Optimising feed production on acid soils

Helen Burns
Development Officer, NSW DPI - Wagga

Holbrook, 23rd November, 2016

Any factors that reduce plant vigour will affect establishment and production

- Major factors <u>in your control</u> are:
  - →nutrient deficiencies,
  - →weed and pest populations,
  - →<u>soil acidity</u>

AND selection of the most suitable crop and pasture species for your situation and soil type.

NSW GOVERNMENT | Department of Primary Industries

What is to be covered today

- Some typical soil profiles
- A quick refresher on acid soils
  - how soils become acidic
  - how lime increases pH
- The effect of subsoil acidity on productivity
- Management options to minimise the effects of acidity

NSW GOVERNMENT | Department of Primary Industries

Acknowledgements:

1. Revisit NSW DPI work from 1980s to 2000s

   Acid Soil Action, Mark Conyers, Brendan Scott

2. *Improving the performance of legumes on acid soils of HRZ* – GRDC: Mark Norton, Peter Tyndall (NSW DPI), growers in NSW, VIC, SA and TAS,

   Grower groups – HLN

3. *Subsoil acidity project* – GRDC: NSW DPI, CSU, La Trobe Uni, CSIRO, Grower groups – HLN

NSW GOVERNMENT | Department of Primary Industries

AIM: To optimise productivity and long-term sustainability of production systems

- pH ($CaCl_2$) target **> 5.0….**
  - Most plants and soil microbes are pH sensitive
  - A healthy plant is more tolerant of disease and adverse conditions (e.g. waterlogging)

Agricultural <u>production</u> systems result in net acidification of the soil

NSW GOVERNMENT | Department of Primary Industries

Shallow soils on hillsides - Tenosols

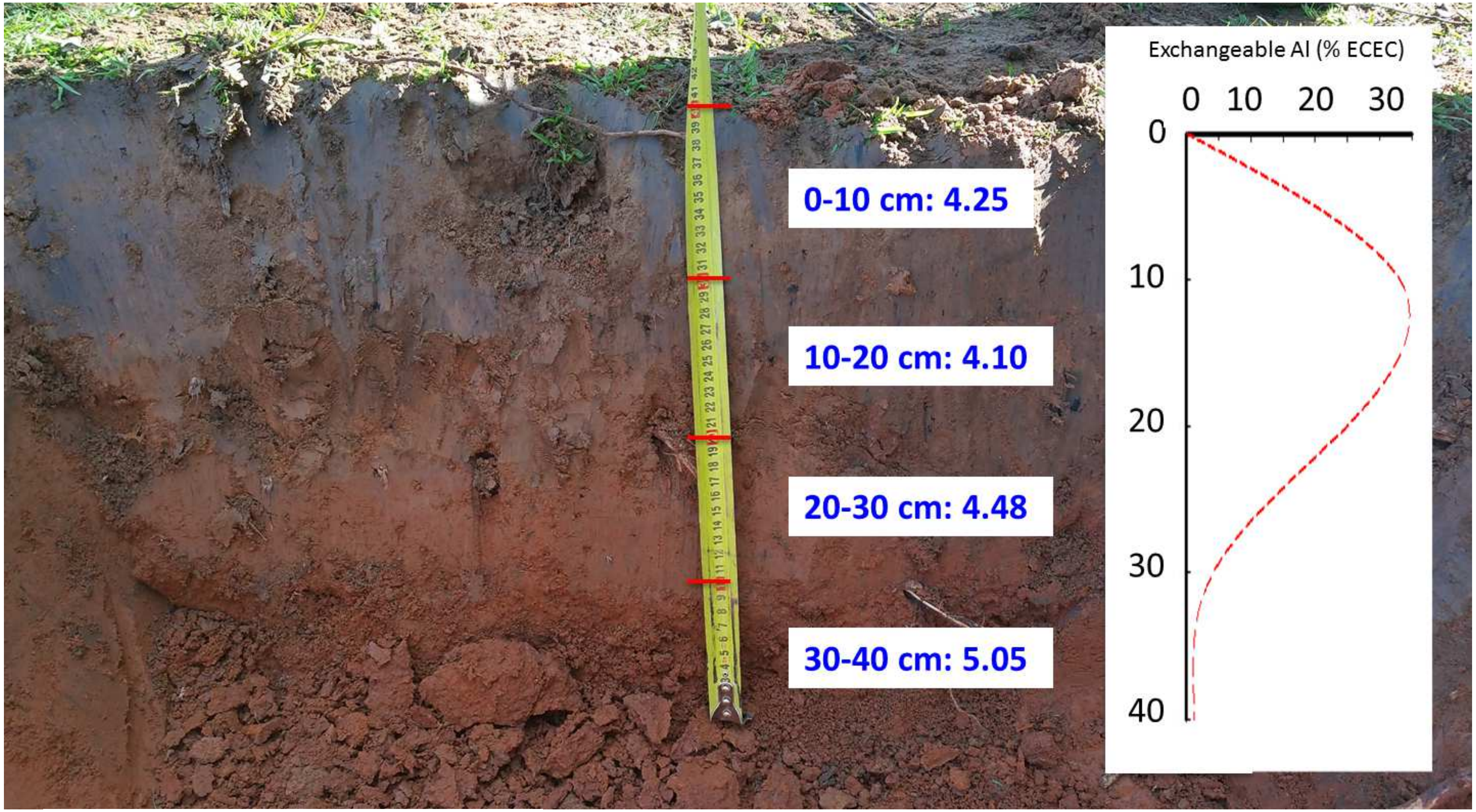
pH

~ 5.0

4.5

Source: Google Maps

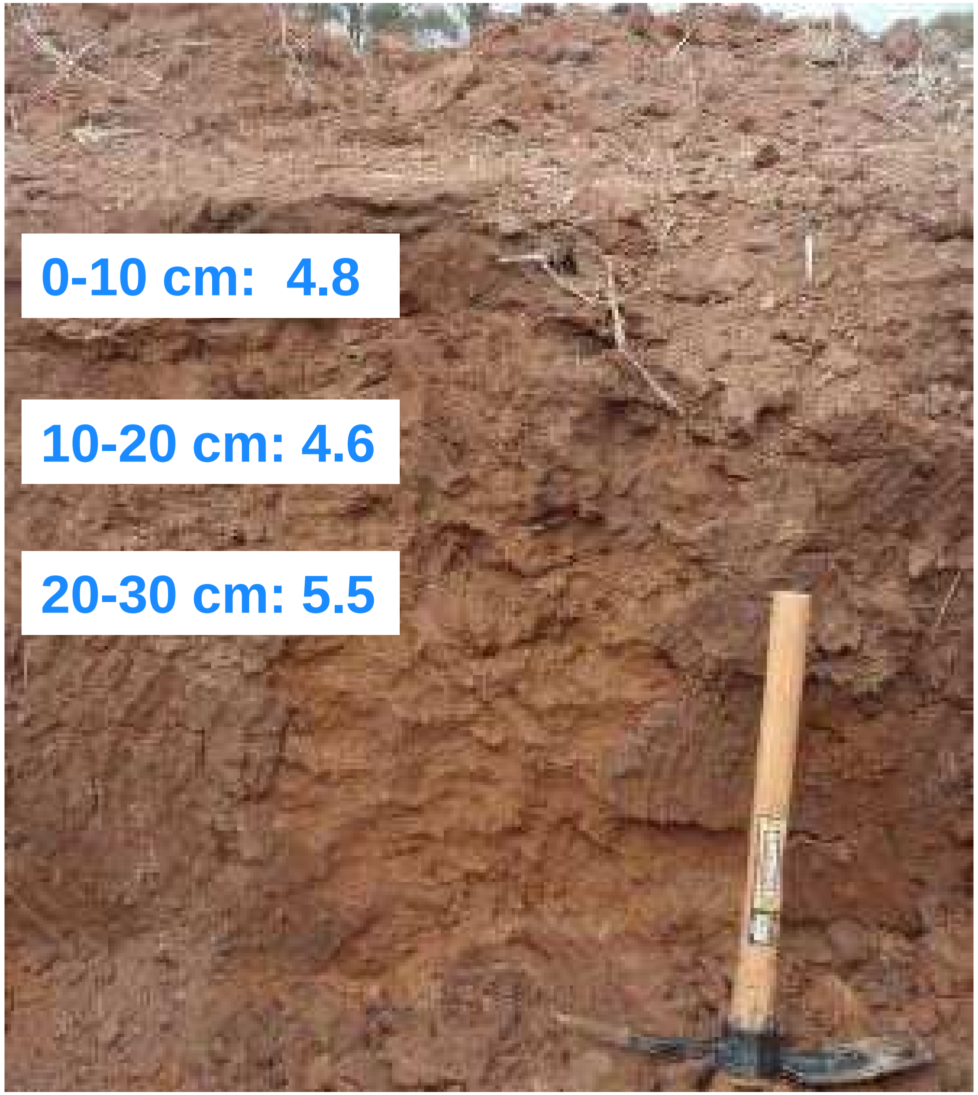
Sodosols: CEC 4.0



Source: Mat Dun (CSU)

Department of Primary Industries

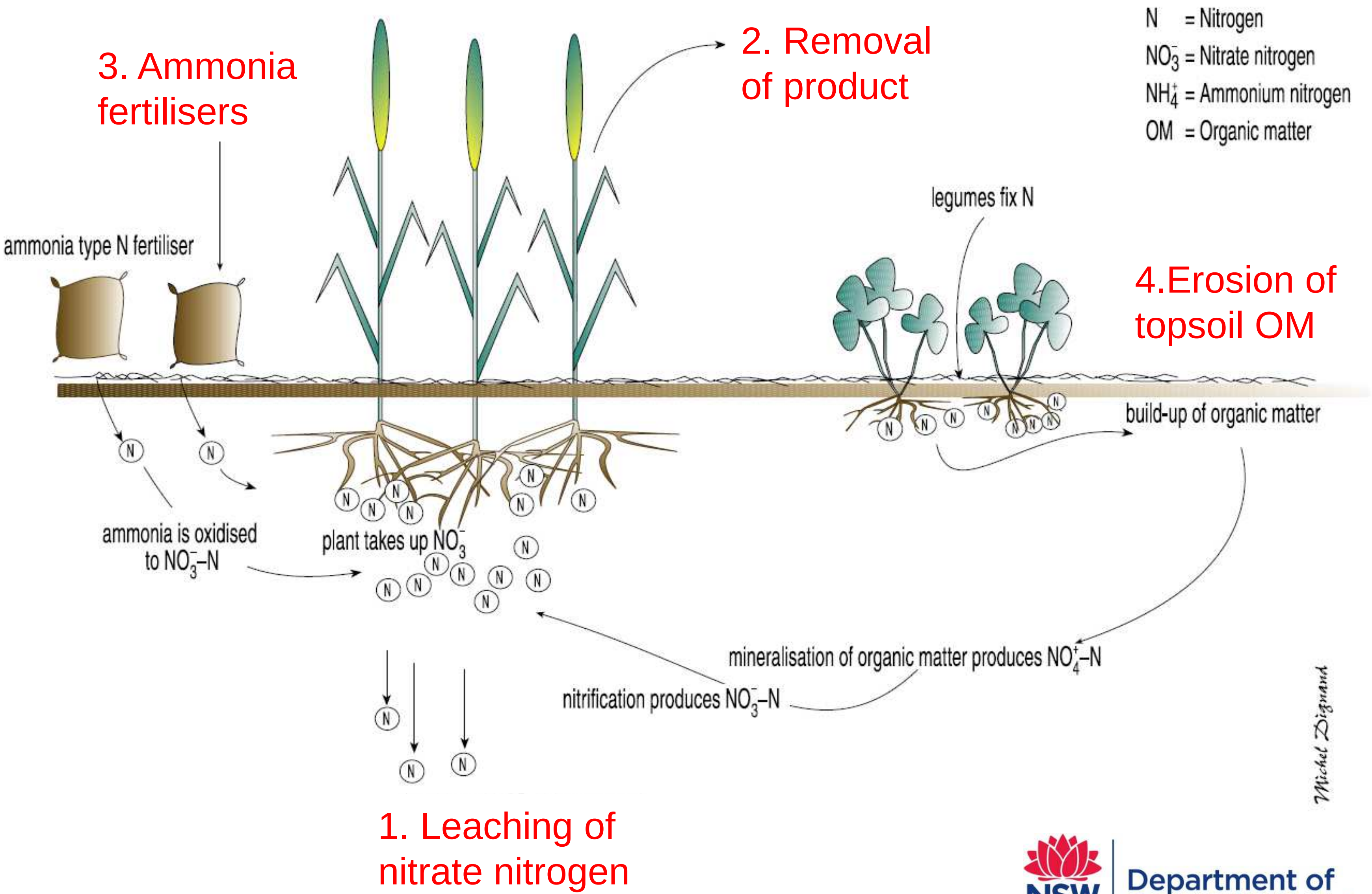
Red-brown chromosol: CEC 7.0



GRDC Grains Research & Development Corporation

NSW GOVERNMENT Department of Primary Industries

Agricultural practices that acidify soils



Department of Primary Industries

Minimising subsoil acidification:

- Reduce nitrate leaching
  - vigorous plant growth reduces nitrate leaching
  - budget N fertiliser to match crop needs
  - avoid using ammonia fertilisers: sulphate of ammonia & MAP
- Minimise erosion of topsoil – rich in OM
- Monitor pH
- Balance product removal with lime inputs

NSW GOVERNMENT | Department of Primary Industries

Product removal and acidification:

Product	Lime required (kg/t of produce)
Lupins	**20**
Wheat	9
Lucerne hay	**70**
Grass hay	25
Meat	**17**
Wool	4

Plant growth in acidic soils

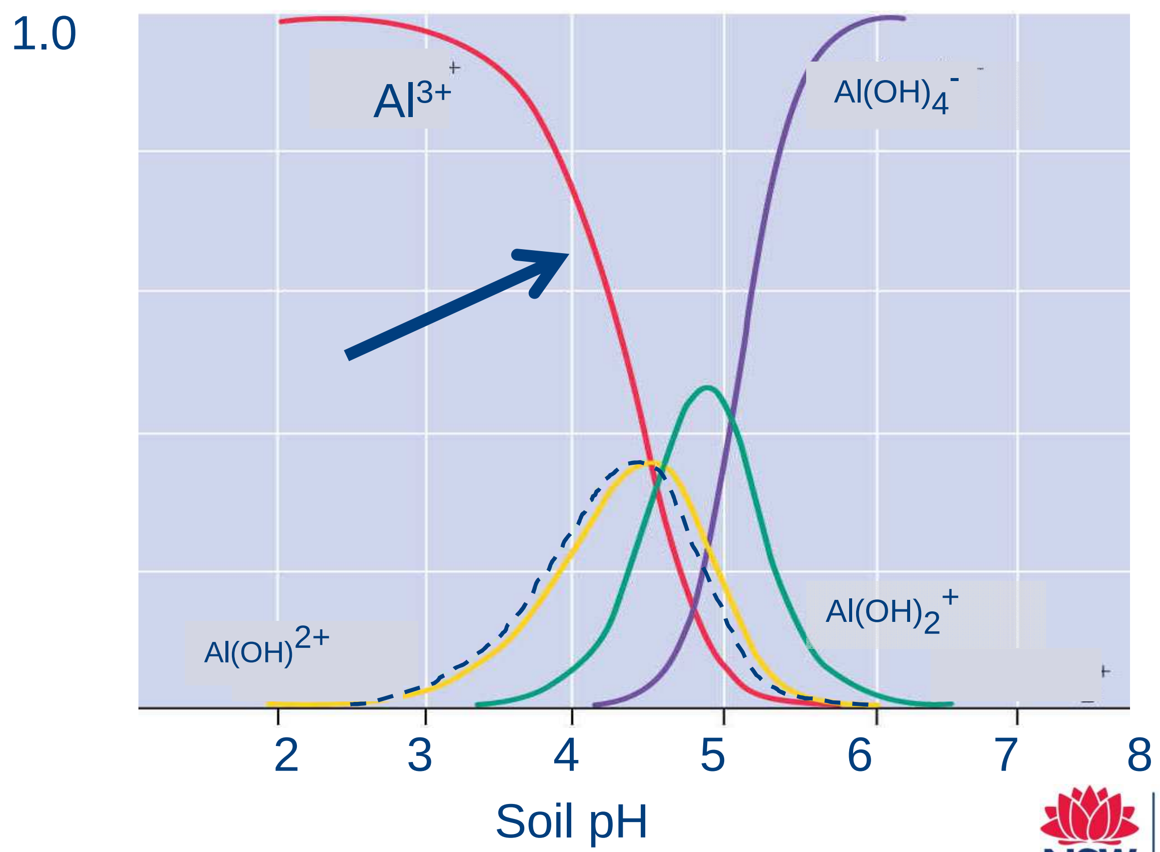
pH ($CaCl_2$) < 5.0	pH ($CaCl_2$) > 5.0
Aluminium toxicity – root growth	Aluminium not available to plants: > root growth → access to water & nutrients
Reduced microbial activity	Rhizobia survival, effective nodulation
Mineral deficiencies	> Molybdenum and Phosphorus availability
Manganese toxicity in non-cereals	Mn not available to plants
Proton toxicity	

NSW GOVERNMENT | Department of Primary Industries

Aluminium and soil pH

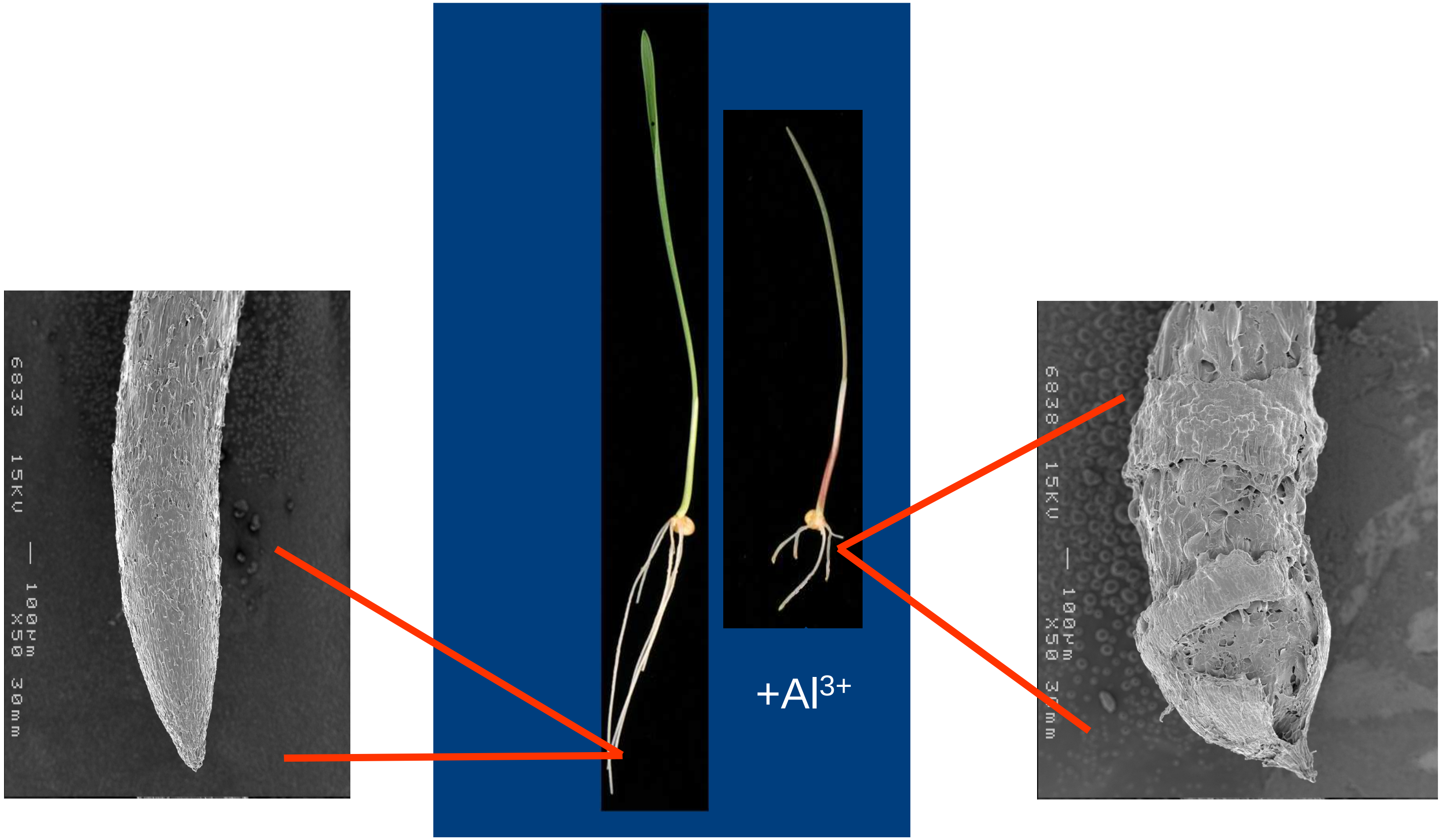
- Al^{3+} is the toxic form

levels increase rapidly when soil pH < 4.7



Al^{3+} inhibits growth of roots & root hairs

Al^{3+} stimulates roots of tolerant species to release anions (negative charge) to counter the effect of aluminium cations



NSW GOVERNMENT Department of Primary Industries

Sensitivity to aluminium

(Will vary with soil type and presence of other factors that may cause additional stress and reduce early vigour of establishing plants)

	Exchangeable Aluminium (%)	
Highly tolerant	20-30	Spear grass, wire grass, triticale, narrow leaf lupins,
Tolerant	15-20	Annual and perennial ryegrass, cocksfoot, chicory, weeping grass, wallaby grass, kangaroo grass, tolerant wheat varieties
Moderately sensitive	10-15	Established phalaris, tall fescue, most wheats, albus lupins, some barleys
Sensitive	5-10	Phalaris seedlings, canola, barley
Highly sensitive	<5%	Lucerne, medics, tall wheat grass, most barleys, faba bean, chickpea, lentil,

From: UpJohn B, Fenton G and Conyers M (2005) Soil acidity and liming. NSW DPI Agfact AC.19
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/167209/soil-acidity-liming.pdf
Ayres etal(2016) and Temperate Perennial Pasture Establishment Guide, NSW DPI
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/679126/temperate-perennial-pasture-establishment-guide.pdf

NSW GOVERNMENT Department of Primary Industries

Management can influence sensitivity to acid soils – e.g. sowing time

Aluminium tolerant

rice

rye and triticale
narrow-leaf lupin, cocksfoot
tolerant wheat, perennial rye, fescue

Sub clover & white clover
canola /tolerant barley, albus lupin, phalaris seedlings

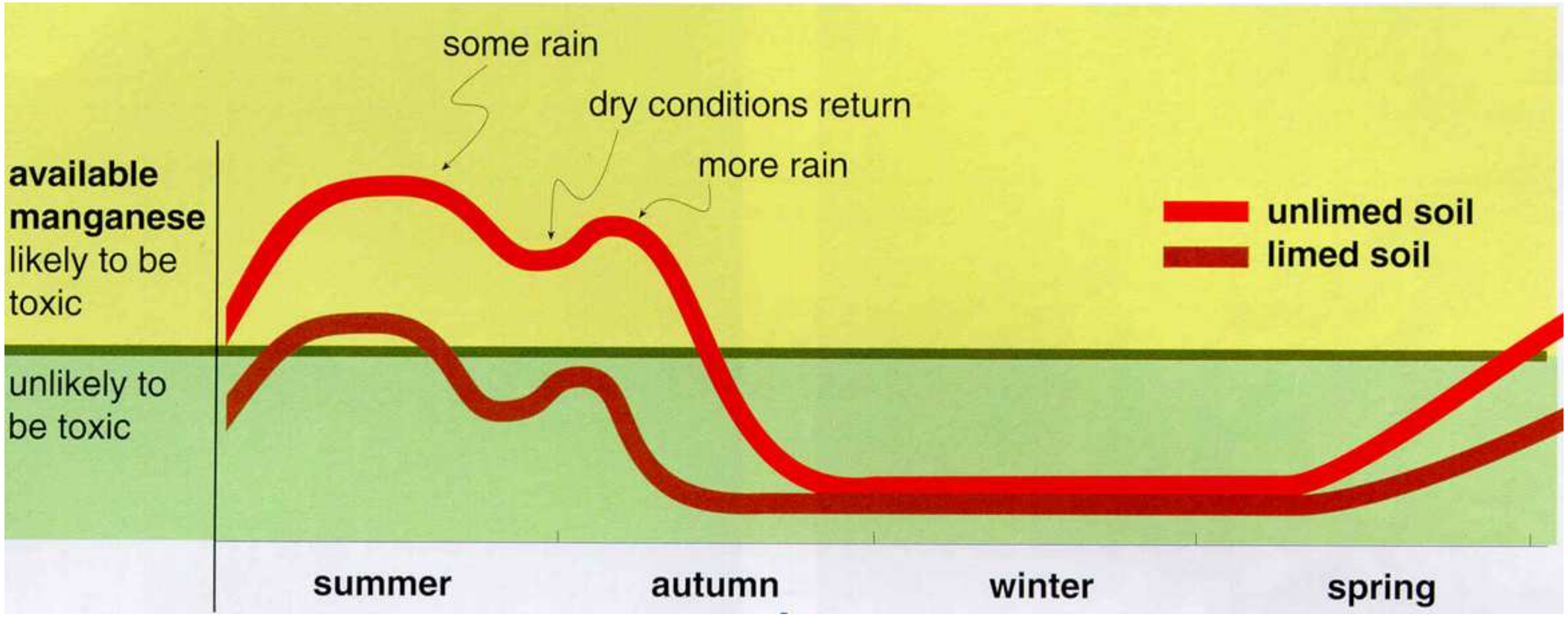
sensitive wheat lucerne

sensitive barley

faba bean, field pea, lentil, chickpea

Aluminium sensitive

Seasonal variation in available Mn



Rhizobia survival and soil pH

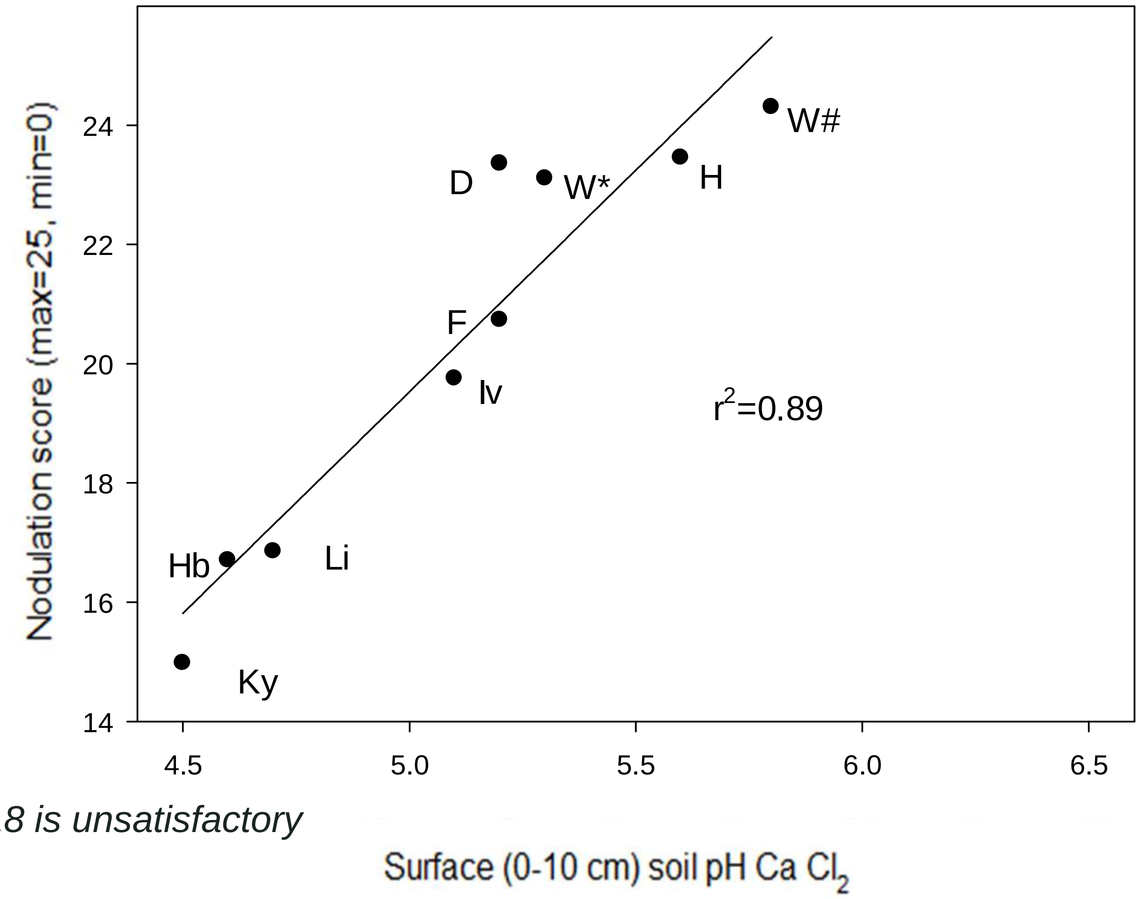
Host legume	pH 4	pH 5	pH 6	pH 7	pH 8
Cowpea, mungbean, lupin, serradella					
Soybean					
Clovers					
Pea, faba bean, lentil, vetch					
Chickpea					
Medics					

Dark green - ideal pH range,
Pale green – satisfactory
Amber- unsatisfactory
Red – Unsuitable

Source: Drew et al (2012) Inoculating legumes: A practical guide
GRDC publication

NSW GOVERNMENT | Department of Primary Industries

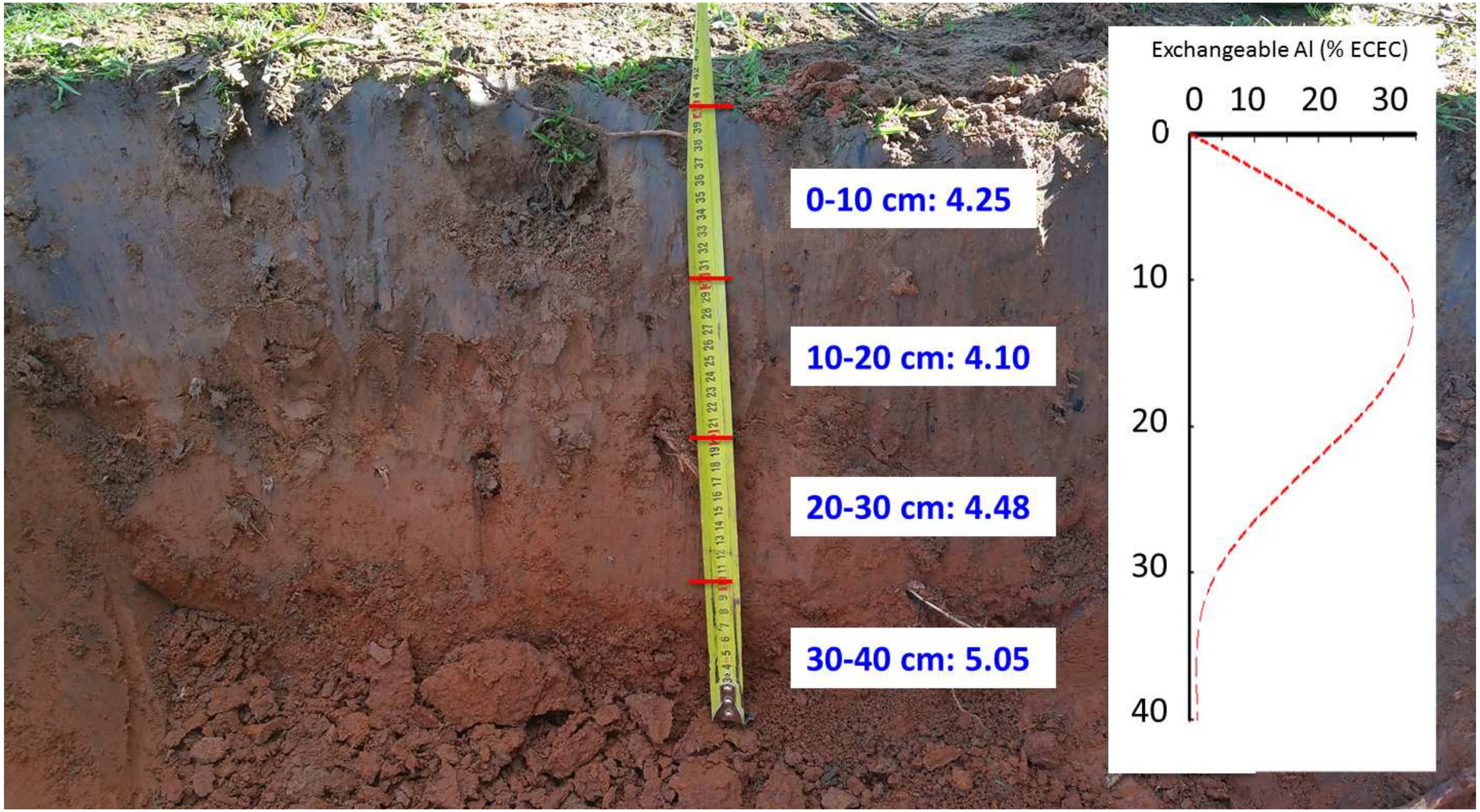
Impact of pH on legume nodulation*
Faba bean - 2015



**Nodulation score <18 is unsatisfactory*

Holbrook sodosol: CEC 4.0

Source: Mat Dun (CSU)



Sodosol
– 4t/ha of lime applied in since 2005

Depth (cm)	Podosol / Sodosol
0-10	4.2 →5.2
10-20	4.1
20-30	4.5

Faba beans – mid September 2015

Poorly nodulated, stunted faba bean crop in foreground. Canola in distance appears to be relatively healthy.

NSW GOVERNMENT | Department of Primary Industries

Poorly nodulated faba bean

Showing severe root pruning

0-10 cm soil test – pH_{Ca} 5.2

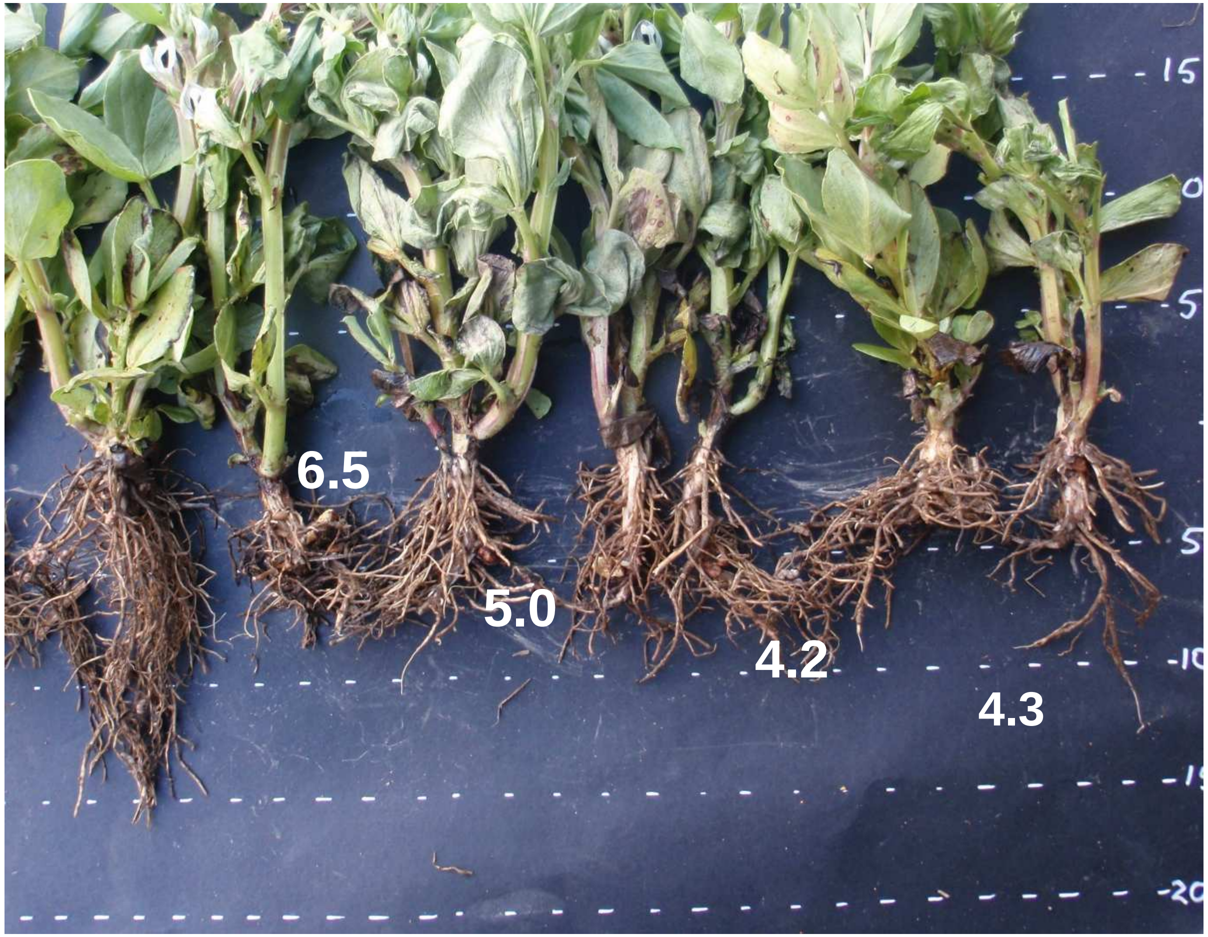
Poor vs well nodulation faba beans

Plant on left showing stunted root systems typical of Aluminium toxicity, main taproot not penetrating subsoil

NSW GOVERNMENT | Department of Primary Industries

Soil samples show stratified pH

Traditional soil sampling that combines soil layers from 0-10 cm does not identify severe acid layers in the top 10 cm. Exchangeable aluminium level at pH 4.2 is 35%



The canola crop growing in faba bean paddock is also affected by the ‘hostile’, acidic subsoil.

Canola root growth was restricted by the acid layer below 6 cm.
Although the site has a compaction layer at about 8-10 cm, deep ripping alone is not likely to improve root growth. It is likely that the distorted root growth has been constrained by a combination of factors:

- Acidity
- High aluminium levels
- Wet conditions

Deep ripping to target the ‘hardpan’ may be seen as an obvious solution to “j-rooting”, but roots would grow into the acidic subsoil if the acidity issue was not also addressed.

GRDC Grains Research & Development Corporation

NSW GOVERNMENT Department of Primary Industries

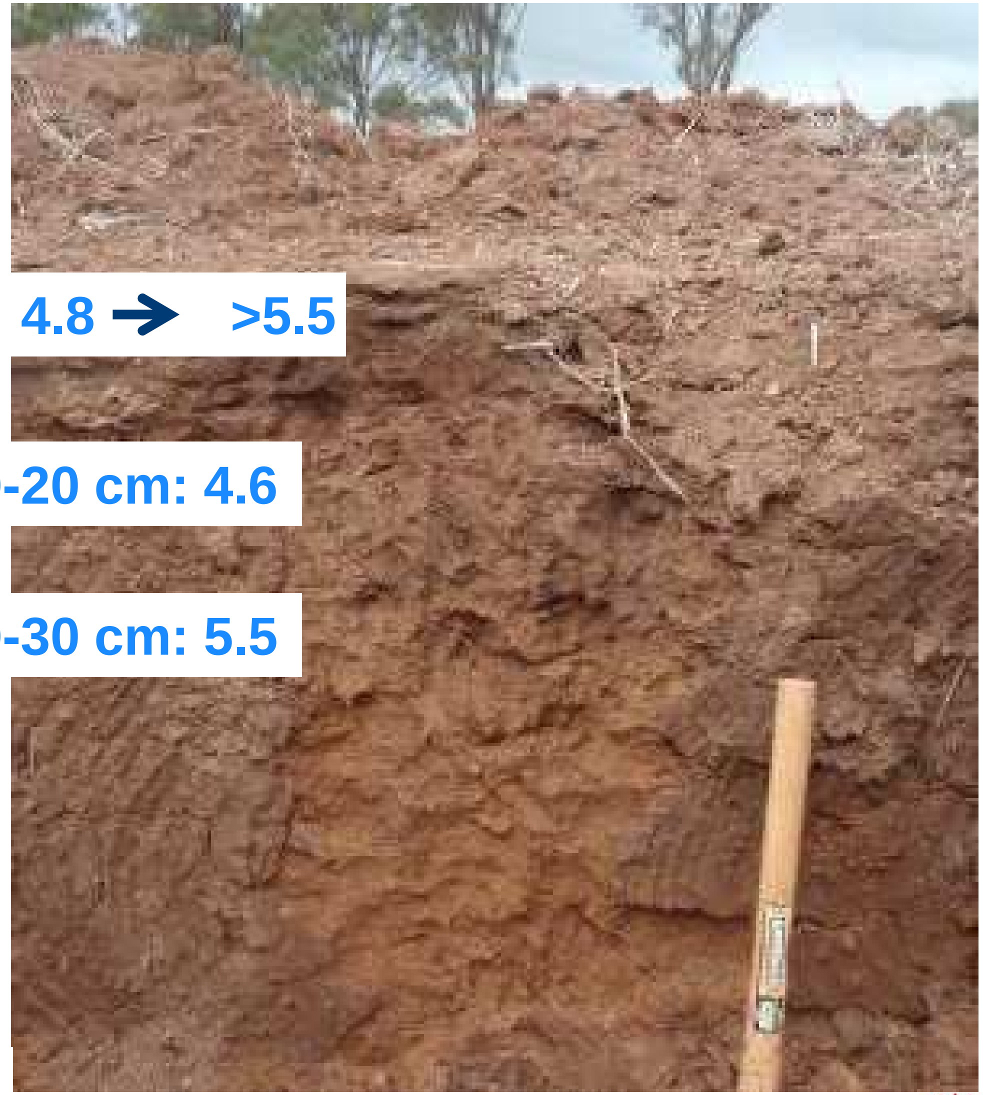
Maximising productivity from acid soils

Depth (cm)	Podosol / Sodosol
0-10	4.3 → **5.2**
10-20	4.1
20-30	4.5

- Response to surface liming – **CHECK nodulation of legumes**
- Can strategic tillage be used to speed up lime response and raise pH? If tillage is not an option , delay sowing sensitive species until topdressed lime effect has moved below the surface layers (e.g. >5 cm)
- Maintain pH > 5.5 to impact on subsoil pH - increase 15-20 cm by 1.0 unit after 20 years on clay loam soils, faster on lighter texture soils
- Subsoil pH limits yield potential of acid sensitive crops – sow tolerant species!

NSW GOVERNMENT | Department of Primary Industries

What is happening down soil profile



NSW GOVERNMENT | Department of Primary Industries

Maximising productivity from acid soils

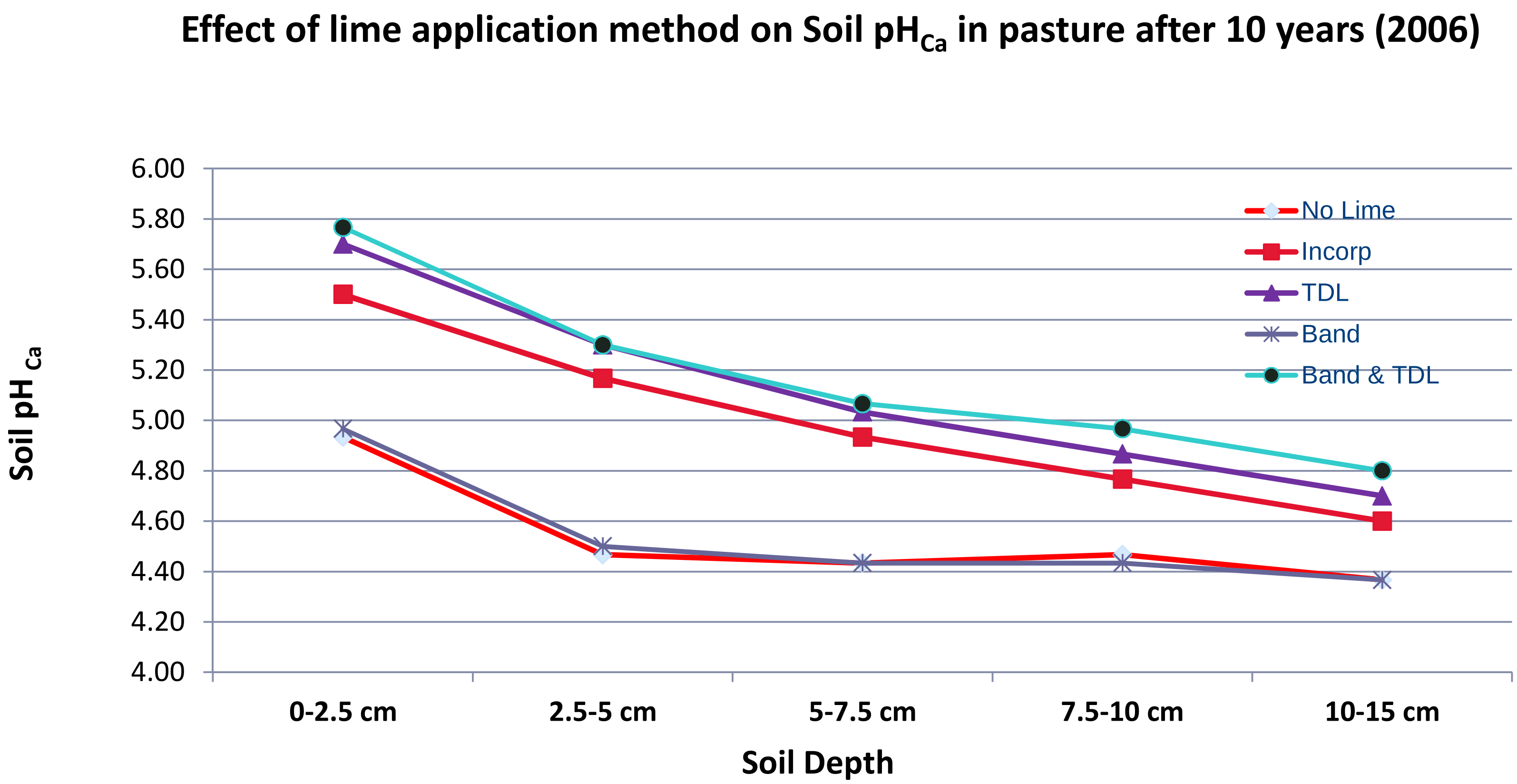
Depth (cm)	podosol	chromosol
0-10	5.2	4.8→ **5.5**
10-20	4.1	4.6
20-30	4.9	5.5

- **Check topsoil for stratified pH – can strategic tillage be used to improve lime distribution?** Target pH in 10-20 cm to remove subsoil acidity constraints
- Maintain pH > 5.5 to impact on subsoil pH – MASTER research site SE of Wagga -increase 15-20 cm by 1.0 unit after 20 years on clay loam soils,
- Consider crop and pasture selection AND strategies to avoid other stresses

NSW GOVERNMENT | Department of Primary Industries

Lime movement at Yass

Light texture, gravelly soil



Treatments: **No lime**
Incorp -3t/ha incorporated
TDL - 3t/ha topdressed – no incorporation
Band- Single super + lime each at 150 kg/ha
Band & TDL

Conyers, unpublished

NSW GOVERNMENT Department of Primary Industries

PRIORITY is vigorous growth to minimise impact of hostile subsurface

- Adequate nutrition (P, N or effective nodulation)
- Sow early in window to avoid cold wet conditions

TO

- Minimise exposure to stresses in hostile layers
- Reduce susceptibility to disease
- Improve tolerance to waterlogging
- Improve capacity to overcome ‘hardpans’

NSW GOVERNMENT | Department of Primary Industries

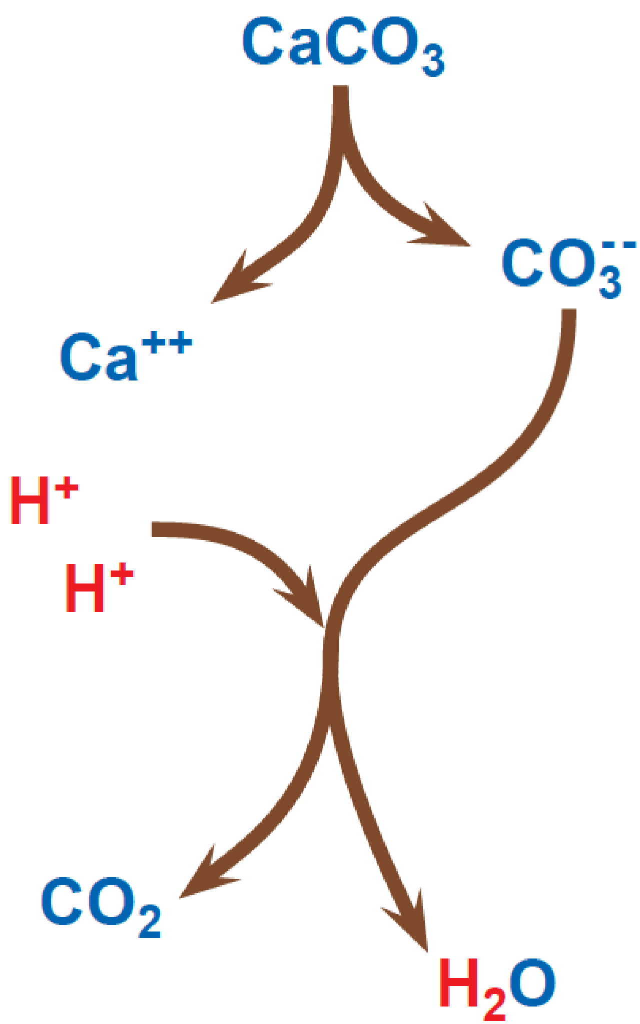
LIME QUALITY

Lime quality dictates:

1. How much pH will change
2. Speed of response

Liming material	**Neutralising value**	**Fineness**
Agricultural lime (Calcium carbonate)	60 → 98	Fine grade *90% passes through 250 µm sieve*

Lime – how it increases pH…

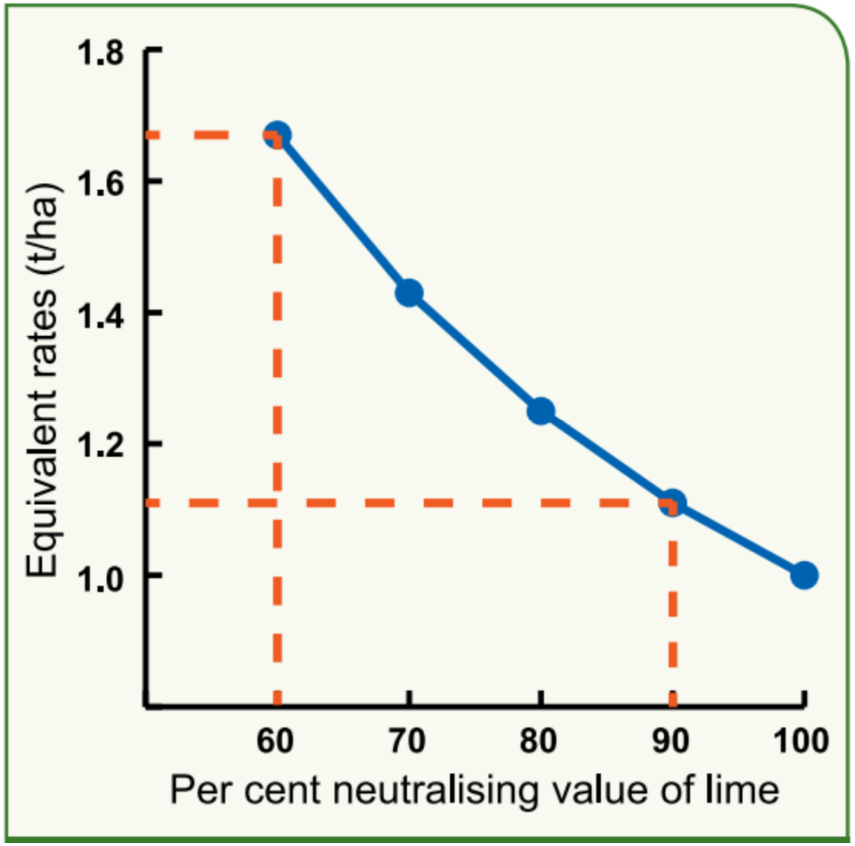


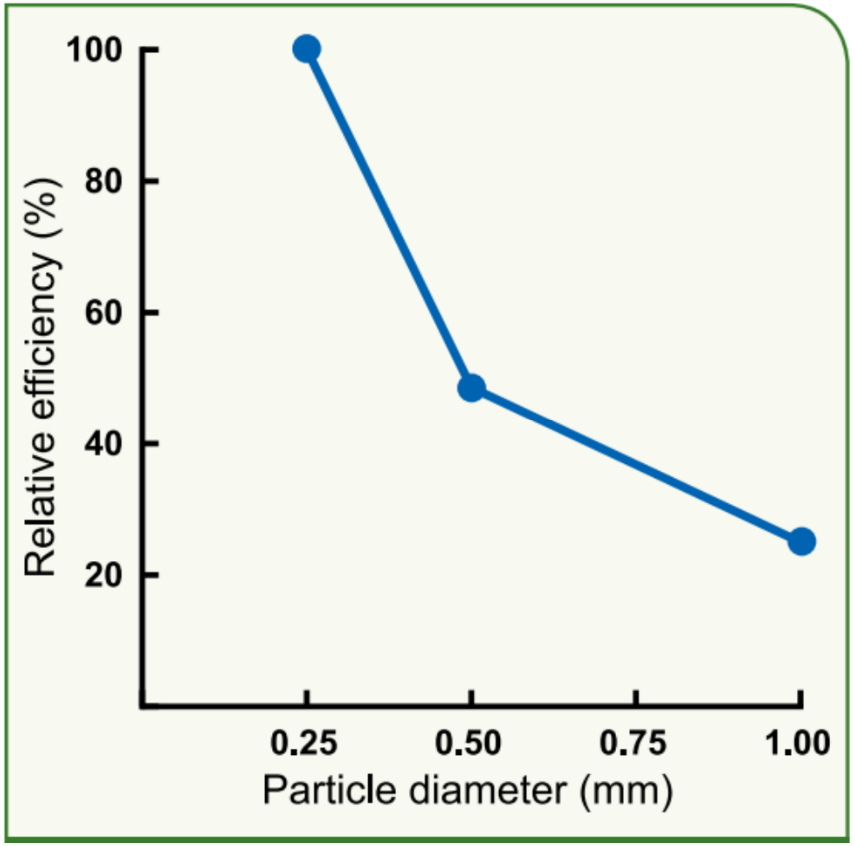
- When lime reacts with water in moist <u>acid</u> soils the calcium and carbonate ions separate.
- The Ca^{2+} ions binds to clays and OM
- The $(CO_3)^{2-}$ ions react with ‘free’ hydrogen in the soil solution to form carbon dioxide and water.
- The soil pH will increase when the H^+ ions form water in the soil

Source: Gazey et al 2014 (DAFWA)

The most responsive lime will have

- High neutralising value (NV); 100 = pure limestone
- Fine particle size (0.25 mm = 250 µm, i.e. at least 90% of the product will pass through a 250 µm sieve).





Source: Gazey (2011)

What is the best value lime?

- Neutralising value (NV)
- Fineness

Efficiency of the product

$$= NV \times fineness \div 100$$

Comparative cost

$$= (Spread\ cost \times 100) \div Efficiency$$

NSW GOVERNMENT | Department of Primary Industries

Comparing costs:

	Lime A	Lime B
Fineness	50	90
NV	95	95
Efficiency	47.5	85.5
Price***	$85 / t spread	$100 / t spread
Comparative cost	$179/t lime	$117/t lime

***Moisture level – ideally 1 to 3%

NSW GOVERNMENT Department of Primary Industries

Key messages

Liming should be a paddock-by-paddock decision

- Highly productive paddocks will have highest acidification rates – *productivity will decline over time*
- Acid layer at depth of 5 – 15 cm is common
  - accentuated under zero till systems - lime topdressed
- Monitor trends in soil pH
  - 0 – 10 cm sample check for stratification (0-5, 5-10 cm)
  - 10 - 20 cm check is OK for chosen crop/pastures
- Incorporate fine-grade lime with high NV for most rapid pH change
- Maintain pH in 0-10 cm at >5.5 to improve subsoil

NSW GOVERNMENT Department of Primary Industries

QUESTIONS?

NSW GOVERNMENT | Department of Primary Industries