Effective acid soil management

Associate Professor Jason Condon (CSU and NSW DPI)

Helen Burns (NSW DPI)

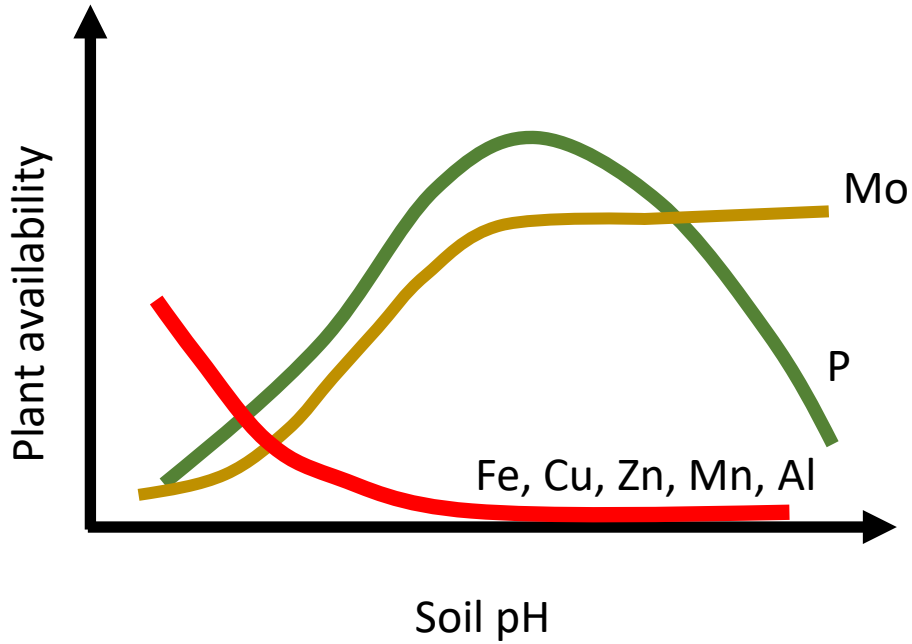
Anne-Maree Farley (NSW DPI)

James Holding (FarmLink), Helen McMillan (CWFS), Nick McGrath (HLN)

Acidity

Affects plant growth

Nutrient availability



Source: agric.wa.gov.au

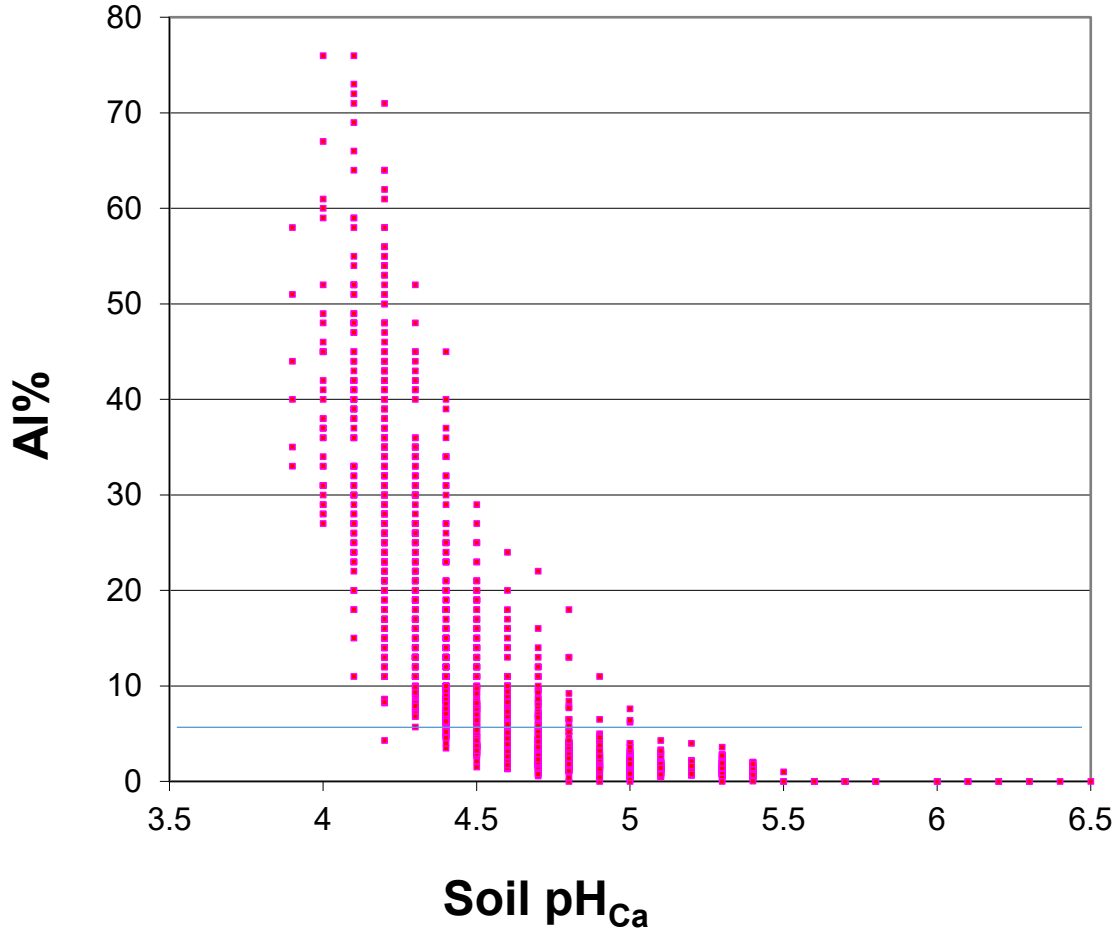
Acidity

Affects plant growth

Nutrient availability

Aluminium toxicity

Nil 2% Al +lime 0% Al



Source: Karl Andersson

Acidity

Affects plant growth

Nutrient availability

Aluminium toxicity

Root growth decreased

Nodulation decreases

Acidity

Affects plant growth

Nutrient availability

Aluminium toxicity

Root growth decreased

Nodulation decreases

Phosphate binds with iron and aluminium = decreased P for plants

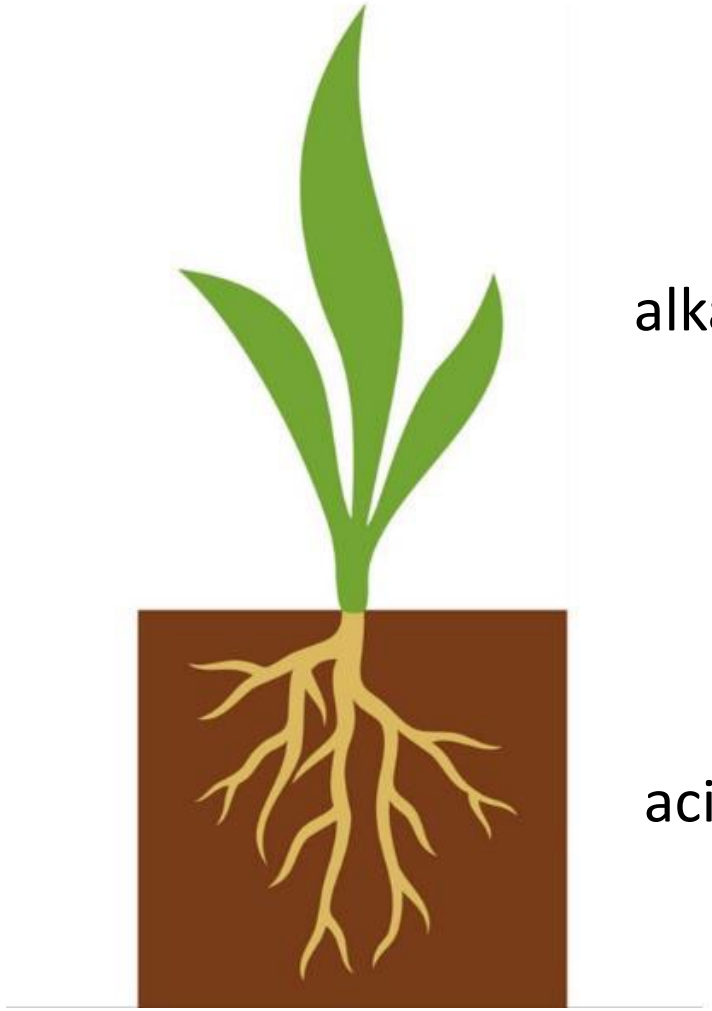
Plants susceptible to attack (pest and disease)

Productive agriculture is acidifying

Product removal:

Nitrogen inputs:

Urea, ammonium, legumes



alkaline

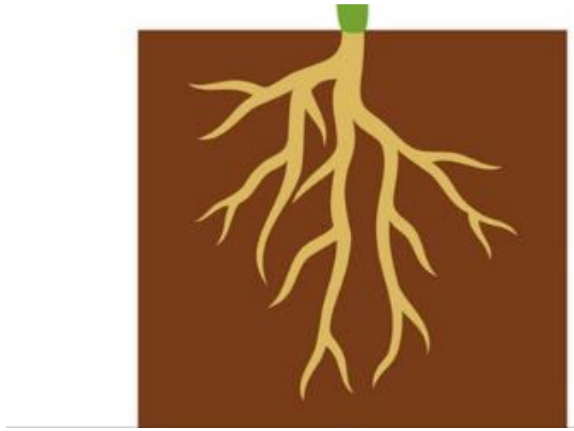
acid

Productive agriculture is acidifying

Product removal:

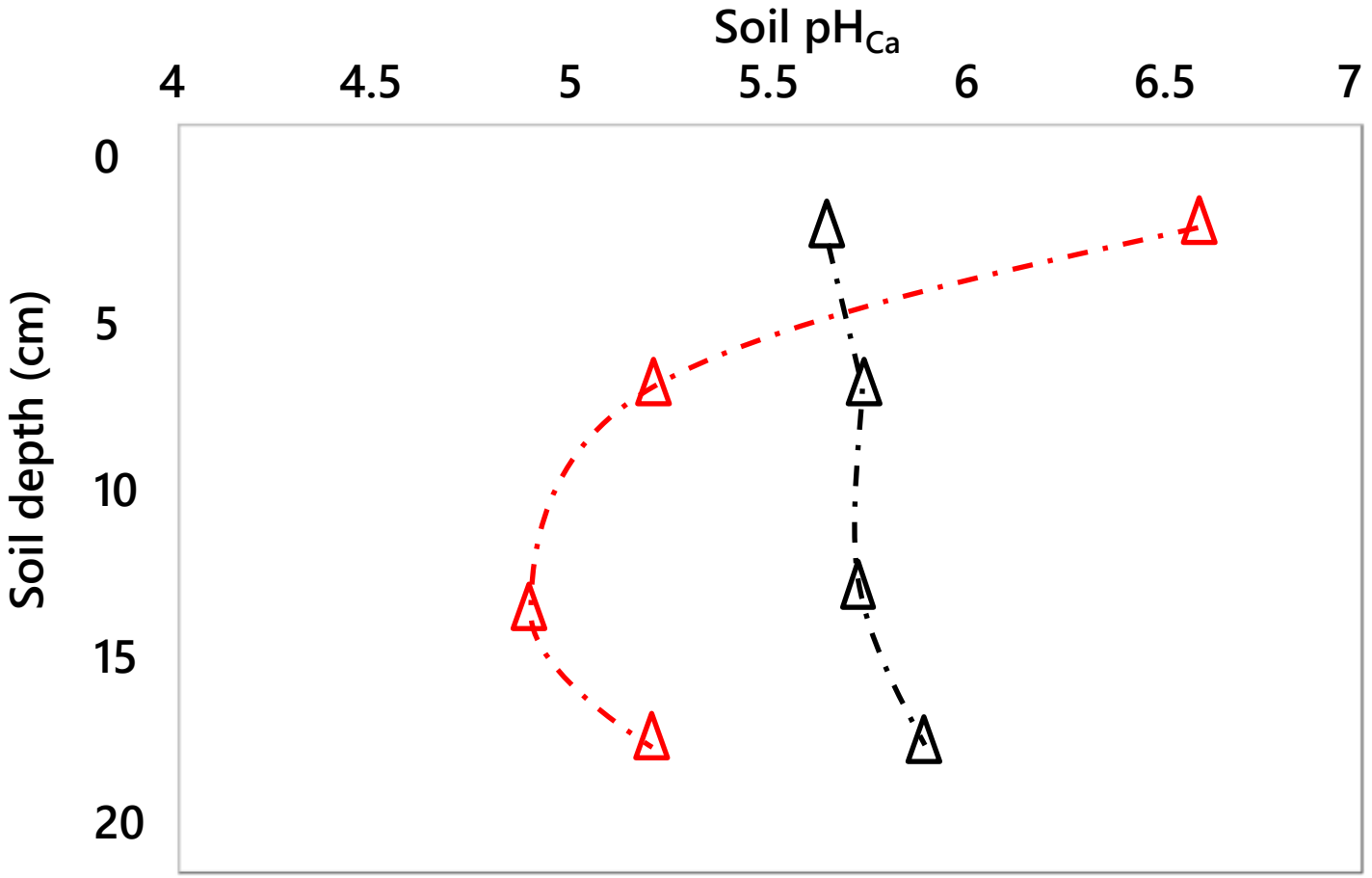
Nitrogen inputs:

Urea, ammonium, legumes



acid

Productive agriculture is acidifying: paired 'paddocks'



Source: Helen Burns

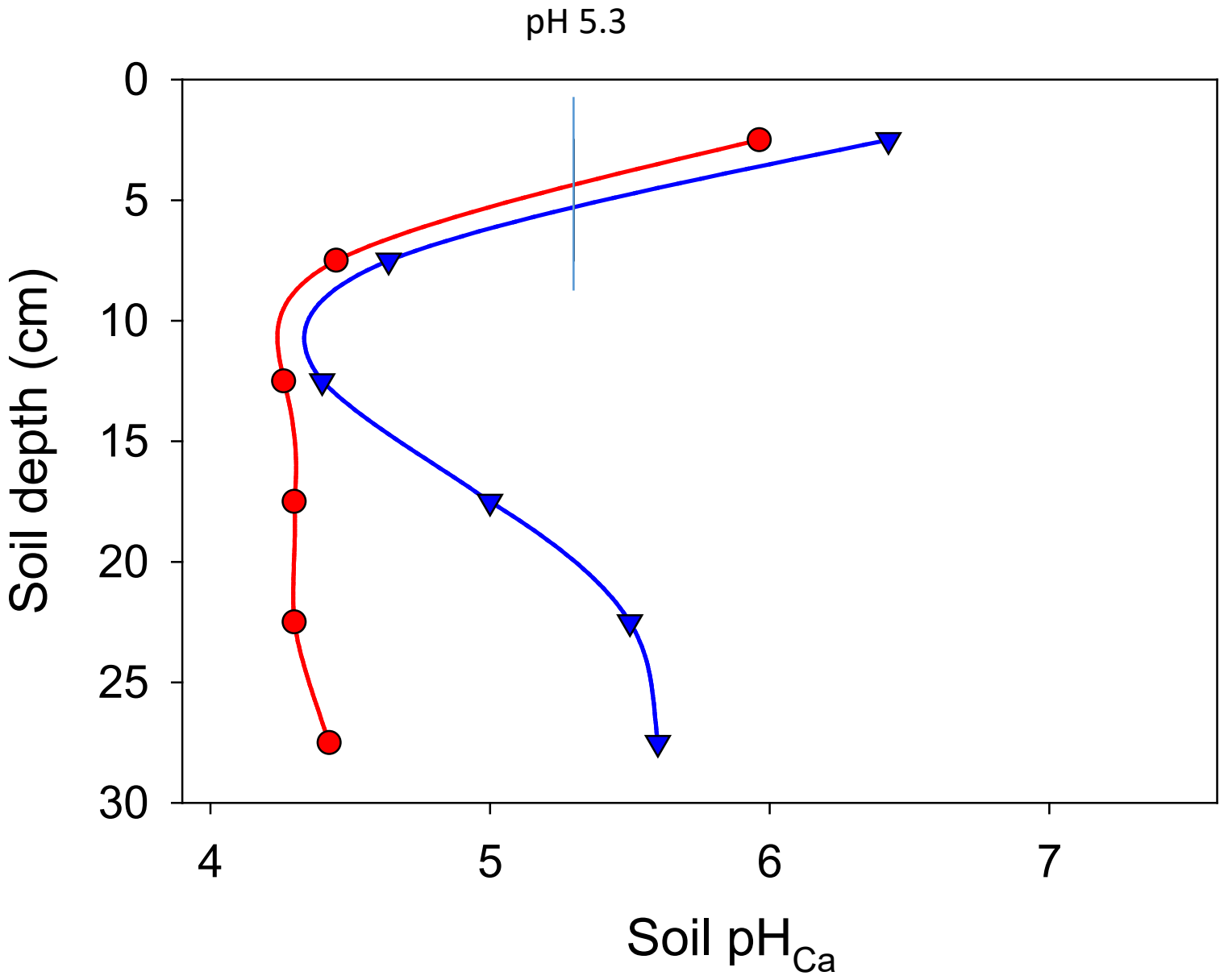
CEC ~ 10

Black triangle:
Undisturbed native pasture - cemetery

Red triangle:
Highly productive crop/legume-based pasture rotation.
Lucerne hay cuts
Yields up to:
7.5 t/ha wheat
2.8 t/ha canola
2.8 t/ha lupins

3 lime applications @2.5t/ha
1994, 2003, 2018

SAMPLING DEPTH


pH 5.3
0
5
10
15
20
25
30
Soil depth (cm)
4
5
6
7
Soil pH$_{Ca}$

Effective management of soil acidity - Sampling

- 5 cm intervals to 20 cm when thinking of liming (severity of problem, where it is, how much lime is needed)

- AND checking the lime applied **did what you wanted** especially **BEFORE** sowing sensitive plants

- Only analyse things you use – pH, exchangeable cations, Colwell P, and maybe OC%

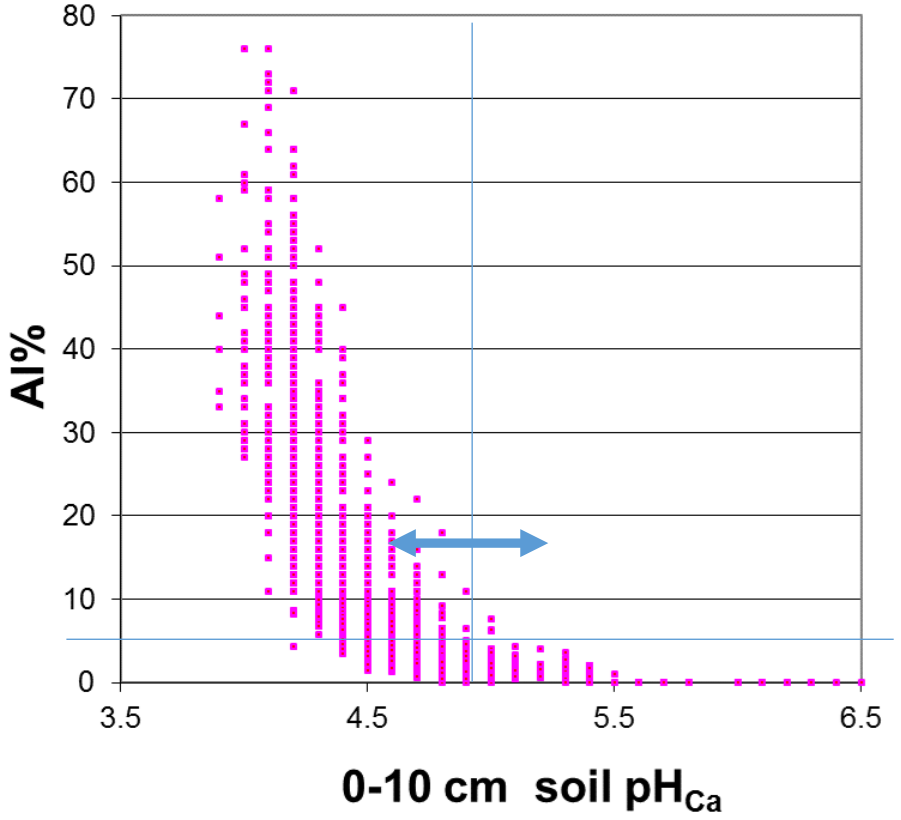
Liming strategies

Old liming strategies not as good as we thought

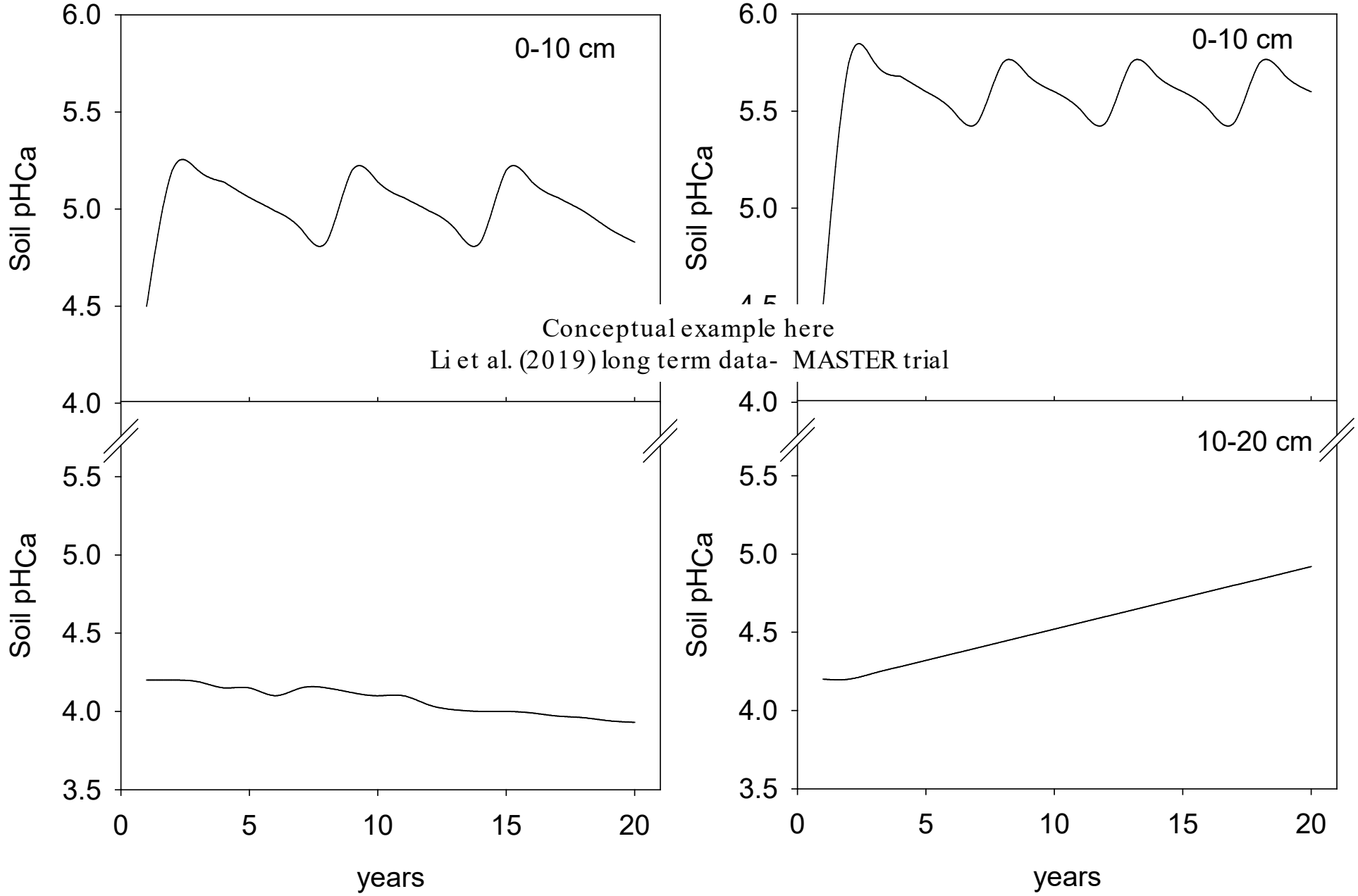
Sample for pH 0-10cm (maybe 10-20 cm)

Apply lime when pH is below pH_{Ca} 4.8

Apply enough lime to bring pH_{Ca} just above 5 (remove Al^{3+})



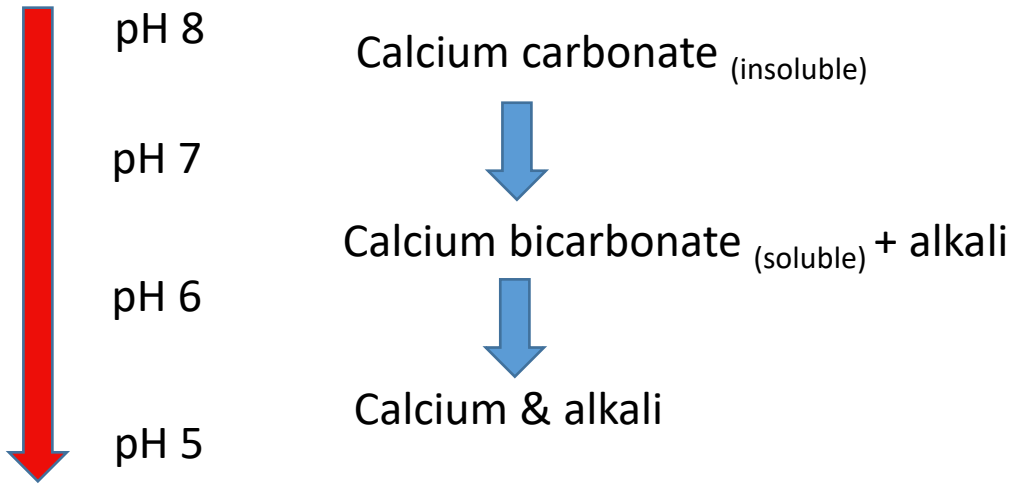
Source: Karl Anderson



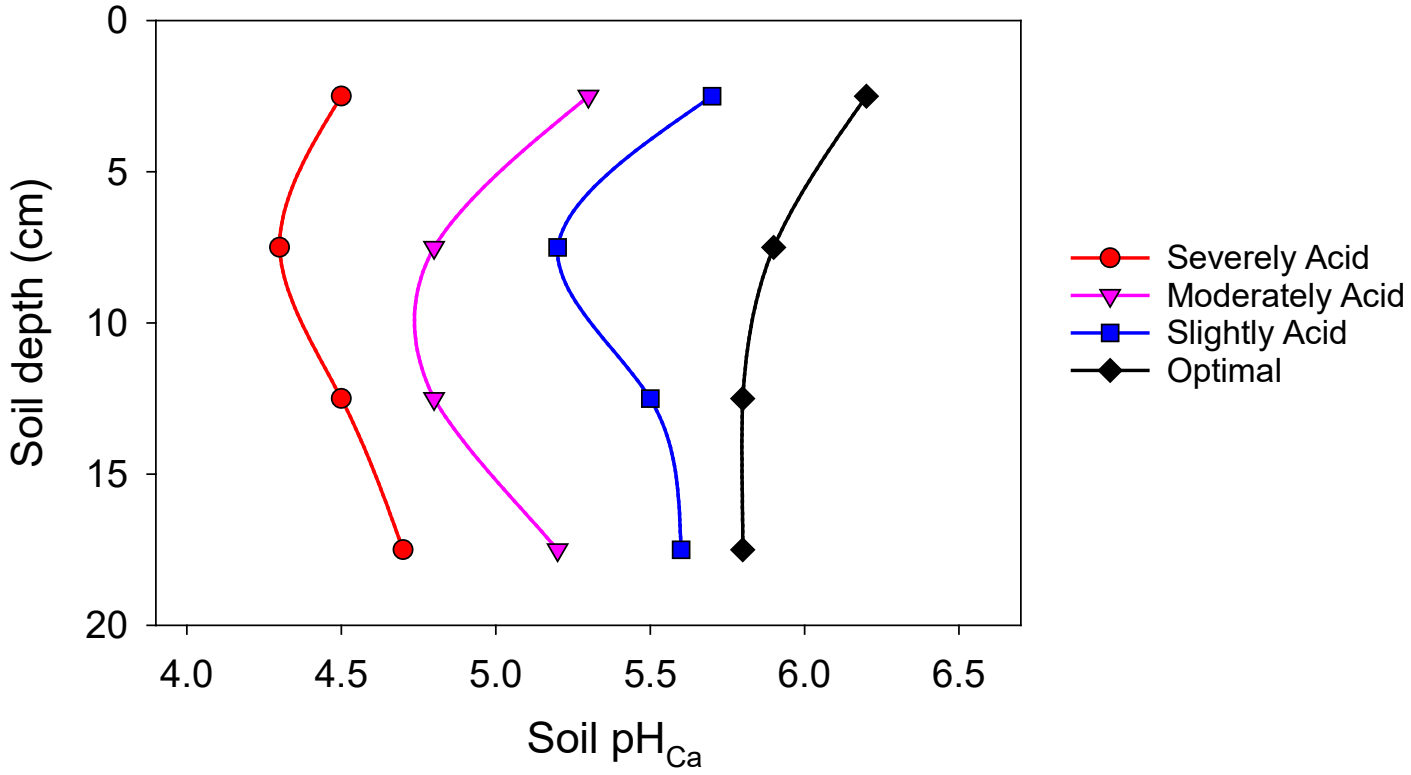
Conceptual example here

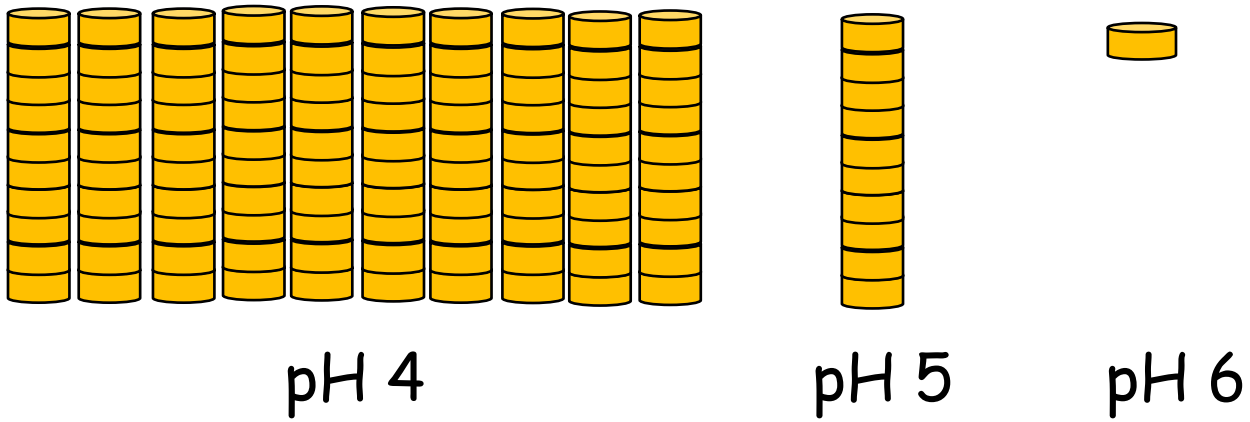
Li et al. (2019) long term data- MASTER trial

- New pH target = pH_{Ca} >5.5 above acid layers



Act early


0
5
10
15
20
Soil depth (cm)
4.0
4.5
5.0
5.5
6.0
6.5
Soil pH$_{Ca}$
Severely Acid
Moderately Acid
Slightly Acid
Optimal


pH 4
pH 5
pH 6

When to act ? Lime Rate x Incorporation Sites

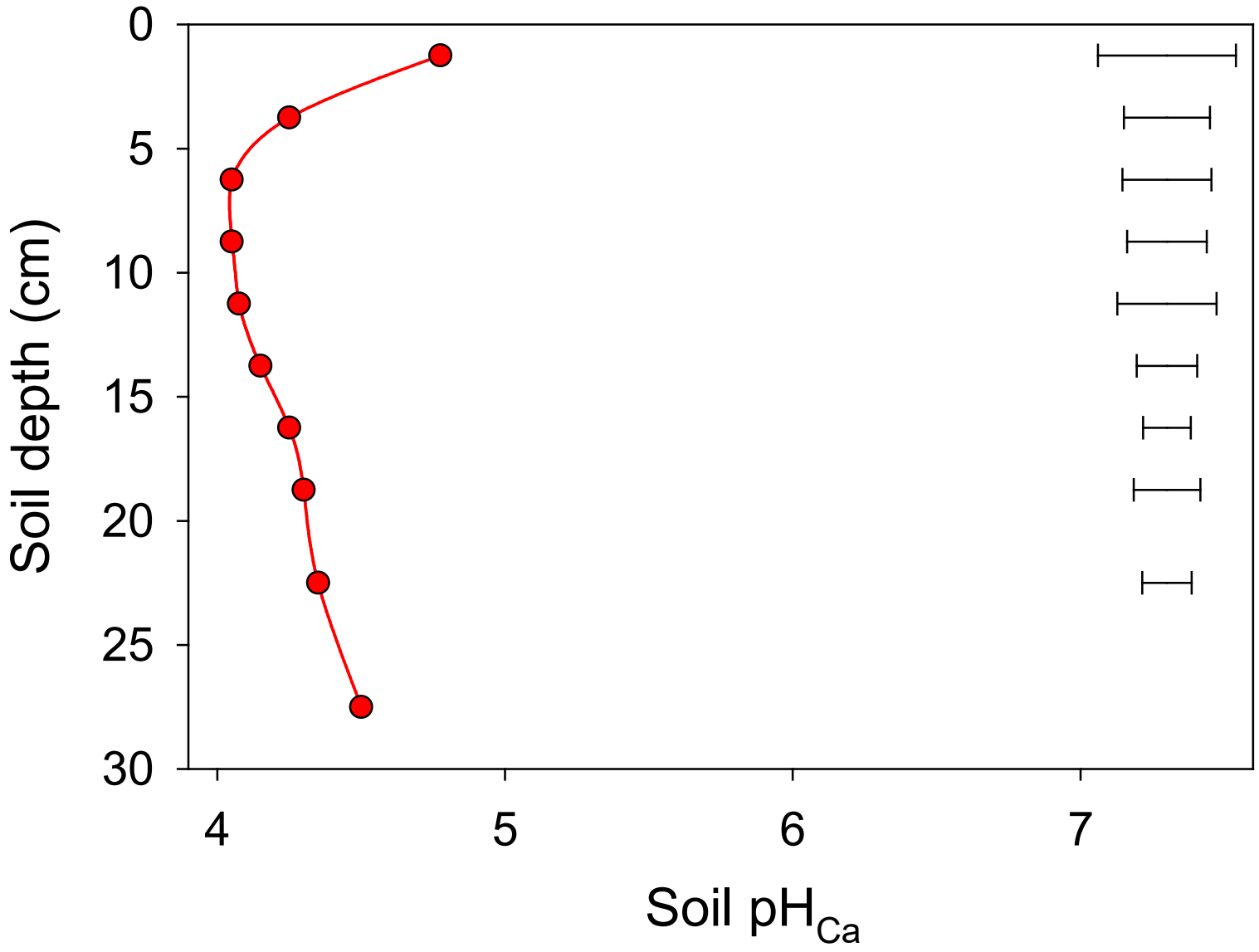
	Lyndhurst	Morven	Toogong
pH_{Ca} @ 5-15 cm	3.9 to 4.1	4.0 to 4.3	4.8 to 4.9
Lime rate targeting >5.2	4.7 t/ha	3 t/ha	1 t/ha
Lime rate targeting >5.5	5.9	4	2.8
Lime rate targeting >5.5 (in 0-5 cm surface layer)	2.9	2	1.4
'Once-in-a generation'	7	6	3.8

Effectiveness of lime applications

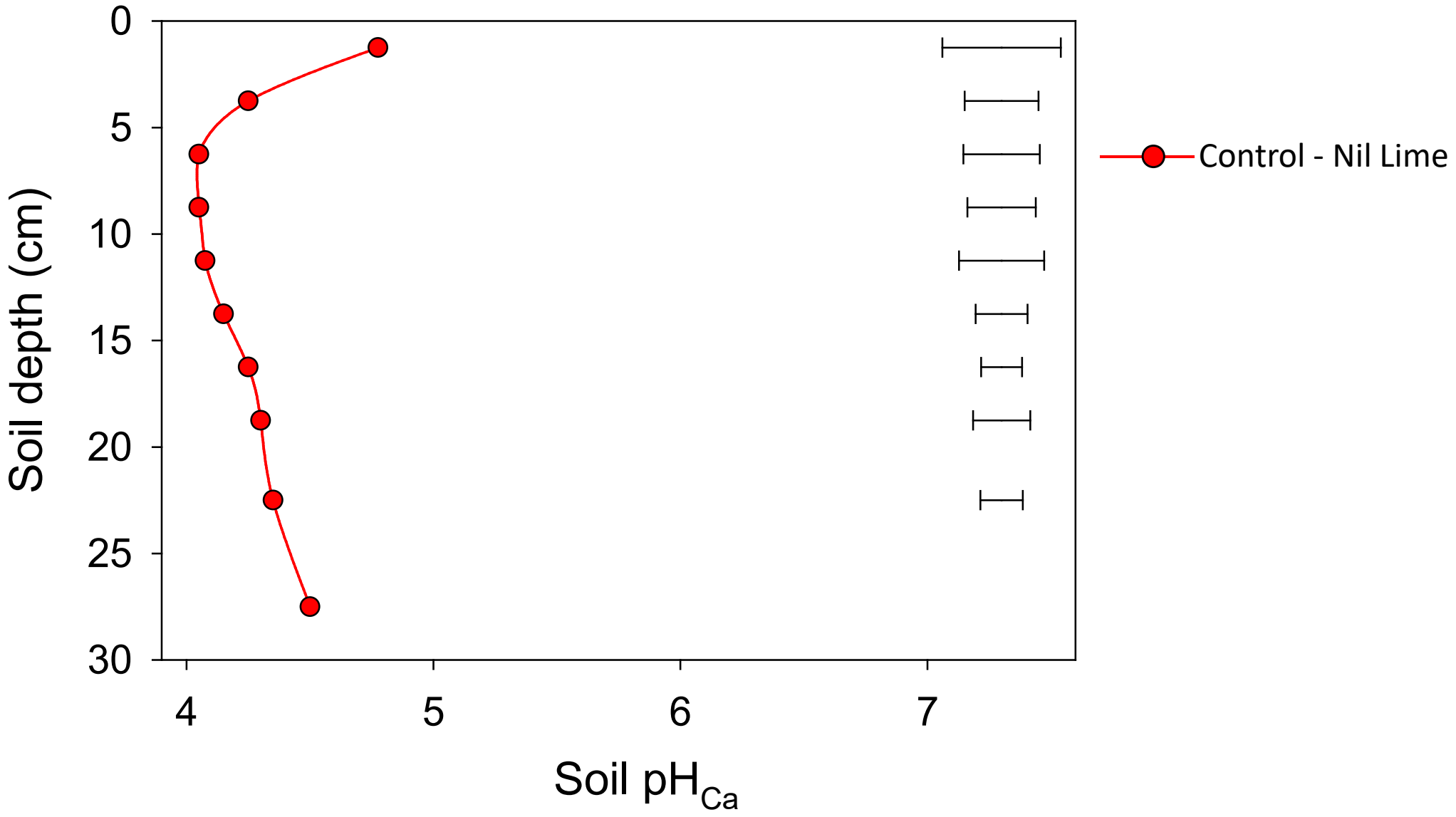
Effect of pH target and incorporation – Lyndhurst

	Lime rate (t/ha)
Lime rate targeting >5.2	4.7
Lime rate targeting >5.5	5.9
Lime rate targeting >5.5 (in 0-5 cm surface layer)	2.9
'Once-in-a generation'	7

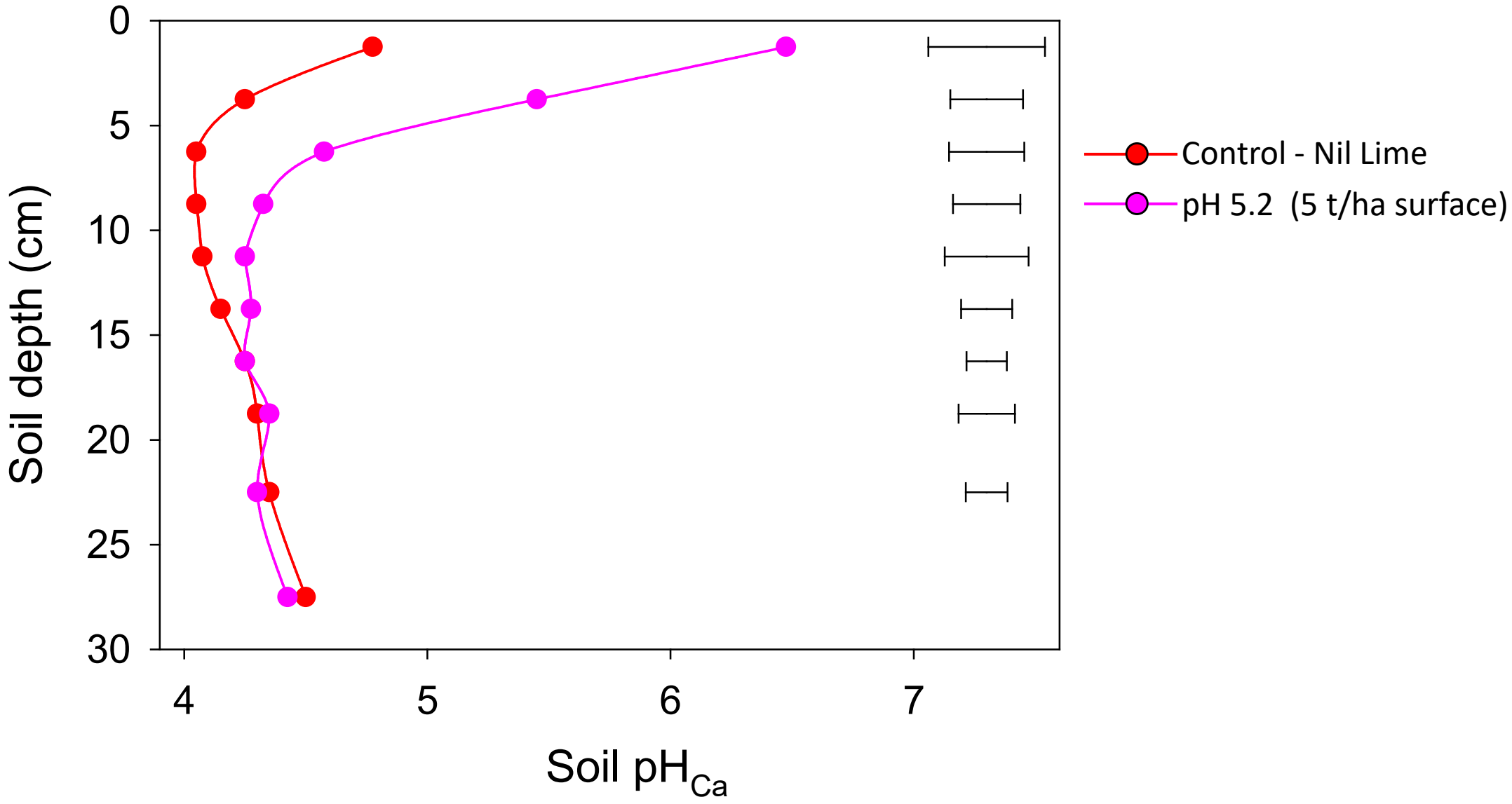
Effect of pH target and incorporation – Lyndhurst



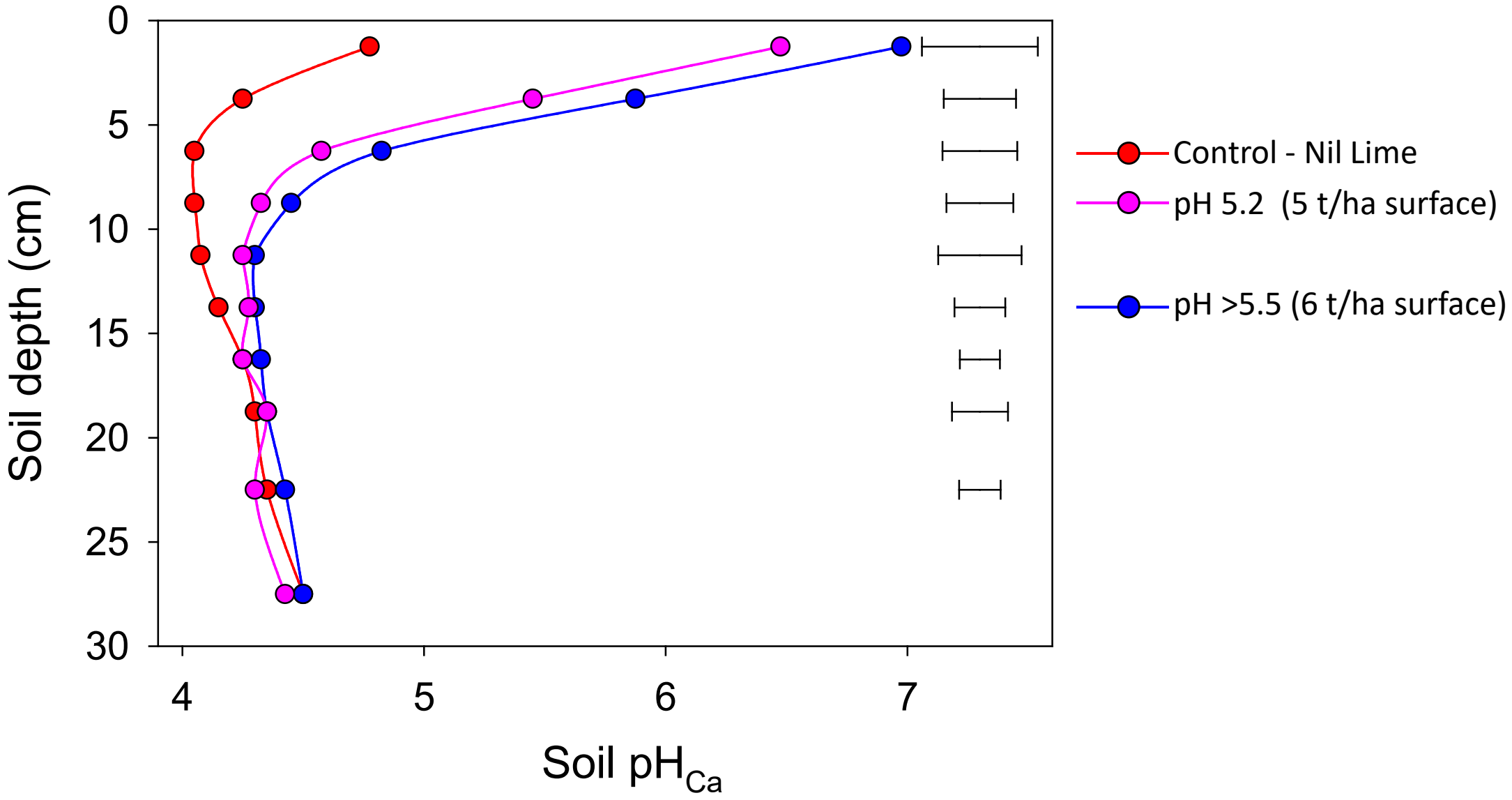
Effect of pH target and incorporation – Lyndhurst



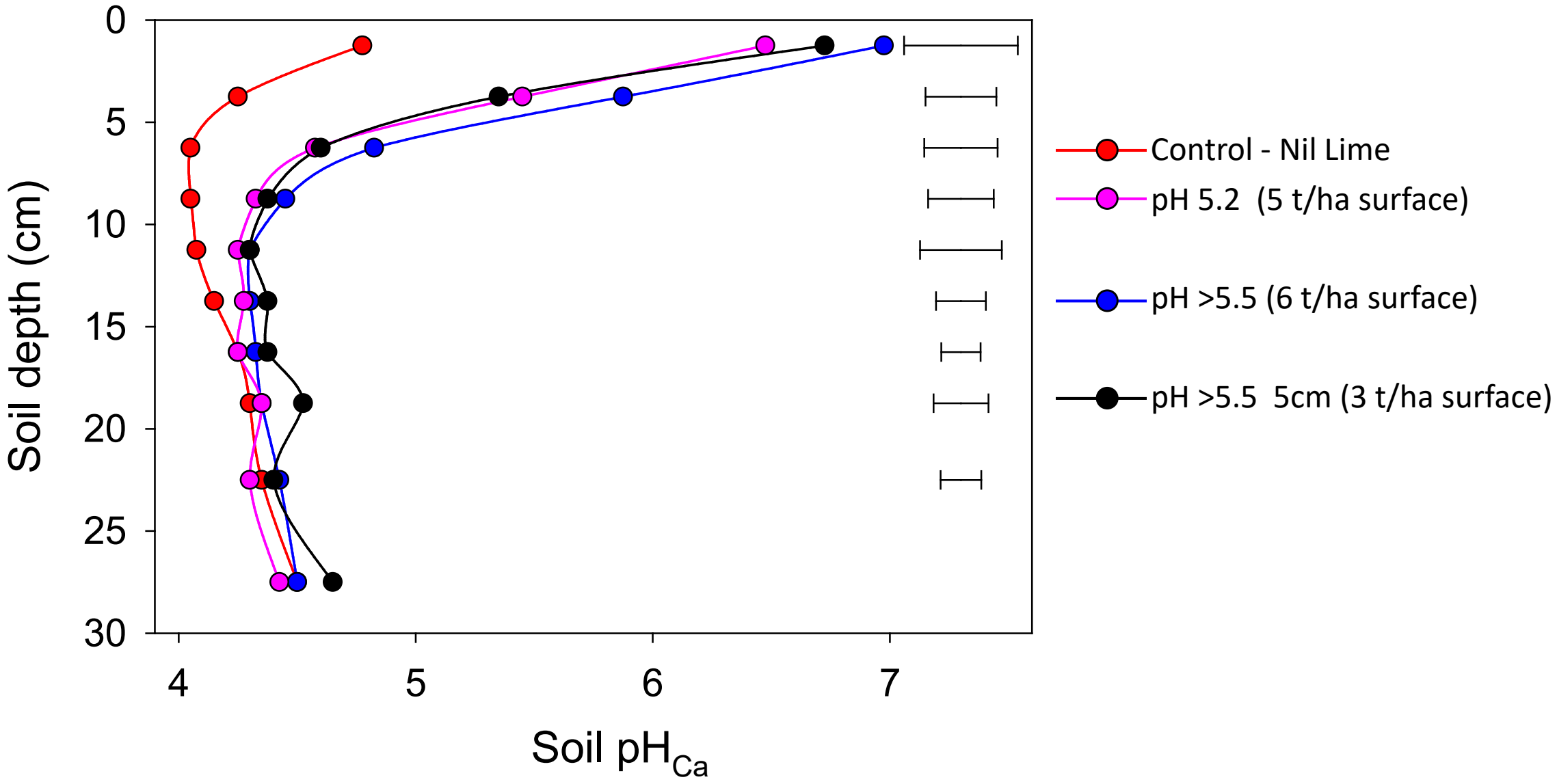
Effect of pH target and incorporation – Lyndhurst



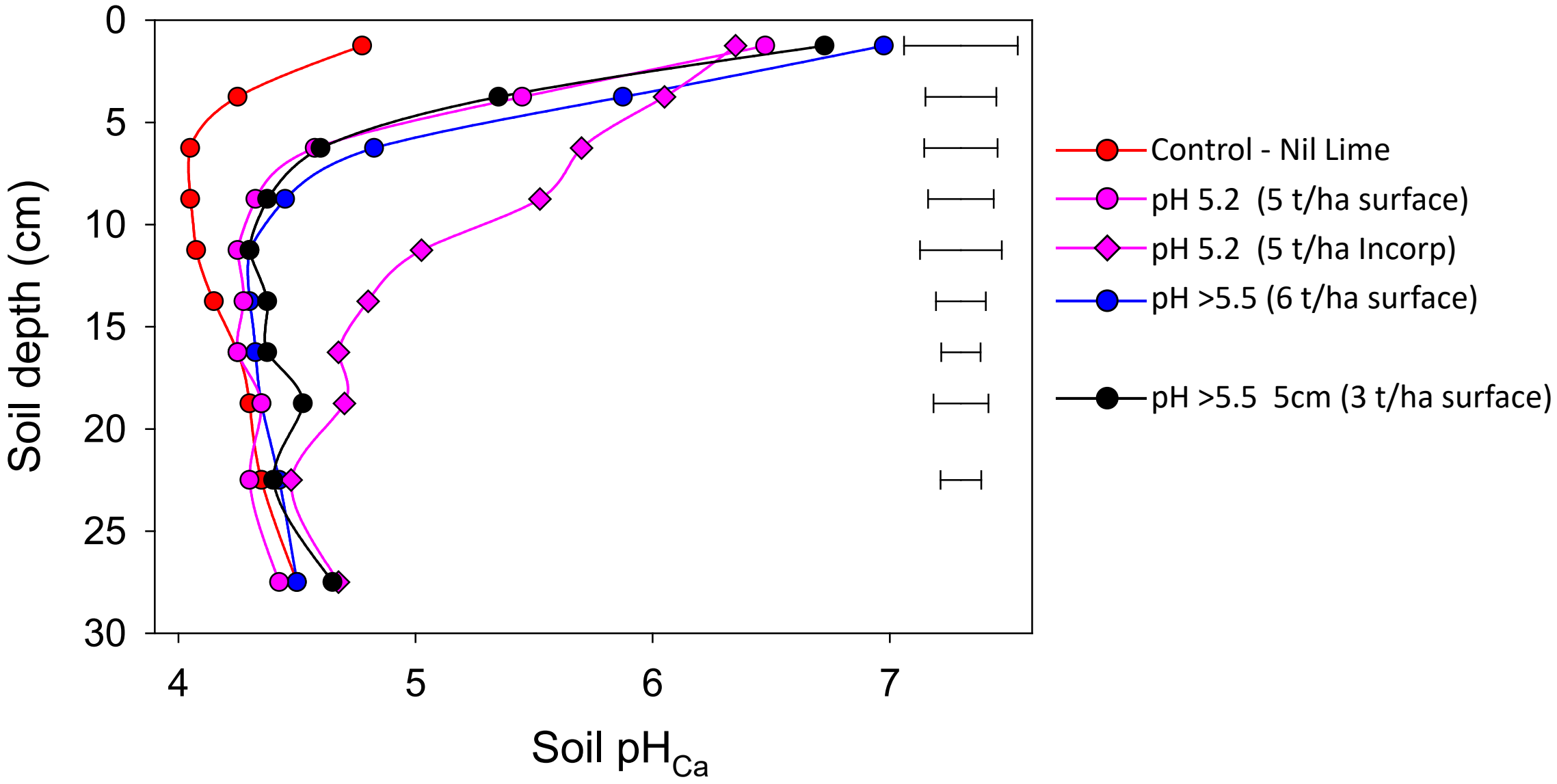
Effect of pH target and incorporation – Lyndhurst



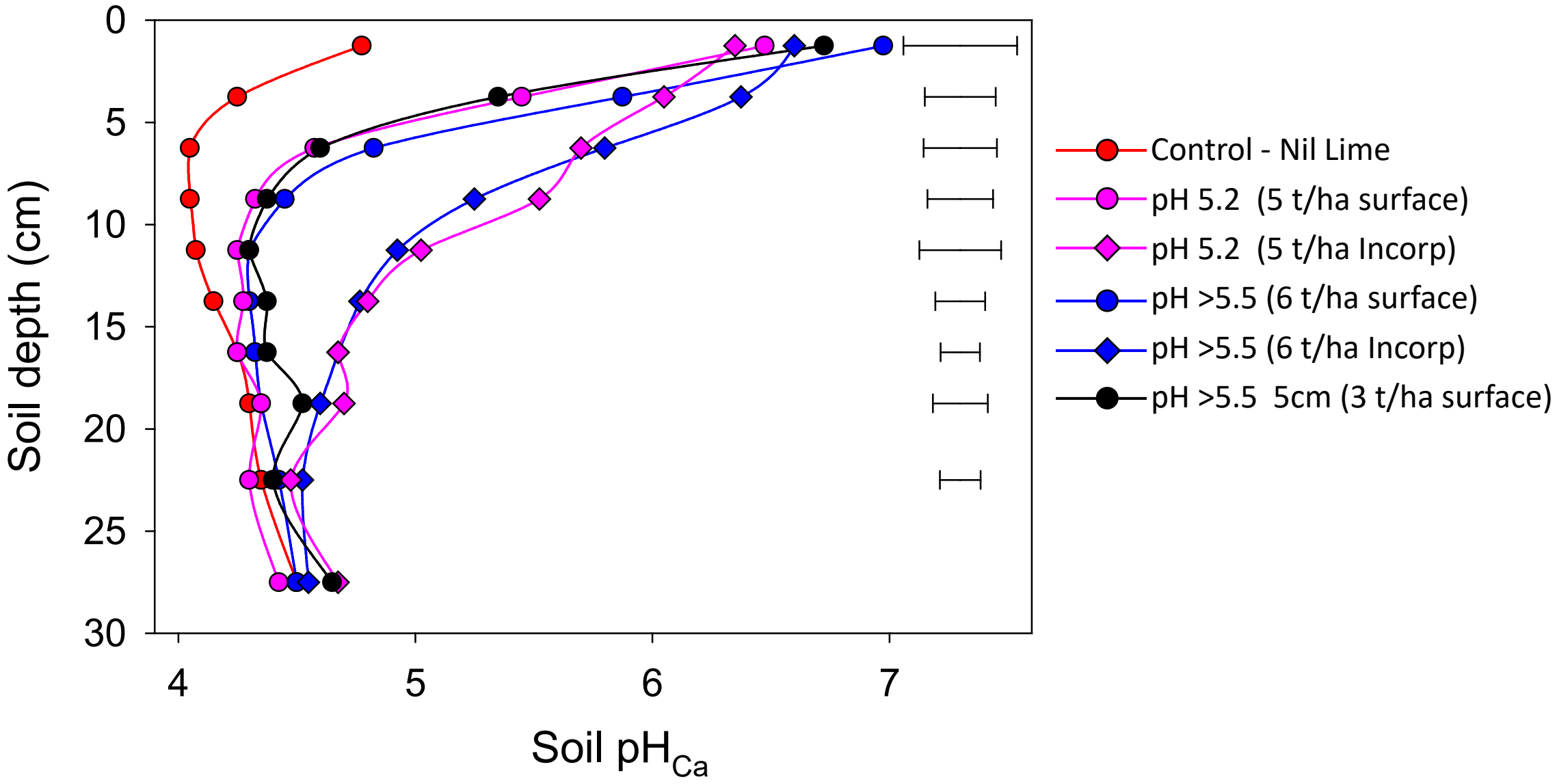
Effect of pH target and incorporation – Lyndhurst



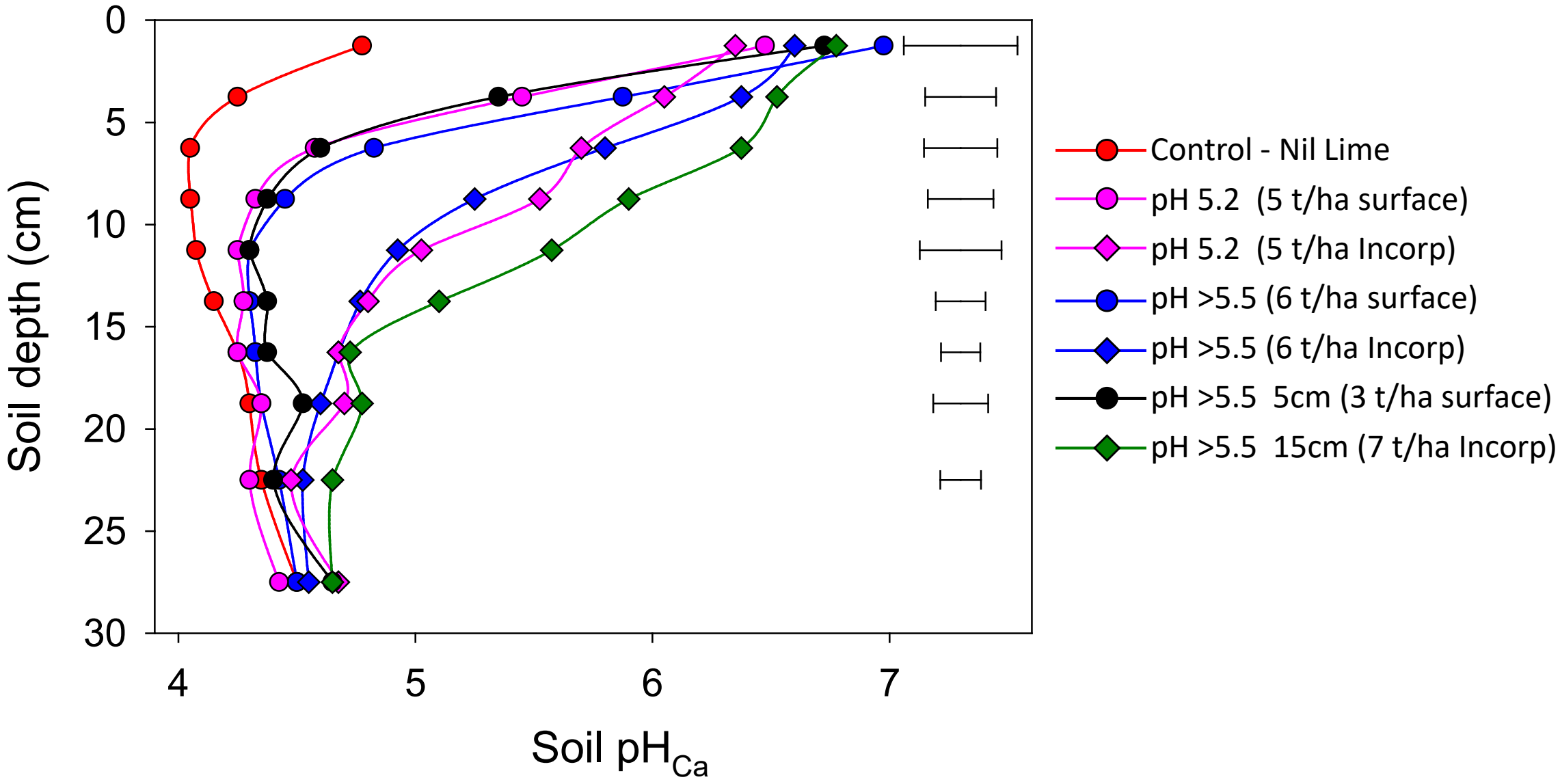
Effect of pH target and incorporation – Lyndhurst



Effect of pH target and incorporation – Lyndhurst



Effect of pH target and incorporation – Lyndhurst




Buffer (nil)
5 t/ha Inc
5 t/ha surface
6 t/ha surface
6 t/ha Inc
Nil
7t/ha Inc
3 t/ha surface

Effective management of soil acidity - Effectiveness

Temora – established 2020
Farmlink (James Holding)

2022 data shown

4 t/ha lime to get to pH 5.5
Incorp depth 10 cm

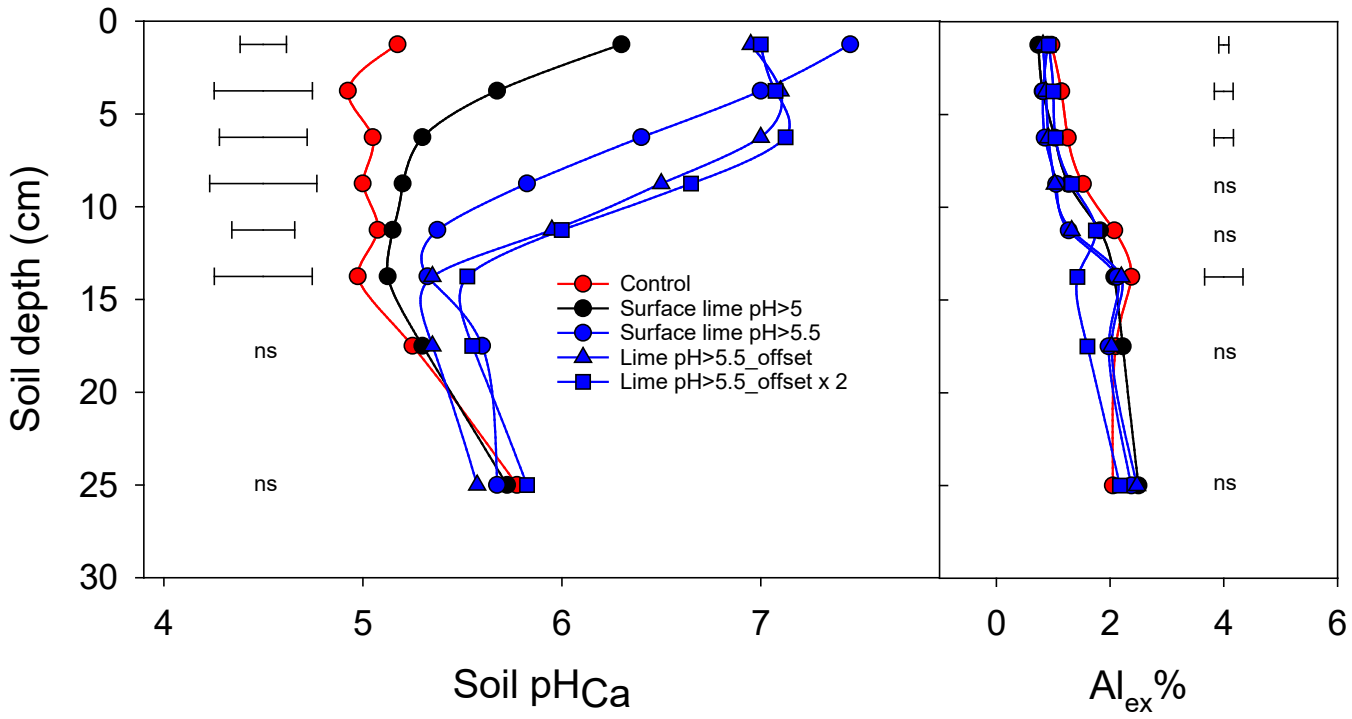



Photo: James Holding (Farmlink)

Mn toxicity 2022

Now what?

Effective management of soil acidity - Now what?

Methul 2022

Remove acidity as a constraint

↓

Better root growth

↓

Change in nutritional needs??
Soil carbon and biology??

Effective management of soil acidity - Now what?

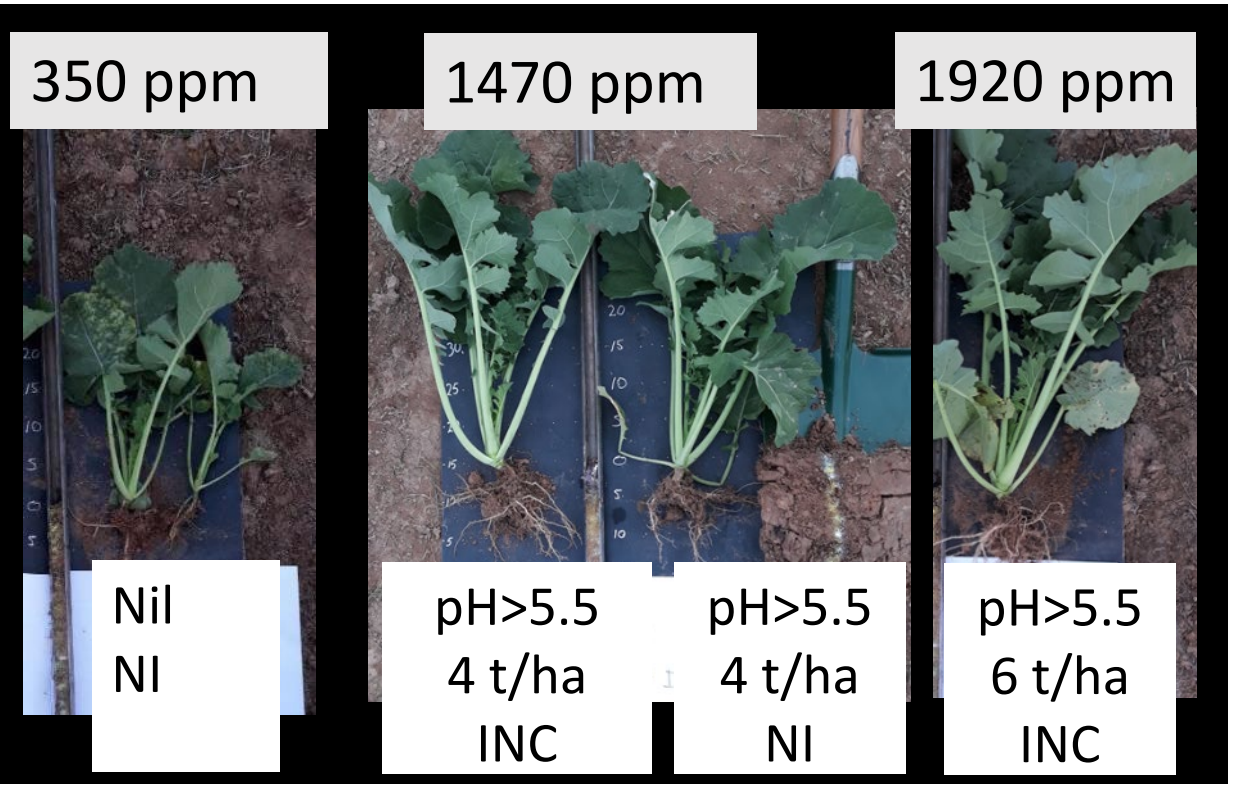
Nil Lime

pH_{Ca} >5.5 (4 t/ha Inc)

Less herbicide????

Effective management of soil acidity - Now what?

Morven – April 2020



Remove acidity as a constraint

↓

Change plant response

↓

Change in fertiliser practice?

Effective management of soil acidity - Now what?

Molybdenum toxicity

- Mo application post liming

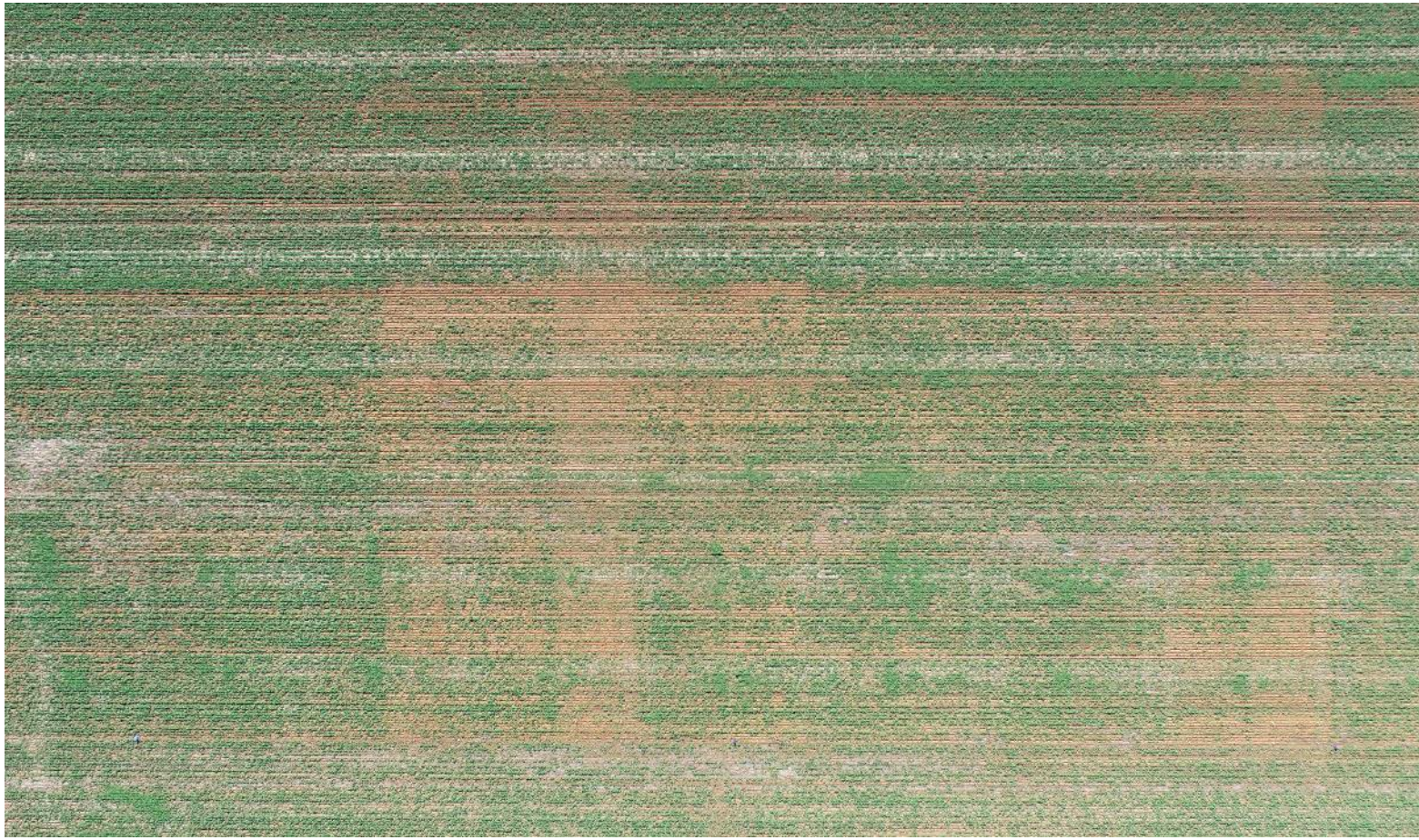
Control

Source: Grace Kaveney

Effective management of soil acidity - Now what?

Molybdenum toxicity

- History of Mo use before liming (canola, pastures)



Source: Nick McGrath

Effective management of soil acidity - Now what?

Deep incorporation:

- Soft ground - (sowing)
  - (grazing)
- Hostile subsoil
- Aggregate stability
- Erosion risk

Charles Sturt University

Summary

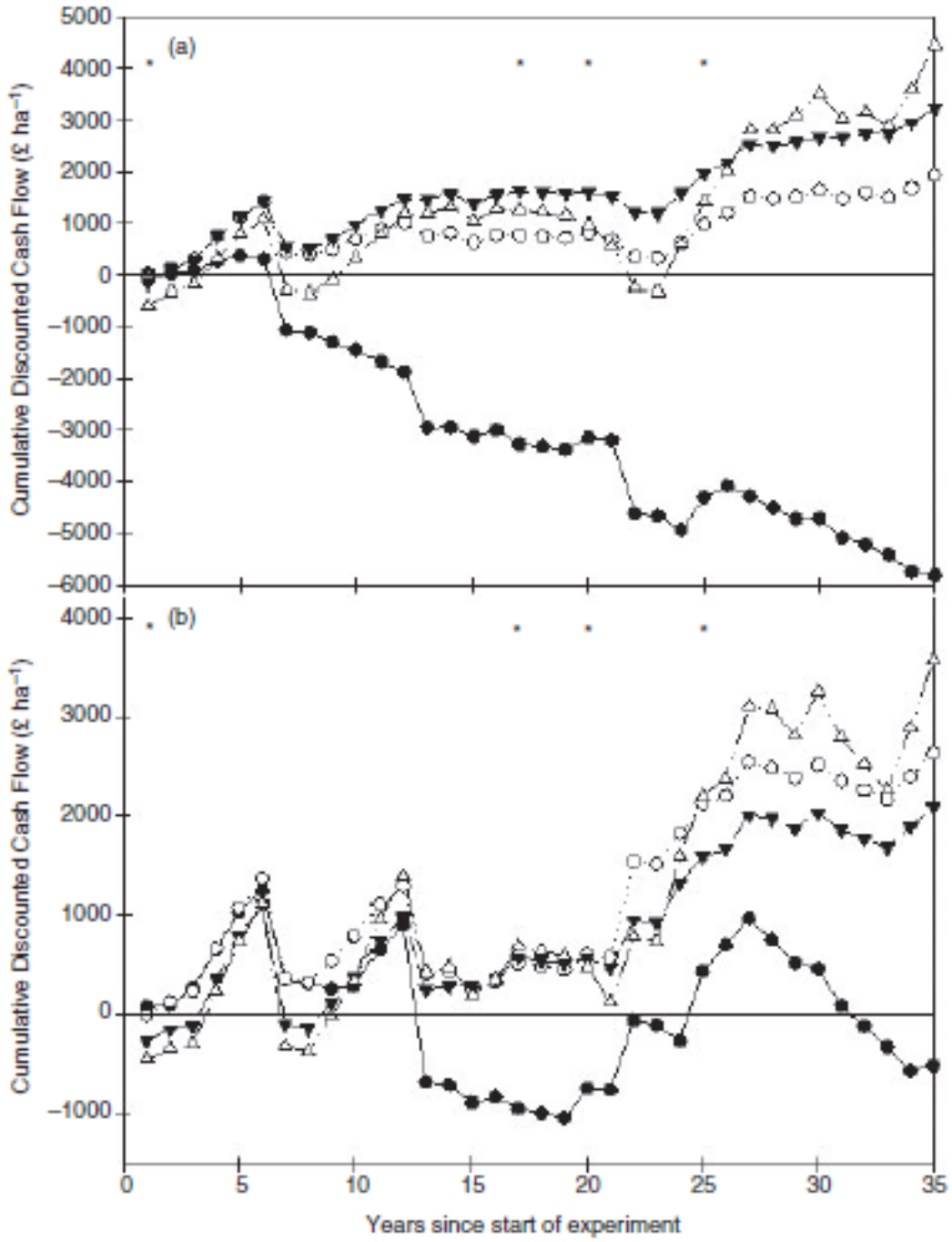
- Incorporation gets you a head start – put enough lime on to do the job
- Lime is a capital expense - has long term benefits (choice of species)
- Ag production is an acidifying process (don't ignore it on your good soils)
- Sampling in 5 cm intervals to 20 cm defines the pH stratification
- Keeping pH_{Ca} >5.5 helps liming effect move deeper…..make pH 5.5 reliming trigger

Is it worth doing? - NSW production outcomes of liming

Location (Region) ***years***	**Enterprise/Pasture**	**Response to lime**	**Average annual gross margin ($/ha c.f no lime)**	**Reference**
Wagga Wagga (SE slopes) *1992-2004*	Sheep/Perennial	+3.8 DSE	+$25	Li and Conyers (2006), Brennan and Li (2006)
Ebor (Northern TL) *1999-2002*	Cattle/Improved	+16% more beef production	+$89	Duncan (2003)
Binalong (Southern TL) *1999-2004*	Sheep/Perennial	+2.4 DSE (+5.6 DSE annual SSP)	-$4 (+$46)*	Leech (2006)
Laggan (Southern TL) *2015-2020*	Sheep/Perennial	+2.9 DSE	+ $181	Lieschke (2021)

Note gross margins are those at the time of research and does not account for current commodity prices

clay loam



Sandy loam

Holland and Behrendt 2020

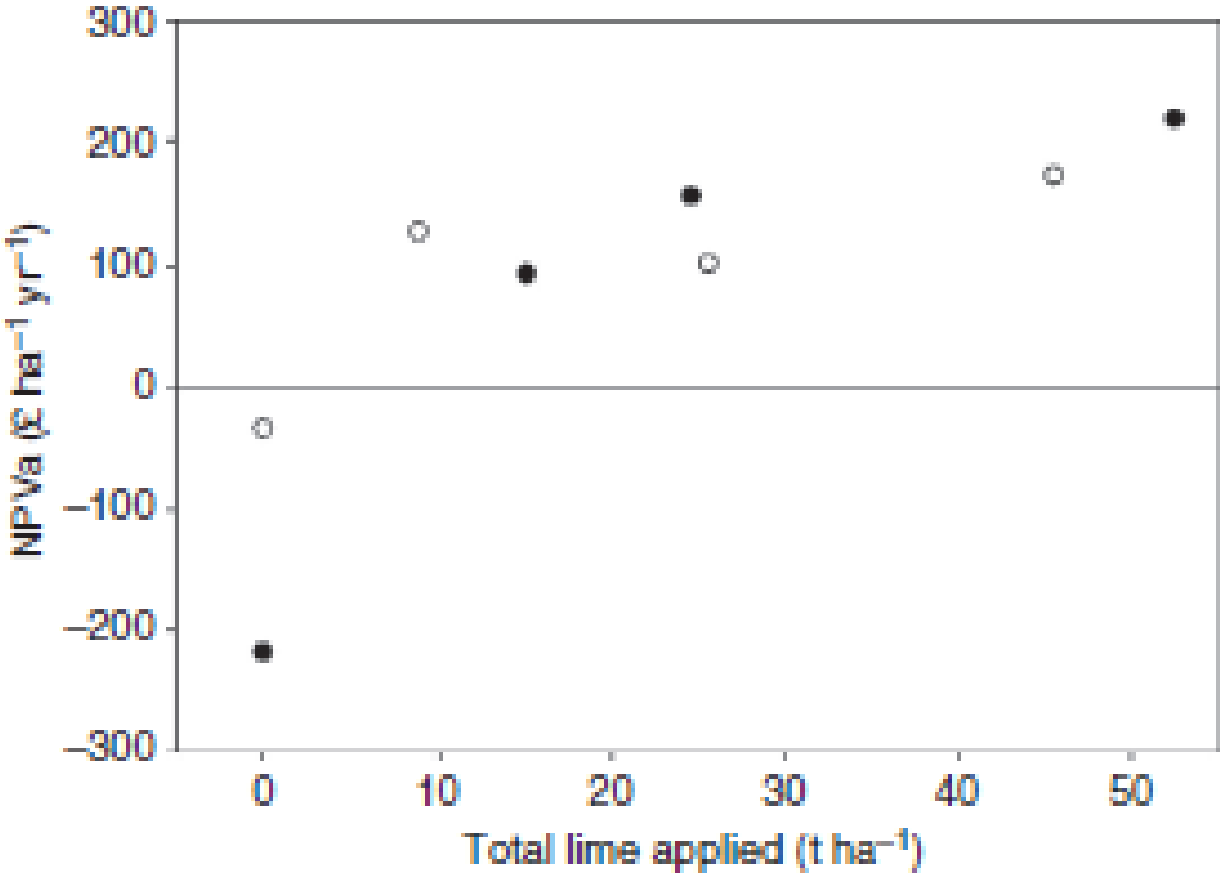
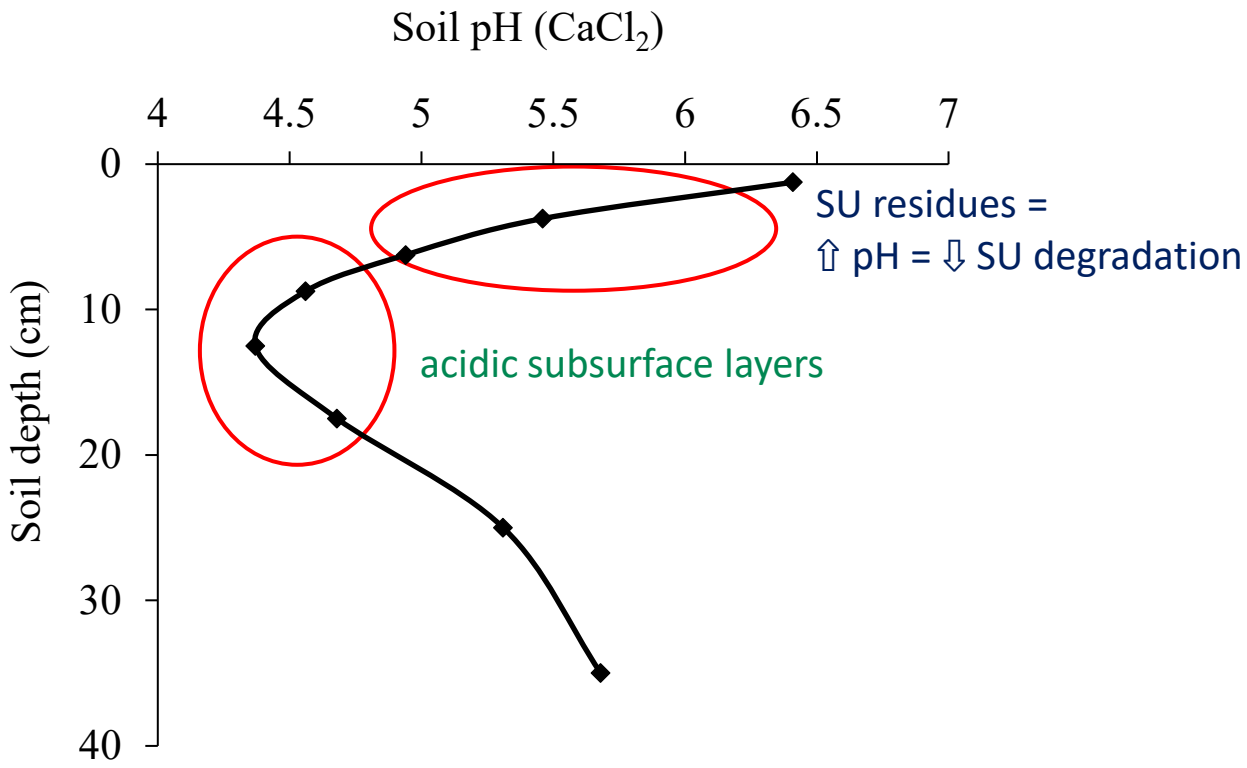


FIGURE 2 The annualized net present value (*NPVa*) (£ ha^{-1} $year^{-1}$) at four different total amounts of lime applied (t ha^{-1}) at Rothamsted (●) and Woburn (○) over 35 years at median total liming costs and median crop price

Holland and Behrendt 2020

Effective management of soil acidity - Now what?

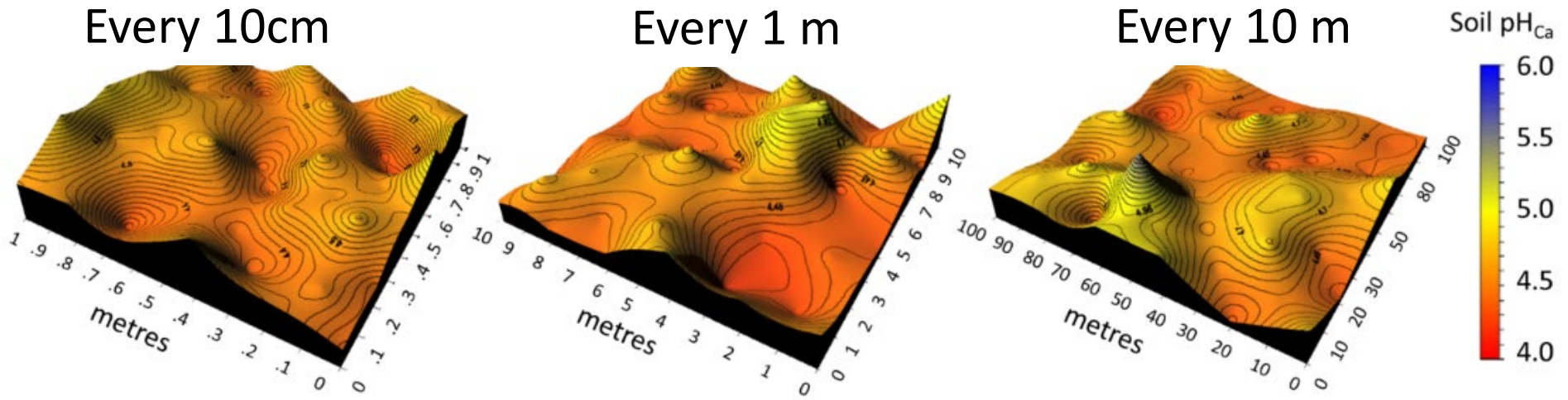
Unexpected herbicide damage Legume damage could be caused by:



Anne-Maree Farley Wagga updates 2020

How to manage? – start by measuring the actual soil

Measuring a highly variable property



More subsamples = less noise

25-30 is good for pH

But we can grow acid tolerant crops

use of tolerance (Fox 1980):

like

Acidity

pH = - log H^+ concentration

H^+ concentration = in soil solution
(changed by nature and agriculture)

-ve = H^+ concentration ↑ pH ↓

log = 1 acid pH 6
10 acid pH 5
100 acid pH 4

But we can grow acid tolerant crops

use of tolerance (Fox 1980):

like

‘the hazard of flying a low powered aircraft up a narrow canyon. The course starts easily and the scenery is beautiful,

But we can grow acid tolerant crops

use of tolerance (Fox 1980):

like

‘the hazard of flying a low powered aircraft up a narrow canyon. The course starts easily and the scenery is beautiful, but options run out very quickly

But we can grow acid tolerant crops

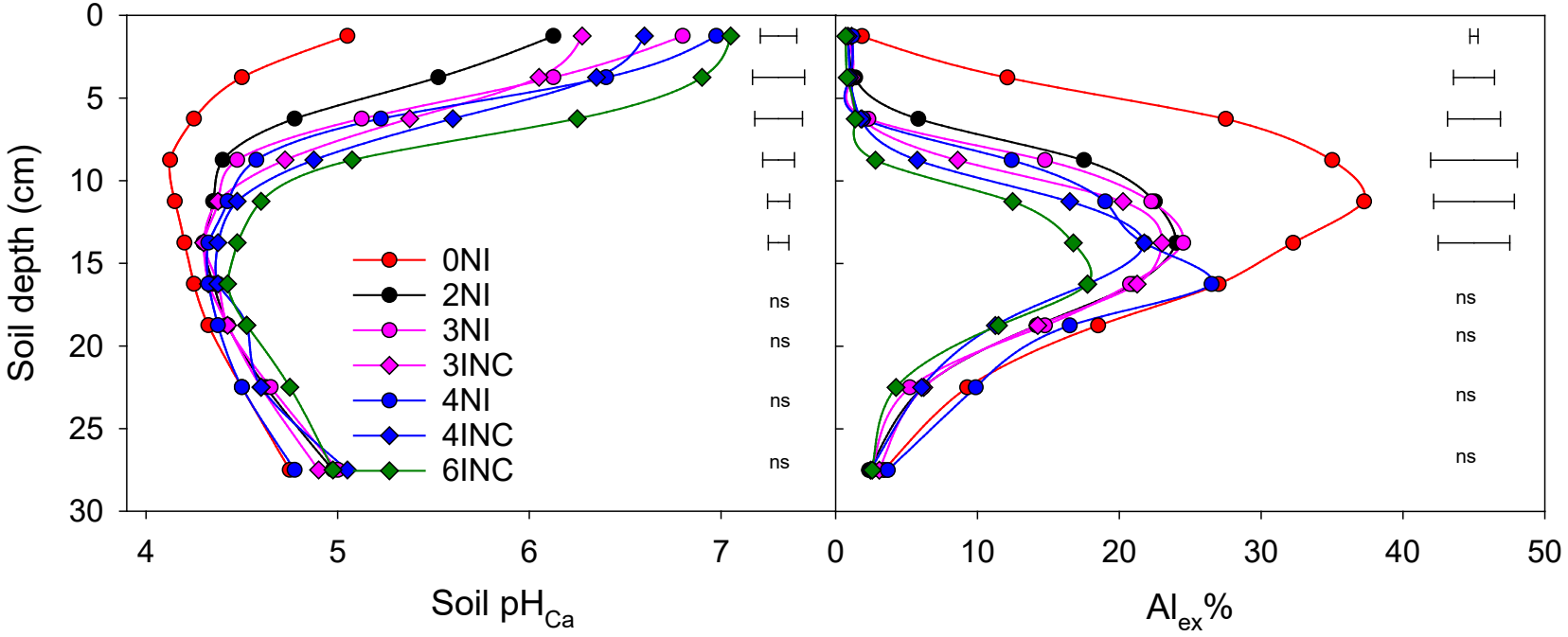
use of tolerance (Fox 1980):

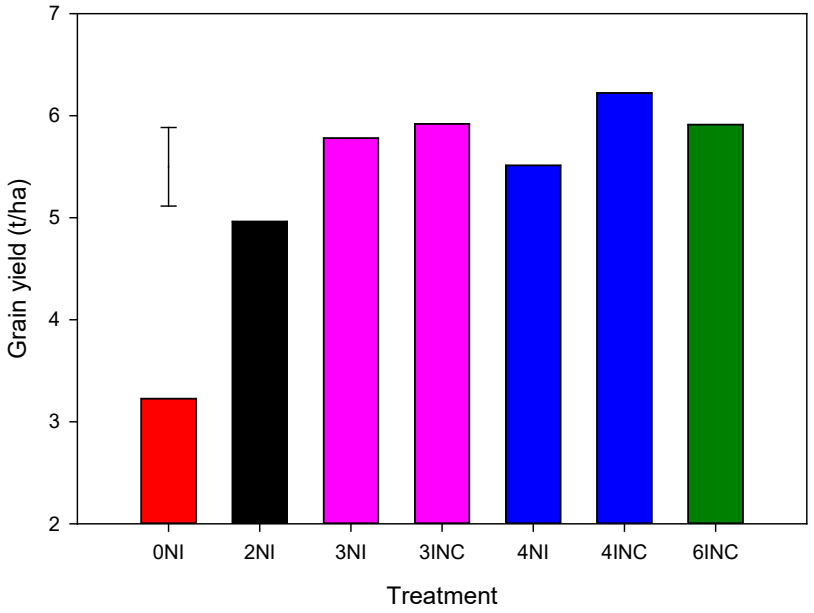
like

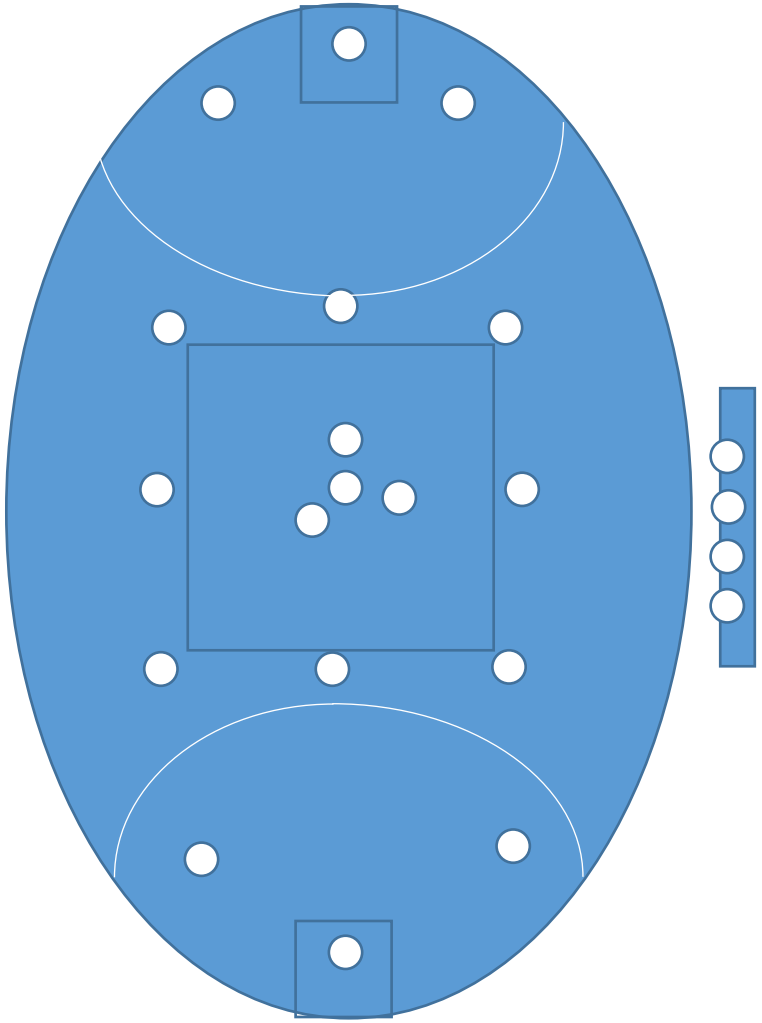
‘the hazard of flying a low powered aircraft up a narrow canyon. The course starts easily and the scenery is beautiful, but options run out very quickly and to continue is to invite disaster’

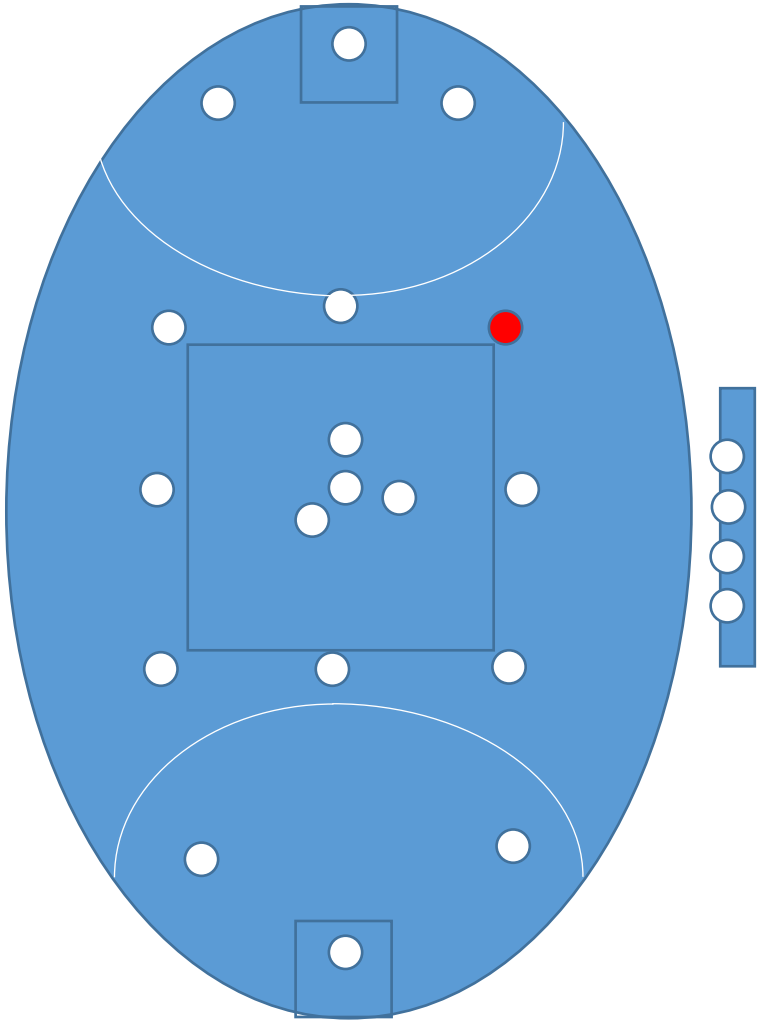
Effective management of soil acidity - Effectiveness

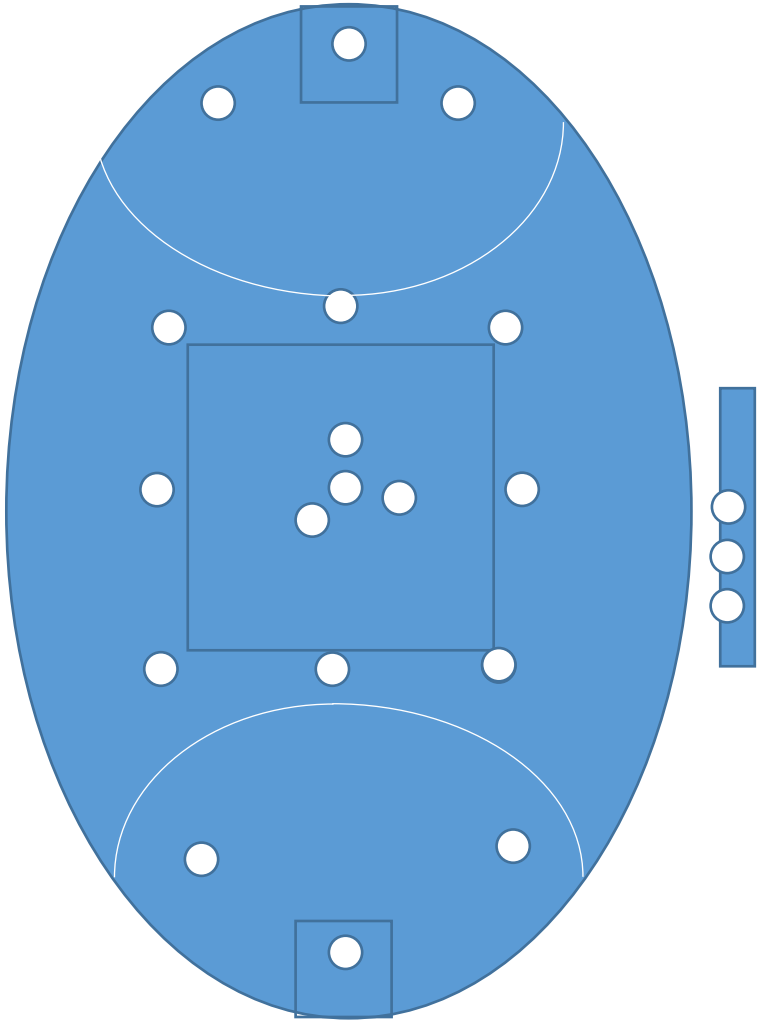
Morven – established end of 2019
2021 data shown Holbrook Landcare Network (Nick McGrath)

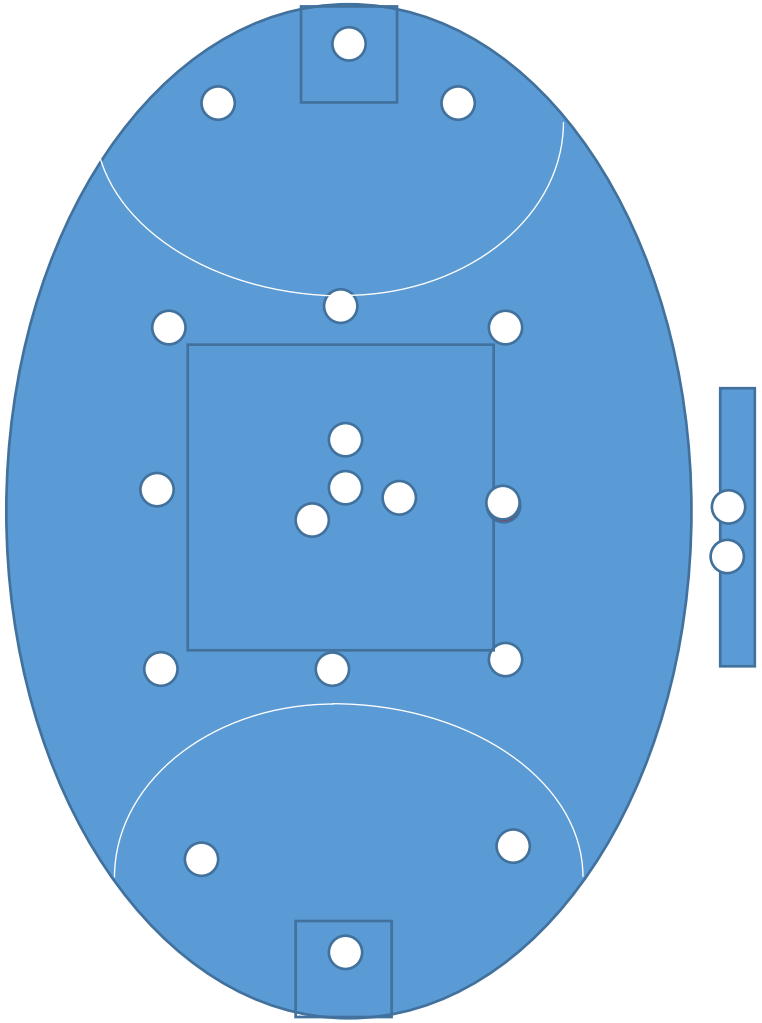


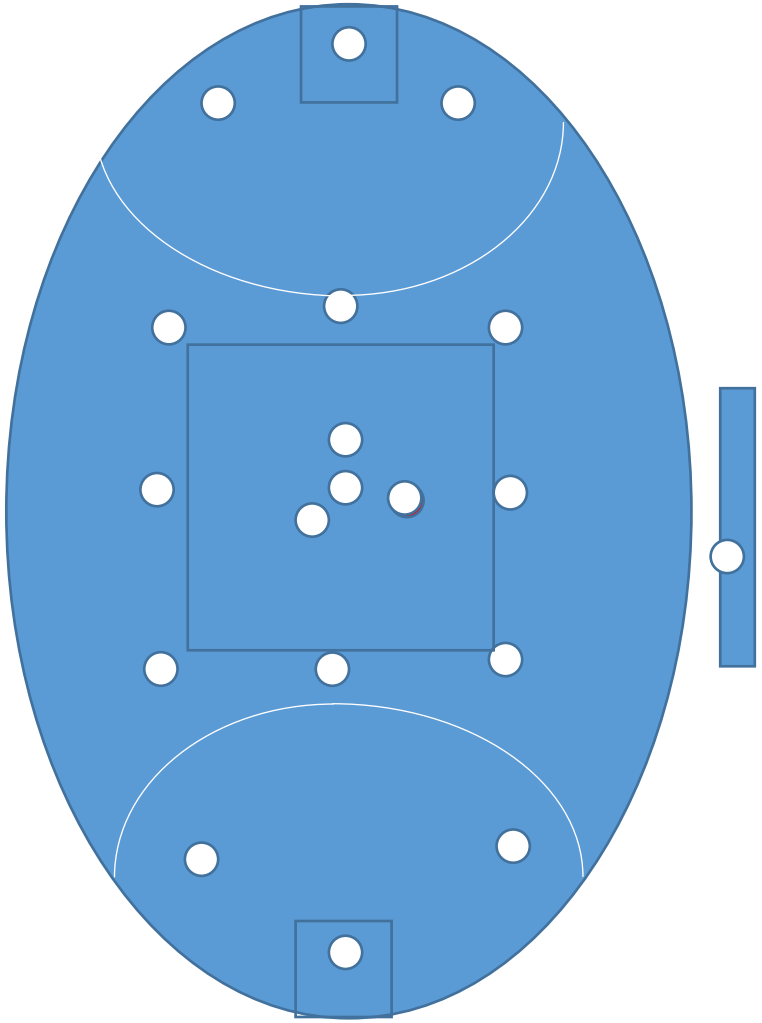


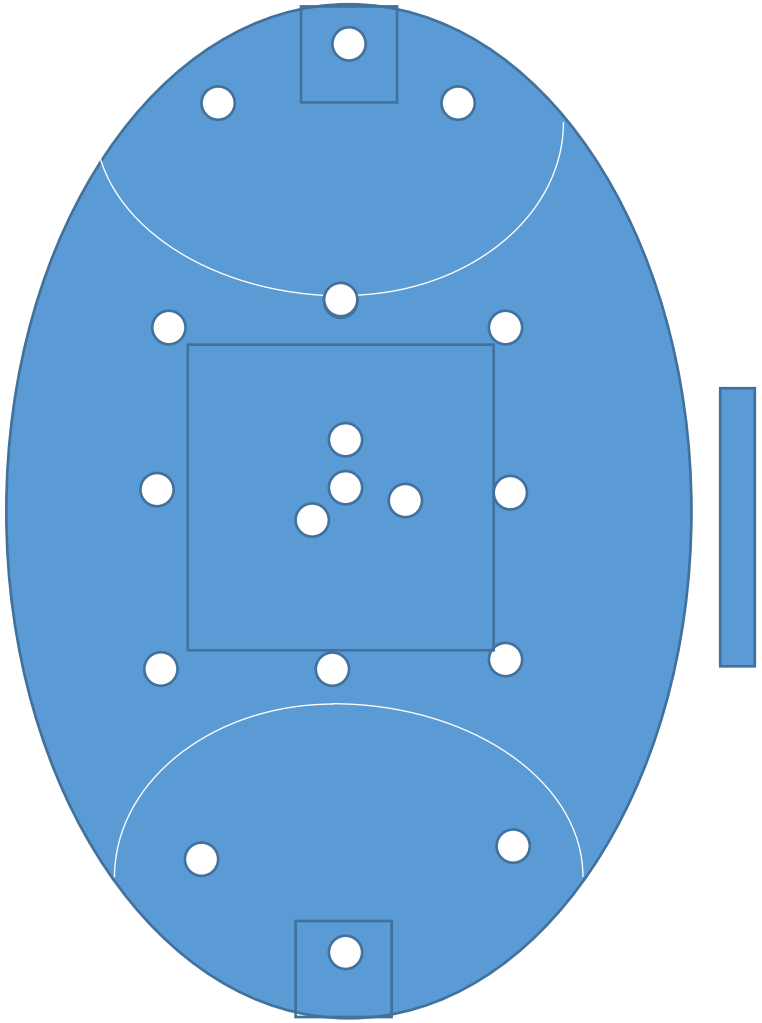


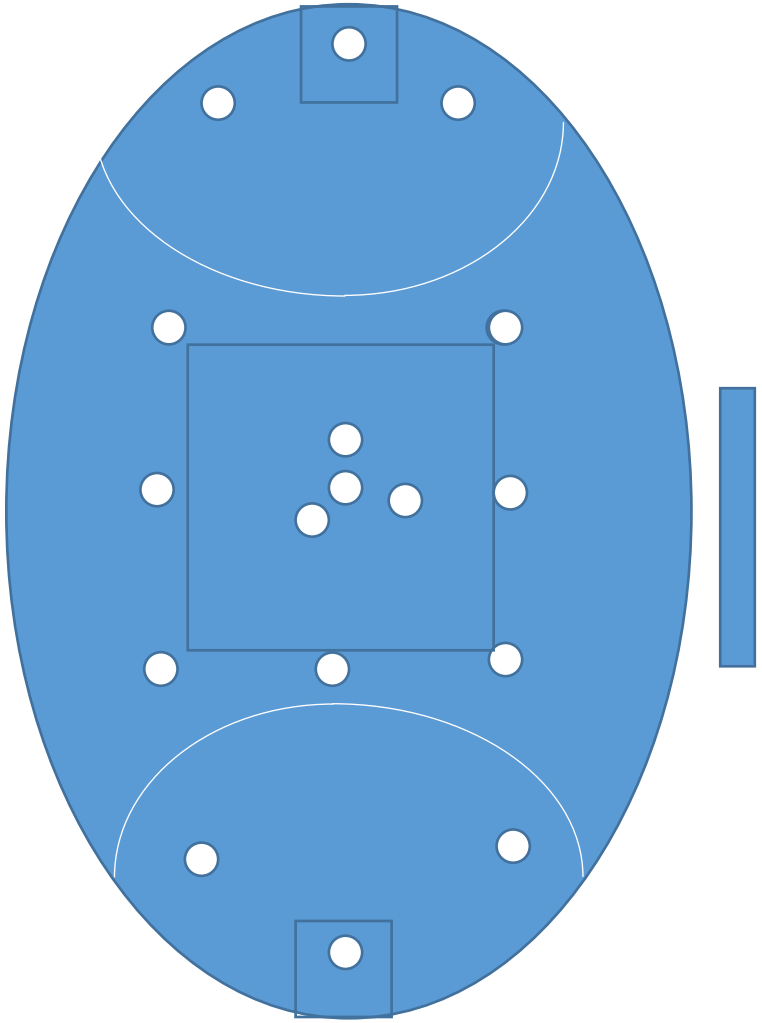


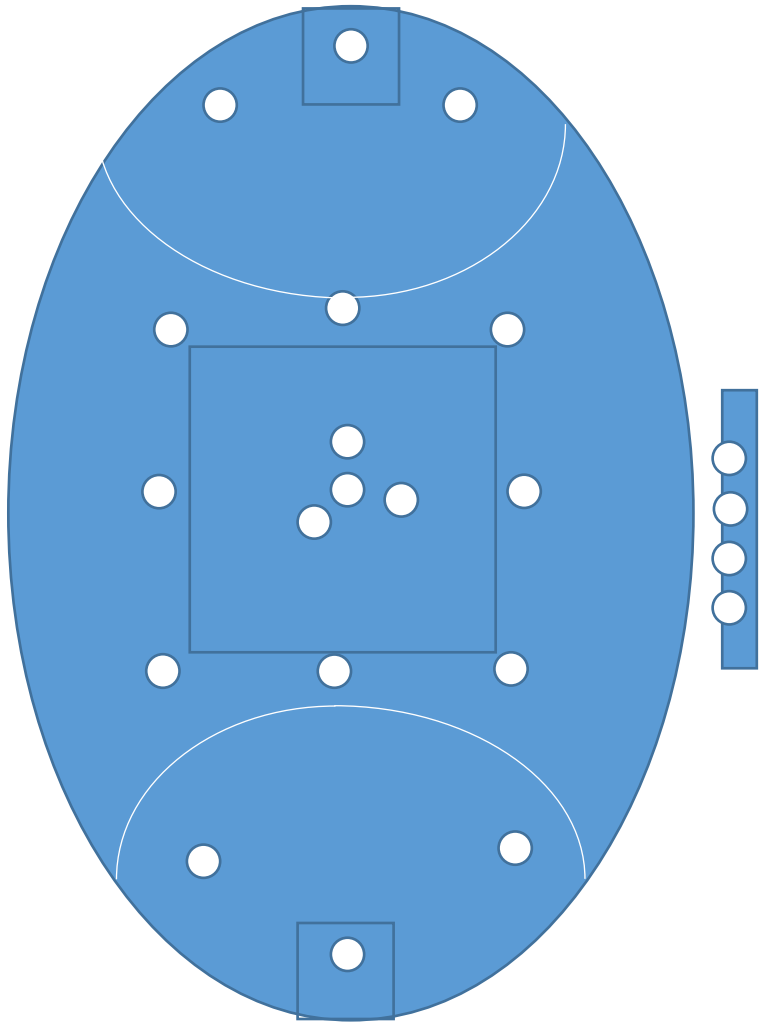


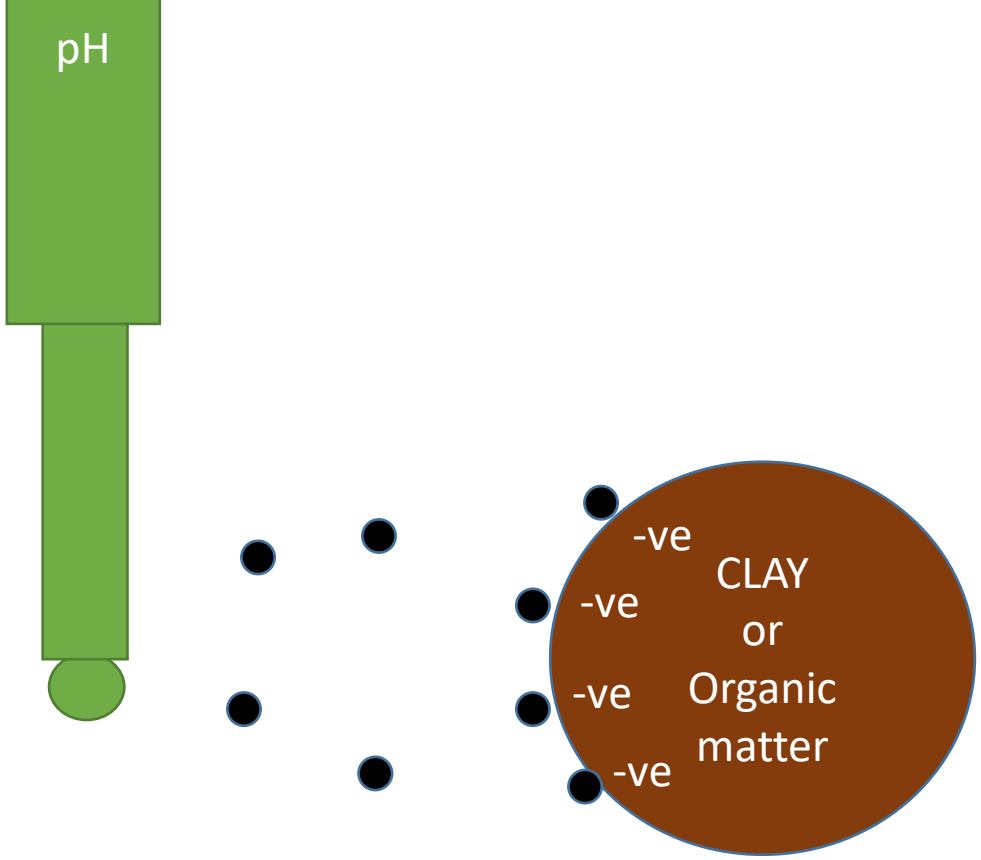


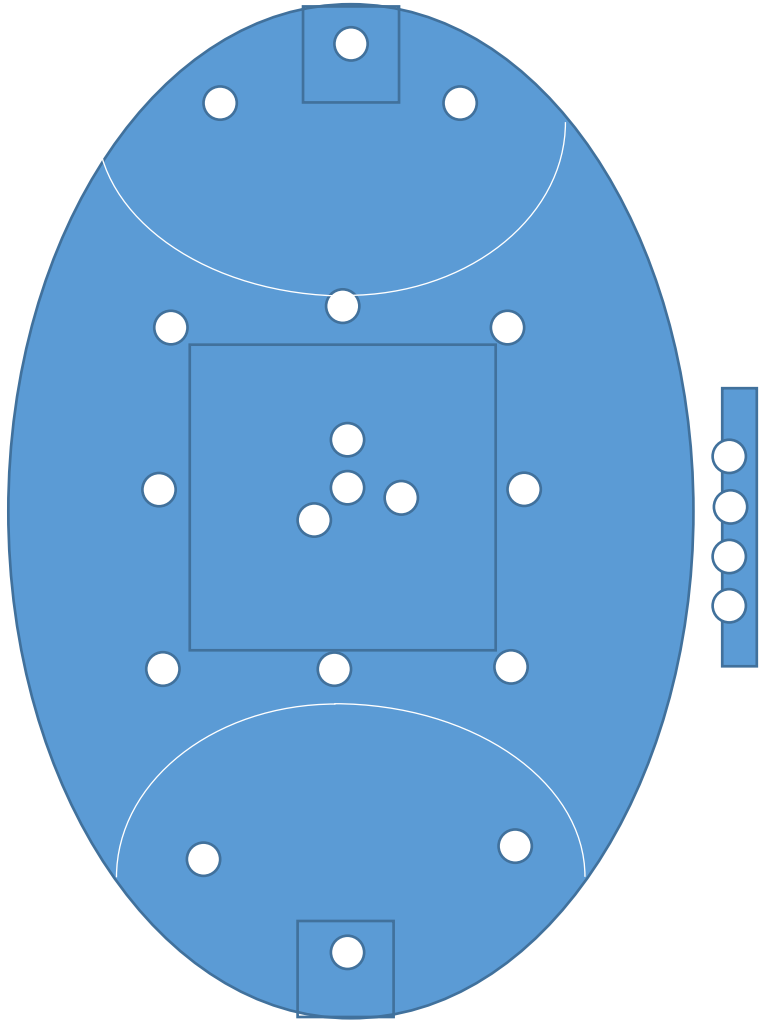


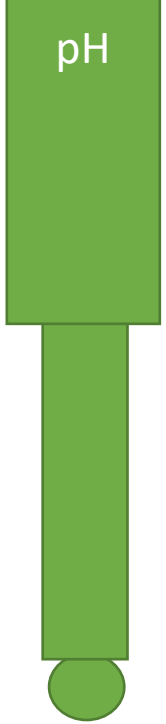


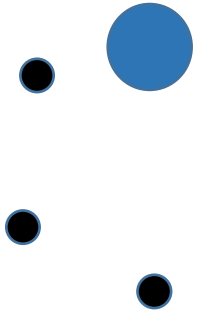


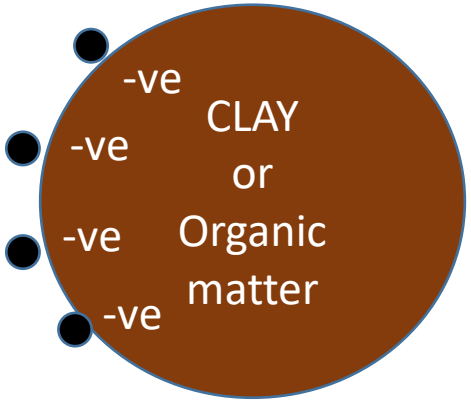


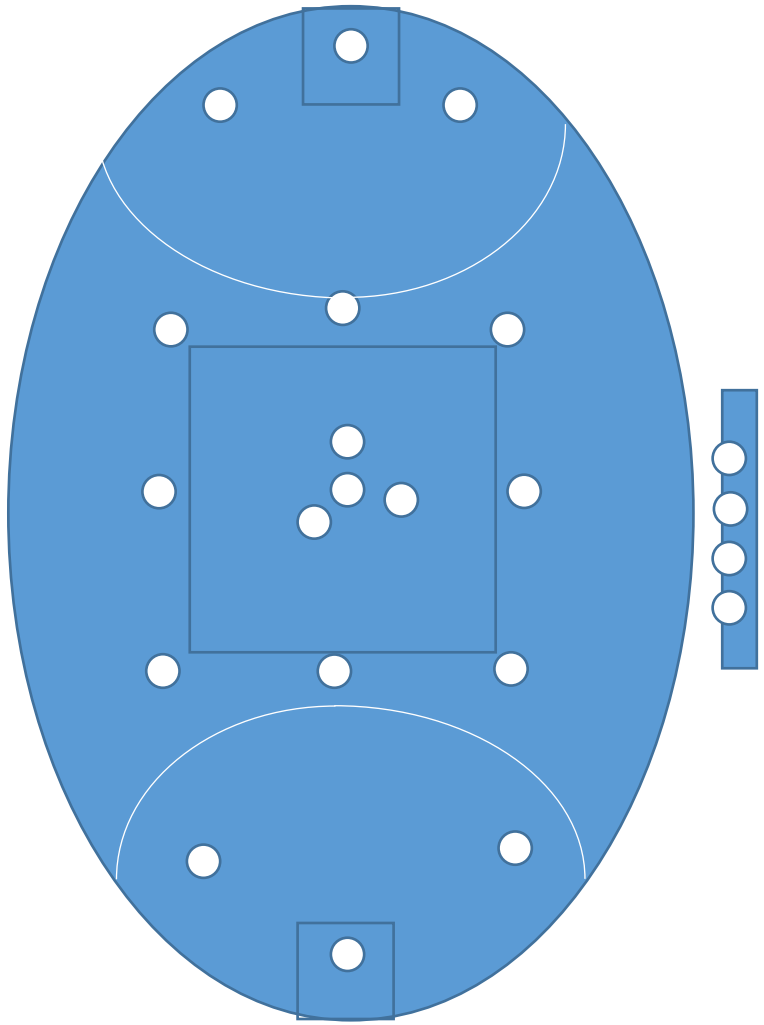

pH
-ve
-ve
-ve
-ve
CLAY
or
Organic
matter

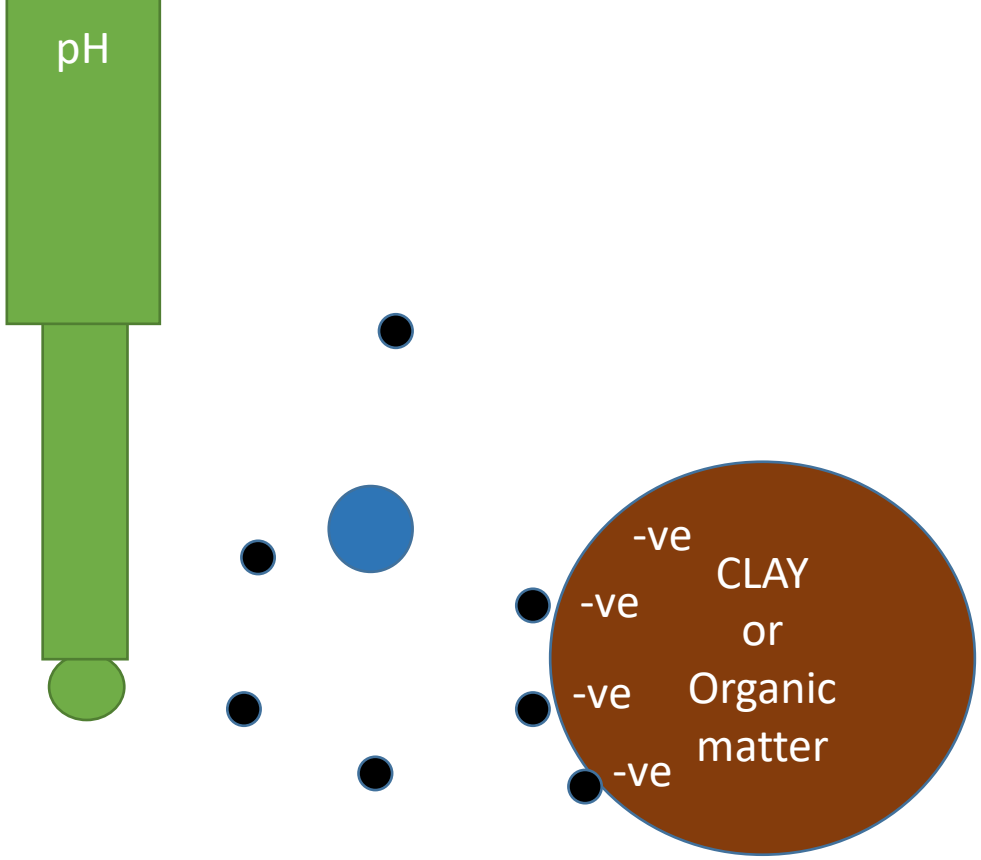


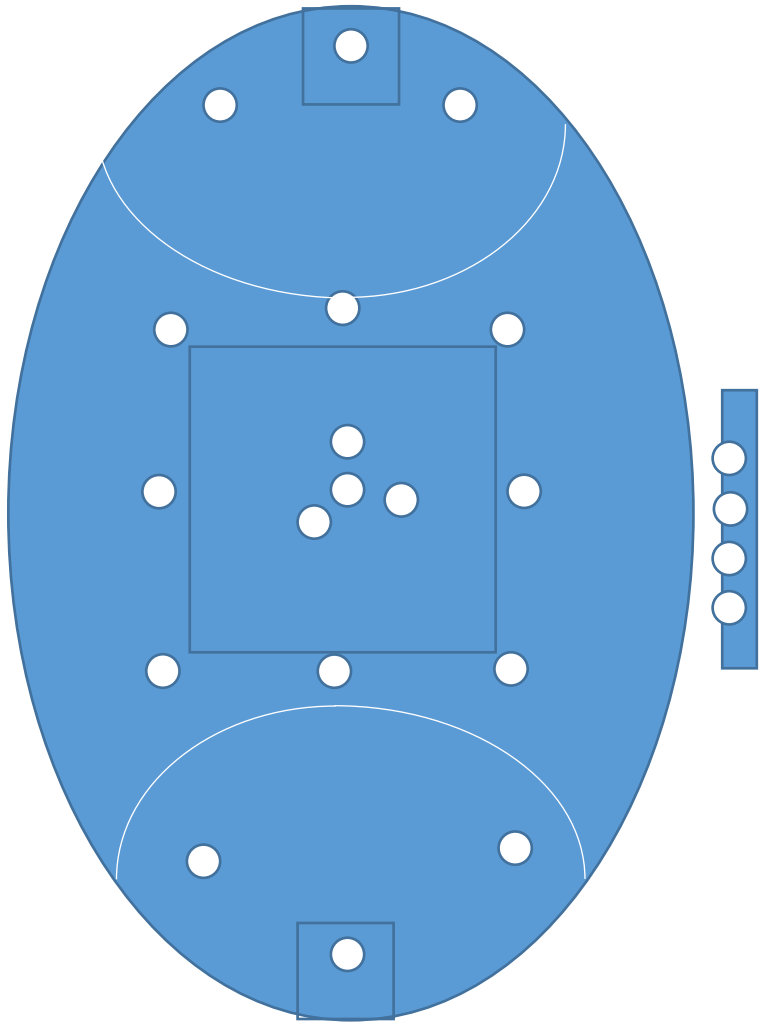

pH

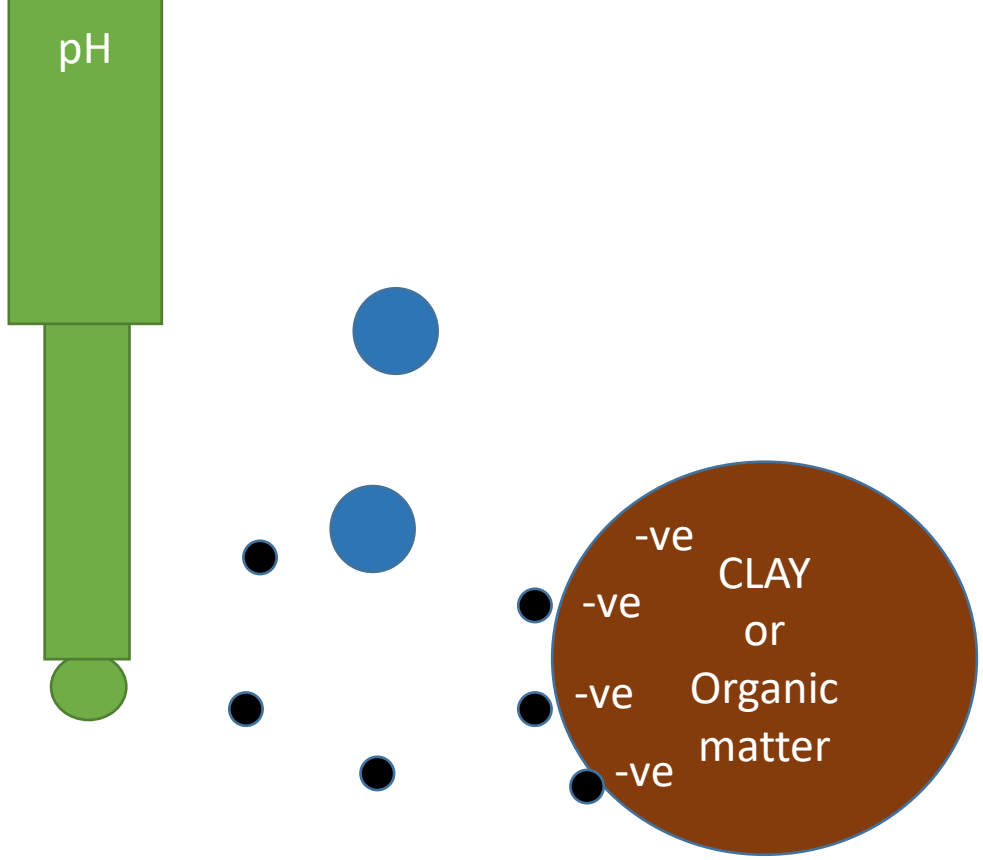



-ve
-ve
-ve
-ve
CLAY
or
Organic
matter



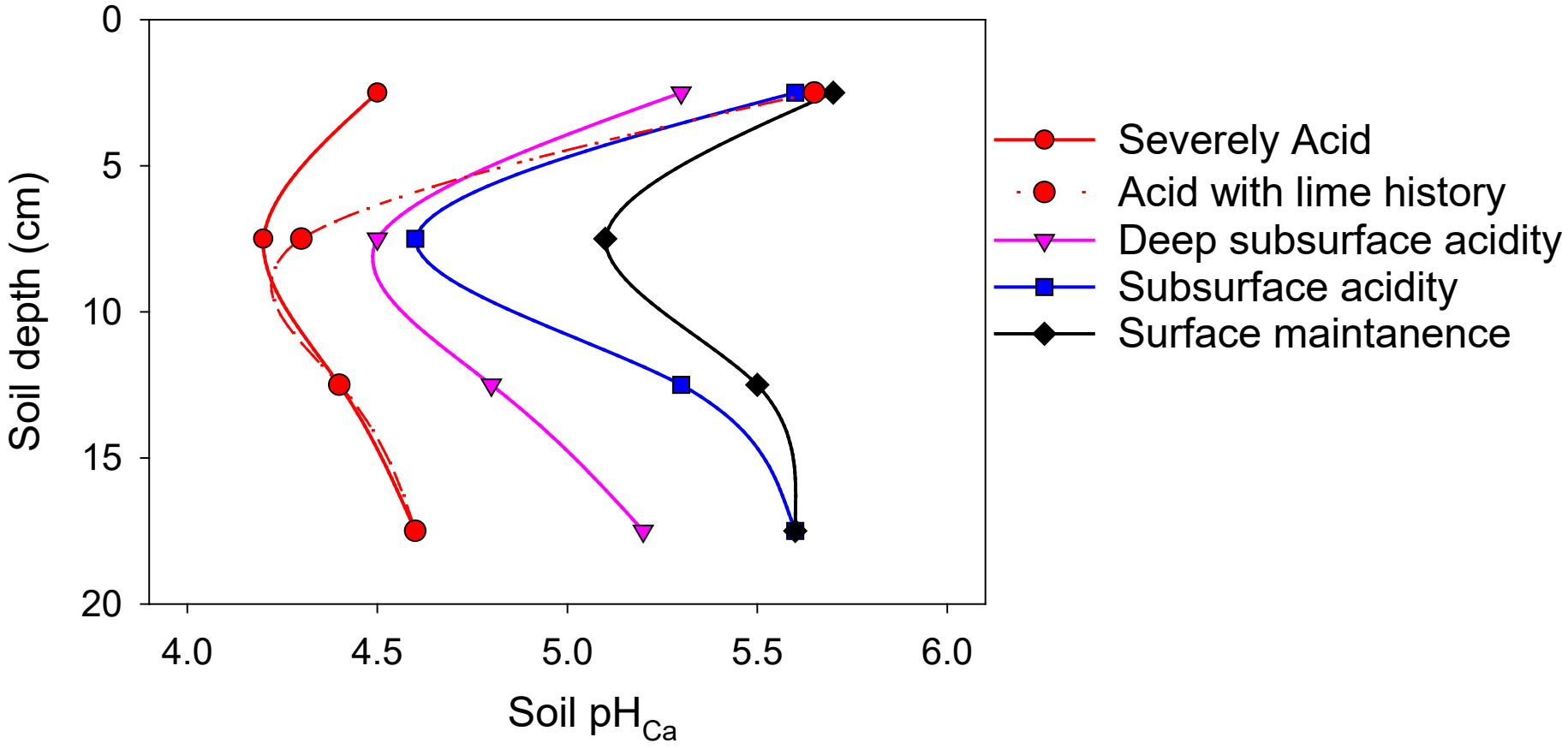

pH
-ve
-ve
-ve
-ve
CLAY
or
Organic
matter





More clay = bigger interchange bench
= more buffering capacity

Effective management of soil acidity - Sampling



How much lime?

- Target pH
- Starting pH
- pH buffering capacity

How much change in pH per tonne of lime

How much lime?

ECEC = pH buffering surrogate

Soil test ECEC (meq/100 g)	Lime required (t/ha) to lift the pH of the top 10 cm:			
	from 4.0 to 5.2	from 4.3 to 5.2	from 4.7 to 5.2	from 5.2 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
6	5.5	3.0	1.2	0.8
7	6.3	3.3	1.4	1.0
8	7.1	3.8	1.6	1.1
9	7.9	4.2	1.8	1.2
10	8.7	4.6	1.9	1.3
15	12.5	6.7	2.8	1.9

How much lime?

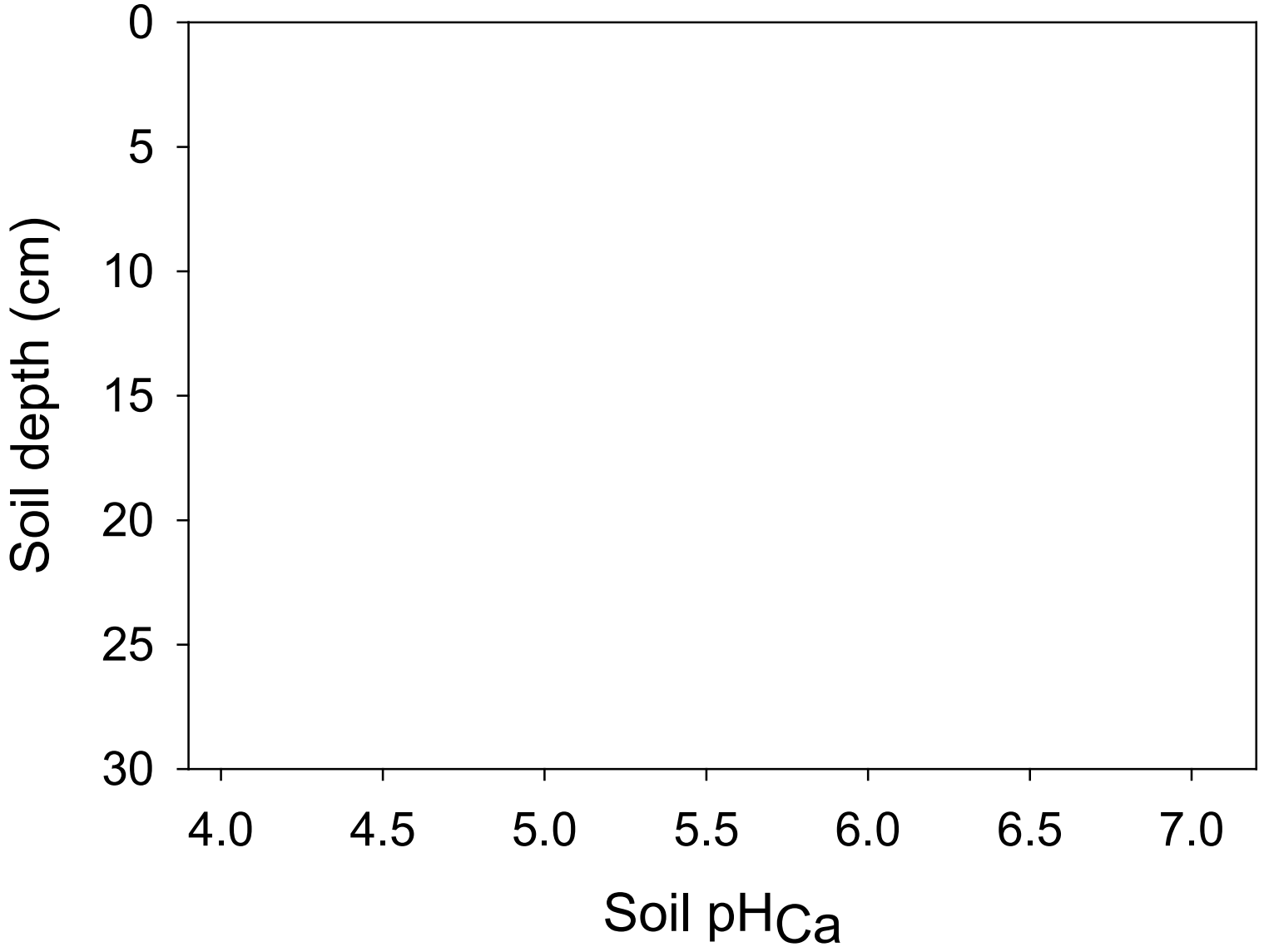
If using 5 cm intervals:

Use table for CEC and starting pH and halve the lime rate (was based on 10 cm)

Then add lime calculated for each 5 cm interval

Then consider likely depth of incorporation, where the acidity is and adjust rate

Effect of implement – Grenfell results - FarmLink

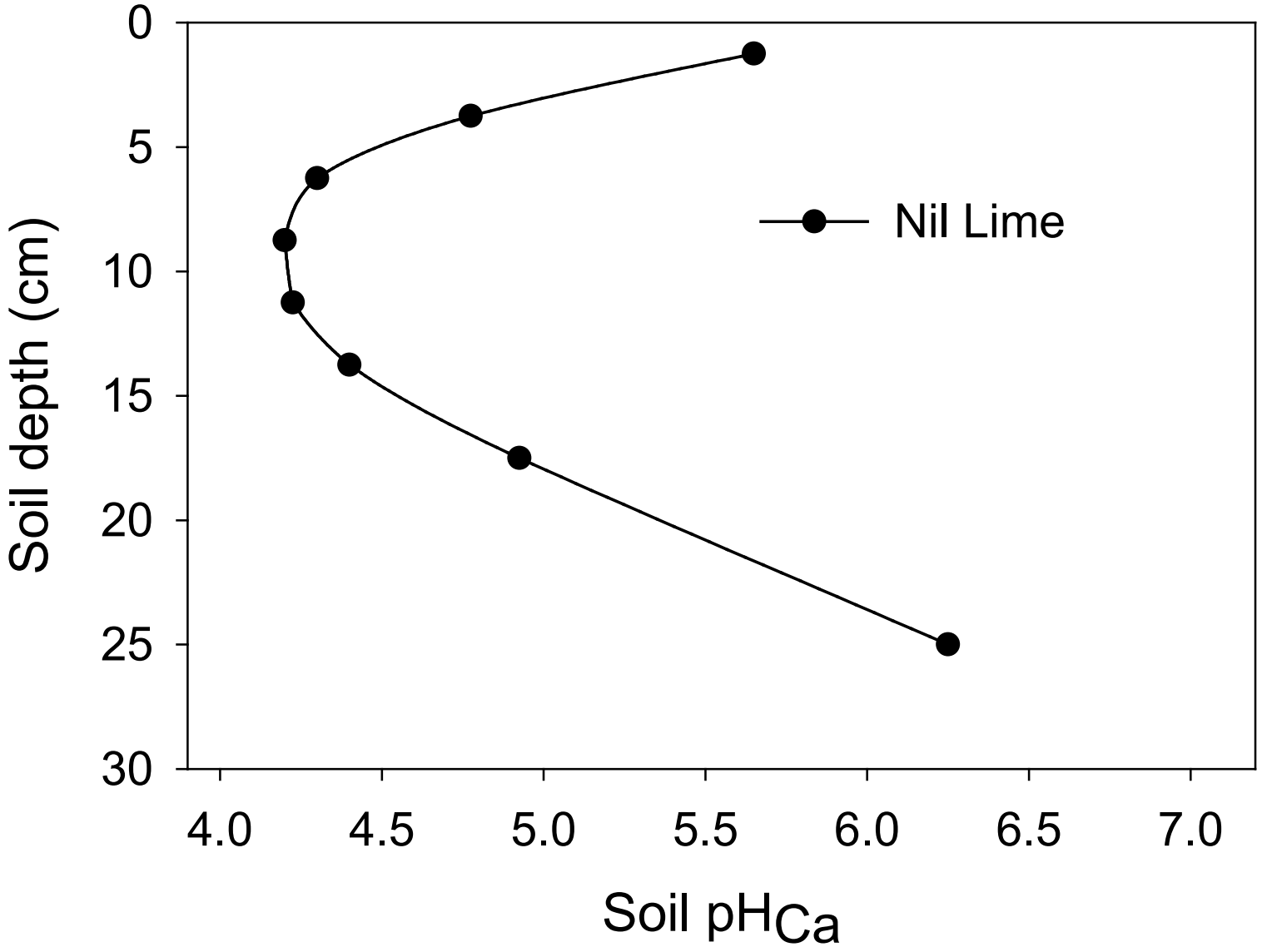


established 2020
(James Holding)

Lime 0 and 7 t/ha

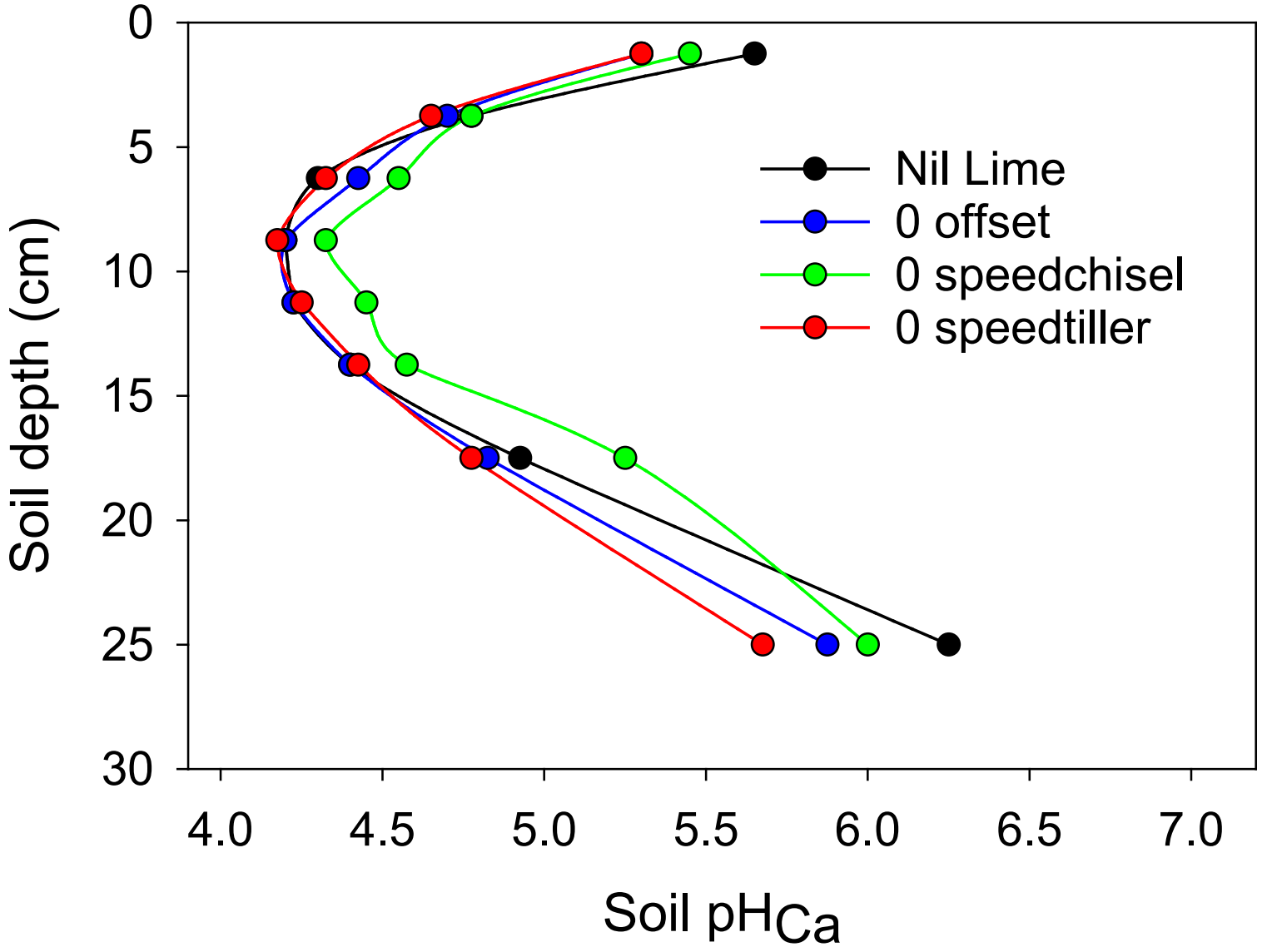
Surface
Inc offset
Inc speedtiller
Inc speedchisel

Effect of implement – Grenfell results - FarmLink

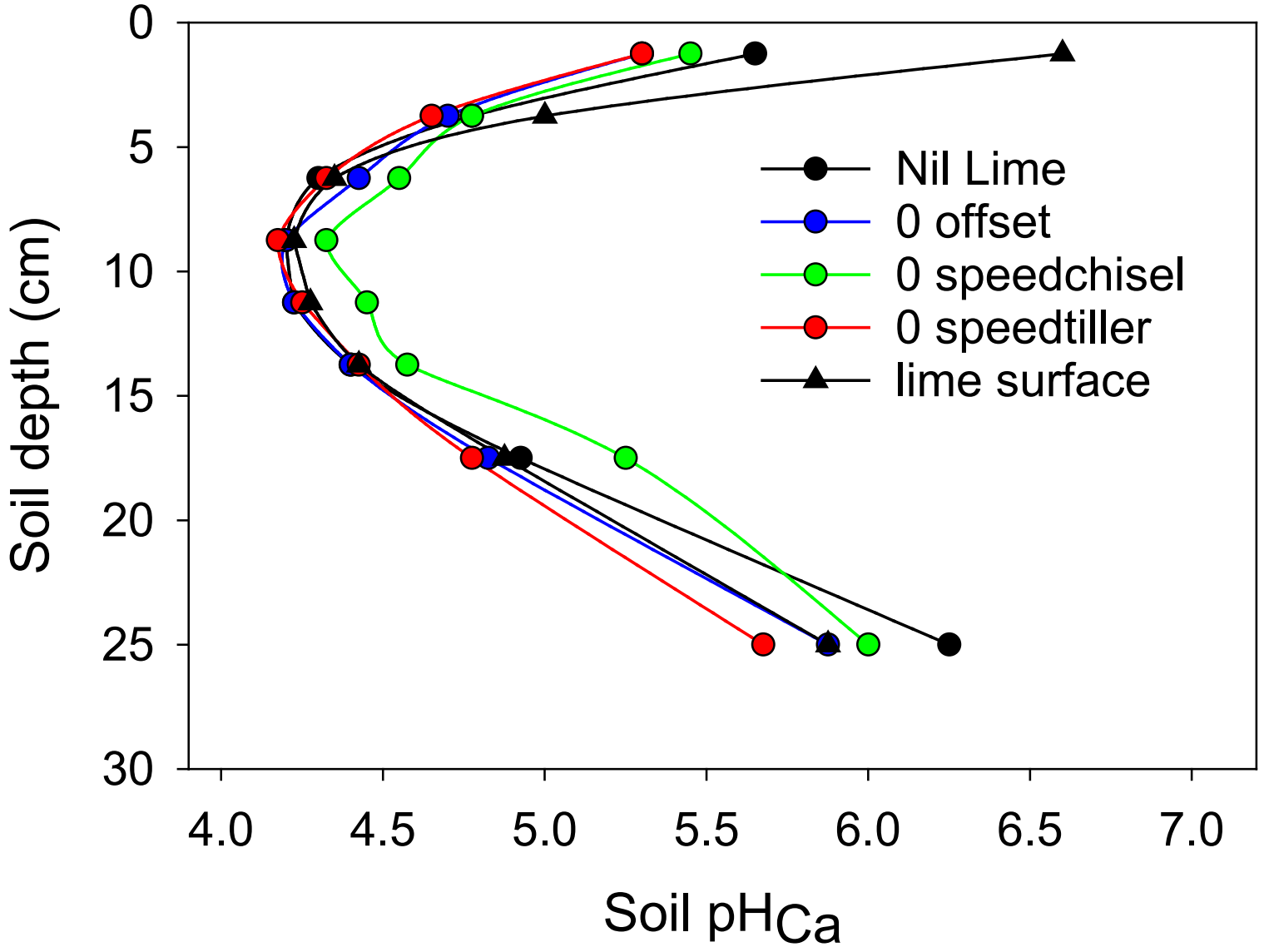


2021 data

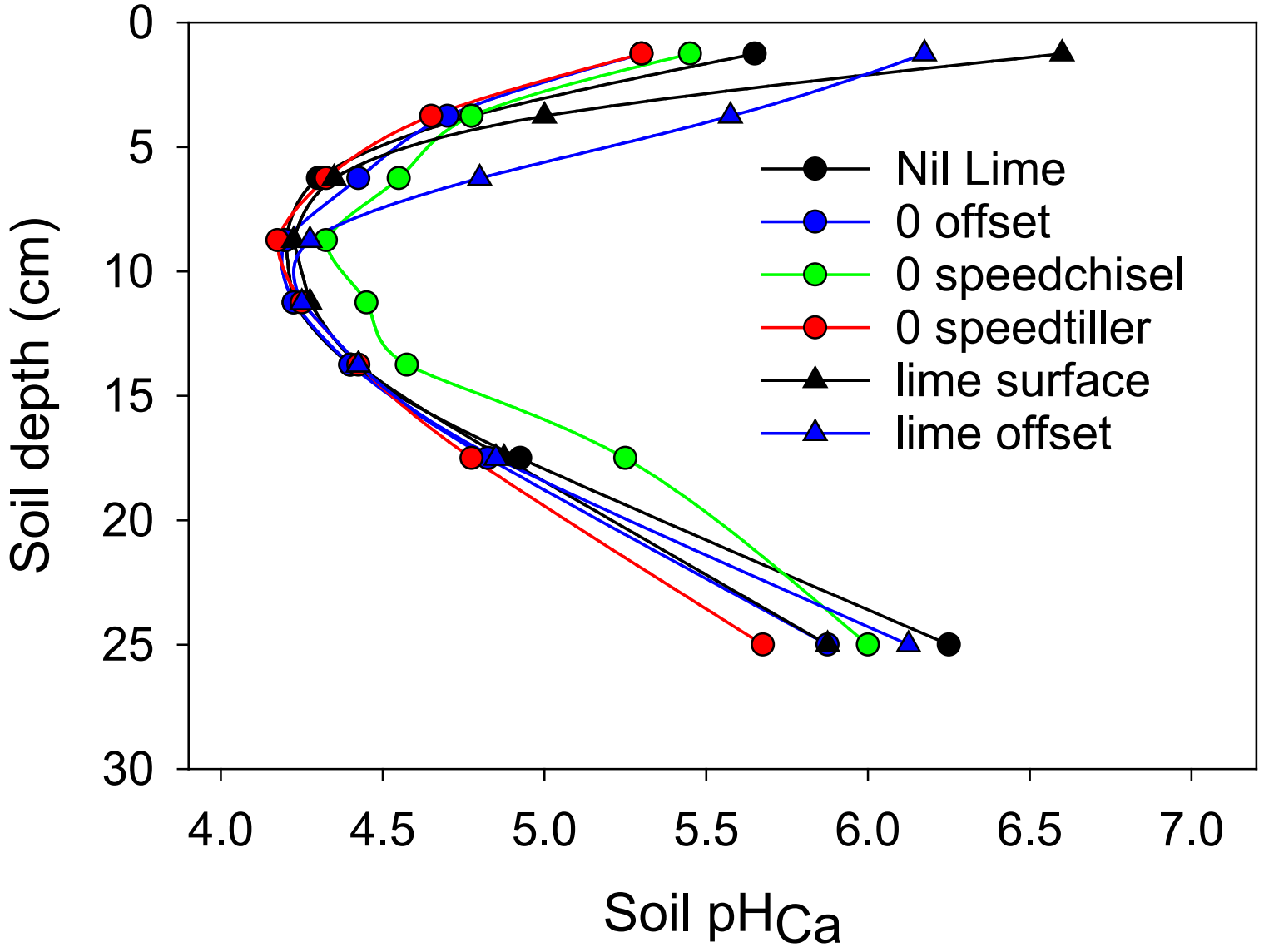
Effect of implement – Grenfell results - FarmLink



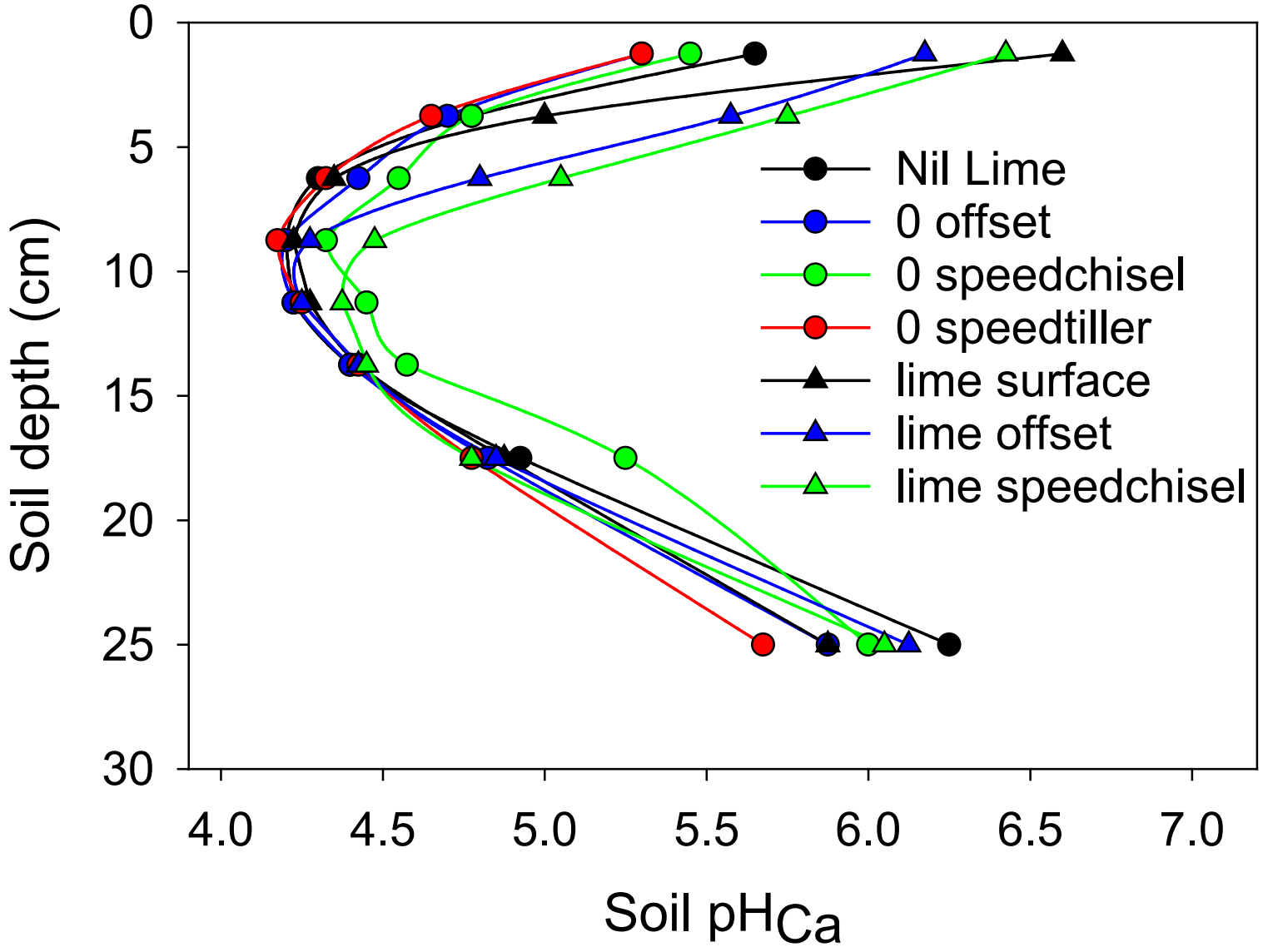
Effect of implement – Grenfell results - FarmLink



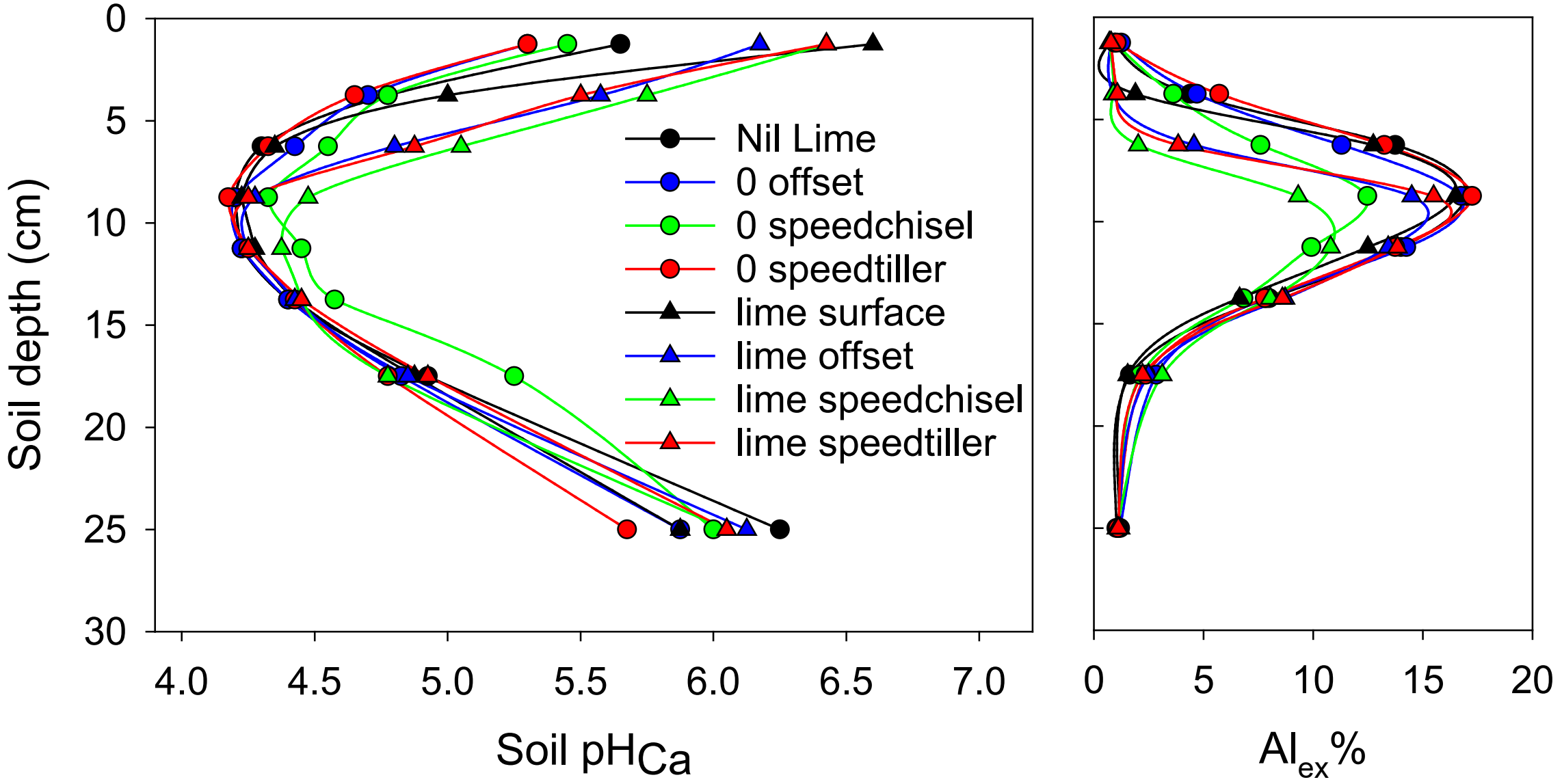
Effect of implement – Grenfell results - FarmLink



Effect of implement – Grenfell results - FarmLink



Effect of implement – Grenfell results - FarmLink



Depth of incorp ≠ Depth of mixing