NTS
Nutri-Tech Solutions®

Brewing Microbes and Monitoring Outcomes

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

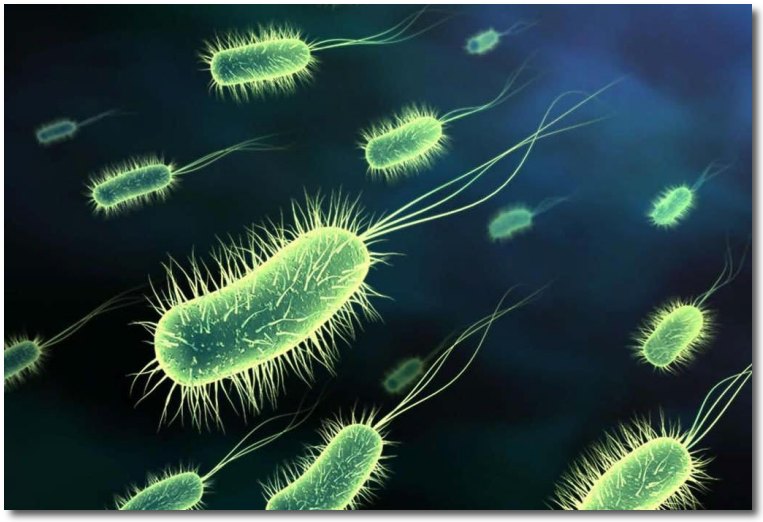
5. **To manage plant disease** – both the phyllosphere and the rhizosphere are best managed with the numbers game (the more good guys the better). Compost tea also delivers antagonists, predators, and immune elicitors.

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.

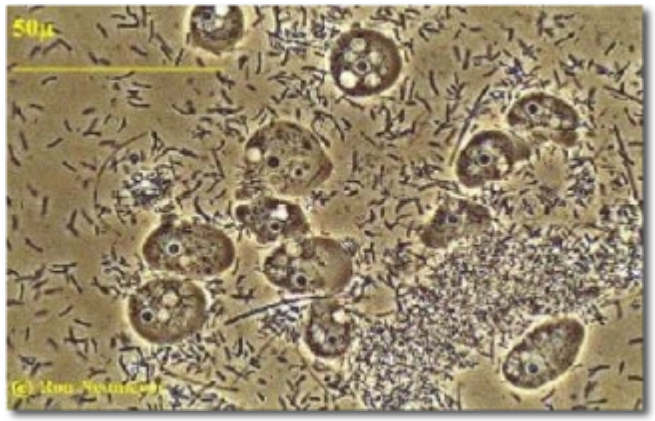
Mechanics of Compost Tea Protection

2. Antagonism

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

3. Predation

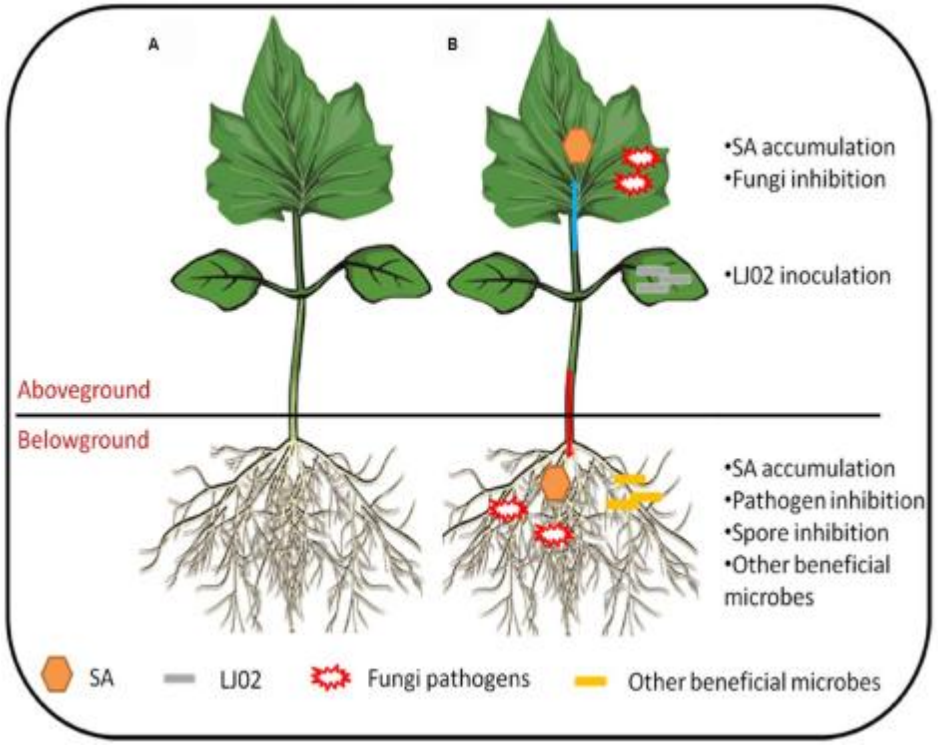
Sometimes the best way to carve out your own niche in the rat race is to simply eat your competitors.



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_2 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.

By Graeme Sait

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_2 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**.

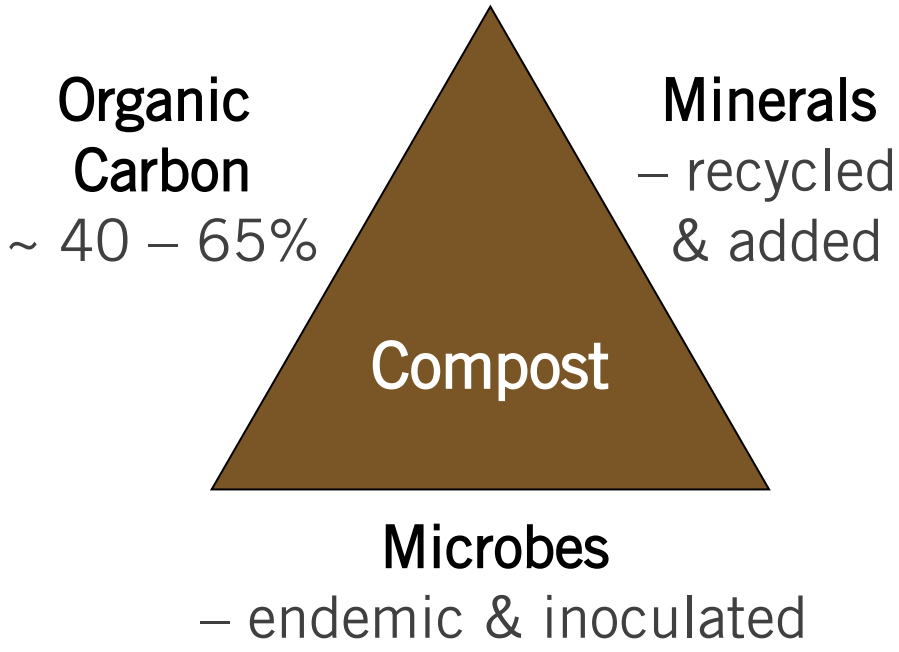
What is Composting?

- **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.

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_2 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).

Mineralisation 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%.

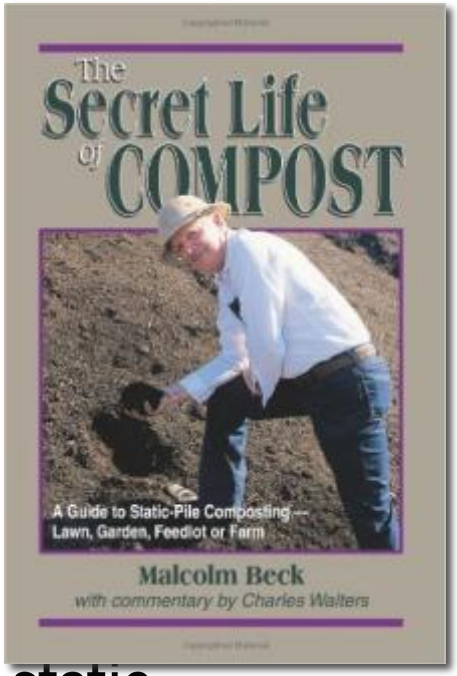
What is Paramagnetism?

- 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_2 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**.

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_2 monitoring** to ensure adequate aerobic activity.
- CO_2 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.

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_2 levels should not exceed **20%** or this will intoxicate aerobic microbes.

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).

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.

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**.

Are We There Yet?

- A slight **ammonia smell** may still be evident in finished compost.
- This may also indicate the need for more **browns** (carbon) – check temperature as a final guide.
- The compost is ready when the temperature inside the pile is steadily dropping (less than **40°C**). The decomposed plant matter should be mostly humified (amorphous) and there should be a strong **earthy**, forest floor smell.

In-field testing – Avoiding Blind Nutrition

- There are a variety of tools used in **Nutrition Farming®** to determine nutrient requirements.
- These include; nitrogen, potassium, sodium and calcium meters. This **monitoring** also involves refractometers, sap pH meters, and simple pH strips.
- **Nitrogen meters** can provide instant feedback as to the levels of the most abundant mineral in the plant.
- **Nitrogen** can be under-supplied, but more often oversupplied. In each case, there is a price to pay. The goal is to find the '**sweet-spot**' for your crop.

In-field testing – Avoiding Blind Nutrition

- Your **potassium meter** can prove to be the most valuable tool in the kit.
- Potassium is the **most mobile** of all minerals. It moves from the lower leaves to the upper leaves as soon as the deficiency begins.
- By the time you have **finally detected** the deficiency (measuring the top leaves with leaf analysis), the deficiency has been present for some weeks. At this point you have **lost yield,** and you can't play catch up.
- The trick is to measure the **top leaf** and the **bottom leaf** with your potassium meter.
- There should be no more than 10% **variation** between these readings. If the lower leaf is significantly lower, then you have uncovered a K shortage, and you need to act now.

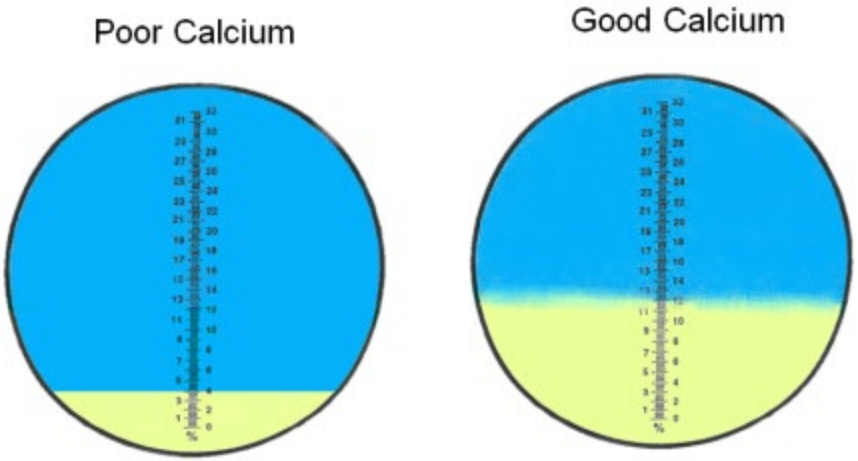
In-field testing – Avoiding Blind Nutrition

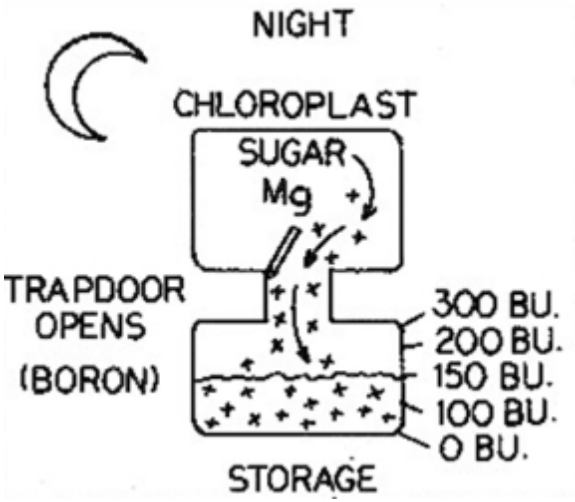
The refractometer directly measures **dissolved solids** in plant sap, so it is an indication of your skills as a chlorophyll manager.

However, this essential tool indirectly measures five other things including;

1. **Monitoring calcium status** – a sharp, distinct line means calcium deficiency. The goal is to achieve a fuzzy line.

2. **Measuring boron deficiency** – brix levels should vary between late afternoon and morning. If there is no change, then sugars have not been translocated to the roots, due to the boron-controlled, trap door failing to open.





In-field testing – avoiding blind nutrition

3. **Indicating nutrient imbalances** – brix levels should be similar throughout the plant. If there is significant variation, further investigation is warranted.

4. **Determining foliar effectiveness** - if you have made a good nutrient choice, you will see a very rapid increase in brix levels.

5. **Assessing likely weed pressure** - the weeds should always have a lower brix level than your crop, or you have fertilised for the weed.

The Plant Sap pH Meter

American researcher, **Bruce Tainio**, has discovered that plant sap pH is a simple and accurate guideline for the following:

a) Enzymatic **breakdown of carbohydrates** for plant growth and vitality.

b) Risk potential for **insect damage**.

c) Risk potential for **foliar disease** attack (fungi, bacteria and viruses).

The Plant Sap pH Meter

d) **Nutritional balance** in the growing crop.

e) **Quality** of fruit and vegetables.

f) **Shelf-life** of fruit and vegetables.

If sap pH is lower than 6.4, then there is a **cation** problem, with possible deficiencies of calcium, magnesium, potassium and/or sodium. Low pH suggests fungal problems. At pH **4.5** the probability for fungal attack is 100%.

Conversely, if sap pH exceeds 6.4, then the most likely cause will be an imbalance of the **anions** nitrogen, phosphate or sulfur. At pH 8 the likelihood of insect attack is **100%**!

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.

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.

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

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.

Fertility Monitoring – PCSM Meter

- **Paramagnetism** is the determining factor in the fertility superiority of volcanic soils.
- These soils can attract **ELF** radio waves and convert them into tiny light particles called **biophotons**. This effectively provides a light stimulus to soil life and plant roots.
- The **PCSM meter** allows you to monitor the relative fertility of any field, at any time. It simply involves collecting 50 grams of soil in a small plastic container and placing it in the machine.
- The machine is set up, prior to each use, by placing a pre-measured sample into the well and **calibrating** accordingly.

In conclusion..

Regenerative agriculture has now become a revolution.

Understanding the tools is essential for success. Hopefully you are now better equipped to thrive.