(3) Foliar nutrient sprays of citrus

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Foliar Nutrient Sprays

- Provide a quicker response than soil applied especially in situation not favourable for soil uptake
  - i.e. Zn/Mn uptake in cold alkaline soils
- Sprays should be catered to suit site conditions
  - Most can be mix together nutrients, but should not be highly concentrated as cause leaf burn
    - Must check compatibility – bucket test
- All urea mentioned for foliar spray is low buiret urea (0.4%)
  - Normal urea (1.5% biuret) can burn leaves

Buiret toxicity
Photo: Futch etal, 2001

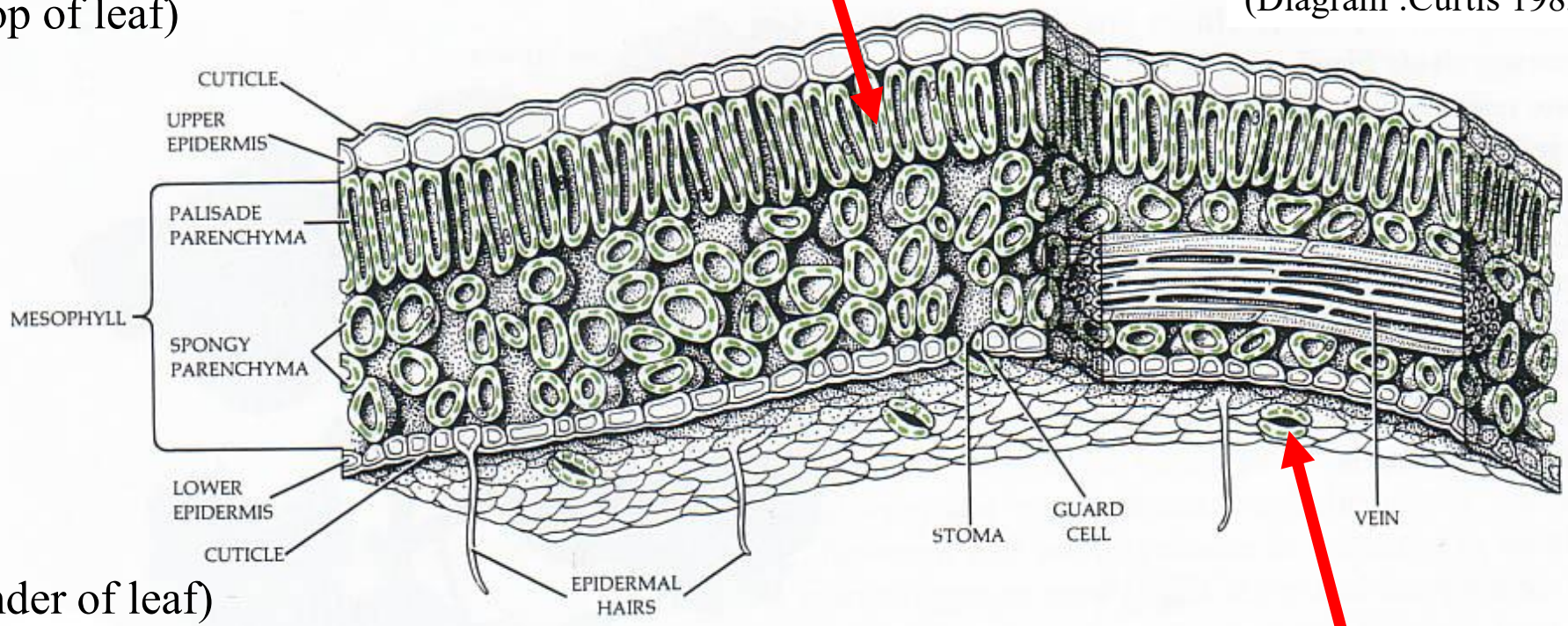
Foliar uptake

- Two main pathways of foliar uptake

1) Through leaf cuticle

(Top of leaf)

(Diagram :Curtis 1983)



(under of leaf)

2) Through stomata on leaf underside (leaf air/water vapour pores)

Foliar Nutrient Sprays

- Cuticle Penetration
  - Waxy leaf coating (cuticle) restrictive to quick penetration of salts (hydrophobic – repels water)
  - Salts enter through cuticle cracks/pores (ectodesmata) but only in a liquid from
    - Once salt crystallises on leaf, no uptake occurs
    - Ectodesmata more prevalent on underside of leaves
      - Numbers reduced by age and stress – high temp, drought, high sunlight & disease
      - Lined with negative charges so positive charged elements are favoured (i.e. potassium, calcium, zinc, manganese)

(reference -Wojcik, 2004)

Foliar Nutrient Sprays

- Cuticle Penetration
  - Uptake not affected by temperature but strongly affected by humidity
  - Speed of uptake is related to ability of salts to form a liquid in high air humidity, size of hydrated (water added) salt and salt electrical charge
    - Higher electrical charge = less uptake
    - Larger the hydrated ion = less uptake (chelates difficult to penetrate – must drop out ion)
      - Smaller : Ammonium – potassium – sodium – calcium – magnesium : larger

(Wojcik, 2004)

Foliar Nutrient Sprays

- Cuticle Penetration
  - Ability of salts to form a liquid is “Point of Deliquiescence (POD)”
    - Minimum air humidity next to the salt for it to become liquid
    - Potassium carbonate : 44% - penetration doubled when humidity rose from 50% to 90%
    - Potassium chloride : 86% (max penetration 90% and lower at 100%
    - Potassium nitrate : 95%
    - Mono potassium phosphate:97% (max 100%)

(Schonherr, 2001)

Stomatal Penetration & Spray Adjuvants

- Surfactants “wetters” aid in spreading solution all over the leaf
  - Possibly to use less volume to get the same coverage
- Spreading capability is measured in dynes/cm
  - Fresh water is 70 dynes and most surfactants modify solutions down to 40-20 dynes
    - Affected by concentration of surfactant in solution
- Also have a some penetrating action through waxes/cuticles (depending on acitve)

(Wojcik 2004)

Stomatal Penetration & Spray Adjuvants

- Stomatal penetration occurs below 30 dynes/cm (Neumann et.al. 1974)
- Organosilicones most effective & expensive! ~ 20 dynes/cm
- Iron sulphate sprays with silicon surfactant re-green chlorotic leaves, no surfactant had minimal impact (Neumann et.al. 1974)

Foliar Nutrient Sprays

- Urea
  - Does not have a electrical charge so it can “slip easier between the crack/pores”
    - Up to 10 to 20 times more penetration than other forms of N
      - 54% uptake within 2 days compared to 8% with potassium nitrate (Lea-Cox, 1995)
    - Penetration related to urea loosing bonds holding wax/cuticle molecules together – “opens up the net”
    - Can help penetration of “some” ions
      - Not effective on Mg or P in apples
  - High ammonia is toxic to trees ; do not spray high rates on stressed trees – drought ,salinity
    - Use low rates 0.25%

(Wojcik, 2004)

Foliar Nutrient Sprays

- Trials demonstrate that you can feed most of N to a tree by foliar application nearly as effectively as total soil application
  - Three year young (1-3yo) Hamlin tree trial showed all N (urea) as foliar as effective as soil applied N (Albrigo et.al. 2000)
    - Less total applied N via foliar and much less environmental contamination of N (leaching)

Foliar Nutrient Sprays

- Adding urea enhances uptake of nutrients (Soybean trials : El-Fouly et.al. 1990). Urea had a similar effect to chelating nutrients
  - Chelating nutrients and adding urea had an additive effect on further increased uptake
- Trials that report responses generally have nutrient deficiencies
  - Be wary of trial report data, can be misleading

Foliar Nutrient Sprays

- Potassium phosphite
  - Reported as a nutrient and fungicide spray in many fertiliser company brochures, but scientific evidence shows it has no direct nutritional value (contradictory information ??) (Landschoot etal 2005, Varadarajan etal 2002)
    - Plants use the PO_4 form and are unable to metabolise PO_3
    - PO_3 causes disruption to P metabolism in phytophthora fungus and suppress fungus growth
    - Must be converted to PO_4 by bacteria in the soil for plant use (plants excrete PO_3 out of root)
    - Lovatt reports yield increase with KPO_3, but no leaf P data published
      - Potassium or fungicide response?

Foliar Nutrient Sprays

- Winter urea application increase fruit numbers & size
  - Clementine mandarin in Morocco, 1.6% Urea, June & July (Otamani et.al. 2000)
  - California, Navel, Urea 1.2% @ runoff (6000L/ha) mid July increase fruit numbers and size (Ali et.al. 1994)
    - Suspect effect not due to nutrition, but the stress effect of ammonium to enhance flowering
    - Not successful in Israel (personal communication Y.Erner)

Foliar Nutrient Sprays

- End of cell division (mid Dec) foliar urea or 2 x MKP increased fruit size – California (Lovatt, 1999)
  - 3% urea sprayed before leaf drip (so not to cause burn (2500L/ha)
  - MPK liquid fertiliser (0-28-26) 4.6L/ha applied in mid Oct and mid Jan

Potassium (K)

- In calcareous soils foliar K more effective than soil applied K (K availability) (Alva et.al. 2006 & Calvert et.al. 1972)
- Israel use KNO_3 sprays 5% (pH3.5 – HNO_3) Nov- early Dec help boost K & increase fruit size (Erner, 2004)

Foliar Nutrient Sprays

- New leaf flush do not have a good ability to move Mn, Fe, Zn, Mo & Bo from older flush into their new leaf growth (remobilisation) (Marshner 2003)
  - However in general reproductive organs (fruit) are strong sink and able to accumulate these micronutrients
- Therefore, theoretically ineffective to spray trees with micronutrients before new flush occurs (i.e. pre-bud burst)

Foliar Nutrient Sprays

- Young trees can benefit greatly from regular foliar sprays
  - Young tree roots do not consume all the wetted area of the soil and allot of fertiliser can be wasted / leached.
    - Nutrient deficiencies
    - Reduced growth
    - Environmental hazard
  - Monthly/fortnightly sprays of macro & micro nutrients can be excellent way to provide optimum nutrition and growth

Foliar Nutrient Sprays

- Need to do your own trials to assess the need for enhanced nutrition
  - Monitor with leaf analysis and visual
- Once a tree has sufficient micronutrient nutrition, any additional micronutrient application does not have an additive effect
  - i.e. Boron deficiency causes premature shedding of fruit, but extra boron to a tree with adequate levels of boron does not make it hold extra fruit. (Toxicity!)

Foliar Nutrient Sprays

- Many commercial forms of micronutrient mixture sprays that contain a variety of macro & micronutrients
  - Zn, Mn, Mg, Bo, Mo, Cu, Fe
  - Nutrient “insurance policy”
  - Easy to mix and not excessive cost comparative to diesel and labour cost
  - Can mix your own : (rates per 100L)

Example of foliar spray options for Sunraysia (per 100L rates)

Winter	Pre bud burst (late July)	1/3 leaf expansion (pre flower - Sept)	2/3 leaf expansion & root P (Oct)	Fruit size Potassium (Nov)	Summer Urea fruit size (mid Dec)	Summer flush & K (Dec, Jan & Feb)	Autumn flush (if required? i.e. young trees)
1.2kg urea to increase flower numbers : if desired	1kg urea + P (i.e MKP) &/or 1kg KNO_3 to build up nutrition for new growth soon to emerge (NPK mix)	150g $ZnSO_4$ + 100g $MnSO_4$ + 500g urea Can add other micro nutrients depending on need i.e. Mg, Bo, Mo, Cu,. Do not add too much as young leaves sensitive to burn	150g $ZnSO_4$ + 100g $MnSO_4$ + 500g urea + MPK Can add other micro nutrients depending on need	2.5kg to 5kg KNO_3 . 15-20mm fruit size. Israel reports no leaf burn at 5%, but 1969 trial report leaf burn. Do a small section trial. Advisable not to mix $MgNO_3$ with mix. Can add some micro nutrients	3kg urea @ 2500L/ha at end of cell division. Can also do 2 x MKP in mid Nov & mid Jan	150g $ZnSO_4$ + 100g $MnSO_4$ + 500g urea + 1-3kg KNO_3 Can add other micro nutrients depending on need	150g $ZnSO_4$ + 100g $MnSO_4$ + 500g urea Can add other micro nutrients depending on need i.e. 500g MgNO4,

- Many variations. Need to customise to suit your conditions
- Spray just before leaf drip (i.e. up to 3000L/ha mature trees)
- ~ pH 4-6 optimum for uptake. Check compatibility – bucket test

NSW DPI Nutrition Agfact

http://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/management/nutrition/nutrition

- Nutrition Agfact on NSW DPI web extensive information on micronutrient sprays
  - Partial sample of info below

Nutrient deficiency	Treatment	Application rate	Timing	Remarks
Magnesium	*Sprays*			
	Magnesium nitrate	1 kg/100 L	When spring flush leaves are 1/2 to 2/3 expanded.	Repeat sprays annually.
	Alternative spray:[(a)] magnesium sulphate (Epsom salts) + calcium nitrate	 1 kg/100 L 1 kg/100 L	As above.	Mix magnesium sulphate in a half-full vat, then add calcium nitrate separately while agitator is running. Then fill vat.
	Soil			
	Magnesite	0.5–1 t/ha	Any time, but preferable before a cultivation.	Slow but long-lasting on acid soils. Use sprays for citrus on neutral or alkaline soils.
	Magnesium oxide	250 kg/ha		
	Dolomite[(b)]	2–5 t/ha		
Zinc	*Sprays*			
	Zinc sulphate heptahydrate (23% Zn)	150 g/100 L	When spring flush leaves are 1/2 to 2/3 expanded.	This spray is simple to mix and causes minimum residue.
	Commercial liquid preparations	As per the label		
	Zinc sulphate (23% Zn) + hydrated lime	500 g/100 L 250 g/100 L		This spray leaves a white residue but is more durable if rain is likely within 48 hours.
Manganese	*Sprays*			

Foliar Nutrient Sprays

- Trials in MIA demonstrated that spraying at night improved Zn and Mn levels (unpublished)
- Glasshouse trial Florida demonstrated Urea mid-day uptake 40%, morning 50% and night 55% (Bondada, 2001)
  - Probably due to leaf staying wet longer
- However recent work from Brazil showed improved uptake on N during the day when leaf pores (stomata) are open. (Burkhart, et.al. 2000)
  - Perhaps a compromise is early morning spray when conditions are cool and the light will open stomata, second best is night after heat of day passed ?
- Conduct your own trial – need a control (no spray)

Foliar Nutrient Sprays

- Cautionary points:
  - Not to spray during heat of day (uptake & spray burn)
  - Do not spray to “run off”, leaves should not be dripping (i.e. 2000-3000L/ha) – fine mist on leaves best
    - Micro nutrients best target young leaf flush – more uptake
    - Cover underside (abaxial) of leaves – more stomata & thinner wax/cuticle + needs good wetter (i.e. silicon)
    - Higher concentration of mixtures can cause tip burn (spray concentrates on leaf tip)
  - Making custom mixtures – check in bucket for compatibility
  - Do not spray stressed trees with high Urea rates

Summary - Foliar Nutrient Sprays

- Foliar spray used to correct micro nutrient deficiencies but also an opportunity to apply macro nutrients (NPK) via another method
  - Option : About 30-70% of nutrients applied by foliar
  - Reduce leaching and environmental problems
  - Possibly can reduce total fertiliser application rates if new strategy has more effective uptake
  - Significantly benefit young trees – (small root zone)
  - Consider time of day & surfactant (stomata penetration)

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