Acknowledgements

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Session 1
General Plant Nutrition

• Phenological cycle
• Essential nutrients
• Role of nutrient in mangos
• Soil pH
• Leaf and soil testing
The Big Picture

• Healthy non stressed trees are essential for best results.

• Nutrition is only one part of mango management.

• All management practices must come together.

• Climate/environmental effects are another factor.
Mango Phenology

• Study of the growth events of mango trees
• Growth draws heavily on
  – carbohydrate reserves and/or
  – current photosynthesis
• Nutrition, paclobutrazol, water, pruning, pest and disease control all affect growth
• Use phenology to fine tune management
Annual phenological events

• Leaf and root flush/es
• Dormancy
• Flowering and pollination
• Fruit set and development
• Fruit drop
Mango phenology

- Postharvest flush
- Active root flush pre dormancy
- No root flush during vegetative flush
- Flower bud development
- Unwanted flush
- No root flush in flowering period
- Flowering and fruit set
- Fluctuating root flush during fruit development
- Premature fruit drop
- Fruit development
- Fruit
- Roots
- Flush

Flush, Dormancy, Flower, Fruit Development, Harvest, Flush

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Essential Elements

Macro elements

Nitrogen (N)
Phosphorus (P)
Potassium (K)
Calcium (Ca)
Magnesium (Mg)
Sulphur (S)

Trace elements

Boron (B)
Zinc (Zn)
Iron (Fe)
Copper (Cu)
Manganese (Mn)
Sodium (Na)
Chloride (Cl)
Molybdenum (Mo)
Nutrient balance

Law of Minimum Factor

Level of water in barrel represents crop yield

Restricted by most limiting nutrient i.e. nitrogen

If nitrogen is added, the next most limiting nutrient is potassium
Role of the various nutrients

All have critical roles but today will put most emphasis on the 4 most important – N, Ca, B, and K
NITROGEN

Drives and builds
Nitrogen

• Most important element for yield & quality
• Main nutrient affecting growth
  – flush, flowers, fruit & roots

• In mangoes, nitrogen
  – increases tree vigour
  – stimulates flowering in combination with K
  – improves fruit set, retention and yield
  – increases fruit size
  – increases brix
Nitrogen

- Readily translocated in soil & tree
- Trees readily respond to N
- Use, timing and rates vary across industry
- Application timed to growth events
- Influences levels of other nutrients
- Recommend sampling pre-flowering and post-harvest
The nitrogen relationship

Good growers operate here
Nitrogen (N)

- Approximately 78% of the earth’s atmosphere is made up of Nitrogen Gas (N2)

In spite of this...

- The form of N required by plants is often limiting; plants can only take up N in the ammonium (NH4+) or nitrate (NO3-) form
## N impact on nutrient uptake

On Honey Gold in 2007-08 pre-flowering

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Zero N</th>
<th>12g/m² N</th>
<th>Optimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>0.7</td>
<td>0.8 ↑</td>
<td>1.0 - 1.5%</td>
</tr>
<tr>
<td>K</td>
<td>0.36</td>
<td>0.78 ↑</td>
<td>0.7 - 1.2%</td>
</tr>
<tr>
<td>Ca</td>
<td>1.17</td>
<td>3.16 ↑</td>
<td>2.0 - 3.5%</td>
</tr>
<tr>
<td>B</td>
<td>43</td>
<td>60 ↑</td>
<td>50 - 80 mg/kg</td>
</tr>
</tbody>
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## N impact on nutrient uptake

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<th>Optimum</th>
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</thead>
<tbody>
<tr>
<td>Zn</td>
<td>21</td>
<td>56 ↑</td>
<td>20 - 150 mg/kg</td>
</tr>
<tr>
<td>Fe</td>
<td>20</td>
<td>30 ↑</td>
<td>70 - 200 mg/kg</td>
</tr>
<tr>
<td>Cu</td>
<td>39</td>
<td>39</td>
<td>10 - 20 mg/kg</td>
</tr>
<tr>
<td>Mn</td>
<td>55</td>
<td>410 ↑</td>
<td>60 - 500 mg/kg</td>
</tr>
<tr>
<td>B</td>
<td>43</td>
<td>60 ↑</td>
<td>50 - 80 mg/kg</td>
</tr>
<tr>
<td>Mo</td>
<td>&lt;0.01</td>
<td>0.25 ↑</td>
<td>0.05 - 1.0 mg/kg</td>
</tr>
</tbody>
</table>
Nitrogen Deficiencies

• Poor vegetative and reproductive growth
• Decreased defense against disease

  • Reduction in fruit size
  • Poor yield
  • Increased fruit drop

  Decreased $$$$$

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Excessive N or wrong timing - negative effects

- Pre-harvest
  - excessive leaf growth
  - lowers K concentration
- Early fruit set
  - direct Ca from fruit to leaves (leaves are bigger sink)
- Postharvest
  - green, ripe fruit
  - less blush
  - softer fruit
  - increased internal disorders
  - increased postharvest rots
Which is more likely to support next year’s crop?
CALCIUM

Builds
Calcium (Ca)
• Strengthens cell walls (structural component)
• Provides defense from pathogens
• Essential for root hair and leaf development
• Important during cell division
  – most important first 6-10 weeks of fruit development
• Important for fruit quality
  – firmness, shelf life & internal quality
• Needed all year round!
Calcium (Ca)

• Not easily translocated in the tree
• Uptake
  – passive, needs soil moisture
  – best by young roots
  – difficult to get in to fruit from soil or leaf
  – foliar applications of little use
• Uptake speed depends on particle size
• Easily outcompeted by other nutrients
• Plants use more Ca than any other added element
Calcium distribution in fruit
Calcium deficiency
Calcium deficiency
Lack of calcium
“Sitting mango”
(probably Ca shortage in Indonesia)
Calcium distribution
BORON Activates
Boron (B)

• Necessary for all new cell growth
  – flushing, flowering, pollination and fruit development
  – maximise B at flowering and fruit set

• Important in cell walls

• Helps Ca work and therefore fruit quality

• Can help with fruit set in cooler weather

• Affects hormone movement

• Mobile in the soil and but not in the plant

• Easy to go from deficiency to toxicity

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Boron toxicity
Boron deficiency
Boron deficiency in fruit
POTASSIUM

Sizes and Sweetens
Potassium (K)

• Role
  – Involved with water regulation, cell growth and expansion & movement of sugars
  – Activates enzymes in metabolic pathways
  – Thickens cell walls which increases resistance to pathogen and insect attack
  – Important for fruit quality - skin & flesh colour, flavour & fruit size

• Very mobile in the soil and the plant
• Greatest need is with fruit development
Potassium (K)

• K, Ca, Na, and Mg compete for uptake
• Deficiency reduces fruit size, yield and flavour
• Suppressive effect on powdery mildew (mono potassium phosphate)
Potassium deficiency
In summary

- Nitrogen drives and builds
- Calcium builds
- Boron activates
- Potassium sizes and sweetens
Other nutrients
Phosphorus (P)

• Role
  – Important for cell division
  – Involved with the production and movement of energy within the plant
  – Important for seed (and therefore fruit) development
  – Initiates and develops root laterals
  – Necessary to get adequate uptake of other nutrients

• Very mobile in the plant but not in the soil
• Generally not limiting element in mangos
• Soil pH affects uptake
Magnesium (Mg)

- Central molecule in chlorophyll
- Important for photosynthesis & aids phosphorus movement in the plant
- Very mobile in the plant and the soil
- Affects the uptake and availability of other cations (Ca and K)
- Timing need - during active vegetative growth phases
- Excessive can green leaves and fruit
Mg deficiency
Sulfur (S)

- Constituent of plant proteins and photosynthesis
- Very mobile in the soil but not mobile within the plant
- Role in tree growth and fruit quality is not fully understood
- Low levels limit N uptake
- Timing - during all active growth phases
- Yellowing of all leaves could be sign of S deficiency
Zinc (Zn)

- Important for leaf expansion
- Involved with water regulation
- Essential for chlorophyll formation and hormone production
- Immobile in the plant – deficiency at growing points
- High P availability reduces Zn
- Deficiency causes stunted growth, yield decrease and fruitlet abscission
- Timing - during vegetative growth phases
Zn deficiency
Iron (Fe)

- Involved with water regulation in the plant and chlorophyll formation
- Immobile in the plant
- Timing - during vegetative growth phases
- Often low in many farms
- Higher levels in wet soil conditions
Fe deficiency
Manganese (Mn)

- Functions are similar to magnesium
- Helps chlorophyll formation
- Immobile in plant
- Often toxic in other crops esp at low pH
- High Mn can restrict Ca movement to growing points
- Have seen blocks in NT with high and others with low levels
Mn toxicity on citrus
Copper (Cu)

• Involved in photosynthesis, chlorophyll formation and fruit development
• High levels can lead to iron deficiency
• Timing - during vegetative growth phases
• Most trees get enough from foliar fungicidal sprays of copper but minimal used in NT
Molybdenum (Mo)

• Needed for N assimilation
• Enhance uptake of N, K and Ca
• Helps iron absorption, excess reduces iron availability
• Needed in extremely small amounts but deficiency affects growth and yield
SOIL pH

• Measurement of soil acidity or alkalinity
• Soil pH (acidity or sweetness) affects nutrient solubility and plant availability.
• Need correct pH for mangos to maximize nutrient availability
Soil pH Ranges

ACIDITY

NEUTRALITY

ALKALINITY

Very strong
Strong
Moderate
Slight
Moderate
Strong
Very strong

3 4 5 6 7 8 9 10 11

Range in pH common for humid region mineral soils
Range in pH common for arid region mineral soils
Range in pH common for most mineral soils

Attained only by alkali mineral soils

Extremely pH for acid peat soils

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FACTORS DECREASING SOIL pH

Decreasing pH

– Leaching losses of cations such as Ca and Mg
– Water saturated soil
– Erosion of alkaline surface soil
– Acid forming fertilisers such as DAP, SOA
– Addition of elemental S, aluminium sulfate or iron sulfate
FACTORS INCREASING SOIL pH

- Addition of lime/dolomite
- Irrigation water high in Na or Ca Carbonate or bicarbonate
- Erosion of acid or neutral top soil where pH increases with soil depth
Effect of pH on Nutrient Availability
How to increase Soil pH

- 240 kg of lime will increase pH by 0.1
- 400 kg of dolomite will increase pH by 0.1
- Gypsum is neutral and will not affect pH

<table>
<thead>
<tr>
<th>pH</th>
<th>Change</th>
<th>Lime (t/ha)</th>
<th>Dolomite (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>6.5</td>
<td>3.6</td>
<td>6</td>
</tr>
<tr>
<td>5.5</td>
<td>6.5</td>
<td>2.4</td>
<td>4</td>
</tr>
<tr>
<td>6.0</td>
<td>6.5</td>
<td>1.2</td>
<td>2</td>
</tr>
</tbody>
</table>
Effect of particle size on lime reaction

Effect of Particle Size on Lime Reaction

Soil pH level

0 2 wks 6 mth 12 mth 18 mth 24 mth 30th mth 36 mth

0 5.0 5.5 6.0 6.5 7.0

Lime worked into pasture soil.
NSW Irrigation R & E Committee Farmers Newsletter. June 1980, No 147, p 15
To Lower Soil pH (kg S/ha)

<table>
<thead>
<tr>
<th>Soil pH</th>
<th>Sandy soils</th>
<th>Clay soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5</td>
<td>440-660</td>
<td>880-1100</td>
</tr>
<tr>
<td>8.0</td>
<td>1100-1650</td>
<td>1650-2200</td>
</tr>
<tr>
<td>8.5</td>
<td>1650-2200</td>
<td>2200-3300</td>
</tr>
<tr>
<td>9.0</td>
<td>2200-3300</td>
<td>2300-3300</td>
</tr>
</tbody>
</table>

Western Fertilizer Handbook. Rates will vary depending on soil pH, texture, and buffering capacity.
Leaf and Soil Testing

Accuracy of results depends on:

1. Good representative sample collection
2. Choosing a good accredited laboratory
3. Trained/proper interpretation of results
Leaf analysis

• The objective is to get an average of trees, not the best nor the worst
• Sample twice annually [post harvest & pre-flowering]
• Procedure:
  – Sample mature leaves of the same age
  – DO NOT sample soft flush
  – Representative sample across block from average trees
  – 3rd or 4th leaf (last fully expanded leaf) from the growing tip
  – Take leaves from all 4 sides of the tree
  – Sample about 20 trees per block
Ideal Sample Leaves

- Ideal sample leaf
- Too far down flush
Soil Sampling

• Measure levels of elements and pH at that particular time.
• Annually Post Harvest
• Depth of 0-15 cm inside dripline of tree (or where watered if less)
• 2 samples/tree – one each side
• Sample about 20 trees/block
• Sample in conjunction with leaf samples.