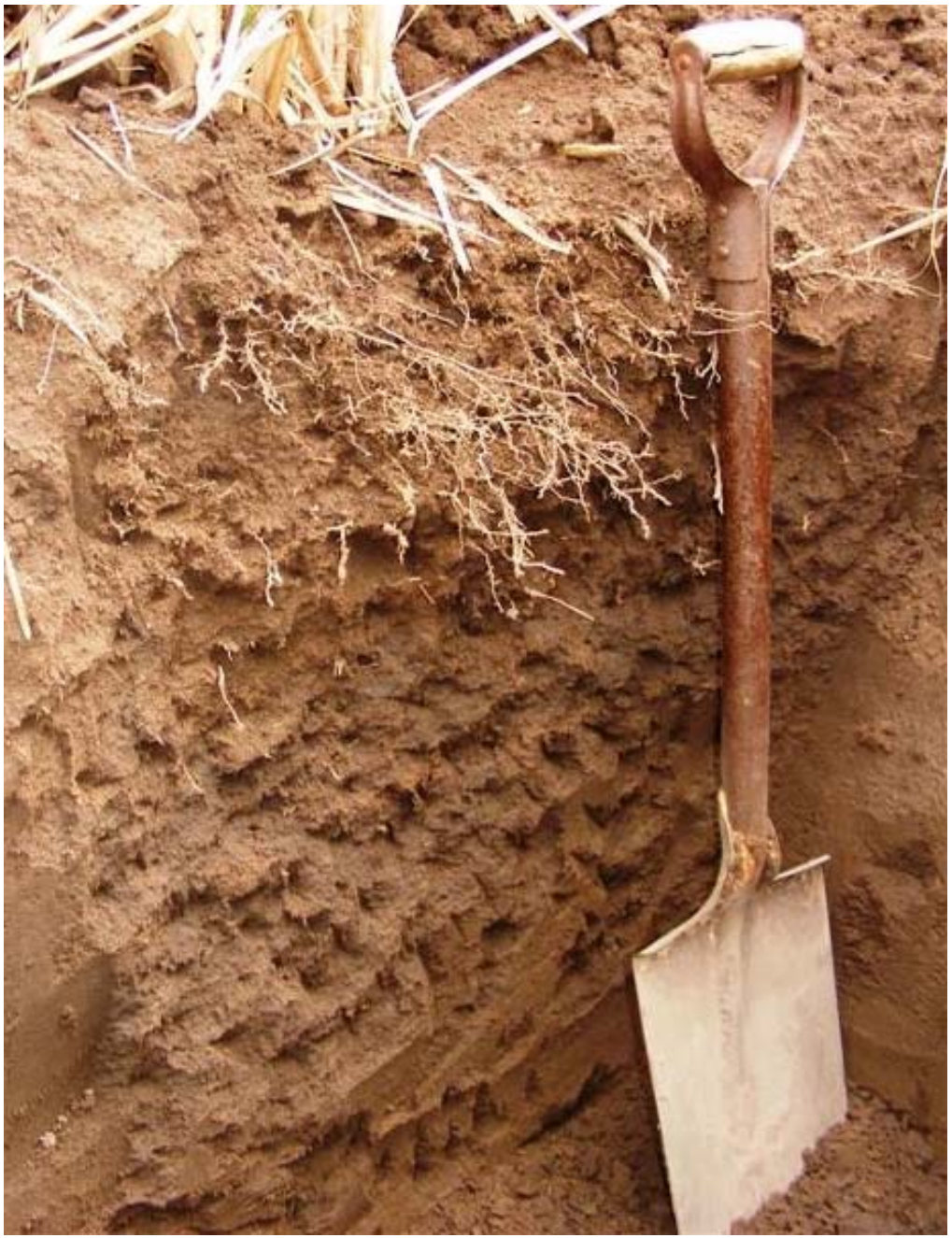


SUBSOIL ACIDITY

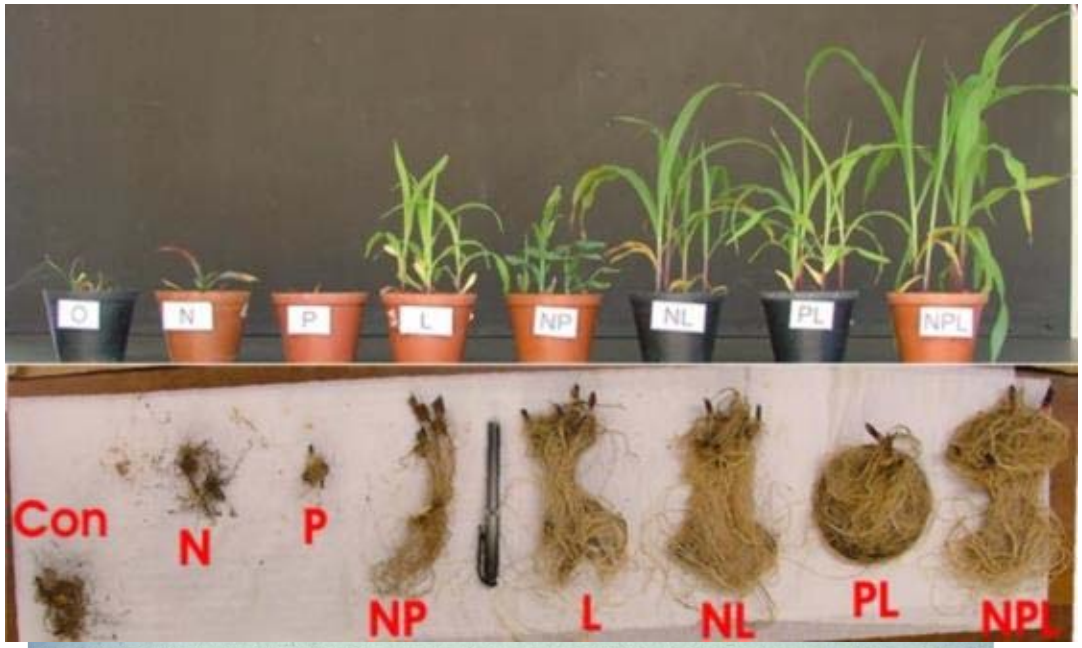
Digging deep for the truth…

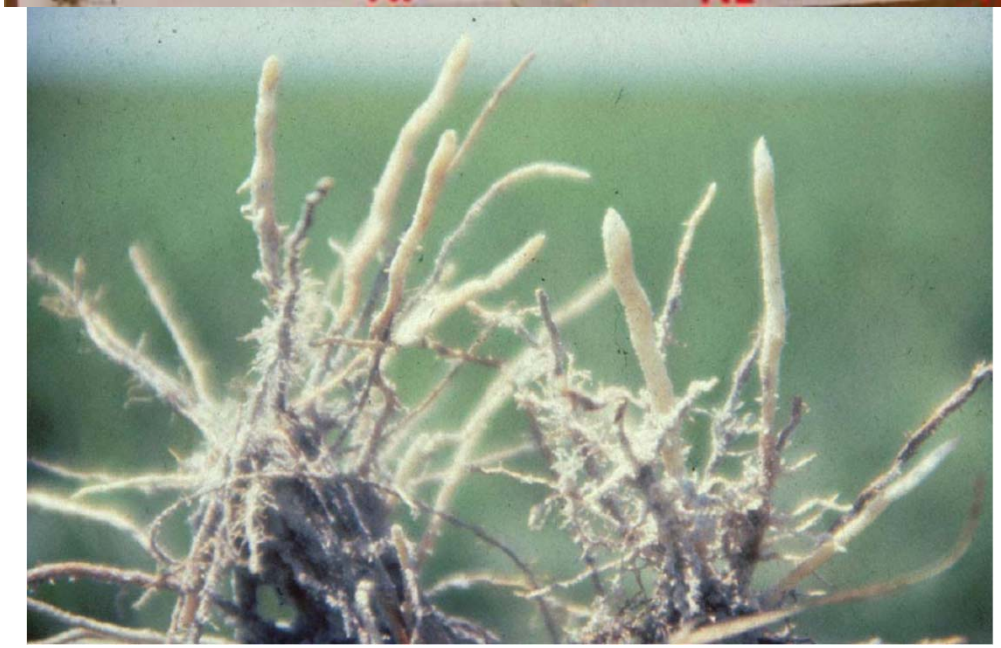
Louis Titshall 24 October

And a special thanks to the engineers…

For the technology to dig deep

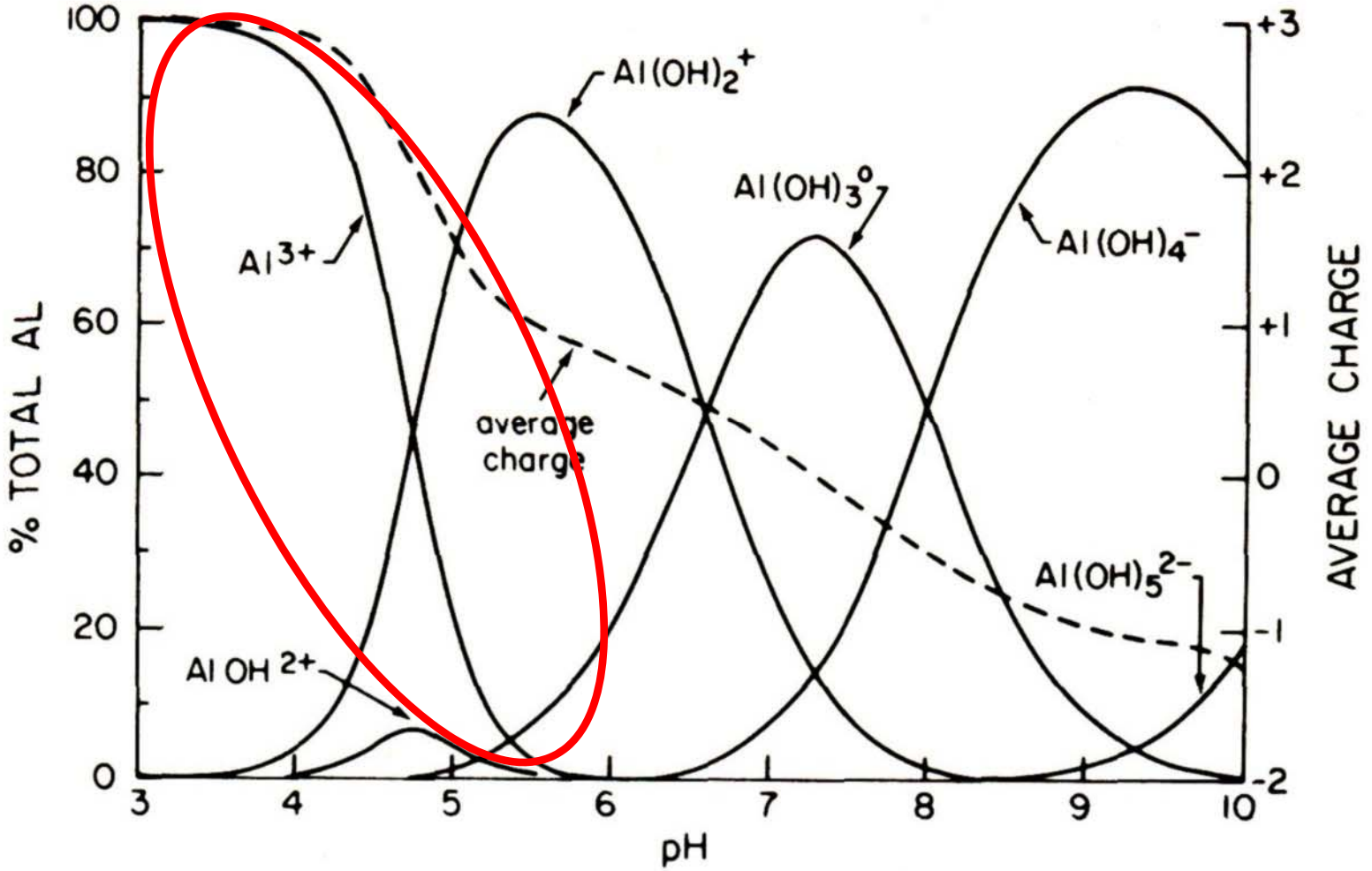
Most crops don’t like acidity

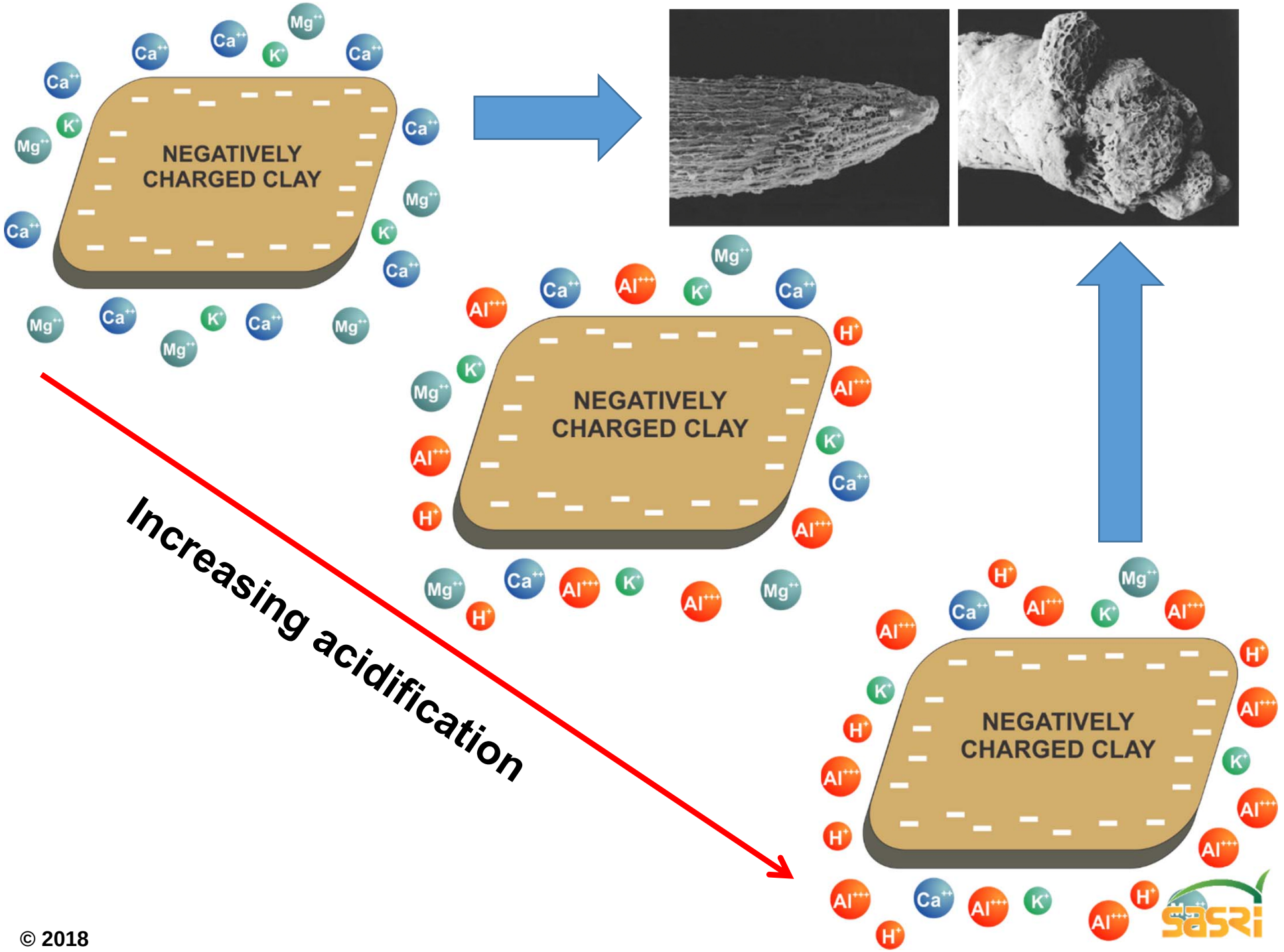




The problem with aluminium

$$Al^{3+} + H_2O = Al(OH)_2 + H^+$$




NEGATIVELY CHARGED CLAY
NEGATIVELY CHARGED CLAY
NEGATIVELY CHARGED CLAY
Increasing acidification

Benefits of liming

- Eliminates toxic Al and Mn.
- Increases nutrient availability.
- Better rooting - improves moisture and nutrient utilisation.
- Supplies Ca and Mg for plant growth.
- Improves N supply from legumes and the soil organic matter.
- Stimulates soil fauna (e.g. earthworms).
- Effect generally limited to the topsoil layers.

So what is the problem?

- Excess acidity below the surface soil (>20cm) that can affect root growth.
- Can extend deep down profile (>80cm).
- Al toxicity, Ca (and other nutrient) deficiency.
- Reduced access to subsoil water.
- In an acid profile, surface liming remedies topsoil acidity.
- Mobility of alkalinity down the profile generally very limited.

Where is this problem coming from?

Origins of this subsoil acidity are debated:

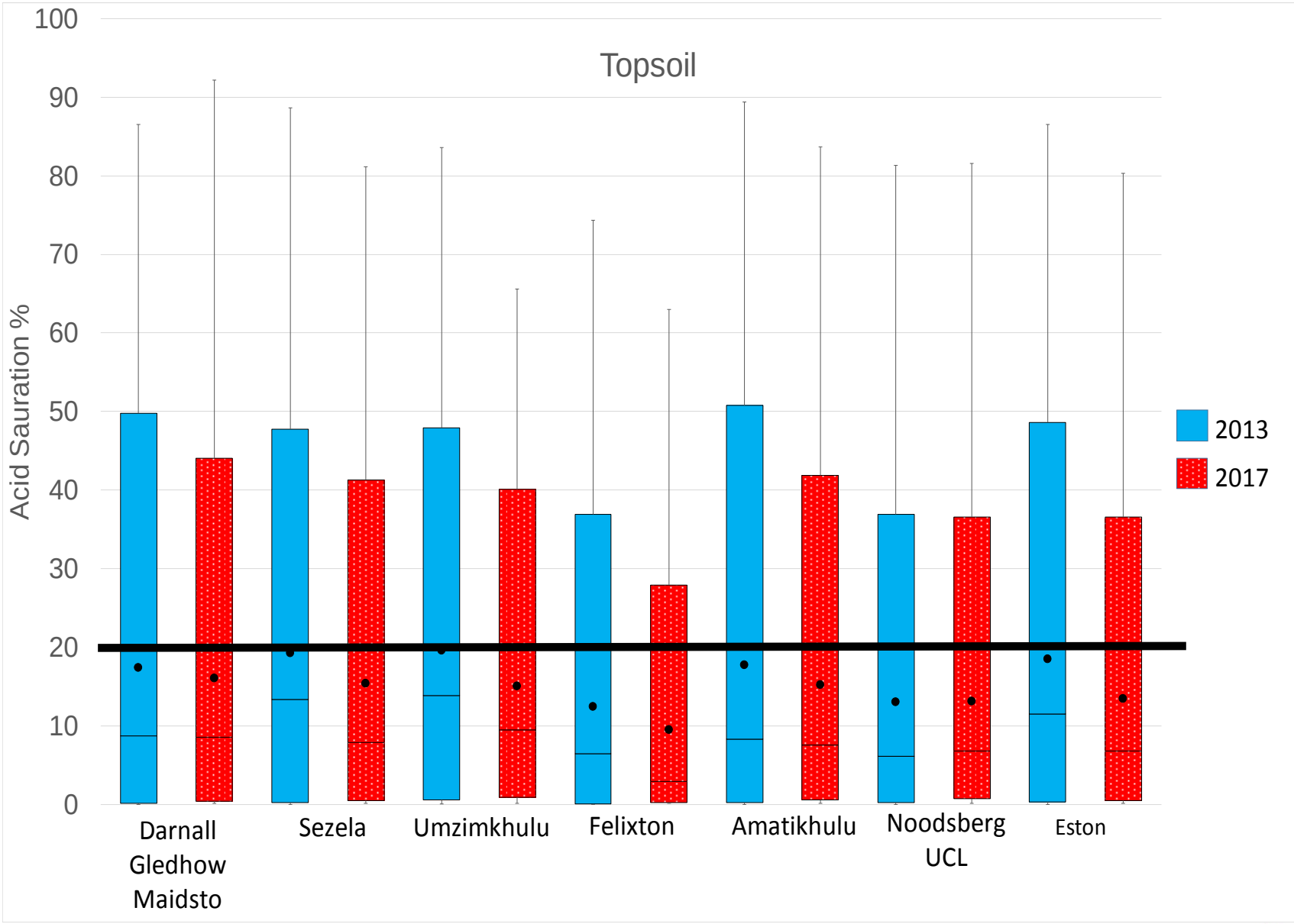
- Inherent in the soil.
- Acidity leaching from the top.
- Cation uptake by roots at depth.
- Leaching of base-cations out of subsoil.
- Mineralisation processes – depth dependent.

But is it a problem…?

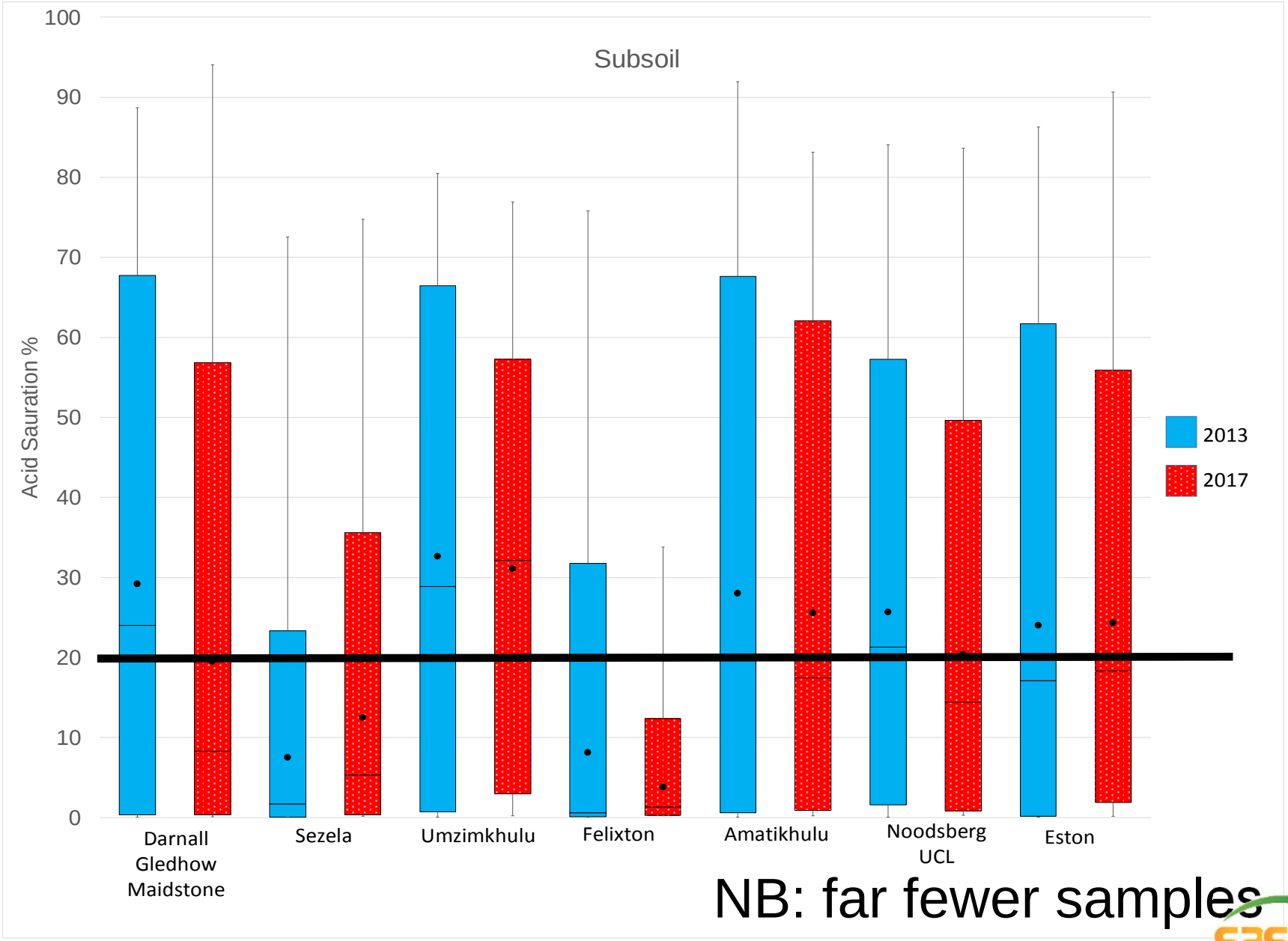
highly sensitive	**carrot, cabbage, tomato** **macs, banana, avocado, litchi**
moderately sensitive	**sunflower / dry bean** **cotton** **sorghum**
moderately tolerant	**maize / lupin** **soyabean** **potato**
highly tolerant	**sweet potato** **sugarcane, cow peas**

Geluksberg acidity demo trials (Farina et al.)

Current status: 0-20cm topsoil depths



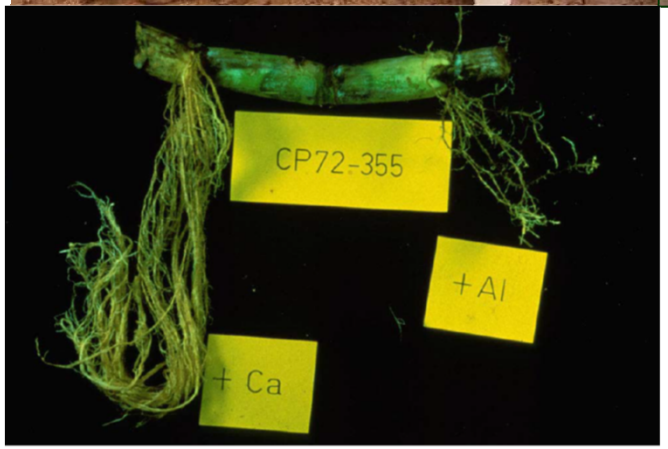
Current status: >20cm soil depths



NB: far fewer samples

So how big of a deal is subsoil acidity in sugarcane?

Even sugarcane has a limit



Too much acidity can rob you of production!!!

- Roots will avoid growing into acid subsoils
- Represents a lost opportunity

Water & nutrients not accessed thus not utilised

5 year-old crop;
yield = 38 t cane/ha
at 15 months

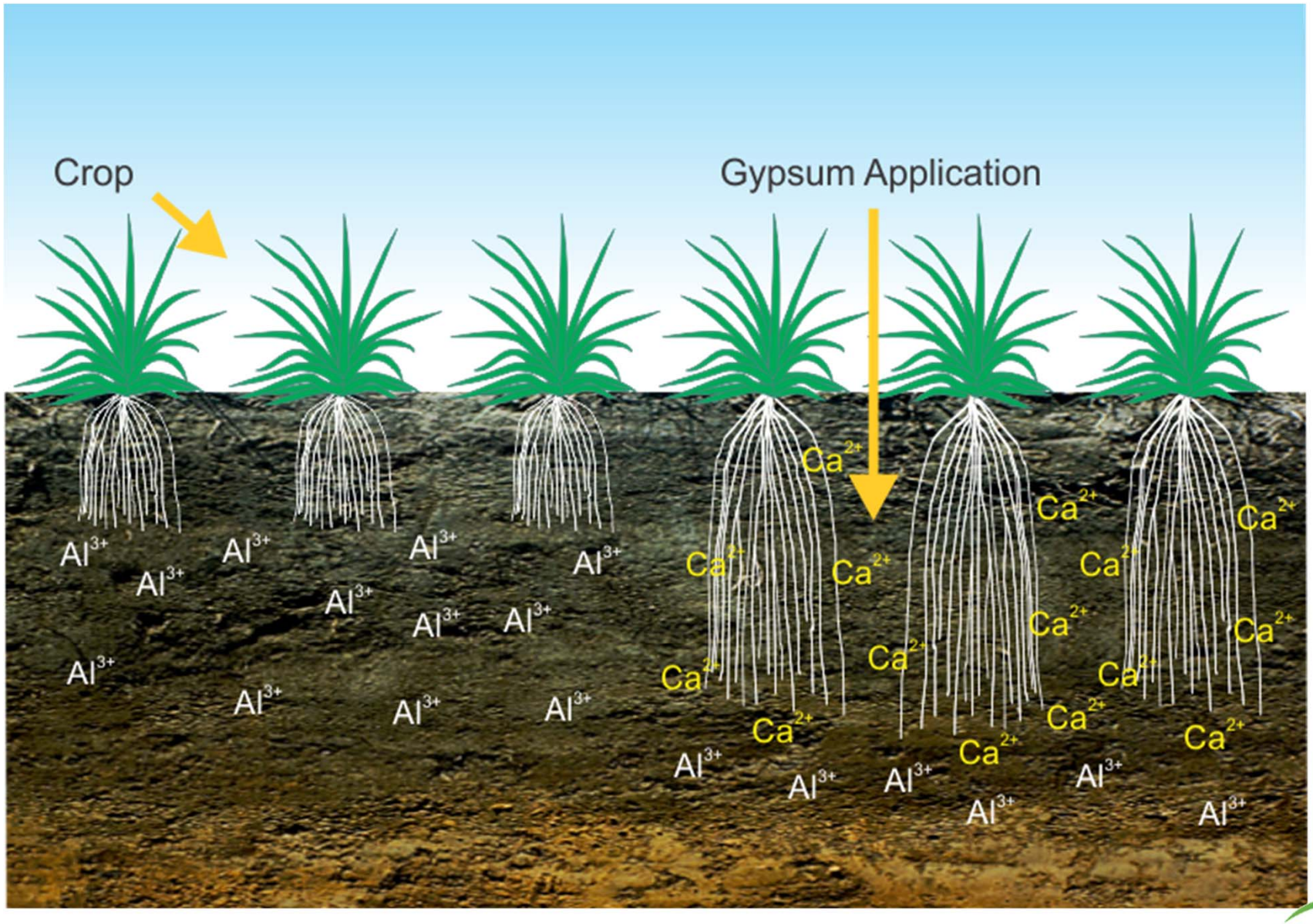
“Acid subsoil conditions”

Araujo et al., 2018

“In the case of sugarcane, the roots play an essential role in the growth of ratoons because after harvest the energy and nutrients needed for regrowth are supplied by the root system. Therefore, restriction of the root system to the superficial layers of the soil can limit the productivity of ratoons, and consequently the longevity of sugarcane plantations”

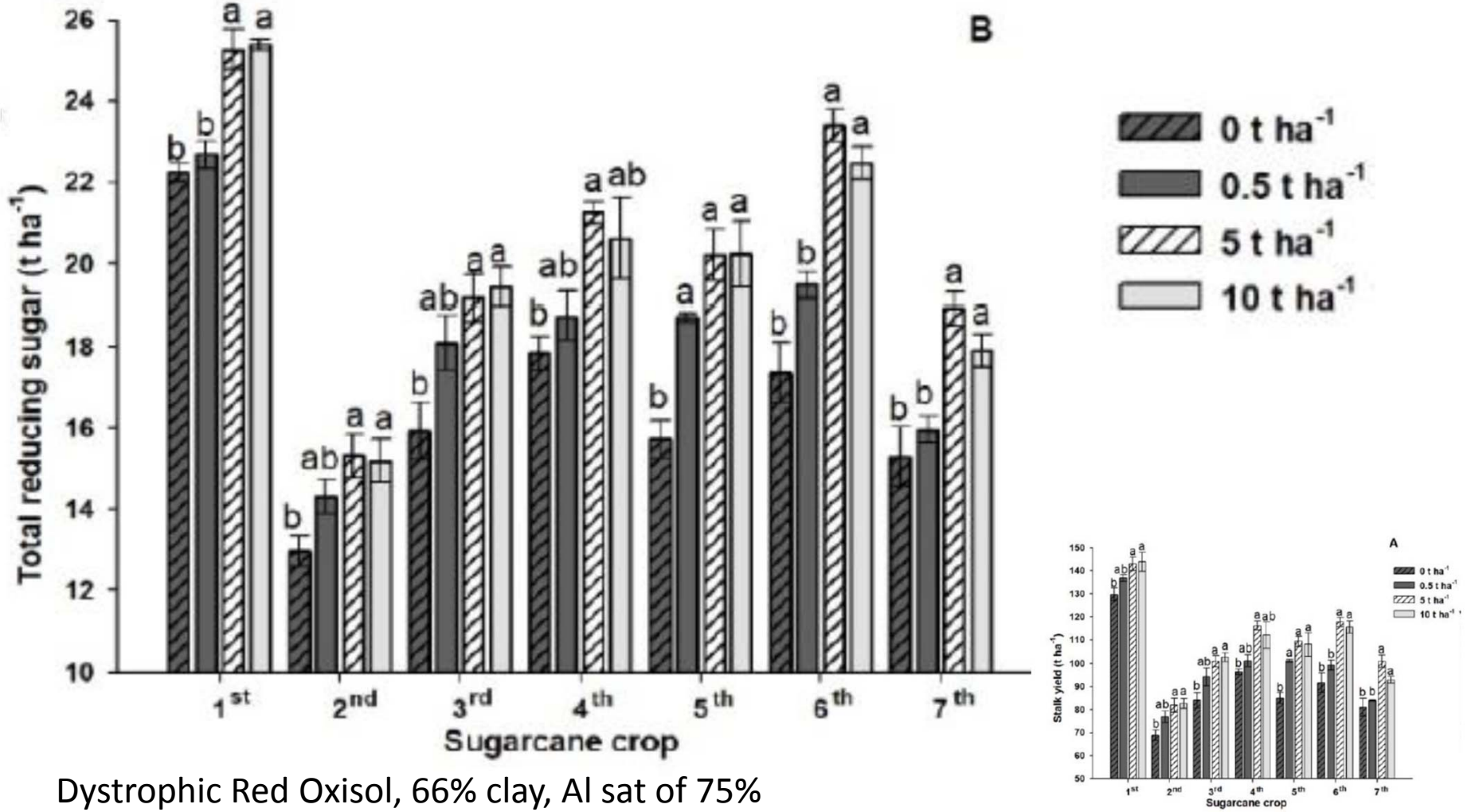
- Is subsoil acidity causing yield loss (assuming you fixed the topsoil)?
- Is it the cause (or part of the cause) of ratoon decline?
- How “fixable” is it?

The magic of gypsum

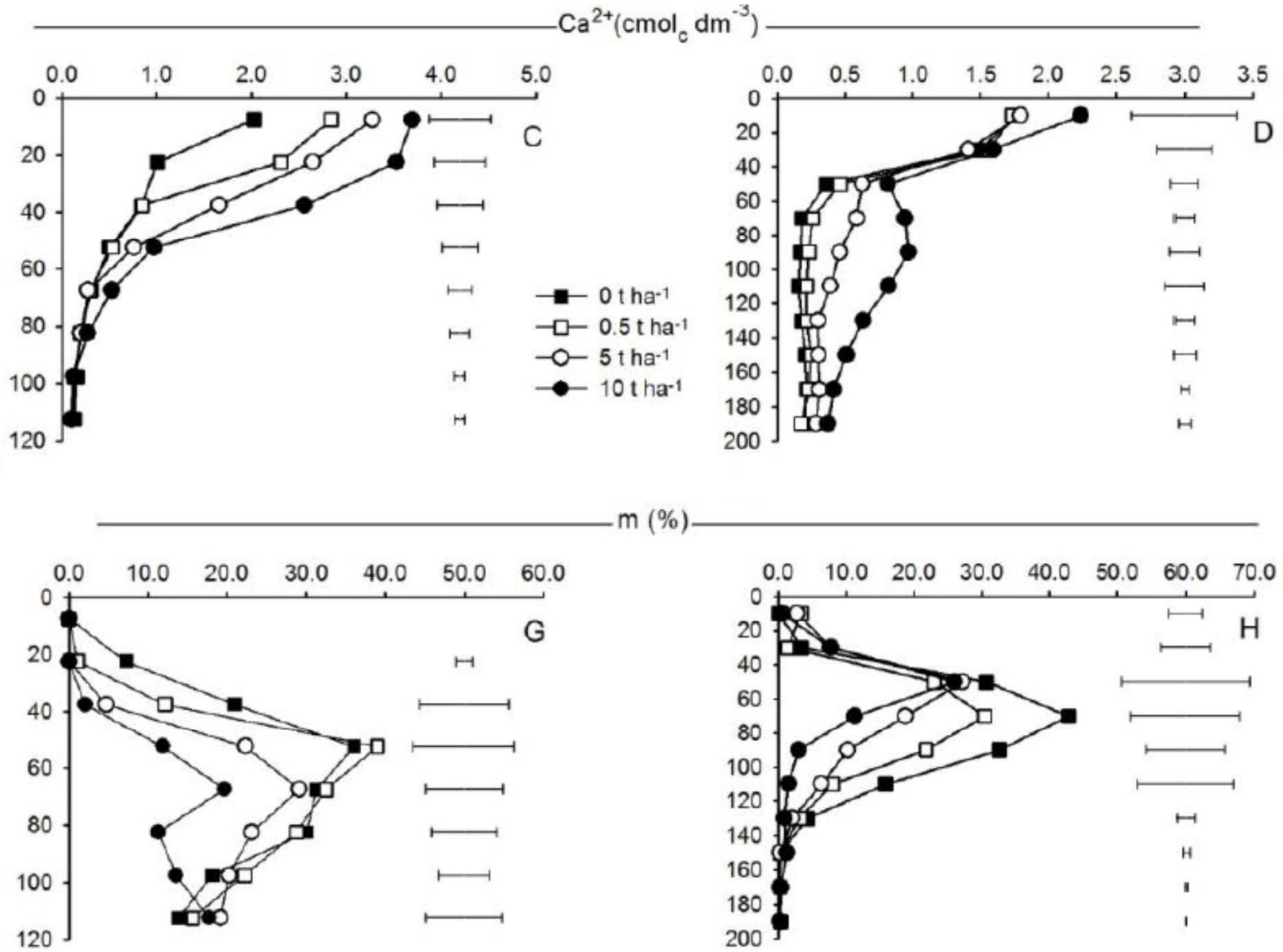


Araujo et al., 2018: The residual effect of gypsum on subsoil conditioning, nutrition and productivity of sugarcane crops.

5 t gypsum over control: P-14%, 1R-18%, 2R-20%, 3R-19%, 4R-29%, 5R-35%, 6R-24%

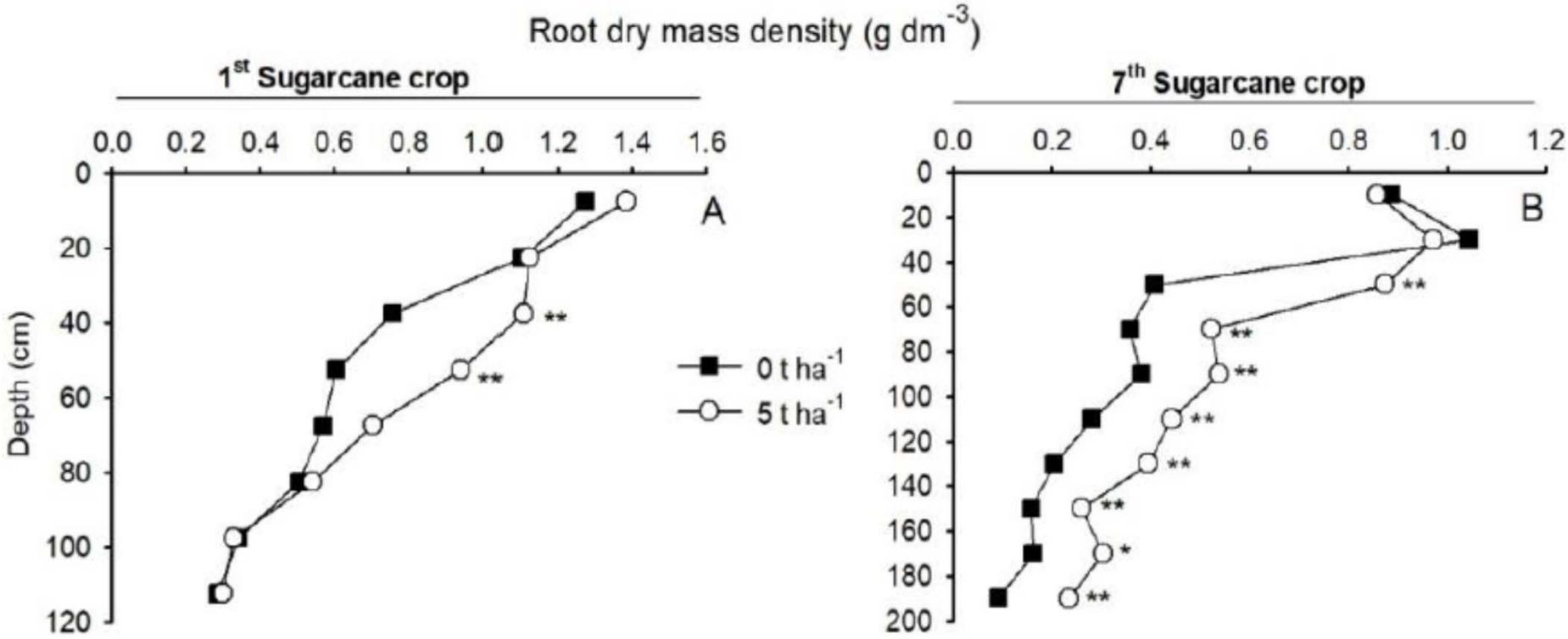


Dystrophic Red Oxisol, 66% clay, Al sat of 75%
All treatments received 7 t/ha dolomitic at start



13 months

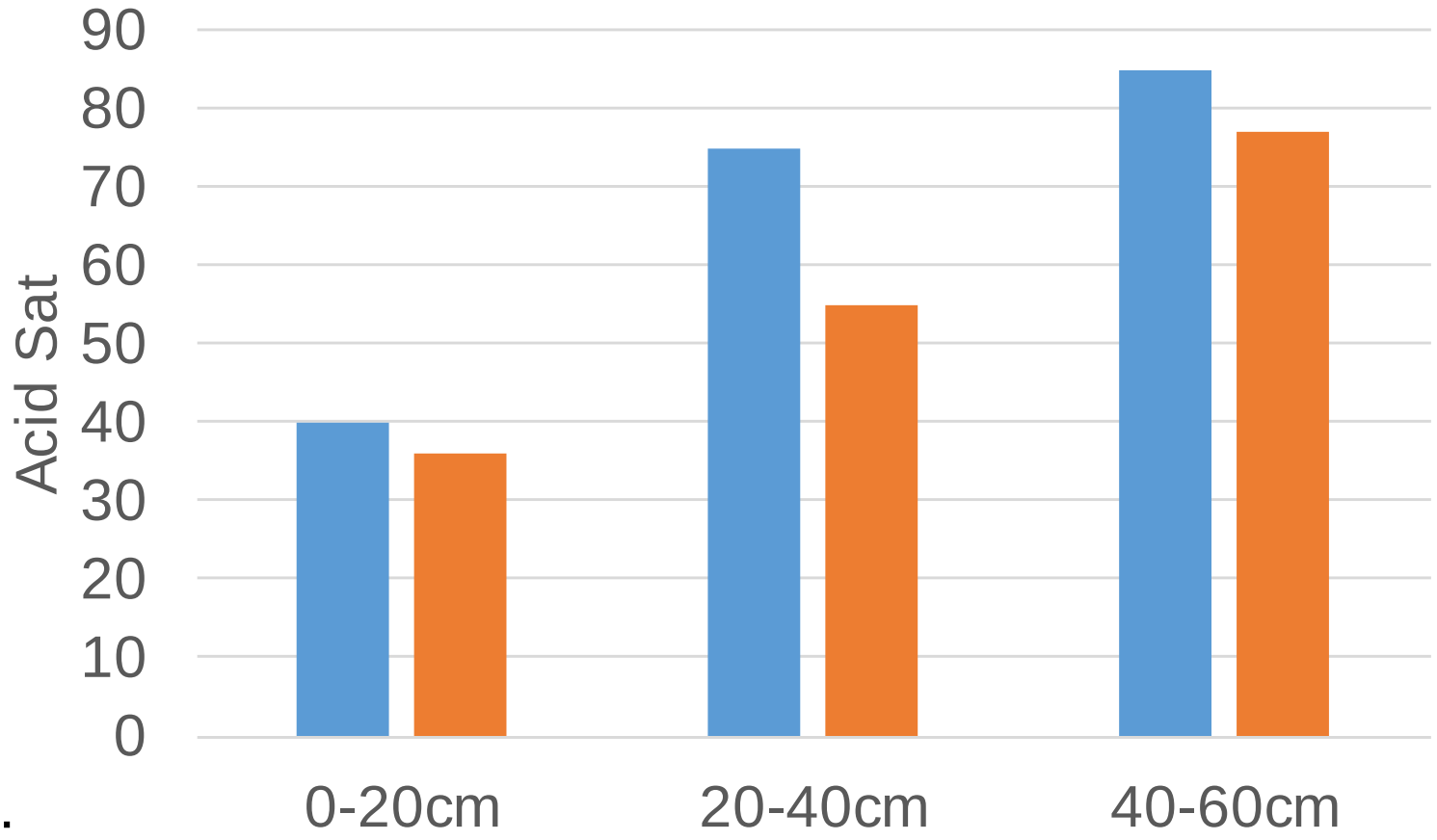
87 months



They concluded:

- The use of gypsum resulted in improvement of the subsoil by increasing S, Ca and Mg and reducing Al saturation.
- The gypsum effect persists upto 87 months.
- This had benefit for root growth into deeper soil layers.
- This resulted in better cane production.
- This was economically feasible.

Several other earlier examples



Yield:
Control 87 t/ha;
Gypsum 101 t/ha
(mean of plant + 4 ratoons)

Dematte 1986

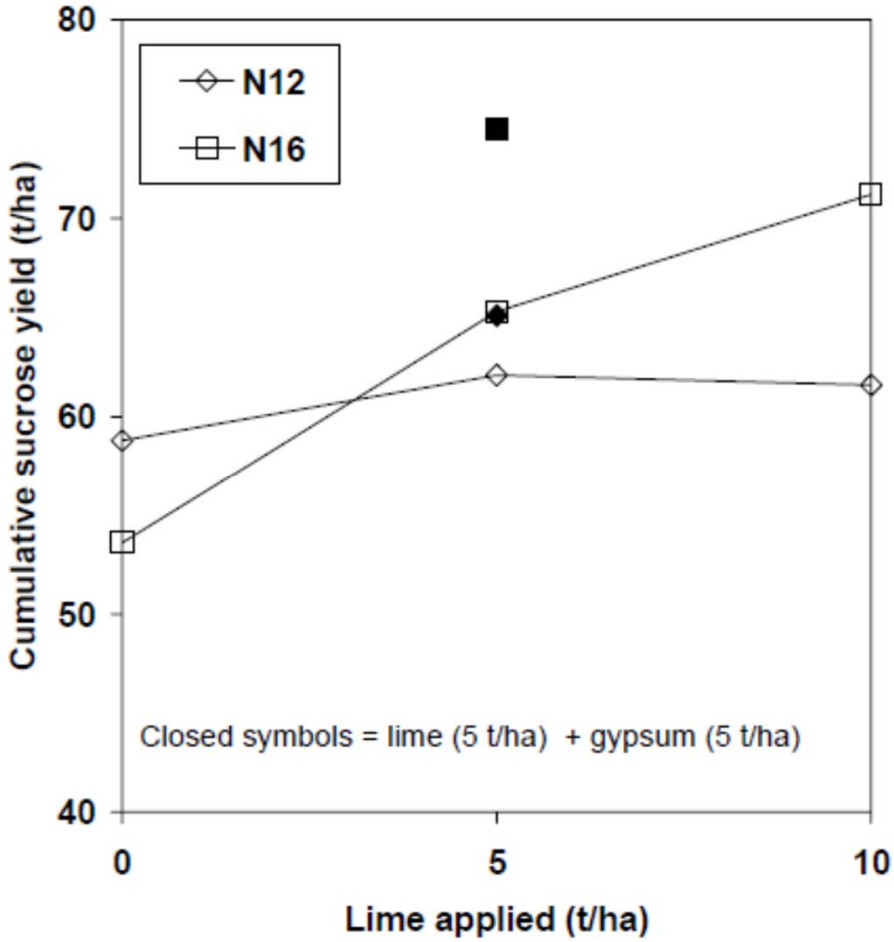
See review by Sumner 2012

What about South Africa:

- Meyer et al., 1991 (lime/PG combos):
  - No significant response on plant (variety N12)
  - Best response on 1R: 6 t/ha lime + 5 t/ha PG (or 3 Lime and 10 PG) – possibly a P response
  - Was not considered worthwhile at the time
  - Soil not “acid” enough.

- Turner et al., 1992:
  - Some benefit to lime and gypsum in combination on underperforming NCo376 ratoon low acid tolerance
  - Effects for N12 and N16 not as clear – marginal
  - Attributed to high acidity tolerance.

The Nixon et al., 2003 study

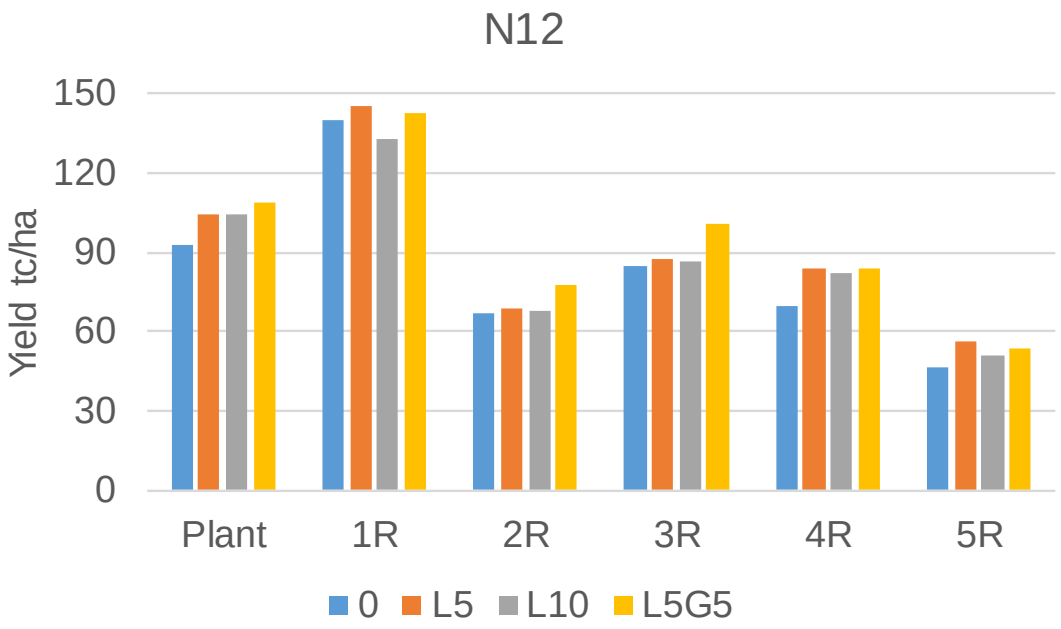


Plant + 5R

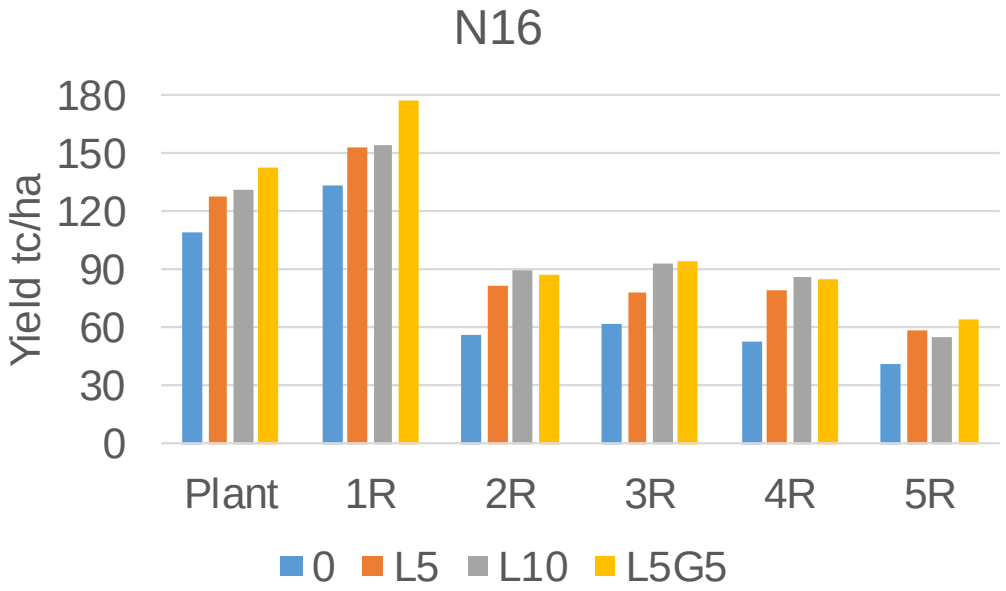
"The use of 5 t/ha gypsum and 5 t/ha lime resulted in 9 t/ha more sucrose from N16 over the cycle compared with 5 t/ha lime alone"

"N12 did not respond to lime over the cycle, but the combination of lime plus gypsum resulted in a cumulative increase of 7 t/ha sucrose, compared with unlimed cane"

A similar story by Elephant et al., 2017 for N39 on a Cartref



N12- acid tolerant
(S)lower response?



N16- less acid
tolerant
Earlier response?

So it seems to me that…

While sugarcane can tolerate acidity and Al, there seems to be benefit in getting Ca into the ground.

Landell et al., 2003: Oxisol subsurface chemical attributes related to sugarcane productivity

"…from the 3rd harvest forth, the crop is more intensely influenced by subsurface attributes".

"The better productivities obtained for eutrophic soils can be justified by their subsurface chemical attributes, as exemplified by their Ca, Mg, and K levels".

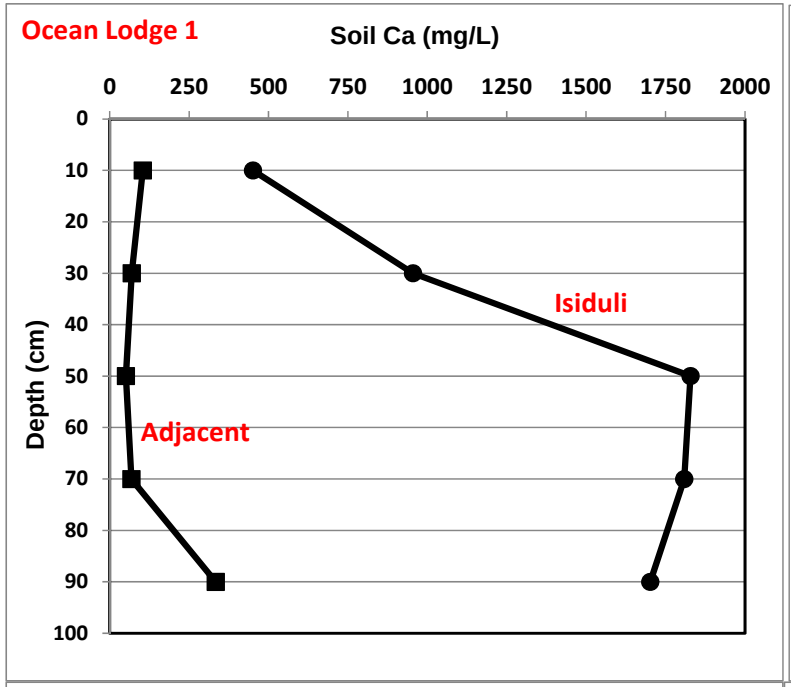
Maybe it has a lot to do with root-turnover and behaviour?

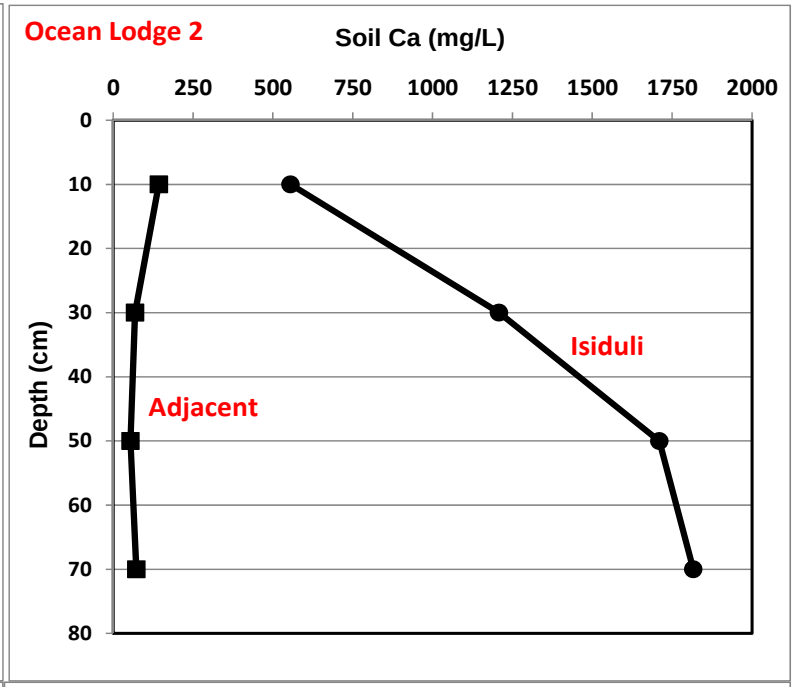
Calcium contributes the most toward root growth in deeper layers (Ritchey et al., 1981).

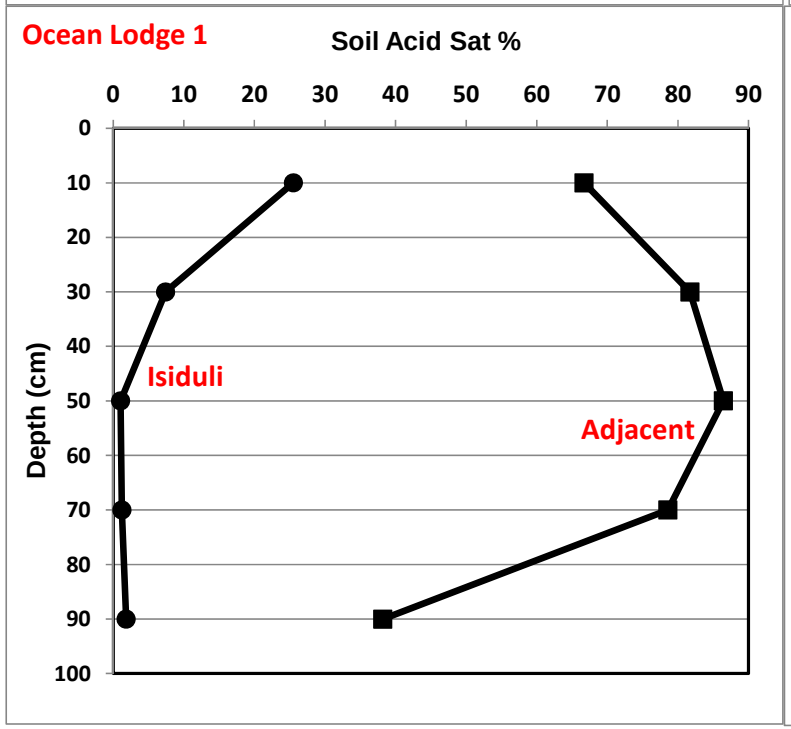
Ca	Mg	K
60	14	32
18	4	15
17	3	14

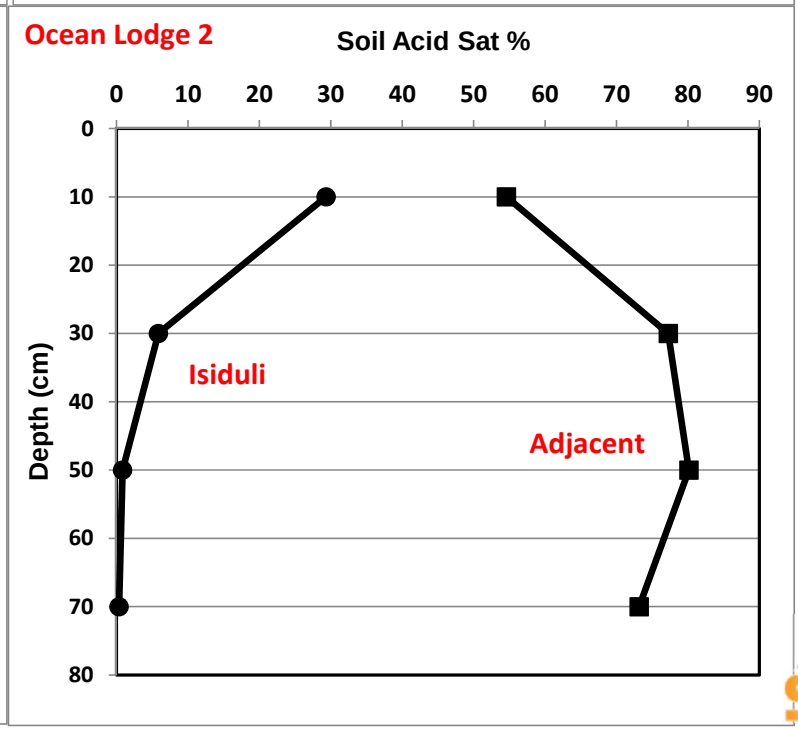
The curious case of the isiduli's

	Stalk height (cm)	
	Ocean Lodge 1	Ocean Lodge 2
Isiduli	162	197
Adjacent	62	104
% yield of Isiduli	+161%	+89%


Ocean Lodge 1
Soil Ca (mg/L)
0 250 500 750 1000 1250 1500 1750 2000
0 10 20 30 40 50 60 70 80 90 100
Depth (cm)
Isiduli
Adjacent


Ocean Lodge 2
Soil Ca (mg/L)
0 250 500 750 1000 1250 1500 1750 2000
0 10 20 30 40 50 60 70 80
Depth (cm)
Isiduli
Adjacent


Ocean Lodge 1
Soil Acid Sat %
0 10 20 30 40 50 60 70 80 90
0 10 20 30 40 50 60 70 80 90 100
Depth (cm)
Isiduli
Adjacent


Ocean Lodge 2
Soil Acid Sat %
0 10 20 30 40 50 60 70 80 90
0 10 20 30 40 50 60 70 80
Depth (cm)
Isiduli
Adjacent

What do we know…?

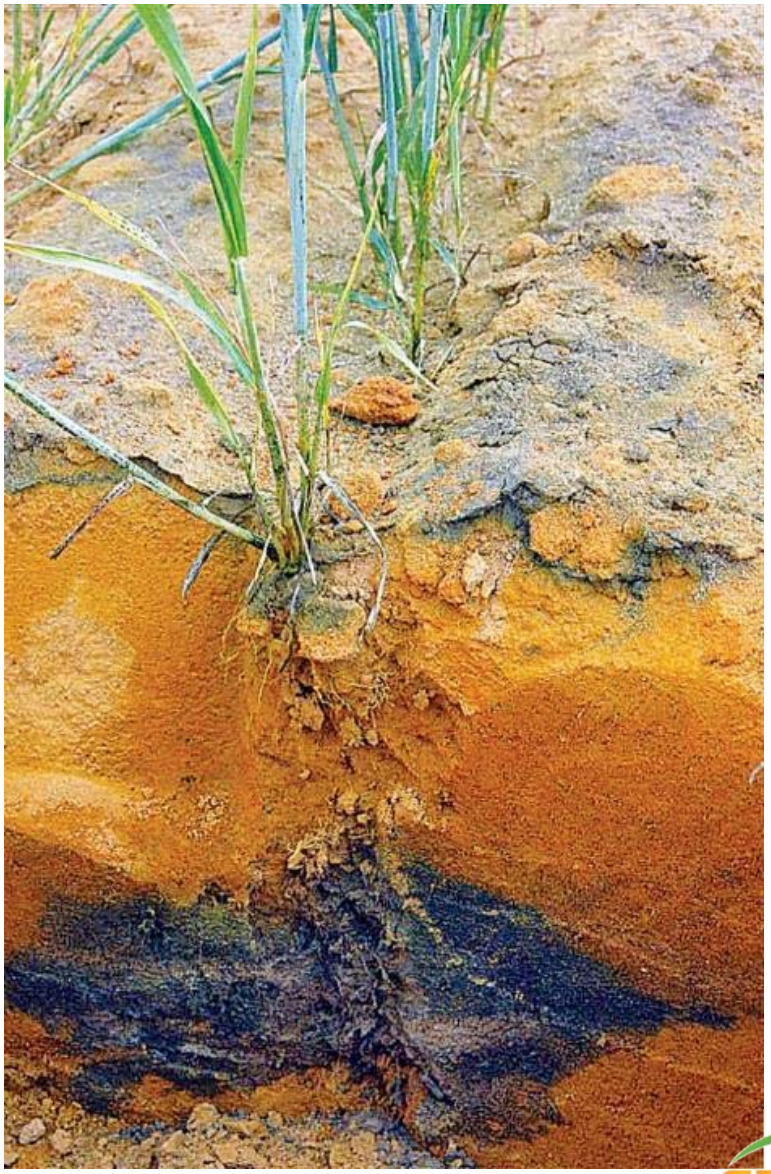
- Evidence of long-term benefit of subsoil acidity amelioration.
- The benefit may not be immediately apparent.
- The benefit is stronger on the well weathered soils with low CEC and high Al.
- Gypsum is effective at subsoil amelioration, but needs to go hand-in-hand with topsoil amelioration.
- Too much gypsum can leach Mg/K from the topsoil.

BUT…

- Need a better handle on the interaction between roots, acidity and subsoil.
- And our new varieties?
- You may also grow something else…

And what about subsurface liming?

Somewhat mixed results for this – so not too sure…



Mobility of lime in a soil seems the key constraint