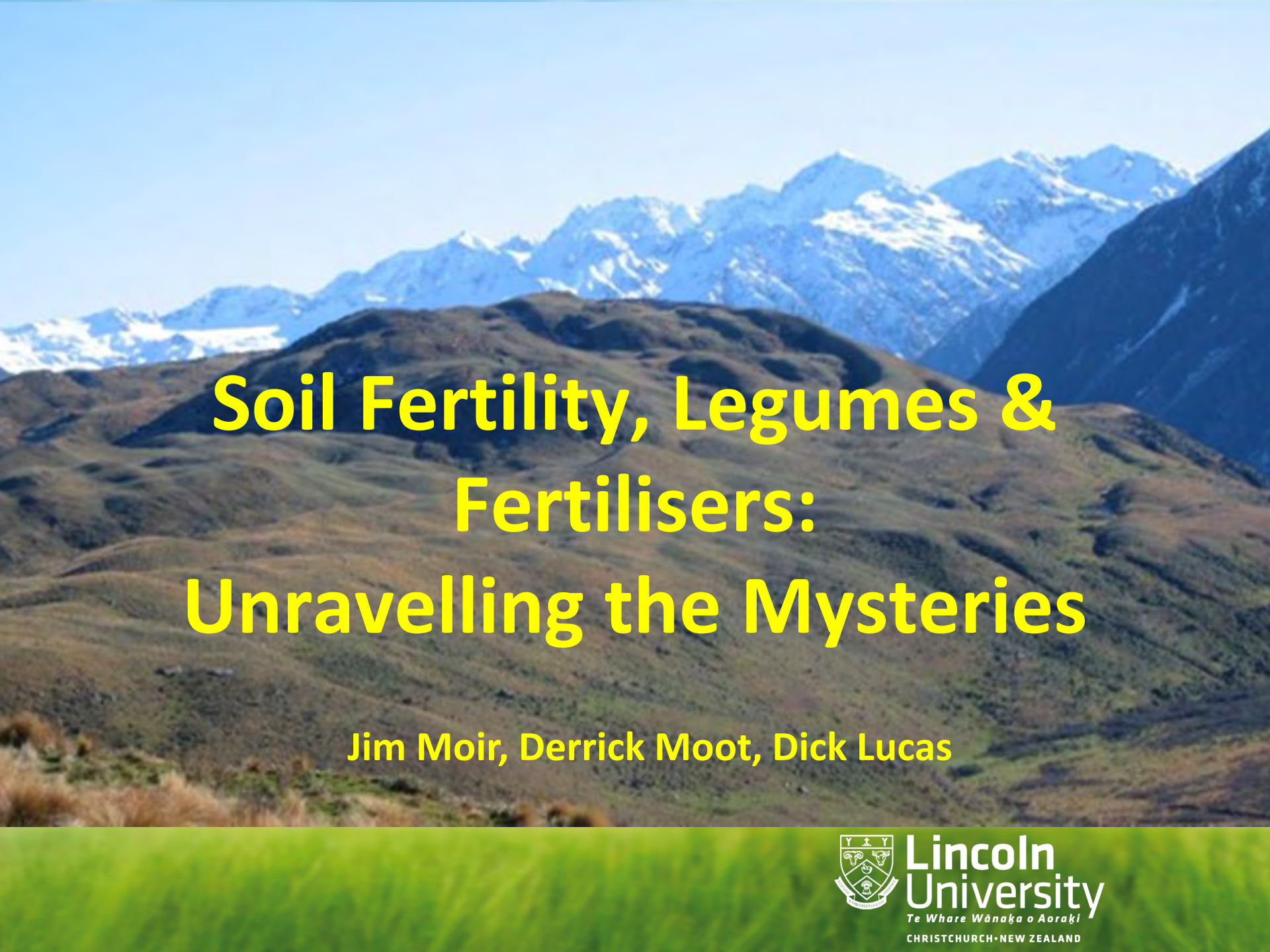


Soil Fertility, Legumes & Fertilisers: Unravelling the Mysteries

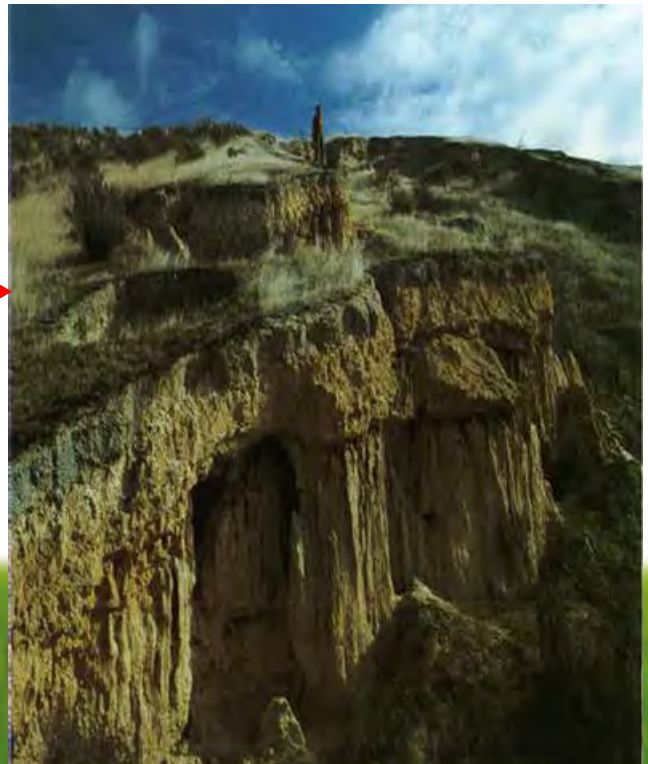
Jim Moir, Derrick Moot, Dick Lucas

Lincoln University
Te Whare Wānaka o Aoraki
CHRISTCHURCH•NEW ZEALAND

Soils

Lowland Soils

- Recent alluvial soils from greywacke (pallic)
- Floodplains & high river terraces*/downlands, 600-700 mm
  - Wairau & Awatere valleys (faults), Seddon soils
- Wither hills (Wairau valley) = loess over conglomerate
  - Weakly consolidated, highly erodable
- http://www.marlborough.govt.nz/Environment/Land/Soils



* Loess covering underlying gravels, and rock (sandstone, siltstone, conglomerate, limestone)

Dry Inland ('intermontane') Basins

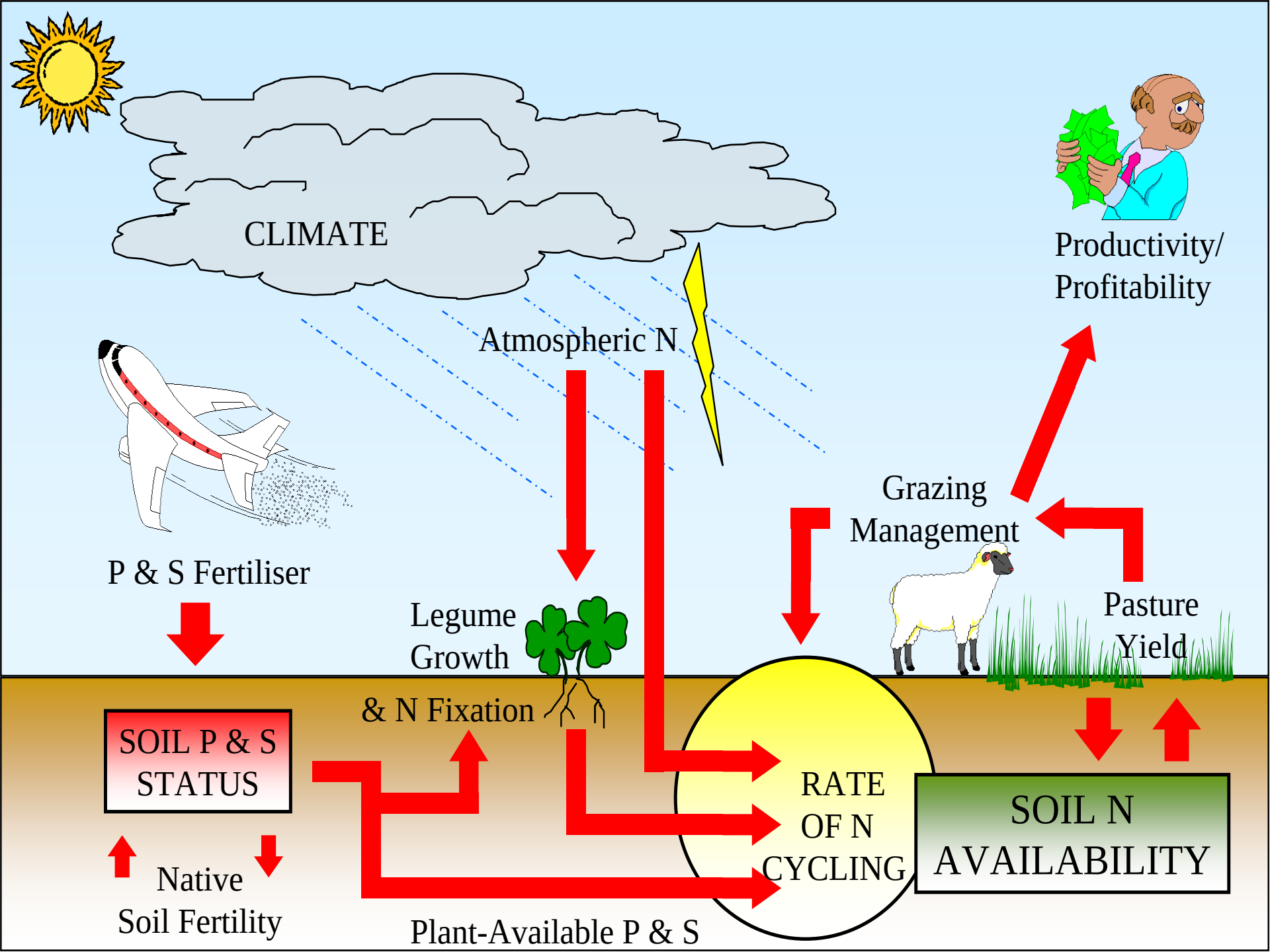
- > 300 m a.s.l. (500-700 mm rainfall)
- Rain shadow
- Glacial fans, terraces, outwash plains, moraines; lakes common
- Soils stony/gravelly, from greywacke
- pH/nutrients good, low leaching
- Gentle slopes, low erosion
- e.g. Hurunui & Haldon steepland soils – Molesworth country, inland Marlborough

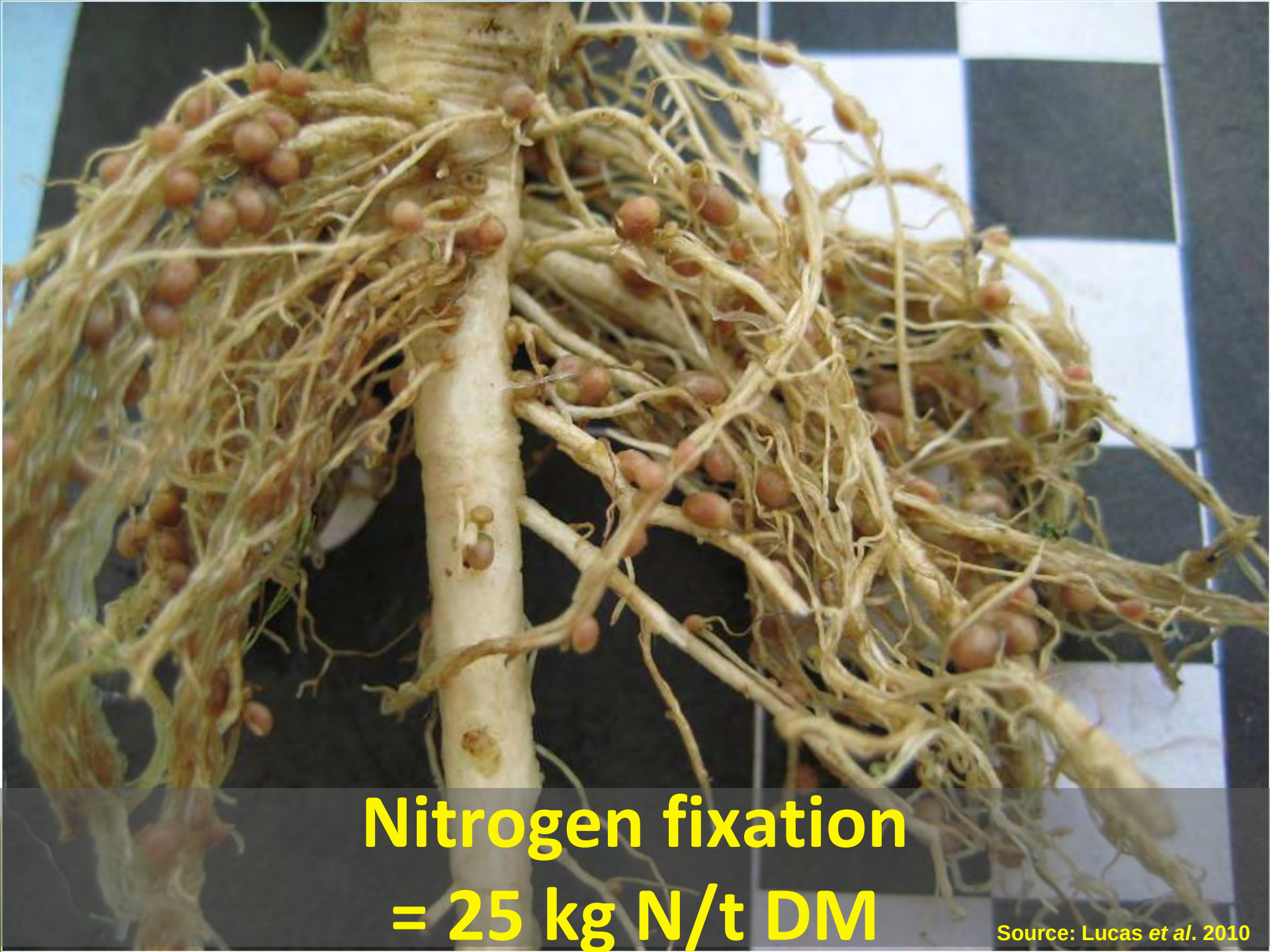
Hill Country Soils (Sounds & West)

- Complex mix of rocks: greywacke, schist, ultra mafic – Mg rich
- Higher rainfall 'Brown' soils.
- Above 200 m: weakly weathered gravels
- Below 200 m: old strongly weathered soils
  - Acidity, podzolization, gleying, high clay (50%!)
- Moutere gravels – clay cemented gravels
  - e.g. Spooner hill soils

Why Fertilize?

Why Superphosphate?

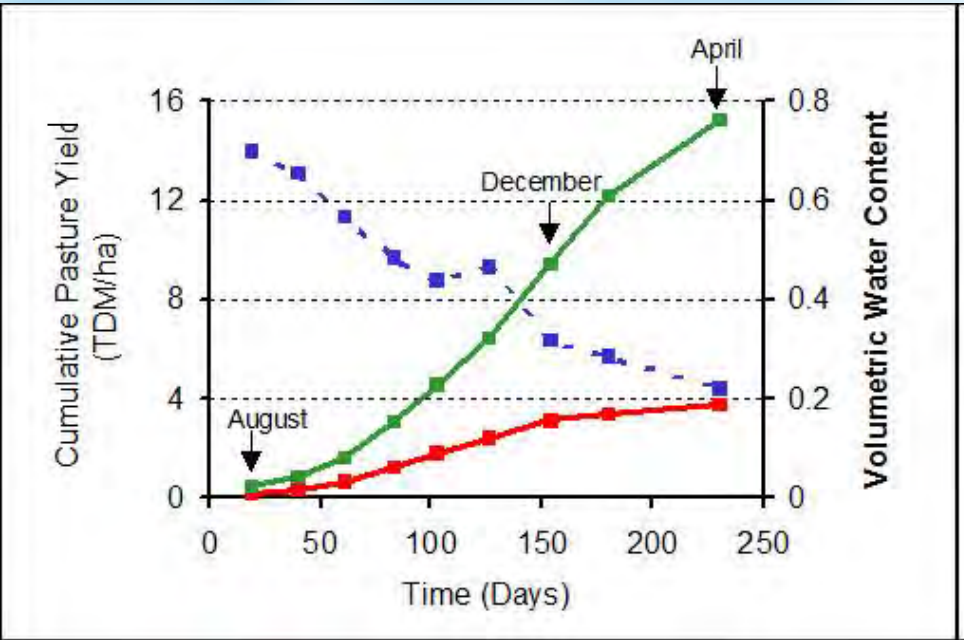

CLIMATE
Productivity/
Profitability
Atmospheric N
P & S Fertiliser
Grazing
Management
Legume
Growth
& N Fixation
Pasture
Yield
SOIL P & S
STATUS
RATE
OF N
CYCLING
SOIL N
AVAILABILITY
Native
Soil Fertility
Plant-Available P & S



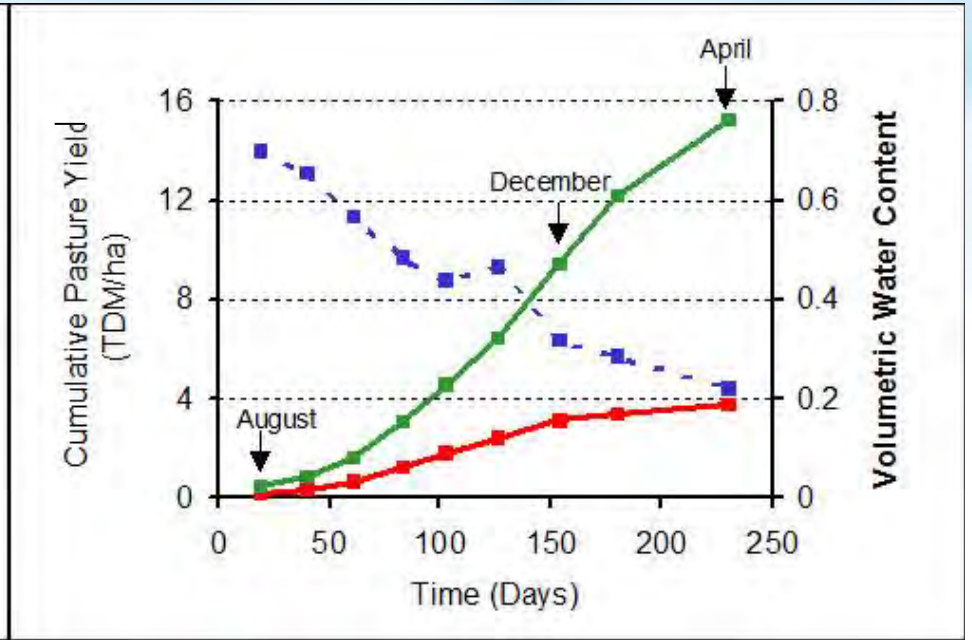
Nitrogen fixation
= 25 kg N/t DM

Source: Lucas *et al*. 2010

Long-term Superphosphate = More Total DM, More Clover



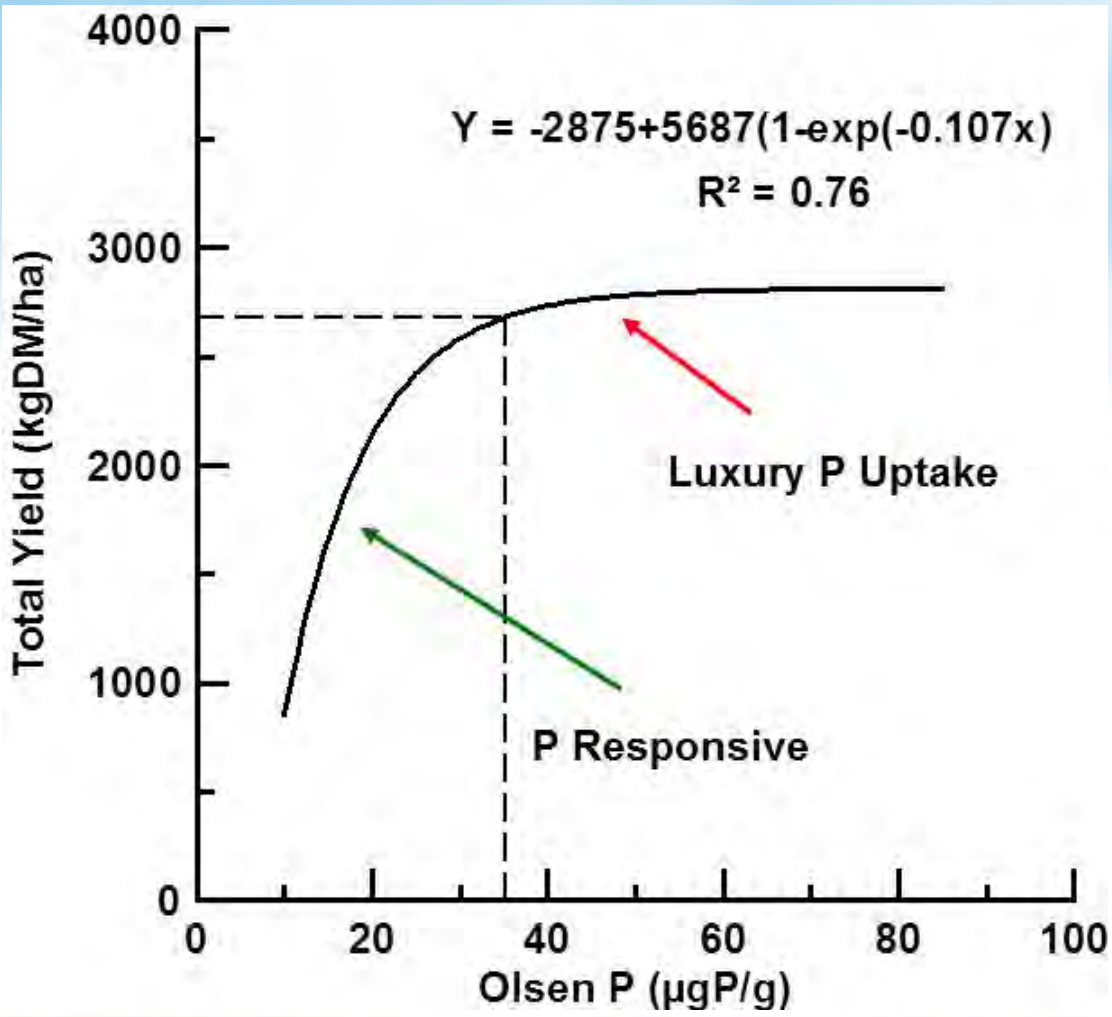
700 mm pa



1400 mm pa

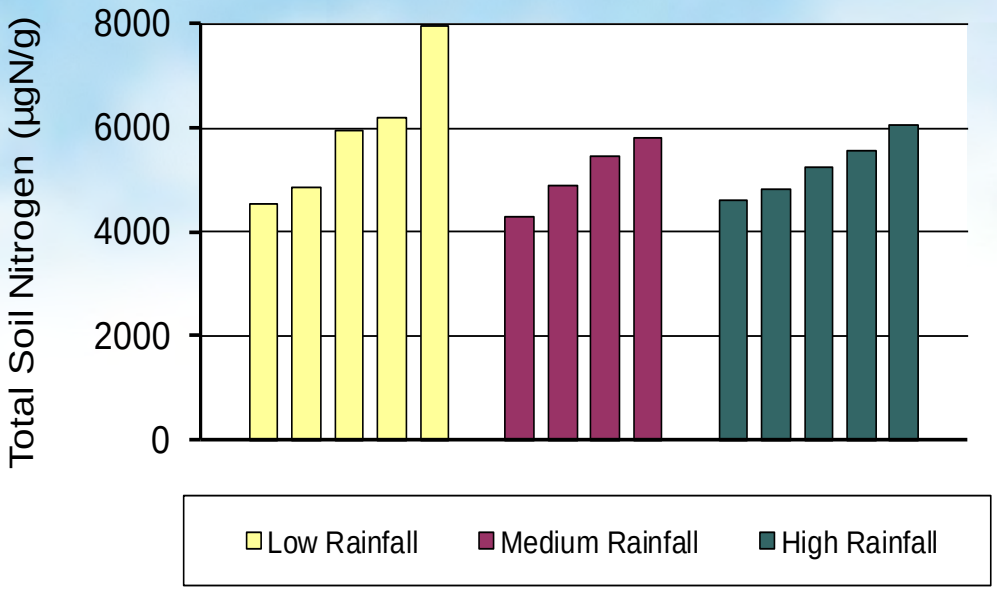
Source: Moir *et al.* 1997

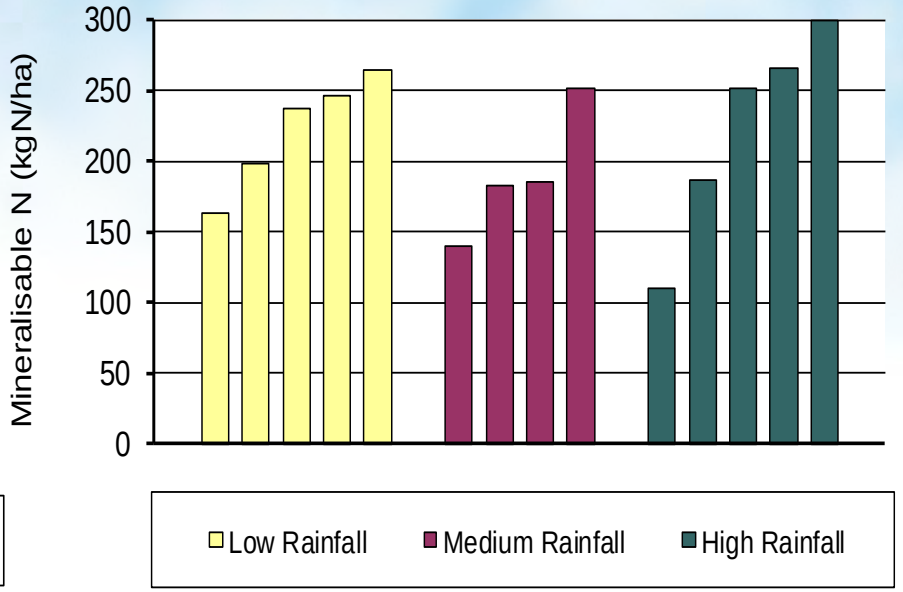
Olsen P – Predicts Growth Well (when soils are moist)



Source: Moir *et al*. 2000

Long-term Superphosphate = More Soil N





- Soil Total and Mineralisable (plant available) N levels increased markedly with higher long-term SSP inputs (Wairarapa hill country)

Superphosphate WORKS!!!

Source: Moir *et al*. 2000

Fertiliser Witchcraft:

Can Nutrients Appear From Thin Air?

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Answer = NO!

100 kg P ≠ 10 kg P : 1 T lime ≠ 100 kg lime

Always calculate fertiliser on a nutrient weight basis ($/kg)

Manufacturers/retailers must, by law, supply information on the concentrations (%) of (N—P—K—S) in fertilisers.

e.g. Single superphosphate is (0-9-0-12).

The choice of fertiliser depends on:

1. Nutrients it contains
2. Concentration of nutrient
3. Form of nutrient
4. Rate nutrient becomes available to plants
5. Cost /kg of nutrient
6. Risk of damage to sensitive plants.

$$\text{Cost/kg Nutrient} = \frac{\text{Cost/tonne fertiliser}}{(10 \times \%\ \text{nutrient in fertiliser})}$$

Remedies to Ward off Fertiliser Witchcraft:

- **Where is the hard science?**
  - **Published in credible international scientific journals?**
  - **Is it applicable to NZ farming systems?**

- **Stick to basic principles, not “creative accounting”**
  - **e.g. ‘Cation base saturation ratios’?!**

- **Practice good soil sampling, basic soil analyses, and back up with herbage analyses if required.**

Soil Acidity, Nutrient Availability & Liming

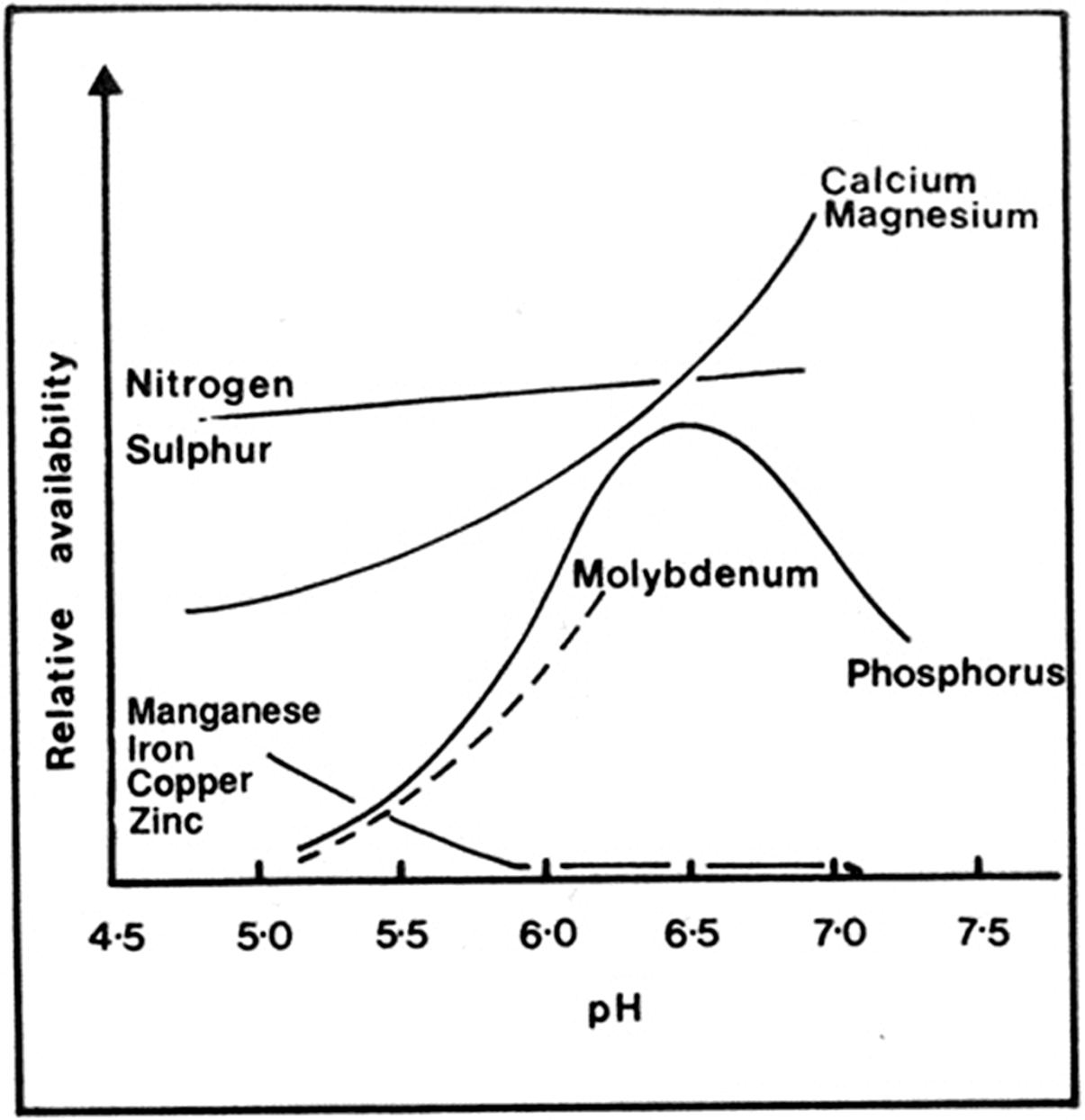
Soil Acidity (H^+) – Formation and Issues

- **A natural process – soils 'weather' (develop over time)**
  - **Older soils = more weathering = higher acidity (lower pH)**

- **Acidity develops by:**
  - **Leaching of 'base' ions (+climate/rainfall)**
  - **H^+ ion release by plant roots**
  - **Microbial activity (organic acids formed)**
  - **Al hydrolysis when aluminosilicate soil minerals are weathered**
  - **Elemental S fertiliser**

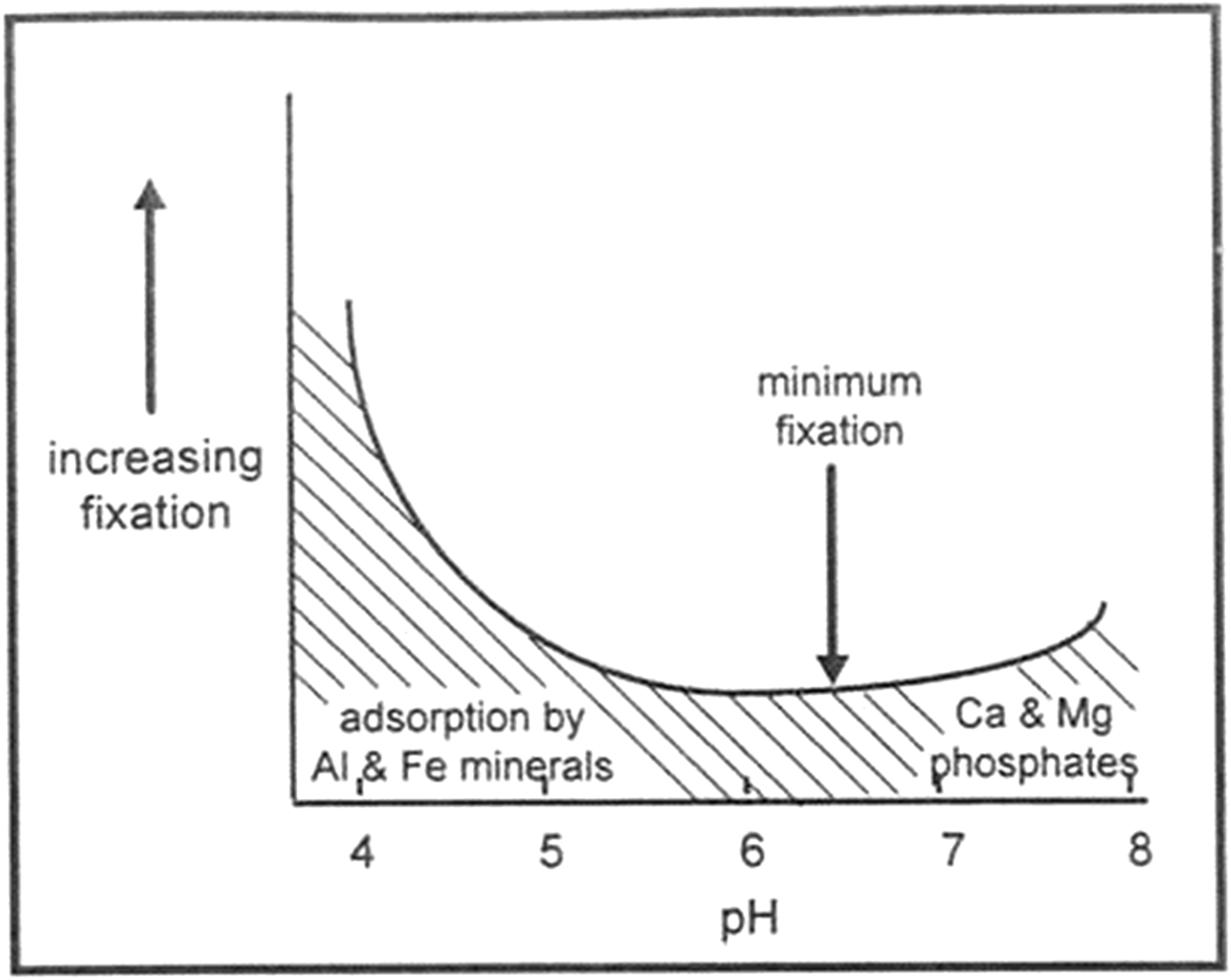
- **Many hill and high country soils have low pH & can be extremely variable down the profile – difficult to manage!**

Soil pH strongly affects nutrient availability to plants



Source: McLaren & Cameron 2005

Soil Phosphorus Availability



Source: McLaren & Cameron 2005

Aluminium Toxicity & Legumes

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THE Issue: Aluminium Toxicity in Legumes

- Lower soil pH (more acidity) = higher Exchangeable soil Al
- Legumes particularly sensitive to soil Al
  - Some species more that others e.g. Lucerne
- Soil Exch Al above 3 mg/kg can cause problems
  - Definite toxicity at 10 mg Al/kg & above

Lucerne: Lees Valley, Nth Canterbury

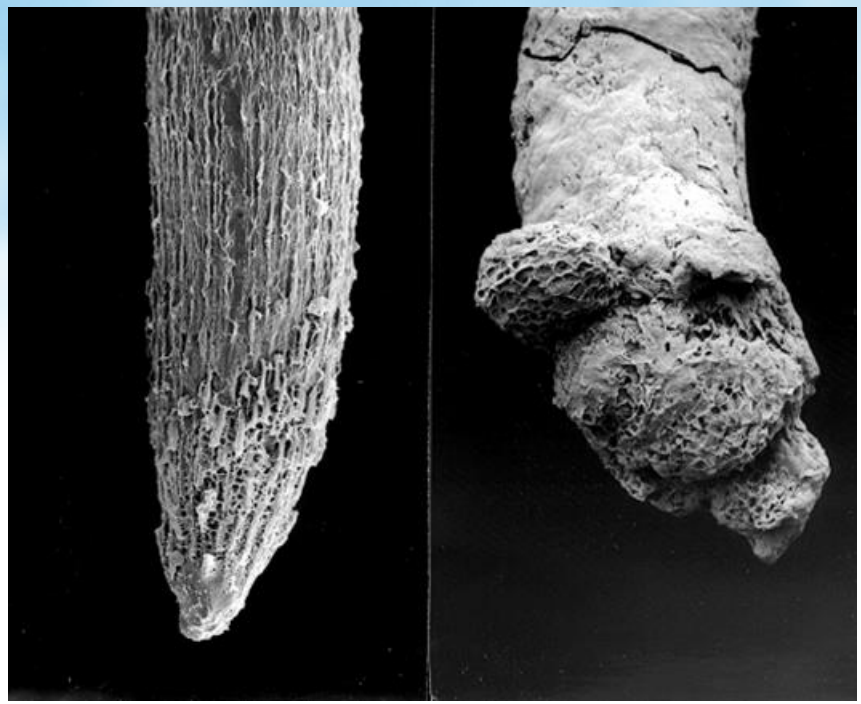
Canterbury Plains

Central Canterbury High Country

THE Issue: Aluminium Toxicity in Legumes

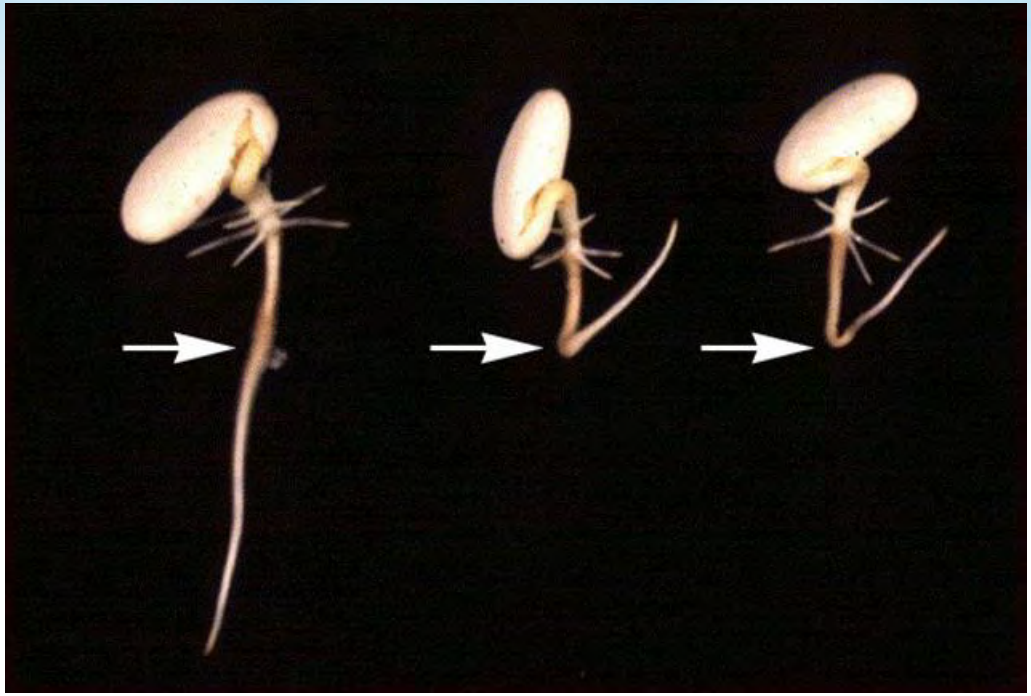
- **Can affect plants severely**
  - **Root damage**
  - **Substantial ↓ in rooting depth (depending on Al location in soil profile)**
  - **↓ in accessing soil moisture (more drought prone)**
  - **↓ in nodulation and N fixation in legumes**
  - **↓ nutrient availability**
  - **↓ yield & persistence**

Aluminium Toxicity - Root Damage



Wheat

(Al 5 mg/kg, pH 5)



Pea

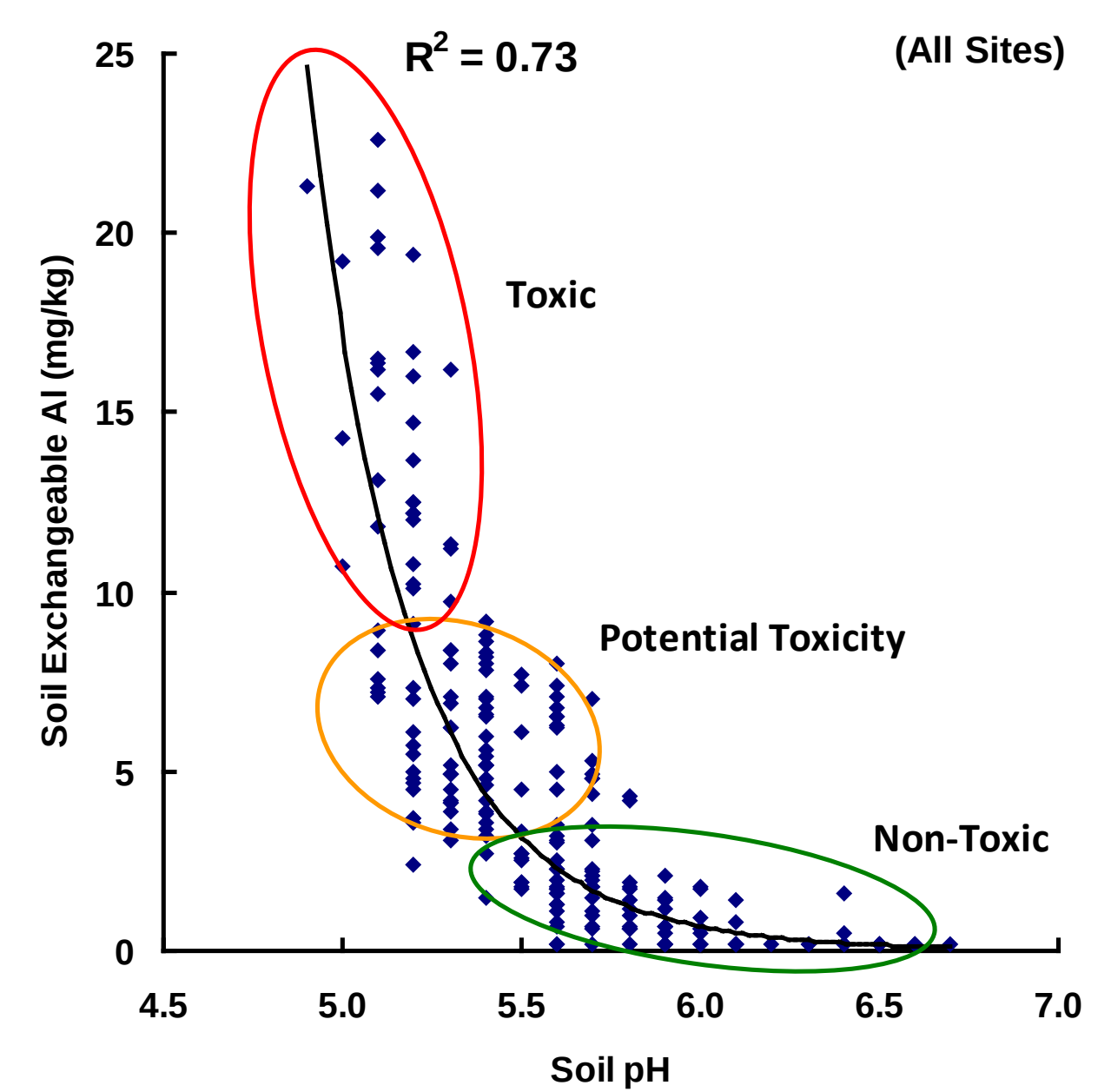
Roots dipped in Al Sol^{n} at arrow

Lucerne - Horizontal root growth

Glenmore Station Tekapo

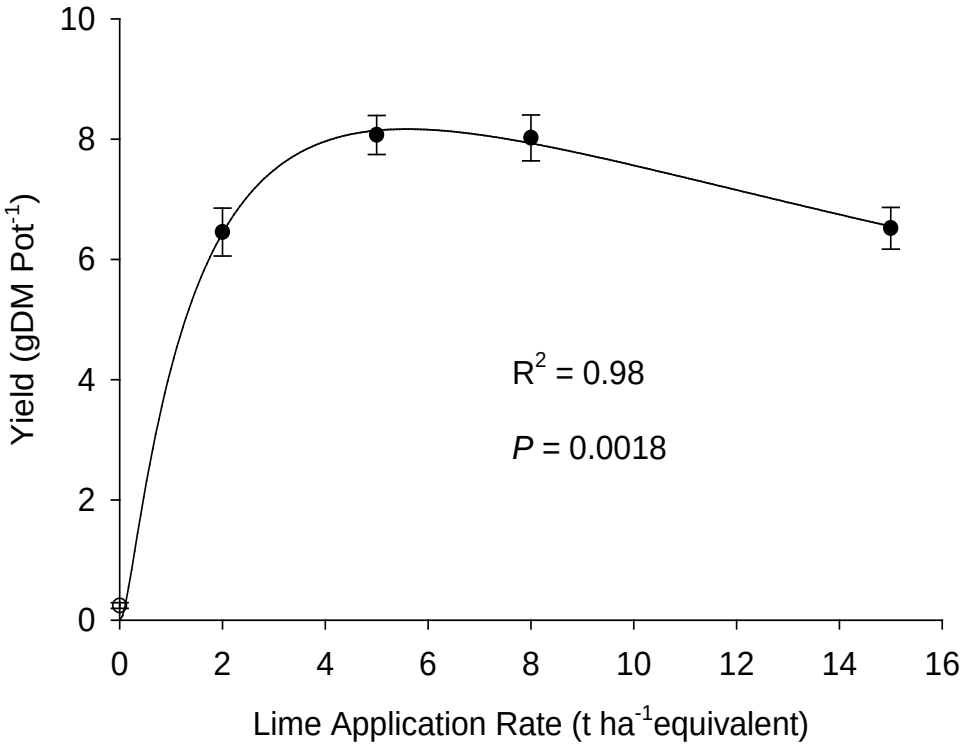
Central Canterbury High Country

Relationship Between Soil pH & Exchangeable Soil Aluminium

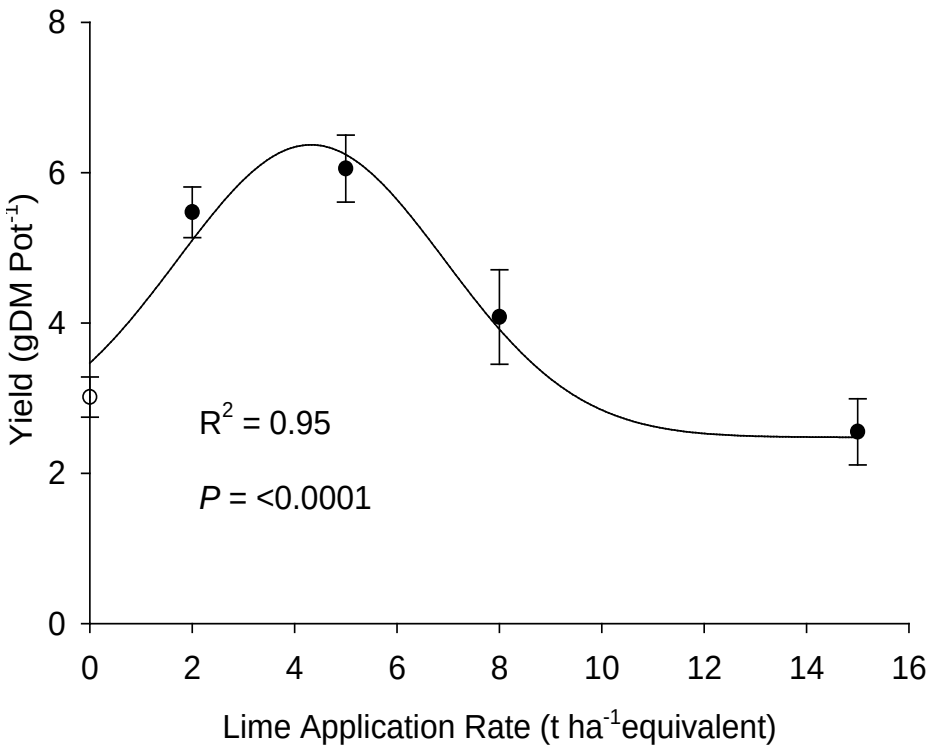


Source: Moir & Moot 2010

Different Legume = Different pH tolerance



Lucerne



Caucasian clover

Source: Moir *et al.* 2011

QUESTIONS?

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