(2) Nutrients of citrus

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Major nutrients of citrus

Nitrogen(N)

Potassium (K)

Phosphorous (P)

Calcium (Ca)

Magnesium (Mg)

Sulphur (S)

Chlorine (Cl)

Minor nutrients of citrus

Zinc (Zn)

Manganese (Mn)

Iron (Fe)

Copper (Cu)

Boron (B)

Molybdenum (Mo)

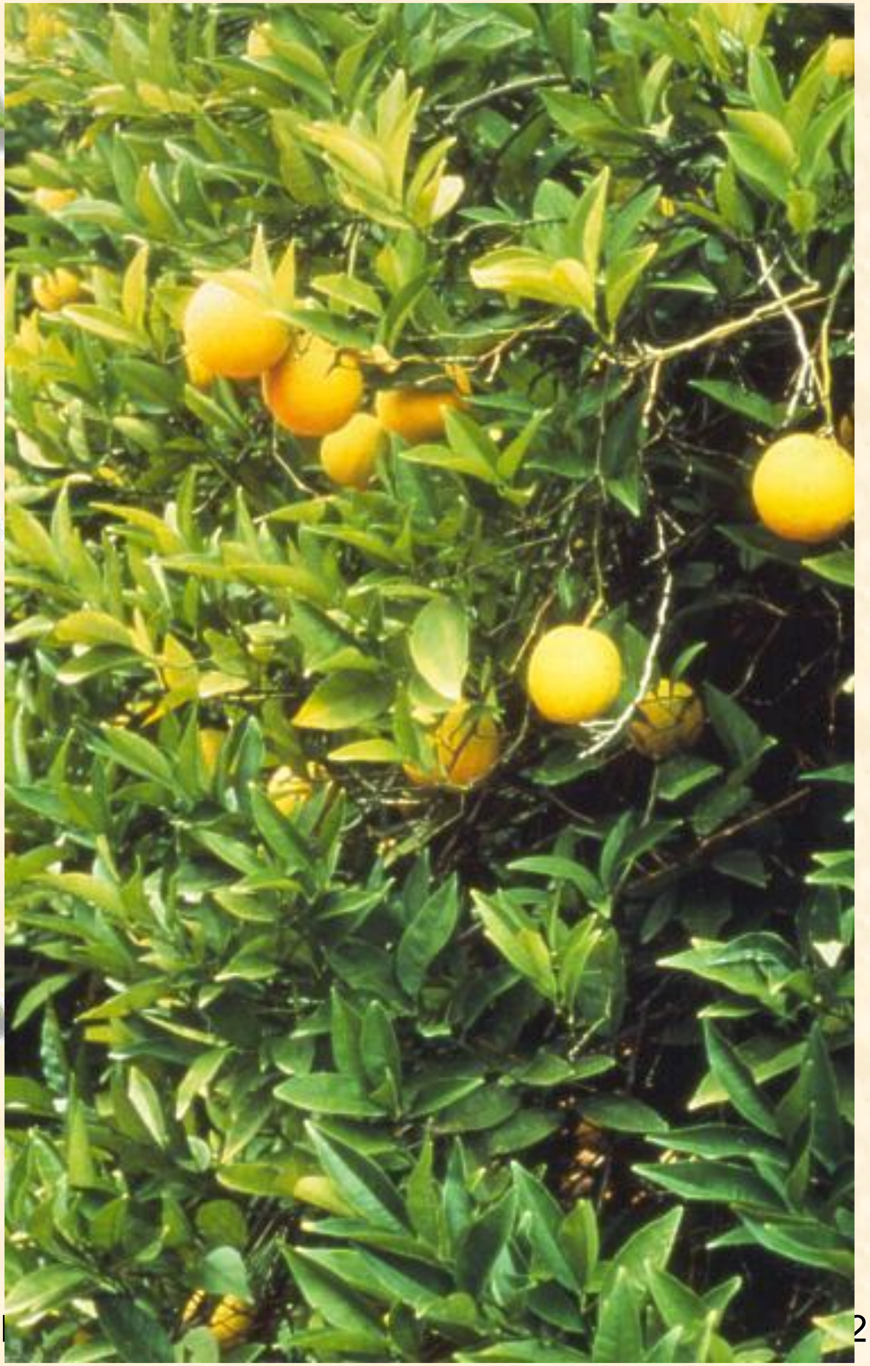
Research data presented

CAUTION

- Most of the research data presented here is from overseas work and is only meant to demonstrate a point. It does not imply that the same fertiliser response will definitely occur under Australian conditions
  - Much research around the world focuses on local soil/climate conditions that predispose the crop to site specific deficiencies and/or fertiliser responses. In many circumstances the observed responses will not occur in other situations

Major Nutrients

Nitrogen (N)



Nitrogen Deficiency

Mobile nutrient so deficiencies occur first in older leaves

Nitrogen Excess
(Dark green leaves)

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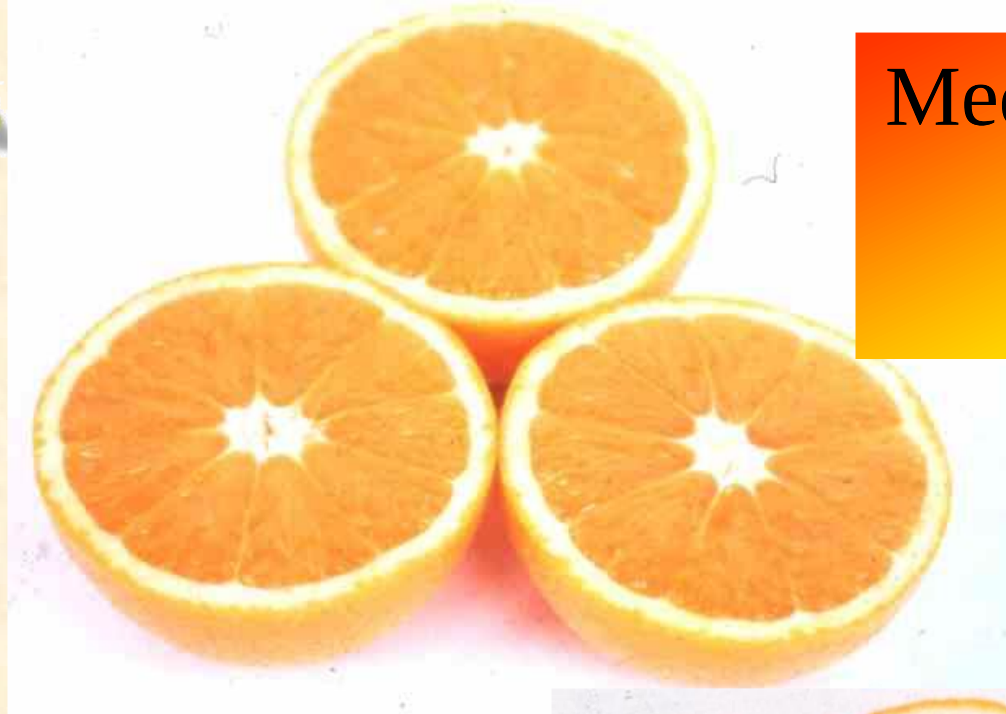
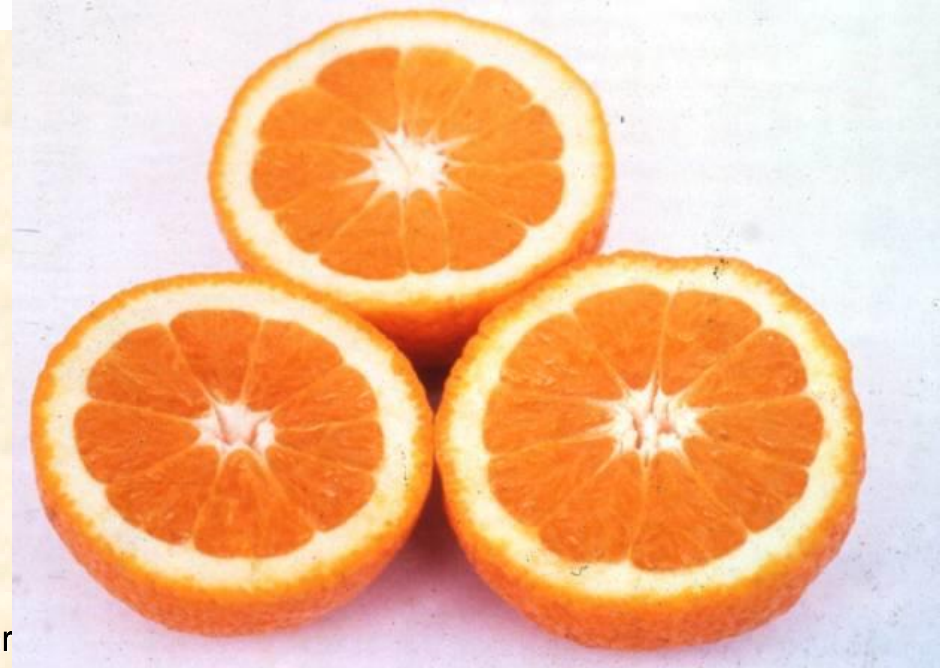
Nitrogen & Fruit quality

- HIGH NITROGEN
  - Increases rind thickness
  - Increases fruit acidity, decreases TSS:acid ratio
  - Delays colour development
  - Increases fruit numbers (indirectly decrease fruit size)
  - Decreases juice content
  - Increases tree vigour (deeper leaf colour from chlorophyll enhancement)

Rough skin (excess nitrogen &/or potassium)



Med. skin (correct nitrogen & potassium)



Thick skin (excess nitrogen &/or potassium)

Nitrogen

- Most important nutrient for application
- No mineral store in soil
  - Potassium (and other elements) can be released from weathering of rocks and clay particles (naturally fertile soils)
  - Nitrogen can come naturally from air and converted into solid N (soil bacteria-N cycle), or artificially applied
    - Natural accumulation 10-50kg/ha (+) – not enough

Nitrogen

- **Application efficiency**
  (how much N applied actually gets used by the tree in your situation?)
  - One reason between productive and unproductive orchards
  - HUGE variation in application efficiency 40% to 80%
    - i.e.. Apply 150kg/ha/year : variation of 60 to 120kg/ha/year gets into the tree
    - How much of your nitrogen gets to the tree?

Root depth

Majority of citrus roots in the top 40cm

(Troyer citrange 9 year old/drip irrigation)

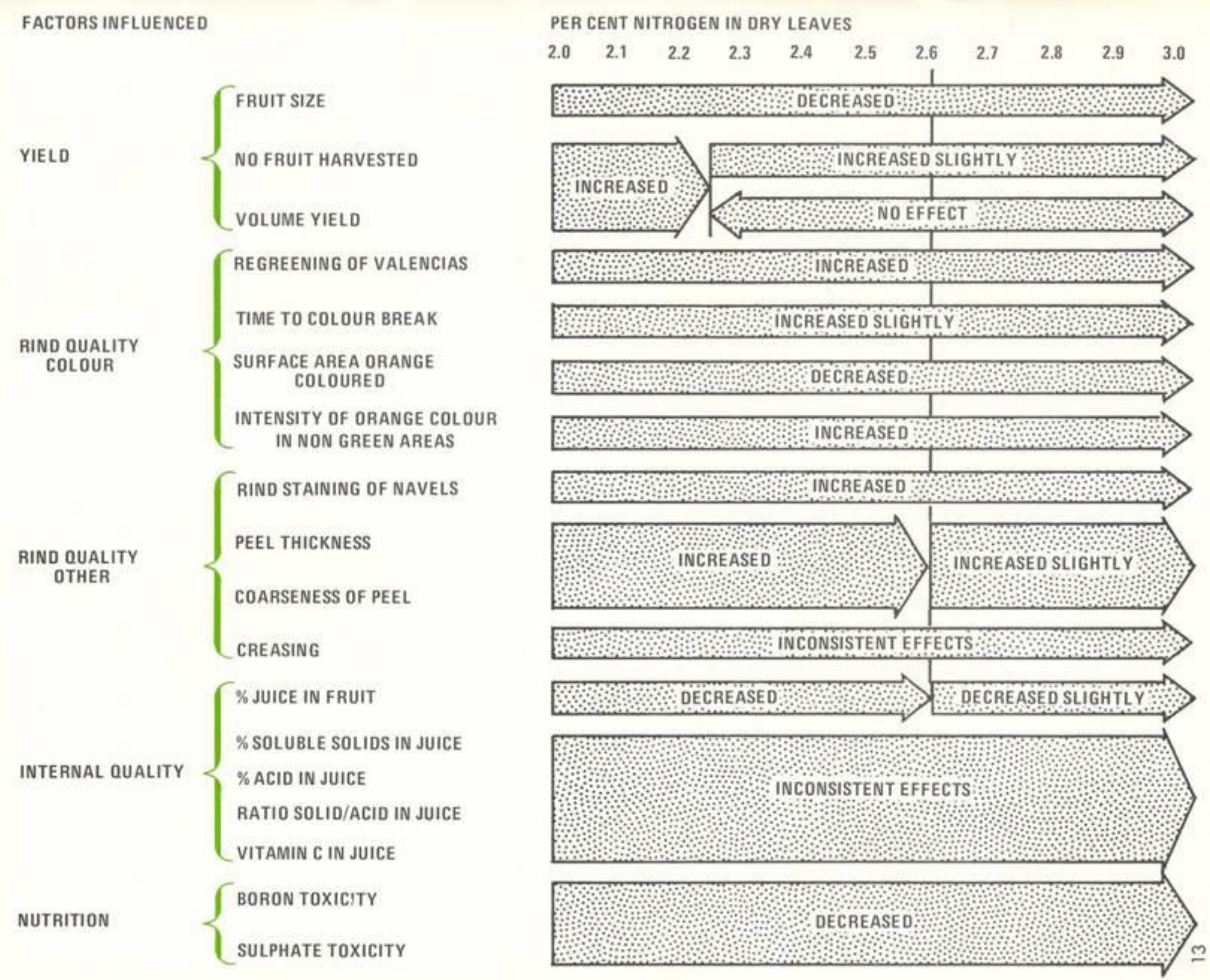
N Tree reserves

- Other trials report a higher contribution of current season N application to fruit (50%)
  - Younger trees must have a higher dependency on current season N
  - Trees fertilised in winter store N in roots and it moves up when warmer (Kato, 1986)
  - Tree mostly use reserves to start activity in spring
  - Majority of uptake in summer

N Tree reserves

- Other trials report a varying efficiency of uptake 40-80% (Lea-cox 2001)
  - Leaching & other losses could be causing N deficiencies
  - Add effect of varying crop levels, N nutrition could contribute to biennial bearing
- N uptake by roots is fast (warm) (McNeal 2000)
  - Differences in rootstocks (physiology) & amount of roots

Nitrogen (N)


FACTORS INFLUENCED
PER CENT NITROGEN IN DRY LEAVES
2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3.0
YIELD
FRUIT SIZE
DECREASED
NO FRUIT HARVESTED
INCREASED SLIGHTLY
INCREASED
VOLUME YIELD
NO EFFECT
RIND QUALITY COLOUR
REGREENING OF VALENCIAS
INCREASED
TIME TO COLOUR BREAK
INCREASED SLIGHTLY
SURFACE AREA ORANGE COLOURED
DECREASED
INTENSITY OF ORANGE COLOUR IN NON GREEN AREAS
INCREASED
RIND QUALITY OTHER
RIND STAINING OF NAVELS
INCREASED
PEEL THICKNESS
COARSENESS OF PEEL
INCREASED
INCREASED SLIGHTLY
CREASING
INCONSISTENT EFFECTS
INTERNAL QUALITY
% JUICE IN FRUIT
DECREASED
DECREASED SLIGHTLY
% SOLUBLE SOLIDS IN JUICE
% ACID IN JUICE
RATIO SOLID/ACID IN JUICE
VITAMIN C IN JUICE
INCONSISTENT EFFECTS
NUTRITION
BORON TOXICITY
SULPHATE TOXICITY
DECREASED
13

Phosphorus (P)

Phosphorus Deficiency

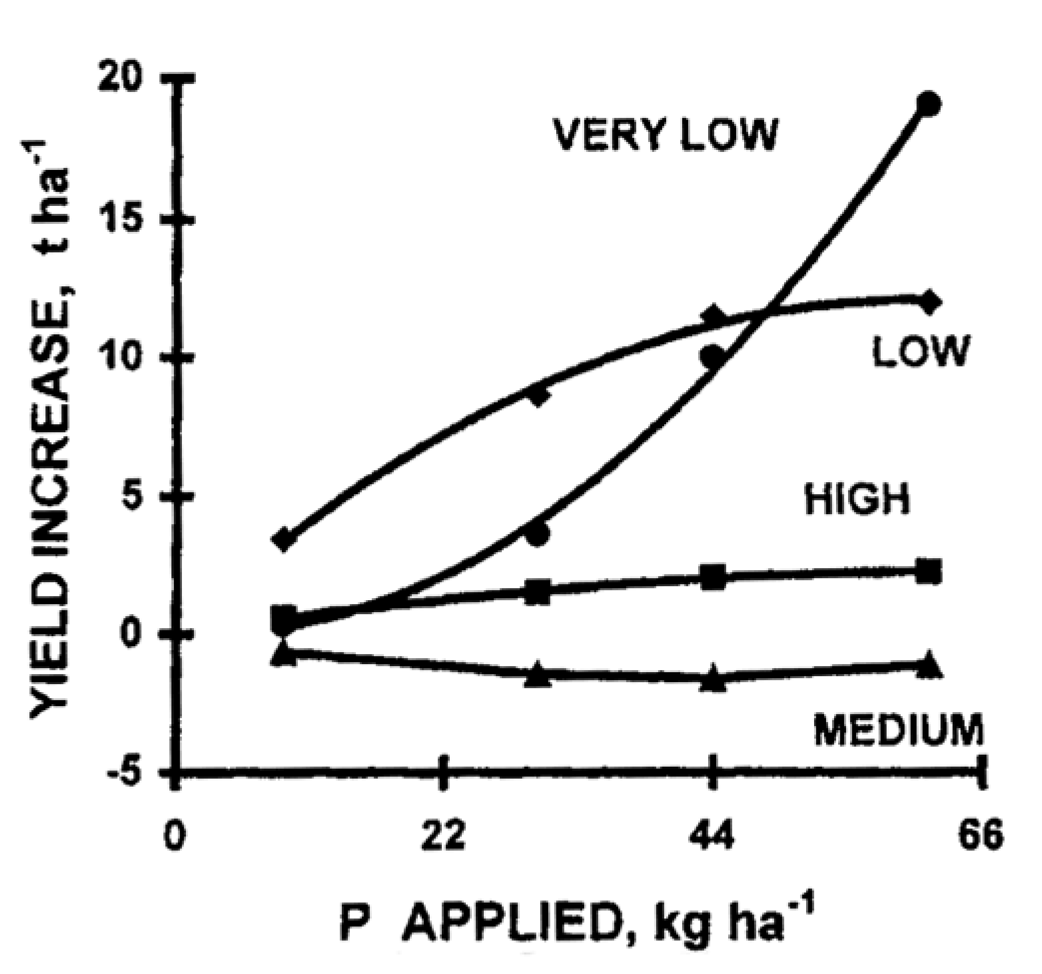
Phosphorus (P)

- HIGH PHOSPHORUS
  - Decreases rind thickness
  - Decreases fruit acidity
  - Reduce fruit size (possibly because of thinner rinds)
  - Higher albedo (possibly because of thinner rinds)

Phosphorus (P)

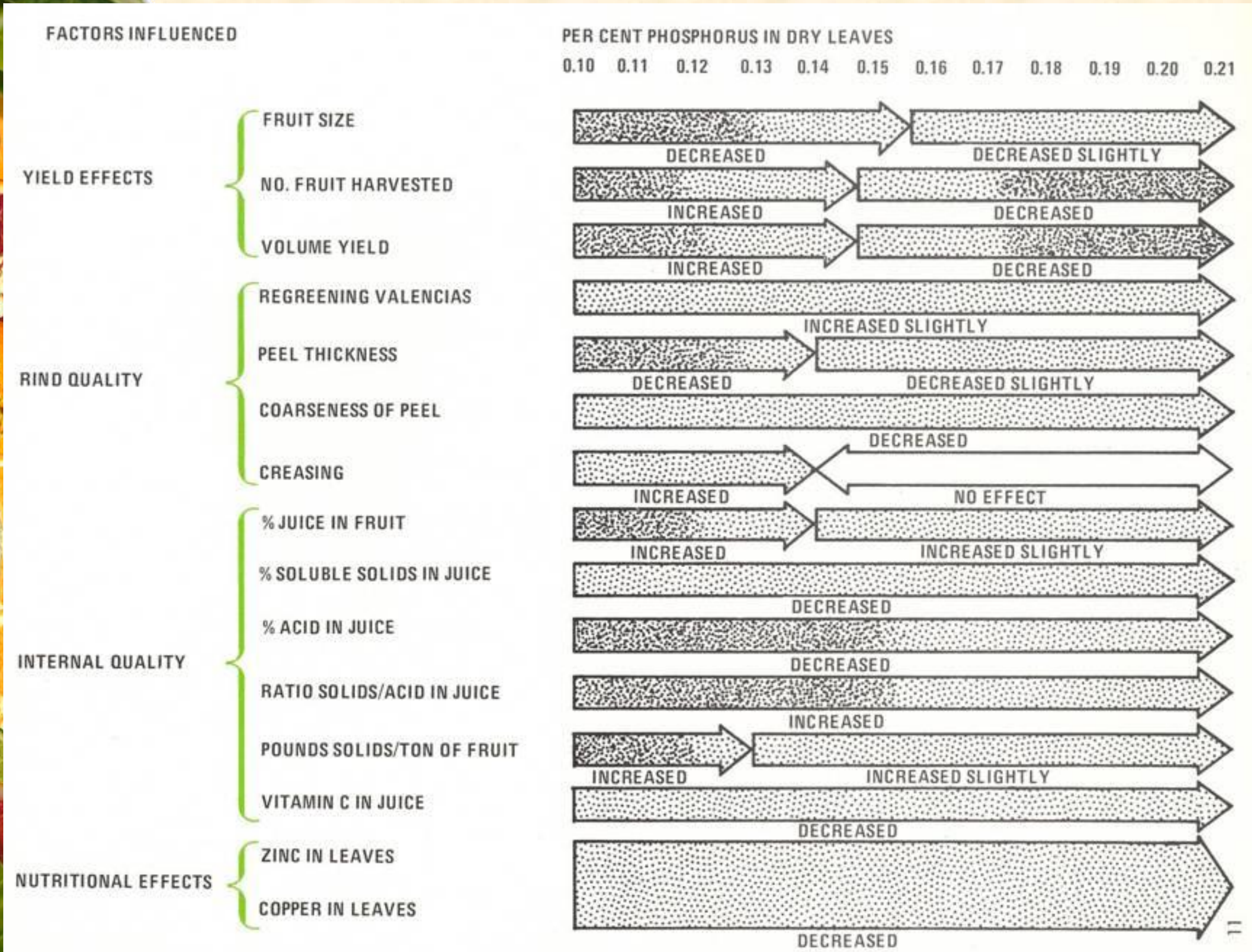
- Tree require it in low levels (i.e. 5kg/annum)
- High levels found in quick growing tissue, promotes root growth (Havelin etal 2005)
- Mobile nutrient within the tree
- Soil can fix P quickly if spread over broad area
  - Banding is best, but take time to penetrate and most will be fixed
- Drip fertigation– phos acid or MAP best
- Moderate rates 20-40kg/ha/year (depend upon leaf & soil test)
- Current theory target in early spring for root growth
  - Most common is banded super ground application of P for sprinkler irrigation or fertigated MAP/Phos acid for drip/sprinkler, however it is possible to apply foliar to 2/3 fully expanded spring flush leaves
- Leaf levels not sensitive to crop load – (Lenz F. 2000)

Phosphorus (P)



- Quaggio, 1998 – Yield response to rates of P application on soils on Brazil with various levels of natural soil phosphorus fertility

Phosphorus (P)



Potassium (K)

Potassium Deficiency

Potassium (K)

Potassium deficiency: Bennet, WF. 1993

Potassium (K)

- Potassium leaf deficiencies seldom seen in field grown citrus (Koo 1968)
  - Leaf drop and decrease in fruit size first symptom often observed
- Increase fruit size (variable)
- Increase yields to 0.7% leaf analysis
- Increase peel thickness
- Slight increase acid in juice
- Slight delay in colouring
- Slight/moderate decrease juice content (larger fruit/thicker peel)

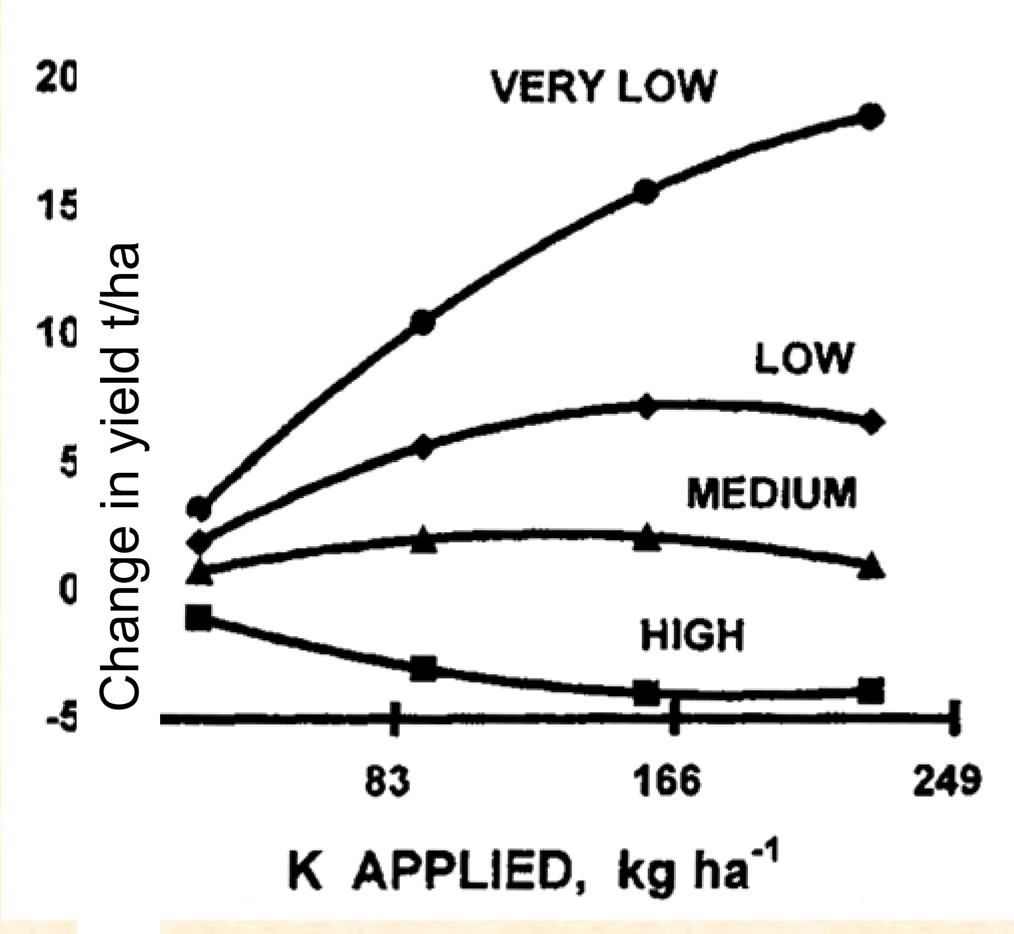
Potassium (K)

- Biological activity includes: (Havelin et.al. 2005)
  - Osmotic potential and (stretching out growing cells – fruit size)
  - opening leaf pores (stomata) water regulation and to let in CO_2 (Bower et.al. 1996)
  - water uptake

Potassium (K)

- Fertiliser trial results highly variable and conflicting results
  - Some applied 1T/ha of K with no significant fruit size increase (Bazeleth, 1980)
  - Other report significant fruit size increase,
  - Variation probably due to large differences in soil K fertility between sites
    - Poor K soil will have very good responses to K application whilst a fertile K soil will have minor response
    - Be wary if reading trial reports

Potassium (K)



K soil test classification

VL: <0.08 cmole/kg

L: >0.08-0.15 cmole/kg

M: >0.15-0.3 cmole/kg

H: >0.3 cmole/kg

- Quaggio, 1998 – Yield response to rates of K application on soils on Brazil with various levels of natural potassium fertility

Potassium (K)

- Potassium deficiency (Florida trial)

Potassium (K)

% K non fruiting 4-7 month old leaves

- Koo 1967 magazine article, no data
  - Florida sandy soils very deficient in K

Potassium (K)

- Maximum uptake from late spring to early autumn. No uptake in winter. (Dass etal, 1997)
- Sweet orange rootstock good absorber of K, citrange & trifoliata weak absorber of K (Dass et.al. 1997)

Potassium (K)

- Highly mobile in the tree and probably has a “reserve” effect like nitrogen
  - Deficiency symptoms usually first appear on older leaves
- May take three or more seasons of soil application to show leaf test improvements (soil interaction ???)
  - In calcareous soils, foliar K more effective than soil applied K (K availability) (Alva etal, 2006)
    - KNO3 sprays increased fruit size even though soil K was high (Du Plessis etal, 1984) : further discussed in “foliar spray” section
  - Some soils have high K fixation or buffering – movement down is slow. Other soils low K fixation or buffering and movement high (Page, 1969)

Potassium (K)

- Leaf levels below 0.7% cause yield and fruit size reductions
- Current Australian recommendation for sufficient leaf analysis levels 0.7 – 1.1%
- Overseas papers suggest that:
  - leaf levels up to 1.3-1.5% will increase fruits size
  - leaf levels after 1.3-1.5% will probably not impact greatly on fruit size
- Perhaps Australian leaf levels for high value navels should be increased to 1.1-1.3% ?
  - Need to do localised trials due to soil variability

Potassium (K)

- Different responses on different soil types
  - Check soil tests and leaf tests
    - Soil solution tests can be misleading but good value for advanced drip fertigation
  - Need local trials
- Not sure if soil can supply peak K demand (fruit fill Dec-Feb), especially high crop load ?
- Suggest targeted application during main fruit fill (Dec-Feb), &/or foliar sprays may provide fruit size benefit in certain situations ?

Potassium (K)

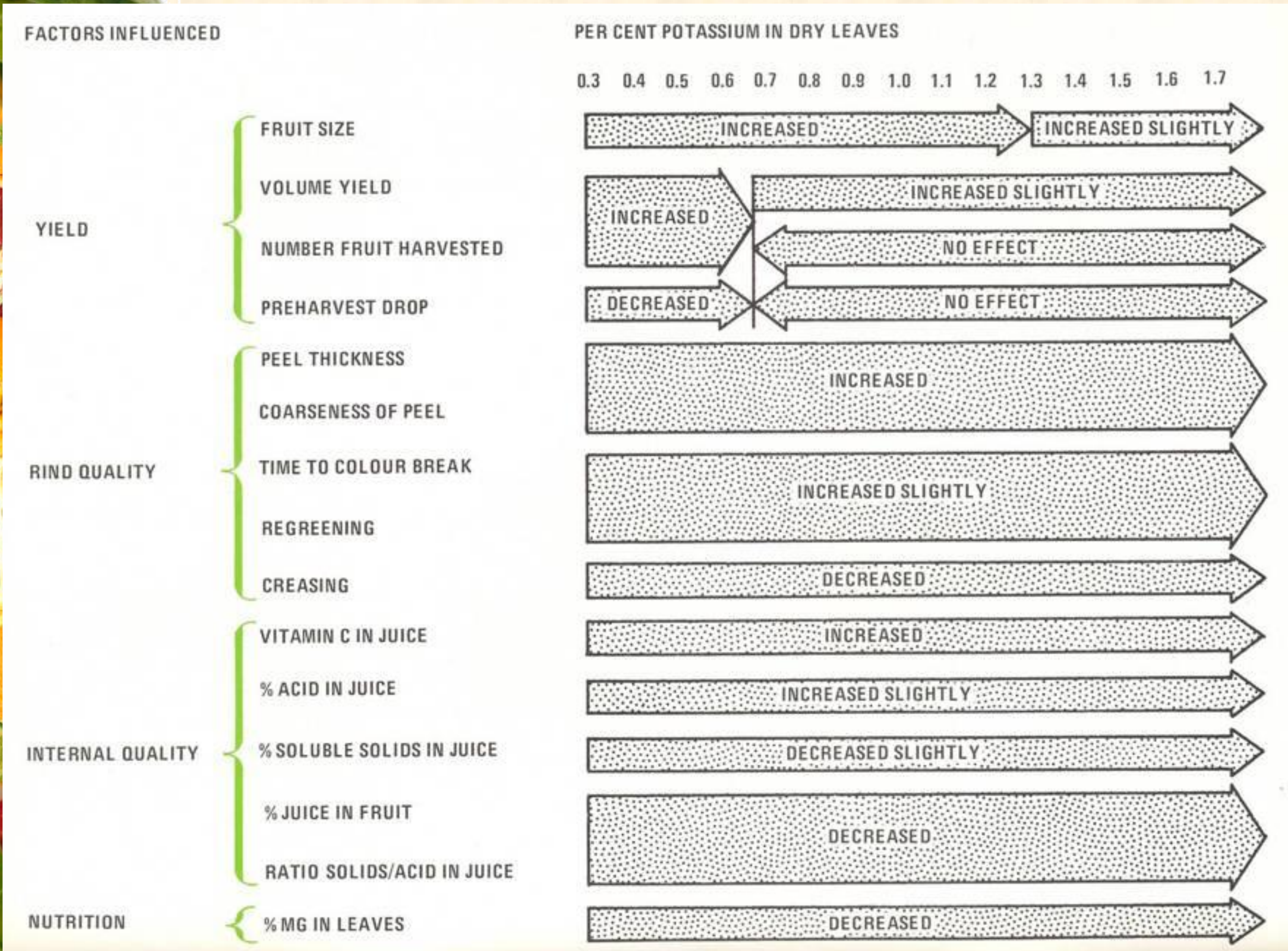

FACTORS INFLUENCED
PER CENT POTASSIUM IN DRY LEAVES
0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7
YIELD
FRUIT SIZE
INCREASED
INCREASED SLIGHTLY
VOLUME YIELD
INCREASED
INCREASED SLIGHTLY
NUMBER FRUIT HARVESTED
NO EFFECT
PREHARVEST DROP
DECREASED
NO EFFECT
RIND QUALITY
PEEL THICKNESS
COARSENESS OF PEEL
INCREASED
TIME TO COLOUR BREAK
REGREENING
INCREASED SLIGHTLY
CREASING
DECREASED
INTERNAL QUALITY
VITAMIN C IN JUICE
INCREASED
% ACID IN JUICE
INCREASED SLIGHTLY
% SOLUBLE SOLIDS IN JUICE
DECREASED SLIGHTLY
% JUICE IN FRUIT
RATIO SOLIDS/ACID IN JUICE
DECREASED
NUTRITION
% MG IN LEAVES
DECREASED

Table 1: EFFECT OF INCREASING NITROGEN, PHOSPHORUS AND POTASSIUM LEVELS IN THE LEAVES ON THE QUALITY OF THE FRUIT. *

	N (Low – High)	P (Low – High)	K (Low – High)
Fruit Size	↘	↘ →	↗
Number of Fruits	↗ ↗	↗ →	↗ →
Production	↗ ↗	↗ →	↗ →
Rind thickness	↗ →	↘	↗
Juice (%)	↘ →	↗	↘
Solids (TSS)	↔	↘ (thin)	↘ (thin)
Acidity (%)	↗	↘	↗
Brix:Acid	↘	↗	↘

(↗ = increasing; ↘ = decreasing; ↔ = insignificant changes)

(From: Du Plessis, 1988)

Magnesium (Mg)

Magnesium Deficiency

NSW DPI Citrus Nutrition Seminar “Short” (S

Magnesium (Mg)

- Deficiencies: smaller fruit size, lower acid, lower TSS, lower juice content, biennial bearing (Chapman 1968 & Sale 1994)
- Required more by seeded varieties as seeds are a sink for magnesium (Tucker 1995)
- Deficiencies can exacerbate Zn and Mn problems (Chapman 1968 & Sale 1994)
- Deficiencies not common in alkaline soils but reported deficiencies in sandy slightly acidic soils
  - However can be induced in any soils by high K application
  - Check your soil test and leaf tests
- Very mobile in the plant so deficiencies normally occur in older leaves (taken from older leaves to supply young leaves & fruit)

Magnesium (Mg)

- Corrected by late spring 1-2% $MgNO_3$ foliar sprays (2/3 leaf expansion) (Erner, 2004) (Jones et.al. 1971)
  - Significant problems may need soil Mg application (magnite) and 4x 2% $MgNO_3$ foliar spray (annual sprays may be required) (Erner, 2004)
    - In some situations foliar sprays are more effective than soil

Calcium (Ca)

Calcium (Ca)

Calcium deficiency - Bennet, WF. 1993.

Calcium (Ca)

- Immobile
- Required in high levels similar to K
- Physiologically
  - Very important as a cell binding agent
    - Associated with albedo breakdown
  - Important for cell division and elongation (growth)
  - Very immobile – once reaches target stays for life
  - Moves in tree with water from root to tree organ
    - High water use organs (leaves : transpiration) have highest Ca content and increase in Ca content in time
- Deficiencies rarely reported around the world
  - Deficiencies mostly occur on leached acidic sandy soils (leaf levels 1.5%- VL) and applications of Ca in conjunction with pH correction (lime) produce significant growth responses and increases in leaf levels to 3% (Anderson etal 1969)

Calcium (Ca)

- Very important in correcting salinity issues
  - Ca will push out sodium from clay particles
  - Assist to reduce uptake of sodium (Gobran, 2001)
- Also improve clay soil structure in some situations

Minor Nutrients

Manganese (Mn)

Manganese Deficiency

Manganese (Mn)

- Mostly immobile
- Deficiency (Wier et.al. 1991)
  - Light green mottled between veins
  - Leaf size remain same
  - More noticeable on southern side of tree
- Often confused with Zn & Fe deficiency
- Easily corrected with foliar spray
  - Manganese sulphate 0.1% (Wier etal, 1991)

Zinc (Zn)

Zn Deficiency

Zn Deficiency

Zn Deficiency - Photo: Futch etal, 2001

Zinc

- Deficiency (Wier et.al. 1991)
  - Leaf : little , mottled, rosetting
  - most prevalent on alkaline soils and some symptoms seen on acidic soil
  - Lowers yield, reduces tree vigour, small fruit and poor quality fruit
  - May encourage water sprouts

Zinc

- Spray of 1% $ZnSO_4$ help severe deficiencies (Dixit et.al. 1983)
  - Autumn spray helped spring flush following season!
- Best to apply to young flush

Iron (Fe)

Iron Deficiency

Iron

- Immobile
- “Iron Chlorosis”
  - Important for chlorophyll growth (Wier et.al. 1991)
- Associated with calcareous soils &/or waterlogging &/or low soil temperature
- Induced by high P (Zegri et.al. 2003)
- Trifoliate rootstocks (incl. citrange & swingle) have difficultly in taking up iron

Iron

- Florida – lack of response from foliar sprays and best result from soil chelate
  - Iron sulphate turns to unavailable oxide in acidic or alkaline soil
- Observed good responses by soil applied chelated iron
  - Hand application
  - Fertigation + pH adjustment of water (6-6.5pH)

After Zegri et.al. 2003

Iron

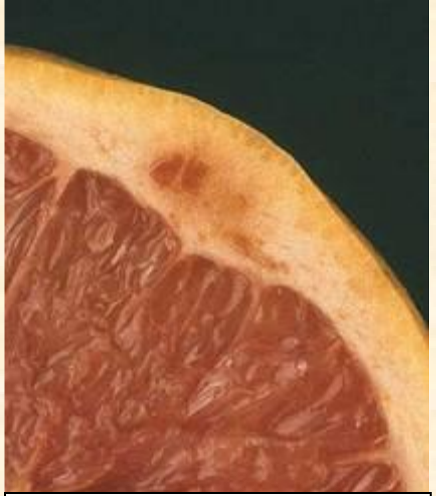
- Not all chelates are equal – (DTPA or EDDHA) for alkaline soils
  - DTPA/EDDHA might be more expensive

Chelate form	Effective soil pH range
EDTA	4.0 to 6.5
HEDTA	4.0 to 6.5
DTPA	4.0 to 7.5
EDDHA	4.0 to 9.0

After Zegri et.al. 2003

Boron (Bo)

Boron



Bo Deficiency
Photo: Futch etal, 2001

- Deficiency (Zegri etal, 2003 & Wier 1991)
  - Hard fruit – gummy lumps in the rind
    - Misshaped fruit
  - Premature shedding of young fruit
  - Death of terminal growth
- Deficiency Correction :
  - 0.1% Borax foliar spray or 1/300 B:N soil application (Reitz etal, 1984) or 1/3
  - Highly immobile : did not move (translocate) to other tree parts when sprayed onto leaves, but moved to all parts of tree when soil applied (Boaretto AE, 2004)
    - Only 5-10% Bo moves from old leaves to new growth (Boaretto RM, 2004)
  - Soil too risky of toxicity and leaching
  - **CAUTION** – very easy to oversupply and KILL trees

Molybdenum (Mo)

Molybdenum

Mo deficiency
Photo: Futch et.al. 2001

- Important for N metabolism
  - formation of proteins
- Mostly immobile
- Deficiency (Zegri etal, 2003)
  - Yellow spots on leaves, often occurs trees unable to uptake from acid soils
  - Deficiencies very rare, if seen, mostly on acidic soils
  - Rumours associated with flowering, but no published information
- Deficiency Correction :
  - Neutralise acidic soils
  - Required in very small amounts
  - Foliar spray NaMo or NH_4Mo (7g/100L)

Copper (Cu)

Copper

Cu deficiency
Photo: Futch etal, 2001

- Known as die back, ammoniation, exanthema
- Names derived from
  - dieback of twigs
  - Association with heavy application of ammonia
  - Gum on surface of twigs
- Mostly immobile
- Deficiency (Zegri et.al. 2003)
  - First symptom vigorous dark foliage and bowing up of the mid rib
  - Twigs are vigorous, long, soft, angular and frequently “S” shaped
  - Branches then dieback and hardened gum on leaves, twigs then fruit
  - Fruit splitting
  - Cause might be excess of N, but often cured with a Cu foliar application
- Deficiency Correction :
  - Foliar spray 1kg/ha of Cu (i.e $CuSO_4$: 120g/100L)

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