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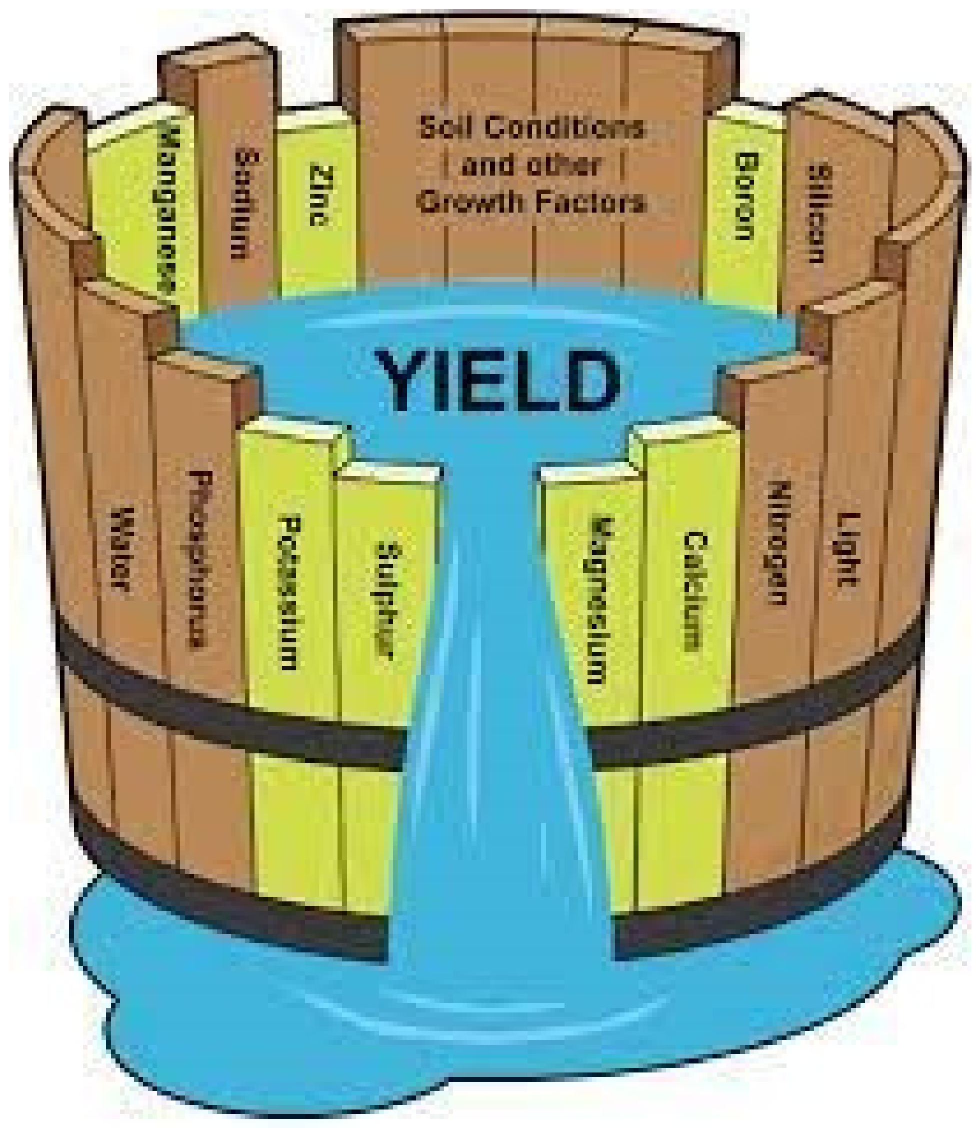
Targeting Plant Nutrition

Effective and Efficient Strategies for Lowering Inputs and Improving Production

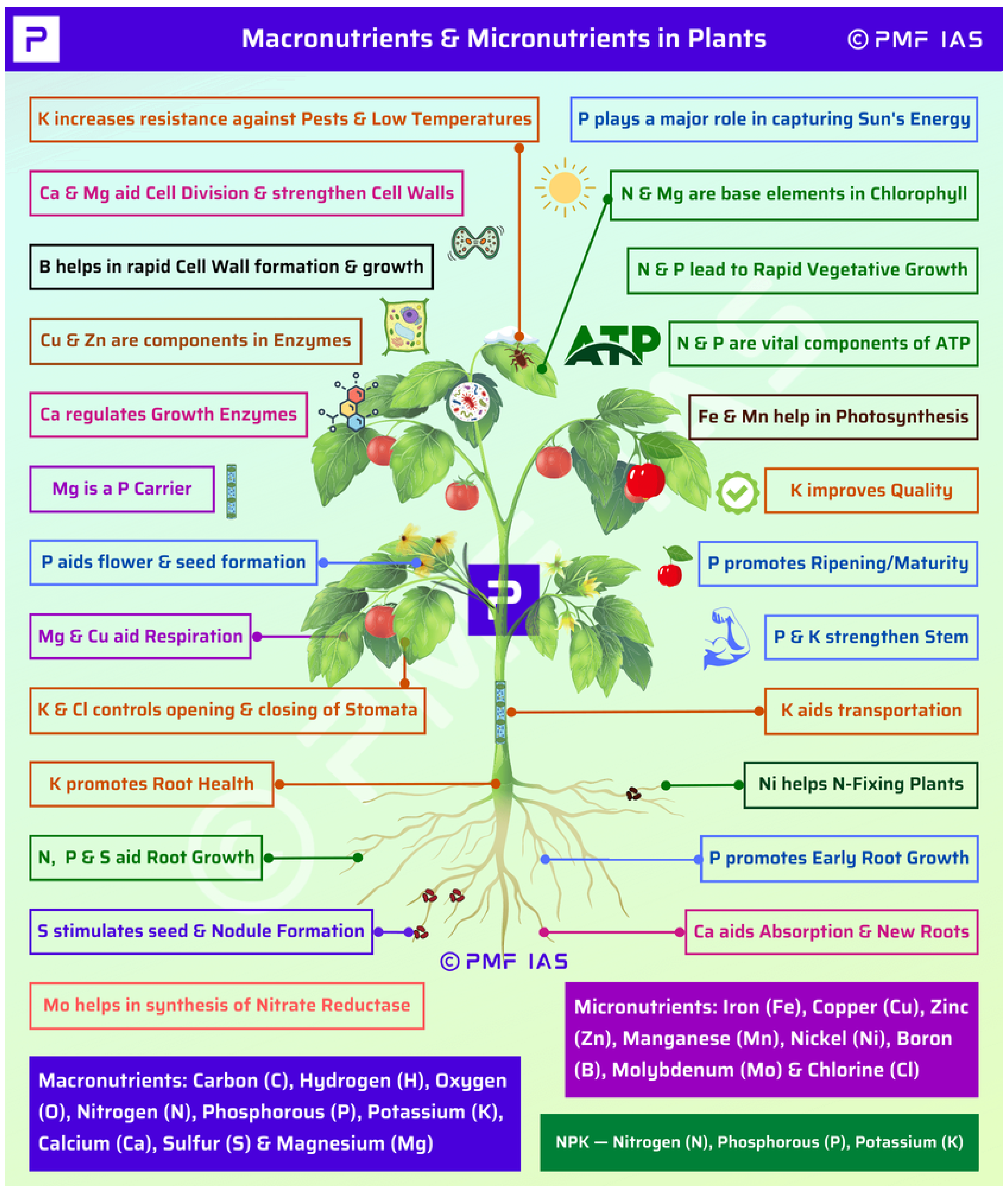
Introduction:

The application of nutrients, or fertilisers, that plants require is an important component in primary production operations. For numerous reasons, crops or pastures, may not naturally get all the nutrients they need from the soil in order to perform well. The considered application of fertiliser is often necessary to meet the desired outcomes of enterprise programs.

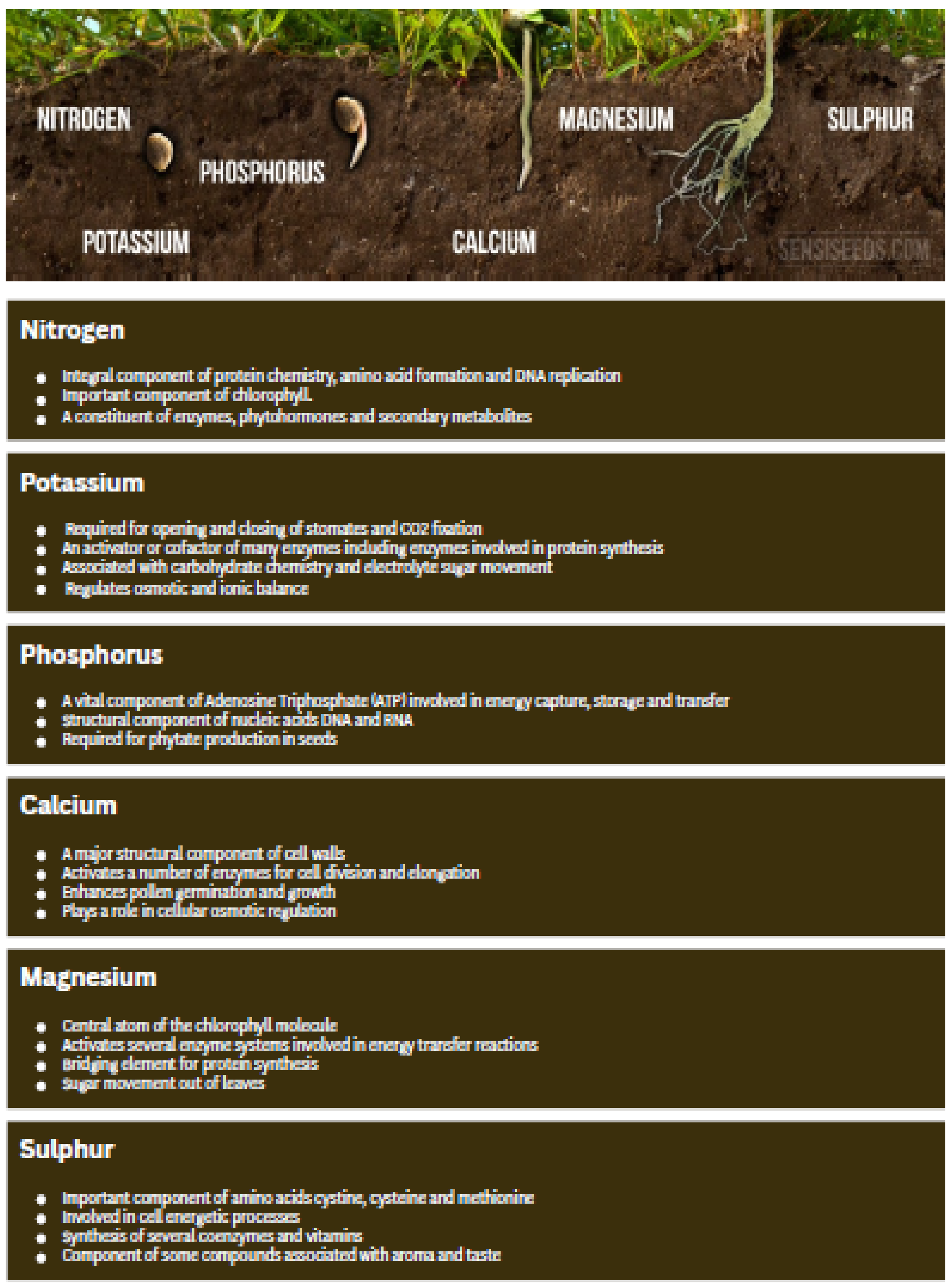


More than ever, there is both an economic and environmental imperative to make nutrient applications as efficient and effective as possible. It is important that growers understand how to determine soil and/or plant nutrient status with appropriate testing and make well informed decisions around fertiliser application in order to get good results and lower costs.

Plant Nutrition

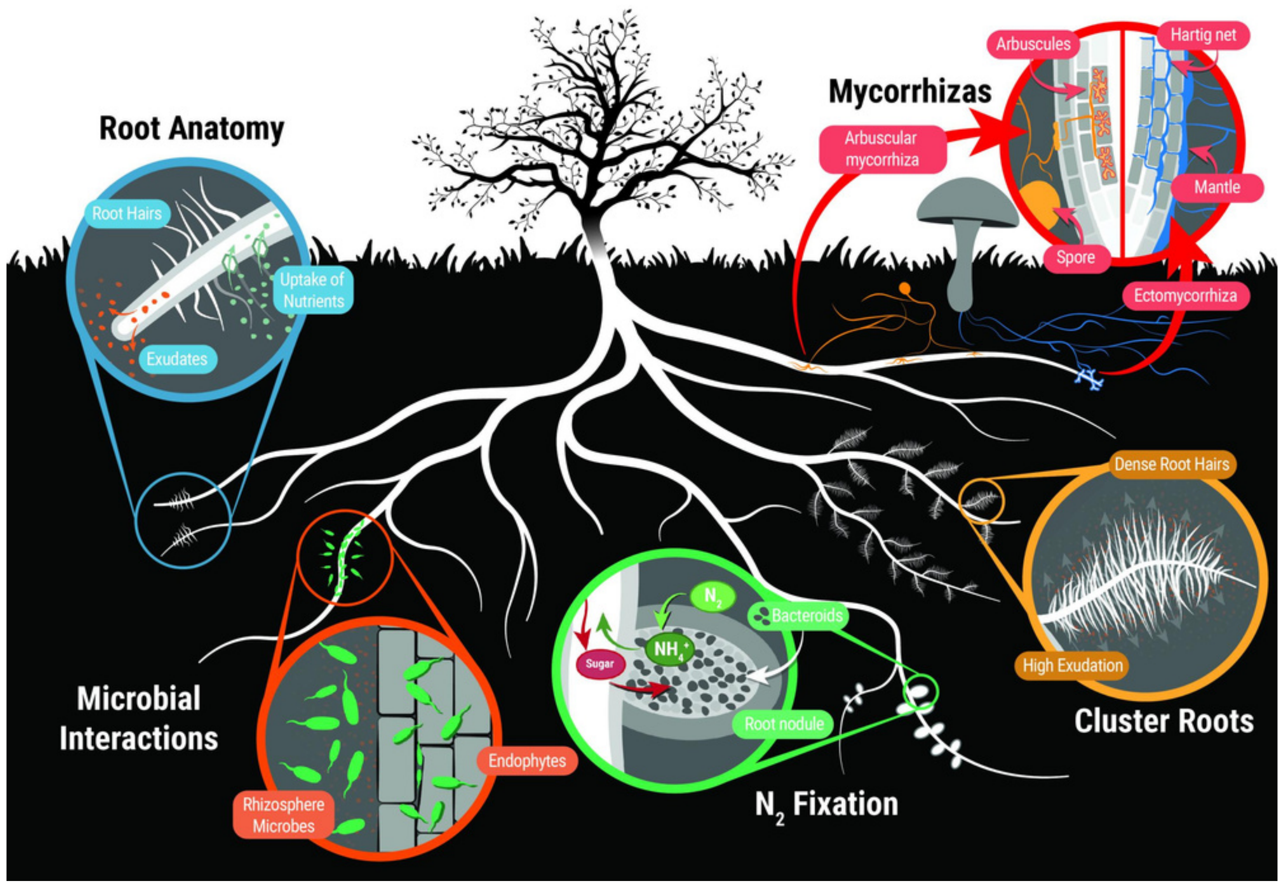


Plant Macronutrient Roles and Functions



Plant Nutrient Uptake: Plants take up most of the nutrients they need through their roots from the soil environment.

- They acquire these nutrients in varying degrees from the soil solution, clay/humus exchange sites, soil biology, the breakdown of organic materials and the surfaces of soil mineral particles.
- It used to be thought that plants only take up ionic nutrients in solution but it is now known that plants can take up whole molecules, complete compounds like amino acids and proteins and even bacterial cells.
- Plants can also absorb a small amount of nutrients from gases, solutions, organic sources and dusts above the ground, through their leaves, stems and reproductive organs.



Different nutrient acquisition strategies. (Source: Plants in Action)

Applied Nutrition

Nutrient Use Efficiency in Agricultural Ecosystems

Various environmental factors affect NUE such as:

- soil dynamics (exchange capacity, moisture content, leaching/runoff, fixation etc...)
- plant characteristics (nutrient absorbing capacity, age, cultivars, root morphology etc...)
- climate (sunlight, rainfall, wind etc...)
- nutrient application (amount, form, timing, placement etc...)
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Nutrient	Efficiency (%)
Nitrogen	30–50
Phosphorus	15–20
Potassium	50–60
Sulphur	8–12
Zinc	2–5
Iron	1–2
Copper	1–2
Manganese	1–2
Boron	2–3
Molybdenum	2–5

Source: Connecting Bio-Priming Approach with Integrated Nutrient Management for Improved Nutrient Use Efficiency in Crop Species

The application of nutrients has the potential to significantly improve, but can also adversely affect, production outcomes, depending on the context, type of fertilisers, amounts used and methods of application. It is important that growers understand how to determine soil and/or plant nutrient status with appropriate methods and make well informed decisions around fertiliser application in order to get desired results, lower costs and prevent ecological issues.

SOIL NUTRIENT STATUS & TESTING

There are a range of methods that can be used to determine the status of your soil or plants to inform the decision-making process around nutrient applications that can be made to improve plant nutrition and minimise waste.

Soil Nutrient Bank Accounts

At any one time there are pools of soil nutrients:

- dissolved in the soil solution
- held on exchangeable sites
- within soil organisms
- within organic matter
- locked up in the soil mineral matrix

These pools of nutrients are in a state of flux. Nutrients are constantly being removed from the soil solution and exchange sites by plants, released from organic matter and liberated from the soil mineral matrix by soil microbes and so on.

Variables such as soil moisture, temperature, cation exchange capacity (CEC), phosphorous buffering index (PBI), acidity/alkalinity (pH) redox state (Eh) and soil carbon levels also significantly influence the state and place nutrients occupy in the soil and their plant availability.

Soil testing methodologies are designed to identify significant soil characteristics and the levels of essential nutrients in the different soil fractions. These are then interpreted in relation to plant nutrient availability.

Field Assessment of Soil

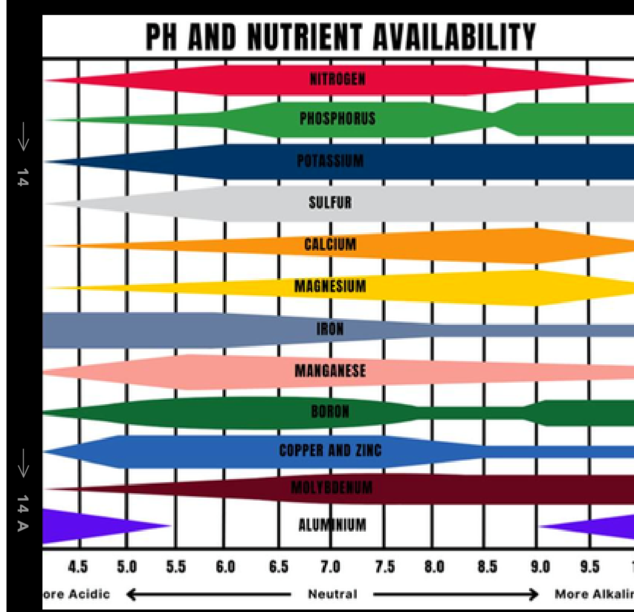
Soil characteristics such as pH, moisture, colour, texture and structure, can be visually observed or tested in the field but these only provide general indication of soil fertility.

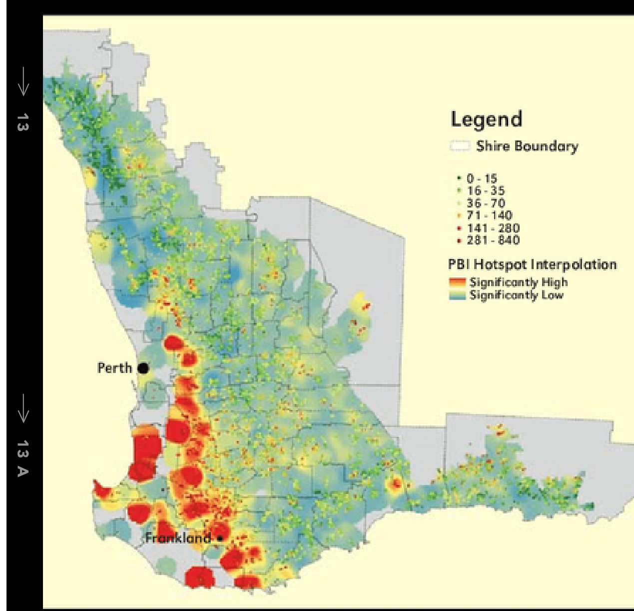
To obtain more comprehensive information, soil samples can be sent to certified laboratories that offer test packages that cover a range of different parameters.

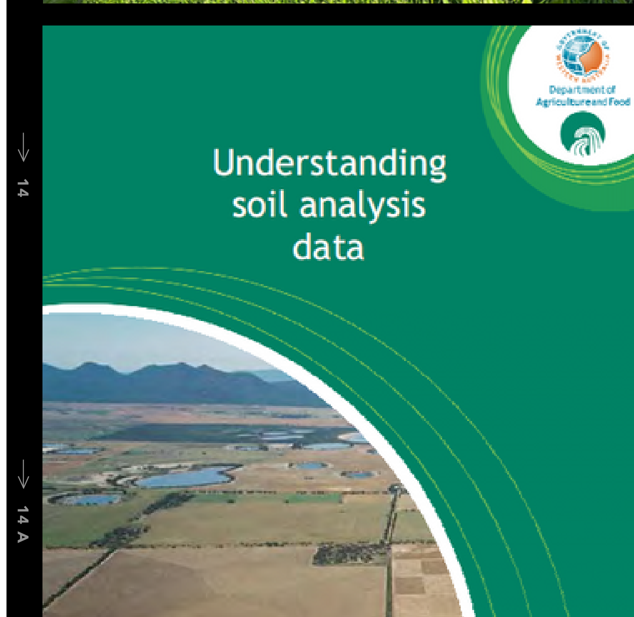
Things to consider when collecting soil samples for testing:

- Accounting for isolating different soils
- Depth of sampling
- Accurate cross section/representation
- Avoiding sites of potential contamination
- Adequate volume of soil
- Seasonal conditions
- Handling & Storage

It is best to follow the sample collection guidelines of the laboratory you are sending your soil samples to.







PLANT NUTRIENT STATUS & TESTING

The optimal concentration range for the different nutrients within plants varies with species, parts, stages of growth and growing conditions.

The balance between different nutrients and their interactions within plants also has a bearing on growth. Nutrients are translocated via the xylem stream, from roots to shoots. Along the way they may be deposited in roots, stems and leaves or transferred to phloem sap. Some nutrients are more phloem mobile than others and can be readily partitioned to different plant parts as needed or stored.

Field Assessment of Plant Nutritional Status

A range of plant testing methodologies can be used to identify the levels of nutrients and other characteristics such as sugar content, pH and electrical conductivity in different plant parts.

Handheld Meters:

- Refractometers
- Horiba LAQUAtwin Meters
- Spectrometers

Leaf Tissue Testing:

- In tissue tests, the ash of whole leaves is analysed for nutrient content.
- All nutrients in the tissue and in the sap are recorded. One issue with this is that nutrient deposits in the tissue from earlier growth may not correlate with the more immediate supply of nutrients, so there can be a lag of several weeks before deficiencies/toxicities show.

Laboratory Plant Testing:

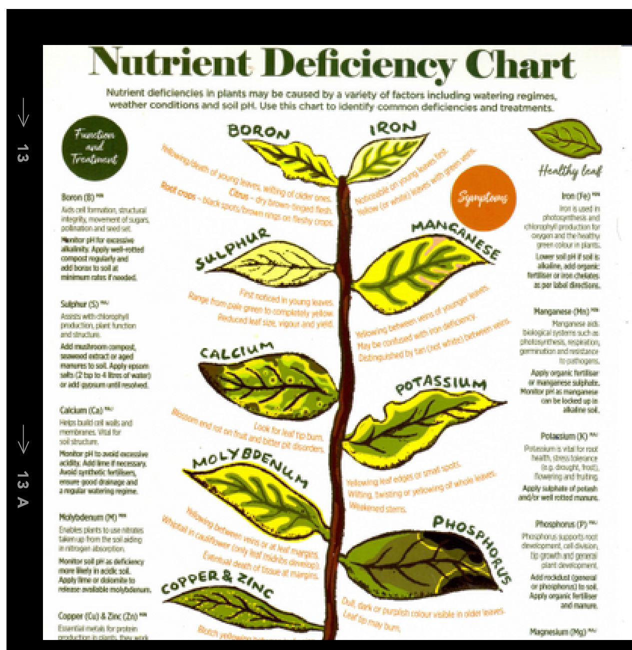
- For a more detailed breakdown of plant nutritional status etc, it is common practice to send plant samples to a laboratory for tissue or sap analysis.

Sap Analysis:

- Plant sap analysis can be carried out to get a reading of different sap parameters at the time of sampling.
- It gives a fairly good indication of current nutrient supply, so issues can be picked up and addressed more immediately.
- Plant sap analysis hasn't been around as long as tissue testing so reference levels for commercial crop species aren't as well established.

Things to consider when collecting plant material samples:

- What plant parts you are testing
- Accurate cross section/representation
- Adequate volume of material
- Weather conditions
- Time of day
- Handling & Storage



Fertilisers

A fertiliser is a natural or synthesised substance containing chemical elements that is manufactured, represented, sold or used as a means to improve the growth and productiveness of plants.

Inorganic nutrients are used for the production of synthetic fertilisers, and organic nutrients are derived from organic materials.

Common Synthetic Fertilisers

- Urea
- Sulphate of Ammonia
- Mono Ammonium Phosphate (MAP)
- SuperPhosphate
- Calcium Nitrate
- Sulphate of Potash (SoP)
- Mono Potassium Phosphate (MKP)
- Magnesium Sulphate
- Zinc Sulphate
- Solubor

Common Organic Fertilisers

- Manure based products
- Fish hydrolysates
- Blood and bone
- Seaweed products
- Compost

Note: Products like Lime, Gypsum, Dolomite, Rock Minerals, Sulphate of Potash, Magnesium Sulphate, Zinc Sulphate, Solubor, Sea Minerals etc… can be used as inputs in organic systems but strictly speaking, they are inorganic fertilisers

Fertiliser Grade: An expression referring to the guaranteed percentage of available Nitrogen, Phosphorous and Potassium (N:P:K) by weight in a fertilizer

Non-Nutrient Fertiliser Components: These are designed to stabilize and/or buffer applied nutrients, adjust the pH, enhance nutrient uptake, stimulate biological activity.

Fertiliser Fast Facts:

Solubility - Not all fertilisers are soluble in water. The following rules of thumb are useful for determining the solubility of fertilisers, although there may be exceptions.

- All ammonium, nitrate, potassium, sodium and chloride salts are soluble
- All oxides, hydroxides and carbonates are insoluble
- All sulfates are soluble except for calcium sulfate

Form - Fertiliser products can be applied in dry or liquid form.

- Dry applied fertilisers: Dry granules | Pellets | Coarse minerals | Rock dusts
- Can be broadcast, banded near crops or placed in planting furrows.

Pros	Cons
Generally cheaper	Poorer distribution through the soil profile
Store well	Harder to apply evenly
Less applications required	Slower nutrient uptake
Can be applied in a wide range of conditions	Granular fertilisers break-down in damp environments
Better suited for heavy pre-planting applications	Need moisture to break down so not as effective in drier weather
Slow-release options	
Less compatibility issues	

- Fertilisers applied as liquids: Soluble powders | Microfine suspension grade products
- Soil drench, injected / dripped into planting furrows, through fertigation or in foliar sprays.

Pros	Cons
Can be applied to the soil and the plant	Must be applied more frequently
Can be put out with fertigation and spray units	May separate, or settle out when stored.
Better distribution over and through through the soil profile	Set-up or application processes may be expensive
Fast acting	Ready-made liquid products are often shorter lived than dry fertilisers
Can be effective in dry conditions	Can't get as much out
Easy to blend and apply with compatible products	

FERTILISER APPLICATION EFFICIENCY

Soil Nutrient Application

Consideration needs to be given to how to best apply the nutrients we need in our context.

- Only applying soluble fertilisers in suitable conditions, when seasonal weather is less extreme
- Using the right form of nutrients for the conditions (i.e. not applying dry fertilisers in dry conditions)
- Negotiating a favourable balance of Carbon to Nitrogen in the soil to ensure the biology has both a source of energy and the nitrogen to make proteins.
- Targeting the placement of soil applications, especially immobile nutrients such as phosphorous, for better plant uptake minimal waste
- Timing applications to foster delivery of the required nutrients to plants when they need them
- Applying soluble fertilisers in lower amounts, more regularly or using slow release forms.
- Accounting for the poor uptake some soil applied nutrients (i.e. the trace elements)

Foliar Applied Nutrition

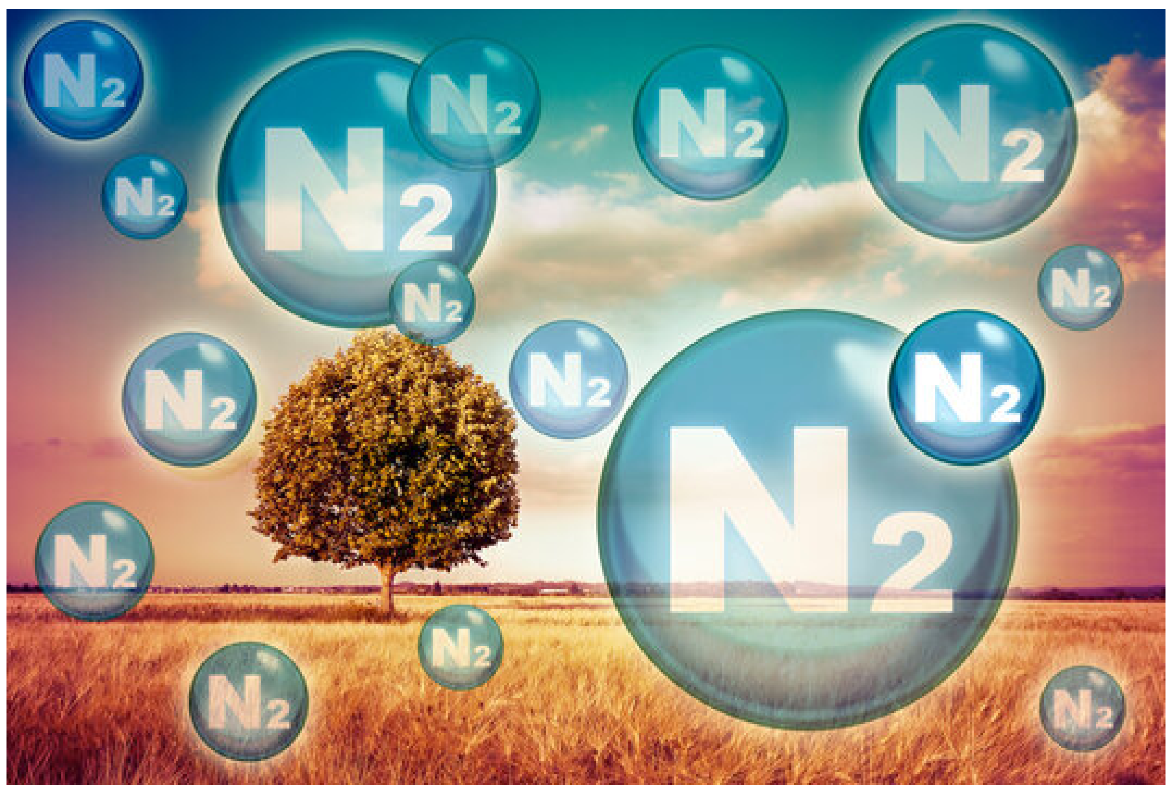
- a means to get nutrients into the plant when soil delivery is compromised by adverse conditions
- efficient uptake of applied nutrients, so significantly lower quantities are needed
- rapid plant uptake to immediately address plant nutrient shortages, especially in leaves
- an effective way of getting trace elements into plants
- have to be applied more regularly
- can't supply adequate quantities of macro nutrients
- involve post germination traffic
- don't deliver plant immobile nutrients, that may be needed, to other parts of the plant besides the foliage i.e. the root zone
- don't effectively supply nutrients that may be required in the soil environment

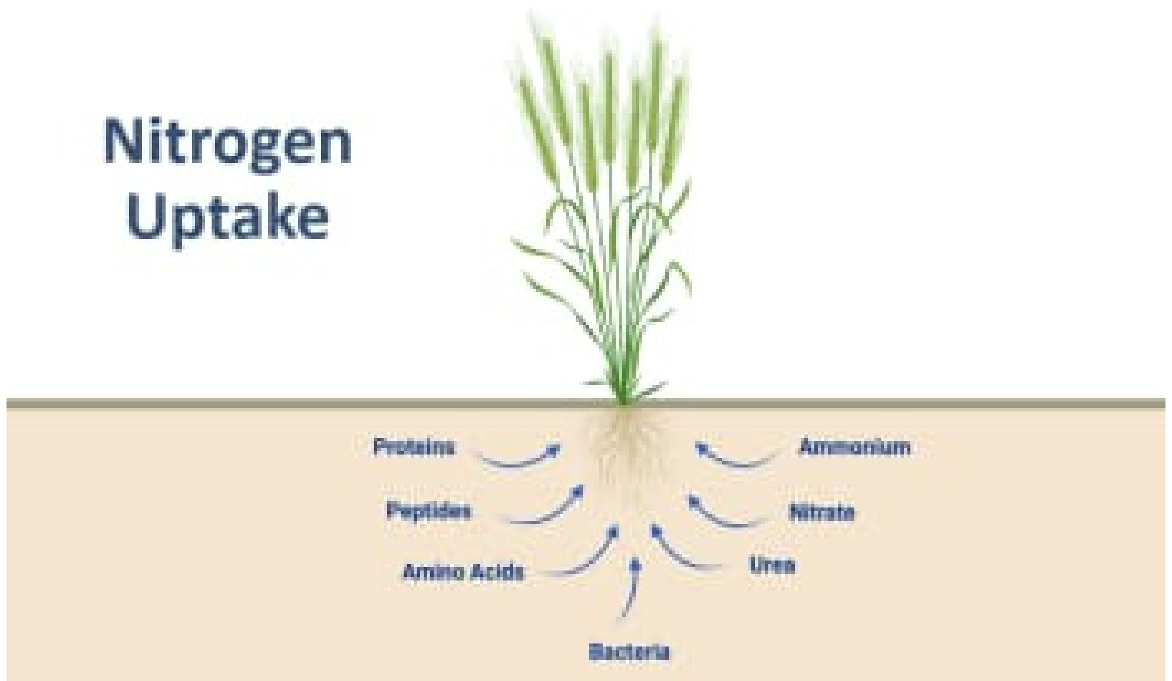
Nutrient Mobility in Soil & Plants

Nutrient mobility	in the soil	in plants
Very Mobile	Prone to leaching - nitrate Nitrogen, sulfate Sulfur, Boron	Nitrogen, Phosphorus, Potassium, Magnesium (Deficiency symptoms appear first in older leaves and quickly spread throughout the plant)
Moderately Mobile	Ammonium Nitrogen (Ammonium Nitrogen is temporarily immobile), Potassium, Calcium, Magnesium, Molybdenum	Sulfur, Copper, Iron, Manganese, Molybdenum, Zinc (Deficiency symptoms first appear in new growth but do not readily translocate to old growth)
Immobile	Organic Nitrogen, Phosphorus, Copper, Iron, Manganese, Zinc (Chelated forms of Copper, Iron, Manganese and Zinc are mobile and resistant to leaching)	Boron, Calcium (Calcium is very immobile)

Source: *Growth and Mineral Nutrition of Field Crops, Third Edition. By Nand Kumar Fageria, Virupax C. Baligar, Charles Allan Jones, 2011. CRC Press, Taylor and Francis Group.*

Nitrogen: As nitrogen is the nutrient that plants take up most from the soil it warrants special mention





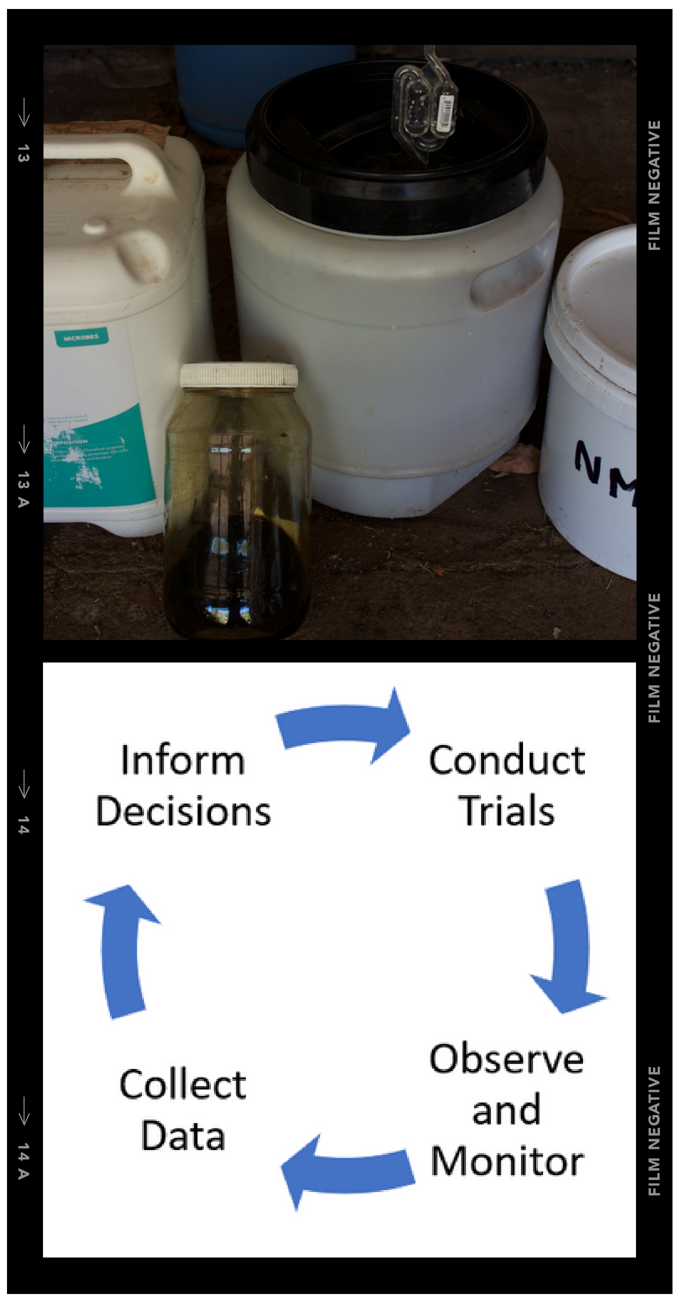
- It takes lots of energy to convert nitrate to ammonia to the amino acids and proteins plants need. There must be an adequate supply of carbohydrates to fuel these reactions.
- Certain nutrients are needed to make the enzymes involved in these conversion processes (i.e. Sulphur and Molybdenum are part of the nitrate reductase enzyme, Nickel is part of the Urease enzyme).
- Other nutrients besides nitrogen are needed to assemble the full spectrum of necessary proteins i.e. Sulphur to form Methionine & Cysteine.
- We can save plants lots of energy by using less energy costly forms of nitrogen, providing an additional source of energy i.e. molasses, and ensuring that there is an adequate supply of the other nutrients required for efficient nitrogen conversion and protein formation.

Biologically Friendly Fertilisation

As soil biology largely determine structural properties and the availability, delivery and cycling of nutrients, we obviously want to minimize compromising and even promote biological activity with nutrient applications.

Things that can be done:

- Avoid burning soil microbiology with large applications of high salt fertilisers.
- Buffer high salt fertilisers with humic substances to reduce harming biology.
- Combine nutrients with biological foods, bio-stimulants, humic/fluvic compounds and chelating/complexing agents to encourage biological uptake
- Don't place high analysis, soluble fertilisers near germinating seeds and fresh roots, especially Nitrogen & Phosphorous, as they decommission biology
- Consider substituting in furrow, planting applications of soluble fertilisers with mineral, organic, chelated/complexed fertilisers and/or foliar applications during establishment
- Keep in mind, fertilization can have a positive effect on soil microbiology where soil is poor by improving plant growth which translates to more microbial food. Microbes also need nutrients



Trial and Observation

When introducing any new practice, it's wise to try things on a small area first to get an idea of what's involved and well they work.

Side by side trials and analysis provide valuable information on the costs and benefit of fertiliser strategies. Once we are confident of the merit of certain fertiliser applications and familiar with their implementation, we can adopt them on a wider basis.

Fertiliser Recipes

Alkaline Humic Liquid Mix – 1000L

1. To produce a humic base liquid, thoroughly mix 50kg of Potassium Humate with water in a 1000L tank.
2. Close and store in a cool, shaded environment.

The following nutrients are all compatible with, and can be mixed in various combinations with, the humic base liquid at the following rates:

- Urea - 500kg
- Ammonium Thiosulphate - 100kg
- Potassium Silicate - 100L
- Solubor - 25kg
- Sodium Molybdate – 500g
- Seaweed liquid or powder (Alkaline) @ recommended rates
- Sea Minerals – 2.5kg

Ingredients may settle over time so give the barrel a good stir before use then let settle for a couple of hours.
Avoid decanting the last fraction of the tank to leave behind any solids that precipitate at the bottom of the barrel and filter before application.

Micronised Lime, Dolomite, Gypsum, Silica, and Rock Phosphate/Guano products can applied with this mix at recommended rates but they don't remain in suspension so require tank agitation during application.
You can also add the extract of 2kg/Ha compost/vermicast and 2.5kg/Ha Molasses to the tank mix but once this active biological component is introduced, it must be put out within a couple of hours otherwise the biology will suffocate.

Application
Soil application - 50L/Ha
Note: can be applied to the foliage of plants at a rate of 15L/Ha but alkaline mixes are less effective as foliar sprays and must be applied with a minimum of 500L water per hectare to prevent leaf burn.

Acidic Liquid Trace Mix

1000L Metallic Sulphate Mix:

Amount	Product	% Nutrient in Product	Final Shuttle Percentage
50kg	Manganese Sulphate	31.50%	1.58%
50kg	Zinc Sulphate	23%	1.15%
50kg	Iron Sulphate	20%	1.00%
25kg	Copper Sulphate	25%	0.62%
2.5kg	Cobalt Sulphate	21%	0.05%
1kg	Nickel Sulphate	22.30%	0.02%

1) Mix 15kg Fulvic Acid and 10kg Citric Acid with 800L water in a shuttle.
2) Add Sulphate Nutrients (Mn, Zn, Fe, Cu, Co) and mix until dissolved.
3) Top up with water then close and store out of direct sunlight.

Foliar application: 10-20L per hectare as needed
Soil application: 25-50L per hectare as needed

200L Sodium Borate and Molybdate Mix:

Amount	Product	% Nutrient in Product	Final Shuttle Percentage
40kg	Solubor	20%	0.80%
2.5kg	Sodium Molybdate	39%	0.10%

1) Mix 3kg Fulvic Acid and 2kg Citric Acid with 160L water in a barrel.
2) Add salt nutrients (Solubor and Sodium Molybdate) and mix until dissolved.
3) Top up with water then close and store out of direct sunlight.

Foliar application: 2-4L per hectare as needed
Soil application: 5-10L per hectare as needed

Notes:
These two mixes are can be combined at a 5:1 ratio prior to application.
Compatible nutrient formulations required in larger volumes can also be added to the spray tank i.e. 10kg/Ha Urea, 7.5kg/Ha Potassium Sulphate, 5kg/Ha Magnesium Sulphate...
Uptake of soil applied trace elements is generally poor.

www.productiveecology.com

200L Liquid Fertiliser Recipes

Phosphorous Mix

Add the following ingredients to a 200L barrel along with some water and mix thoroughly until dissolved in solution. Top up the barrel with water, mix again, close, and store in a cool, shaded environment:

- Fulvic Acid powder - 3kg
- Citric Acid powder – 2kg
- MAP or MKP- 50kg

Ingredients may settle over time so give the barrel a good stir before use.
The following products are compatible with and can be combined with this mix before application, at the following recommended rates:

Urea - 10kg/Ha
Ammonium Sulphate – 7.5kg/Ha
Potassium Sulphate/Nitrate - 7.5kg/Ha
Solubor - 500g/Ha
Sodium Molybdate - 50g/Ha
Fish Hydrolysate - 2.5L/Ha
Fermented (Acidic) Kelp - 2L/Ha

Application
Foliar application - 20L/Ha
Soil application – 50L/Ha

Preferably apply in mild conditions during the early part of the day before it warms up, or towards dusk when it starts to cool down.

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Humic & Fulvic Acid Summary

Property	Humic Acid	Fulvic Acid
Fungal food & stimulant	x	
Bacterial food & stimulant		x
Chelator for metal trace elements		x
Best for foliar applied nutrients		x
High pH	x	
Low pH		x
Product Compatibility (liquid formulations)		
Urea	x	x
Ammonium sulfate		x
MAP (mono-ammonium phosphate)		x
MKP (mono-potassium phosphate)		x
Potassium sulfate		x
Potassium nitrate		x
Magnesium sulfate		x
Magnesium nitrate		x
Calcium nitrate		x
Zinc sulfate		x
Copper sulfate		x
Iron sulfate		x
Manganese sulfate		x
Soluble Boron	x	x
Soluble kelp powders	x	x
Liquid kelp		x
Lime-Life Organic™, Gyp-Life Organic™, Phos-Life Organic™ etc.	x	x

Note: Fulvic acid has very little compatibility problems – the only ones we know of are some extra strong glyphosate formulations.

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Nutrition Farming®

Recipes are downloadable from the full online article 'Targeting Plant Nutrition'. To access please go to https://lower-blackwood.shorthandstories.com/biostimulants-inagriculture/index.html

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This document is a downloadable summary of the online article & content hub **'Targeting Plant Nutrition'**. The article was produced by 'Talkin' After Hours', the Lower Blackwood Landcare's Online Community & Information Hub, and written & collated by Mark Tupman from Productive Ecology. The aim of the article is to assist land managers in making making informed decisions around the use of fertilisers for soil and plant nutrition

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