Soil acidity – targeting the effort

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Crookwell
5th March 2019

Binda / Laggan locality

Know your soil

What is pH_{Ca} down the profile?

Depth (cm)	Basalt	Granites	Alluvials
0-10	5.5	5.0 +	4.2
10-20	5.2	4.6 +	4.1
20-30	6.1	5.0 +	4.5
CEC	>10	4 - 10	2 to 5

Hostility

2000: Lime application on pasture

'Application of lime may not be economic in grazing systems'

It's time to review management of soil acidity ….. 20+ years on

Financial conditions have changed?

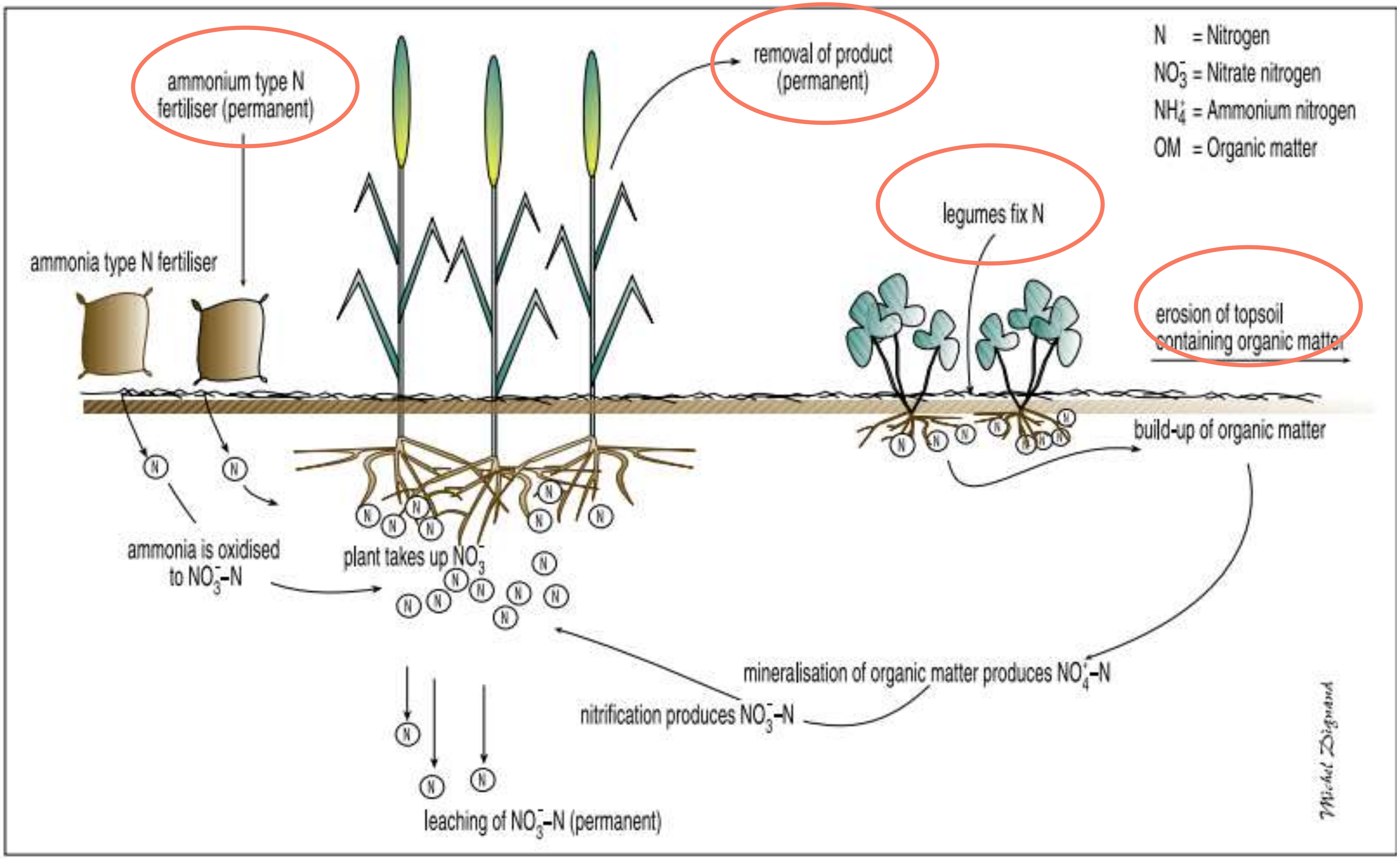
- Land price has increased
- The relative cost of lime has decreased:
  < 5% c.f. 15% of land value
- Interest rates are lower
- Wool and livestock prices are relatively high…………
- Lime is NOT a variable cost – it is a capital investment with residual value

If you are using liming.....

- Do you know if you are improving soil acidity?
  - When is the last time you checked your pH profile?
- What triggers do you use to decide when to lime?
- What is the pH you aim for after liming?

A refresher in the soil chemistry

All agricultural systems acidify – add H^+ ions



NSW DPI Agfact AC 19 - *Soil Acidity and Liming*

Product removal and acidification:

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

Acidification resulting from product removal - the Carbon cycle

$CO_2 + H_2O$ &
Sunshine

In the leaf
$CO_2 + H_2O \rightarrow RCOO^- + H^+$

In the roots
Cations are absorbed (e.g. Ca^{2+}, Mg^{2+}) and H+ is excreted into the soil

The plant becomes more alkaline and the soil becomes more acidic

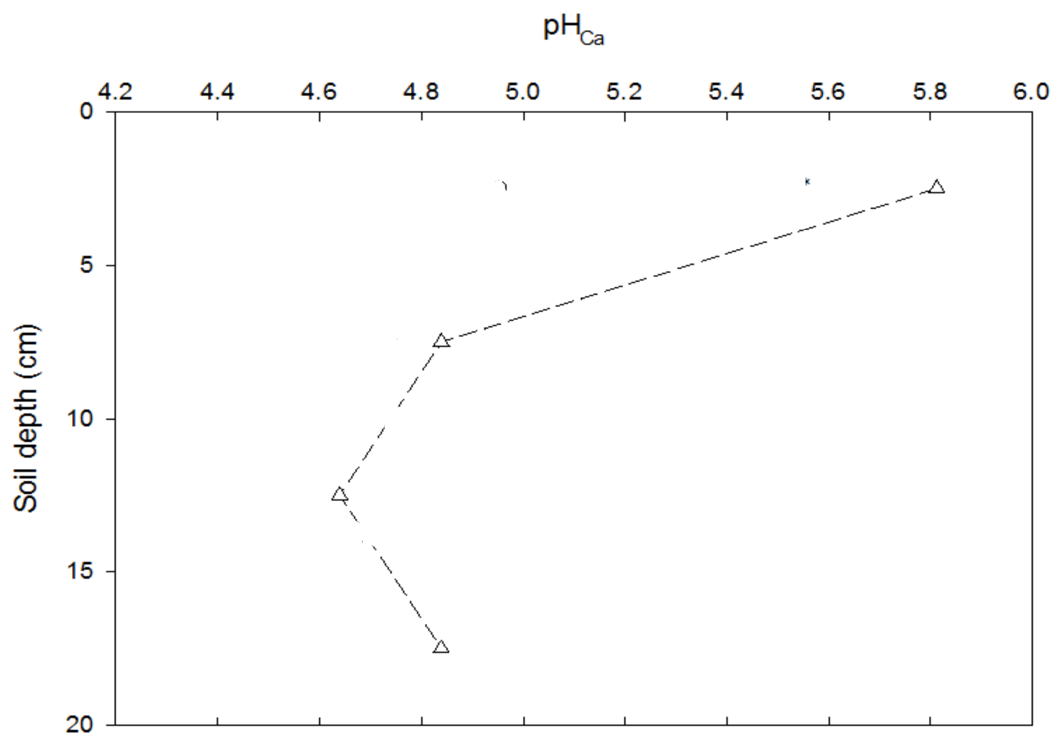
Addition of acid to the soil profile is concentrated in the root zone and is proportional to root density

The alkali plant product is exported

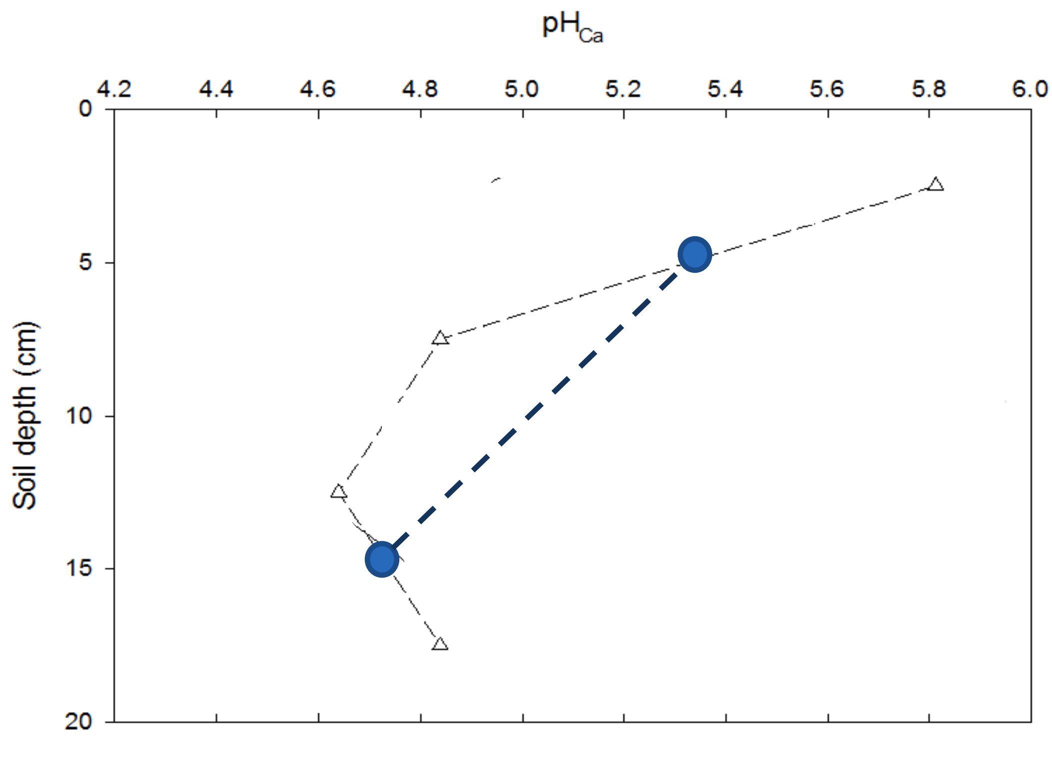
The plant dies and alkali residue remains on the soil surface.

The organic matter converts to $CO_2 + H_2O$ and energy

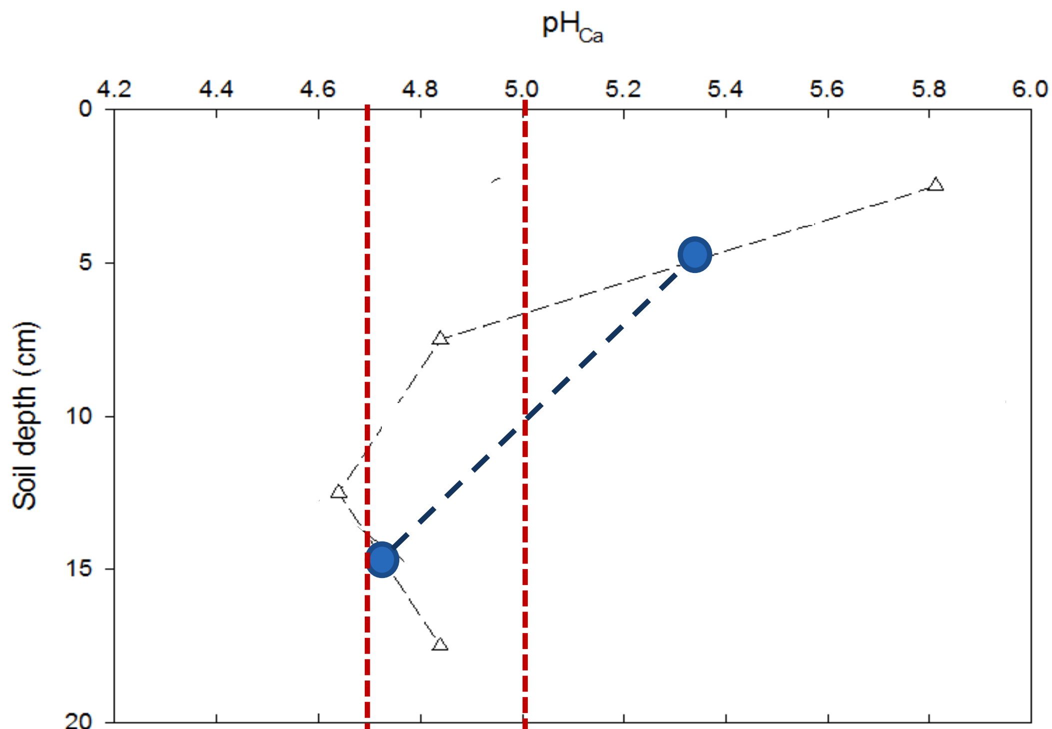
pH stratification……



pH stratification……



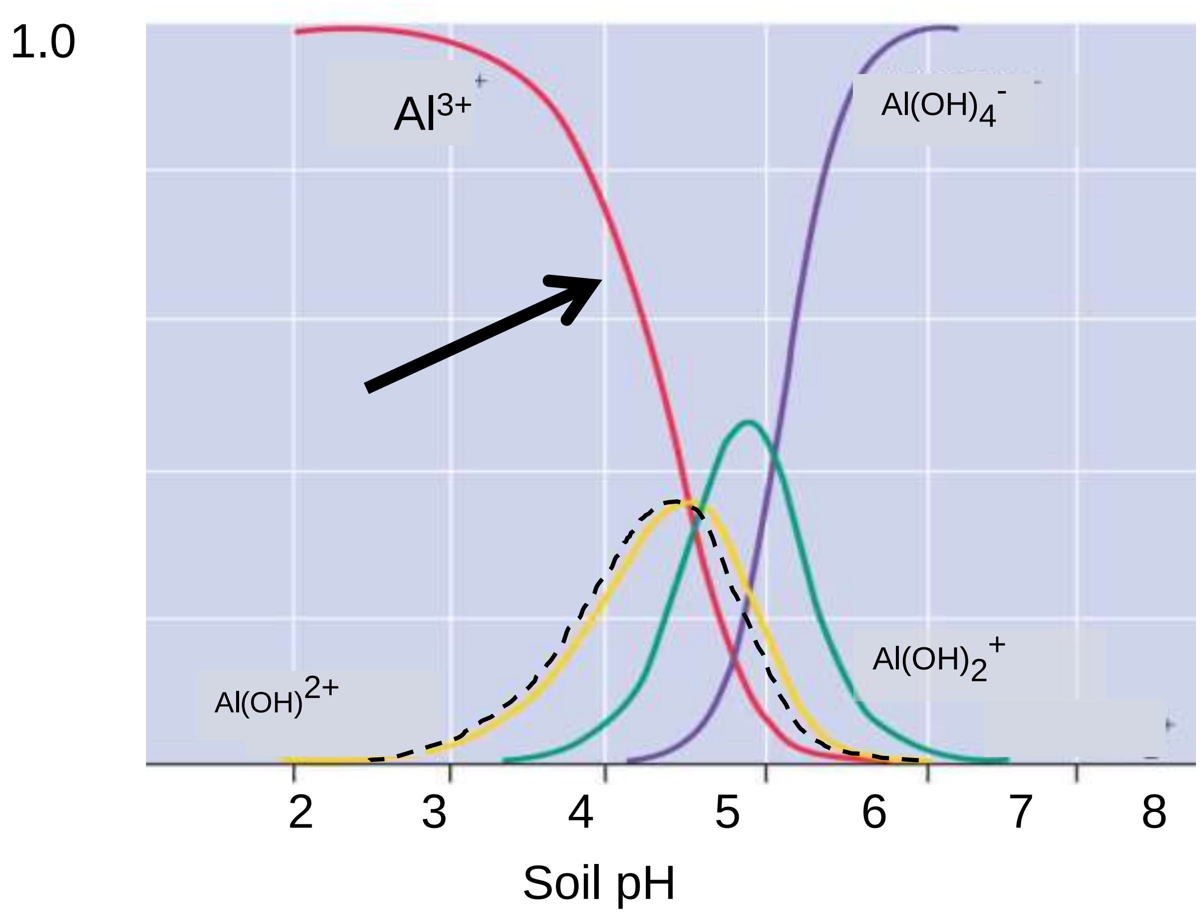
pH stratification……



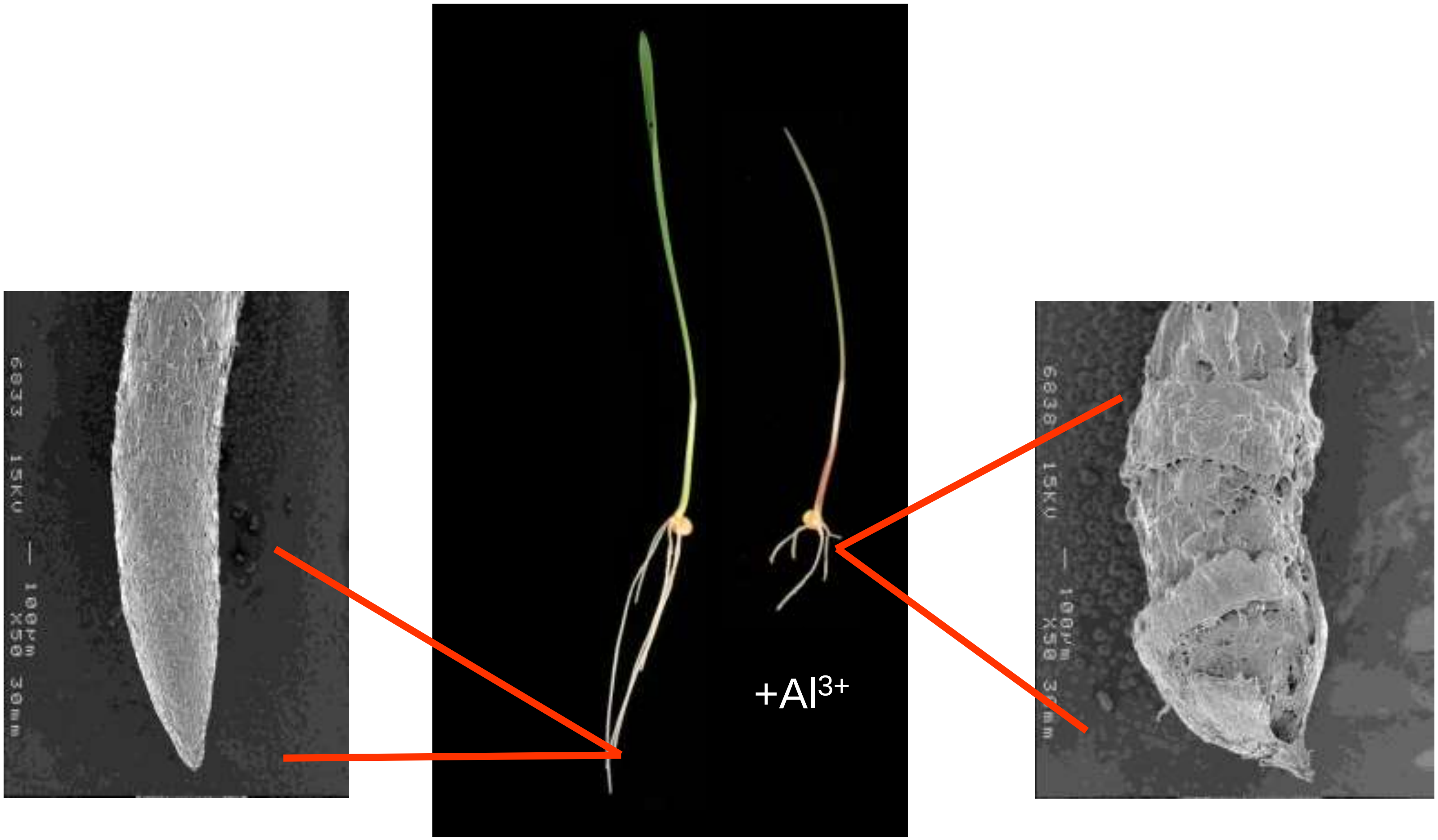
Legume nodulation affected

Yield potential of most plant reduced

Aluminium and soil pH



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



Sensitivity to aluminium

Aluminium tolerant

rice

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

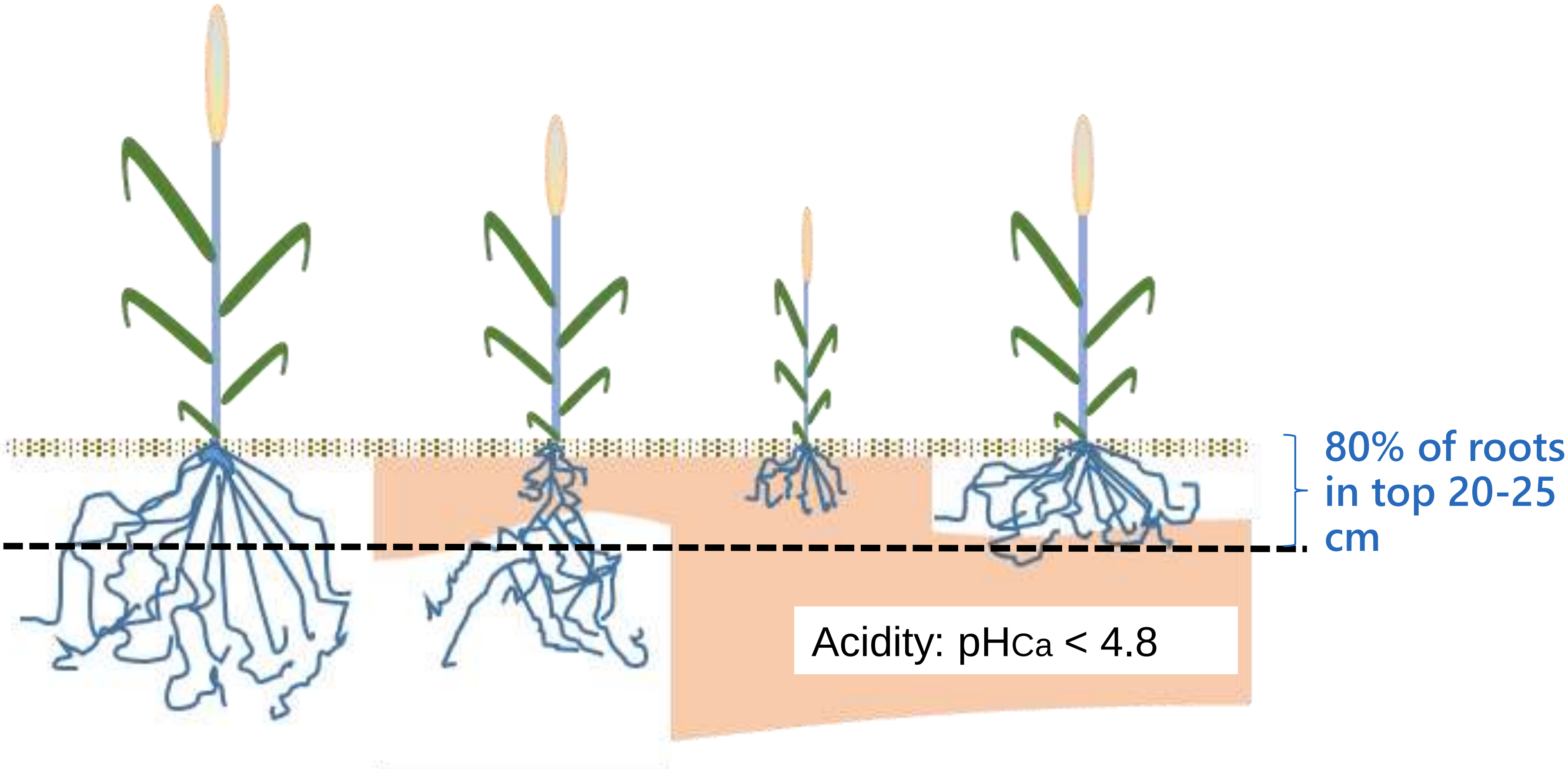
sub clover

canola /tolerant barley, albus lupins, phalaris seedlings, lucerne
sensitive wheat
sensitive barley ≥ durum

faba bean, field peas, lentils, chickpeas

Aluminium sensitive

The pH profile affects plant growth!



Factors affecting 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
Reduces microbial activity	e.g. Rhizobia survival, effective nodulation
Mineral deficiencies	> Molybdenum and Phosphorus availability
Manganese toxicity – vigour of non-cereals	Mn not available to plants

Rhizobia populations and pH

Depth (cm)	pH_{Ca}	Organic C (mg/g soil)	No. Rhizobia /g of soil
0-2	4.45	123.1	63,100
1-2	3.72	56.4	2,190
2-4	3.65	40.2	631
4-6	3.64	31.7	282
6-9	3.70	26.5	1350
9-13	3.80	18.5	195

Source: Richardson and Simpson (1988)

Questions?

MASTER – 18 year lime experiment: 0-10 cm

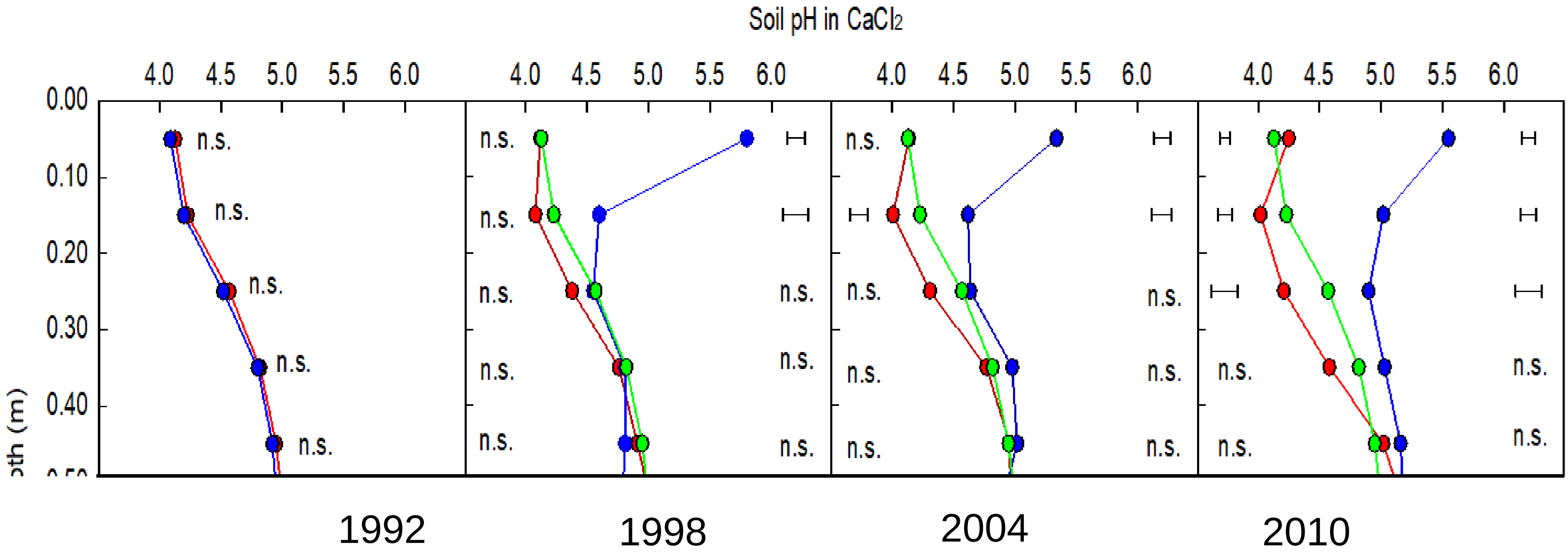
MASTER – 18 year lime experiment: 0-10 cm

approx. 3.9 t/ha incorporated → pH_{Ca} 5.65

2.6 t/ha topdressed

1.4 t/ha topdressed

MASTER long-term trial



- Unlimed
- Limed to maintain pH > 5.5 (on average)
- Starting pH (1992)

MASTER

- Perennial and annual pasture systems acidify soil in depths at a similar rate
- Surface liming can alleviate subsurface soil acidity (i.e. below 10cm) ……….. if soil is limed regularly to maintain pH_{Ca} ≥5.5 to keep the system productive and sustainable
- Soil re-acidification rate is 0.09 pH units per year in the 0-10cm depth
- If pH_{Ca} > 5.5 in 0-10 cm:
  - Soil acidity amelioration rate is 0.04 pH unit per year in the 10-20cm depth

MASTER – 18 year lime experiment: 0-10 cm

Payback for lime in 'prime lamb' system

- PP limed 14.5 vs Nil lime 11.7 dse/ha (23%)

Break-even years (discounted)

Lime	$40		$50		$60		$70		$80		$90		$100	
Lamb	AP	PP	AP	PP	AP	PP	AP	PP	AP	PP	AP	PP	AP	PP
$60	8	9	10	11	16	>18	>18	>18	>18	>18	>18	>18	>18	>18
$65	5	8	9	10	11	17	17	>18	>18	>18	>18	>18	>18	>18
$70	4	5	5	8	9	10	11	17	17	>18	>18	>18	>18	>18
$75	4	5	5	8	8	9	10	11	15	>18	17	>18	>18	>18
$80	4	4	5	5	5	8	9	10	10	11	15	>18	>18	>18
$85	3	4	4	5	5	5	8	9	9	10	11	11	16	>18
$90	3	4	4	4	5	5	5	8	9	9	10	10	11	16
$95	3	3	4	4	4	5	5	5	8	8	9	10	10	11
$100	3	3	3	4	4	4	5	5	5	8	8	9	10	10
$105	3	3	3	4	4	4	4	5	5	5	8	8	9	9
$110	3	3	3	3	4	4	4	5	5	5	5	8	8	9
$115	2	3	3	3	3	4	4	4	4	5	5	5	8	8
$120	2	3	3	3	3	4	4	4	4	5	5	5	5	8

G.D. Li *et al* 2010

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Laggan results – see Matt Lieschke

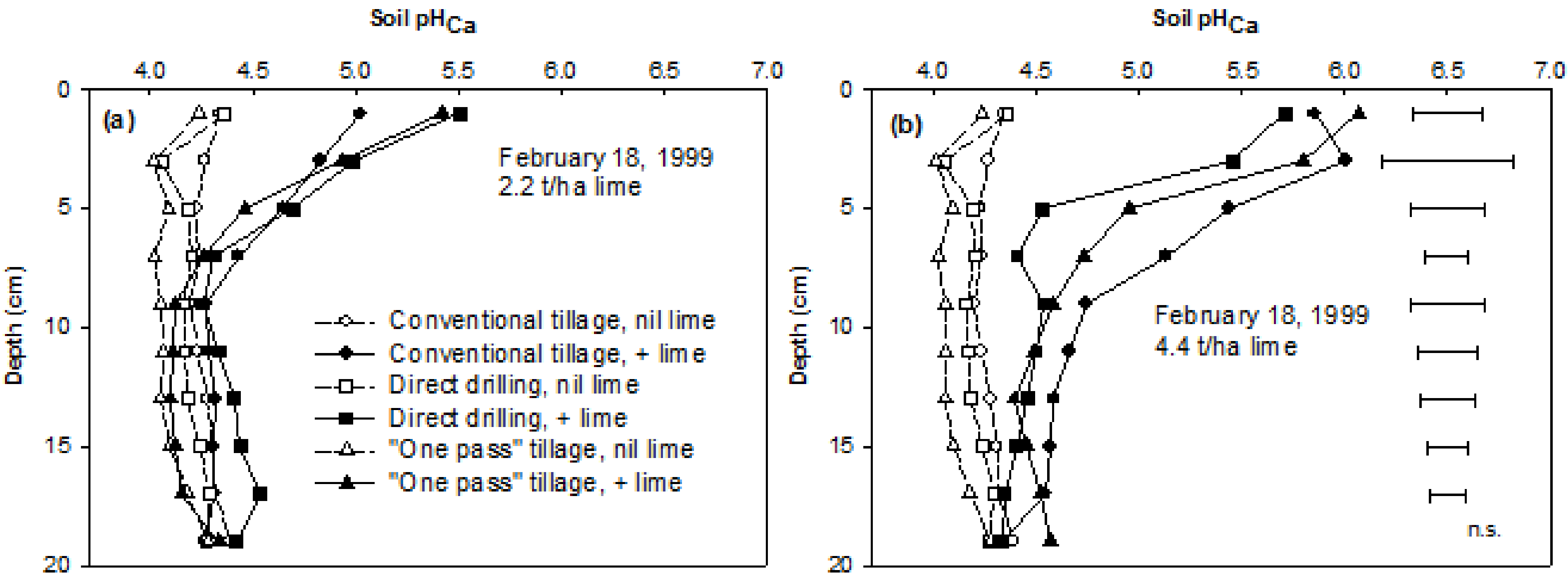
Trtment	2015	2016	2017	Operating profit ($/ha/yr)
Super + Lime	2.5 t/ha lime + 125 kg/ha Mo SSP	125 kg/ha SSP	160 kg/ha SSP	491.29
Control	Nil	Nil	Nil	335.90
Super	125 kg/ha Mo SSP	125 kg/ha SSP	160 kg/ha SSP	433.75

Laggan results – 2017

Average Monthly Pasture Growth Rates (kg DM/ha/day)

Trtment	Summer	Autumn	Winter	Spring	Operating profit ($/ha/yr)
Super + Lime	18	41	16	27	491.29
Control	12	31	11	16	335.90
Super	16	36	14	21	433.75

Lime rate and incorporation -Oolong



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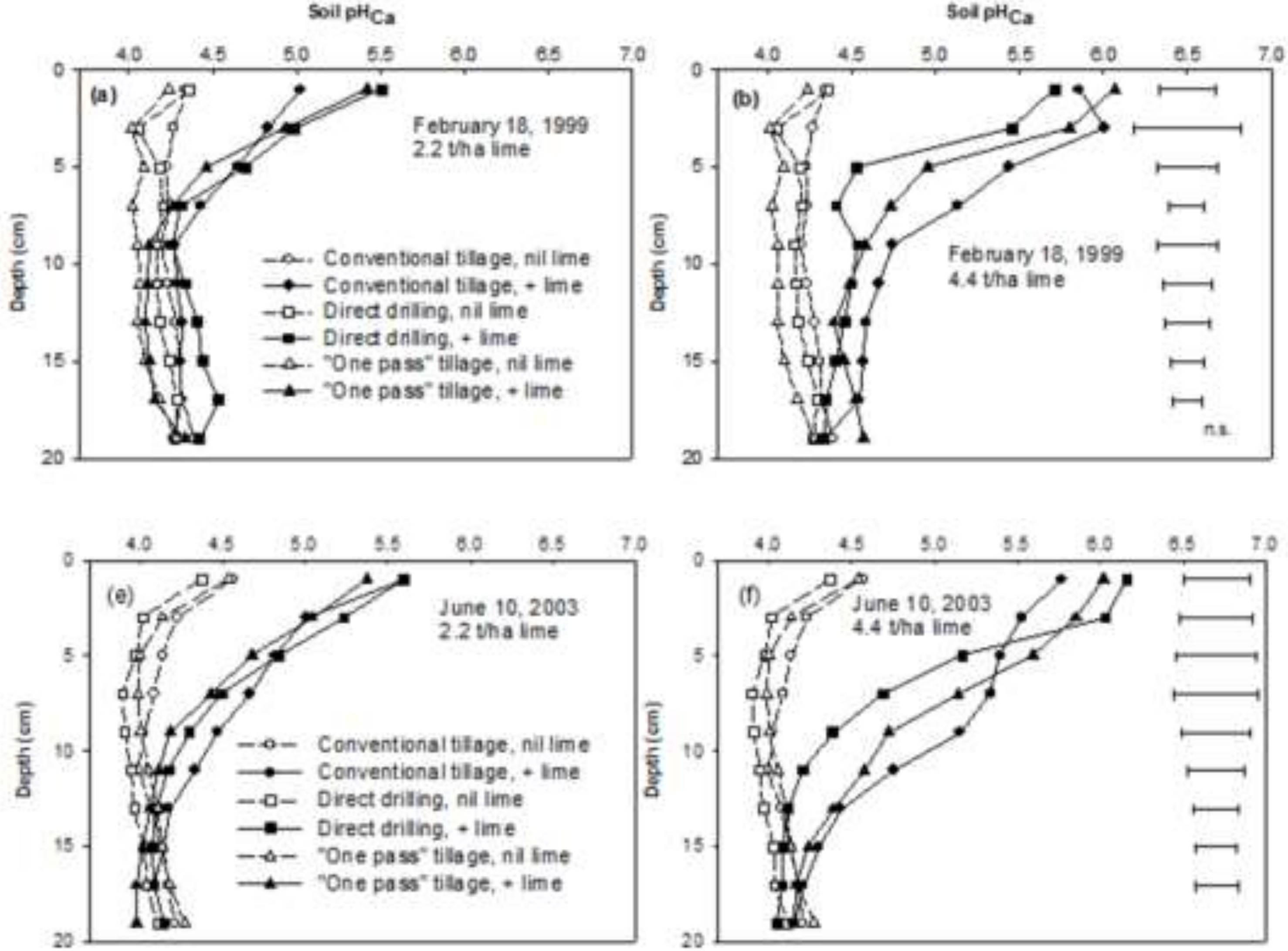
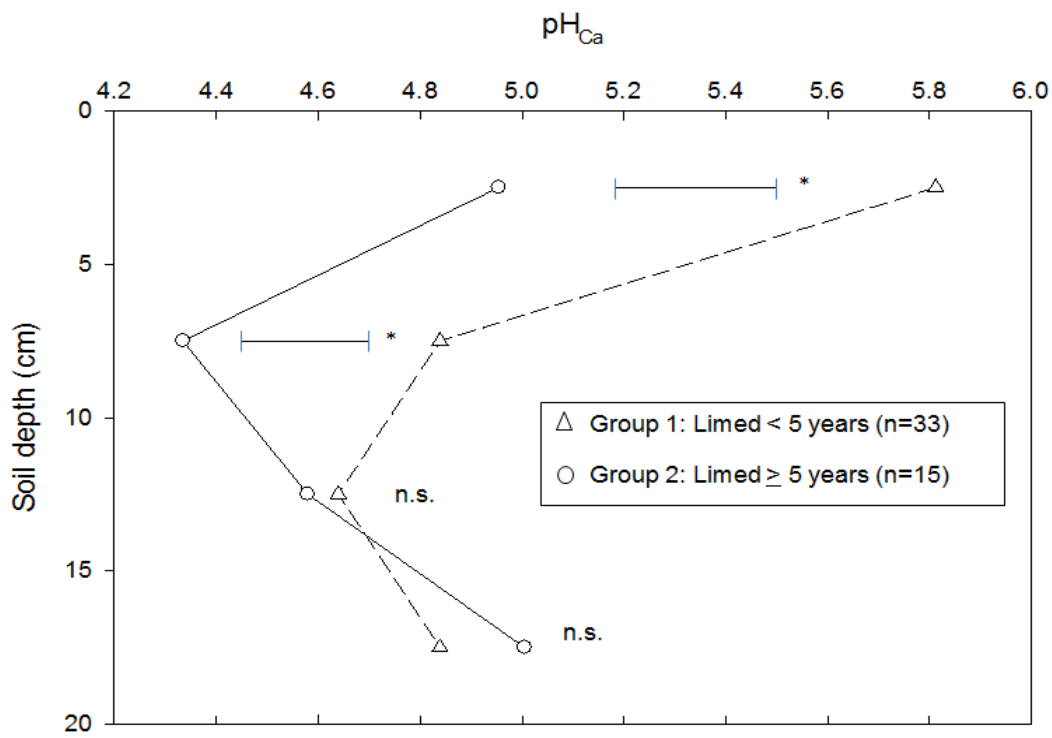


Cropping systems……



Conclusions

- Soil samples collected from traditional depths of 0-10cm & 10-20 cm do not detect pH stratification
- The most acid layer is commonly at 5 – 15 cm BUT more severe with crops in rotation
- Current lime inputs are insufficient to neutralise acidity at 0-10 cm and prevent acidification in the subsurface layers at 10-20 cm.

Superfine lime (t/ha) to lift pH of 0 -10 cm to 5.2 or 5.5

ECEC (meq/100gm)	Lime required (t/ha) to lift the pH of the top 10 cm:				
	from 4.0to 5.2	from 4.3 to 5.2	from 4.7to 5.2	from 5.2 to 5.5	from 4.7 to 5.5
1	1.6	0.8*	0.3*	0.2	
2	2.4	1.2	0.5*	0.4	
3	3.5	1.7	0.7*	0.5	
4	3.9	2.1	0.9*	0.6	
5	4.7	2.5	1.1*	0.7	1.8
6	5.5	3.0	1.2	0.8	2.0
7	6.3	3.3	1.4	1.0	2.4
8	7.1	3.8	1.6	1.1	2.7

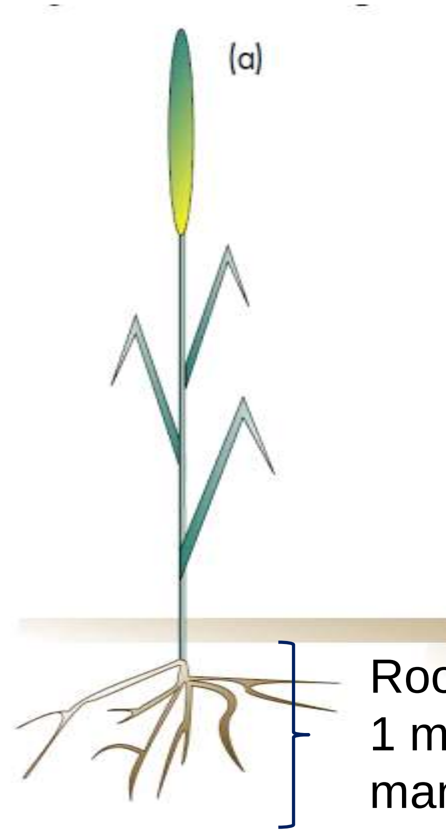
NSW DPI Agfact AC.19 (2005) - *Soil acidity and Liming*

Harden Wedgetail 2017

0-5 cm
pH_{Ca} ~5.0

5-15 cm
pH_{Ca} ~4.2

Canola – 2.3 t/ha



Root depth > 1 m for many spp.

Questions?

Do you need to change your approach to soil acidity?

Depth (cm)	Basalt	Granites	Alluvials
0-10	5.5	5.0 +	4.2
10-20	5.2	4.6 +	4.1
20-30	6.1	5.0 +	4.5
CEC	>10	4 - 10	2 to 5

Mixing lime with gypsum – does it increase rate of alkali movement?

Depth (cm)	Treatment	pH_{Ca}	Al %	Colwell P	Sulfur
0-10 cm	Baseline	4.3	18	56	4.2
	Lime	5.5	0	41	2.9
	Lime + gypsum	5.8	0	34	21
10-20 cm	Baseline	4.2	31	19	2.2
	Lime	4.5	20	12	<2
	Lime + gypsum	4.6	11	12	12

Han:

Organic amendment increased soil pH at layer below the placement, but lime did not

The applied lime increased pH in the surface layer (0-10 cm), allowing the more soluble alkalinity from the organic amendment to move down the profile and increase pH at depth

Norton As soil C increases, Al is less soluble….

P 349 …….accumulation of organic C in the 0–2.5 cm and a movement of alkalinity associated with Organic anions into the 2.5–5 cm (Butterly et al., 2013).

…The positive effects that the higher P level had on pHCa under low lime rates (P2L1 SR1) contrast with those under low P (P1L1 SR1). These effects occurred down to at least 7.5–10 cm and may be associated with higher legume production, and root development caused by the high P,

facilitating greater physical lime movement or indirect biologically induced lime movement resulting from plant growth, nutrient uptake, translocation and subsequent decomposition (Scott et al., 2000). Alternatively the possibly

enhanced uptake by plants of NO3 rather than Ca2+ couldcause addition of alkalinity