Plant Nutrition

The Chicken and the Egg

What came first, healthy plants or healthy soil ?

We all know that good soils grow healthy plants, but without plants, soil would be little more than weathered rock particles

The Nature of Soil

- The type of parent rock material, environmental conditions and location in the landscape determine the initial chemical and physical characteristics of a soil
- Soil also has a biological component, made up of living organisms and dead organic matter.
- Biology has the capacity to modify the physical and chemical characteristics of a soil environment to improve the living conditions

It Starts With Photosynthesis

- Plants, algae and certain bacteria are able to convert water, carbon dioxide and sunlight into simple sugar carbohydrates, releasing oxygen in the process

Carbon Dioxide + Water + Sunlight = Carbohydrates + Oxygen

- The energy captured from sunlight and held in carbohydrates is the energy used for living.
- Carbohydrates are also the initial molecules of Carbon, Hydrogen and Oxygen from which, along with other elements, all organic materials are built.
- This is where organic chemistry begins

Recommended viewing: How to Grow a Planet – Life from Light

It’s all happening in the rhizosphere

The Carbon Economy

Carbohydrates are utilised by living organisms throughout the community food chain. In exchange, these organisms perform a range of services that promote plant growth as it is in their best interest to further production of carbohydrates

- nitrogen fixation by nitrogen fixing bacteria
- mineral acquisition by mycorrhizal fungi and mineral solubilising bacteria
- nutrient turn over by animals
- nutrient cycling by decomposers
- humus production, aggregation and soil structuring by soil dwelling organisms
- the manufacture of substances that promote health and immunity
- pollination, distribution etc…

Exudates from living roots are the most energy rich of carbon sources. In exchange for ‘liquid carbon’, microbes in the vicinity of plant roots – and microbes linked to plants via networks of beneficial fungi – increase the availability of the minerals and trace elements required to maintain the health and vitality of their hosts. Microbial activity also drives the process of aggregation, enhancing soil structural stability, aeration, infiltration and water holding capacity.

Christine Jones

Plant Nutrition

- Living Plants are made up of 80-90% water
- 97.5% of dried plant tissue is still made up of the atmospheric elements C, O, H and N
- The remaining 2.5% is made up of minerals that come from the soil

PLANT DRY MATTER WEIGHT

ELEMENT	% DRY MATTER WEIGHT	COMPOUND IT COMES IN
$^{6}C^{12}$	45%	CO_2
$^{8}O^{16}$	45%	CO_2, H_2O, NO_3
$^{1}H^{1}$	6%	H_2O, NH_4
$^{7}N^{14}$	1.5%	NO_3, NH_4 (Rhizobia $N_2 \rightarrow NH_4$)
4 elements/gases	97.5%	
Mg	0.2%	
K	1%	
Ca	0.5%	
P	0.2%	
S	0.1%	
5 elements	2%	

9 elements = 99.5%

MINERAL PERCENT OF DRY WEIGHT PLANT MATTER – COFACTOR ENZYME ACTIVATORS

Micro Elements	Symbol	Atomic Number	Period	Plant Dry Weight %
Boron	B	5	2	0.002
Chlorine	Cl	17	3	0.01
Manganese	Mn	25	4	0.005
Iron	Fe	26	4	0.01
Copper	Cu	29	4	0.006
Zinc	Zn	30	4	0.002
Molybdenum	Mo	42	5	0.00001
All Other Elements				0.46499
				TOTAL: 0.50%

A Wholistic Approach to Plant Nutrition

Putting it All Together

"the whole is greater than the sum of the parts"

- Get to know your limiting factors (seasonal conditions, soil hydration, gas exchange, nutrient bank/availability) and find ways to work on or work with these productivity constraints
- Work on soil physical properties to enable good root penetration, water infiltration, airflow and holding capacity

The Bank Accounts

At any one time a percentage of the soil nutrients are:

- dissolved in the soil solution
- held on exchangeable sites
- within the biological and organic fraction
- locked up in the soil mineral matrix

Multi Species Cover Crops

Peas in Mix

Peas Alone

No Fert ?

Fert ?

Applying Fertilizers to the Soil

- It can be difficult to evenly distribute nutrients through the soil profile or around the root zone
- Various reactions in the soil environment can render certain nutrients unavailable to plants
- It's challenging to match availability and uptake of various nutrients to plant requirements throughout the season with soil applied fertilizers
- High analysis soluble fertilizers, particularly N and P, can hinder microbial colonization
- Soluble nutrients are prone to run off and leaching and can cause environmental issues
- Addressing soil nutrient levels can be expensive and the benefits need to be weighed up against the costs

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- Autumn is the best time to incorporate mineral amendments
- Small quantities of appropriate nutrients can be applied to provide initial nutrition for plants as they get going

Composition of Elements in Organic Soil Inputs

Product	Elements																
	Ca	Mg	K	Na	N	S	P	Zn	Cu	Fe	Mn	Co	B	Mo	Se	Si	C
Lime	40																
Dolomite	25	11															
Gypsum	23					18.6											
Sulphate of Potash			41			18											
Rock Phosphate (Ecogrowth)	21.5	0.76	1			1.6	11.2	80	50	1900	180	10	4.5	1.5	1.2	21	
Guano Gold	32.9	0.21		0.17			13.6	152	50.3	1540	429	11.9	85.3	1.1		23.8	8.6
Blood and Bone (Biosafe)	12.5		0.4		7.7	0.4	6									2	
Seamungus (Neutrog)	5	0.8	0.4		4	1	1	30	7.5	500	45		40				33
Bounce Back (Neutrog)	7	0.65	1.7	0.33	3	2	2	350		2000	500						
Eco Prime Natural (Ecogrowth)	19.5	0.8	0.2		0.2	2.3	5.4	20	20	1600	80	2	3			7.5	13.5
Phospot (Ecogrowth)	18.8	0.7	6.1			3.7	9.8	573	350	1600	160	8			11	16	0.2
Diatomaceous Earth (G.E.Co.)	1	0.6	0.2					42		4000	5	5				70	
Fish Hydrolysis (No Frills)	0.2	0.05	0.34	0.25	3.1	0.34	0.34	43.9	2.6	184	2		37.5		<4.9		
Seaweed Liquid (No Frills)	0.16	0.12	2.8	0.25	0.2	0.2	0.16	20	6	0.21	6		3	1	<1		

percentage

parts per million

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The Soil Food Web - Decomposition

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- Kick start biology with bio-stimulants/primers

Biostimulants

Any substance or microorganism applied that stimulates biology as a means to enhance plant nutrition, stress tolerance and crop quality traits, regardless of its nutrient content

- Humic substances
- Amino acid hydrolysates
- Seaweed extracts
- Beneficial Micro-organisms
- Molasses
- Milk
- Chitosan and other biopolymers
- Wood vinegar
- Etc…

Soil Primer Recipe

For 1 Hectare (scale up as required):

- Fill the spray tank with enough water to cover a hectare.
- Add 2-4L liquid seaweed or 0.5-1kg soluble seaweed powder, premixed in water, to the tank.
- Add 4-8L fish hydrolysate.
- Add 2-4L molasses, pre-mixed with warm water.
- Add 0.5-1L sea minerals (optional).
- Add compost extract made from 2kg good quality, mature compost.
- Spray out within a couple of hours of adding the compost, as the microbes will start feeding/growing and need oxygen.
- 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.

Note: due to the nature of different extraction processes, there may be compatibility issues with certain products.
Perform a jar test of the tank mix beforehand.

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- Establish strong plant microbe associations from the beginning by applying compost/vermicast extracts and inoculants with seed/seedlings

Compost & Vermicast

Small quantities or extracts of high quality mature fungal rich compost and/or vermicast be used at planting to promote the establishment of strong plant microbiome

Treatment : Control

Recipes

Compost Slurry for Seed Coating

- Place 1kg of sieved Compost/Vermicast in a fine mesh strainer bag and suspend in a 20L bucket.
- Pour a little water through the bag and massage in the water to make a slurry with the consistency of a runny pancake batter.
- Add microbe foods - 1 tablespoon of molasses (carbohydrate) dissolved in a cup of warm milk (protein) and 25g of seaweed powder (minerals)
- Slowly add the slurry to the seed in a bucket or cement mixer, stirring as you go until the outside of the seed is coated with a thin layer of moisture (approx. 250mL litre compost slurry per 25 kg seed).
- Mycorrhizal fungi/rhizobia inoculants and micronized humates can also be added in small amounts at this stage, lightly coating the seed.
- Continue mixing until the seed is dry and not sticking together.

Compost Extract for Seed, Plant and Soil Application

- Place 2kg of sieved Compost/Vermicast in a fine mesh strainer bag and suspend in a 200L drum
- Top up the drum with water and using a pump, cycle water from the drum through through the bag back into the drum.
- Just before application, microbe foods such as fish hydrolysate (4-8L), soluble seaweed (2-4L liquid/500g-1kg powder) and molasses (2-4L) can be added to the tank mix.
- Compost Extract can be applied in furrow with seed at planting, or added to a spray tank and applied to plant foliage and/or the soil to stimulate plant and soil biology

Plant Microbial Colonizers

- These microbe groups are only active on living plants but can survive and spread in dormant states between growing seasons
- Reproductive material is found in root fragments, seeds and soil around plant roots
- Commercial inoculants can be used to introduce microbial cultures into new growing environments
- Each plant species hosts specific types of microbes and must be matched with appropriate cultures
- Legumes specifically host rhizobia species i.e. peas, beans, clovers etc…
- Certain annual plant species typically host a wide range of endomycorrhizae fungi species including sorghum, millet, oats, sunflowers etc…
- Some tree families host a wide range of ectomycorrhizal fungi species i.e. Pinaceae, Betulaceae, Fagaceae, Myrtaceae etc…

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- Kick start biology with bio-stimulants/primers
- Establish strong plant microbe associations from the beginning by applying compost/vermicast extracts and inoculants with seed/seedlings
- Implement targeted nutrition strategies

Nutrient Roles

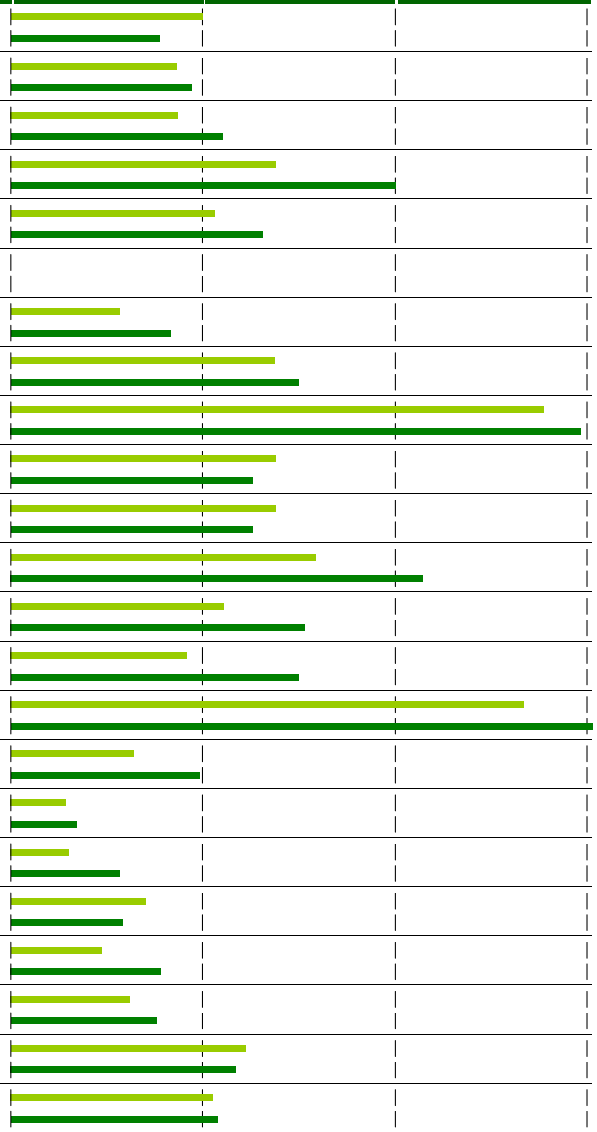
Nutrients	Structure	Photo-synthesis	Protien Synthesis	Strong Growth	Reproductive Support	Fruit Fill & Quality
Potassium						
Calcium						
Magnesium		*	*	*		
Sodium						
Ammonium						
Nitrate						
Total Nitrogen		*		*		*
Chloride						
Sulphur						
Phosphorous						
Silicon	*					
Iron						
Manganese		*			*	*
Zinc						
Boron	*		*		*	*
Copper						
Molybdenum						

* = deficiency

Plant sap-sample	[1] 202212201176 [2] 202212201177		**Sample Date:**	13-12-2022	
Name:	Productive Ecology		**Location/plot:**	Grange Investments	
Address:	5 Ryans Road 6285 Margaret River Australia		**Cultivation:** **Crop:** **Plant part:**	Avocado Orchard Avocado [1] Leaf (young)	[2] Leaf (old)

Remarks

Mineral		Current Level	Optimum	
Total Sugars	%	2,2	2,2 - 3,7	[1]
	%	1,7		[2]
pH		4,8	5,5 - 5,8	[1]
		5,2		[2]
EC	mS/cm	7,6	8,7 - 10,8	[1]
	mS/cm	8,9		[2]
K - Potassium	ppm	3741	3375 - 4350	[1]
	ppm	4353		[2]
Ca - Calcium	ppm	100	85 - 325	[1]
	ppm	159		[2]
K / Ca		37,23		[1]
		27,44		[2]
Mg - Magnesium	ppm	375	660 - 1750	[1]
	ppm	546		[2]
Na - Sodium	ppm	25	17 - 40	[1]
	ppm	29		[2]
NH4 - Ammonium	ppm	127	25 - 65	[1]
	ppm	142		[2]
NO3 - Nitrate	ppm	<20	< 40	[1]
	ppm	<20		[2]
N in Nitrate	ppm	<5	< 9	[1]
	ppm	<5		[2]
N - Total Nitrogen	ppm	472	360 - 550	[1]
	ppm	579		[2]
Cl - Chloride	ppm	406	290 - 1360	[1]
	ppm	860		[2]
S - Sulfur	ppm	230	250 - 680	[1]
	ppm	464		[2]
P - Phosphorus	ppm	640	360 - 540	[1]
	ppm	760		[2]
Si - Silica	ppm	15,6	24,4 - 39,2	[1]
	ppm	23,9		[2]
Fe - Iron	ppm	0,70	2,40 - 7,15	[1]
	ppm	0,81		[2]
Mn - Manganese	ppm	3,20	10,80 - 51,90	[1]
	ppm	6,14		[2]
Zn - Zinc	ppm	2,10	3,00 - 5,15	[1]
	ppm	1,74		[2]
B - Boron	ppm	1,68	3,60 - 9,20	[1]
	ppm	2,83		[2]
Cu - Copper	ppm	0,28	0,45 - 1,25	[1]
	ppm	0,34		[2]
Mo - Molybdenum	ppm	<0,05	< 0,10	[1]
	ppm	<0,05		[2]
Al - Aluminium	ppm	1,58	1,27 - 7,12	[1]
	ppm	1,75		[2]



Consult your advisor for appropriate fertilizer recommendations.

Plant sap-sample	[1] 202301241155	**Sample Date:**	17-1-2023
	[2] 202301241156		
Name:	Productive Ecology	**Location/plot:**	Grange Investments
Address:	5 Ryans Road	**Cultivation:**	Avocado Orchard
	6285 Margaret River	**Crop:**	Avocado
	Australia	**Plant part:**	[1] Leaf (young) [2] Leaf (old)

Remarks

Mineral		Current Level	Optimum	
Total Sugars	%	2,3	2,2 - 3,7	1
	%	4,0		2
pH		5,6	5,5 - 5,8	1
		5,6		2
EC	mS/cm	10,4	8,7 - 10,8	1
	mS/cm	11,4		2
K - Potassium	ppm	3933	3375 - 4350	1
	ppm	3917		2
Ca - Calcium	ppm	331	85 - 325	1
	ppm	381		2
K / Ca		11,88		1
		10,29		2
Mg - Magnesium	ppm	1394	660 - 1750	1
	ppm	1986		2
Na - Sodium	ppm	112	17 - 40	1
	ppm	134		2
NH4 - Ammonium	ppm	69	25 - 65	1
	ppm	45		2
NO3 - Nitrate	ppm	<20	< 40	1
	ppm	<20		2
N in Nitrate	ppm	<5	< 9	1
	ppm	<5		2
N - Total Nitrogen	ppm	512	360 - 550	1
	ppm	538		2
Cl - Chloride	ppm	2193	290 - 1360	1
	ppm	2709		2
S - Sulfur	ppm	530	250 - 680	1
	ppm	768		2
P - Phosphorus	ppm	403	360 - 540	1
	ppm	261		2
Si - Silica	ppm	18,0	24,4 - 39,2	1
	ppm	18,8		2
Fe - Iron	ppm	5,48	2,40 - 7,15	1
	ppm	4,66		2
Mn - Manganese	ppm	34,27	10,80 - 51,90	1
	ppm	31,97		2
Zn - Zinc	ppm	26,73	3,00 - 5,15	1
	ppm	24,10		2
B - Boron	ppm	2,70	3,60 - 9,20	1
	ppm	3,16		2
Cu - Copper	ppm	1,08	0,45 - 1,25	1
	ppm	0,74		2
Mo - Molybdenum	ppm	0,10	< 0,10	1
	ppm	0,08		2
Al - Aluminium	ppm	3,61	1,27 - 7,12	1
	ppm	4,07		2

Consult your advisor for appropriate fertilizer recommendations.

Cereals Trace Nutrient Recipe

Amount	Product	% Nutrient in Product	Final Shuttle Percentage
25kg	Manganese Sulphate	31.5%	0.8%
25kg	Zinc Sulphate Hepta	23%	0.6%
25kg	Iron Sulphate Hepta	20%	0.5%
15kg	Solubor	20%	0.3%
10kg	Copper Sulphate	25%	0.25%
5kg	Cobalt Sulphate	21%	0.1%
2.5kg	Sodium Molybdate	39%	0.1%
	Total Sulphur (from Sulphates)		1%

Mix 20kg Fulvic Acid with 1000Lwater in a shuttle.
Decant 1/5 of this mixture into a 200L drum.
Add Sulphate Nutrients (Mn, Zn, Fe, Cu, Co) to the 1000L shuttle, top up with water and mix until dissolved.
Add salt nutrients (Solubor and Sodium Molybdate) to the 200L barrel and mix until dissolved.
Close and store out of direct sunlight.

Notes:
These two mixes can be combined in the spray tank.
Nutrients required in larger volumes can be added to the spray tank separately i.e. 5kg/Ha Potassium Sulphate, 5kg/Ha Magnesium Sulphate…

Foliar application - 20L per hectare every 10-14 days or as needed.
Soil application - 40L per hectare every 10-14 days or as needed

DIY Foliar Trace Nutrients Recipe

For a 1 Hectare Application (scale up as required):

- In a 20L bucket add 500g Fulvic Acid ,pre-mixed with water (organic/amino acids are used to get nutrients into the right chelation/redox state for effective plant uptake and utilisation)
- If you wish to store the mixture, add a further 300g citric acid
- Fill the bucket with water
- Decant 4 litres of this mix into a separate container.
- Add appropriate amounts of required sulphate nutrients for a 1Ha foliar application i.e. 1kg Iron Sulphate, 1kg Manganese Sulphate,, 500g Copper Sulphate, 100g Cobalt Sulphate, 50g Sodium Molybdate etc… to the 20L Bucket
- Add appropriate amounts of the salt nutrients for a 1Ha application i.e. 500g Solubor, 50g Sodium Molybdate to the smaller container.
- Mix well until all ingredients are dissolved, adding more water if necessary
- Close and store out of direct sunlight

Notes:

These two mixes can be combined in the spray tank.

Nutrients required in larger volumes can be added to the spray tank separately i.e. 5kg/Ha Potassium Sulphate, 5kg/Ha Magnesium Sulphate…

If applying this solution to the soil, double the application rate

Foliar Nutrient Application

- In a barrel, mix recommended rates of chelated nutrient solution with 5-10L/Ha of fish hydrolysate.
- Fill the spray tank with water and if using bore or dam water (rainwater can be used as it is) adjust the pH to below 6 with citric acid. *This really important measure is used to neutralise reactive carbonates and bicarbonates in groundwater. The effect is temporary so the mix must be sprayed out within a few hours of pH adjustment.*
- Add nutrient, fish hydrolysate solution to the spray tank.
- Check the tank pH again to make sure it is between 4-6, preferably between 5-5.5.
- Add the recommended amount of a suitable surfactant/spreader/sticker agent.
- Spray out in dry 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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- Establish strong plant microbe associations from the beginning by applying compost/vermicast extracts and inoculants with seed/seedlings
- Implement efficient nutritional strategies with targeted seasonal applications, carbon based fertilizers and foliar nutrient sprays
- Keep the soil covered with a diversity of living plants and organic residues
- Manage vegetation to promote and prolong photosynthetic activity with succinct grazing, canopy management etc…
- Minimize/avoid heavy tillage, compaction and biocides

Questions ?