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**Nutrition Matters**

Articles and Ideas from the Pioneers of Nutrition Farming®



# Building Soil Health and Resilience

By Graeme Sait



# The State of Play – Minerals, Microbes and Humus

Introduction

By Graeme Sait



# The NTS Story – From Soil Health to Planetary Health

- Nutrition Farming is an integrated, holistic system, recognising the profound links between soil health, crop resilience, animal vitality, farmer's health and planetary wellness.

**Nutrition  
Farming®**



# Anatomy of an Awakening

NTS is now consulting with major organisations and Governments globally.

This has included:

- Training **The Dole Corporation, Greenyard Farms and Driscoll's Berries** in the US.
- Training the entire **Agriculture Departments** in Laos, Singapore, Malaysia, Vietnam and Brazil.
- Meeting **Agriculture Ministers** in Canada, India, and the UK.
- Training growers from **Supermarket chains** in South Africa and the UK.
- Mentoring Climate Change **action groups**, like Kiss The Ground.
- Consulting globally with large **grower cooperatives**.



## The Chemical Experiment

For the past ten decades, we have employed a **chemical, extractive model** for our food production.

We began this experiment by dumbing down crop nutrition to just **3 minerals**, while removing a little of all 74 minerals, with each season.

Soon after adopting this **simplistic nutrition**, we experienced unparalleled pest pressure and science stepped up to the plate.

The **toxic rescue chemicals** became our saviour, but we have increased their use every year thereafter.



### The Wake Up Call

A global awakening is underway. We are finally recognising the unsustainability of this symptom-treating approach and many are seeking change.

The drivers of this revolution include the following:

1. The current **chemical experiment** perfectly fits the definition of “unsustainability” i.e. more chemicals are used every year and yet overall pest and disease pressure increases each year (**1.1 million tonnes** of chemicals were applied last year).
2. A fair marker for the relative success of a society is the **health of children**. Recent US research involved 1400 school children who were monitored for the presence of the **13** most commonly used farm chemicals. To the horror of the researchers, every child had **unacceptable levels** of every farm chemical.



## The Wake Up Call

3. At our current rate of top soil loss, there is just **60 years** until zero remains.
4. We've lost **2/3** of our humus and that carbon is now the lion share of the CO<sub>2</sub> blanket trapping more heat and changing our climate.
5. The recent trend involving the monitoring of **soil life** has revealed a **decimation** of key creatures in the soil. This includes earthworms, protozoa, cellulose digesters, N-fixers, phosphate solubilisers and many organisms responsible for **nutrient delivery** (glyphosate).



## The Wake Up Call

6. Our food has become a **shadow** of its former self, with less flavour, shelf life, and medicinal qualities.
7. **Degenerative illness** associated with compromised nutrition has become our largest killer.
8. There is a global movement towards **'putting a face to your food'** which is the basis of the global farmers market phenomenon, and a direct-to-consumer, supermarket model in Japan.
9. Poor **soil nutrition** is poor animal and poor human nutrition (Recent WHO report). Mineral delivery is a function of both mineral and microbial **balance**.



## The State of Play – Minerals, Microbes and Humus - Introduction

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10. Conventional agriculture is the biggest single contributor to greenhouse gases including **25%** of the worlds CO<sub>2</sub>, **60%** of methane and **80%** of nitrous oxide (310 x more potent than CO<sub>2</sub>).
11. If the world were to reduce CO<sub>2</sub> emissions by **100%** tomorrow, then in **200 years** time we would be down to the atmospheric CO<sub>2</sub> levels of **1975** (still too high). We are locked into self-destruct mode and the only saviour is **agriculture**.



# The State of Play – Minerals, Microbes and Humus - Introduction

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12. **Carbon credits** for building humus in the soil are an urgent necessity and an absolute certainty. Building **1%** humus in US soils removes 4.5 billion tonnes from their **8 billion** tonne contribution to the problem.
13. Building humus is a **biological process** so anything that is detrimental to that process will be viewed as **unacceptable** at some point.



# 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.

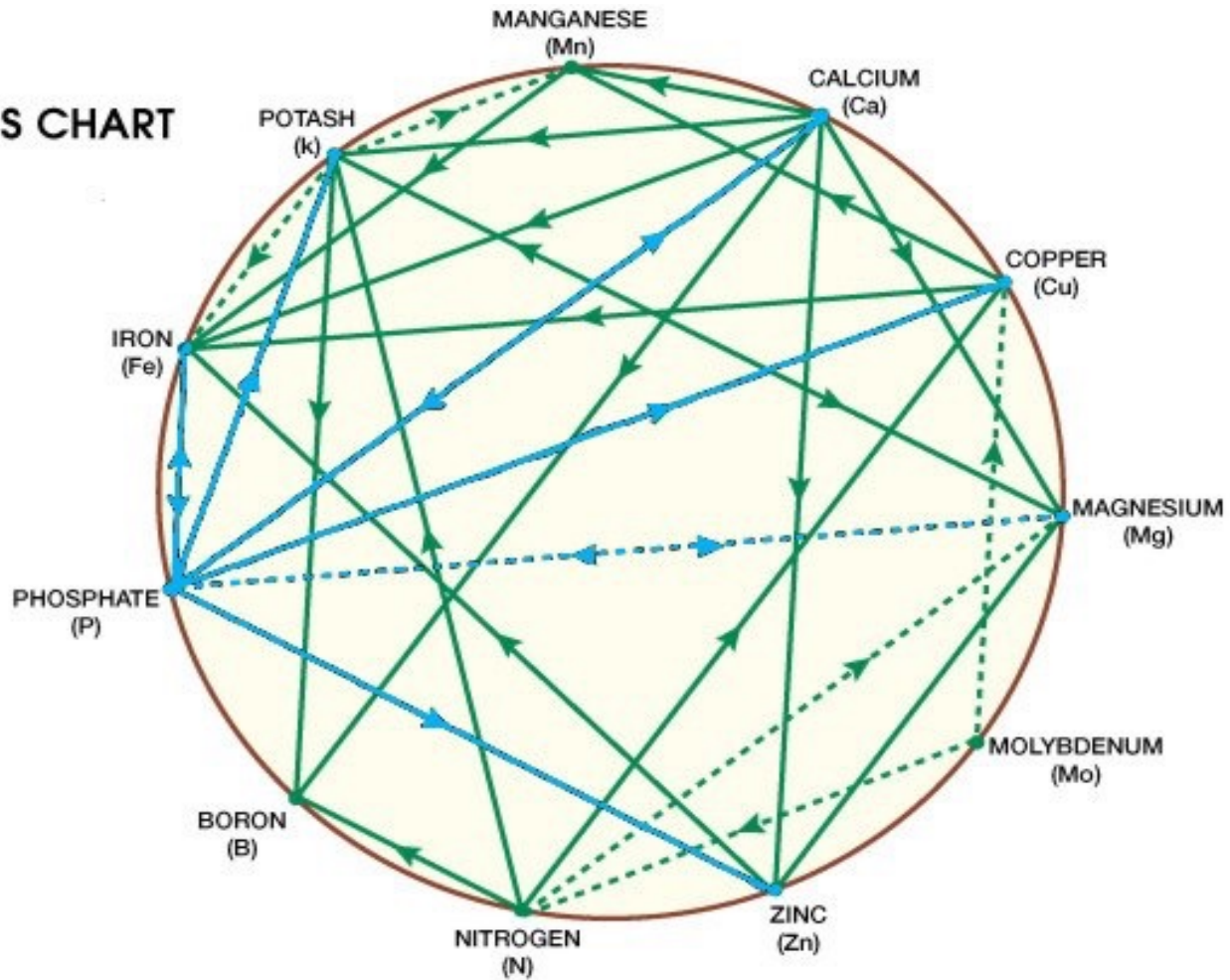
There is a **specific balance** between soil minerals that determines productivity.

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 foliar).

# The State of Play – Minerals, Microbes and Humus - Introduction

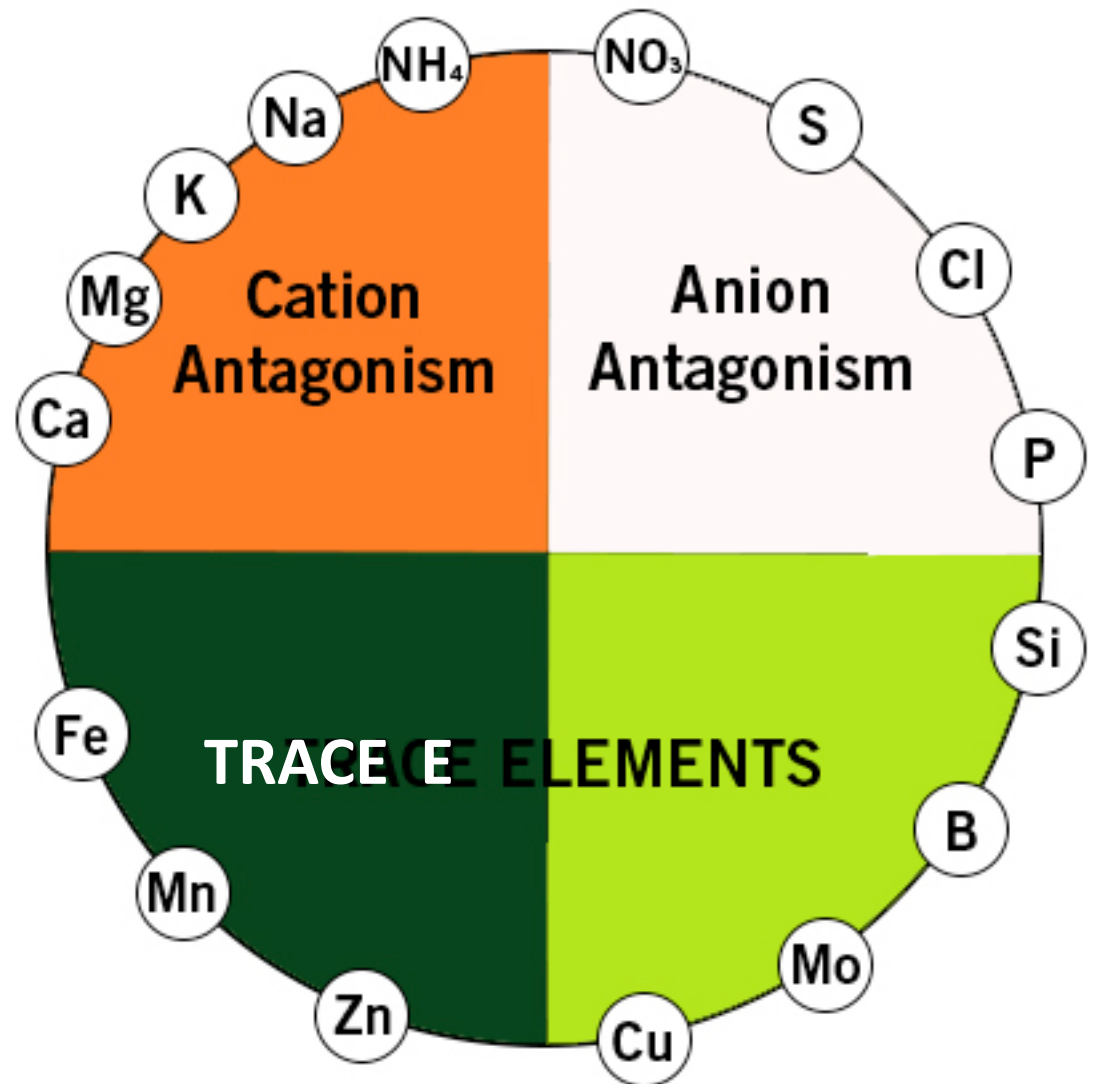
MULDER'S CHART



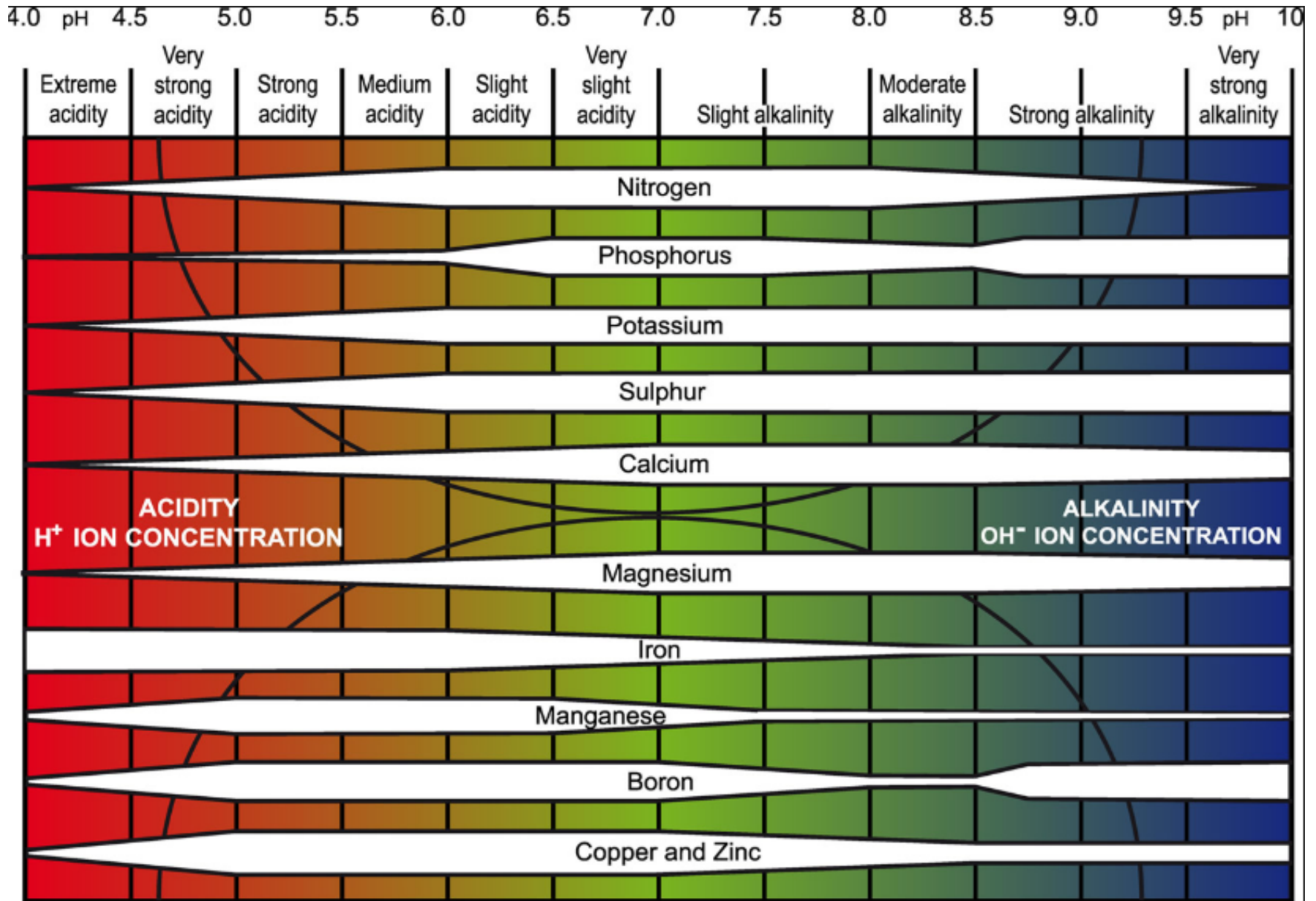
- Antagonism** ——— A decrease in availability to the plant of a nutrient by the action of another nutrient. (see direction of arrow)
- Stimulation** - - - - - An increase in the need for a nutrient by the plant because of the increase in the level of another nutrient.

# The State of Play – Minerals, Microbes and Humus - Introduction











- 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.



# The State of Play – Minerals, Microbes and Humus - Introduction



# Critical Terms and Concepts

CATIONS	ANIONS
 $\text{Na}^+$	 $\text{Cl}^-$
 $\text{Mg}^{2+}$	 $\text{SO}_4^{2-}$
 $\text{Ca}^{2+}$	 $\text{HCO}_3^{2-}$
 $\text{K}^+$	 $\text{Br}^-$
 $\text{Sr}^{2+}$	 $\text{CO}_3^{2-}$

- When minerals are broken down to their smallest component, they are termed **ions**.
- There are two types of ions based upon their electrical charge. Positively charged ions are called **cations**, while negatively charged ions are called **anions**.
- Their respective charges determine the storage, plant availability, and interplay between minerals in the soil.

# The State of Play – Minerals, Microbes and Humus - Introduction

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## MAJOR CATIONS:

Calcium	Ca <sup>++</sup>
Magnesium	Mg <sup>++</sup>
Potassium	K <sup>+</sup>
Sodium	Na <sup>+</sup>
Hydrogen	H <sup>+</sup>
Aluminium	Al <sup>+++</sup>
Ammonium	NH <sub>4</sub> <sup>+</sup>

## MAJOR ANIONS:

Phosphate	PO <sub>4</sub> <sup>3-</sup>
Sulphate	SO <sub>4</sub> <sup>2-</sup>
Nitrate N	NO <sub>3</sub> <sup>-</sup>

## MINOR CATIONS:

Zinc	Zn <sup>++</sup>
Iron	Fe <sup>+++</sup>
Manganese	Mn <sup>++</sup>
Copper	Cu <sup>++</sup>
Cobalt	Co <sup>++</sup> or Co <sup>+++</sup>

## MINOR ANIONS:

Borate	BO <sub>3</sub> <sup>-</sup>
Molybdate	MoO <sub>4</sub> <sup>2-</sup>

Note the abbreviations and number of their charges.

## Minerals, Microbes and Humus

- The interplay between minerals, micro-organisms and the humus that is their mutual storehouse is the essence of a **Nutrition Farming** approach.
- We have identified **ideal levels** of minerals in the soil and in the plant and several **key ratios** that determine mineral efficiency.
- We have discovered an effective way of looking at plant tissue analysis where we strive to achieve luxury levels of **four key minerals**.
- We also utilise a system of in field monitoring that enables much more **precision** in mineral nutrition.



## Mastering Microbes

Soil micro-organisms are the **hidden workforce** which determine farming success.

They have been **assaulted** on all fronts in modern agriculture and there can be tremendous gains in their regeneration.

The **microbe management** component of Nutrition Farming involves the following:

1. Developing practices that are **microbe friendly** (including reduced tillage, buffering salts and chemicals etc.)
2. Introducing new microbes with **compost** and microbial inoculums.



## Mastering Microbes

3. Feeding soil life with **cover crops** and stubble digestion

4. Creating optimum conditions and stimulating microbes with **humates**

5. **Foliar fertilising** to more rapidly increase chlorophyll that generates exudates

6. Eliminating the most **damaging chemicals**

7. Bringing back **earthworms**



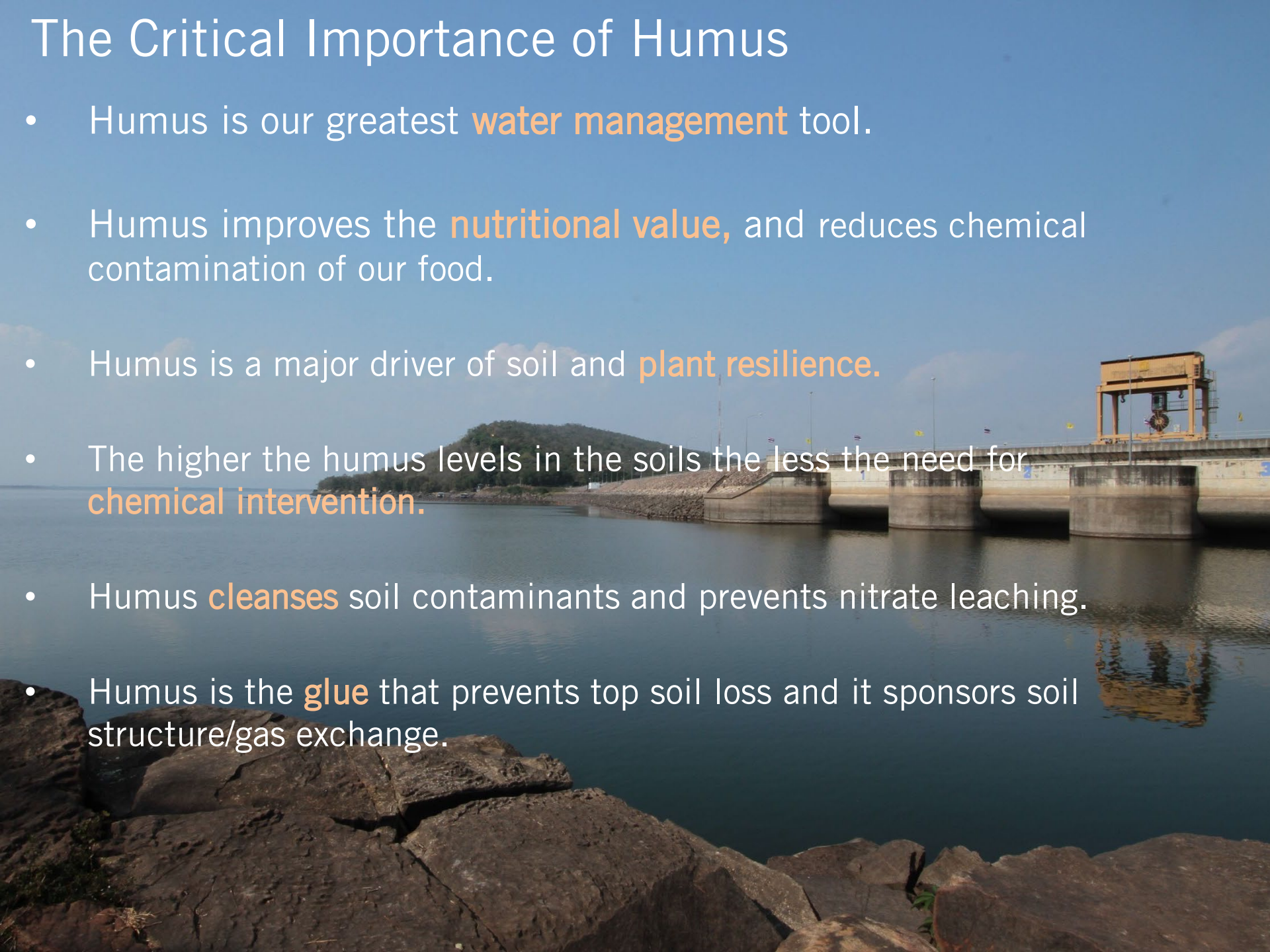


## The Critical Importance of Humus

- Humus is the sweet smelling, chocolate coloured substance, produced by micro-organisms that serves as their **home base** and support system.
- It is also a **storage** medium for all minerals.
- Microbes are the **bridge** between the soil and the plant.
- There is a microbe behind every **mineral**.

# The Critical Importance of Humus

- Humus is our greatest **water management** tool.
- Humus improves the **nutritional value**, and reduces chemical contamination of our food.
- Humus is a major driver of soil and **plant resilience**.
- The higher the humus levels in the soils the less the need for **chemical intervention**.
- Humus **cleanses** soil contaminants and prevents nitrate leaching.
- Humus is the **glue** that prevents top soil loss and it sponsors soil structure/gas exchange.



# In Conclusion...

A man wearing a dark cap and a plaid shirt stands with his back to the camera, looking out over a vast field of golden crops. The sun is low on the horizon, creating a warm, golden glow across the entire scene. The field stretches to the horizon, with a line of trees visible in the distance under a hazy sky.

Nutrition Farming addresses the powerhouse link between soil health and human health.

It is now understood that soil health may well be the biggest player in addressing climate change.

When we address root causes rather than treat symptoms farming becomes more profitable.

We grow food with forgotten flavours, nutrient density and greater medicinal value and farming becomes much more fun!



# The Magic and Myth of Cover Cropping

By Graeme Sait

# Seven Reasons To Cover Crop

1. **To provide biodiversity** – this is a central rule of nature. Plants all do better in the presence of other plants. This is the fatal flaw in the monoculture model.

In one large scale US study, comparing different cover crop inclusions, it was found that, in every case, it was **“the more the merrier”**.

Part of this improved crop response relates to increased **biological activity**, but there is more involved.



# Seven Reasons To Cover Crop

2. **To help manage weeds** – Nature is messaging us about the need for plant cover, because weeds come up whenever there is a vacuum. Our response has been to use and abuse **herbicides** to the point that they have become amongst the most destructive chemical inputs.

Cover crops **interplanted** in field crops can reduce the need for herbicides, simply because they outcompete the weeds.



## Seven Reasons To Cover Crop

3. **To feed soil-life** – It can be argued that a bag of seed can be of more value than a bag of fertiliser.

The cover crop provides enhanced photosynthesis and **30%** of the sugars produced are pumped into the soil to feed beneficial microorganisms.

Different plants feed different microbes, so the greater the **biodiversity** above ground, the greater the biodiversity below.



## Seven Reasons To Cover Crop

4. **To build humus** – Cover crops can stimulate humus-building soil-life, converting sugar (carbon) exudates into humus.

When the cover crop is slashed, or compressed with a **roller crimper**, it can decompose and further increase organic matter levels.

The **oxygen pathways** introduced by crops like daikon radish further stimulate humus-building organisms.



# Seven Reasons To Cover Crop

5. **To prevent erosion** – This precious top-soil enters the ocean along with the P and N it contains and creates algal blooms, which have created massive dead zones in our oceans.

In the US the average top-soil loss per year is **3 – 5 tonnes per acre**.

The problem is worsening with weather extremes, because rain is a major cause of erosion.

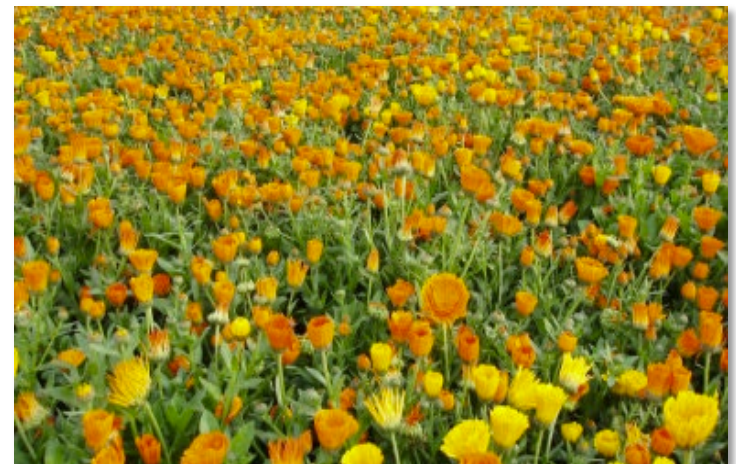


## Seven Reasons To Cover Crop

6. **Management of pests** – Crops like **mustard** and **marigolds** are very effective nematicides and other cover crops can reduce root disease.

**Cover crops** can also serve as trap crops for pests and/or they can host beneficial predators.

These crops can also attract **pollinators**, which are essential for most fruiting crops.



## Seven Reasons To Cover Crop

7. To supply nitrogen – high protein legume plow-downs can provide up to **100 kg of N** per hectare (200 kg of urea per Ha).

The nitrogen is rapidly delivered due to the **10:1** up to **15:1** C:N ratio of legumes.

Even crops like winter rye, annual rye grass and wheat, can have a **15:1** C:N ratio before flowering.



## Growing Your Own Nitrogen

It can be handy to understand the **equation** that allows you to calculate the **amount of N** you are producing with a cover crop.

- As a rule of thumb, **100%** ground cover, at 6 inches high, equates to **2.2 tonnes** of dry matter per ha.
- You add **150 kg** per ha for each additional inch.
- The equation is: **Dry matter per ha x % of N.**



# Growing Your Own Nitrogen

## N-content of Cover Crops

Annual Legumes	Perennial legumes	Grasses
Pre-bloom: 3.5-4% N	Pre-bloom: 2.5-3% N	Pre-bloom: 2-3% N
Post-bloom: 3-3.5% N	Post-bloom: 2-2.5% N	Post-bloom: 1.5-2.5% N

**Lets try the equation (Dry matter per Ha x % of stand x % of N):**

Assuming that you have 100% ground cover of a pre-bloom annual legume, grown to a height of 12 inches, here is how you do it...

$$\begin{aligned} &2,200 \text{ kg} + 6 \times 150 \text{ kg} (900 \text{ kg}) \times 100\% \times 4\% \text{ N} \\ &= 124 \text{ kg of N or } 260 \text{ kg of Urea} \end{aligned}$$

## Cover Cropping Cautions

1. Always watch out for **nitrogen drawdown** with high carbon crops.

Allow **three weeks** minimum before planting and use cellulose digesters if necessary.

**Additional nitrogen** may also be required.

2. **Turning-in** a green manure crop will always provide more N than no till, because there is always gaseous N lost following herbicide burn down.



## Cover Cropping Cautions

3. When working in the cover crop keep in the **A horizon** (top few inches). Deep tillage buries N and it may leach before the roots arrive (Howard Rotavator).
4. Combine lower N higher C grasses with legumes to slow down the **N release**.
5. Rye, wheat, oats, hairy vetch and brassicas are all known to have an **allelopathic** effect, so mix them up and alternate to avoid a build up of these bio-chemicals.



## A Multi-Benefit Brassica

The term “**tillage radish**” is clever marketing to capitalise on the potential of a cover crop brassica called Daikon Radish. These benefits include:

1. The radish can grow beyond 30 inches and is a powerful **N scavenger**, absorbing 150 kg of N in Autumn and releasing it in Spring.
2. It breaks **hard pans** and suppresses Spring weeds.
3. It produces **glucosinolates**, biochemicals that discourage root disease and root knot nematodes.



# The Magic and Myth of Cover Cropping

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## Cover Crop Principles

1. **The more the merrier** – nature embraces biodiversity, e.g., four legumes under cereals works much better than one. Four grasses under legumes outperforms a single grass.
2. **Cover crops as a drought tool** – it may seem counterintuitive, but the associated fungal stimulation produces macro-aggregates to dramatically improve water absorption. A living soil can absorb 8 – 20 inches of rain in an hour, compared to flow-off, erosion and floods.
3. **Use cover crops to stimulate AMF** – combination is the secret here. Dr Wendy Taheri has demonstrated that the combination of oats and crimson clover is a powerful mycorrhizal stimulant. The effect is even more powerful if you include white and yellow clover.



# The Magic and Myth of Cover Cropping

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## Cover Crop Principles

4. **Tips to improve wheat** – add 2.5 kg of daikon radish with Winter wheat seed. It will only get pencil thin before Winter, but will accumulate calcium, boron and zinc and deliver this kick-start in spring as the wheat breaks dormancy.
5. **Determining seeding rates** – surprisingly, higher seeding rates are better in dry conditions because the plants cool the soil down and provide the capillary action to harvest banked moisture. 30 – 40 kg might be applicable in dry conditions, while 10 – 15 kg is more appropriate in wet, heavy clay soils.



# The Magic and Myth of Cover Cropping

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## Cover Crop Principles

6. **Practice pasture cropping – Colin Seis** – the goal is to get direct-drilled cover blends to account for 40% of species, then things really change. The associated fungal diversity from multiple clovers makes much better use of urine and manure. **Leaf chicory** is like a pre-biotic for the rumen. **Plantain** is a deep-rooted nutrient accumulator that is anti-parasitic.
7. **Don't overdo seeding rates** – always remember “less is more, and more is too much”. Many cover crops have failed through over-seeding.
8. **Keep a below-ground focus** – the biological dynamics are the key, not a leafy show. You might be boosting biology with the young plant or soaking up mineral excesses and stabilising leachables with the older plant.



# The Magic and Myth of Cover Cropping

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## Plant Specific Purposes

1. **Barley** is mycorrhizal in the Spring. At this time it also releases exudates that increase P and K availability.
2. **Cereal Rye** is a real N scavenger in early Spring, saving that mineral for later release. This can impact weed pressure, as some weeds germinate in Spring in the presence of 50 ppm of nitrogen. Soy beans need extra N at pod fill, so the decomposing rye gives just what they want when they need it.
3. **Triticale** is related to cereal rye but its different release pattern enables spoonfeeding of the cash crop for a much longer time.



# The Magic and Myth of Cover Cropping

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## Drought-proof Your Farm With Cover Crops

The **Paul Scherrer Institute** of Switzerland researched the mechanics of drought-proofing with cover crops. Their findings include:

1. Soil with a few mm of roots has **30%** more moisture due to water crystal exudates of microbes in the root zone.
2. Roots themselves are **90%** water.
3. Roots excrete a gel-like mucilage (mucigel) that can absorb **10 times** their own dry weight in water.
4. **40** tonnes of crop residue digests down to 10 tonnes, increasing organic matter by 1%, (worth over **\$2000** per ha in nutrients).





## **In Conclusion...**

**Cover Crops are a multi-purpose wonder.**

**You can build humus, change soil structure, counter drought, reduce weed pressure and feed your soil life with this simple addition of biodiversity.**



# Understanding Your Soil Test & Developing Your Nutrition Program

By Graeme Sait

# Understanding Your Soil Test & Developing Your Nutrition Program

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## 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.



# Understanding Your Soil Test & Developing Your Nutrition Program

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## How To Take A Soil Test

1. Soil is collected from **multiple sites** (20 to 30) across the paddock in a criss-cross fashion to try and achieve a fully representative sample of the area.
2. It is critically important that if the test site has features **different soil types** (i.e. clay and sand), that only the more dominant of these soil types is collected.
3. The soil collected generally represents the **top 15cm**, as that is where most of the roots are active. With deep rooted crops, like lucerne, it can be of benefit to test down to greater depths.
4. A specialised **soil sampler** can be used for you can slice and collect six-inch profile with a spade. Alternatively, a 30mm length of hard **polypipe** can be marked with a pen, 15cm from the end, driven into the soil with a hammer and banged on the side of a bucket to release the captured soil.
5. The 20+ samples in the bucket are thoroughly mixed, before removing a **500g sample** that is shipped to the soil lab. This sample should be identified with the paddock name, and the crop involved.



## 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.

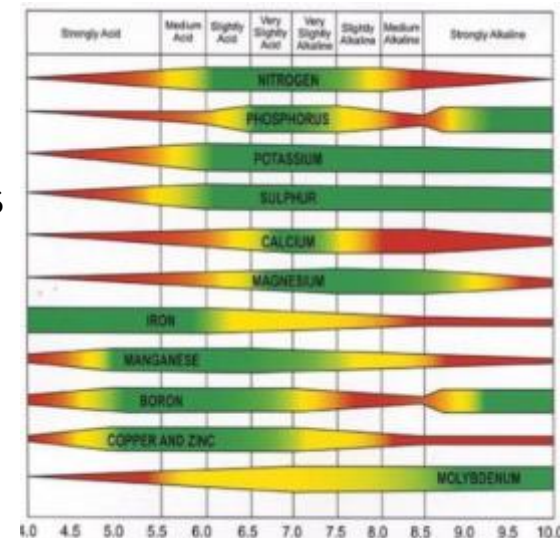


Soil Material	Storage
Sand	2 – 3 CEC
Silt	5 – 7 CEC
Heavy Clay	30 – 60 CEC
Humus	250 CEC
<u>Humic Acid</u>	450 CEC
<u>Fulvic Acid</u>	1400 CEC

# Understanding Your Soil Test & Developing Your Nutrition Program

## 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

### 4a. Soil E.C.

- **Electrical conductivity** in the soil can be measured with a simple meter.
- This is a measure of the presence, or lack of, **mineral salts**.
- It is a misconception to assume that E.C. relates only to excess **sodium**.
- Potassium has more impact on E.C. than sodium. I.e. low E.C. can often relate to a **potassium deficiency**.
- **Dr Carey Reams** used a E.C. meter as a principal tool to monitor soil fertility.
- As a rule of thumb, soil E.C. should be a minimum of **200** milliSiemens per meter (mS/m) at planting. Before flowering (the business end of the season), this figure should be **600 mS/m**.



## 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. **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.



## 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.

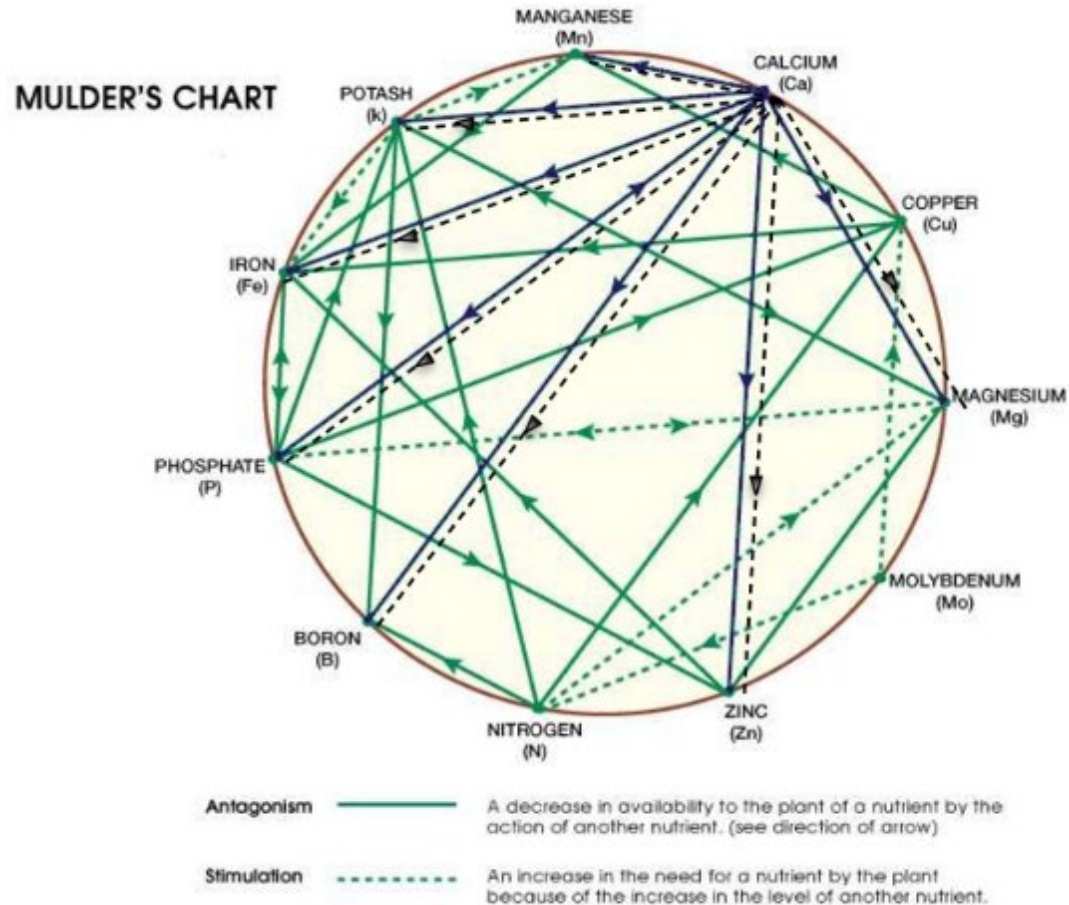
- High magnesium creates tight closed soils where **gypsum** is so important.
- **Magnesium sulphate** should never be used in the soil. It is only applicable as a foliar spray.



## Understanding the Key Minerals

9. **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



### 9. 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**.

# Understanding Your Soil Test & Developing Your Nutrition Program

## Understanding the Key Minerals

### 9. 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**”.



## Understanding the Key Minerals

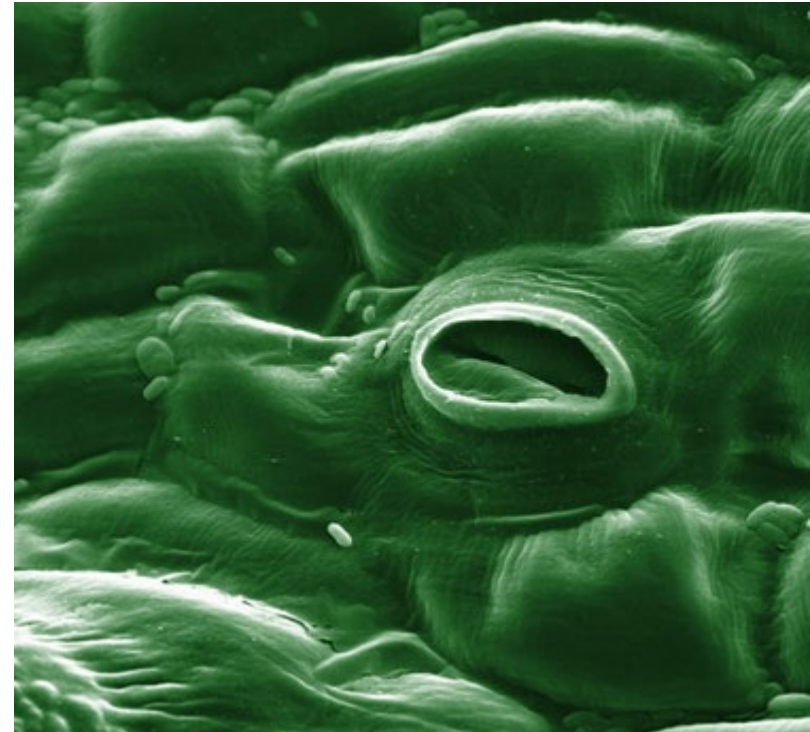
10. **Potassium** – this super mobile mineral does not become part of cell structure, but races around the plant to where it is required.

- 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

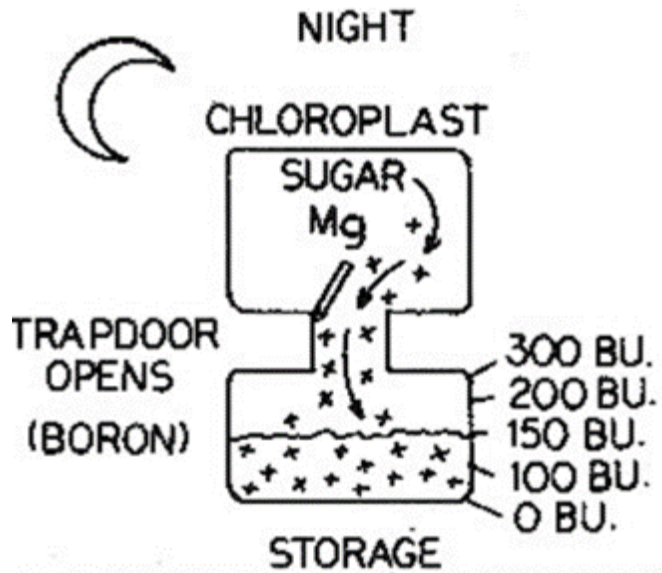
11. **Sulphur** – We used to get our sulphur for free, until acid rain damaged forests and waterways, and sulphur emissions were banned.
- **Organic matter** is the only thing that stores highly leachable sulphur in the soil, and we have lost 2/3 of our humus.
  - Sulphur is about **protein formation**. 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

12. **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

13. **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 Your Soil Test & Developing Your Nutrition Program

## Understanding the Key Minerals

- 14. 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.
- 15. 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™).



Zinc Deficiency in Wheat



## Understanding the Key Minerals

16. **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
<u>Pasture on clay soil:</u>			
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



# Understanding Your Soil Test & Developing Your Nutrition Program

## 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	LOW		
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	LOW		
Calcium (Mehlich III)	4052 ppm	4839 ppm			
Magnesium (Mehlich III)	1247 ppm	415 ppm			
Potassium (Mehlich III)	114 ppm	404 - 809 ppm	LOW		
Sodium (Mehlich III)	104 ppm	40 - 119 ppm			
Sulphur (Morgan)	43 ppm	30 - 50 ppm			
Aluminium (Mehlich III)	5 ppm	< 16 ppm	LOW		
Silicon (CaCl <sub>2</sub> )	63 ppm	> 100 ppm			
Boron (Hot CaCl <sub>2</sub> )	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	LOW		
Molybdenum (Nitric Acid)	0.24 ppm	0.5 - 2 ppm	LOW		
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				
<b>BASE SATURATION</b>					
(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 %	LOW		
Sodium	1.31 %	0.50 - 1.50 %			
Aluminium	0.16 %	0.50 %	LOW		
Hydrogen	9.00 %	10.00 %			

## The Benefit of Tissue Testing

- **Leaf testing** can often be of more value than soil testing, because it directly monitors the plants nutritional requirements at any point of the season.
- Leaf testing involves collecting multiple samples of the **first fully developed leaf** on your crop.
- The leaves are typically collected in a **paper bag**, correctly labelled, indicating the paddock and the crop, and then shipped to the lab.
- Do not use **plastic bags**, or the sample may sweat during shipment and you may be monitoring the minerals in the associated mould rather than the leaf.



## Feeding Through the Foliage

- Foliar fertilising is **10-15 times** more efficient than soil-based applications.
- Small inputs can produce **big results** at a low cost due to this increased efficiency.
- A more rapid response means more effective **chlorophyll management** with flow-on effects to soil life.
- This technology was originally favoured by those involved in more intense horticulture. However, it is now regarded as a **problem solver** and **yield booster** for all crops, including pasture and broadacre.





## Seven Reasons to Foliar Spray

1. **To rapidly correct deficiencies** – particularly important in short cycle crops.
2. **To relieve crop stress** – events like transplant, drought, frost, heat, water-logging and pest pressure can be countered with direct inject.
3. **To bypass soil-based issues** – this might include lock-ups from excesses, deficiencies, leaching in light soils, and nutrient competition.
4. **To boost yield** – this is particularly relevant to the use of plant growth promotants and natural hormones.

## Seven Reasons to Foliar Spray

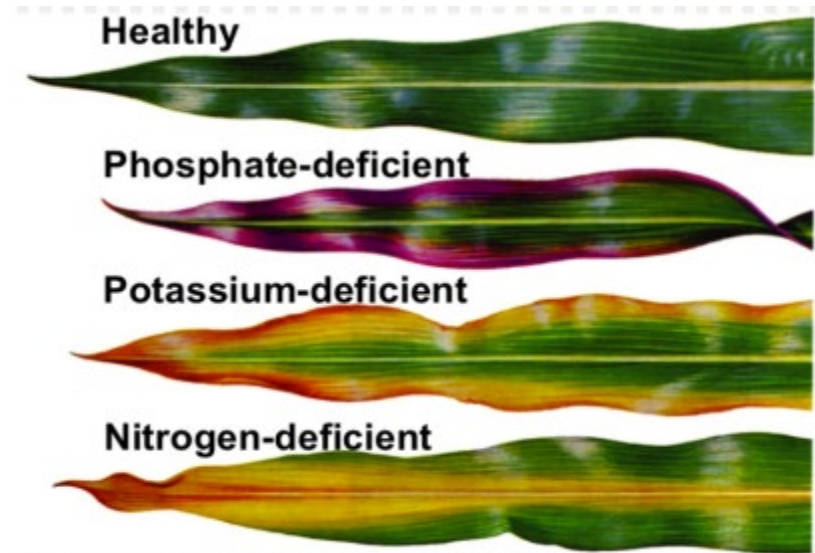
5. To improve crop quality and associated resilience – foliar fertilisers are the most effective way to lift brix levels, to increase nutrient density and disease resistance.
6. To swing the crop from vegetative to reproductive - this is often required, if we have overdone vegetative minerals like nitrate nitrogen.
7. To build nutrient density and protein levels in pasture – this is a highly effective way to increase stock weight and animal health, when finishing stock or improving fertility levels.



# Understanding Your Soil Test & Developing Your Nutrition Program

## Determining what is required

- **Visual monitoring**, in-field testing, and leaf analysis, can all help to determine **what** is required, and **when**.
- **Visual monitoring** involves checking for blotches, pale colours and stripes. Stem strength, leaf size and thickness, root health and visible microbial activity are all helpful indicators.
- **Photographing** your deficiency (determined by a leaf test) with your mobile phone, enables an ongoing reference point.
- The goal is to **recognise key deficiencies** immediately, to facilitate a rapid response.



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## Leaf Testing – Removing the Guess Work

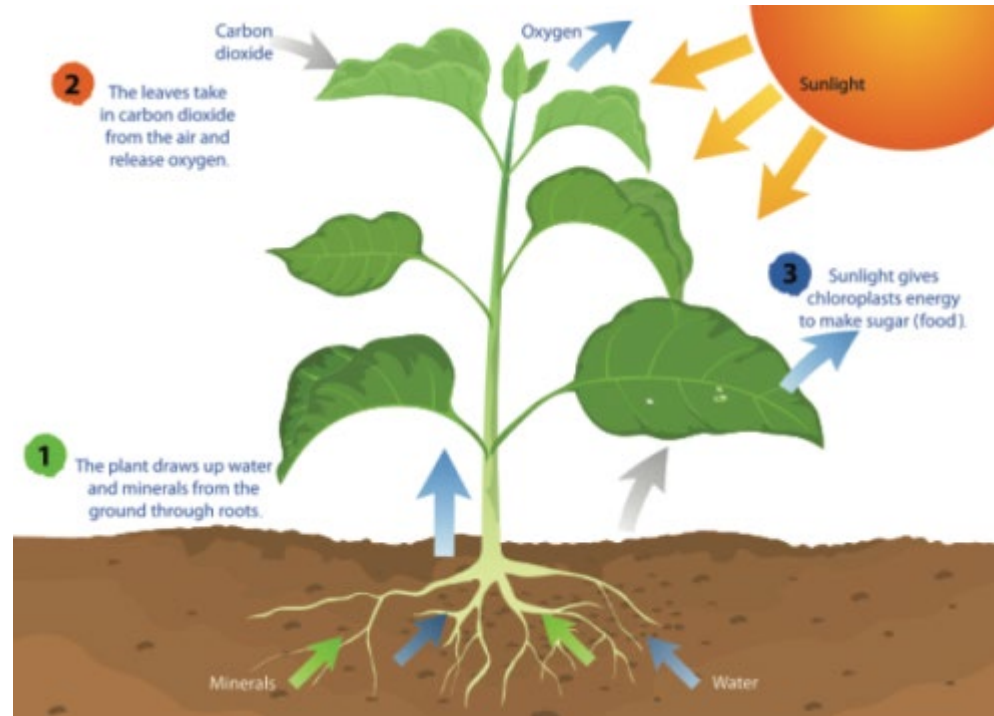
- **Leaf testing** is as simple as asking the plant what it wants, and responding to that information.
- It can be **more productive** than soil testing, as it is monitoring exactly what the plant is accessing.
- The **foliar route** is the most effective way to bypass soil-based lock-ups (as evidenced when leaf tests do not correspond to your soil tests).
- Leaf testing **before flowering** (the business end of the season) is essential for all crops.



## 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

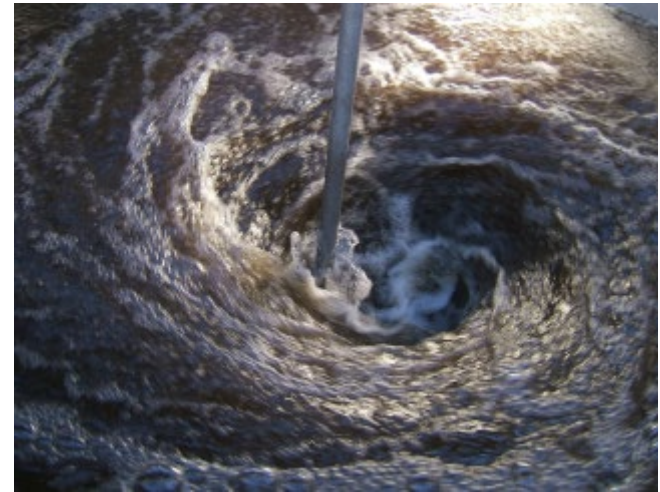
**CONTACT NO:** XX XXXX XXXX

ELEMENT OR CATEGORY	YOUR LEVEL	ACCEPTABLE RANGE	DEFICIENT	ACCEPTABLE	EXCESSIVE OR TOXIC
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	N/A		

## Achieving the Best Foliar Response

### 1. Putting the microbes behind the minerals

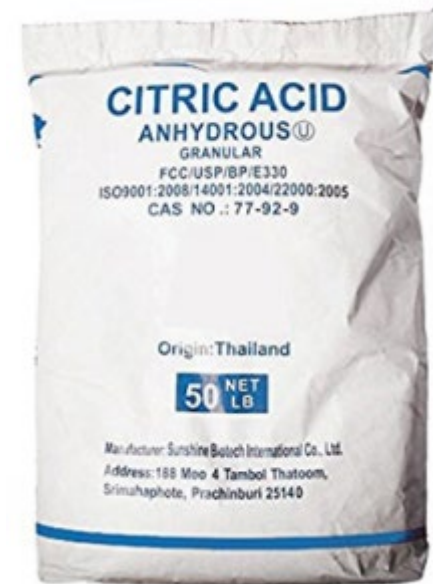
- It is always a **wasted opportunity** to apply any microbial inoculum, without some nutrition.
- Similarly, the addition of minerals added to compost, **dramatically increases** the fertilising response.
- Part of the **enhanced foliar response** is linked to a stimulation of stomatal openings, following a sudden influx of **CO<sub>2</sub>** (from 5 billion organisms per teaspoon).
- The concept of microbial enhanced nutrient delivery (**MEND™**) can result in significant fertiliser reduction and associated savings.



## Achieving the Best Foliar Response

### 2. Understanding the pH factor

- The **pH** of the spray solution can impact the end result.
- The **ideal pH** for a vegetative response is **7**, while the perfect pH for a reproductive response is **6**.
- A **fruiting response** can be sponsored with a more acidic brew, but this is based upon acid shock.
- A bag of **citric acid**, and a **waterproof pH meter**, are essential tools to modify pH of the spray solution.



## 3. Achieving a reproductive push

### Flowering Recipe

Apply **Super Phosphate** at 250 – 300 kg/ha around roots.

Apply an acidic foliar spray with reproductive minerals:

- **Nutri-Sea Liquid Fish™**  
(max. 5 L/ha)
- **Phos-Force™** (pH <2)  
(max. 4 L/ha)
- **Manganese Sulphate** – 2 kg/ha
- **Fast Fulvic™** (max. 3 L/ha)
- **Cloak™** spray oil



## Achieving the Best Foliar Response

### 7. Understanding mineral mobility

- Minerals **vary** in the speed at which they move into and around the plant.
- The most mobile minerals are **NPK**, magnesium and manganese.
- The least mobile of all minerals is **calcium**.
- Most crops will benefit from a foliar spray of **chelated calcium**, as this mineral is of such importance.
- Foliar calcium can even move directly **through the skin**, into the fruit, to boost quality and shelf-life.



## Achieving the Best Foliar Response

### 9. Getting your timing right

**Timing** is critically important with foliar sprays. This could involve the time of the day, time of the month, or the stage of the crop cycle. Here are some guidelines:

1. The best time of the day is **early morning**, or evening. Stomates open in the morning to absorb the dew. Avoid spraying in the heat of the day, when stomates are closed.
2. **Microbial inoculums** are the perfect partner for **nutrition**. When we put the microbes behind minerals, there is always an enhanced response (CO<sub>2</sub> stimulates stomatal opening).



## Achieving the Best Foliar Response

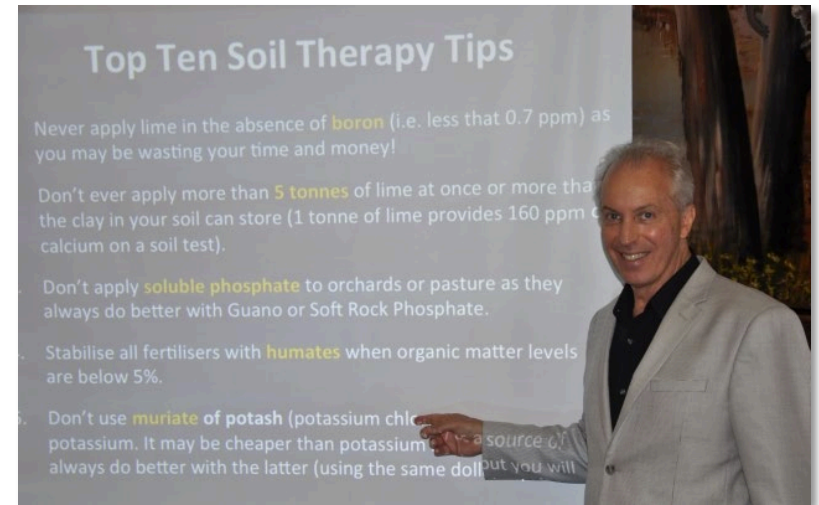
### 9. Getting your timing right

3. There can be considerable gain in foliar spraying according to **moon cycles**. The best time to spray is during any of the **6 days** leading up to a full moon. The least productive time, is any of the 6 days leading up to a new moon. There is more movement of plant sap, leading up to a full moon (like tides).
4. It can be very productive to foliar feed **young foliage**, as there is more rapid translocation. Some growers begin with very small amounts of nutrients at the two-leaf stage.
5. A leaf analysis, **prior to flowering**, will provide an indication of nutrition action for the business end of the season. **Boron**, applied before flowering, is of value for virtually every crop. There is also a massive potassium draw-down after flowering.



## Precision Nutrition

1. **Nutrition programming** is about the power of precision.
2. Crop monitoring and appropriate **action** is the key.
3. Programs should be based upon **viability** and **cost effectiveness** in each situation.

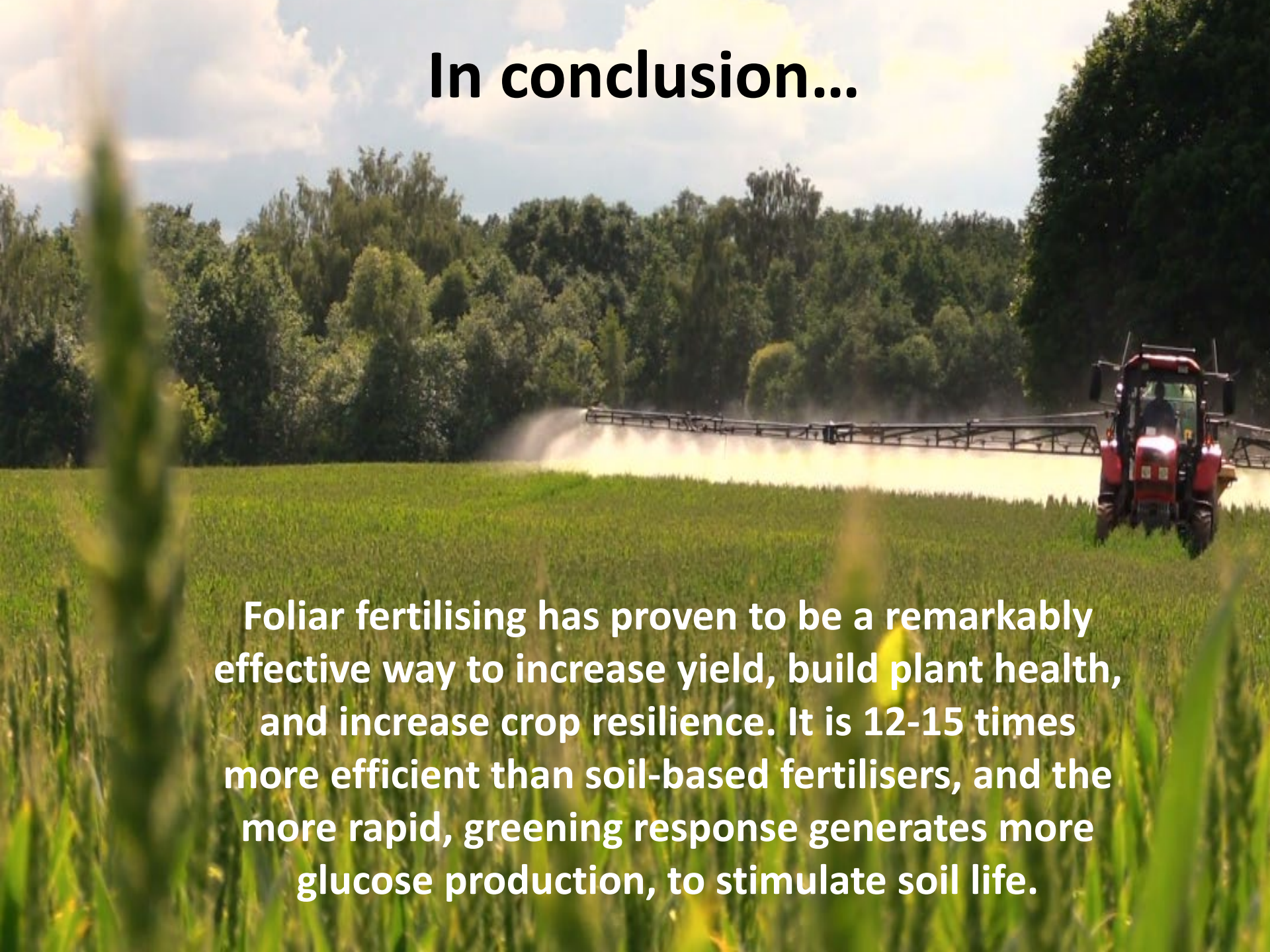


## Horticulture Example **LBLC EXAMPLE HERE**

- There is much more scope for correction and balancing in intensive cropping scenarios (vegetables & fruit).
- Here the problems can be more commonly associated with excesses, rather than shortages. The minerals most over-supplied are NPK, and copper.
- Organic matter is often an issue, and here there is the opportunity to use correctives like compost, cocktail cover-cropping, and higher dose humic acid.
- It is common for leaf tests to differ markedly from soil tests, because of the antagonistic impact of excesses. This makes tissue testing absolutely essential.



# In conclusion...



**Foliar fertilising has proven to be a remarkably effective way to increase yield, build plant health, and increase crop resilience. It is 12-15 times more efficient than soil-based fertilisers, and the more rapid, greening response generates more glucose production, to stimulate soil life.**



# Specialist Microbial Inocula & Compost Tea

By Graeme Sait

## Microbial Inoculums – Boosting the Beneficials

- The introduction of a **new workforce** can be species-specific or it can involve broad spectrum micro-organisms to increase **diversity**.
- Compost tea and worm juice are examples of **broad spectrum inoculums**.
- Compost tea is a remarkably **cost effective** biological strategy, as it involves just 1 Kg of compost per 100 litres along with 1 litre of food (this can involve less than **\$5 per hectare**).
- Worm juice involves the unique organisms incubated in the gut of an earthworm. If you do not have earthworms on your farm, you do not have these important organisms.



# Microbial Inoculums – Boosting the Beneficials

## Seven benefits of Compost Tea

1. **Increases predator counts** - to reduce soil pathogens
2. **Detoxification** – this cost effective influx of 5 billion organisms per teaspoon can clean up soil contaminants including chemical residues.
3. **Reduces fertiliser use** – the inclusion of compost tea with liquid fertilisers improves nutrient uptake (MEND®), thereby reducing salt excesses and leaching.
4. **Increases bio-mass and diversity** – modern farming involves significant collateral damage to soil-life. Compost tea helps to compensate.



## Microbial Inoculums – Boosting the Beneficials

### Seven benefits of Compost Tea

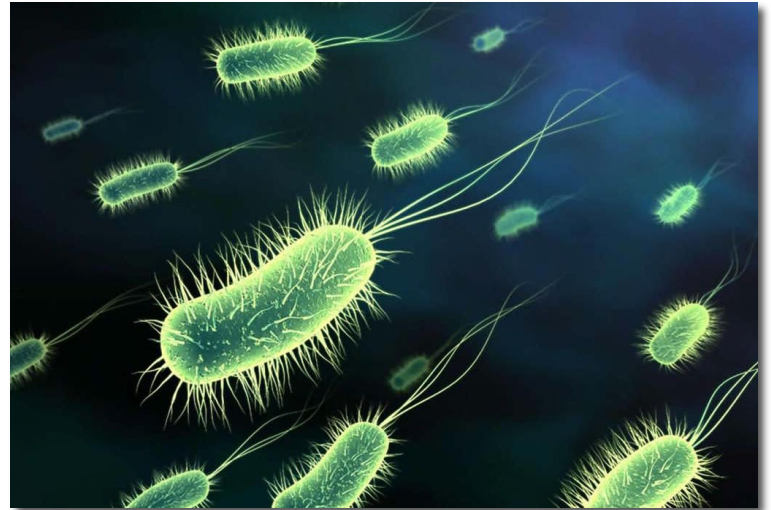
5. **To manage plant disease** – both the phyllosphere and the rhizosphere are best managed with the numbers game (the more good guys the better). Compost tea also delivers antagonists, predators, and immune elicitors.
6. **To increase crumb structure and infiltration** - the trillions of organisms applied per hectare in the compost tea create the mini and macro aggregates that determine crumb structure. This open friability improves water infiltration (hugely important in the face of climate change).
7. **To stretch your compost further** – 1 Kg of compost effectively produces 100 Kgs of microbial inoculum. You will not get the carbon and stable nutrients found in compost, but you will get the many microbial benefits.



# Mechanics of Compost Tea Protection

## 1. Competition for space and elements

Food and board on the root or leaf surface are both in limited supply. When 50 litres of compost tea, containing up to 5 billion organisms per teaspoon, is applied to those surfaces, there will inevitably be serious competition.



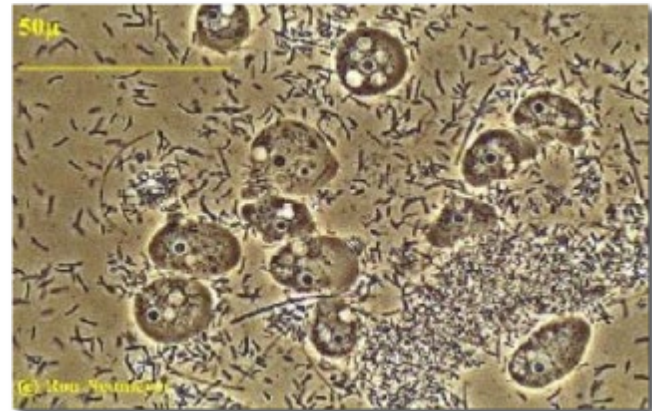
## Mechanics of Compost Tea Protection

### 2. Antagonism

Many beneficial microbes produce exudates which repel, repulse or antagonise competitors.

### 3. Predation

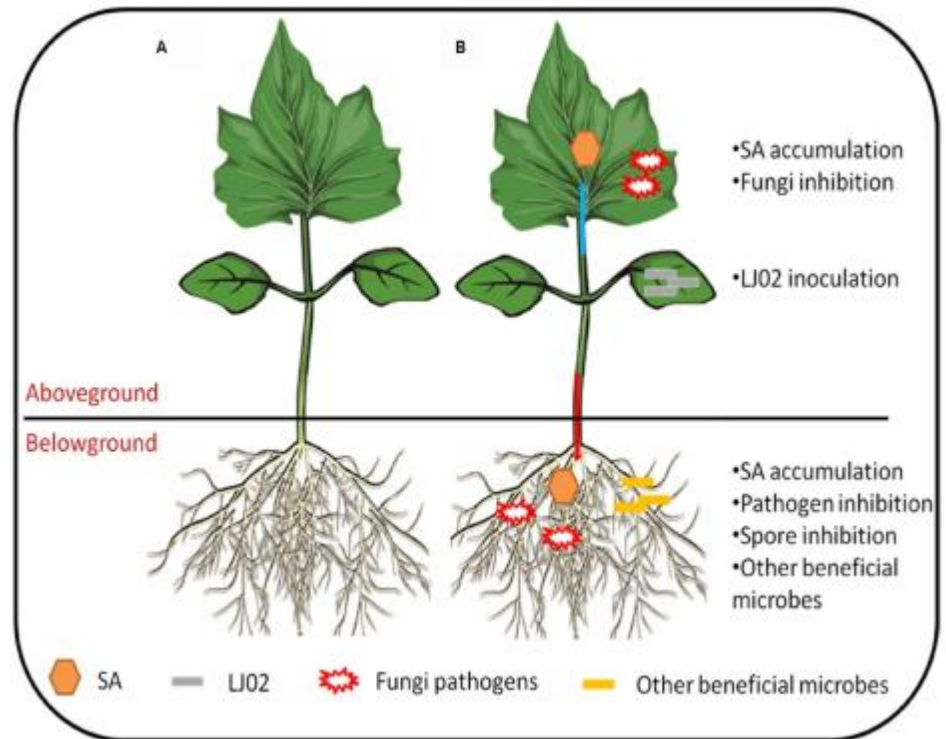
Sometimes the best way to carve out your own niche in the rat race is to simply eat your competitors.



## Mechanics of Compost Tea Protection

### 4. Induced Resistance

Induced Systemic Resistance (ISR) is an exciting, new field of research in natural plant protection. Compost tea promotes the production of these and other plant substances.



# Compost Tea



**Dr Ingham** claims that “a good compost tea can control all known **diseases** in the soil and on the leaf”. This is a big statement to say the least, however many of our growers, (especially organic & biodynamic), have had good results using this technique.

Brewing compost increases the number of beneficial microbes and allows for the economical application of a microbial inoculum.

Producing **quality compost tea** relies on quality starting materials and good brewing technique.

# Compost Inoculum

A **quality compost** contains a diverse range of beneficial organisms and is free from pathogens.

This can be achieved by using good composting technique and diverse starting materials.

Care must be taken when using composted manures due to the possible presence of **pathogens** which can increase in number during compost tea brewing.



# Methods of Brewing Compost Tea

### Non-Aerated Tea

- No addition of O<sub>2</sub> resulting in anaerobic conditions.
- Limited diversity.
- Takes 2 weeks or more.
- Species selected may produce useful antibiotics.

### Aerobic Tea

- Air bubbled through the solution during brewing.
- Food can be added leading to proliferation of beneficial species.
- Takes 1 – 3 days.
- Less chance of contamination as plant and human pathogens prefer a lower oxygen environment.

## Microbe Food

The higher the **species variety** and **numbers**, the more **diverse the food** source required.

Examples of food sources are:

- Amino acids
- *Aloe vera* (fungal)
- Micronised minerals
- Humic acid (fungal)
- Fulvic acid
- Kelp (fungal)
- Fish (fungal)
- Molasses (bacterial)
- LMF™



The food source should make up no more than **1%** of the brewed volume.

## Plant Growth Promotants & Immune Elicitors

### **Kelp benefits:**

- **Mannitol**, a powerful chelating agent
- **70 minerals** derived from seawater
- 4 natural **growth promotants** - cytokinins, gibberellins, auxins and betaines
- **Complex carbohydrates** - fungi feeders
- **Vitamins** - required by plants, microbes and humans





## Brewing Technique for Aerated Tea

- Important to maintain a dissolved O<sub>2</sub> level above 6 ppm throughout.
- The brewing tank & equipment should be **cleaned well** with a sanitising agent (e.g. bleach or Path-X™) & rinsed thoroughly before brewing.
- **Chlorinated water** should be aerated for 30 minutes before brewing.
- Starting water temperature should not exceed **25°C**. The microbes might generate higher temperatures during multiplication but over warm water can reduce oxygen carrying capacity.

## Tea Brewing Considerations

- The brew can be steered in a **task-specific direction** via the addition of specific food sources during brewing e.g. rock phosphate, lime, potassium sulfate.
- **Fungal numbers** can be boosted by adding decaying leaf litter to the compost tea.
- Soil from the plot to be treated can be included in the brew to ensure the presence of **native organisms**.
- Monitor the **smell** of the end product – a bad smell indicates that the brew has become anaerobic.



# Application Considerations

- Good leaf coverage is the key to performance. At least **70%** of the leaf should be drenched with compost tea organisms for best results.
- The tea should be applied as a **mist** (medium droplets) so the organisms stay on the leaf.
- Spray in **late afternoon** as UV light can kill the microbes.
- **50 L/ha** of compost tea is the ideal application rate per metre of canopy height.



## Application Considerations

- Existing disease may require **two treatments** per week to regain control.
- Consider the “**home base**” approach when applying a compost tea, i.e. include a material to buffer or house the microorganisms for example fish, kelp and/or fulvic acid.



# Microbial Inoculums – Boosting the Beneficials

### Protozoa Tea – Nutrient Cycling and Larger Roots

- **Protozoa** are a hugely important balancing mechanism in the soil. They are responsible for maintaining a manageable bacterial community.
- A healthy soil can contain **one million** protozoa per teaspoon, but that declines to less than **one thousand** in a stressed soil.
- Protozoa can be easily **brewed on-farm** to replenish your workforce.
- **Lucerne hay** contains large numbers of all 3 forms of protozoa. Hay is added to the brewing tank at 3-5%, along with **liquid fish** and molasses. The mixture is then brewed with oxygen for 2 days.



## Microbial Inoculums – Boosting the Beneficials

### Protozoa Tea – Five Key Benefits

1. **Recycling nitrogen in the ammonium form** – one watermelon sized protozoa consumes ten thousand pea sized bacteria each day and spits out the nitrogen excess for plants to utilise.
2. **Root structure architects** – protozoa stimulate much more branching and root surface area particularly in grasses, cereals, and sugarcane.

#### A trio of root-building benefits:

- Amoeba produce auxins (root stimulating hormones).
- Protozoa stimulated bacteria also release auxins.
- Nitrifying bacteria are also stimulated and the nitrates trigger lateral root elongation.



# Microbial Inoculums – Boosting the Beneficials

### Protozoa Tea – Five Key Benefits

- 3. Recycling all minerals** - protozoa are constantly mineralising elements found in organic matter and bacteria.
- 4. Stimulation of earth worms** - protozoa are the favourite food of earth worms. One course participant reported an increase from 1 earthworm per 11 shovelfuls, to 11 earth worms per shovelful, after a single application of protozoa tea.
- 5. Stimulation of nitrogen fixers** - 'grazing' by protozoa stimulates nitrogen fix in bacteria just as pruning stimulates your fruit trees.



### Task Specific Inoculums

- There are now microbial inoculums available to address most problems including **nutrition** and **pest issues**.
- Most of these can be successfully **brewed** to reduce costs and extend their benefits.
- These include **nitrogen-fixing** organisms (Bio-N™ and Bio-Plex™), **phosphate solubilising** organisms (Bio-P™), Trichoderma, **Bacillus Subtilis**, insect-eating organisms (Myco-Force™) and fungi that kill **nematodes**.





# Building Humus and The Benefits Of Compost

By Graeme Sait

## Accepting The Challenge

- Our only response to the **global warming challenge** has been to ‘talk’ about reducing CO<sub>2</sub> emissions.
- If we were to cut emissions by **100%** tomorrow morning, then in 200 years time we would drop down to the atmospheric CO<sub>2</sub> levels present in **1975**.
- These levels are too high and the oceans continue to **heat and acidify**.
- There are very few scientists that would agree that we have **200 years** left.
- So, is it **all over** bar the shouting?



## Accepting The Challenge

- The answer is a resounding ‘no!’, but there are **5 key understandings**.
  1. We cannot make new carbon – the planet’s finite reserves move between the soil, living things, and the atmosphere, as part of the **carbon cycle**.
  2. The lions share of this carbon is **stored in the soil** – in fact, there is almost double the amount found in the soil compared to that found in the atmosphere (1550 vs 800 gigatons).
  3. **Two-thirds** of the carbon that used to be found in the soil, as humus, is now in the atmosphere. Organic matter levels have dropped from **5%** down to **1.5%** due to industrial agriculture.



## Accepting The Challenge

4. This carbon lode from the soil is the **chief culprit** in thickening the blanket of greenhouse gasses which trap the heat, warm the oceans and dramatically impact our climate (**250 gigatons** from industry etc., **476 gigatons** from our soils).
5. The solution is to **put the carbon back**, from whence it came. When we build organic matter in our soils, we are effectively stepping into the carbon cycle and **sequestering** carbon that would have otherwise returned to the atmosphere.



## Fungi To The Rescue

- **'Active' carbon** produced by bacteria (lawn clipping compost) has a short shelf life in the soil. It oxidises and returns to the atmosphere as CO<sub>2</sub> within 12 months.
- **Stable humus** is manufactured by fungi through creating a stable bond between clay and humus colloids.
- This form of carbon remains in our soils (and out of the atmosphere) for at least **35 years**.
- The sad story relates to the **disastrous loss** of cellulose digesting fungi from our farming soils.
- For example, there are just **10%** of **mycorrhizal** fungi remaining in our soils.



## The Top Ten Humus Building Hints

1. **Don't burn down your cover crop** – a herbicide burn down results in losses of the three key nutrients that can become gasses - carbon, nitrogen, and sulphur. It is a much better strategy to work the cover crop into the **A horizon** (the top few inches of your soil).
2. **Include legumes in every pasture and under every cereal crop** – legumes, like clover, tend to feed fungi. These creatures generate the larger aggregates that create **crumb structure** (better infiltration and gas exchange). The clovers under your cereal crops also deliver nitrogen and they release acid exudates to prize apart calcium and phosphorus (the two most important minerals for **photosynthesis**).



## The Top Ten Humus Building Hints

3. **Plant cocktail cover crops** – we now understand that the combination of five plant families in a blend, sponsors the release of phenolic compounds into the soil. These antioxidants spark beneficial soil-life.
  - **Soil structure** changes, humus creation hastens, and **soil-life** thrives.
  - The **five families** include: grasses, cereals, brassicas, legumes and chenopods.
  - **Chenopods** and **brassicas** should only make up 1 - 5% of the blend, as they release chemicals that dissuade friendly fungi.



## The Top Ten Humus Building Hints

4. **Discover humates** – humic acid is the most powerful promoter of the beneficial humus building fungi that are missing in most soils. Humates also sponsor **crumb structure** that can help reclaim the humus building apparatus of your soil.
5. **Embrace compost** – compost provides vast diversity and numbers of beneficial organisms to reclaim humus building capacity. There can be **5 billion** organisms in a teaspoon of compost, involving over **30,000** different species. Compost increases soil carbon by many times more than the carbon it contains.



## The Top Ten Humus Building Hints

6. **Minimise tillage** – fungi do not favour the intrusion of cold steel. In fact, tillage slices and dices beneficial fungi. Every time we open our soil, we oxidise carbon and the negative impact is **quadrupled** in the wet.
- The major issue with no-till farming is that it involves **glyphosate**, amongst the most toxic chemicals ever applied to our soils.
- When this chemical is inevitably banned, roller crimpers, cover crops, and alternatives will come to the fore. **Human initiative** always delivers.



# Collateral Damage

- **Glyphosate** was originally patented as a chelating agent and can wrap around cations and make them unavailable.



- **'Yellow flash'** on soybeans is a glyphosate induced **manganese** deficiency.
- Glyphosate also reduces the population of **soil organisms** responsible for making **manganese** and **iron** available.
- In one of Professor Don Huber's studies there was a **90%** reduction in manganese reducing organisms. In another, where just **2.5%** of the applied glyphosate reached the soil, there was an **80%** reduction in manganese uptake and **50%** reduction in the uptake of iron.

# Glyphosate and Your Health

- **Chronic illness** – exposure to glyphosate correlates with chronic illness. Sick people have substantially higher levels of glyphosate in their system.
- **Beneficial gut bacteria** – glyphosate destroys these organisms – this is well researched in chickens and cattle. It may be linked to an increasing rate of allergies and gluten intolerance.
- **Magnifies vaccines** – glyphosate makes vaccines more toxic. Exposed children are much more likely to react badly.



# Glyphosate and Your Health



- **Reduced nutrient uptake** – glyphosate is a chelating agent that kills plants through shutting down nutrients, it works the same in humans. Glyphosate-induced vitamin deficiency may have a cancer link.
- **Non-Hodgkins lymphoma** – exposure to glyphosate doubles the likelihood of B-cell lymphoma.
- **Debilitates cytochrome P450** – this is the longevity gene related to detox enzymes.
- **Kidney failure** – Sri Lanka has just banned glyphosate due to an overwhelming number of liver and kidney problems.

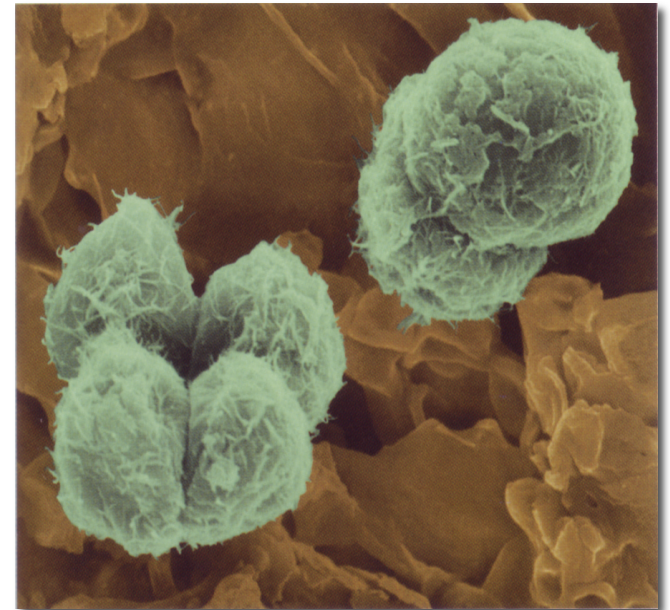
# Huber's Other Findings

- New research has linked glyphosate to **spontaneous abortion** in animals but the research has yet to be done for humans.
- Professor Don Huber has directly linked **40 plant diseases** to the use of glyphosate.
- *Pseudomonas fluorescens* is one creature that is killed by glyphosate. This bacteria protects against take-all and several other diseases.
- Glyphosate locks up trace minerals and creates a **disease susceptible** plant.
- The World Health Organisation have recently completed an in depth analysis of the safety of glyphosate. They have formally recognised that glyphosate is a carcinogen.



# Collateral Damage

- **Algae** are plant-like creatures that serve as an important **food source** for fungi and bacteria.
- **Herbicides** like glyphosate kill algae and shut down this food supply.
- Algae are found in the **top 6 inches** of the soil so despite the loss of the top layer of organisms (found on the surface to access sunlight for **photosynthesis**) there is a good chance they can regenerate.
- However, if the herbicide remains in the soil then this **regeneration** is compromised.



# Building Humus and The Benefits Of Compost

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## Reducing The Damage

- **Glyphosate** takes at least **6 months** to biodegrade in the soil, but then it becomes AMPA, a more damaging and persistent chemical (11 years minimum).
- There is a strategy to make glyphosate **less damaging**.
- It involves the following trio:
  1. **Combine Soluble Fulvic Acid Powder** with glyphosate at the rate of 150 grams per hectare. The 1400 CEC fulvic absorbs the glyphosate, magnifies its uptake, and speeds it's decomposition (the honeypot effect).
  2. **Reduce the pH** of the diluted herbicide **down to 2.9** with citric acid. This can immediately reduce the herbicide requirement by 30%.
  3. **Add a sticker/penetrant** (like Cloak Spray Oil™) to increase efficiency.
- These products have been combined in a product called, **Herbi-Safe**, which is applied at 1L per hectare.



## The Top Ten Humus Building Hints

7. **Bring back your earth worms** – Earthworms are missing in most soils, and there is a price to pay for this loss.

- Earthworms create humus **4 times** more rapidly than standard decomposition.
- They also produce a **fertiliser** from their rear ends, featuring 10 times more potassium, 7 times more nitrogen, 5 times more phosphorus, 3 times more magnesium, and 150% more calcium.
- If you can achieve the holy grail of **25** earthworms per shovelful, they will produce **300 tonnes** of earthworm castings per hectare annually.
- Earthworms also **incubate** a unique group of beneficial organisms that will be lacking in your soil, if the earthworms have gone.





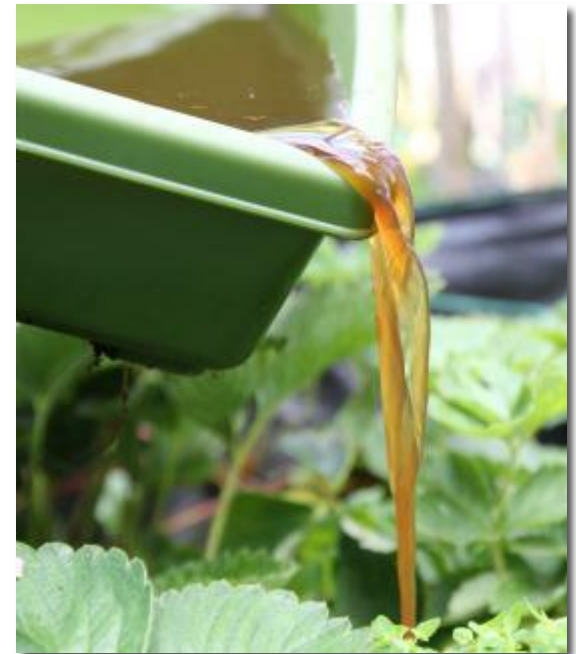
### Vermi-composting – Worms do the Work

- **Vermi-composting** involves special composting worms as well as bacteria and fungi.
- Worms do the turning, and **aerating**.
- But **NO heating stage** meaning weed seeds and stable pathogenic spores may become an issue.
- Raw feed stock may need to be **pre-composted** for this reason.



## Vermi-composting – The Benefits

- The “**worm juice**” (residual liquid from watering the pile) can be collected and used as a fertiliser/bio-inoculum.
- Vermi compost is the most effective compost known. It is highly effective at just **one tonne per acre** (2.5 tonnes per hectare).
- Research at the now defunct Gatton Field days revealed that vermi-compost was around **20 times** more potent than composted cow manure (1 tonne = 20 tonnes).
- The microorganisms **incubated** in the worms gut are unique to these creatures and of **great value** in the soil. If you don't have earthworms in your soil, you don't have these organisms.



### Expanding Earthworms on your Farm

- Earthworms are a little **fertiliser machine** that aerates and changes soil structure and we should all strive to build their numbers.
- A great on-farm strategy involves allocating a paddock to **earthworm production**.
- This area should ideally contain a combination of legumes, grasses and cereals and should be slashed regularly to **feed the worms** (native earthworms are involved here, not composting worms).
- Ideally, It should be irrigated and treated with **humates** and **fish** on a regular basis along with protozoa tea made from **lucerne**.
- Earthworms can be easily transported from this haven to areas of the farm that need **rehabilitation**.



## Building Humus and The Benefits Of Compost

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**8. Incorporate livestock** – Rudolph Steiner believed that a farm was not a farm in the absence of cattle. Pasture cropping and cell grazing combined are proving to be powerful humus building tools.

**Gabe Brown** from North Dakota has been a no-till farmer for 20 years. He heads a group called the “Carbon Cowboys” who have been working with Brazilian agronomist Dr Ademir Calegari.

Gabe has championed the potential of **cocktail cover crops** and **cell grazing**.



# Case Study – Gabe Brown – Results

1. He has reduced fertiliser inputs by 90%.
2. He has trebled and quadrupled organic matter.
3. Gabe has reduced herbicide use by 50% (and falling).
4. Water infiltration has increased from  $\frac{1}{2}$  inch per hour to 8 inches per hour.



# Case Study – Gabe Brown – Results

5. He has **dramatically increased** stock holding capacity with cell grazing and pasture cropping. In 1991 his carrying capacity was 65 cow/calf pairs and 20 yearlings. In 2012 this had increased to 400 cow/calf pairs and 800 yearlings.



# Case Study – Gabe Brown – Results

6. Gabe favours a cocktail incorporating cool season grasses and broadleaves, alternating with warm season grasses and broadleaves.
7. Species include pearl millet, sorghum, sudan grass, proso millet, buckwheat, sun hemp, oilseed radish, turnips, peas, rye grass, canola, phacelia, cow peas, soy beans, sugar beets, red clover, sweet clover, kale, rape, lentils, mung bean & subterranean clover.



# Building Humus and The Benefits Of Compost

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9. **Enhance stubble digestion** – In a living soil, residues should be fully decomposed within 6 weeks.
- If this is not happening, then you need some **help**.
  - **Trichoderma** is a great multi-function option to speed stubble breakdown and associated humus formation. It also provides disease protection, root stimulation and phosphate solubilisation.
  - The other option is to enlist the anaerobes. **BAM™** is proving a highly efficient, cost-effective input for stubble digestion.
  - **Fungal-dominated** compost teas are another option.
  - In all cases the inoculums should be combined with **humic acid** (the lunch box approach).



# Building Humus and The Benefits Of Compost

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10. Provide oxygen for your humus builders – oxygen is the single most important element for crop vigour and resilience.
- Management of **gas exchange** is a key role in crop production.
  - The calcium to magnesium ratio governs the **breathing** of the soil.
  - **Gypsum** is of great value in tight, closed soils.
  - Micronised liquid gypsum can be used to impact the immediate root zone, via **liquid injection**, in heavier, broad acre soils.
  - Fungi create **aggregates** to improve oxygen flow.
  - Interplanting **legumes**, stimulates fungal crumb structure.



# Building Humus and The Benefits Of Compost

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## The Mycorrhizal Marvel

- Nineteenth century, German biologist, **Albert Bernhard Frank**, coined the term, 'Mycorrhiza'.
- He was describing the **partnership** between specific fungi and plant roots.
- **Paul Stamets**, the world's most accomplished mycologist, describes 'earth's natural internet' in his 2008 TED Talk.
- Mycorrhizal fungi effectively provide a **1000%** increase in root surface area, boosting all things **roots can offer** (including nutrient foraging and water access).



# Building Humus and The Benefits Of Compost

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## The Mycorrhizal Marvel

- AMF colonises **90%** of plants, excluding brassicas and chenopods.
- Their **benefits** include; scavenging for immobile minerals like phosphorus and zinc, mining potassium, delivering calcium, immune elicitation, nematode protection, and nitrogen supply.
- The big story is **glomalin**, the sticky carbon substance, responsible for 30% of all humus production.
- In 2010, **Ren Zen Zang**, from South China Agriculture University, found that when attacked by pathogens, plants release chemical signals (on the MN), that **warn** their neighbours.



# Building Humus and The Benefits Of Compost

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## Your Gains from Reclaiming your MN.

- In 2013 **David Johnston**, and colleagues from the University of Aberdeen, showed broad beans shared the news of aphid attacks on the MN.
- Again, those beans with mycelium, activated their **anti-aphid** chemical defences.
- Those without, **did not**.
- The plants were encased with plastic above ground, to prevent **atmospheric messaging**.
- “The warning was definitely transferred via **mycorrhizal networks**” concluded Johnston.



# Building Humus and The Benefits Of Compost

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## What has Killed Off 90% of Our Mycorrhizal Fungi?

This invisible network is particularly fragile and has been decimated in modern agriculture. The major culprits are:

1. **Tillage** slices and dices The MN. Minimum till is the best option
2. Unbuffered, **high salt index fertilizers**, dehydrate the mycelium
3. **DAP/MAP**, unbuffered, can frizzle the MN like putting a blowtorch to human hair.
4. **Nematicides**, of all kinds are particularly toxic to mycorrhizal fungi. This is ludicrous, if you can recognise that the best known natural control of root knot nematodes in **AMF**.



# Building Humus and The Benefits Of Compost

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## What has Killed Off 90% of Our Mycorrhizal Fungi

5. **Fungicide-treated seed** makes it very difficult for AMF to colonise and begin their massive 6-week expansion effort
6. **Long fallows** are a horror show for Mycorrhizal fungi, as they have no food source.
7. **Glyphosate** has been recently found to be compromising mycorrhizal fungi - minimize inputs and fast-track the breakdown.
8. **High N and P fertilisers** sponsor a plant shutdown of glucose to fuel hyphae growth - why do I need you?
9. Genetically modified, **BT crops** release exudates that impact AMF.



# Building Humus and The Benefits Of Compost

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## Reclaiming Our Mycorrhizal Networks

1. **Seed treatment** in broad acre crops can cost as little as \$7 per hectare. This will not give full colonisation, but the network will begin to form.
2. **Seedling treatment** for orchard crops is the perfect way to colonise from day one.
3. Treating introduced seed when **pasture cropping**, can reduce the cost of pasture re-colonisation.
4. Using mycorrhizal fungi as a highly effective **nematicide**, reduces the vast damage otherwise associated with this chemical option.
5. **Oats and crimson clover** are a cover crop combination that stimulates mycorrhizal fungi.



## In-Field Microbe Monitoring

- An exciting new technology allows the measurement of **soil life potential**, not previously possible.
- The **microBIOMETER** involves an inexpensive, in-field testing kit, linked to a smartphone App, to enable the fast-tracking of microbe monitoring.
- **Microbial biomass** is the best single indicator of soil health (Doran 2000) – poor fertility soils have very low microbial populations, while highly fertile, productive soils have high microbial populations.



# Building Humus and The Benefits Of Compost

## In-Field Microbe Monitoring

### How Does It Work?

A **powdered formula** is added to a vial of premixed soil and water.

Over a **ten-minute** period the fungi, bacteria, protozoa, Actinomycetes and nematodes are enveloped and isolated in the solution.

A **few drops** of this living solution are collected from the vial with an eye dropper and dripped onto a card.

A **smartphone** or iPad App is then utilised. The camera is activated by the App, and a beam of light illuminates the entrapped microbes on the card.



# Building Humus and The Benefits Of Compost

## In-Field Microbe Monitoring

- A score representing **microbial biomass** soon appears on the screen and it is identified and stored on the App for future reference.
- **Ideal levels** vary between compost teas, compost and microbial inoculums. Here are the guidelines for soil microbial biomass;



### Readings:

- Below 200 very poor
- 200 – 300 low
- 300 – 400 average
- 400 – 500 good
- Above 500 excellent



# Building Humus and The Benefits Of Compost

## In-Field Microbe Monitoring – Benefits of This New Technology

- The ability to conveniently measure microbial biomass gives farmers the power to **monitor** and **track** the effects of farming practices, in particular to determine the value of different soil amendments and the efficacy of different **cover crops**.
- This tool also allows growers to determine the **quality** of DIY and commercial inoculums, and to differentiate the good from the bad.
- This test costs a **fraction of the price** of conventional laboratory analysis. Test card refill kits are available (10 per pack).
- The kit involves a **smartphone/iPad** app to digitally analyse and store readings for tracking soil health. The base starter kit also involves ten testing cards.



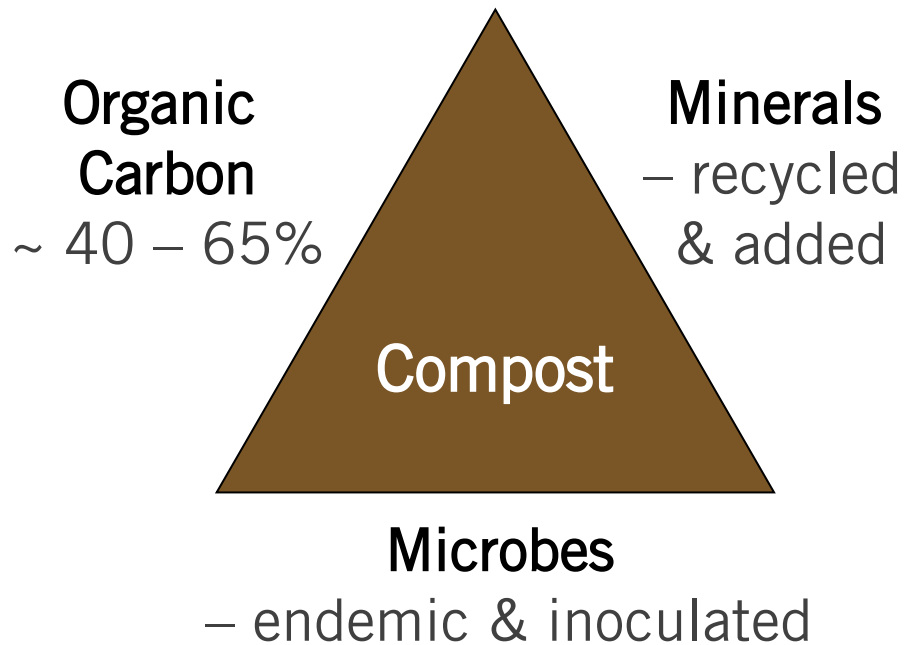
## What is Composting?

- **Composting** is the biological reduction of organic wastes to humus namely by bacteria, fungi and other microorganisms.
- However, in order to **accelerate** this natural process there is a scientific intervention by humans using the carbon to nitrogen ratio, the help of soil microbes and controlled **oxidation**.



## Compost and Soil Health

- Foundations of Soil Health:



*“Compost is a package of biological benefits with stable nutrients, active soil microbes and rich humic compounds.....”*  
*Rodale Institute, 2009*

# The Benefits of Compost Carbon

- Both water and nutrient retention are enhanced. **Humus** holds its own weight in water and it is the only colloid in the soil that can **store all minerals**, both negative and positive.
- Improved **soil structure** – aeration, porosity and crumb structure are all linked to the biological inoculum that is compost.
- **Increased CEC** – particularly important in light soils.
- **Food for soil life** – earthworms arrive when compost is applied, as do the less visible soil creatures.



# Building Humus and The Benefits Of Compost

## Humus and Water Retention

- Soil **water-holding capacity** increases dramatically with increased soil carbon.
- Humus offers the **most efficient** water storage technique as plant roots can access the extra moisture so easily and there is no evaporation.
- An increase of 1% organic matter means that **170,000** litres of extra water per hectare can be stored.
- This 1% also binds up **132 tonnes** of CO<sub>2</sub> in the soil that would otherwise have been in the atmosphere.



# Compost as a Microbe Inoculum

- A teaspoon of good compost can contain as many as **5 billion** organisms and thousands of different species.
- These beneficial microbes restore **biodiversity** and the balance that comes with it. This balance creates a **disease suppressive** soil.
- These beneficials **neutralise pathogens** through competition for nutrients and space, consuming competitors, production of inhibitory compounds and induced disease resistance (boosting plant immunity).
- Compost has also been shown to stimulate the development and growth of **Mycorrhizal fungi** (AMF).



## Mineralization with Compost

- **Minerals** complexed with the humus in compost will not leach like water soluble fertilisers.
- The new workforce introduced with compost can boost nutrient delivery – Microbially Enhanced **Nutrient Delivery** (MEND).
- African research has shown that when minerals were included with compost they were much more efficient than the uncomposted fertilisers (up to **ten times** more efficient).
- **Microbe exudates** stimulate the plant to uptake minerals. (i.e.hormones and vitamins).
- **Slow release**, stable minerals in compost help avoid the overloads (nitrogen) that sponsor **pest pressure**.



## Enriching Your Compost

There are several ingredients that will boost the fertiliser power of your compost including:

- **Zeolite** – at 6% for N and K retention.
- **Seaweed** – brilliant if you have access – growth promotants and trace minerals.
- **Humates** – brown coal is a great input at 20%.
- **Bonemeal** and cottonseed meal – N source.
- **Wood Ash** – great source of potassium but must be collected and stored to avoid leaching.
- **Rock phosphate** – if P is needed. Don't exceed 20%.



## What is Paramagnetism?

- Professor **Phil Calahan** identified **paramagnetism** as the reason that volcanic soils always outperform non-volcanic soils.
- These soils can attract, store and convert **atmospheric energy** (extra long frequency (ELF) radio waves originally created by lightning) into tiny light particles called photons.
- **Photons** effectively deliver a light source to the roots and the organisms living around the roots (the rhizosphere).
- Paramagnetic stimulation can **treble** the activity of beneficial microbes (hence the enhanced performance of volcanic soils).
- **Basalt crusher dust** is the best paramagnetic input but energy levels vary (send your samples to NTS for our free testing service).



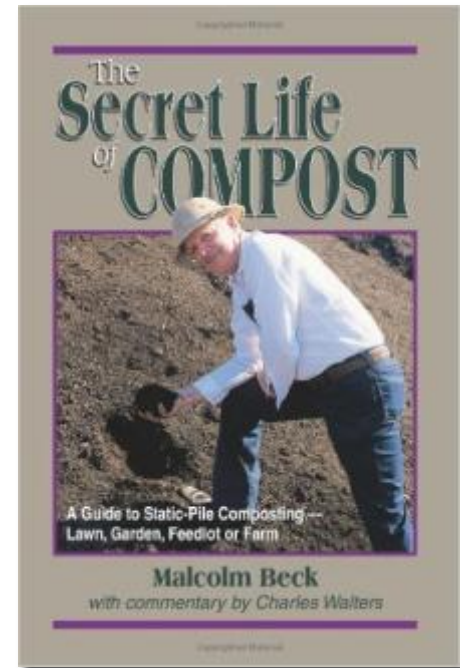
## Raw Materials – What to Avoid

- **Chemically treated** wood products – arsenic.
- **Meat**, bones and fatty foods – they attract pests and can stink.
- **Weeds** – seeds can be killed with heat but it is better to avoid them and not take the risk.
- **Diseased plants** – disease can also be killed but it is better not to risk this.
- **Pet litter** – can harbour human parasites and disease. Particularly cat faeces.
- **Human poo** – smell and pathogen potential.
- Large quantities of **pine needles** – very acidic.
- **Couch** and nut grass – rhizomes can survive.



## Static Pile Composting

- This technique, popularised by US compost Guru, **Malcolm Beck** (“The Secret Life Of Compost”) takes twice as long (6 months) but has several benefits.
- **Aeration** comes from air spaces in the mixture determined by particle size.
- The large pile (3 metres high) remains relatively **static** and is turned just 3 – 4 times.
- Produces **great compost** due to less fungal disruption, less loss of CO<sub>2</sub> and less leaching (and it also requires a lot less water than windrow composting).



## Static Pile – Aerated



- This is always **fungal dominated** because there is no compost turning.
- **Aeration** is provided by either blowing or sucking air through the stack (alternating air movement leads to similar temperature and moisture throughout the stack).
- Perforated 4 inch **plastic drain pipe** and a caged blower fan can be used as a air supply.
- Pile height should be limited to **< 3 m** to maintain uniform aeration.
- This technique can also involve **static aeration** through slits in concrete floor.

## Actively-Managed Compost



- This technique involves commitment and considerable energy to achieve **high quality**. It may require turning daily during the first 10 – 14 days (this usually involves a compost turner).
- Pre-sourced materials are mixed together. **Greens & browns**, preferably shredded, should be added in layers.
- This technique usually takes **12 – 14 weeks**.

# Building Humus and The Benefits Of Compost

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## Windrows

- A **Windrow** is a long narrow pile built of the materials to be composted.
- As a general rule:  
Height = 1 – 2 m      Width = 2 – 3 m  
Length = Depends on how much space you have. The longer the better.
- This compost will be **bacterial dominated** because the turning disrupts the fungi.
- Piles of less than 1 cubic metre tend to be **poorly insulated** & lose heat or dry out reducing microbial activity.
- Larger windrow piles require close **CO<sub>2</sub> monitoring** to ensure adequate aerobic activity.
- CO<sub>2</sub> is the gas released as **decomposing microbes breathe**, so it offers an indication as to microbe activity (i.e. too much or too little).



## Thermophilic & Mesophilic Stages



- **Thermophilic** – This is the first stage (1 – 2 weeks) of composting where high temperatures are reached and OM is broken down by heat-loving organisms. These creatures produce gums, waxes, lignins, sugars & amino acids.



- **Mesophilic** – The temperature reduces and the oxygen increases. New groups of microorganisms move in and colonise the compost and bind these compounds into stable humic substances.

# Building Humus and The Benefits Of Compost

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## Temperature and Aeration

**Temperature** should be monitored for best results.

Professor Elaine Ingham outlines:

- Temperature must exceed **57°C** for at least 3 days to kill weed seeds and pathogens.
- The temperature should, however, not exceed **65°C**, otherwise beneficial microbes will die.

Turn the compost for increased aeration – CO<sub>2</sub> levels should not exceed **20%** or this will intoxicate aerobic microbes.



# Building Humus and The Benefits Of Compost

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## Moisture Content

- **Moisture content** is critical to microbial action.
- Water can be added when the pile/windrow is being built or during turning.
- It is essential to **monitor** moisture levels.
- Ensure **handfuls** are taken from around, and within the pile. Avoid any dry or wet spots to try and gain an indication of average moisture within the pile.
- Ideally the compost should have a consistency and moisture content so that when it is squeezed, there will only be a couple of drops (like a wrung sponge – that is **60% moisture content**).



# Building Humus and The Benefits Of Compost

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## Bacterial or Fungal Dominance

- Orchards, timber plantations and berries are **fungal dominated** crops and will often prefer a fungal compost.
- This involves 5% manure, 50% green and 45% brown.
- Pasture, vegetables and all other crops prefer **bacterial domination**.
- This involves 25% manure, 50% green material and 25% brown.



# Building Humus and The Benefits Of Compost

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## Problems of Poor Compost

### Risks include:

- Weed seed introduction
- Multiplying undesirable microbe species
- Nutrient tie-ups or draw-downs in soil from application of unbalanced compost (N)
- Nuisance odours
- Toxic leachates

All of these can be overcome with proper management during composting.



## Compost Quality

- Your **nose** and **eyes** are the best for deciding when a pile is ready, as the length of the composting process is variable, depending on water, microbes, oxygen, temperature and composition.
- Take a **sample** from deep in the pile with one hand only.
- The material should be **dark brown** in colour and slightly warm (not black or too hot).
- If it really **stinks** it is not ready and may require turning or a modified recipe to improve the **aeration**.



# Building Humus and The Benefits Of Compost

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## DIY Protective Compost

*Trichoderma* can be rapidly expanded by creating a 4-week compost in an aerobic frame.

It is important that the compost can **breathe** on all sides and from underneath, if it is to be completed within the short time frame.

**Straw** and **organic cow manure** are combined in equal amounts and premixed before they are layered within the wire netting frame.



## DIY Protective Compost

The cubic meter **compost bin** is created using a pallet as a base, with a star picket on each corner. Chicken netting is wrapped around the 4 steel posts, and an opening is left at the front, which can be closed at the completion.

The *Trichoderma* **inoculum** is applied to each 30 cm layer, before each layer is thoroughly wet down.

Greenish **hyphae** should be visible throughout the compost within a week, as the trichoderma multiply.



## The Benefits of Vermi-Compost

- **DIY Vermi-compost bins** can be of tremendous value on the farm, as a source of both compost and worm juice.
- Earth worms incubate a unique group of **beneficial microbes** that protect from disease, deliver minerals, and produce humus.
- Earth worms decompose organic matter **4x faster** than any other form of decomposition.
- DPI research in Queensland revealed that vermi-compost outperformed the next best compost **20-fold**.
- A 1000L shuttle can be converted to a worm bin for less than **\$200**.



## In Conclusion...

- **Composting** is arguably the most important thing that any of us can do to build humus to help reverse **climate change**.
- Storing carbon in the soil as humus is the single most effective way to keep **CO<sub>2</sub>** out of the atmosphere.
- Building humus with compost is also the single most effective way to build **fertility** and **profitability**, so it is the ultimate win/win situation.
- I hope some of you feel **inspired** to begin composting. Thank you.



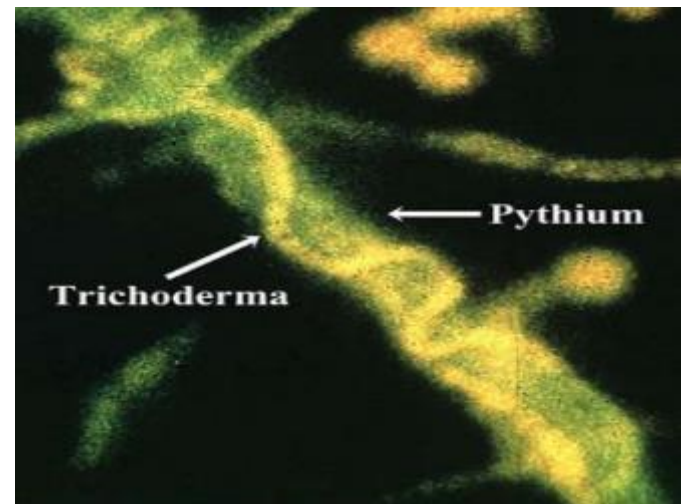


# Composting Demonstration

By Graeme Sait

## Trichoderma – Understanding the Versatile Freak

- **Trichoderma** is a beneficial fungi that can improve multiple processes in your growing enterprise.
- It was originally thought that the key benefits included **antibiosis** and **mycoparasitism**.
- However, it is now thought that **Induced Systemic Resistance (ISR)** may provide the lion's share of the benefits.
- Trichoderma infects and **colonises** the outer layer of plant roots, and establishes **chemical communication** with the host plant.



### Trichoderma – Understanding the Versatile Freak



- The trichoderma ‘infection’ induces resistance mechanisms to wall off the invader.
- This, in turn, triggers **ISR** and associated plant growth responses.
- Once **colonisation** and communication are cemented in, the relationship lasts for the **full crop cycle**.
- This symbiotic relationship effects plant physiology, by changing **plant gene expressions**.
- **Several hundred** genes are affected.

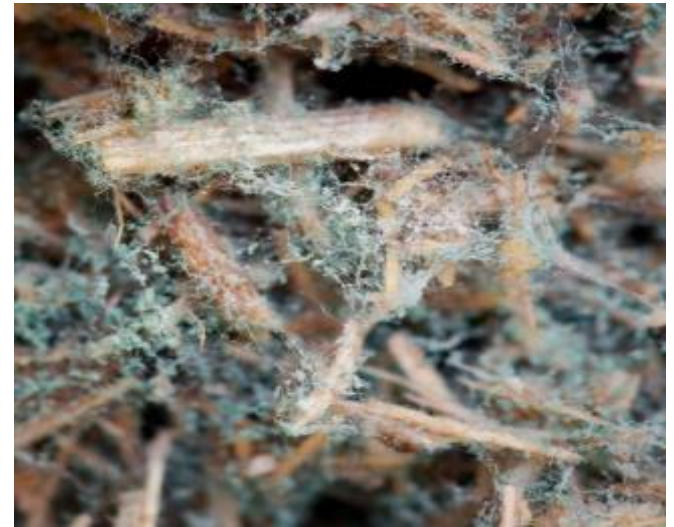
### Trichoderma – Understanding the Versatile Freak



- These changes in **gene expression** improve plant performance.
- This includes: widespread **immune elicitation** in both dicots and monocots.
- Trichoderma are **resistant** to most farm chemicals, which makes them ideal for **integrative** control i.e. pickled seeds.
- Unlike crop chemicals, trichoderma offer **long lasting** protection, often remaining active for the full crop cycle.
- They also have great **longevity** in the soil due to the formation of **chlamydospores**.

## Top Ten Roles of Trichoderma

1. **Humus creation** – trichoderma is a voracious cellulose digesting fungi that can convert fibrous organic matter into stable humus.
2. **Parasitising disease organisms** – they attack and feed upon many destructive disease organisms including: rhizoctonia, phytophthora, pythium, xanthomonas, fusarium, verticillium, alterneria, sclerotinia, pseudomonas syringae and botrytis.
- Trichoderma uses **remote sensing** to local the pathogen. It then coils around the disease organisms and releases **chitinase** to ensure ease of hyphal penetration, before consuming the host.



## Top Ten Roles of Trichoderma

3. **Out-competing pathogens** – trichoderma are one of the most successful rhizosphere inhabitants (10,000 propagules per gram).
  - Their success relates to a **high reproductive capacity**, resilience and unfavourable conditions, capacity to modify their surrounds, efficiency in **nutrient utilisation**, and antagonism to pathogenic fungi.
  - Part of this advantage relates to their capacity to chelate and utilise available **iron** in the root zone. Pathogens have a strong requirement for iron, and they struggle when trichoderma have consumed limited iron reserves (**pythium** is controlled in this manner).



## Top Ten Roles of Trichoderma

4. **Stimulate root and shoot growth** – trichoderma release auxin-like hormones that provide a profound effect. Astute nursery growers have realised the multiple benefits of adding trichoderma to potting mix.
5. **Boosting plant immunity** – trichoderma triggers a measurable increase in phytoalexins within the plant (the equivalence of antibodies in human immunity).
6. **Stabilising phosphorus** – the acid exudates from this organism break the bond between locked up calcium and phosphate, and deliver both minerals to the plant.



### Top Ten Roles of Trichoderma

7. **Improving nitrogen use efficiency** – only 33% of applied nitrogen is utilised in small grain production. In one study by Gary Harman (the founder of T22), there was a 30-50% reduction in N applications without loss of yield.
8. **Facilitating signalling** – we are rapidly realising that there is much more happening between microbes and plants, than was ever envisaged. There is evidence that secondary metabolites produced by trichoderma may serve as signalling molecules.



### Top Ten Roles of Trichoderma

9. **Production of secondary metabolites** – trichoderma is a prolific producer of over 300, including peptides, terpenoids, pyrones and indolic-derived compounds. These substances push both vigour and immunity.
10. **Producing antibiotics** – these powerful protectants include trichothecin, trichotoxin, sesquiterpine and paracelsin.



## Key Characteristics of Trichoderma

1. This organism is **compatible** with other beneficial inoculums including mycorrhizal fungi, bacillus subtilis, and BAM™, increasing versatility.
2. It is highly effective in **substrates**, particularly coco peat.
3. Trichoderma can be used as a **post-harvest treatment** to prevent rotting diseases, like anthraxnose.
4. Trichoderma can be used for **bioremediation** of chemically contaminated soils. These organisms can degrade a wide range of insecticides, organochlorides, organophosphates, carbonates.
5. Trichoderma helps with **salt and drought stress** – it is a good combination with bacillus subtilis to help counter climate change.



## Key Characteristics of Trichoderma

6. Trichoderma can be added to a **compost** in the later stages to create a disease-suppressive end-product.
7. A good growing medium to **expand trichoderma** involves diatomaceous earth, wheat flour, and molasses.
8. A major tool in **propagation**. When soaking cuttings in water, the addition of trichoderma can be more powerful than rooting hormone.



## DIY Trichoderma compost

- We have been teaching the simple production technique to expand **Trichoderma**. It involves 1 tonne of compost within a simple netting frame.
- The **recipe** is simply half straw and half cow manure.
- Our first attempts failed due to **contaminated** cow manure sourced from a conventional dairy farm.
- It was only when we were able to include **organic cow manure** that the strategy delivered the desired outcome.





# Brewing Demonstration

By Graeme Sait

# Microbial Inoculums – Boosting the Beneficials

## Beneficial Anaerobes

- Professor **Teruo Higa** recognised the profound importance of the anaerobic side of soil life.
- He developed a product call **EM** which has transformed much of Asian agriculture.
- The NTS product, **BAM™**, is based upon the original EM formula with some new inclusions.
- **BAM™** contains over **80 different microbe varieties** including lactobacillus, purple non-sulphur bacteria (pnsb), fermenting fungi, yeast, and actinomycetes.



# Microbial Inoculums – Boosting the Beneficials

### Beneficial Anaerobes - multiple benefits of BAM™

- **Boosts nitrogen fixation** – BAM™ includes PNSB (anaerobic nitrogen fixers), and their aerobic counterparts, azotobacta.
- **Powerhouse compost accelerant** - BAM™ can be used to produce an eight-week, anaerobic compost with a 910 Kg yield. It can also be used in aerobic compost to speed the process considerably. However, the yield will not be as high.
- **Suppresses pathogens** – these anaerobes have proven highly effective in the soil and on the leaf surface as antagonists of disease organisms.
- **Produces superior haylage** - hay can be bailed with as much as 70% moisture, and the end product, just like fermented food, contains more nutrition.



## Microbial Inoculums – Boosting the Beneficials

### Beneficial Anaerobes - multiple benefits of BAM™

- **Transforms manure ponds** – BAM™ can turn a smelly liability into an invaluable asset.
- **Detoxification** - these anaerobes can speed the decomposition of chemical residues. In fact, they are one of the few organisms capable of removing dioxins from water and soil.
- **Increases soil heat** - in one Chinese study, a 3 metre snow pack rapidly disappeared in the treated field.
- **Biological seed treatment** – BAM™ triggers germination in all plants.
- **Weed reduction** – this germination enhancement triggers many more weeds to germinate after application. The following seasons, there are less and less weeds, as the seed bank has been diminished.



# Microbial Inoculums – Boosting the Beneficials

### Beneficial Anaerobes - multiple benefits of BAM™

- **Highly effective stubble digester** – can be sprayed on crop residues to speed breakdown and conversion to humus.
- **Cleaning stock water** - Apply to water troughs at 0.01% (1:10, 000) cleanse the water and remove algae.
- **A living fertiliser** – BAM™ can be fertigated, liquid injected, or foliar sprayed to boost plant growth, health and yield.
- **Removes problem smells** - highly effective in piggeries and feed lots or when composting smelly ingredients.



# Microbial Inoculums – Boosting the Beneficials

### Beneficial Anaerobes - benefits of BAM™ in the home

- **Clean septic tanks** – 500 mLs added to the tank removes smells.
- **Kills mosquito larvae** - EM is a recognised control mechanism for mosquitos.
- **Household cleaner** - can be used in the bathroom, shower, and kitchen benches. Will also deodorise smelly carpets.
- **Removes dog smells** - apply to the coat of the animal and to the bedding.
- **A living deodorant** - BAM™ kills the organisms responsible for underarm odours and removes the anaerobic smell.



# Microbial Inoculums – Boosting the Beneficials

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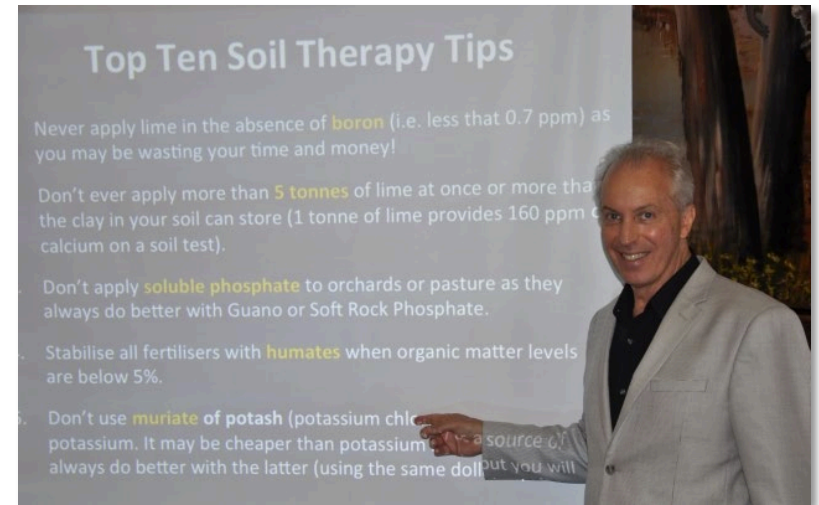


# Soil Therapy Recommendations

By Graeme Sait

## Precision Nutrition

1. **Nutrition programming** is about the power of precision.
2. Crop monitoring and appropriate **action** is the key.
3. Programs should be based upon **viability** and **cost effectiveness** in each situation.



## Precision Nutrition

4. Existing fertiliser programs and disease management practices should be analysed to look for **inefficiencies and improvements**.
5. A \$20 per hectare **broadacre program** will be based upon creating the biggest response for the smallest investment.
6. In more **intensive horticulture**, it is a very different story, with a bigger budget and much greater expectations.



# Nutrition Farming® – Wheat Program

### PROGRAM GOAL:

The aim here is to increase soil fertility, plant resilience and plant brix, (complex carbohydrates and mineral content), while reducing chemicals and increasing yield.

**Pre-Planting** – determine nutrient status and key soil limiting factors by taking a **reliable soil test** with an informative, easy to understand report.

**Seed treatment** is the most cost effective way of ensuring quick, even germination and getting some biology onto the seed to improve water and nutrient access and crop resilience.

**Seed-Start™** promotes germination, while **Nutri-Life Platform®** contains mycorrhizal fungi and *Trichoderma* fungi to enhance nutrient delivery, root zone health and plant resilience.





# Nutrition Farming<sup>®</sup> – Wheat Program

**Liquid Inject** – programs can be tailored according to your soil test. Alternatively, Springboard<sup>™</sup> is a broad-spectrum, convenient liquid containing plant-available nutrients in a carbon-rich, easy to handle liquid that provides a great pop-up response and also provides support to the microbes in Nutri-Life Platform<sup>®</sup>

**Early-Mid Tillering** – there are certain phases during the crop cycle where there is an opportunity to increase yield and protein content. NTS Plant Therapy<sup>™</sup> during early tillering will determine the key nutrient requirements needed at this stage.

**Zinc** is the most important inclusion in this first foliar spray, but NTS Stimulate<sup>™</sup> and Triacantanol should also be included.





## Nutrition Farming® – Wheat Program

**Pre-Flowering** – If the season justifies another foliar spray, follow up with another leaf test at this key growth phase to optimise crop protein.

The key issue here is **Boron**, as this mineral plays such an important role in the entire reproductive process. A foliar of **1 kg** per hectare of soluble boron at this time can provide an amazing cost-to-benefit ratio.

**NTS Stimulate Liquid™** should always be combined with the boron.

### Wheat Program Rationale

1. The **seed treatment** (Seed-Start™) provides key nutrition for a kick-start and early- season resilience. Manganese is essential due to glyphosate shutdowns.
2. **Mycorrhizal fungi** and *Trichoderma* (Nutri-Life Platform®) combined with Seed-Start™ can help control fungal diseases and glyphosate-induced issues like Take All.
3. The **Soluble Humate Granules™** buffer the burning effect of DAP/MAP while magnifying fertiliser effects, stabilising phosphate and stimulating soil life.
4. **NTS Stimulate Liquid™** provides kelp, fulvic acid, and a powerhouse plant growth promoter (PGP). It is a perfect synergist with the zinc and boron sprays.

#### Extras if required:

**The N kick** – 10 kg of Urea with 10 L of DIY Humic Acid if N is required.

**The K kick** – during seed fill, K is often the limiting factor. Foliar apply potassium sulfate at 8 kg per hectare with 300 g of NTS Fulvic Acid Powder™.

# Soil Therapy Recommendations

## Wheat Soil Test














### KEY FACTORS:

- Low organic matter
- High magnesium
- Low calcium
- Marginal potassium
- Marginal phosphorus
- Low zinc
- Low boron
- Marginal copper
- Low manganese

ALBRECHT CATEGORY	YOUR LEVEL	IDEAL LEVEL	NUTRIENT STATUS		
			LOW	MEDIUM	HIGH
CEC	26.71				
TEC	32.58				
Paramagnetism	130	200 +	█		
pH-level (1:5 w ater)	5.90	6.3		█	
Organic Matter (IR Gas Anal.)	1.40 %	4 - 10 %	█		
Conductivity (1:5 w ater)	0.18 mS/cm	0.1 - 0.2 mS/cm		█	
Ca / Mg Ratio	2.57 :1	7.00 :1	█		
Nitrate-N (Morgan)	4.0 ppm	10 - 20 ppm	█		
Ammonium-N (Morgan)	5.0 ppm	10 - 20 ppm	█		
Phosphorus (Mehlich III)	35 ppm	50 - 70 ppm	█		
Calcium (Mehlich III)	3660 ppm	4561 ppm	█		
Magnesium (Mehlich III)	856 ppm	391 ppm	█		
Potassium (Mehlich III)	304 ppm	254 - 635 ppm	█		
Sodium (Mehlich III)	115 ppm	38 - 112 ppm	█		
Sulphur (Morgan)	8 ppm	30 - 50 ppm	█		
Aluminium (Mehlich III)	0.3 ppm	< 15 ppm			
Silicon (CaCl <sub>2</sub> )	47 ppm	> 100 ppm	█		
Boron (Hot CaCl <sub>2</sub> )	0.50 ppm	1 - 3 ppm	█		
Iron (DTPA)	178 ppm	40 - 200 ppm	█		
Manganese (DTPA)	18 ppm	30 - 100 ppm	█		
Copper (DTPA)	1.2 ppm	2 - 7 ppm	█		
Zinc (DTPA)	1.1 ppm	5 - 10 ppm	█		
Molybdenum (TAE)	0.75 ppm	0.5 - 2 ppm	█		
Cobalt (TAE)	3.75 ppm	2 - 40 ppm	█		
Selenium (TAE)	0.70 ppm	0.6 - 2 ppm	█		
Texture	N/A				
Colour	N/A				
<b>BASE SATURATION</b>					
(Levels are not really relevant in soils with a TEC below 5)					
Calcium	56.18 %	70.00 %	█		
Magnesium	21.89 %	10.00 %	█		
Potassium	2.39 %	2.00 - 5.00 %	█		
Sodium	1.53 %	0.50 - 1.50 %	█		
Aluminium	0.01 %	0.50 %			
Hydrogen	18.00 %	10.00 %	█		

## Wheat Leaf Test

### Growth Stage: Tillering














ELEMENT OR CATEGORY	YOUR LEVEL	ACCEPTABLE RANGE	DEFICIENT	ACCEPTABLE	EXCESSIVE OR TOXIC
N - Nitrogen	2.90 %	3.5 - 5.4 %			
P - Phosphorus	0.40 %	0.3 - 0.5 %			
K - Potassium	3.20 %	2.4 - 4.0 %			
S - Sulphur	0.30 %	0.15 - 0.4 %			
Ca - Calcium	0.20 %	0.21 - 0.4 %			
Mg - Magnesium	0.20 %	0.13 - 0.3 %			
Na - Sodium	0.40 %	< 0.5 %			
Cu - Copper	28 ppm	5 - 50 ppm			
Zn - Zinc	9 ppm	15 - 70 ppm			
Mn - Manganese	200 ppm	25 - 300 ppm			
Fe - Iron	80 ppm	25 - 100 ppm			
B - Boron	4.0 ppm	5 - 10 ppm			
Mo - Molybdenum	0.4 ppm	0.1 - 0.5 ppm			
Si - Silicon	N/A ppm	>500 ppm	N/A		

- Low **nitrogen** and deficient **calcium** suggest a benefit from foliar spraying calcium nitrate at 2 kg per hectare with 300 g NTS Fulvic Acid Powder™.
- The **zinc** deficiency should be addressed with Triacontanol.
- The **boron** deficiency should be addressed with Brix-Fix™

# Soil Therapy Recommendations

## Wheat Leaf Test

Growth Stage: Heading to Pre-flowering

ELEMENT OR CATEGORY	YOUR LEVEL	ACCEPTABLE RANGE	DEFICIENT	ACCEPTABLE	EXCESSIVE OR TOXIC
N - Nitrogen	2.80 %	1.75 - 3.0 %			
P - Phosphorus	0.20 %	0.2 - 0.5 %			
K - Potassium	1.20 %	1.5 - 3.00 %			
S - Sulphur	0.17 %	0.15 - 0.65 %			
Ca - Calcium	0.50 %	0.20 - 1.00 %			
Mg - Magnesium	0.60 %	0.15 - 1.0 %			
Na - Sodium	0.30 %	< 0.5 %			
Cu - Copper	6 ppm	5 - 50 ppm			
Zn - Zinc	28 ppm	20 - 70 ppm			
Mn - Manganese	90 ppm	16 - 200 ppm			
Fe - Iron	120 ppm	10 - 300 ppm			
B - Boron	0.8 ppm	1.5 - 4 ppm			
Mo - Molybdenum	0.35 ppm	0.1 - 0.5 ppm			
Si - Silicon	N/A ppm	N/A			

There is a drawdown of **potassium** and **phosphorus** from flowering onwards. This can be addressed with a foliar spray of MKP at 2 kg per hectare with 200 g of NTS Fulvic Acid Powder™.

**Boron** must be addressed at this point and **copper** is marginal.