Good Nutrient Application

The 4Rs of Fertiliser Application

- Right Type
- Right Rate
- Right Time
- Right Place

Nutrient Use Efficiency in the Agricultural Ecosystems

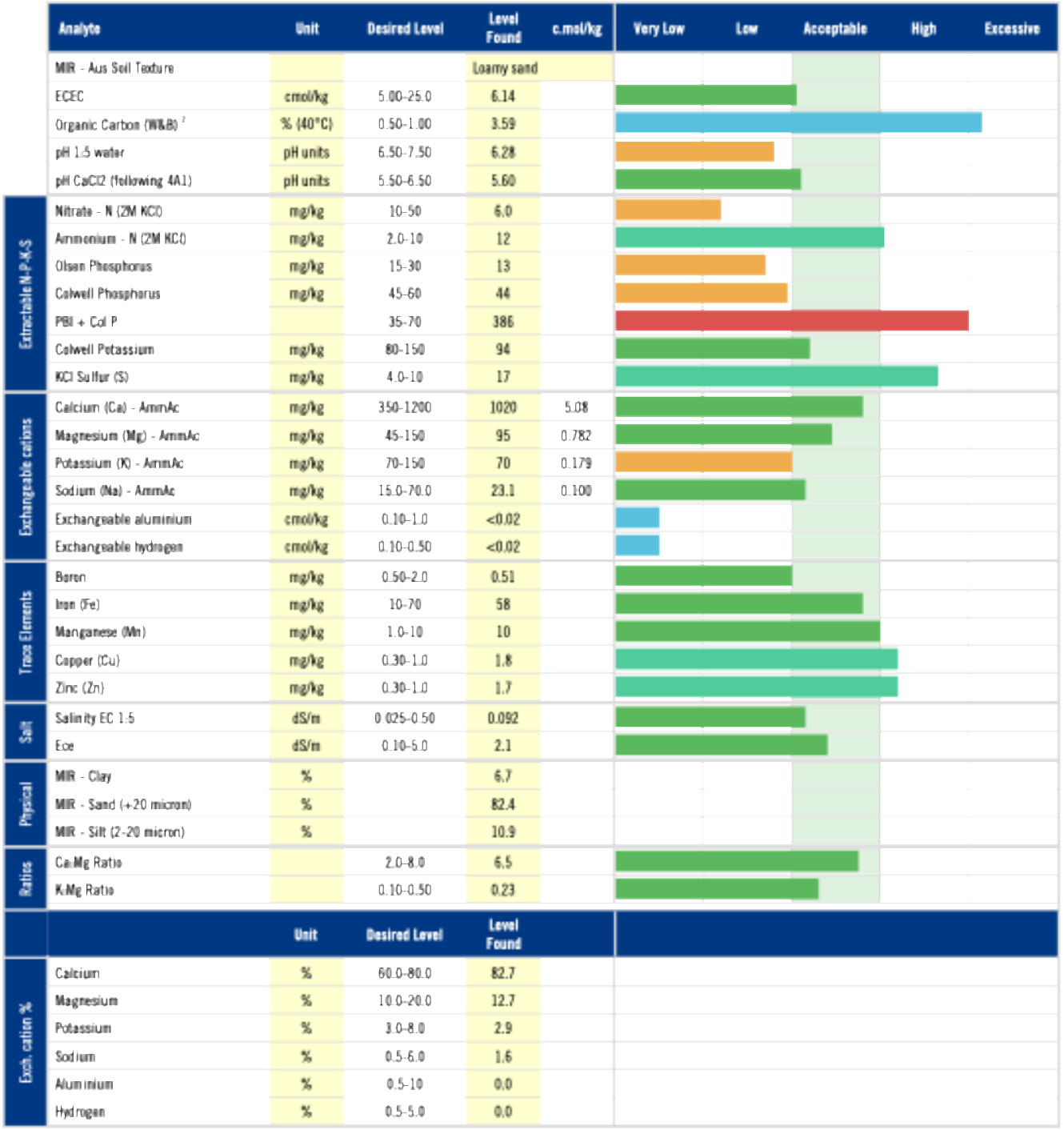
Nutrient	Efficiency (%)
Nitrogen	30–50
Phosphorus	15–20
Potassium	50–60
Sulphur	8–12
Zinc	2–5
Iron	1–2
Copper	1–2
Manganese	1–2
Boron	2–3
Molybdenum	2–5

https://www.mdpi.com/2077-0472/11/4/372

Contextual Factors Affecting NUpE

- soil characteristics (physical, chemical and biological)
- plant characteristics (nutrient absorbing capacity, age, cultivars, root morphology etc…)
- climate (sunlight, rainfall, temperature etc…)

Test,
Don’t
Guess



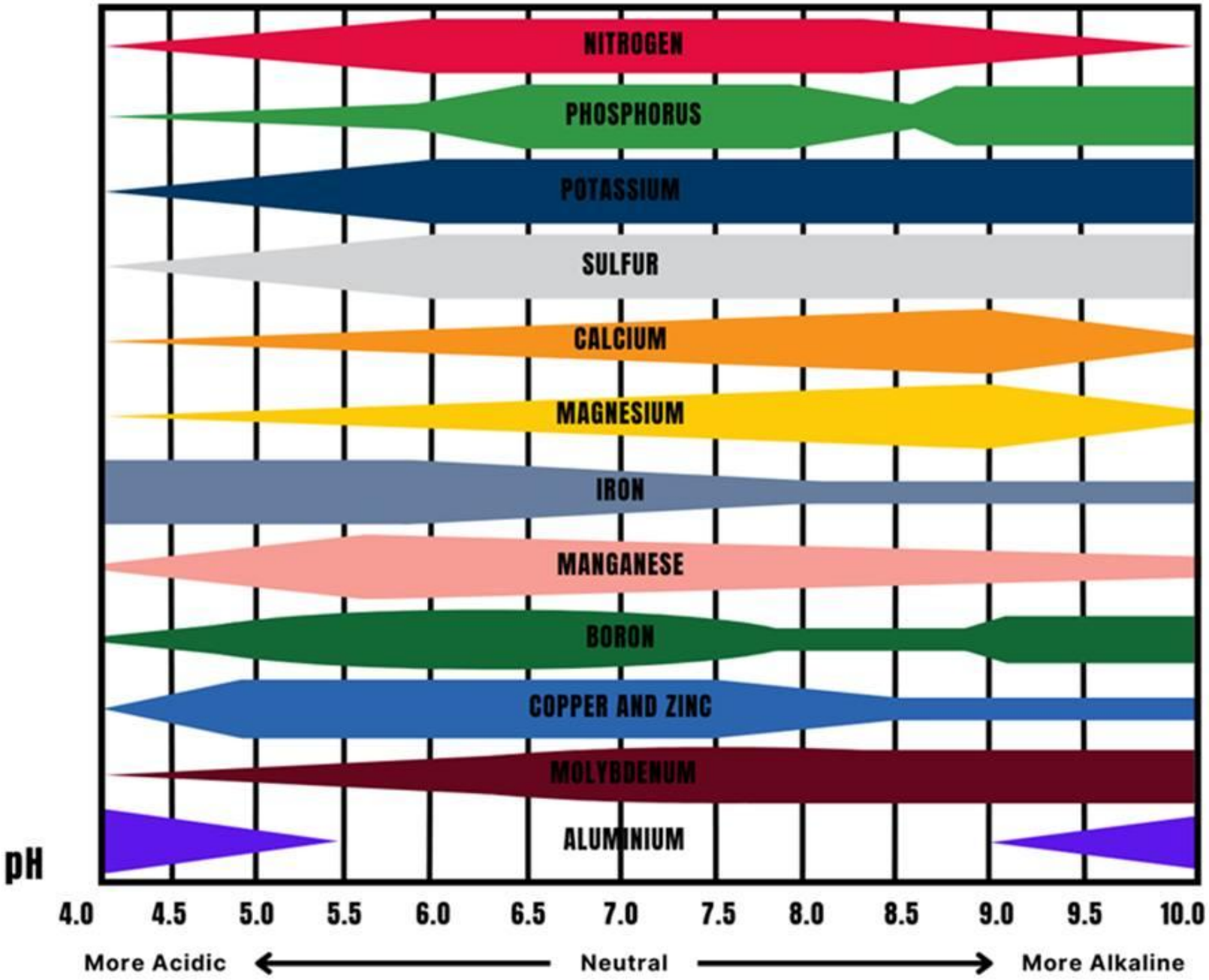
	Analyte	Unit	Desired Level	Level Found	c.mol/kg
	MIR - Aus Soil Texture			Loamy sand	
	ECEC	cmol/kg	5.00-25.0	6.14	
	Organic Carbon (W&B) [2]	% (40°C)	0.50-1.00	3.59	
	pH 1:5 water	pH units	6.50-7.50	6.28	
	pH CaCl2 (following 4A1)	pH units	5.50-6.50	5.60	
Extractable N-P-K-S	Nitrate - N (2M KCl)	mg/kg	10-50	6.0	
	Ammonium - N (2M KCl)	mg/kg	2.0-10	12	
	Olsen Phosphorus	mg/kg	15-30	13	
	Colwell Phosphorus	mg/kg	45-60	44	
	PBI + Col P		35-70	386	
	Colwell Potassium	mg/kg	80-150	94	
	KCl Sulfur (S)	mg/kg	4.0-10	17	
Exchangeable cations	Calcium (Ca) - AmmAc	mg/kg	350-1200	1020	5.08
	Magnesium (Mg) - AmmAc	mg/kg	45-150	95	0.782
	Potassium (K) - AmmAc	mg/kg	70-150	70	0.179
	Sodium (Na) - AmmAc	mg/kg	15.0-70.0	23.1	0.100
	Exchangeable aluminium	cmol/kg	0.10-1.0	<0.02	
	Exchangeable hydrogen	cmol/kg	0.10-0.50	<0.02	
Trace Elements	Boron	mg/kg	0.50-2.0	0.51	
	Iron (Fe)	mg/kg	10-70	58	
	Manganese (Mn)	mg/kg	1.0-10	10	
	Copper (Cu)	mg/kg	0.30-1.0	1.8	
	Zinc (Zn)	mg/kg	0.30-1.0	1.7	
Salt	Salinity EC 1:5	dS/m	0.025-0.50	0.092	
	Ece	dS/m	0.10-5.0	2.1	
Physical	MIR - Clay	%		6.7	
	MIR - Sand (+20 micron)	%		82.4	
	MIR - Silt (2-20 micron)	%		10.9	
Ratios	Ca:Mg Ratio		2.0-8.0	6.5	
	K:Mg Ratio		0.10-0.50	0.23	

		Unit	Desired Level	Level Found
Exch. cation %	Calcium	%	60.0-80.0	82.7
	Magnesium	%	10.0-20.0	12.7
	Potassium	%	3.0-8.0	2.9
	Sodium	%	0.5-6.0	1.6
	Aluminium	%	0.5-10	0.0
	Hydrogen	%	0.5-5.0	0.0

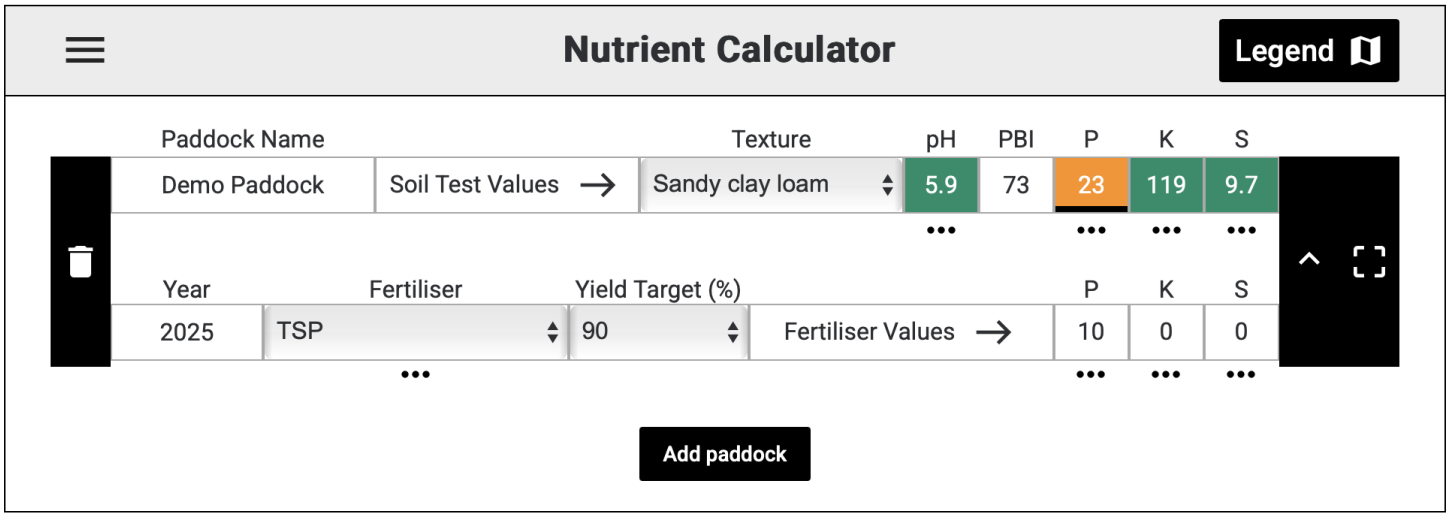
Phosphorous Buffering Index

PBI Category	Classification	Colwell P indicating good soil P status
<15	Extremely low	20-24
15 – 35	Very very low	24-27
36 – 70	Very low	27-31
71 – 140	Low	31-36
141 – 280	Moderate	36-44
281 – 840	High	44-64
> 840	Very high	64+

PH AND NUTRIENT AVAILABILITY



FARMACIST



ABOUT THE CALCULATOR | HOW TO USE THE CALCULATOR

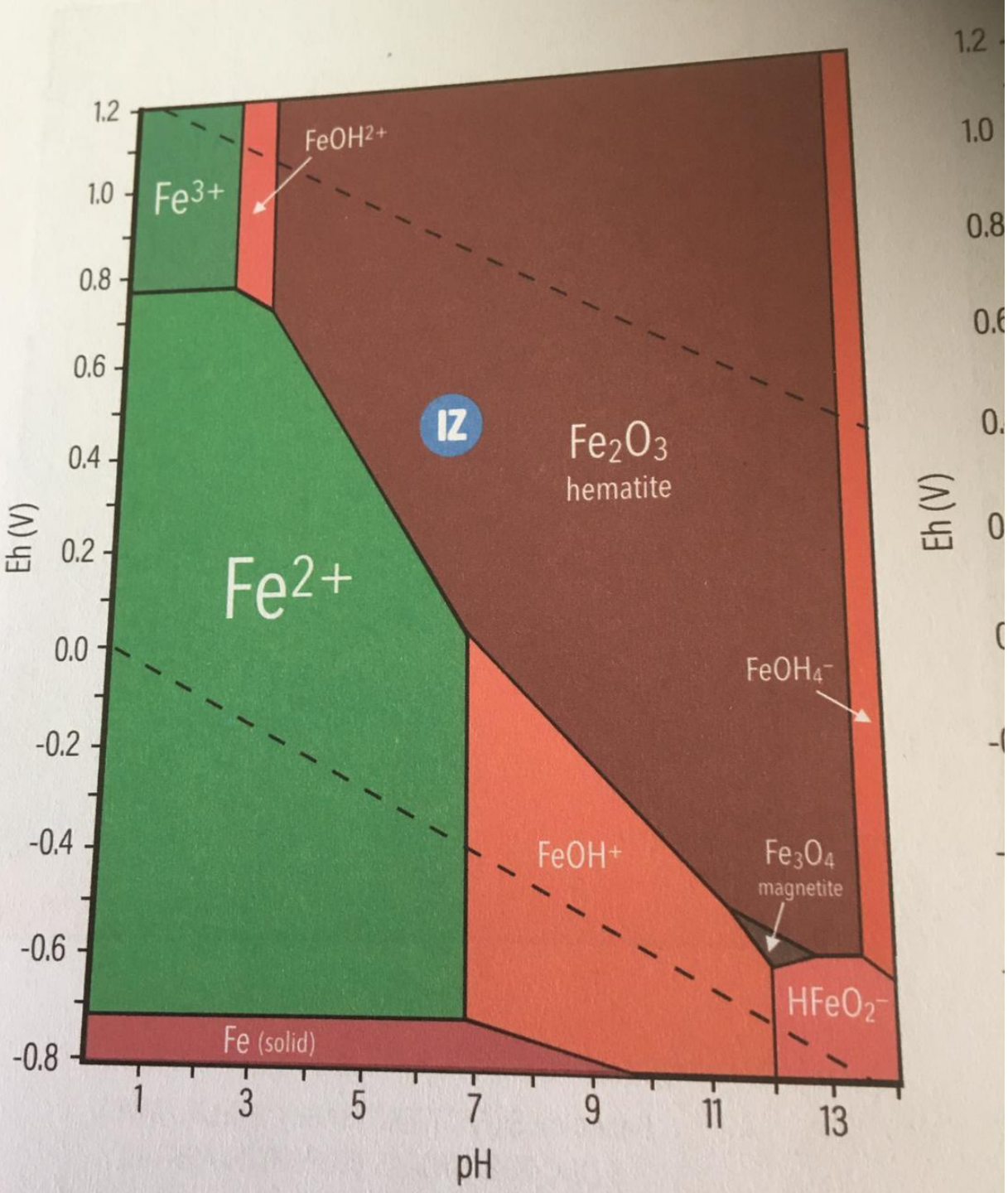
The Nutrient Calculator determines nutrient status, and estimates the quantities of phosphorus, potassium or sulphur required to increase current soil test values to meet target values (termed ‘capital quantity’) to achieve a user-defined relative yield.

It uses soil test results from a representative 0–10 cm soil sample that has been analysed for phosphorus buffering index (PBI), Colwell phosphorus, Colwell potassium, sulphur (KCl-40S) and pH (CaCl2).

Growers and consultants can manually enter their soil test results or import results from a spreadsheet to produce colour coded reports.

Note:

- The calculator is intended only for high rainfall (>600 mm annual) pastures in south west Western Australia. The calculator uses soil sample test results to estimate soil nutrient status and requirements, and the fertiliser rates to supply required nutrients.
- The calculator uses critical soil test values derived from nutrient response trials across Australia to estimate soil nutrient status. It does not analyse the economics of the estimated nutrients required.


1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
Eh (V)
1
3
5
7
9
11
13
pH
Fe^{3+}
$FeOH^{2+}$
Fe^{2+}
IZ
Fe_2O_3
hematite
$FeOH_4^-$
$FeOH^+$
Fe_3O_4
magnetite
$HFeO_2^-$
Fe (solid)

ANALYTES

Paddock	General Grey	Strip 1	Strip 2	Strip 3	Strip 4
Site	Oats	Oats	Oats	Oats	Oats
Target Yield	-	-	-	-	-
Lab No.	1HBP24159	1HBP24160	1HBP24162	1HBP24165	1HBP24167
Weight/Age	0g/0d	0g/0d	0g/0d	0g/0d	0g/0d
Nitrogen (%)	2.82	3.15	3.1	3.18	2.51
Nitrate-nitrogen (mg/kg)	18	19	27	28	12
Phosphorus (%)	0.36	0.52	0.51	0.45	0.33
Potassium (%)	3.67	3.85	4.1	4.11	3.75
Sulfur (%)	0.24	0.28	0.28	0.3	0.23
Copper (mg/kg)	5.7	7	7	7.6	4.9
Zinc (mg/kg)	22.4	23.9	23.5	24.2	19.8
Manganese (mg/kg)	27.7	19.6	22.5	29.8	31.5
Chloride (%)	0.82	1.57	1.31	1.25	1.16
Iron (mg/kg)	51.8	58.7	57.6	63.7	47.1
Boron (mg/kg)	3.9	3.5	4.3	5	3.3
Calcium (%)	0.26	0.37	0.39	0.33	0.31
Magnesium (%)	0.15	0.17	0.2	0.18	0.15
Sodium (%)	0.27	0.19	0.26	0.18	0.25
Molybdenum (µg/Kg)	4670	5166	6328	6188	3496

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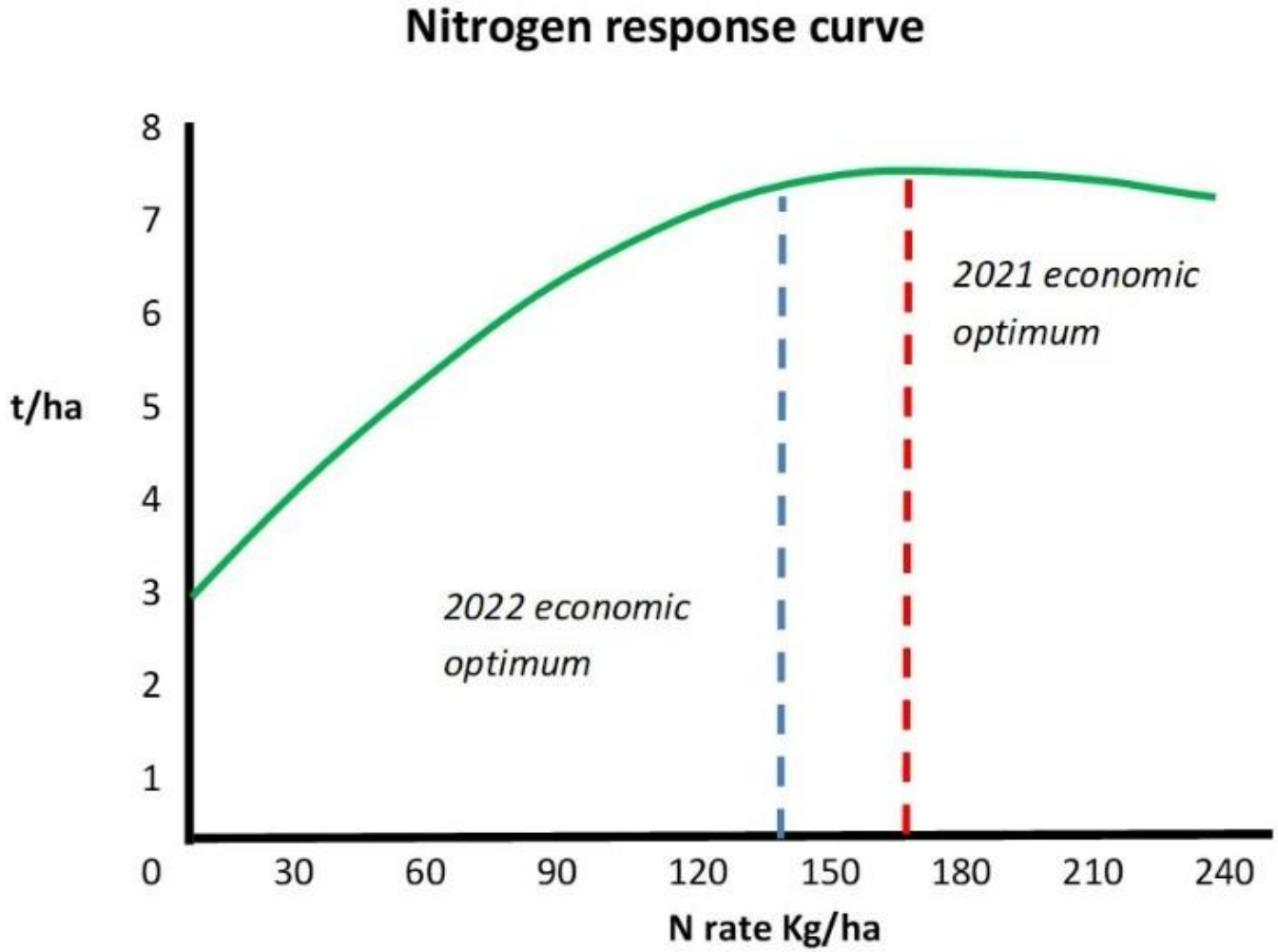
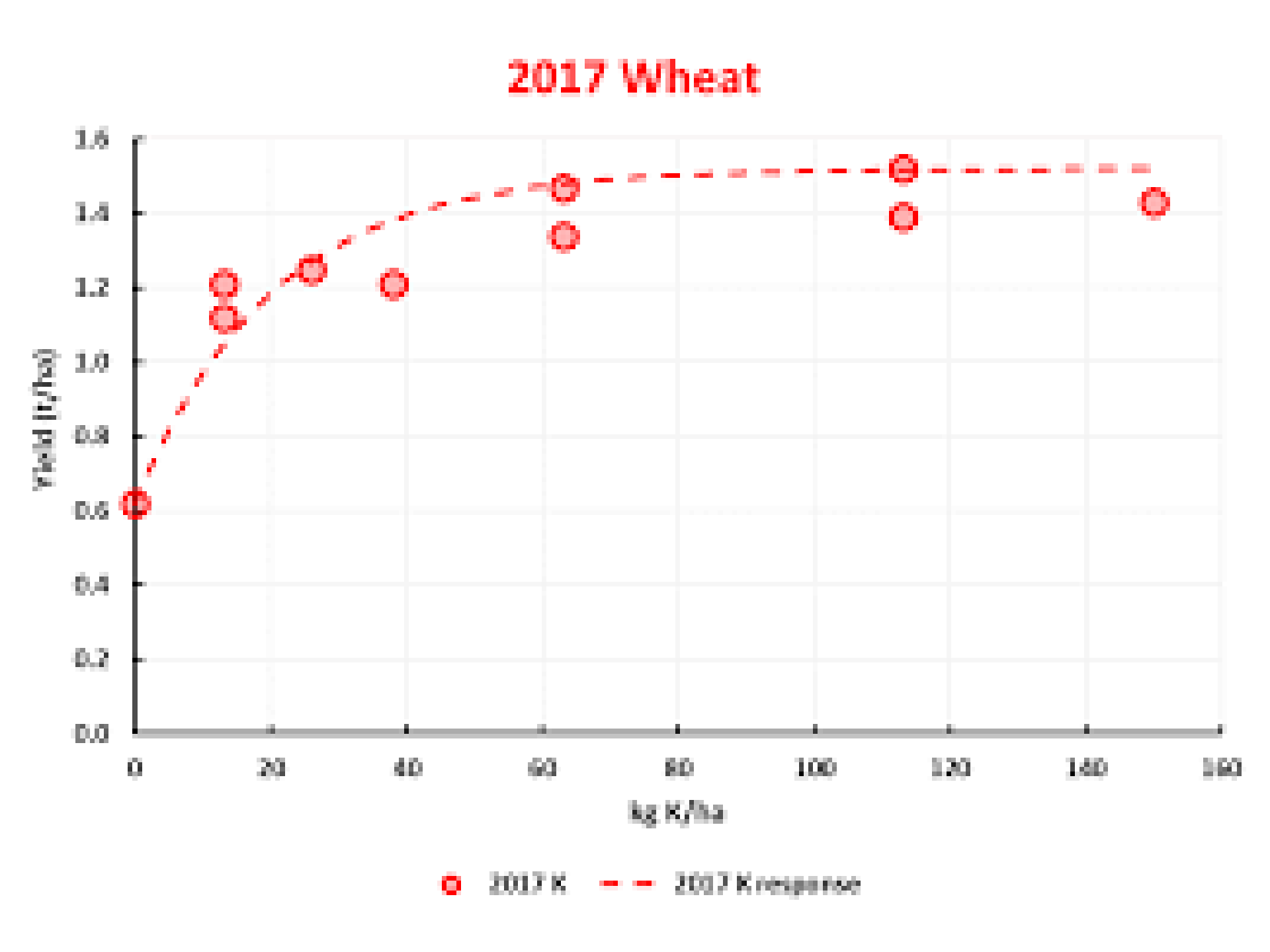
Product Formulae, Analyses and Solubility

Product	Formula	Typical Analysis					Solubility kg/100 L at 20^0 C
		% N	% P	% K	% S	% Other	
Urea	$CO(NH_2)_2$	46					105
Ammonium Sulfate	$(NH_4)_2SO_4$	21			24		75
MAP	$NH_4H_2PO_4$	12	26				37
MKP	KH_2PO_4		22.5	28			23
Potassium Nitrate	KNO_3	13		38.3			32
Potassium Sulfate	K_2SO_4			41.5	16.5		11
Calcium Nitrate	5 $Ca(NO_3)_2$. $NH_4NO_3.10H_2O$	15.5				19% Ca	250
Magnesium Sulfate	$Mg\ SO_4.7H_2O$				12.4	9.6% Mg	71
Solubor	$Na_2B_8O_{13}.4H_2O$					20.5% B	9.5
Copper Sulfate	$CuSO_4.5H_2O$						32
Iron Sulfate	$FeSO_4.7H_2O$				11.2	19.7% Fe	48
Manganese Sulfate	$MnSO_4.H_2O$				19	31% Mn	70
Sodium Molydbate	$Na_2MoO_4.2H_2O$					39% Mo	65
Zinc Sulfate	$ZnSO_4.7H_2O$				11	22.7	96


Nitrogen response curve
t/ha
8
7
6
5
4
3
2
1
0
30
60
90
120
150
180
210
240
N rate Kg/ha
2021 economic optimum
2022 economic optimum


2017 Wheat
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Yield (t/ha)
0
20
40
60
80
100
120
140
160
kg K/ha
2017 K
2017 K response

significantly

Nutrient Mobility in Soils

Nutrient mobility in the soil

Very Mobile – (prone to leaching) Nitrate Nitrogen, Sulphates, Boron

Moderately Mobile – Ammonium Nitrogen (Ammonium Nitrogen is temporarily immobile), Potassium, Calcium, Magnesium, Molybdenum

Immobile – Organic Nitrogen, Phosphorus, Copper, Iron, Manganese, Zinc (Chelated forms of Copper, Iron, Manganese and Zinc are mobile and resistant to leaching)

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.

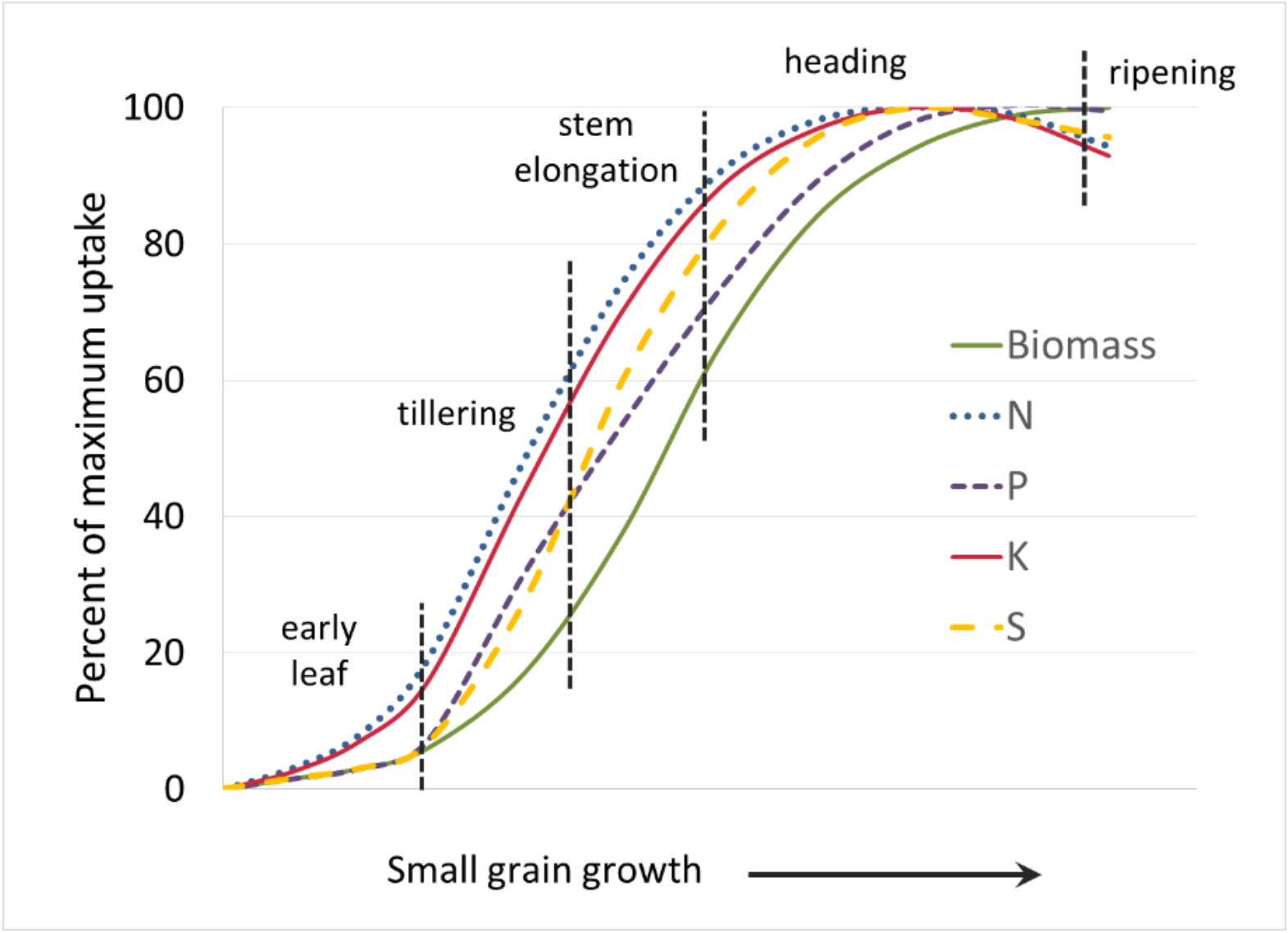
Salt Index of Common Fertilizers

Fertilizer	Analysis	Salt index[a]	Relative salinity[b]
Sodium nitrate	16.5 N	100.0	100.0
Ammonium nitrate	35 N	104.7	49.4
Ammonium sulphate	21 N	69.0	53.7
Calcium nitrate	11.9 N, 17 Ca	52.5	30.1
Urea	46 N	75.4	26.7
Diammonium phosphate	21 N, 23 P	34.2	12.7
Monoammonium phosphate	12 N, 27 P	29.9	12.7
Superphosphate (single)	7.8 P	7.8	16.5
Superphosphate (triple)	19.6 P	10.1	8.5
Potassium chloride	49.8 K	116.3	38.5
Potassium nitrate	13 N, 38 K	73.6	23.6
Potassium sulphate	45 K	46.1	17.0
Calcium carbonate	40 Ca	4.7	1.9
Calcium sulphate	23 Ca	8.1	5.8
Magnesium sulphate	16 Mg	44.0	44.5

Contextual Factors Affecting NUtE

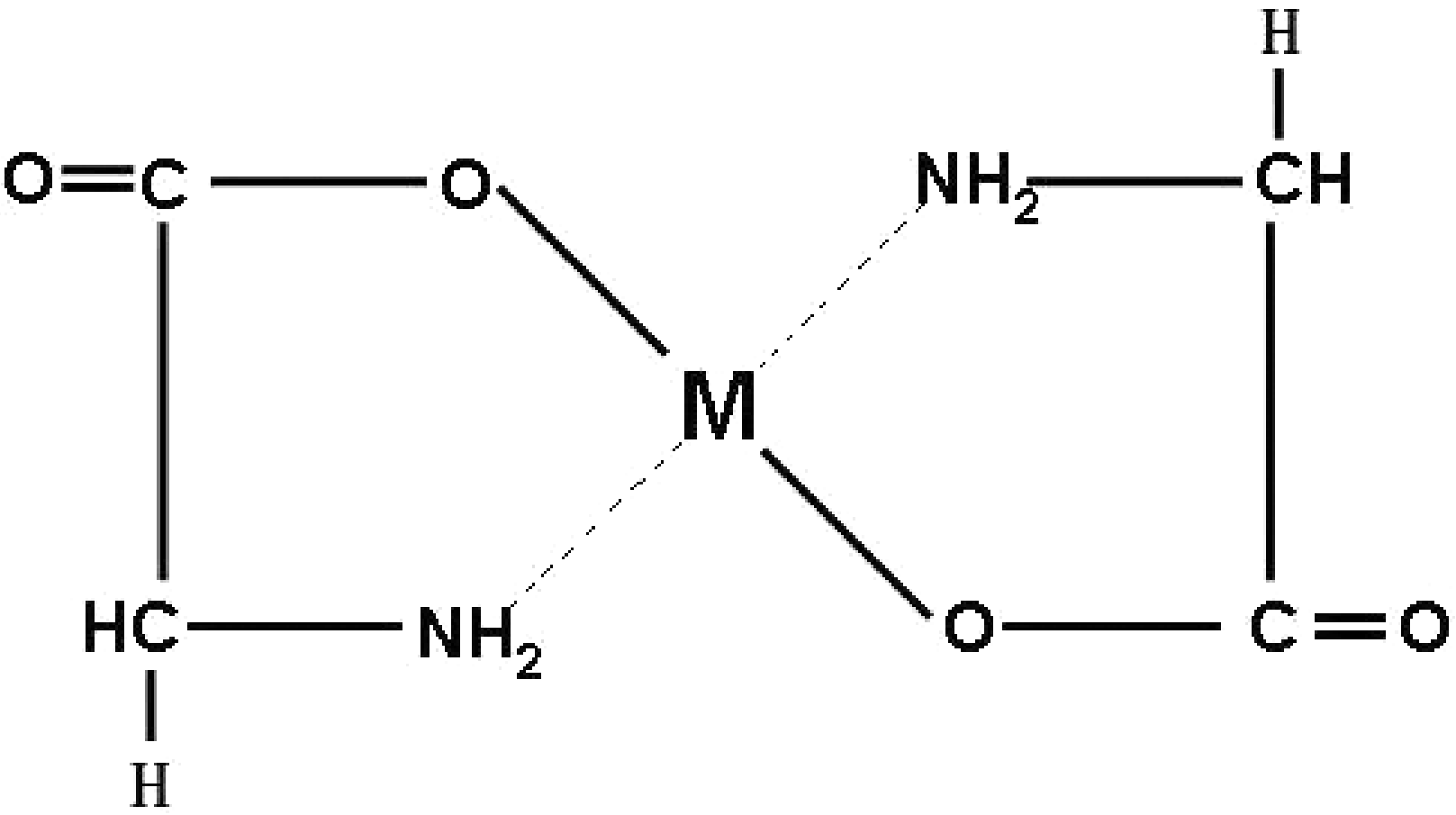
- Crop Requirements
- Nutrient form
- Enzyme co-factors
- Energy supply
- Nutrient balance

Crop Requirements



https://landresources.montana.edu/soilfertility/nutuptake.html

Organic Chelation



Efficient Protein Synthesis

- It takes lots of energy to convert nitrate to ammonia, to amino acids and proteins so the form of nitrogen you apply can save or cost the plants energy
- Certain nutrient co-factors 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 protiens i.e. Sulphur to form Methionine & Cysteine

Nutrient Roles in the Plant

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

Liquid Trace Element Formulation

Recipe:

Amount	Product	% Nutrient in Product	Final Shuttle Percentage
25kg	Manganese Sulphate	32.00%	0.80%
25kg	Iron Sulphate	20%	0.50%
25kg	Zinc Sulphate	23%	0.60%
20kg	Copper Sulphate	25%	0.50%
20kg	Solubor or Boric Acid	20%	0.40%
10kg	Cobalt Sulphate	21%	0.20%

1) Mix 20kg Fulvic Acid and 5kg Citric Acid with 800L water in a shuttle.
2) Add the above nutrients, one at a time to the 1000L shuttle and mix well until dissolved.
3) If required, you can also add up to 1kg of Nickel Sulphate to this mix.
4) Top up with water, then close and store out of direct sunlight.

Ingredients may settle a little over time so give the barrel a good stir before use.

Application:

Foliar Application Rate - 10L/Ha

Note: this mix can be applied at higher rates to the soil, but the uptake of soil applied trace elements is generally much poorer.

Other optional inputs that can be added to the diluted spray tank mix prior to application include:
10-20kg/ha Urea
10-15kg Potassium Nitrate
5-7.5kg/Ha Potassium Sulphate
5-7.5kg/Ha Magnesium Sulphate
50-100g/Ha Sodium Molybdate
4-5L/Ha Fish Hydrolysate
4-5L/Ha Molasses

Ongoing Improvement