Principles of Orchard Nutrition

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AgFirst

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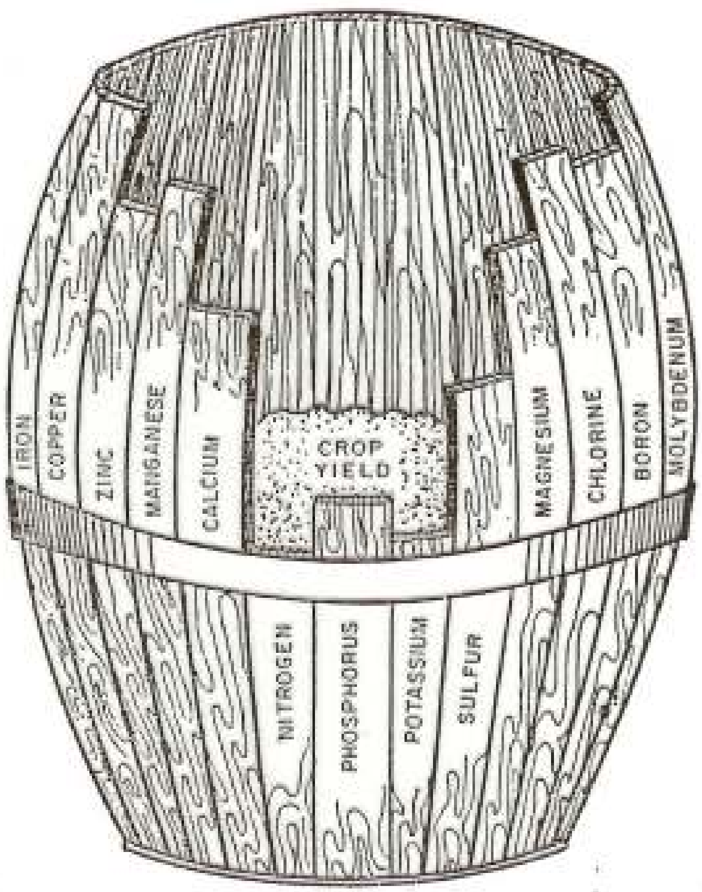
General Principles

- Nutrition is generally a very small proportion of production costs (< 2%).
- Poor nutrition management can severely inhibit canopy development, reduce yields and fruit quality.
- Fruit Crop Nutrition is not an exact science.
  - More about pushing levels in the right direction
  - Keep nutrition balance (eg cations K-Mg-Ca)
  - Often several options /opinions on addressing issues

The most limiting nutrient will have the greatest effect on growth



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How Does the Soil Hold Nutrients ??

- When we add fertilisers, they dissolve and divide into charged particles. These nutrient ions have either a small positive (cations) or negative charge (anions).
- Soil particles have a negative charge and so attract the positively charged nutrient ions (cations). A lot like a magnetic attraction.
- Negative ions (anions) tend to stay in solution and so move more readily in the soil moisture.
- Because cations are held by the soil particles you can apply fertilisers and build up the fertility of your soils.

Soil moisture is necessary for plants to obtain nutrients from the soil.

THE ABSORPTION COMPLEX OF THE SOIL

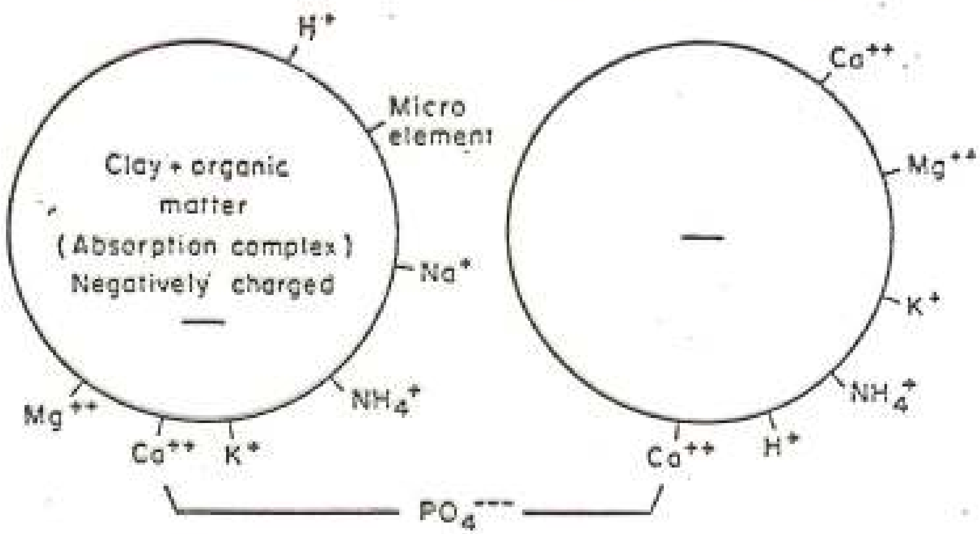

FIGURE 2. Diagram of the absorption complex of the soil, greatly enlarged, showing how negatively charged particles of clay or organic matter are surrounded by absorbed, positively charged, nutrient elements of cations. The main cations and anions contained in the soil solution are:

Cations		*Anions*	
H^+	Hydrogen	NO_3^-	Nitrate
K^+	Potassium	Cl^-	Chloride
NH_4^+	Ammonium	CO_3^{--}	Carbonate
Na^+	Sodium	SO_4^{--}	Sulfate
Ca^{++}	Calcium	PO_4^{---}	Phosphate
Mg^{++}	Magnesium		
Metallic microelements		Nonmetallic microelements	

Nutrient Cations & CEC

- Cation Exchange Capacity(CEC) measures the number of negatively charged binding sites on the soil complex which cations (eg Ca, K & Mg) can bind to.
- This gives an indication of the quantities of these nutrient cations the soil can hold.

Soil Texture	Usual CEC Range
Sandy Loams	8 - 20
Silt Loams	15 - 30
Clay Loams	20 - 40
Peats	50 - 100

eg. Sandy Soils have a low CEC so can only adsorb and retain relatively low quantities of cations → use the 'little and often' principle

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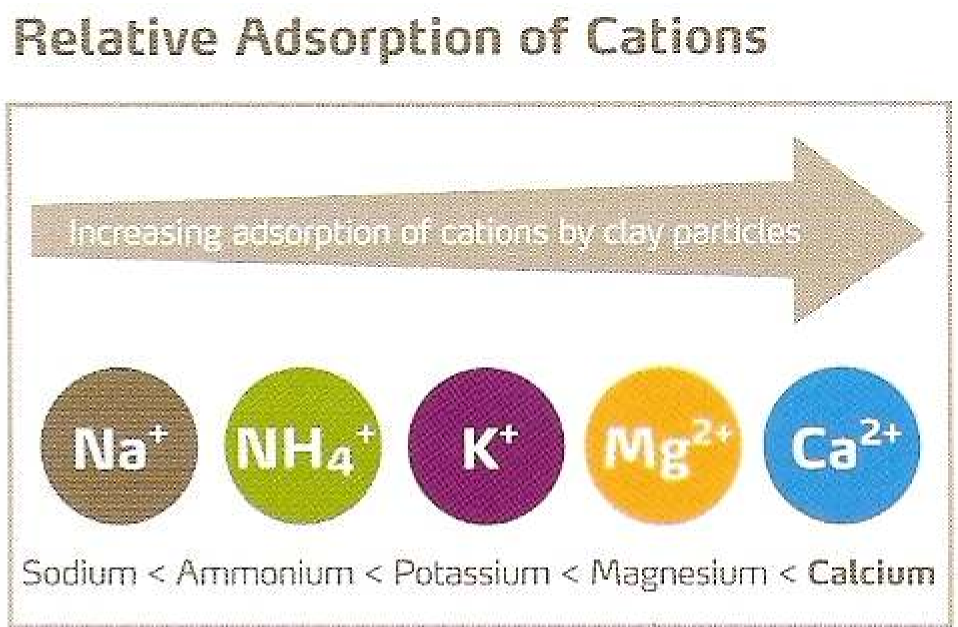
- Cations with a higher charge are held more strongly than those with a smaller charge.
- Fertilisers can change the amount of exchangeable cations quite quickly.
- Parent material can also have a strong effect. Eg. Limestone based soils will be high in calcium.



Nutrient Interactions

Calcium, Magnesium and Potassium

% Base Saturation & Bulk Density

- ***Percent Base Saturation*** - is an estimate of the percent of the soil CEC that is occupied by particular cations (Ca, Mg, K & Na).

	Apples	Kiwifruit
Calcium	70 – 80 %	55 – 70 %
Magnesium	8 – 10 %	6 – 10 %
Potassium	3 – 4 %	4 – 5 %

Potassium (K)

- an example of cation interactions

- Base levels can vary considerably.
- Related to fruit size, colour and acidity.
- Fruit crops vary considerably in K requirements.

Apples	0.5 – 0.8 me/100g	3 – 4 % Base sat
Kiwifruit	0.7 – 1.00 me/100g	4 – 5 % Base sat

- Potassium is a cation nutrient. Excessive K will inhibit the uptake of Calcium & Magnesium

→ **Don't apply more Potash than is needed.**

Effect of Potassium on availability of Calcium & Magnesium

K soil saturation	Composition of Leaves		
%	**% K**	**% Ca**	**% Mg**
0	0.4	1.4	1.5
0.5	0.5	1.2	1.1
1.0	0.8	1.1	0.7
2.0	1.0	0.3	0.6
4.0	2.1	0.7	0.4
8.0	2.1	0.6	0.3
12.0	2.2	0.6	0.4
16.0	2.2	0.4	0.4
20.0	3.1	0.3	0.4

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Magnesium Deficiency

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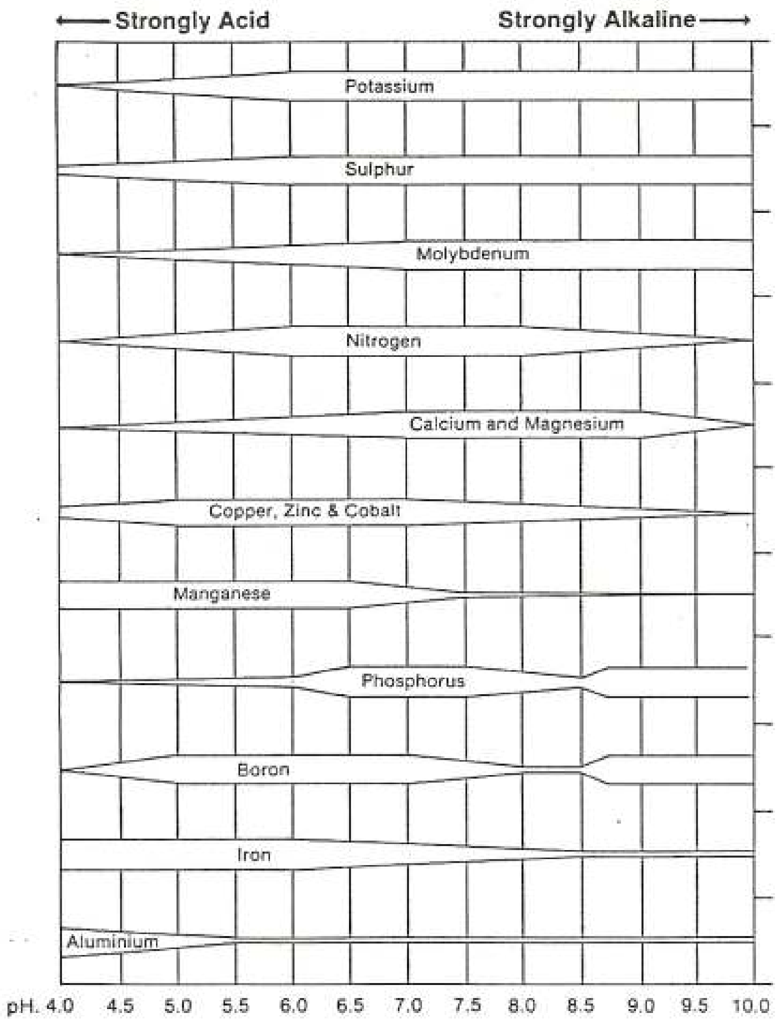
Magnesium

- Several imp't roles
  - Component of chlorophyll
  - Carbohydrate production and transport
  - Protein synthesis
- Very mobile in the tree. With low Mg, older leaves yellow first as Mg moves to newly developing leaves.
- Crop status depends on both soil level Mg and the relationship of soil Mg to K.
  - Ratio of 1.5 – 2.0 xMg to 1 K
- Use leaf analysis and soil tests to determine if low Mg is caused by low soil Mg or a low Mg:K ratio.
- Foliar applications are often used to supplement soil supply of Mg.

Soil pH

- A measure of soil acidity (< 7) or Alkalinity (> 7).
  - A LOG SCALE → pH 6 is 10X more acid than pH 7
    pH 5 is 100X more acid than pH 7
- pH important as it affects the availability of soil nutrients.
  - For apples we target a Ph of 6.5 – 6.8. Maximises the availability of major nutrients (eg. Phosphorus, calcium, magnesium) and limits the availability of less desirable elements such as aluminium and copper.
  - More likelihood of trace element deficiencies above 6.9 eg. Zn, Mn, Fe.
  - Possible trace element toxicity at lower pH. eg Al, Mn toxicity, P deficiency. Reduced Ca availability.

How pH Affects Availability to Plants of Nutrients in the Soil, as Indicated by the Width of Various Bands.



Notes:

Deficiencies liable at low pH.

Some reduction at low pH.

Similar to K. Solubility increases with pH.

Bacterial fixation curtailed below about pH 5.5.

May be deficient in acidic soils. Non-available at very high pH.

May be toxic in acidic soils and deficient where pH 7.0.

Similar to Cu, Zn & Co.

Liable to be fixed by Fe, Al, Mn at low pH; insoluble forms at high pH, also Ca inhibition.

Over-liming may cause deficiency. Toxicity dangers at very high pH.

Similar to Cu, Zn & Co.

Liming to pH 5.5 recommended to avoid toxicity dangers at low pH.

Source: After Truog (1948).

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Adjusting soil pH

- Increasing Soil pH
  - Ag Lime the most effective – 40 % Ca
  - Dolomite Lime – 22% Calcium, 11% Mg
- Lowering Soil pH
  - Acidic Ferts eg. Urea, Ammonium Sulphate
  - Finely ground sulphur
  - Maxi Sulphur Super
  - Aluminium Sulphate

Quantities of Ag Lime or Dolomite to adjust soil pH
(tonnes per hectare)

Soil pH	Light Soil	Medium and Volcanic Soils	Heavy soils & soils with high organic matter
6.5	Nil	Nil	Nil
6.3	0.5	0.75	1.5
6.0	1.0	1.5	2.5
5.8	1.25	2.5	4.0
5.5	1.5	3.0	5.0
5.3*1	2.0	4.0	6.0
5.0*1	2.5	5.0	7.0

*1 – If pH is this low in a planted orchard, initiate a programme to correct it over two to three years. Heavy single rates of Lime can adversely affect availability and uptake of Mg.

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The Calcium Issue

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Calcium movement

Is transported in the water conducting tissues – Xylem

Is largely immobile in the phloem

- After bloom, aided by transpiration, calcium is transported into fruit via the Xylem.
- About 6 weeks post bloom (when cell enlargement begins) the Phloem takes over supplying the fruit interrupting the Ca supply.
- As fruit size increases the calcium concentration decreases.
- Just prior to harvest there is often another increase in Ca movement into the fruit.

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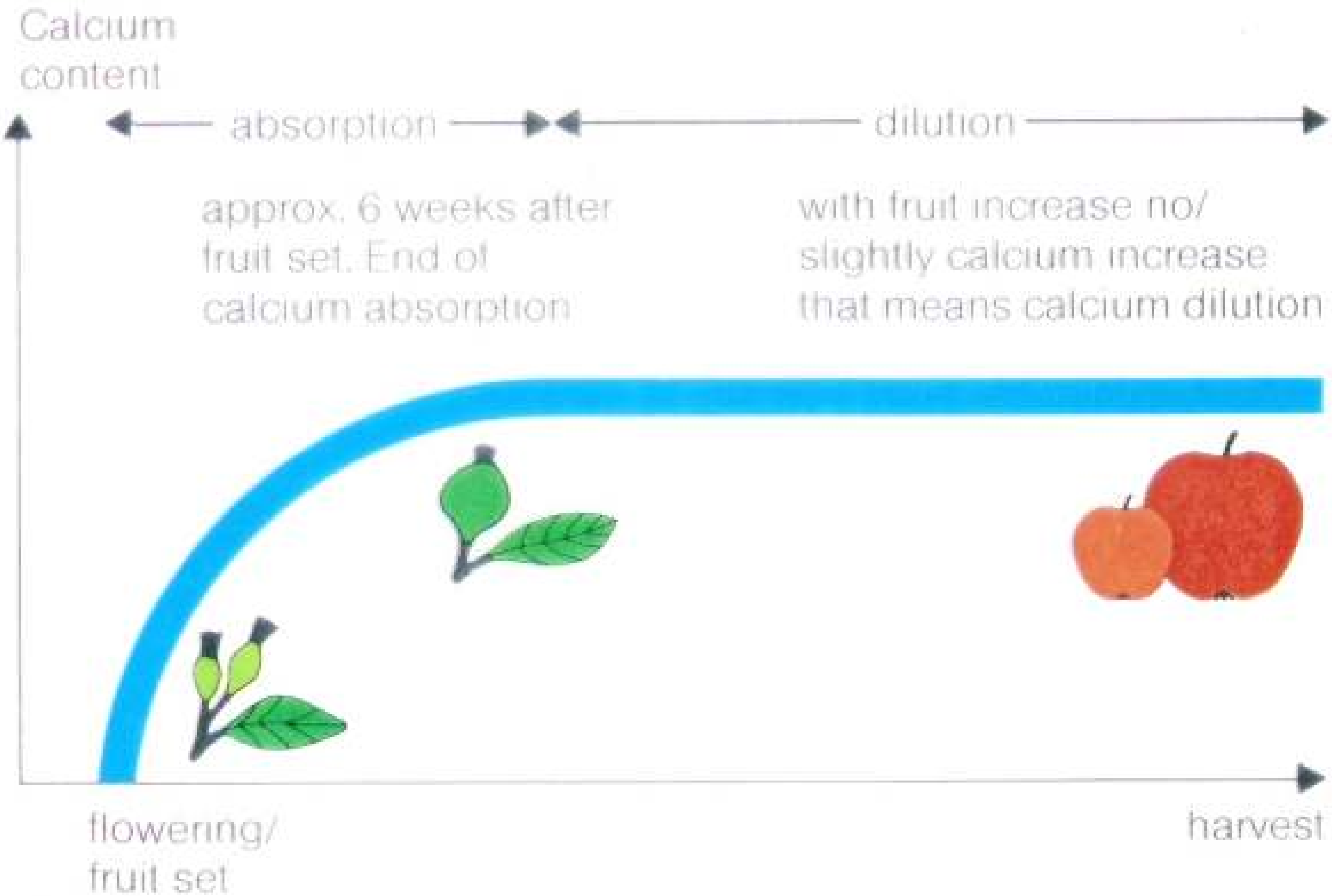
Scheme of calcium-absorption in apple fruits
(according to C. B. Shear and M. Faust)



Calcium interactions

- ***The calcium cation has a positive charge so competes with other cations Potassium, Magnesium and the Ammonium both in the soil and in the fruit. So high amounts of K, Mg and NH_4 compete with calcium for plant uptake.***

  → Don't apply more Potassium/Magnesium than is needed

- Is intense competition between vegetation and fruit for available Ca → stimulating growth works against good fruit Ca levels.
  - Be careful about Nitrogen applications.
- Be aware of Boron levels as low B can reduce calcium movement in the tree.
- Pollination and Fruitset - higher seed numbers results in higher Calcium

The Calcium Issue

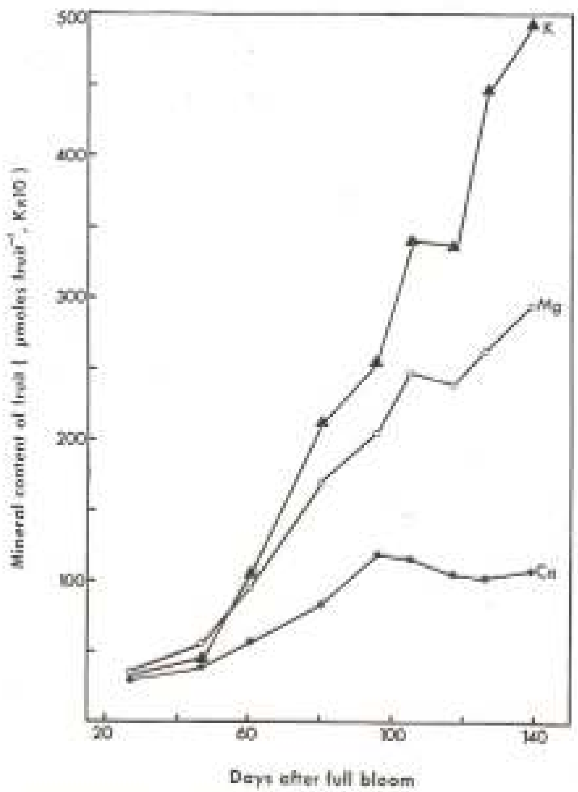


Fig. 1 Mineral content of apple fruit during fruit development. Note that the data are those of total fruit content, and not concentration.

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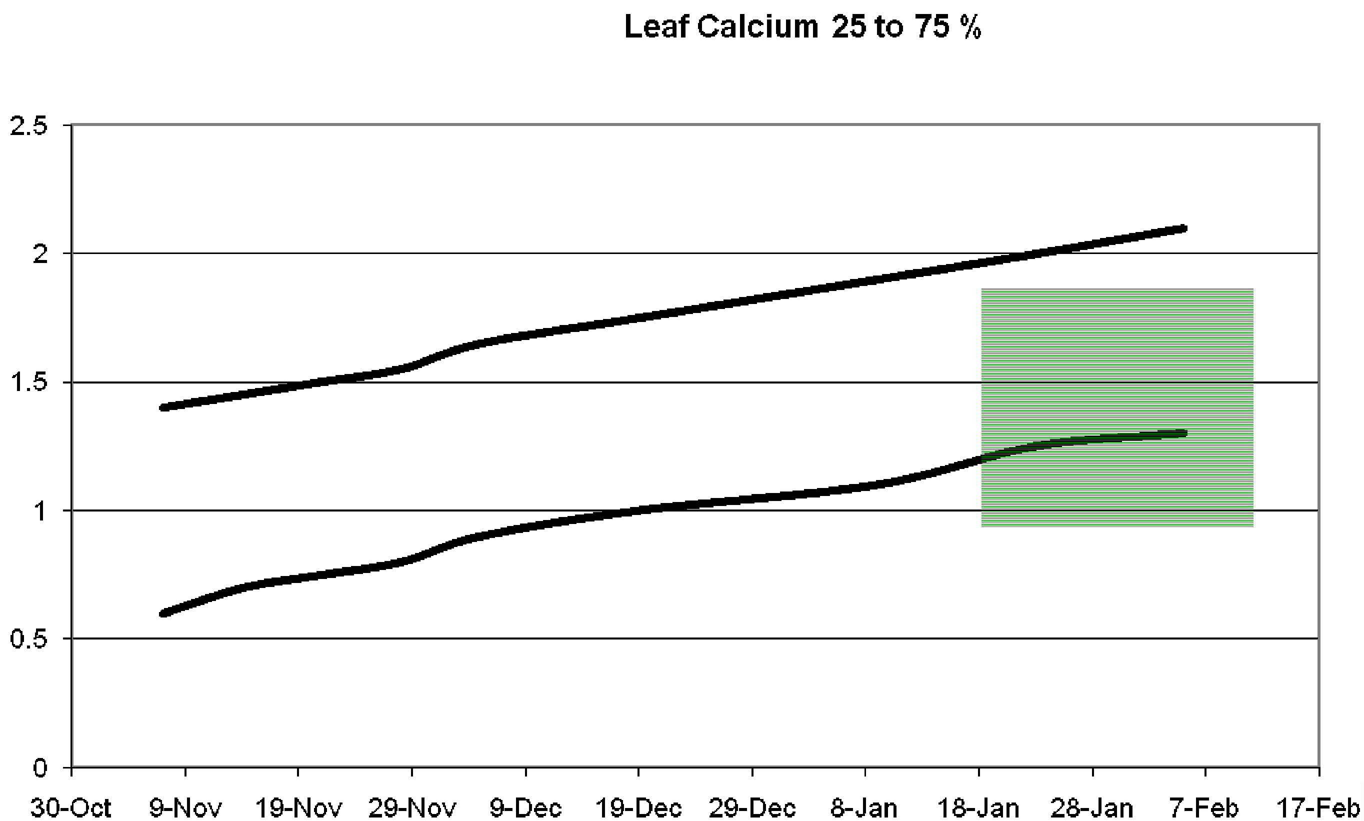
Leaf Calcium

- South Tyrol Reference Curve



Aicher, M and Stimpfl, E.
Acta Hort. 594, ISHS 2002.

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Calcium Management

- Attain adequate soil calcium levels.
- Avoid excessive Potassium, Magnesium.
- Avoid moisture stress over early fruit development period.
- Ensure a good crop load balance.
  - want good pollination and fruitset
  - avoid overthinning
  - thin early
- Avoid practices that result in excessive vigour.
- Ensure adequate plant boron status.
- Implement a season long supplementary calcium programme.

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Phosphate

- Fruit crops usually have a low demand.
- P deficiency or toxicity is not common.
  - Deficiency is made worse by
    - Low organic matter
    - Acidic soils
    - Cold wet conditions
- Base soil level of 30 – 60 ug/ml.
- May need high P inputs to raise soil P on light and volcanic soils and to maintain soil P on high P fixing soils.
- Normally applied as a base dressing June/July.

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Vigour and Fruitset

Seed number per fruit in relation fruit diameter and calcium concentration.

SEEDS	FRUIT DIAMETER	FRUIT CALCIUM
per fruit	(mm)	(ppm)
0 - 1	67	174
2 - 3	70	208
4 - 5	71	215
> 5	72	223

Bramlage, W.J., Weis, S.A., and Greene, D. Hort Science 25: 351-353. 1990.

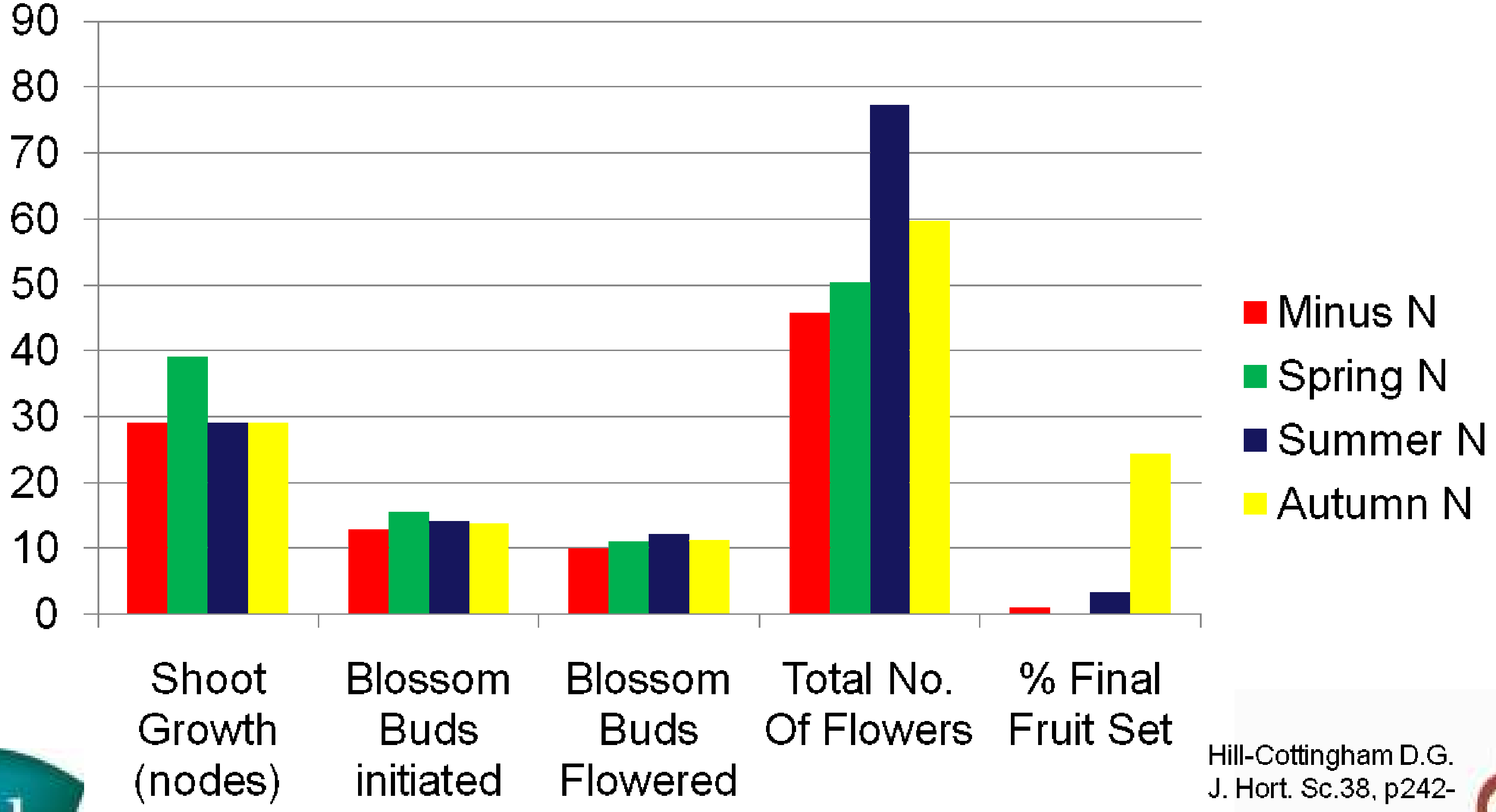
Nitrogen

- Good N status important for plant growth & development. Two growth phases ion fruit development.
    - **Cell Division** – finishes about 30 days post bloom.
    - **Cell Enlargement**

- Ineadequate N over bloom limits flower development and can increase biennial bearing tendency.

- By focussing on cell division stage we can use N to improve blossom quality and fruit set.

Effect of Time of Application of Nitrogen on Growth & Fruit Set



Hill-Cottingham D.G.
J. Hort. Sc.38, p242-

Nitrogen - timing

- Excess N, especially spring applied, increases vegetative growth and may indirectly contribute to storage disorders.
- Spring applied N will not reach floral parts quickly enough.
- Autumn N applications build up tree reserves for the following spring with minimal effect on vegetative growth.
- Active root activity and nutrient uptake only occurs with sufficient soil moisture.

In a dry autumn irrigate !

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Boron

- Fruit and blossoms are more likely to exhibit B deficiency before symptoms show in a leaf analysis.
- Tree B content and responses are poorly correlated with soil B analysis.
- Pears have a higher B requirement than other tree fruits in early spring – 'Blossom Blast'
- Lab studies show B improves pollen germination and tube growth in apples and pears.
- B sprays on 4 apple varieties in Auckland & Nelson over 5 seasons gave small but consistent increases in fruit set averaging 12 %.
- Research also suggests B enhances within tree Calcium mobility.

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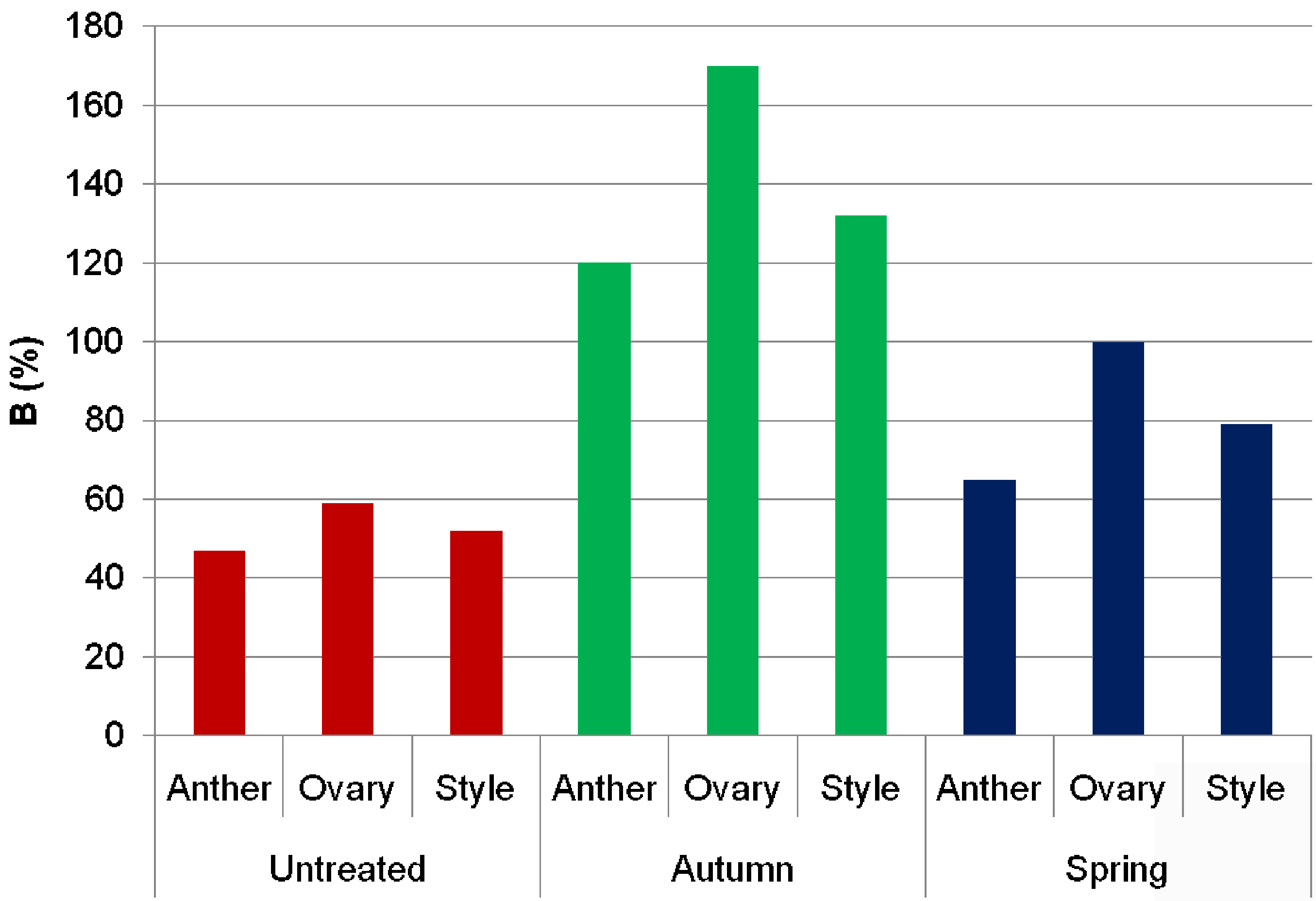
Effect of Autumn/Spring sprays on B content (ppm) of Apple Flowers



Zinc

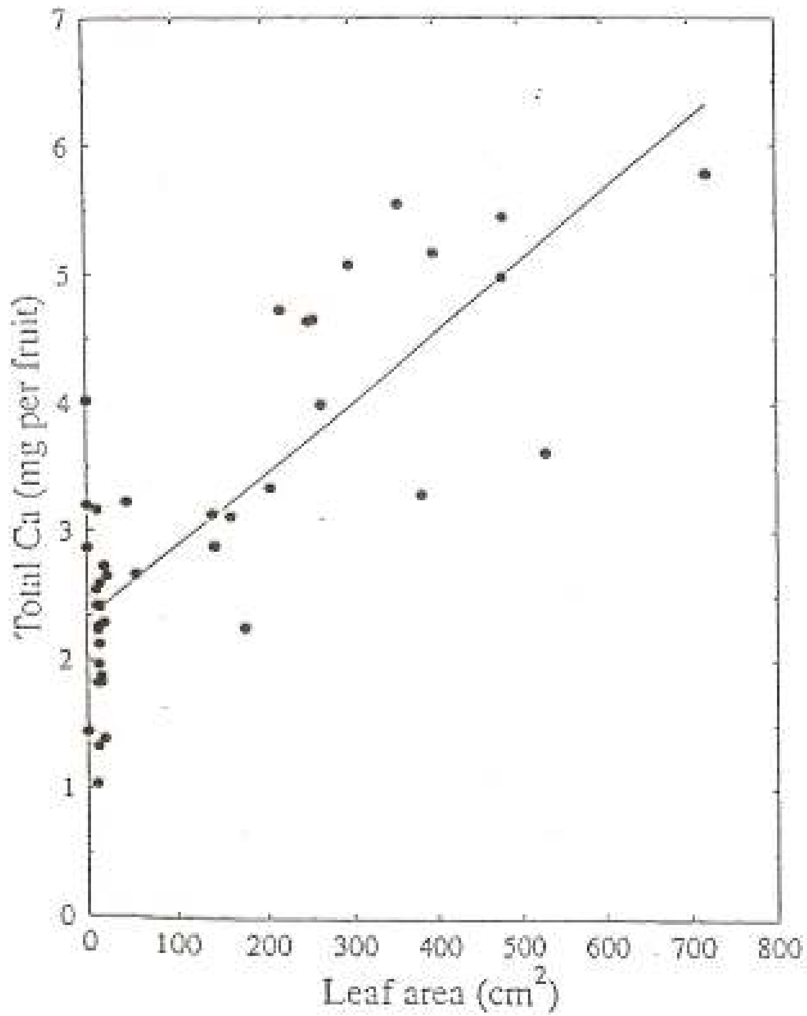
- No direct effect on pollination and fruit set.

- With low levels of Zinc, bourse leaves never become fully expanded → less carbohydrate for blossoms and developing fruit.

- Leaf analysis can help identify issues but need to be wary of false high values due to spray contamination.

- Applications of Zinc containing sprays may have a role in ameliorating Necrotic Leaf Blotch.

The Influence of Bourse+Spur leaf area on Ca content in apple fruit



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Assessing Nutrient Needs

Measuring Nutritional Status

- **Soil Tests** – measure soil pH and macronutrient levels.
  - Maintain correct balance of cations K, Mg & Ca.
    - This will vary for different crops.
- **Leaf Tests** – to help ‘fine tune’ nutritional programs.
    - Diagnostic purposes
    - Determine N and trace element status
- Supply specific crop needs and replace nutrients removed by the crop
- Supply nutrients in the correct form and at the right time.
    - Eg. NO_3^- Nitrogen rather than NH_4^+. Littler or no N close to harvest.
- Correct application methods
- Local Factors
    - Climate, rainfall, soil type.
- Orchard Factors
    - Crop age, production potential.
    - Soil/tissue results, past fert programs, soil type

Soil Testing

- Valuable test of nutrient status of the soil. Particularly soil pH and macro nutrient levels.
- Basic Soil Test measures
  - Soil pH
  - Available P
  - Levels of available cations Ca, K, Mg, Na.
  - Soil CEC → the ability of the soil to be fertile
  - Bulk Desity

Specialist tests such as OM content, avail N, Total soluble salts.

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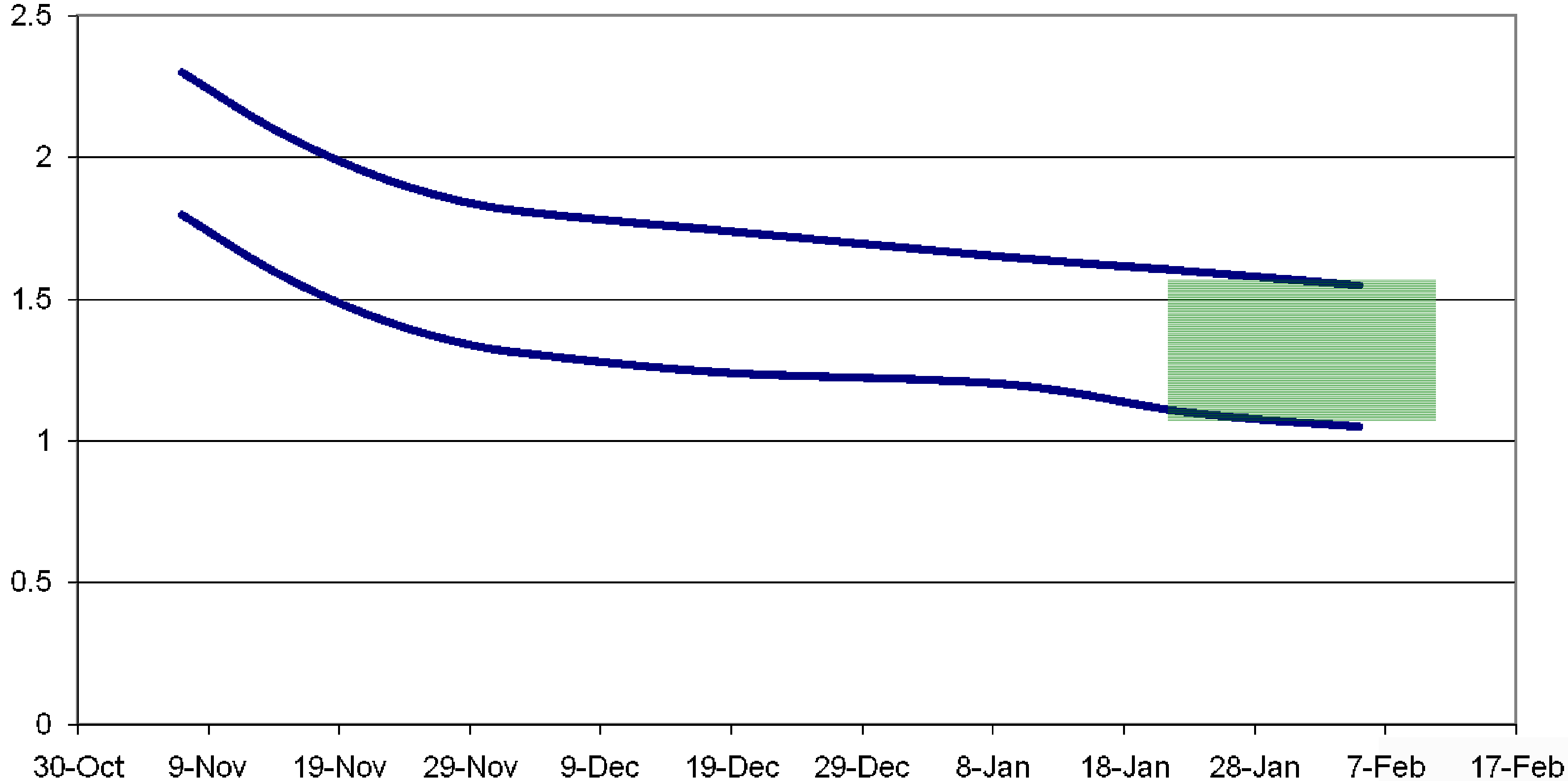
Leaf Testing

- Can't use as an alternative to soil test but rather a valuable adjunct.
- Shows what the plant has been able to utilise. May not always agree with the soil test due to nutrient interactions.
- Can be useful diagnostic aid.
- Basic test measures
  - N, P, K, Ca, Mg, S
  - B, Fe, Mn, Zn and Cu
- Sample the youngest fully expanded leaves on current season's growth.
- Historically sampled in Feb however too late to impact current season's crop. More sampling now carried out earlier in the season with the development of season long curves.

Leaf Potassium

- South Tyrol Reference Curve



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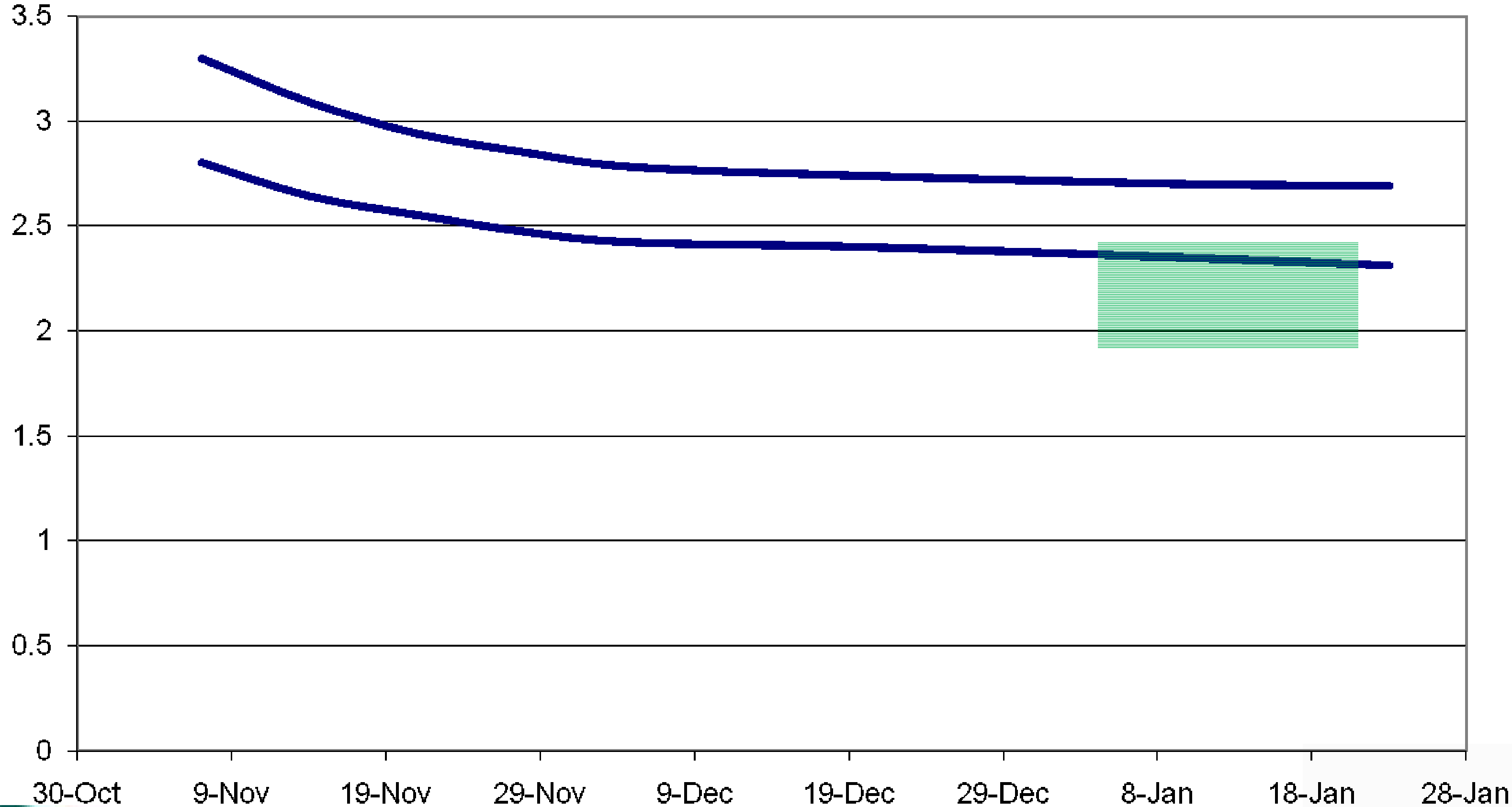
Leaf Nitrogen
- South Tyrol Reference Curve



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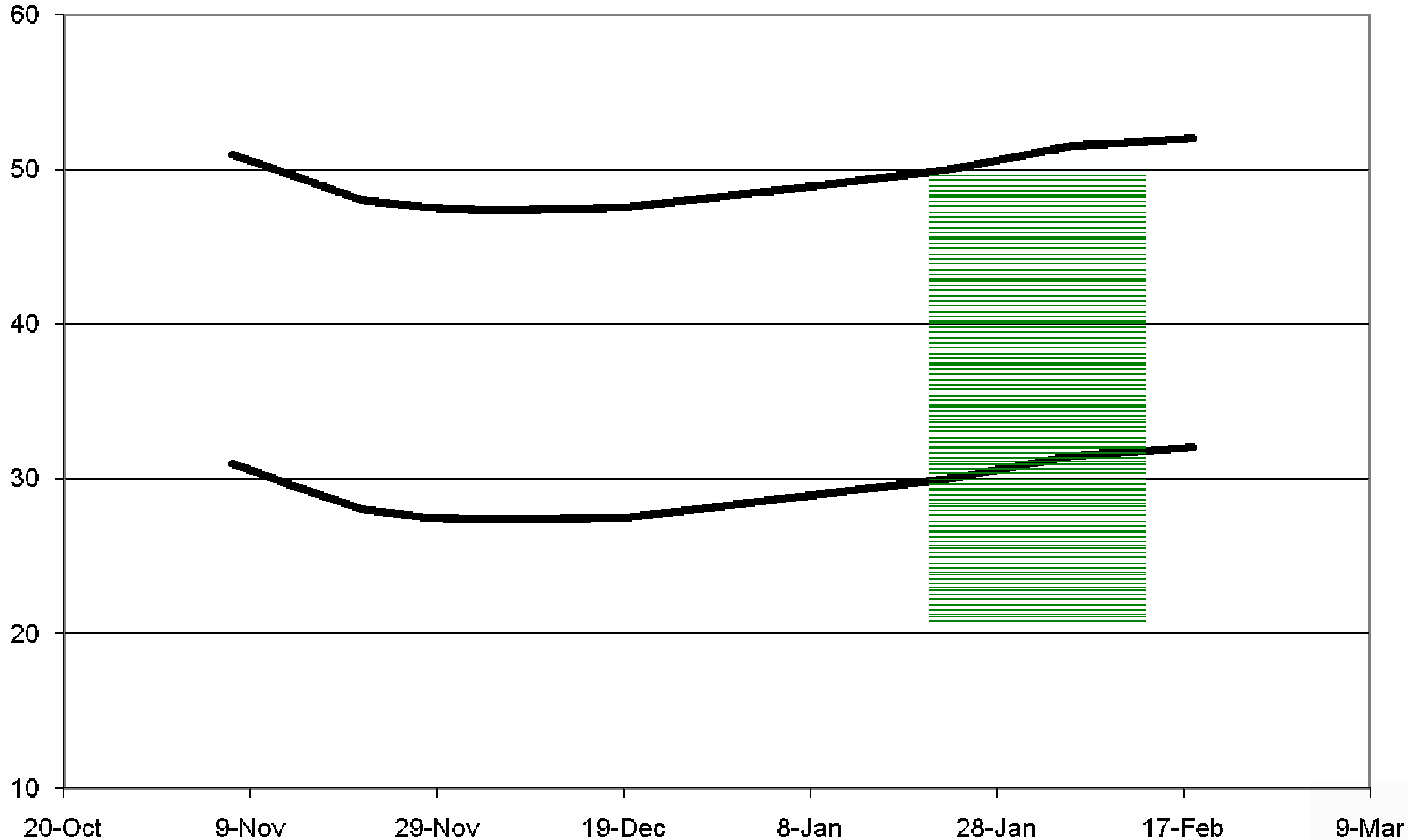
Leaf Boron
–South Tyrol Reference Curve



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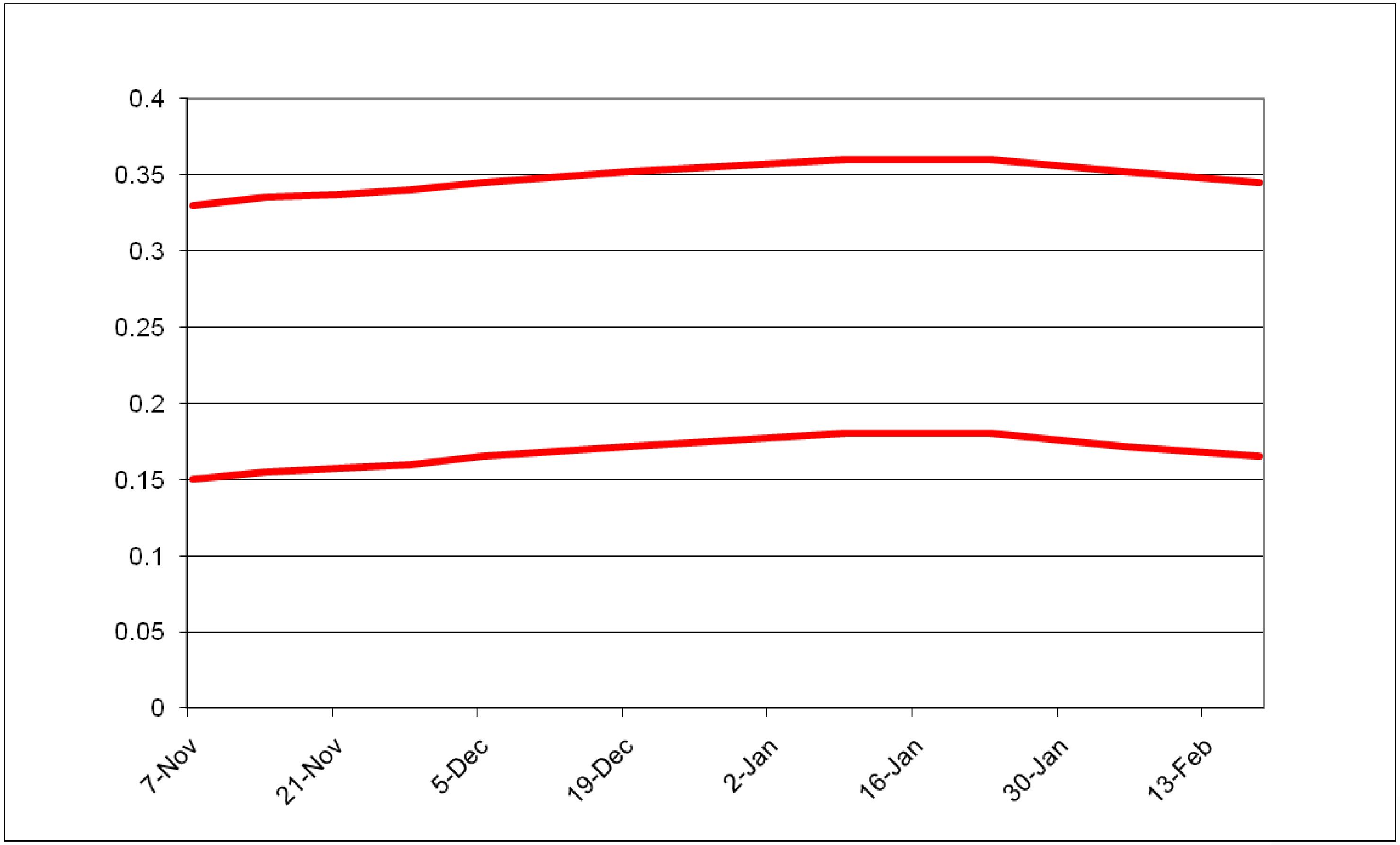
Leaf Magnesium

- South Tyrol Reference Curve



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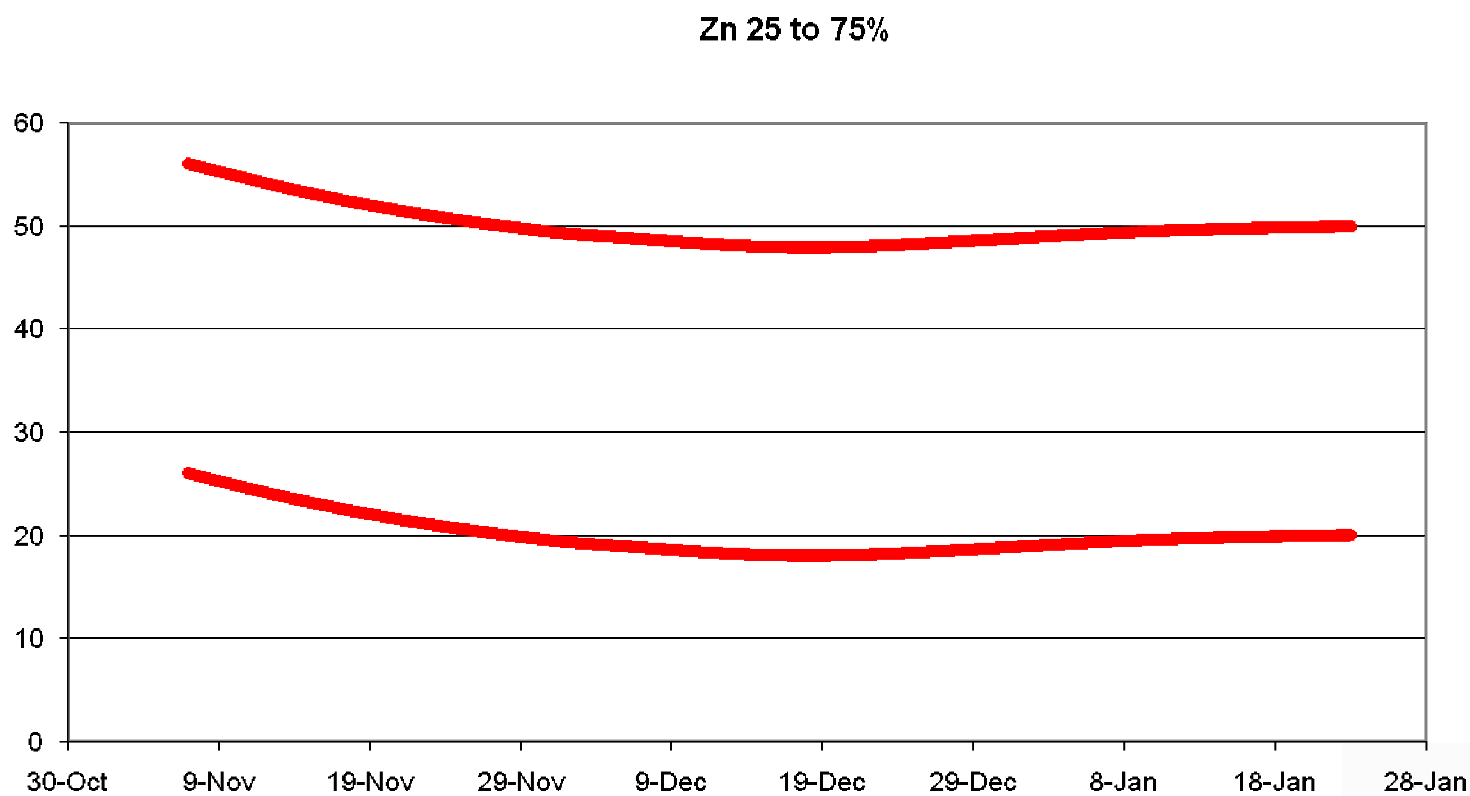
Leaf Zinc

South Tyrol: 25 – 75 % Reference Curves



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Pipfruit Crop Nutrient Removal data
(kg/ha)

Tce/h	750	1500	2000	2700	3500	4500	5500
T/ha	13.5	27	36	49	63	80	100
N	11	23	31	42	54	68	85
P	1.4	2.8	3.8	5.1	6.6	7.1	10.5
K	17	34	45	61	75	100	125
Ca	0.7	1.35	1.8	2.5	3.2	4	5

Data ex - MAF Fertiliser Recommendations Bulletin, 1986.

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Fertigation programme for newly planted trees

Product	Timimg	Appl. method	No. applns	Product g/plant	Product Kg/ha	N %	P %	N kg/ha	P kg/ha
MAP	July	In planting hole	1	100	313	11	22	34	69
Trocoderma		Fertigate	1						
MAP		Fertigate	3	6.9	65	11	22	7	14
$CaNO_3$		Fertigate	14	10	438	16		70	
Urea		Fertigate	14	2	88	46		40	
					Total (kg/ha)			**152**	**83**

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