The importance of potassium to tree crops and nuts especially pistachio

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CALIFORNIA LEAF ANALYSIS STANDARD FOR PISTACHIOS

Element	1995		2000		2005, 2012	
	Critical value	Suggested range	Critical value	Suggested range	Critical value	Suggested range
N (%)	2.3	2.5-2.9	2.3	2.5-2.9	1.8	2.2-2.5
P (%)	0.14	0.14-0.17	0.14	0.14-0.17	0.14	0.14-0.17
K (%)	1.0	1.0-2.0	1.8	2.0-2.2	1.6	1.8-2.0
Ca (%)	1.3	1.3-4.0	1.3	1.3-4.0	1.3	1.3-4.0
Mg (%)	0.6	0.6-1.2	0.6	0.6-1.2	0.6	0.6-1.2
Na (%)	?	?	?	?	?	?
Cl (%)	?	0.1-0.3	?	0.1-0.3	?	0.1-0.3
Mn(ppm)	30	30-80	30	30-80	30	30-80
B(ppm)	90	120-250	90	120-250	90	150-250
Zn(ppm)	7	10-15	7	10-15	7	10-15
Cu(ppm)	4	6-10	4	6-10	4	6-10

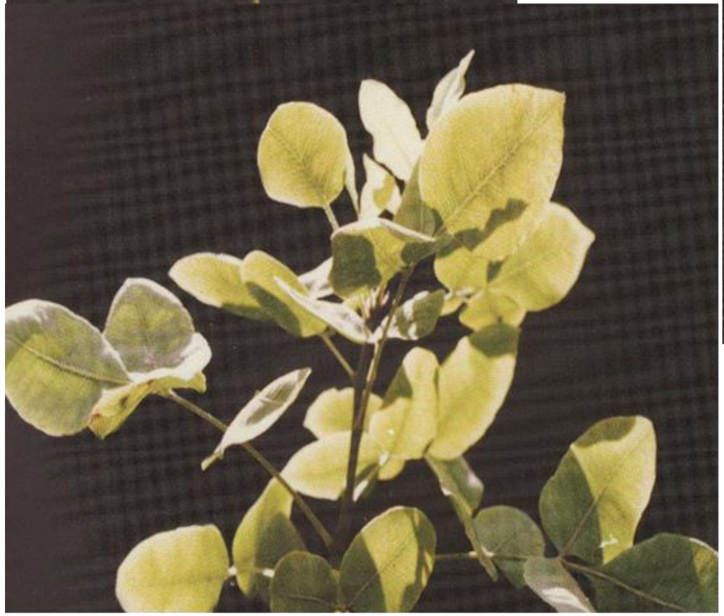
Potassium is an essential macro-nutrient

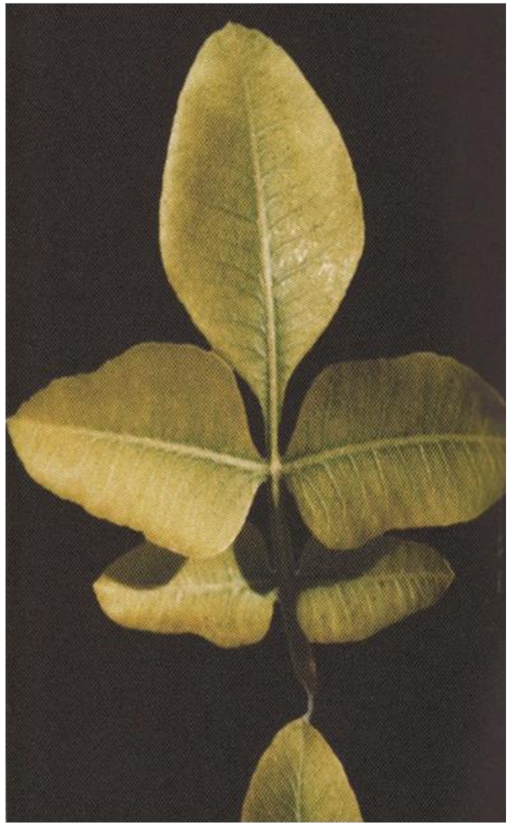
- K is not in any plant structures or important molecules
  - N, S – protein; P – phosphoric acid in DNA; Ca - cell wall; Mg - chlorophyll
- K is common cation in cytoplasm and vacuole
  - K level in early growing season is low and graduate increased
- K regulating pH, osmotic pressure, water stress (stomatal regulation) on photosynthesis
- activating enzymes, protein synthesis,
- carbohydrate translocation in phloem to fruits and roots (potassium malate).
- On-year, some nuts contain 70% K for whole tree

It is mobile in the plant

- K is phloem-mobile macronutrients that are readily translocated from leaves to developing fruit
- Deficiency symptoms first appear on older leaves
- Fruit have a high demand during development
  - Leaves of different ages and close to or far from fruit have different K concentrations
- K level for leaf analysis in off-year is higher than in on-year
  - This is in contrast with Ca and Mg

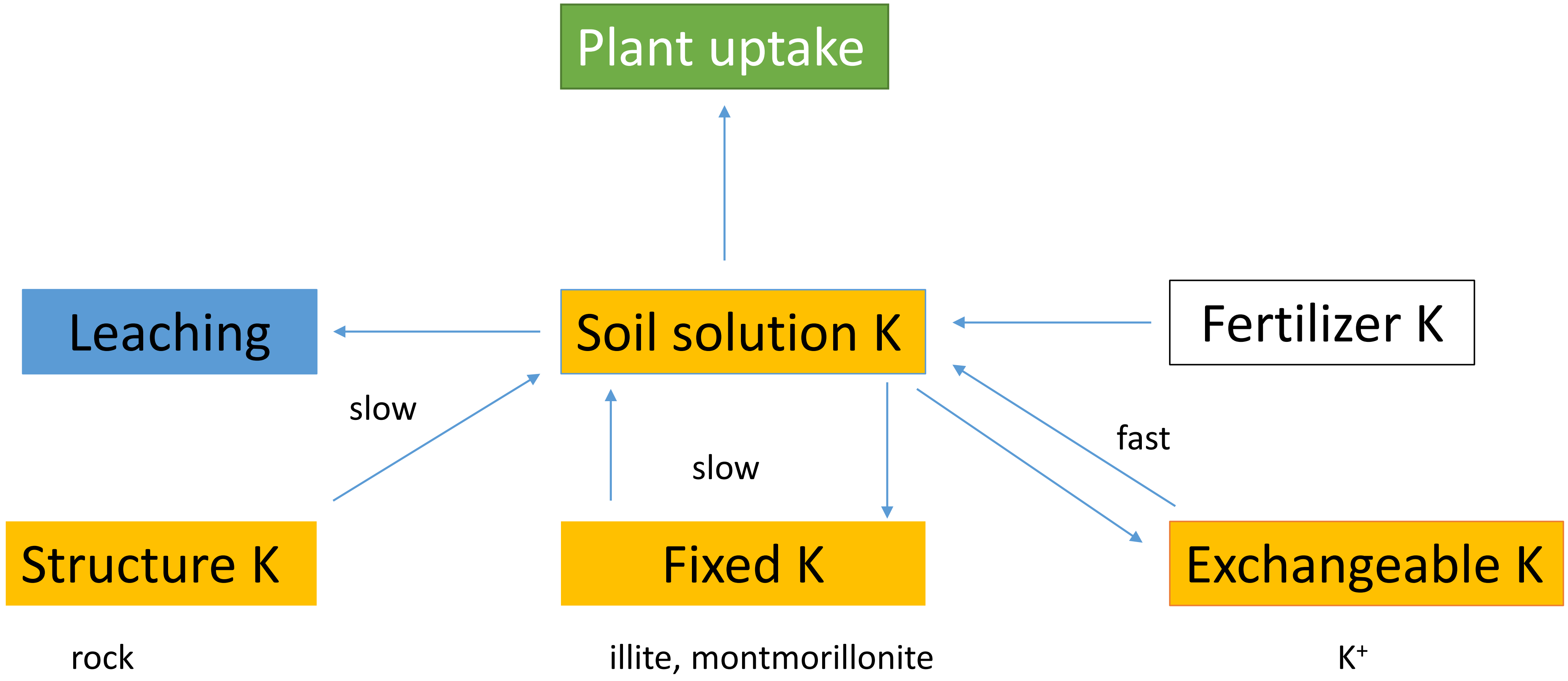
Symptoms of deficiency





- Mobile nutrient
- Older Leaves
- Leaf burn

K in soil



Plant uptake
Leaching
Soil solution K
Fertilizer K
slow
fast
slow
Structure K
Fixed K
Exchangeable K
rock
illite, montmorillonite
K+

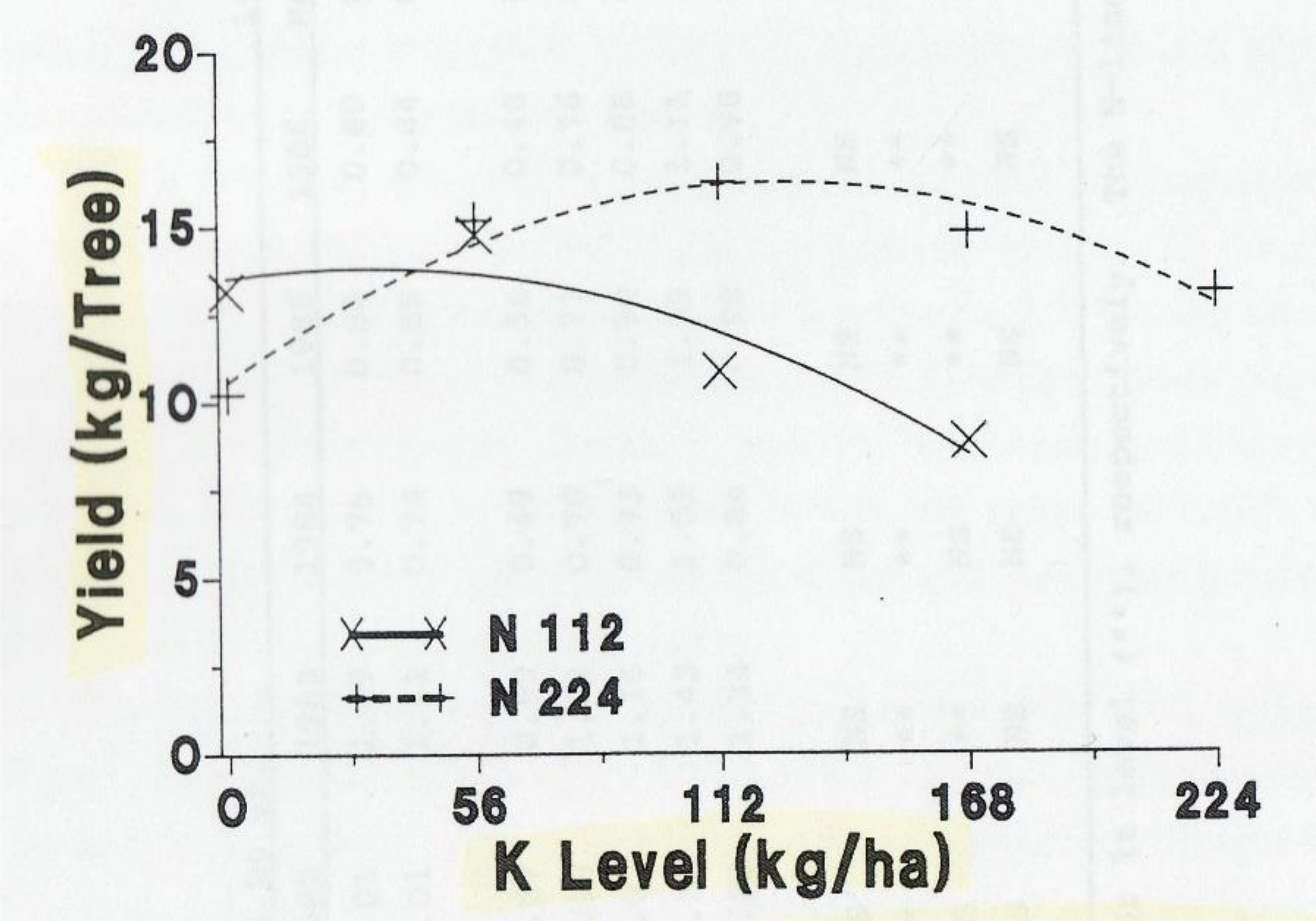
Uptake of potassium

- Soil moisture affects the K release or fixation.
  - Roots occupy < 1% of soil volume
  - K moves to the root surface primarily via diffusion
  - in summer, K availability is reduced if there is no irrigation
  - Low Oxygen (<1%) reduce K uptake
  - Optimum temperature is 20°C
- K downward mobility in soil is slow
  - reaches the 30 - 45 cm depth by year 3
  - the 45-60 cm depth by year 5,
  - Large amount K remained at 0 – 30 cm
- Drip line
  - More water, more K available
  - Soil K concentration was reduced below drip line compared to between rows.
  - After 5 year drip irrigation, leaf K (apple) may reach deficient level (Nielsen, 2000)

Partitioning in the tree

- K from bud break to pollination is increasing.
- Total K peaked each year during January.
  - Wood contained the most K about 35%,
  - followed by the large roots about 25% and
  - leaves about 18%.
  - Fruit accounted for less than 1% of the tree's total K content in January.
- From January to harvest, most mobile K goes to nuts, especially leaf
- Leaves may serve as a K reservoir for fruit when K uptake by the tree is limited
- leaf K concentrations have been consistently found to be about 20-30% lower in fruiting spurs than in non-fruiting spurs.

Tree response to potassium, depends on nitrogen availability



Leaf analysis standard

- K standard historically
  - Pistachio: 0.7-0.9 (1985), 1-2 (1995), 1.8-2-2.2 (2000), 1.6-1.8-2.0 (2005)
  - Pecan: 0.96 (1950), > 0.58 (1974), 0.75 (1975), 1.25-1.5 (1978),
- Leaf is a pool (warehouse), K is transport (truck)
  - If most truck away, no big problem
  - Real K deficiency is < 0.8%
  - > 1% should have no problem unless problem is found
    - California colleague said > 1.4% no problem

K removal

Merchantable yield	N	P	K
(kg)	3.39 %	0.36 %	2.52 %
1000	41.3	4.4	30.6
2000	82.5	8.8	61.2
3000	123.8	13.2	91.8
4000	165.1	17.6	122.4
5000	206.3	22.0	153.0

- About 100 kg K /ha a year
- Some from soil
- Some from fertilizer

Soil analysis standard

- In Australia, many crops and pastures have standard K in soil (Peverill et al, 1999)
- But not for fruit/nut tree
- “Understanding your soil test report” by Orr (2006) for Colwell K (mg/kg)
  - Very low - <50
  - Low – 50 – 150
  - Marginal – 151 ~ 200
  - Optimal – 201 ~ 250
  - High > 250

Potassium fertilisers

- Potassium nitrate
  - soluble, used in drip fertigation, also contains nitrogen
  - K cost per kg approximately $3.12 allowing for the nitrogen
- Sulphate of potash
  - Not so soluble, more suited to broadcast soil application
  - K cost per kg approx. $3.90
- Muriate of potash (KCl)
  - potential chloride risk, though this is not so important with pistachio
  - K cost per kg approx. $1.60

Other methods for K application

- Foliar application
    - 1% KNO_3 or K_2SO_4
- Leaf injury by foliar application
    - Concentration
    - Nature of anion
    - Frequency
    - Adjuvants or not
    - Foliar K application is useful when Leaf K around 0.4-0.8%
- Trunk Injection (Not commonly used)

Response to applied potassium

- Slow.
  - We had 2-year trial for K but even for leaf analysis not clear
  - No response in 3 years but clear in years 5 and 6 in pecan (Smith, 1985)
- However, response to K has been very inconsistent.
  - In some reports, annual K applications did not influence yield or leaf K
  - whereas others show K increased yield, growth
  - Leaf K concentration in pecan was significantly greater using 93 or 186 kg K/ha than no K during 3 years of the study (Smith, 1985);
  - however, the magnitude of the increase was not as great as expected (Smith, 1985).
- As I noticed, most trials on paper did not have soil test record of K

Conclusions

- Potassium is an important nutrient
- Many Australian orchard soils are quite well provided with potassium. Sandy soils at risk.
- Severe deficiency shows up on leaves, whereas leaf analysis can identify at risk orchards
- The balance sheet for potassium suggests applications of as much as 30 kg of actual K per tonne of dried and hulled nuts might be needed