Soil constraints, interpreting soil tests and making fertiliser decisions

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This workshop is funded by the Australian Government's Natural Heritage Trust and delivered by Glenelg Hopkins CMA and Southern Farming Systems

Topic areas

Soil Principles

Overview of the main soil constraints in SW Victoria & tips on how to identify

- Nutritional constraints
- Soil acidity
- Soil structural issues

Interpreting soil test results to make fertiliser decisions

- Targets
- Calculating what you need
- Choosing products
- Using calculators
- Considerations of cost

Fertiliser costs, prioritising paddocks & tips

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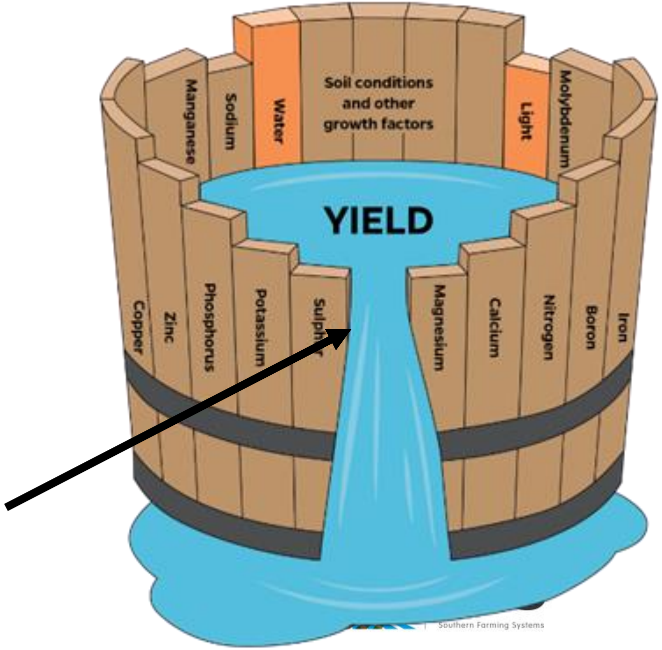
Soil Principles/Concepts

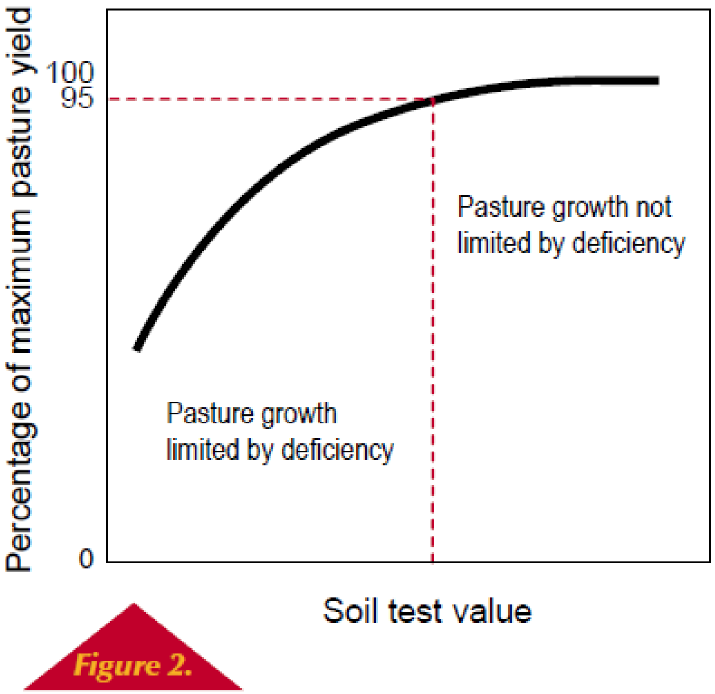
Liebig's law of the minimum

- Plants will grow only as much as the least available nutrient allows them to.
- Yield is not governed by the total or most abundant resource or balances in cations.
- Least nutrients tend to be the ones plants have high requirements for (N, P, K, S).



Minimum

Soil test pasture response relationships exist for P, K, S and soil pH



A generalised calibration relationship between relative pasture production and soil test value.

Trials have allowed calibrations between the soil test and pasture production to be defined.

Upper limit to the amount of nutrient a plant needs.

Critical soil test value is at 95% of maximum yield.

These allow us to choose what anticipated production level to aim for e.g. 90%.

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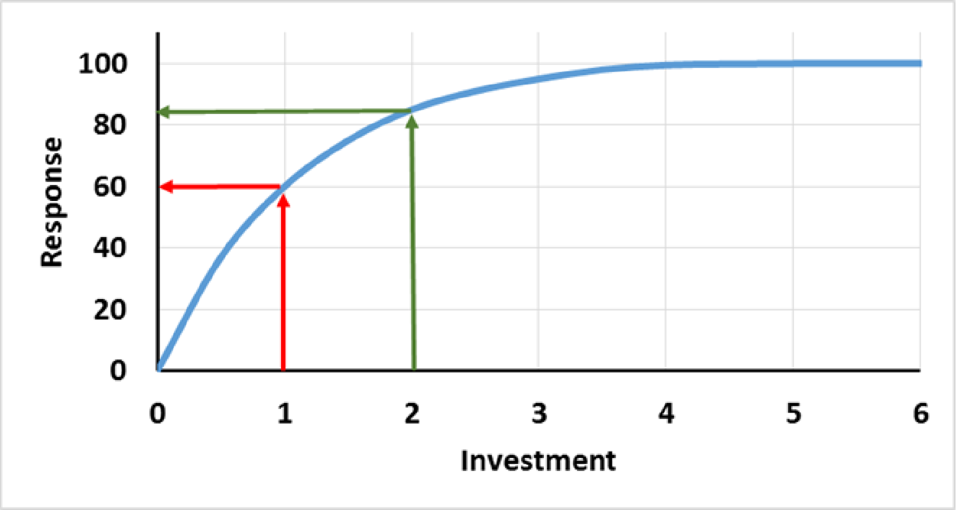
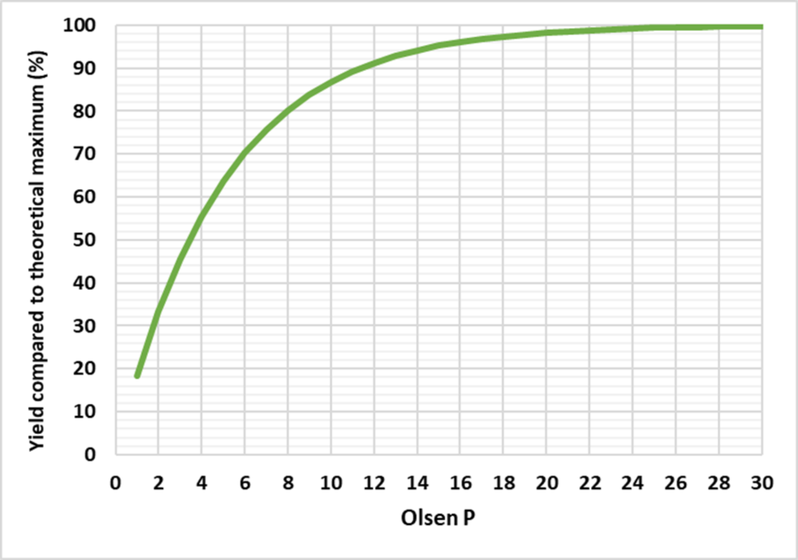
Law of diminishing returns

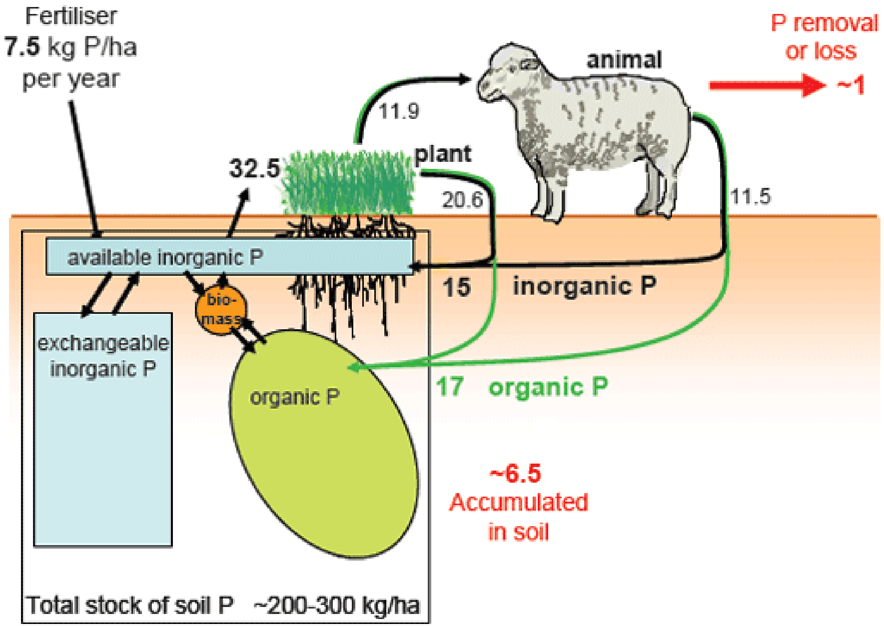
Diminishing response to increasing nutrients or pH.
The decrease in marginal output for every additional input.





Law of conservation of matter

- Fundamental scientific principle stating that matter cannot be created or destroyed—only transformed
- Means nutrients contained in products sold off the farm (hay, animals) or 'tied up' by the soil are not replaced, so the pool of nutrients in the soil becomes depleted.



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Fertiliser grows fat & longer leaves

Example: Long term phosphate trial, Hamilton PVI:

15 kg P/ha/year (Olsen P 13) grew 2.8 t DM/ha in winter and 12.4 t DM/ha/yr

1 kg P/ha/year (Olsen P 5 mg/kg) grew 1.6 t/ha in winter and 6 t DM/ha/yr.

Main soil constraints in SW Victoria & how to identify them?

Hidden hunger

Leaf symptoms show up when deficiencies are severe.

Identification of soil nutritional constraints:

- Soil tests - most nutrients but not molybdenum.
- Tissue test clover in spring for micronutrients.
- Test strips.
- Compare growth in urine or dung patches, gateways, stock camps to the rest of paddock.

Photo: Lisa Warn, N response

Test (mg/kg)	Rest of paddock	Urine patch
Nitrogen (Nitrate & ammonium)	7*	53
Phosphorus (Olsen)	33.5	27.3
Potassium (Colwell)	217	435
Sulfur (KCl40)	6.8*	13.1

* = below critical value

Soil acidity

Impacts:

Nutrient availability

- Molybdenum decreased at < 5.0
- Aluminium becomes soluble & potentially toxic < pH 4.8.
- Phosphorous tied up by Al when pH < 4.3

Root growth and nutrient uptake.

Legume nodulation – rhizobia sensitive

Soil Biology - slows mineralisation

Measured by pH – potential hydrogen ions.

pH varies throughout the soil profile

Acidity is generally confined to the topsoil

Soil acidity affects root growth hence nutrient supply

- **Acid layer, pH(Ca) 4.0, about 50% Exc. aluminium**

Photo Latrobe Uni

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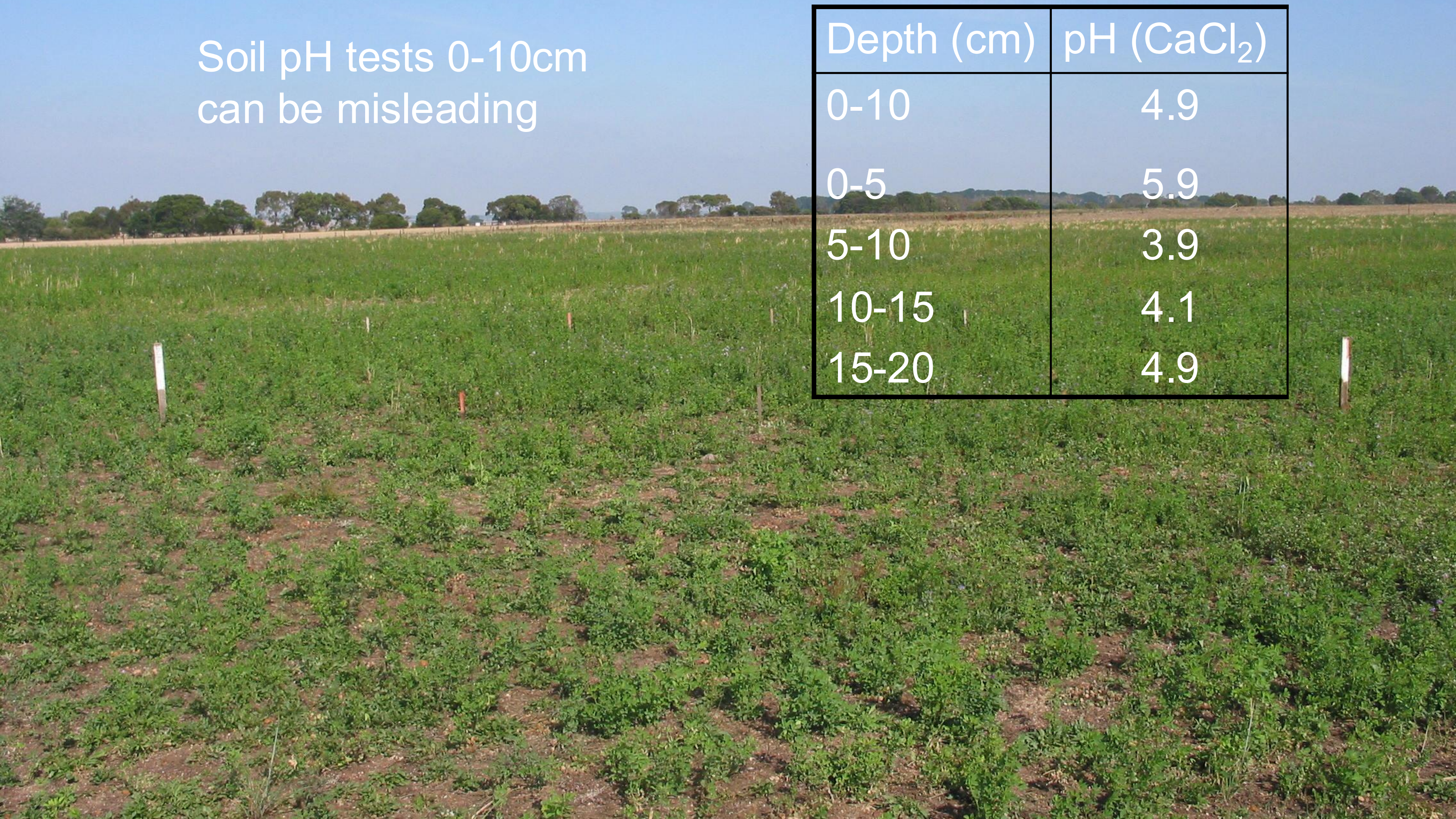
Effect on nodulation

If lime has been applied, it can mask acid bands at 5 to 15 or 20cm.

Soil testing in 5 cm increments is a better way to assess what's happening.

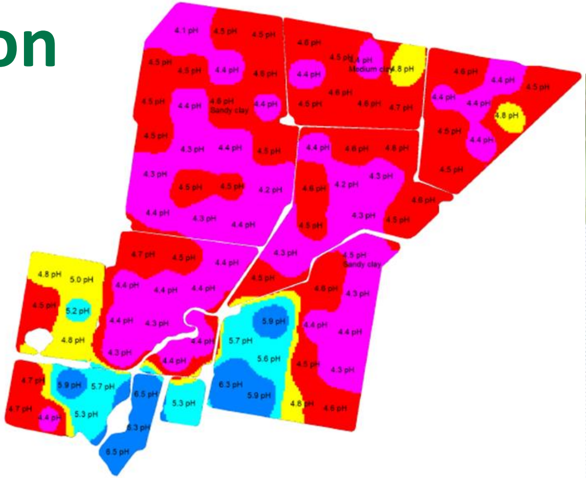
Do this for sensitive crops.



Soil pH tests 0-10cm can be misleading

Depth (cm)	pH ($CaCl_2$)
0-10	4.9
0-5	5.9
5-10	3.9
10-15	4.1
15-20	4.9

Identification



Spatial variation

Soil testing

pH testing kits

Observations to use

- Nodulation – few or whitish (not pink) nodules on legume roots
- Weed indicators, sorrel but also silver grass, bent grass and fog grass favoured by reduced N fixation and low nitrogen

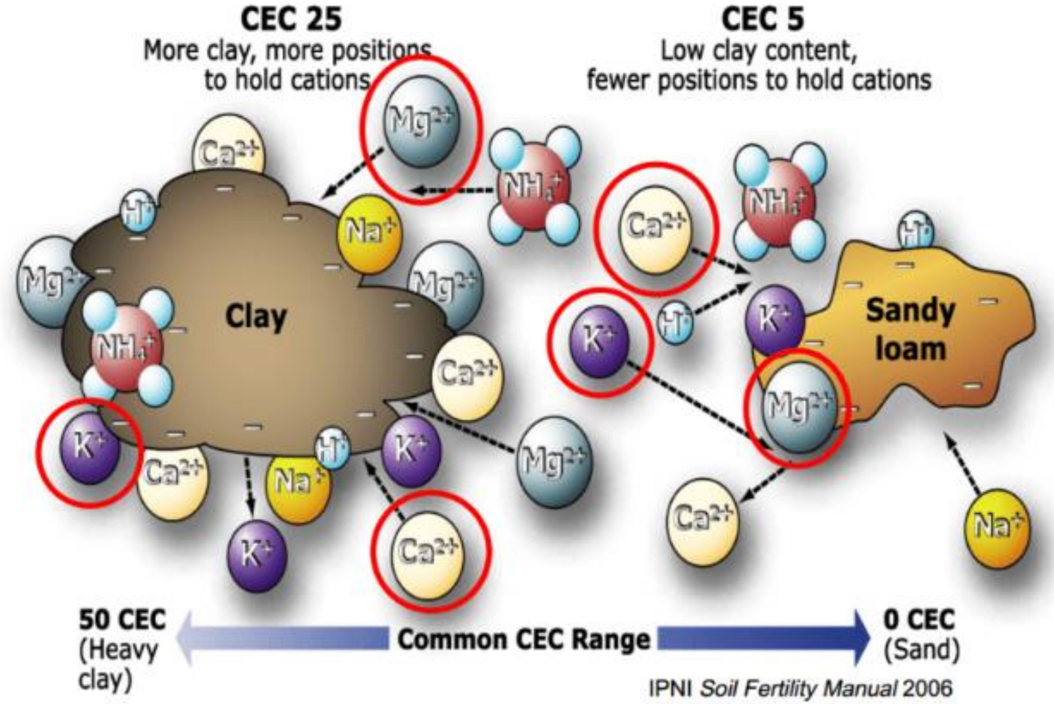
Soil structural issues

Influenced by:

High exchangeable sodium

High exchangeable magnesium

Amount of soil organic carbon



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Exchangeable sodium % (ESP)

High ESP weakens aggregates & soils can disperse.

More apparent at depth but treat if on the topsoil.

ESP greater than 6% is sodic.

Do an aggregate stability test to check for dispersion.

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Soil organic carbon

SOC < 1%, functionally impaired, soil will slake (soil aggregates fall apart).

2% is considered optimal for aggregate stability.

General targets: SOC greater than 2% in crops & 3% in pastures.

But aim for the upper limits of what our soils & climate can produce.

Check root growth

Barriers to root growth

- Dense clay layers
- Buckshot
- Rock layers
- Compacted layers
- Carbonate (high pH)
- Salinity
- Plough pans
- Waterlogging (No oxygen)
- pH & Aluminium

Understanding soil tests

What is measured in a soil test?

ANALYSIS		UNITS	Example
Phosphorus	(Olsen)	mg/kg	5.3
Potassium	(Colwell)	mg/kg	124.0
Sulphur	(KCL40)	mg/kg	7.6
pH	(1:5 water)		5.3
pH	(CaCl2)		4.3
Salinity (EC)	(1:5 water)	dS/m	0.04
Soil Texture			Loam
Organic Carbon		%	2.71
Nitrate		mg/kg	23.0
Ammonium		mg/kg	12.0
Phosphorus	(Colwell)	mg/kg	11.0
Phosphorus Buffering Index		PBI	160.0
Calcium	(Exch)	meq/100 g	2.24
Magnesium	(Exch)	meq/100 g	1.60
Sodium	(Exch)	meq/100 g	0.27
Potassium	(Exch)	meq/100 g	0.32
Aluminium	(Exch)	meq/100 g	0.72
Calculations			
Sum of cations	(CEC)	meq/100 g	5.15
Calcium/Magnesium ratio			1.4
Sodium % of cations (ESP)			5.2%
Aluminium % of cations			14.0%

Fertility

Acidity /pH

Salinity

Soil structure

Rate and type of product

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Phosphorous Buffering Index (PBI)

Phosphorous Buffering Index - is a measure of how strongly your soil holds onto phosphorus (P) after it's been applied as fertilizer.

Cowell P critical values for different PBIs to achieve 95% of maximum pasture production

PBI category	PBI Description	90%	Critical P Value (95%
36-70	Very low	27	29 (27-31)
71-140	Low	31	34 (31-36)
141-280	Moderate	36	40 (36-44)
281-840	High	45	55 (44-64)

PBI reflects clay (soil texture) and organic matter content and so can be used to help interpretation of S & K.

Interpreting soil test results

Step 1. Interpret results - identify which nutrients are limiting production

Step 2. Set targets

Step 3. Calculate nutrients / lime required to meet targets for the set time period

Step 4. Choose a fertiliser/lime to give the nutrient rate required

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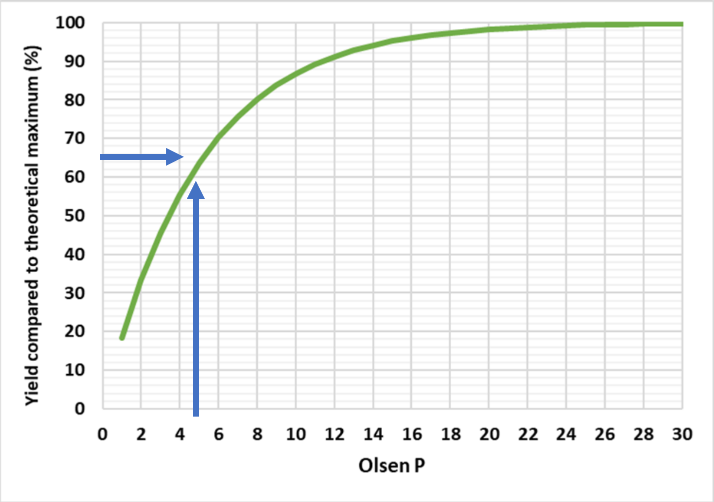

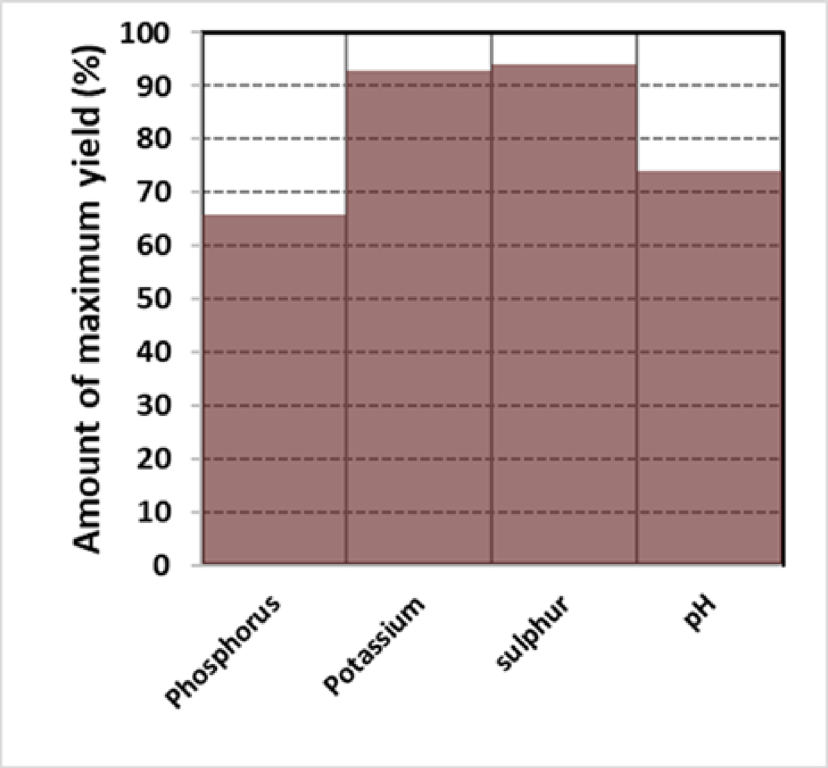

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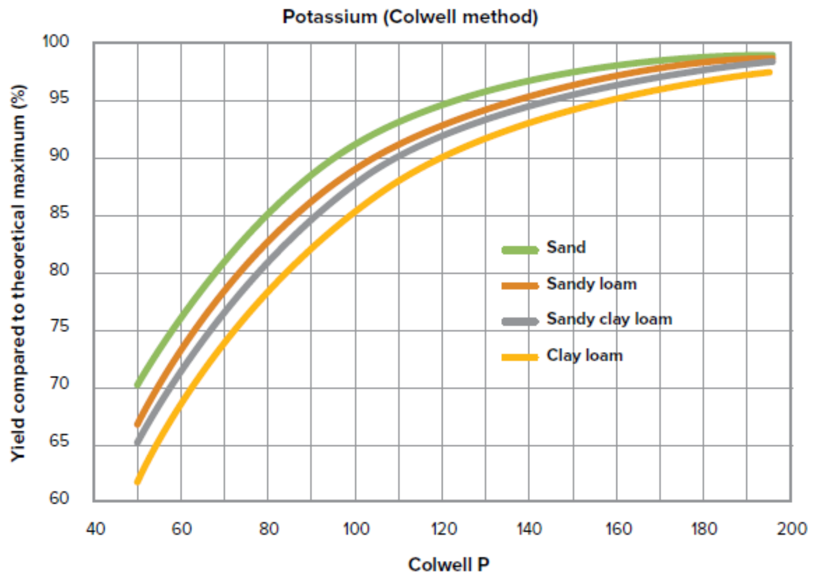
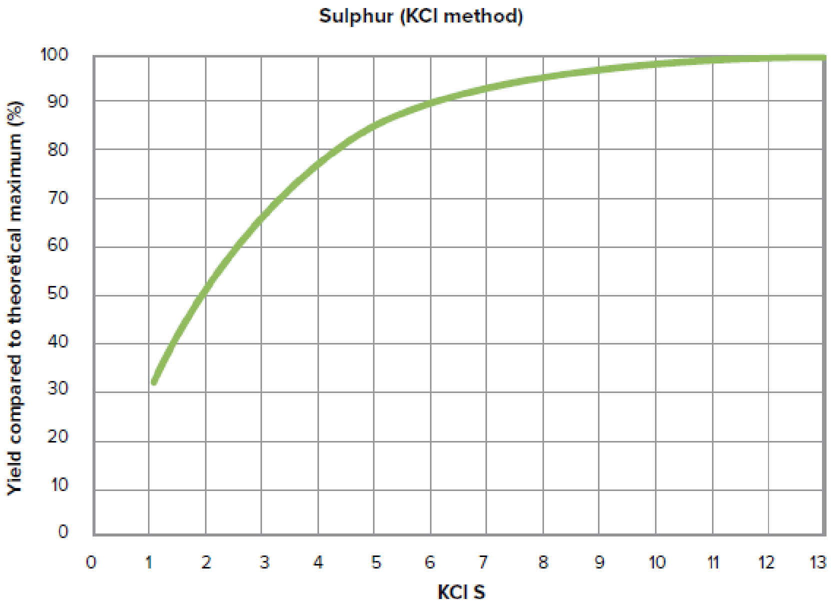
Potassium & Sulphur response curves





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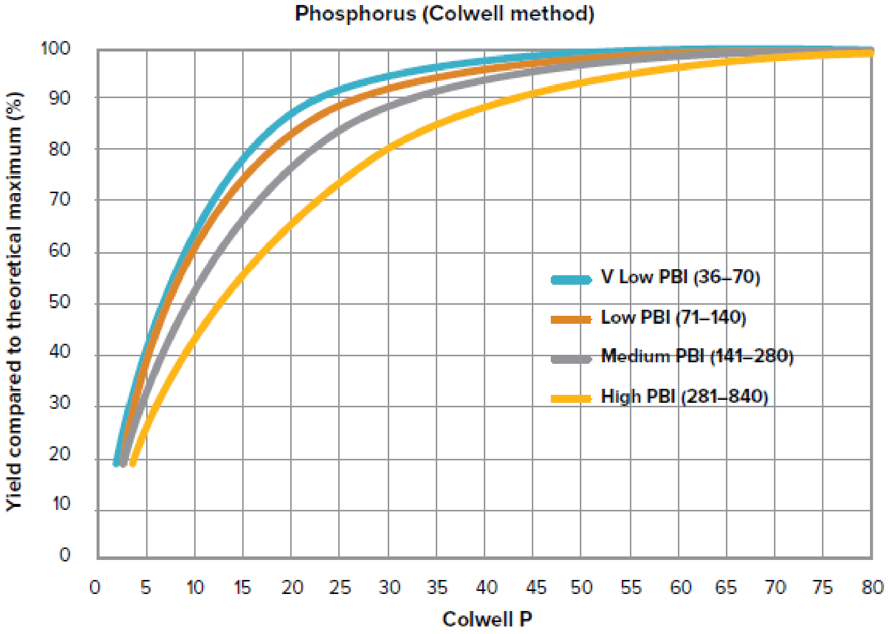
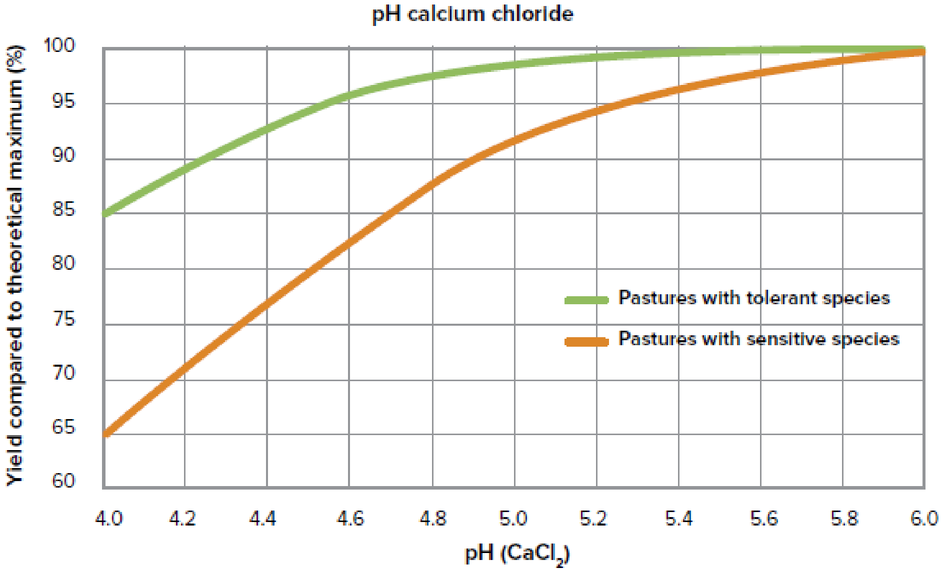
Phosphorous (Cowell) and Soil pH response curves





Species more sensitive include Lucerne, phalaris

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Step 2. Set production targets

- increase – capital + maintenance scenario
- maintenance – maintain current fertility
- decrease – no fertiliser or lime

Target nutrient levels for achieving 95% of potential production

Nutrient	Target level
Phosphorus (Olsen)	15
Phosphorus (Colwell)	28 (PBI<70) to 54 (PBI>280)
Potassium (Colwell)	125 (sand) to 150 (clay),
Sulphur (KCl_{40})	8

Native grasses prefer lower fertility less than Olsen P 8-12 mg/kg or Cowell P 19 mg/kg (Moderate PBI 190)

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Determine Future Stocking Rates

Use production curves to calculate the anticipated extra growth % and work out how many additional DSE/ha you could run.

E.g. Olsen P is currently 8, your target is 12.
Move from 80% pasture production to 90%, potential to produce an extra 10% pasture.
Current stocking rate is 10 DSE/ha, 10% x 10 = 1 DSE/ha
Future stocking rate 11 DSE/ha

Capital application of nutrients

Capital application of nutrients – use PBI to determine how much capital nutrient is needed to shift the nutrient by 1 unit

Nutrient	PBI < 100	PBI 100 - 300	PBI > 300
Phosphorus (Olsen)	8	9	10
Phosphorus (Colwell)	2.3	2.5	2.8
Potassium (Colwell K)	2.0		
Sulphur (KCL_{40} S)	7 (maint) to 15 (if deficient)		

Only P is well understood.

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Maintenance

Suggested annual maintenance nutrient requirements (kg nutrient per DSE per year)

Nutrient	Maintenance
Phosphorus (P)	0.7 (PBI < 100) to 1.2 (PBI > 300)
Potassium (K)	1.2
Sulphur (S)	0.7

Gypsum recommendations

Only apply gypsum if dispersion is present if trying to improve soil structure.

Gypsum lookup rate table (t/ha)

Cation exchange capacity (CEC)	Exchangeable sodium percentage (ESP)					
	6	8	10	12	14	16
10	0.5	1.6	2.7	3.7	4.8	5.9
12	0.6	1.9	3.2	4.5	5.8	7.0
14	0.7	2.2	3.7	5.2	6.7	8.2
16	0.9	2.6	4.3	6.0	7.7	9.4
18	1.0	2.9	4.8	6.7	8.6	10.6
20	1.1	3.2	5.3	7.5	9.6	11.7

Example: ESP is 10% and CEC is 12 apply 4.5 t/ha of Gypsum.

[2] = Assumes a bulk density of 1.35 (clay), 19% purity, 40% gypsum efficiency and 50% leaching.

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Step 3 Calculate the nutrients / lime required to meet targets over a desired time period.

Step 4. Choose a fertiliser/lime to give the rate required.

Excel calculator developed by Cam Nicholson, Nicon Rural

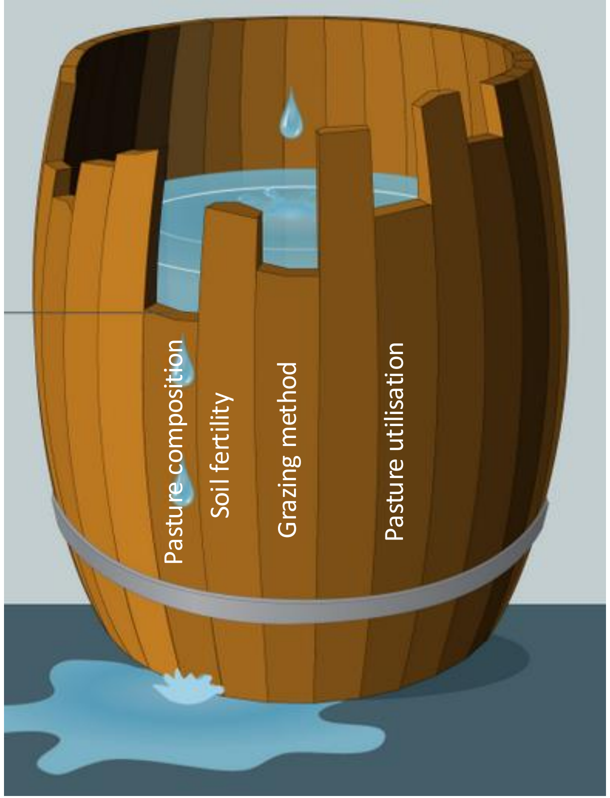
LimeAssist

NLP Lime Calculator

The calculator decisions are likely to be broadly right but unlikely to be exact.
Regular soil testing every 3 to 4 years is the only way to refine the general assumptions.

Fertiliser costs, prioritising paddocks & tips

Is it soil condition that is limiting production or something else?



- Want responsive species.
- If pastures continually grazed, they can't express additional growth.
- Fertiliser grows more grass, if you can eat it, don't use it.

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What paddocks to prioritise for fertiliser?

- Newly sown pastures.
- Paddocks with plant species that will respond.
- The higher the content of improved sown pasture species, the higher the priority.
- Where you want to retain species (clovers drop out at Olsen P <6, improved grasses < 7).
- Paddocks you need to perform. Eg Lambing paddocks.
- Paddocks where fertiliser will give you the biggest bang for your buck (steep part of the curve before diminished returns).

Tip for determining cost effective fertilisers

Calculate Cost spread/unit of nutrient

Eg Super costs spread is \$465/t and contains 8.8% P, the price per kg of P is:

(\$465/8.8)/10 =\$5.3/kg P

Eg MAP costs spread is \$1050/t and contains 22% P, the price per kg of P is:

(\$1050/22)/10 =\$4.8/kg P

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Tips

Soil acidity and liming
* If you need lime but can’t afford it this year, then just wait until you can.
* More cost effective to maintain good topsoil pH than to have to fix deeper acidity.

Gypsum
Gyp, Rip & Sow for a long lasting treatment.

Sulphur fertiliser
* Elemental sulphur is highly soil acidifying.
* Sulfate sulphur fertilisers are preferred but are subject to more leaching on lighter textured soils.

Tips on fertilisers

Potash Fertilisers
Potassium can leach through lighter textured soils. If large quantities needed (greater than 40 kg/ha then smaller split applications or apply over two years rather than large amounts.

A lot of potassium is removed in a hay or silage harvest, usually between 60 to 100 kg per hectare (15-25 kg K/tonne of DM/ha).

If boosting spring growth prior to hay, if soil potassium levels are already adequate, the pasture can have ‘luxury uptake’, which doesn’t result in extra growth.

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Animal health and fertilisers

Don’t apply lime and molybdenum in the same year as it can cause copper deficiency in livestock.

Grass tetany risk on high potassium soils if:

$K \div (Ca + Mg)$ = A result higher than 0.07

(use cations meq/kg or cmol(+kg)

If you have high potassium paddocks, don’t calve down on them, (> 250 mg/kg) due to potential metabolic disorders.

Wrap Up & Evaluation

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YAPs Soils Workshop Evaluation

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