NTS
Nutri-Tech Solutions®

Soil Mineral Management - Understanding Your Soil Test

By Graeme Sait

Getting Back To Root Causes

- Poor quality crops and increasing pest pressure are never an **accident** or a question of bad luck.
- A fungal disease is not a **deficiency of a fungicide.**
- Medicine, veterinary science and agricultural science have all become based upon the **treatment of symptoms**.
- The problem is not solved. The chemicals serve as a temporary **bandaid**.
- Nutrition Farming is all about getting back to the **root cause** and solving the problem.

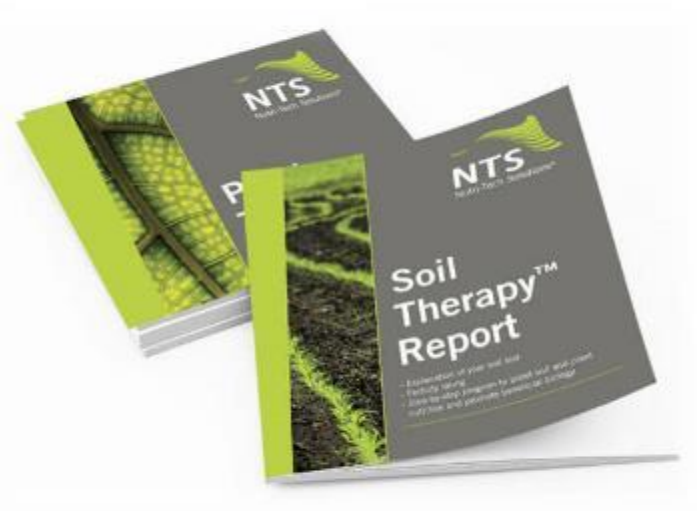
Start With a Good Soil Test

Crop nutrition should never involve guesswork. Informed nutrition is essential to avoid driving blind.

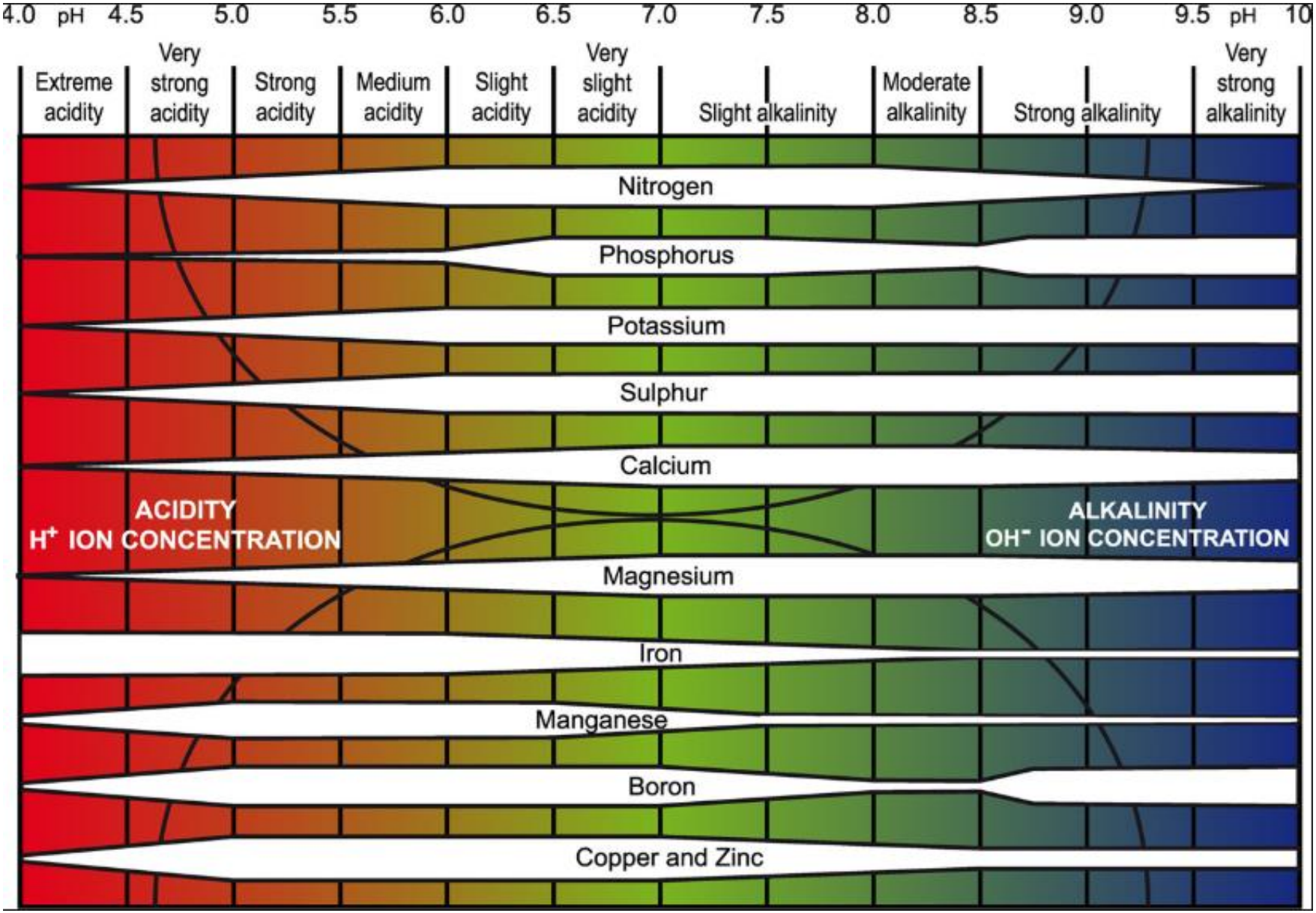
There is a **specific balance** between soil minerals that determines productivity.

Seek a lab or consultant (NTS Soil Therapy™, Brookside, etc) with an understanding of how to achieve this productive state of **balance**.

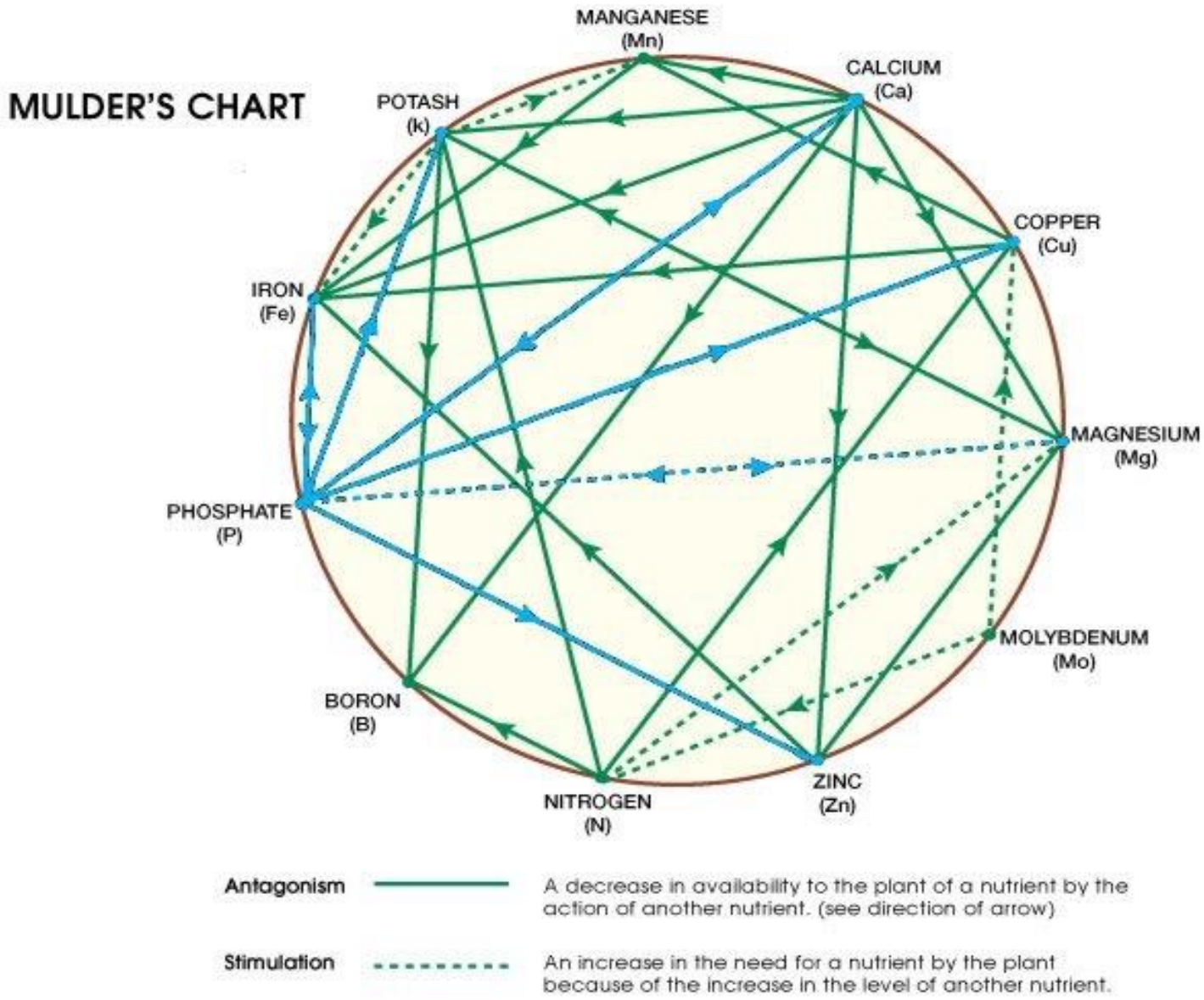
If necessary corrections are unaffordable then liquids can be used for **crop nutrition** (liquid inject and foliars).



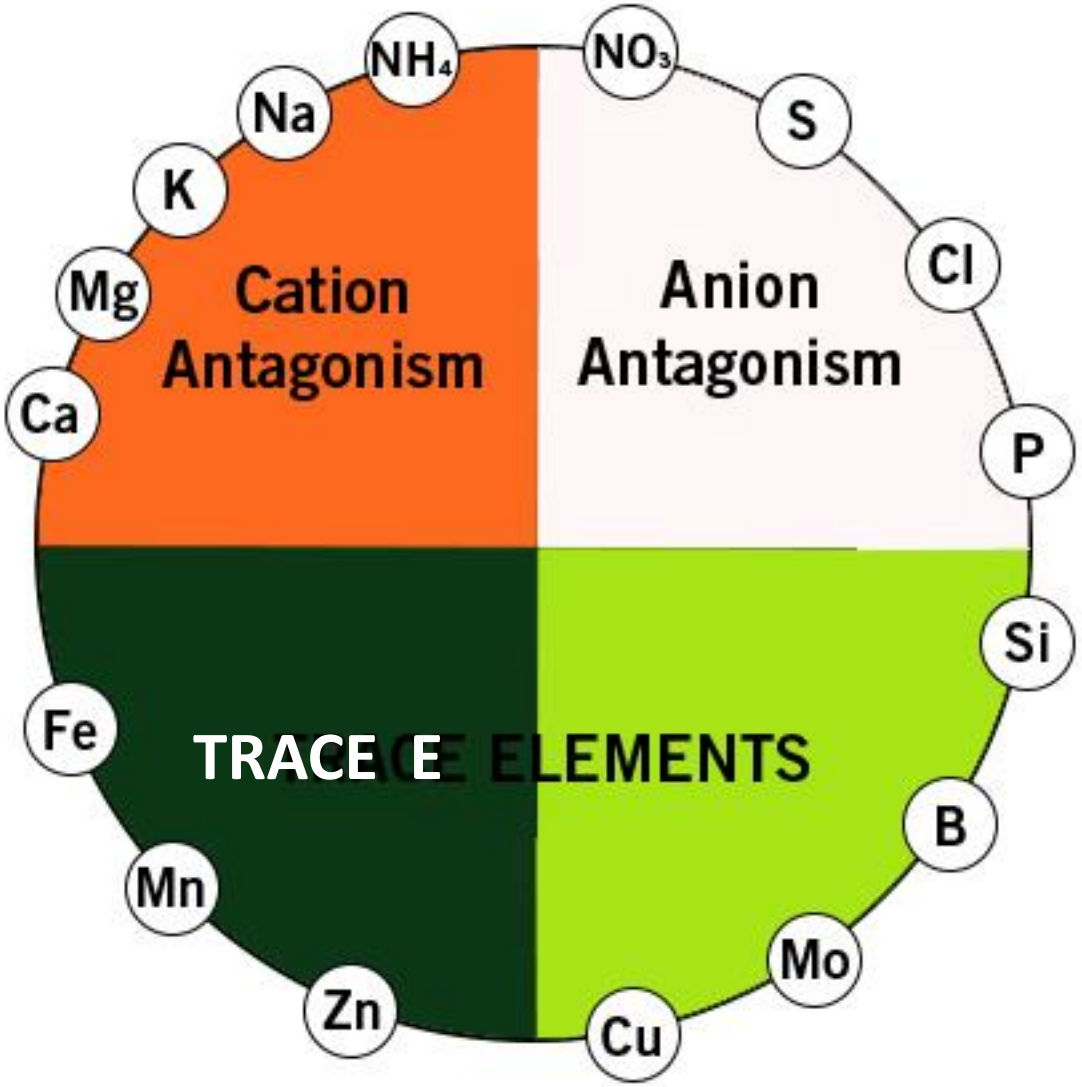
Cutting-Edge Nutrition Strategies for Coffee



Cutting-Edge Nutrition Strategies for Coffee



- This pie chart highlights how the minerals **impact** one another.
- Too much of any major cation or anion will **shut down** another mineral in the same group.
- Everything within each quartile **directly impacts** everything else within that segment of the pie i.e. too much gypsum effects phosphorus, chloride, and nitrate nitrogen uptake.



Soil Test Understanding

- It is critically important to **reclaim responsibility** for your own enterprise, rather than dependence upon those with vested interests.
- Ideally, you need to fully understand the **lessons** from your soil test.
- You will then be equipped to develop your own **nutrition program**.
- **Knowledge** is your empowerment, in the regenerative approach.

Soil Tests – 5 Productive Add-Ons

1. **Chloride** – often not required but essential when needed (for vegetative growth).
2. **Silicon** – as this mineral is missing in most soils and it determines diseases resistance.
3. **Molybdenum** – Needed to access free nitrogen from the air.
4. **Cobalt** – supports nitrogen-fixing organisms.
5. **Selenium** – so important for both animal and human health (and plant health)

The Key Ratios

1. Ca : Mg ratio
2. Mg : K ratio
3. P : S ratio
4. P : Zn ratio
5. K : Na ratio
6. Fe : Mn ratio

ALBRECHT CATEGORY	YOUR LEVEL	IDEAL LEVEL	NUTRIENT STATUS
			LOW / MEDIUM / HIGH
CEC	31.45		
TEC	34.56		
Paramagnetism	350	200 +	
pH-level (1:5 water)	6.40	6.3	
Organic Matter (IR Gas Anal.)	6.52 %	4 - 10 %	
Conductivity (1:2 water)	0.20 mS/cm	0.2 - 0.6 mS/cm	
Ca / Mg Ratio	1.95 :1	7.00 :1	
Nitrate-N (Morgan)	29.7 ppm	10 - 20 ppm	
Ammonium-N (Morgan)	11.2 ppm	10 - 20 ppm	
Phosphorus (Mehlich III)	23 ppm	50 - 70 ppm	
Calcium (Mehlich III)	4052 ppm	4839 ppm	
Magnesium (Mehlich III)	1247 ppm	415 ppm	
Potassium (Mehlich III)	114 ppm	404 - 809 ppm	
Sodium (Mehlich III)	104 ppm	40 - 119 ppm	
Sulphur (Morgan)	43 ppm	30 - 50 ppm	
Aluminium (Mehlich III)	5 ppm	< 16 ppm	
Silicon ($CaCl_2$)	63 ppm	> 100 ppm	
Boron (Hot $CaCl_2$)	0.70 ppm	1 - 3 ppm	
Iron (DTPA)	283 ppm	40 - 200 ppm	
Manganese (DTPA)	28 ppm	30 - 100 ppm	
Copper (DTPA)	5.0 ppm	2 - 7 ppm	
Zinc (DTPA)	2.3 ppm	5 - 10 ppm	
Molybdenum (Nitric Acid)	0.24 ppm	0.5 - 2 ppm	
Cobalt (Nitric Acid)	1.80 ppm	2 - 40 ppm	
Selenium (Nitric Acid)	0.30 ppm	0.6 - 2 ppm	
Texture	Clay Loam		
Colour	Red Brown		
BASE SATURATION			
(Levels are not really relevant in soils with a TEC below 5)			
Calcium	58.62 %	70.00 %	
Magnesium	30.07 %	10.00 %	
Potassium	0.85 %	3.00 - 6.00 %	
Sodium	1.31 %	0.50 - 1.50 %	
Aluminium	0.16 %	0.50 %	
Hydrogen	9.00 %	10.00 %	

Key Mineral Ratios

The **calcium to magnesium** ratio is most important as it determines soil structure and associated gas exchange.

This ratio effectively determines if a soil can **breathe**.

A soil without breath is like an animal nearing death (**oxygen** is required for soil microbes and plant roots while CO_2 must exit for photosynthesis).

This is why **calcium** is always the first thing to address when balancing a soil.

The Key Ratios

The **ideal** calcium to magnesium ratio varies depending on soil density. In a light sandy soil, that ratio should be 3:1 in favour of calcium.

In a heavy, clay soil there is more calcium required to open up that soil, so the ratio should be **7:1** in favour of calcium.

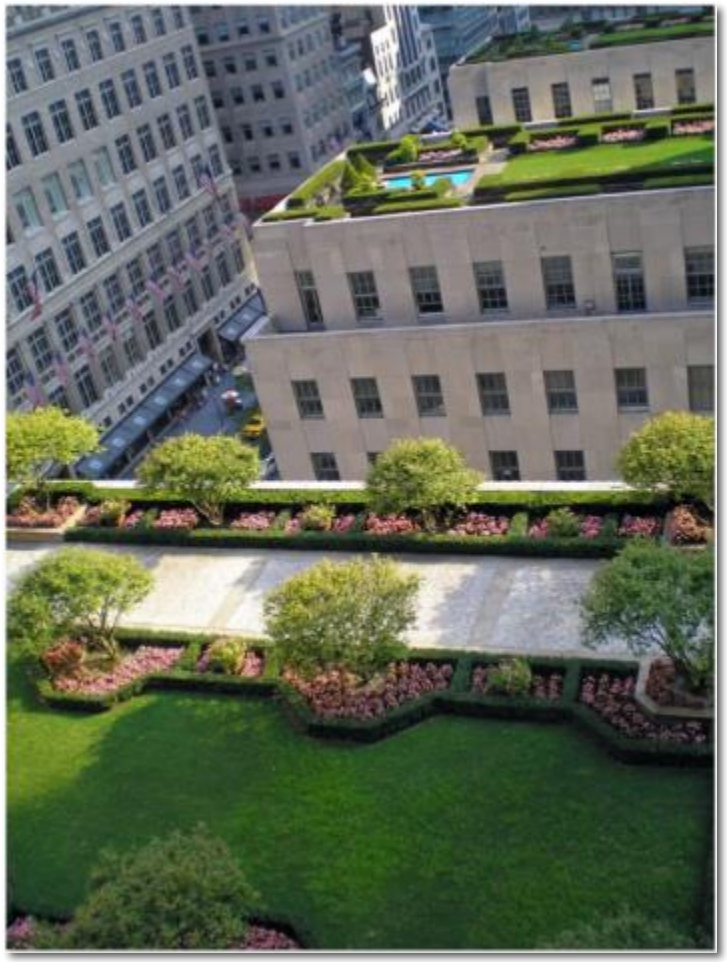
Calcium opens (flocculates) the soil as it is a large ion with two positive charges that attaches to tiny, negatively charged particles of clay and pushes them apart. Magnesium is a small ion that does the opposite.

The Key Ratios

The **magnesium to potassium** ratio is second in importance. You should aim to achieve equal ppm of both elements on a soil test (i.e. 400 ppm K and 400 ppm Mg).

When this happens you have maximum plant availability of both **K and Mg**, but it also stimulates maximum phosphorus uptake.

In **high magnesium** soils, this ratio can never be achieved but there may be more need for applied K and P as a result.



The Key Ratios

The **phosphorus to sulfur** ratio helps to determine the performance of these two key anions.

Sulfur is often neglected as we no longer receive this mineral **free from the air**.

Sulfur is critical for healthy root growth, **protein formation** (essential for plant immunity), and chlorophyll density.

When we lift sulfur levels to match P levels, there is a substantial improvement in **soil and plant health**.

The Key Ratios

The **phosphorus to zinc** ratio is next in importance. Here we like to see 10 parts of P for every 1 part of Zn.

If this this ratio is achieved there will be **maximum performance** of both minerals.

Too much of either **inhibits** the other.

Don't ever try to achieve this ratio in **high phosphorus** soils as the zinc will tie up other elements.

The Key Ratios

The **potassium to sodium** ratio is critical to ensure availability of the second most abundant mineral in the plant (K).

If sodium **exceeds potassium** in terms of base saturation, then sodium becomes a destructive influence.

This can be a common problem where **recycled, saline water** is involved.

The Key Ratios

The **iron to manganese** ratio is important to ensure optimum uptake of both minerals.

Ideally, iron should always be **higher than manganese** on a soil test.

The ratio should be between **1.1:1 and 2:1** in favour of iron.

Unfortunately, the uptake of both minerals is seriously impacted by **glyphosate**.

Understanding the Terminology

- **Cation exchange capacity (CEC)** – offers an immediate guideline as to storage capacity in your soil.

Key guidelines:

1. Ignore base saturation percentages in light soils with a **CEC below 5.** Here, the goal is **500 ppm** of calcium, and **120 ppm** of both magnesium and potassium.

2. The term **'cation exchange'** refers to an exchange that takes place when a cation is removed from the clay colloid by the hungry plant. The plant must maintain electrical balance so it 'exchanges' the cation **hydrogen** with whatever cation it strips from the colloid. Hydrogen is the **acid** element.

Soil Material	Storage
Sand	2 – 3 CEC
Silt	5 – 7 CEC
Heavy Clay	30 – 60 CEC
Humus	250 CEC
Humic Acid	450 CEC
Fulvic Acid	1400 CEC

Understanding the Terminology

3. **TEC** – refers to total exchange capacity. It means that the percentage of the non-nutrient mineral hydrogen has been factored into the equation.

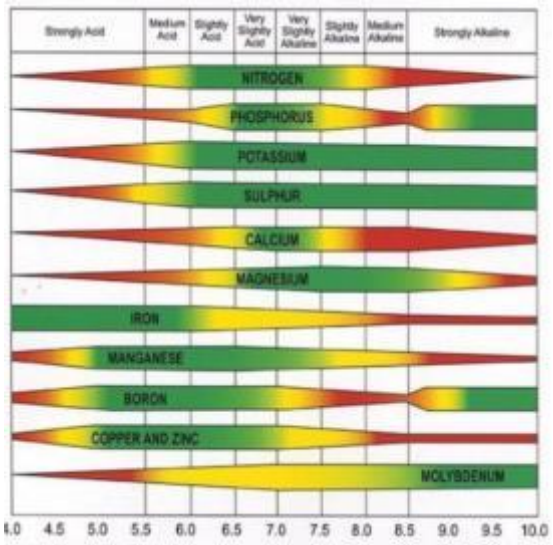
- Without the inclusion of **hydrogen** in the mix, you can be misled into thinking you have an adequate cation balance, when in actual fact, half of your clay storage may be filled with this acid-forming, non-nutrient mineral.

4. **Soil pH** – minerals are most available at a soil pH of 6.4

- It is much easier to correct an acid soil than to address a **highly alkaline** soil.

- Often, you will need to bypass the soil and **foliar spray** minerals like iron, manganese and boron when the soil pH is above 8.

- **Manganese** and **boron** are critical before flowering. Manganese impacts seed production while boron affects multiple aspects of reproduction.



Understanding the Terminology

5. **Organic matter** – This is the most important guideline for high production fertility.

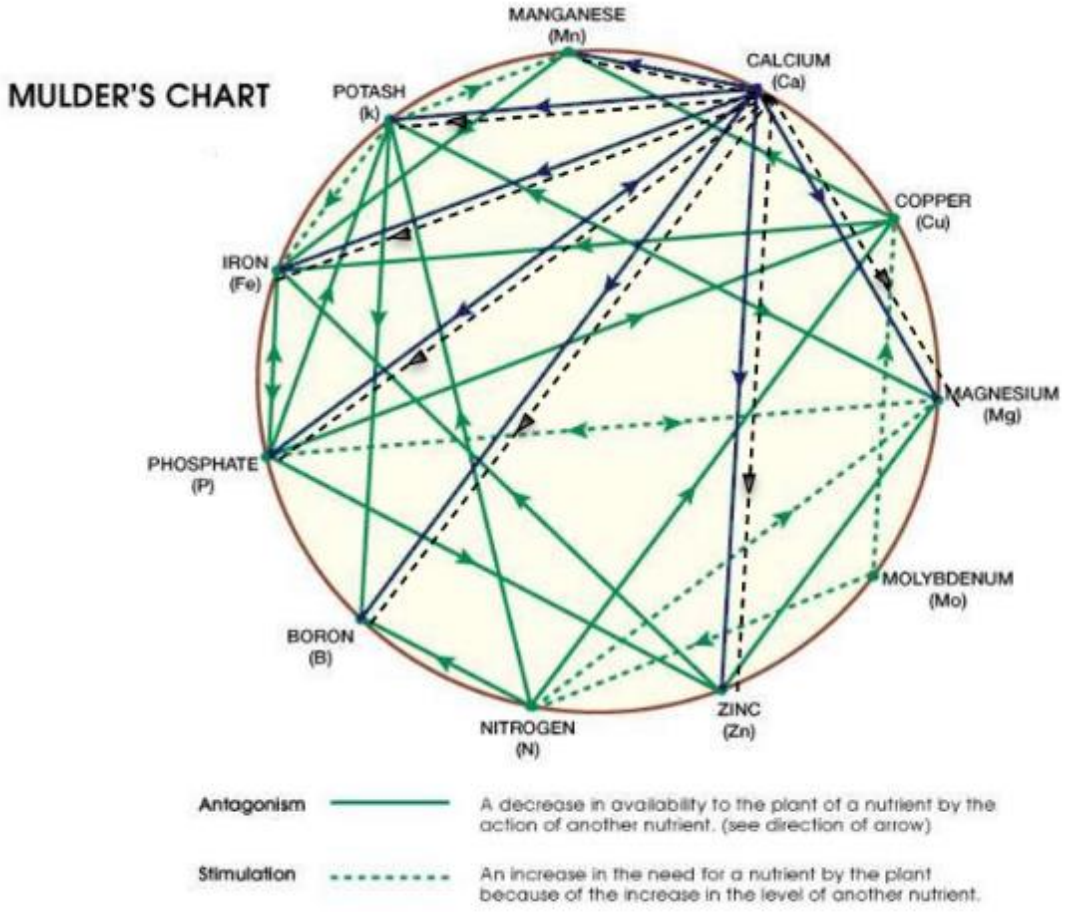
- **Soil structure**, improved water and nutrient retention, crop resilience, soil stability and enhanced infiltration are some of the many **benefits** of organic matter.

6. **Estimated nitrogen release** – refers to the fact that organic matter stores both ammonium and nitrate nitrogen, and releases a percentage of its N storehouse during the crop cycle.

Understanding the Key Minerals

7. Calcium – This is the mineral that should be addressed before all else.

- We refer to calcium as **"the trucker of all minerals"**, as it directly impacts, both negatively and positively the uptake of **seven** different minerals
- Calcium is also the doorman that determines mineral availability at the **cell membrane**.
- It is the **most important** mineral in humans, animals, the soil, and your crop.



Understanding the Key Minerals

7. Calcium –

- In the soil calcium is critical for **gas exchange**.
- In the plant, it determines **cell strength** and associated resilience.
- It is also a key player in **crop quality, shelf life, and the availability of nutrients.**
- It also impacts the activity of beneficial microbes, via increased oxygen through **flocculation**.

Soil Mineral Management

Understanding the Key Minerals

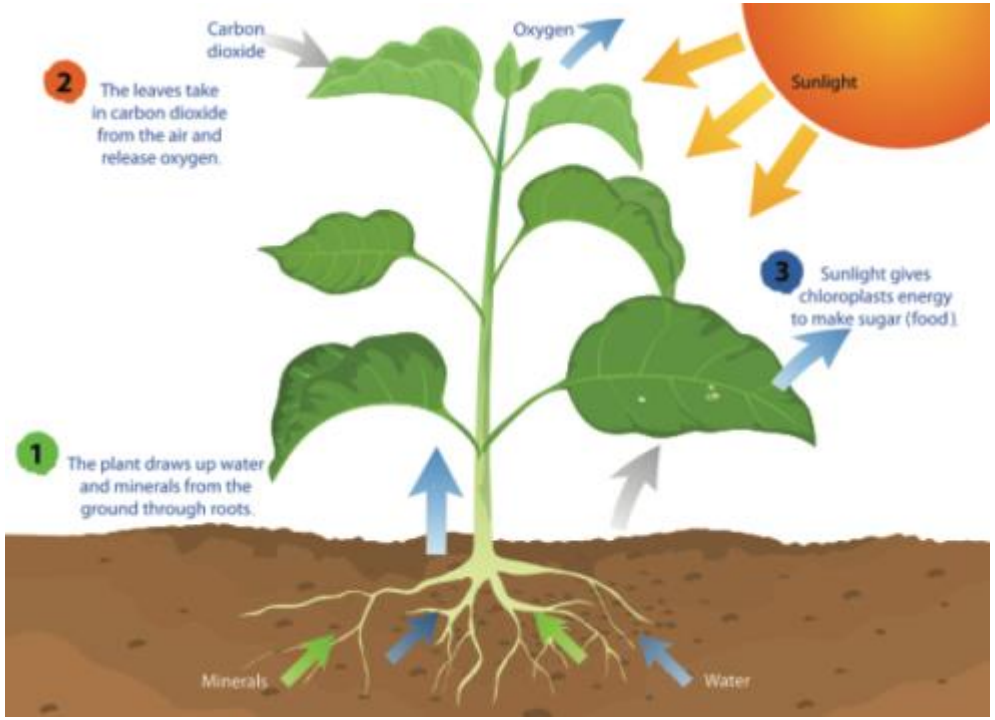
7. Calcium –

- Minerals vary in their **mobility**. N, P & K are the most mobile. Calcium is the least mobile of all minerals.
- That means it **moves very slowly** into the plant, around the plant, and into the fruit and seeds.
- Many mineral **excesses**, including nitrogen, magnesium and potassium, inhibit calcium milk intake.
- **Foliar fertilising** is essential for good calcium supply.
- Calcium is one of the critically important minerals we call **"The Big Four".**

Leaf Testing – Removing the Guess Work

Understanding "The Big Four"

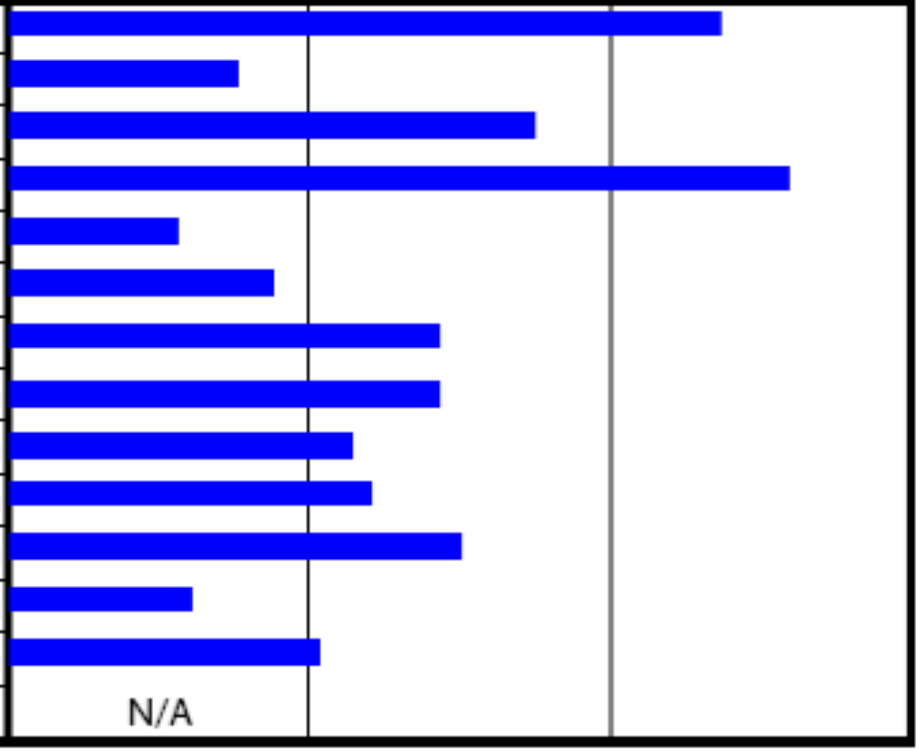
- When **four minerals** are maintained at luxury levels, according to a leaf test, there can be a very productive outcome.
- The **big four** minerals include; calcium, magnesium, phosphorus and boron.
- All four are directly related to the most important of all plant processes, **photosynthesis**.
- The sad story is that in 30% of all of the leaf tests we analyse, all four of these important minerals are deficient (let alone at their optimum level).



PLANT THERAPY™

DATE:	02.04.2009	**LAND USE:**	Rye Grass
NAME:	Mr Sample	**PADDOCK:**	Sample Paddock
ADDRESS:	-	**SAMPLE REC:**	28.03.2009
		CONTACT NO:	xx xxxx xxxx

ELEMENT OR CATEGORY	YOUR LEVEL	ACCEPTABLE RANGE
N - Nitrogen	4.5 %	2.3 - 4.2 %
P - Phosphorus	0.15 %	0.2 - 0.5 %
K - Potassium	3 %	1.5 - 3.5 %
S - Sulphur	0.54 %	0.2 - 0.45 %
Ca - Calcium	0.11 %	0.2 - 0.6 %
Mg - Magnesium	0.14 %	0.16 - 0.4 %
Na - Sodium	0.3 %	< 0.7 %
Cu - Copper	8 ppm	5 - 12 ppm
Zn - Zinc	20 ppm	15 - 50 ppm
Mn - Manganese	100 ppm	50 - 300 ppm
Fe - Iron	55 ppm	50 - 60 ppm
B - Boron	3 ppm	5 - 15 ppm
Mo - Molybdenum	0.16 ppm	0.15 - 0.5 ppm
C - Carbon	%	N/A



Understanding the Key Minerals

8. Phosphorus – we find **Mehlich III** extraction to give the best overall guideline. We aim for 50-70 ppm.

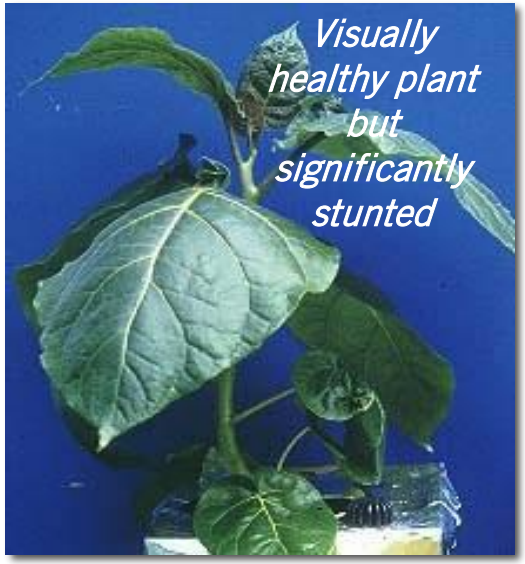
Guidelines:

- Just **27%** of applied DAP/MAP is utilised. The balance becomes part of a massive frozen bank account.
- There is little sense in applying water soluble phosphate to **pasture** and **orchard crops**, considering the loss factor.
- In field crops, DAP/MAP should always be stabilised with **Soluble Humate Granules (SHG)**. This practice also buffers the burning impact on mycorrhizal fungi and plant roots. **5%** of SHG does the job while also providing other benefits.

P Deficiency in Plants

- Stunted shoot & root system
- Leaves lack lustre
- Yellowing
- Blue green or purplish leaves
- Symptoms appear first in older leaves

P is very mobile in the plant



Refractometer = total dissolved solids

- A good guideline to P levels as sugars can not be produced without phosphate.
- The higher the brix the stronger the plant, good energy reserves to fuel any demand response (e.g. pest attack, onset of flowering or a growth spurt on a sunny day after rain).
- Taste, Nutrition, Colour, Size, Shelf Life.

Brix to Control Insects

INCREASED PEST & DISEASE RESISTANCE

- **P provides fuel** for energy expensive plant defence systems.
- This includes **anti-fungal agents** and production of **biochemicals** which are distasteful to insects.
- Phosphate is essential for sugar production and **increased sugar levels** are **unattractive** to insects. i.e. it can convert to poisonous **alcohols** in their bodies.

Ravaging the Root Zone

Study the roots to evaluate the biological **impact** of harsh fertilisers.

- Look for fuzzy coating around the roots and how it holds onto the soil.
- This **fuzzy coating** represents billions of fungi and bacteria and their sticky exudates and hyphae effectively hold the soil to the roots.

Combining Soluble & Slow Release

DAP/MAP with humates plus Guano Granules or a similar **Soft Rock** phosphate alternative.

RATIONALE:

- The acid phosphate is buffered and stabilised by the humates.
- The guano offers citrate soluble and slow release phosphate so there is a complete release pattern throughout the crop cycle.
- **Soil life** is both protected and stimulated with this fusion approach.

Understanding the Key Minerals

7. **Phosphorus**

- Strategies to reclaim locked up phosphorus include: **compost**, legumes, fulvic acid, mycorrhizal fungi, and **stubble digestion** programs.

- Magnesium can stimulate the uptake of phosphorus, while high **potassium** can limit P availability.

8. **Magnesium** – this mineral is the centre of chlorophyll, so a shortage will mean substandard photosynthesis.

- High magnesium creates tight closed soils where **gypsum** is so important.

- **Magnesium sulphate** should never be used in the soil. It is only applicable as a foliar spray.

Understanding the Key Minerals

9. **Potassium** – this super mobile mineral does not become part of cell structure, but races around the plant to where it is required.

- K is involved in stomatal opening, stem strength, vegetative growth and, most importantly, the **sizing up** of grains and fruit.
- The '**money mineral**' is best managed by monitoring top and bottom leaves, and ensuring that there is no more than **10% variation** between the two sites.
- **Potassium sulphate** is always the best option even though it costs more.
- A **potassium metre** is the best tool to manage this mineral.

Understanding the Key Minerals

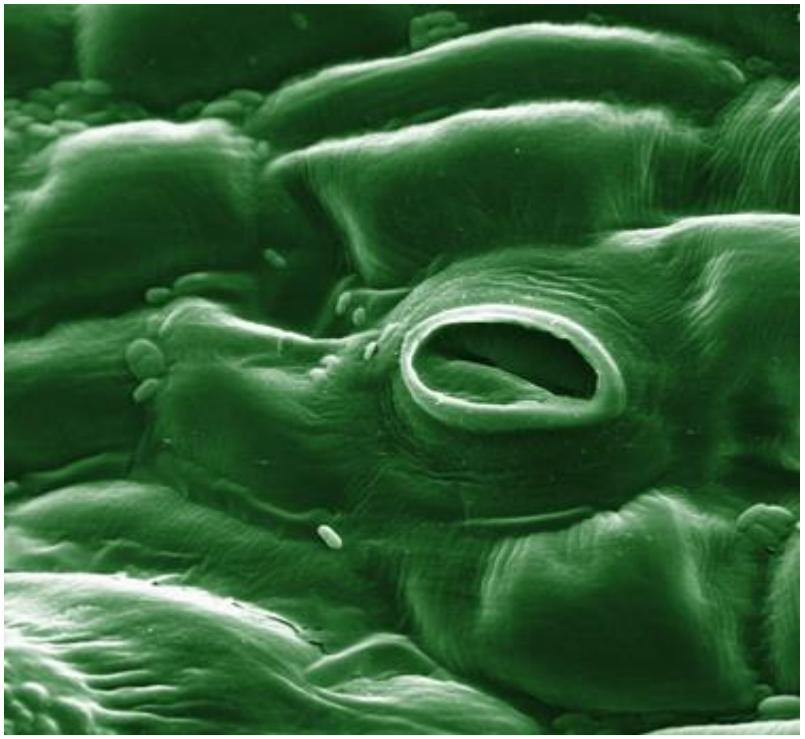
10. **Sulphur** – We used to get our sulphur for free, until acid rain damaged forests and waterways, and sulphur emissions were banned.

- **Organic matter** is the only thing that stores highly leachable sulphur in the soil, and we have lost 2/3 of our humus.

- Sulphur is about **protein formation**. Protein drives plant, animal, and human immunity.

- Sulphur availability is impacted by other **major anions** (vice versa). The 1:1 sulphur to phosphorus ratio is critical.

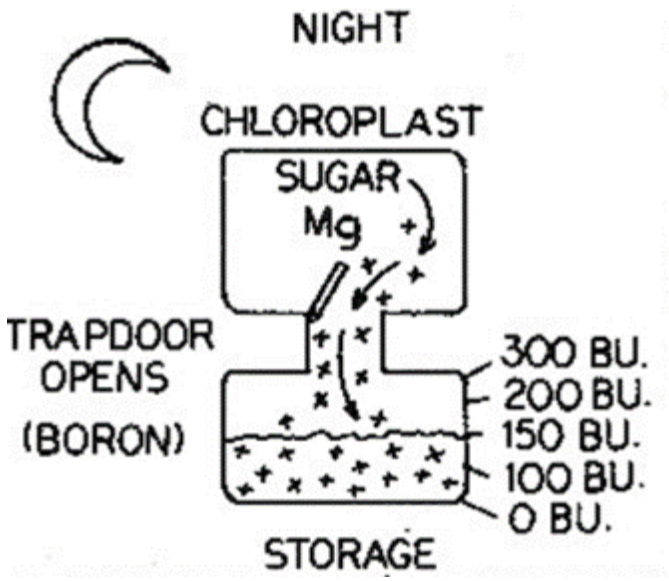
- **Elemental sulphur** can give a more profound response because the gas emitted while it is biologically converted to sulphates can be absorbed through the stomates.



Understanding the Key Minerals

11. **Silica** – This mineral strengthens the cell wall to resist insects and disease.

- The plant available form is **missing** in most soils, and appears to be linked to the chemical extractive model (**100ppm** is needed).
- Silica also prevents **lodging**, improves nutrient translocation, combats mineral excesses (sodium), improves photosynthesis, and increases resistance to both biotic and abiotic **stress** (heat, cold, drought, transplant).
- Most importantly, silica is a major **immune elicitor**, hence the link to increase yields when we address the shortage.
- Liquid, micronised **diatomaceous earth** is the most versatile silica source.



Understanding the Key Minerals

12. **Boron** – This is the most important calcium synergist. It is a highly leachable anion, and is only stored on the humus colloid. Ideal soil levels are 1 ppm – 3 ppm.

- Boron is deficient in most leaf tests we analyse, and it is most effective as a **foliar spray** directly **before flowering**. It is critical for grain and fruit formation.
- Boron opens the **trap door** in the chloroplast to allow translocation of glucose around the plant and down to the roots. 30% of this is fed to soil microbes. If the door remains shut, the microbes suffer.
- A **refractometer** can help identify a boron deficiency (Brix should always be lower in the morning).
- Boron should always be applied with **humic acid** to stabilise and magnify the mineral.

Understanding the Key Minerals

13. **Zinc** – 5-10 ppm is required. This mineral governs leaf size, so a deficiency will always be costly.

- The **phosphate to zinc ratio (10:1)** is critical for availability, and for the energy roles of both minerals.
- Zinc sulphate can be easily chelated with **fulvic acid** to create a zinc fulvate.
- **Copper fungicides** can induce zinc deficiencies.

Zinc Deficiency in Wheat

14. **Copper** - Is about protection from fungal disease, chlorophyll density, stem strength, and protein formation.

- **Copper fungicides** are the least sustainable method of disease control. It is far better to get copper **into the plant** efficiently rather than drenching soil and plant with a heavy metal (Copper Shuttle™).

Understanding the Key Minerals

14. **Molybdenum** – This mineral is needed to fix nitrogen and to convert nitrates to proteins. Three molybdenum-based enzymes are linked to stress resistance.

- **80%** of the soils we test are molybdenum deficient. We need minimum levels of **0.5ppm** in the soil.
- It is a highly **leachable anion.**
- Molybdenum deficiency is widespread on **legumes** and **maize** in acid soils. This is related to the antagonistic effect of iron.
- Light, **sandy**, low humus soils are often molybdenum deficient.

Potential crop improvements in Waitaki County, New Zealand, by the use of molybdenum fertilisers. From LOBB [170]

CROP AND SOIL	CONTROL, NO MOLYBDENUM	YIELDS WITH MOLYBDENUM	% INCREASE
Lucerne on sandstone soil	3,060	13,920	355
Lucerne on clay soil	13,664	19,488	43
Rape on sandstone soil	7,616	53,536	603
Rape on clay soil	8,288	14,784	78
Pasture on clay soil:			
a	3,300	6,233	89
b	2,038	9,357	359
c	3,561	17,450	390
d	995	1,505	51
e	4,968	7,028	44
f	2,080	2,868	38
g	13,700	20,500	50
h	12,200	18,800	54

In Conclusion…

Understanding the interplay between minerals is essential to maximise productivity.

Soil tests are important, to avoid driving blind, but you must understand the data.

Knowledge is more important than inputs in the regenerative approach.