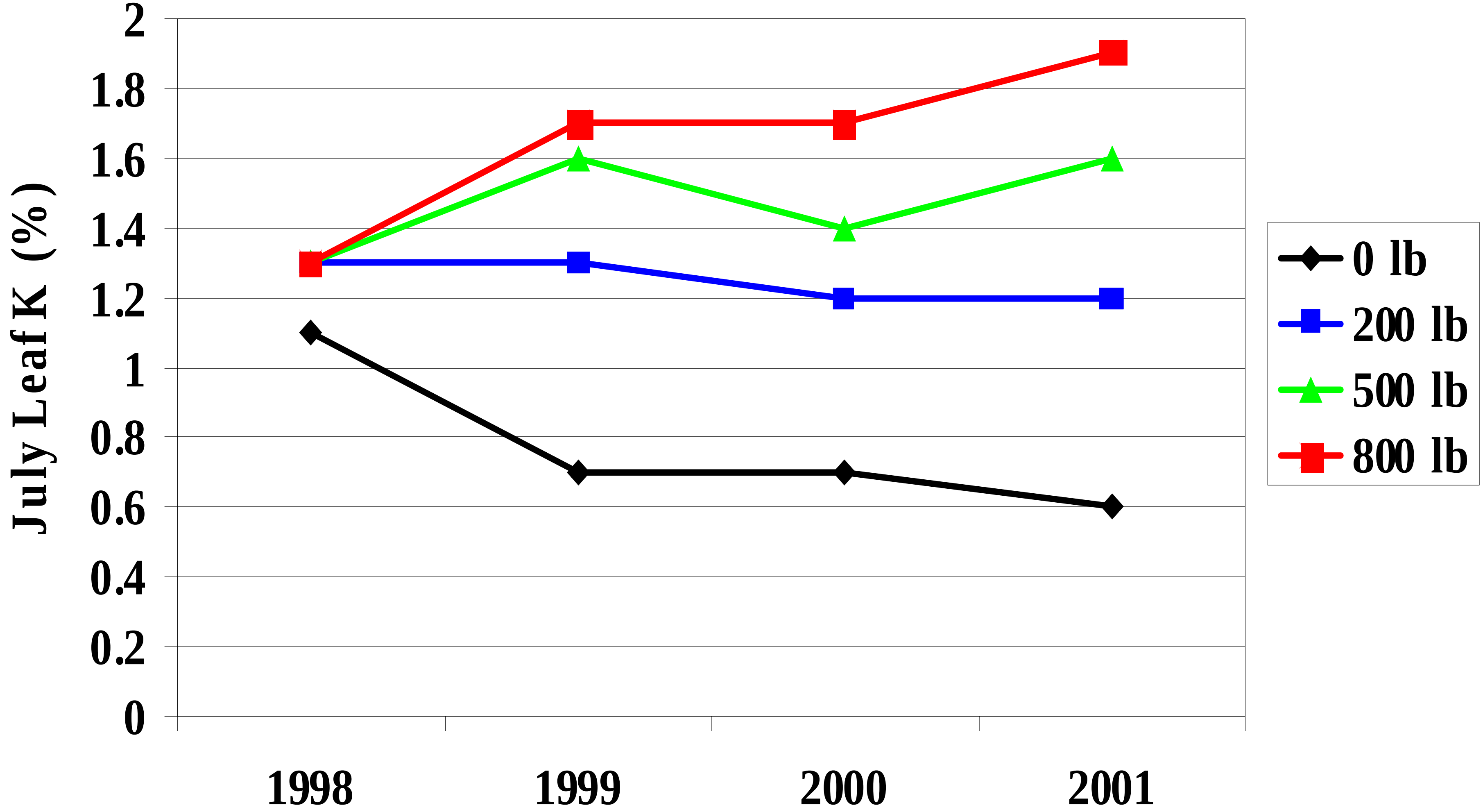
Weinbaum, Duncan, Reidel

- Purpose: to reassess critical K leaf levels
  - determine at which point almond yields are no longer responsive to added K
  - Determine how K deficiency leads to yield reduction (i.e. flower number, percent fruit set, fruit / kernel size)

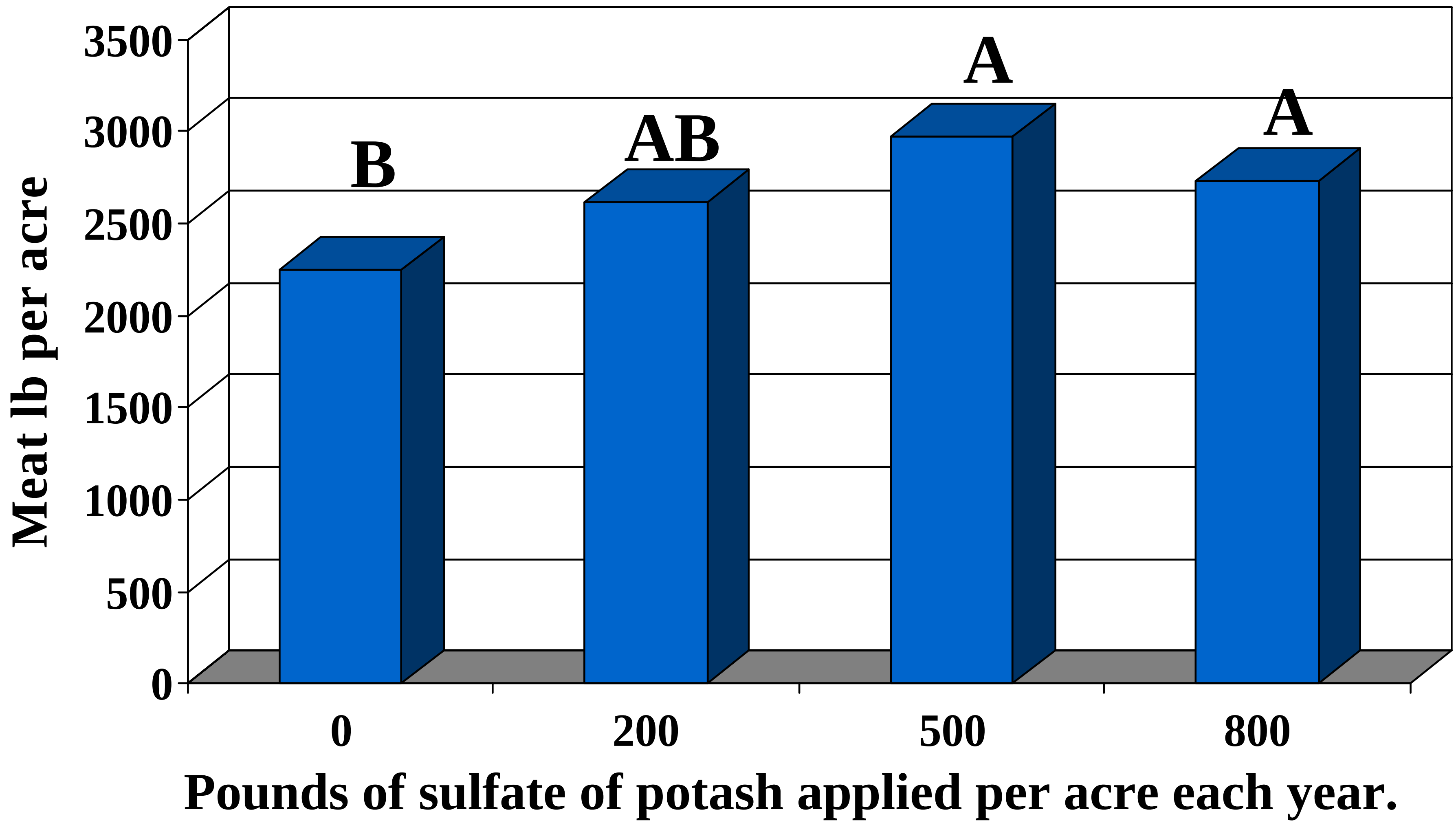
Potassium Trial 1998-2002
Salida, CA

- A range of of tree K status was established through differential fertilization over 4 years
  - 0, 200, 500 or 800 lb. K_2SO_4 applied annually
- Each year we monitored leaf K, spur survival, spur renewal, shoot elongation & yields

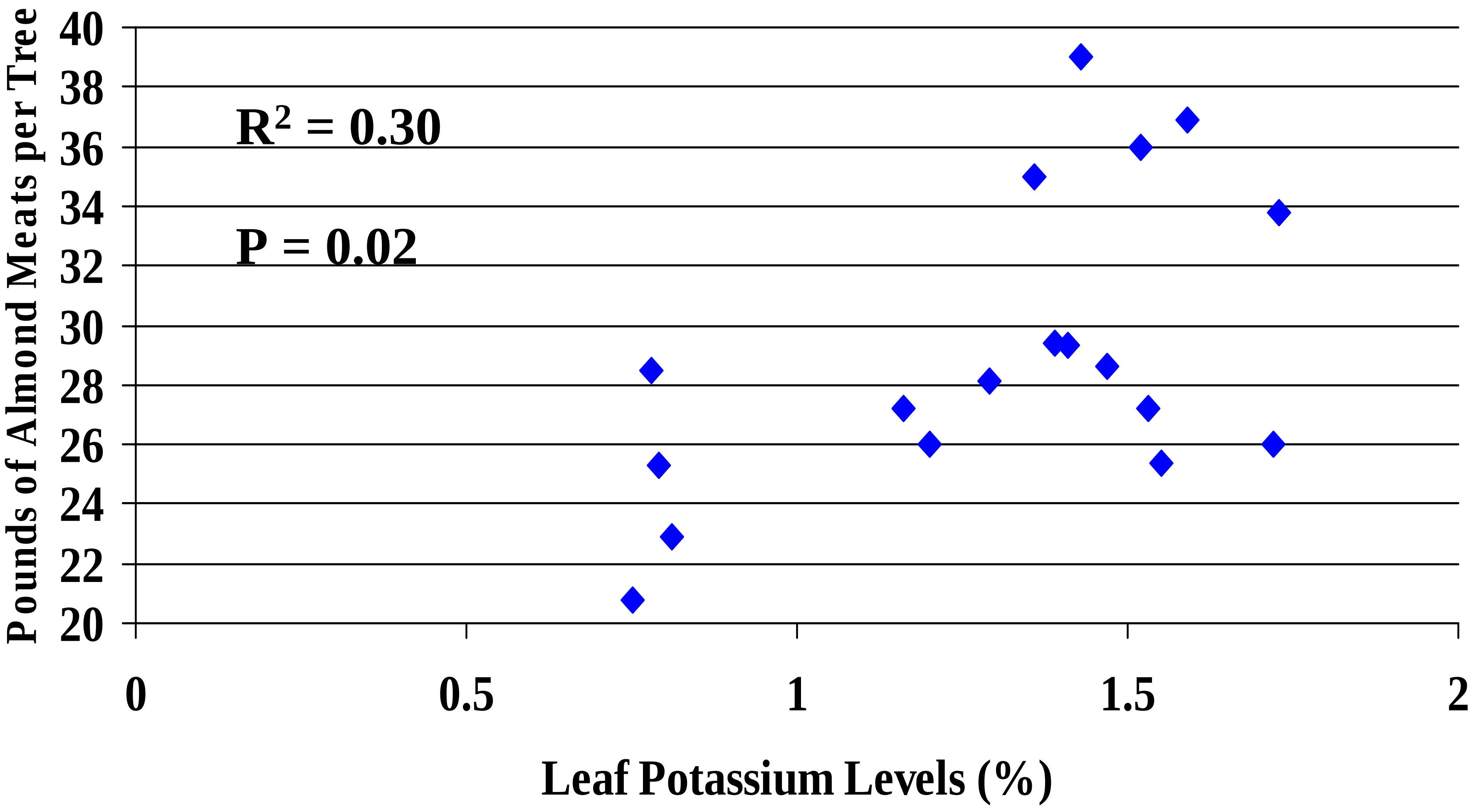
Leaf Potassium Dynamics During Four Years of Differential Fertilization with Potassium Sulfate



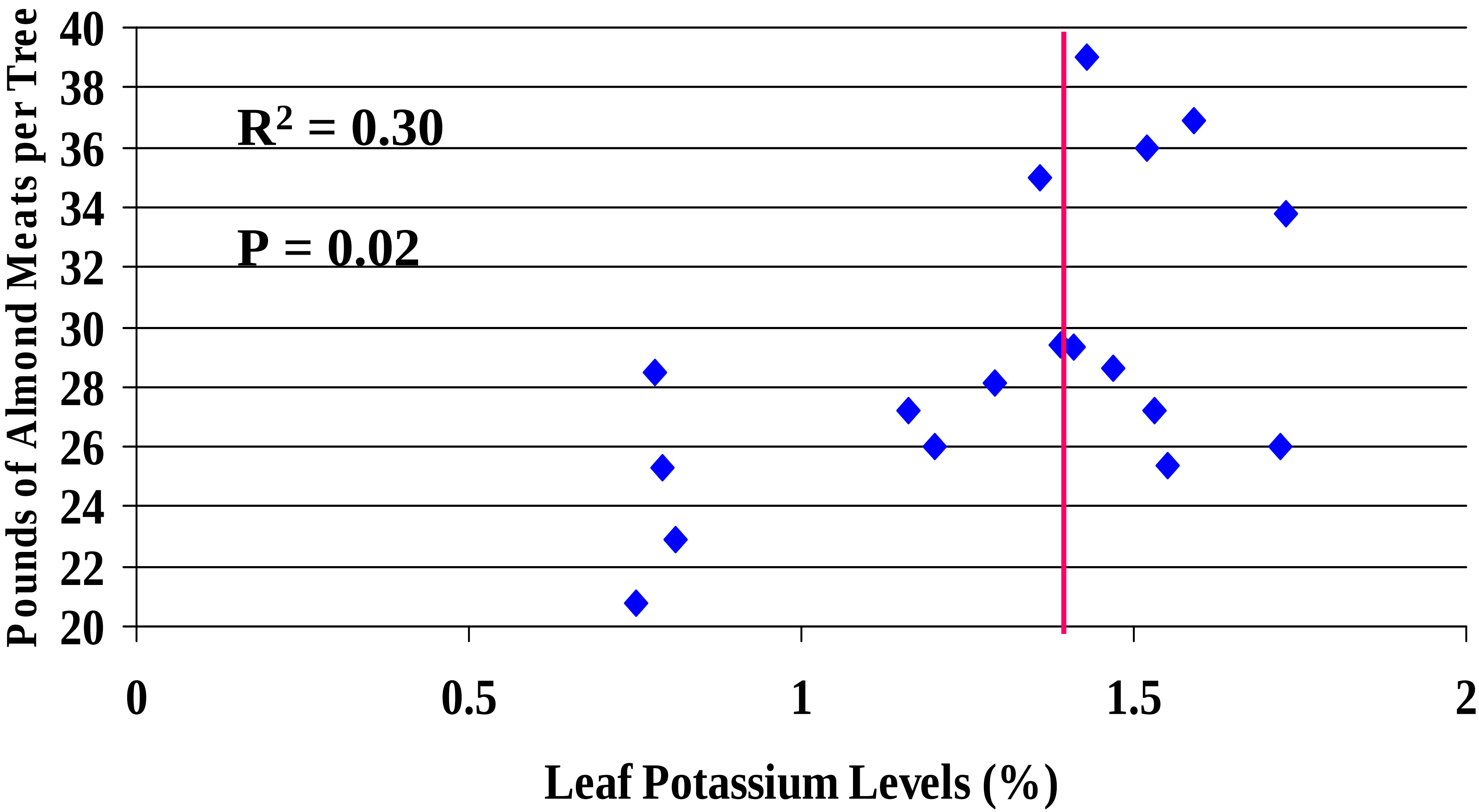
Yield of Nonpareil Almond Trees After Four Years of Differential Potassium Fertilizer Rates 2002



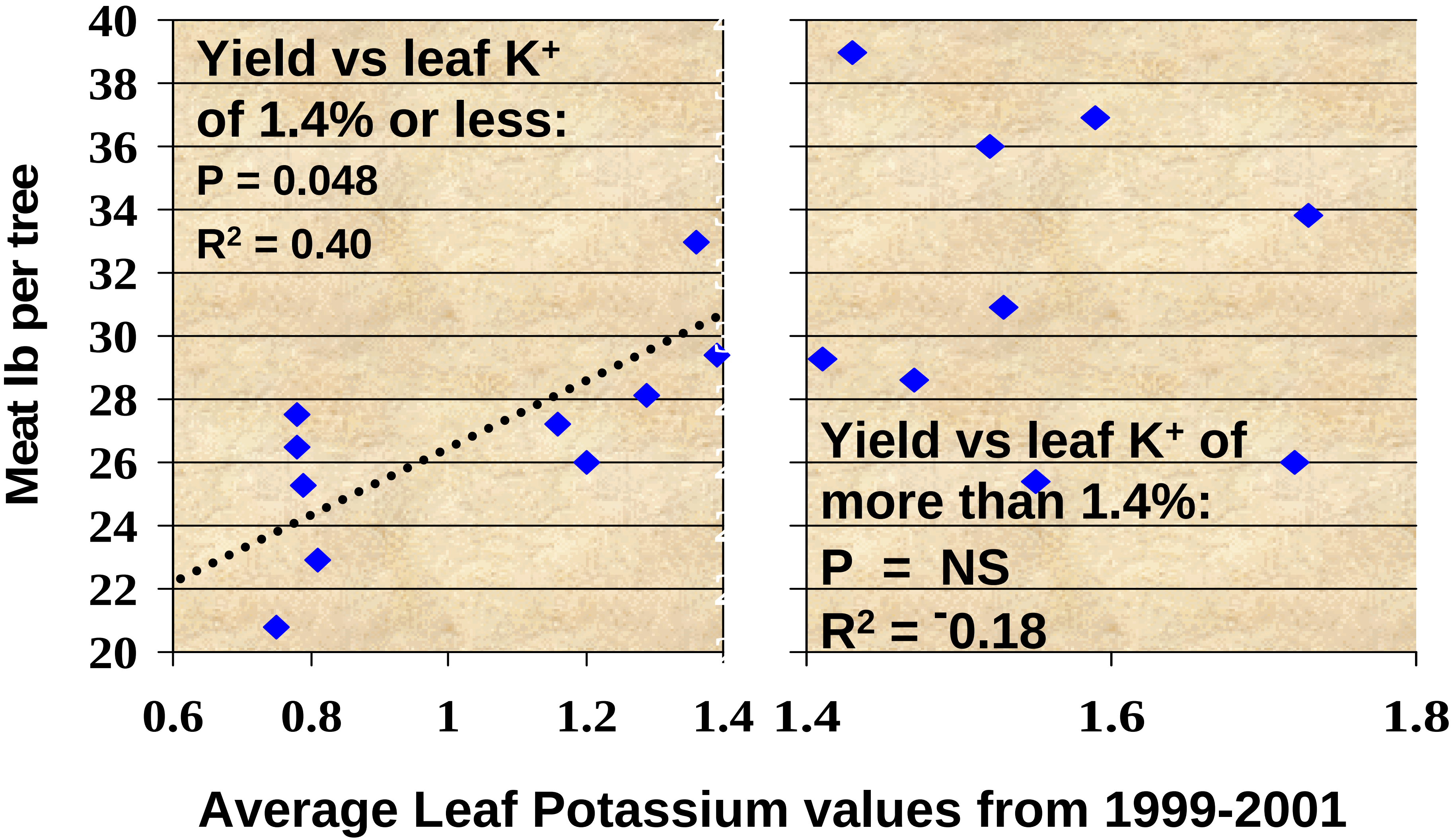
2002 Almond Yields as Related to Average Leaf K+ Values From 1998-2002



2002 Almond Yields as Related to Average Leaf K+ Values From 1998-2002



Relation of 2002 Almond Yields to 1999 - 2001 Leaf K^+ Values



Summary of Results of 5 Year Trial

- 200 lb of annually applied sulfate of potash barely maintained K leaf levels
- It took 4 years of 800 lb K_2SO_4 applications to raise leaf levels from 1.2% to 1.9 %
- Unfertilized trees fell from 1.2% to 0.6%
- Leaf symptoms not obvious until 1% K or less

Summary of Results of 5 Year Trial

- It took three years to significantly affect yield

- Inadequate K did not affect
  - percent fruit set
  - kernel size

Summary of Results of 5 Year Trial

- Inadequate potassium reduced yield because:
  - Mortality of fruiting spurs was increased
  - Flowering of surviving spurs was reduced
  - Shoot growth and spur renewal was reduced

Summary of Results of 5 Year Trial

Data suggest that 1.4% K^+ in July sampled leaves is pretty close to correct economic threshold

Now that we have established that the K^+ critical level is 1.4%, what is the best way to fertilize?

Annual Potassium Needs

- Almonds
  - nitrogen ~ 200 lb. N / acre
  - potassium ~ 250 lb. K_2O / acre

- Peaches
  - nitrogen ~ 100 lb. N / acre
  - potassium ~ 125 lb. K_2O / acre

Annual Potassium Needs

- Although peaches and almonds use more potassium than nitrogen each year, do we need to add more potassium than nitrogen each year to maintain sufficient levels??

- Not always (not usually??)

Annual Potassium Needs

- Depends on:
  - soil parent material
  - soil texture (leaching)
  - irrigation system
  - amount of potassium carried away each year

Potassium Nutrition

- Soils may contain 900 - 1500 lb K_2O / 1000 ft^2 (1 foot deep)
  - 90-98% in primary material (unavailable)
  - 1-10% trapped in expanding lattice clays
  - Only 1-2% of total soil K^+ is contained in the soil solution and on exchange sites & is readily available to plants
  - Steady release and low leaching make potassium less likely to be deficient (compared to N)

Potassium Nutrition

- Fertilizers are expressed as % K_20
- Taken up by plant as K^+
- Remains in the plant as K^+

Potassium Fertilizers Should be Applied in a Concentrated Band

- Soil particles are negatively (-) charged
- K^+ ions are bound tightly to soil particles
- Soil particles must be saturated with K^+ before it is available in soil solution

Is it cost efficient to apply a “Tree & Vine” fertilizer (i.e. 15-15-15)?

Cost to Supply 250 lb K_2O Using Various K Fertilizers

Banded

- Muriate of potash (KCl): 60-63% K_2O
  - 400 lb KCl @ $185 / ton = $38 / acre
- Sulfate of potash (K_2SO_4) ~ 52% K_2O
  - 480 lb K_2SO_4 @ $270 / ton = $65 / acre

Injected

- Potassium thio sulfate (0-0-25-17)
  - 1000 lb @ $270 / ton = $135 / acre
- Liquid K_2SO_4 (1-0-8-2.5)
  - 3125 lb @ $85 / ton = $133 / acre

One last K Trial

-Roland Meyer & John Edstrom, 1996-1999

- Experiment compared surface banded K2SO4 with injected K sources:
  - potassium sulfate
  - potassium chloride
  - potassium thiosulfate
  - mono-potassium sulfate
- Three irrigation systems
  - microsprinklers
  - double-lined drip
  - single-lined drip

Yield & Leaf K Values Related to Potassium Fertilizer Formulation

Single line drip

	1998 leaf K+	1998 yield	1999 leaf K+	1999 yield
No K	1.18 d	2449 ab	1.09 d	2383 c
1 lb K_2O (K_2SO_4)	1.78 b	2469 ab	1.73 ab	2944 abc
2 lb K_2O (K_2SO_4)	1.87 ab	2494 ab	1.94 a	2607 bc
1 lb K_2O (MKP)	1.77 b	2786 a	1.37 cd	3280 a
1 lb K_2O (KTS)	1.73 bc	2307 ab	1.71 ab	2741 abc
2 lb K_2O (K_2SO_4 band)	1.48 c	2102 b	1.53 bc	2431 c

Yield & Leaf K Values Related to Potassium Fertilizer Formulation

Microsprinklers

	1998 leaf K+	1998 yield	1999 leaf K+	1999 yield
No K	1.26 f	2645 abc	1.38 f	2332 e
1 lb K_2O (K_2SO_4)	1.71 e	2916 abc	1.87 e	2725 cde
2 lb K_2O (K_2SO_4)	2.33 bc	2698 abc	2.63 bc	3054 abcd
1 lb K_2O (MKP)	2.06 cde	2952 ab	2.04 de	3475 ab
1 lb K_2O (KTS)	1.81 de	3207 a	1.91 e	2500 de
2 lb K_2O (K_2SO_4 band)	2.11 cd	2325 c	2.07 de	3456 ab

Bottom Line for Nickels Field Trial

- Injected mono-potassium phosphate tended to give the highest yields, followed by injected K_2SO_4
- Banded K_2SO_4 increased leaf K and yield substantially in microsprinkler and double-lined drip plots, but not in single-lined drip plots
- There was no relationship between K fertilization and kernel size

Drip hose too far from K application

Drip hose needs to be over K fertilizer

Roger’s Recommendations

1.4% leaf K is probably a pretty accurate critical value

I don’t argue with any grower who wants 2-3% K - its their money!

I don’t believe grower testimonials that higher K = higher yields

Roger's Recommendations

Banding dry K fertilizers is probably best for flood irrigation, maybe micros

Using KCl instead of K_2SO_4 is probably OK in flood-irrigated, sandy locations (monitor Cl)

Banding is not efficient in drip-irrigated orchards - better to inject

Correcting K+ deficiency takes a long time with substantial loss in yield

By the time you see deficiency symptoms, trees are already deficient and yield is lost

Monitor with leaf samples - maintain an ‘adequate’ cushion above 1.4% K