Principles of Soil Acidity, Liming, Calcium and Magnesium Nutrition

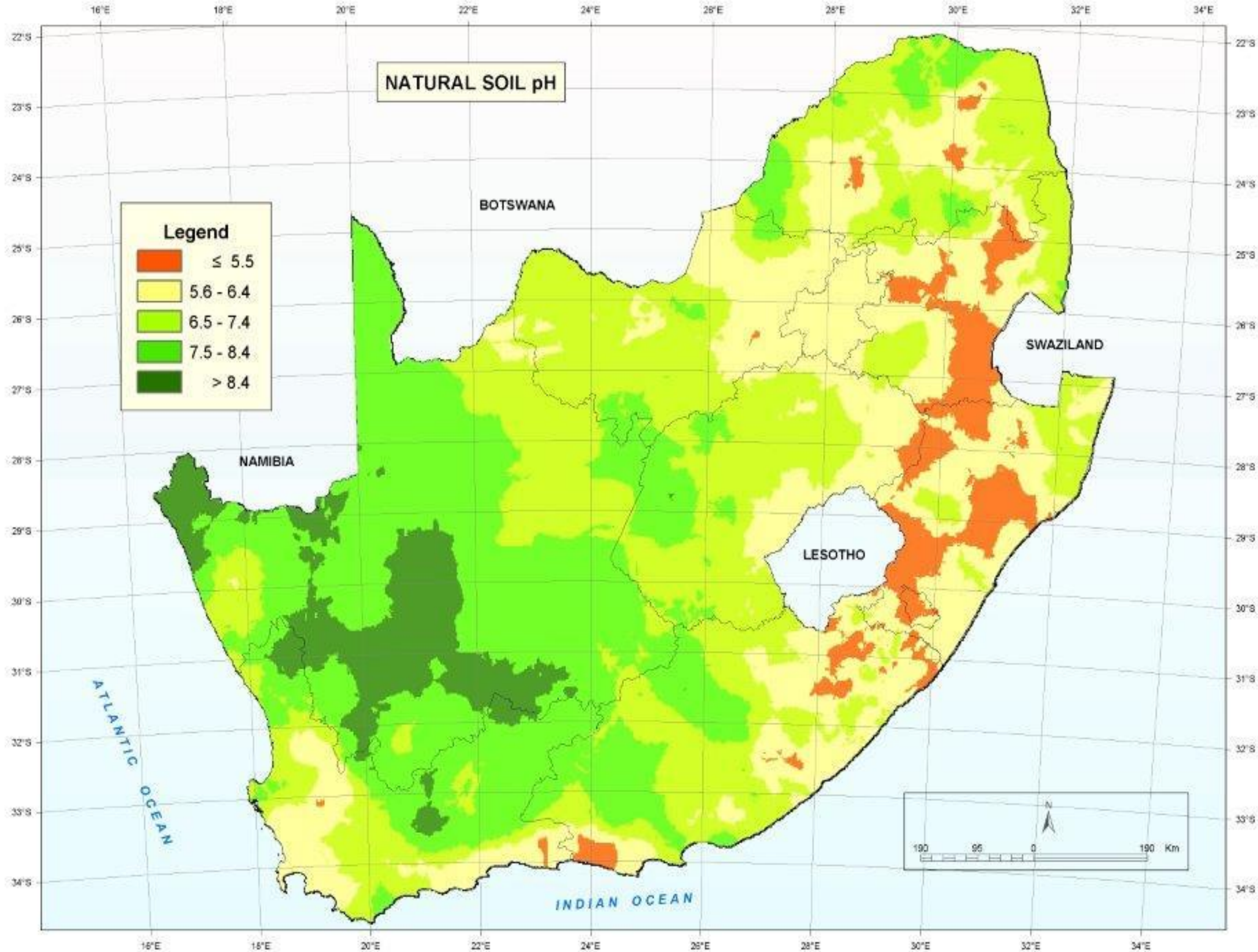
Fertasa Soil Acidity Workshop
May 2019

Neil Miles

Acknowledgements
Mart Farina, Guy Thibaud, Alan Manson


Is soil acidity a serious problem?
Yes…..and no!
Mart Farina


Is soil acidity a serious problem?
Yes…..and no!



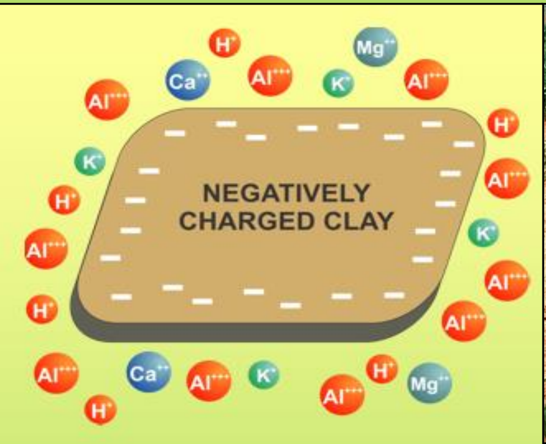
ARC - Soil, Climate and Water

This presentation ....

1. What, precisely, is the problem?

2. Impact on plant growth

3. Correction

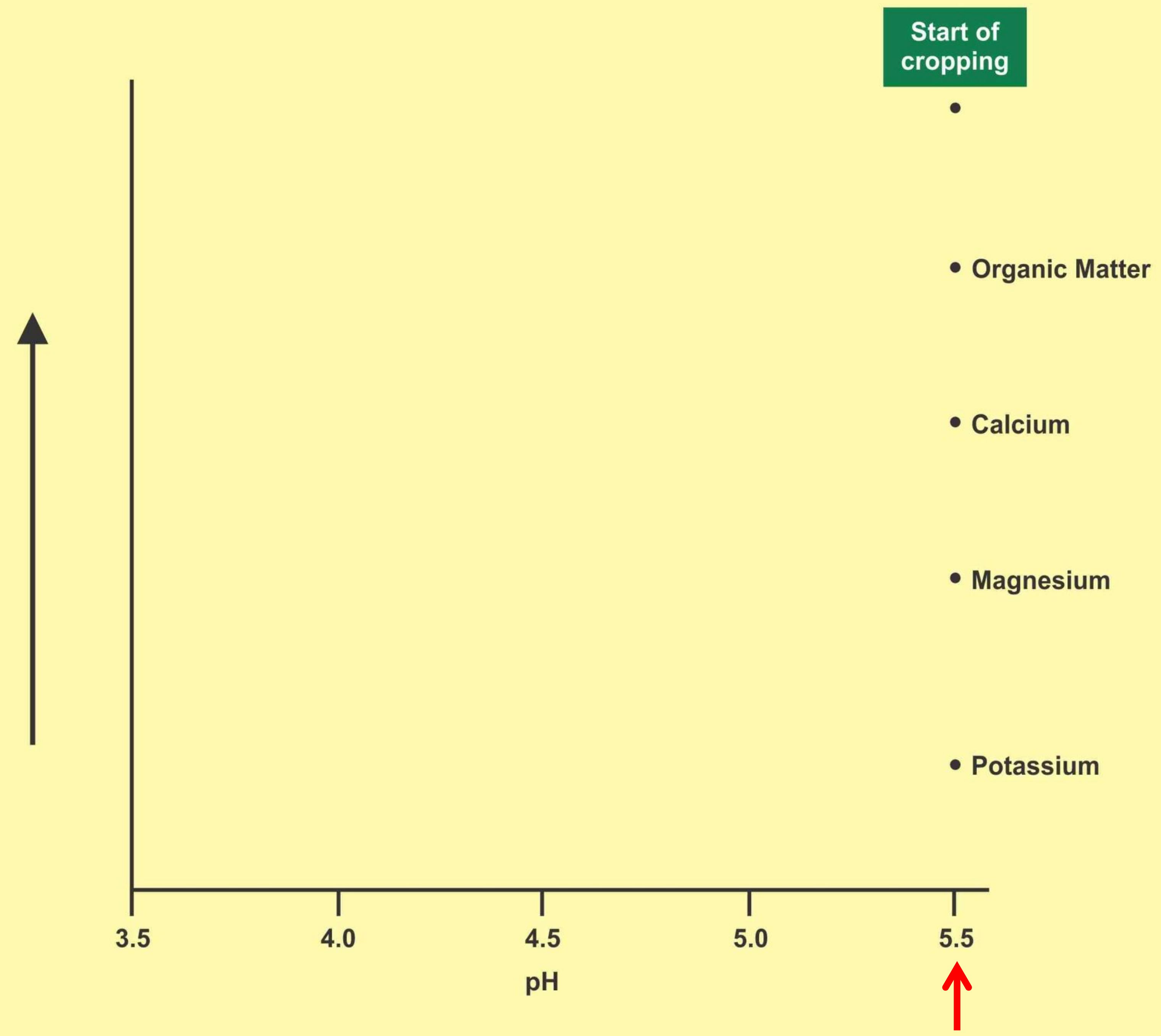


Causes of soil acidity

- Natural:
  - *high rainfall* (leaching of bases) over long time periods (older land surfaces)
  - more rapid in well drained *sands* than in moderately and *poorly-drained loams and clays*
- Man-induced:
  - ammonium fertilizers
  - removal of nutrients in harvests and by animals (milk & meat)
  - tillage (oxidation of organic matter)
  - industrial pollution
  - forestry

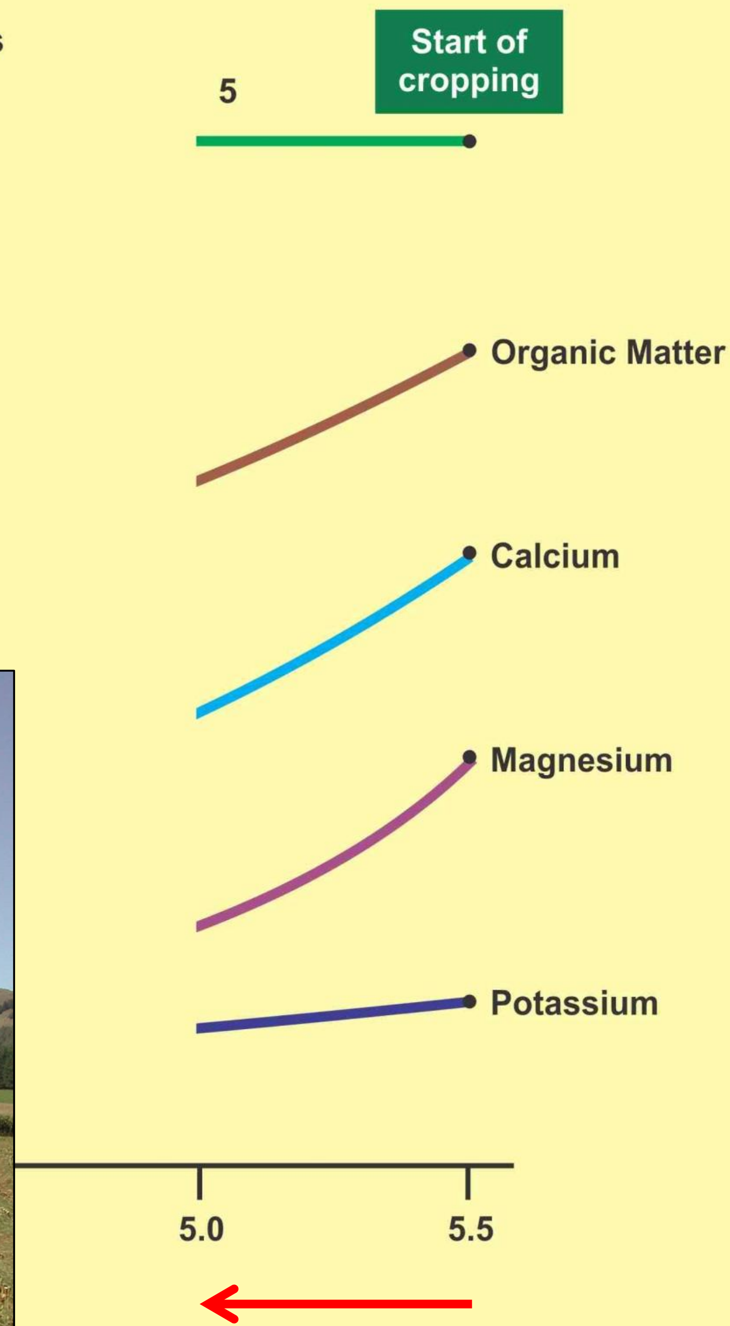
Most plants can grow at very low pH in nutrient solution culture!

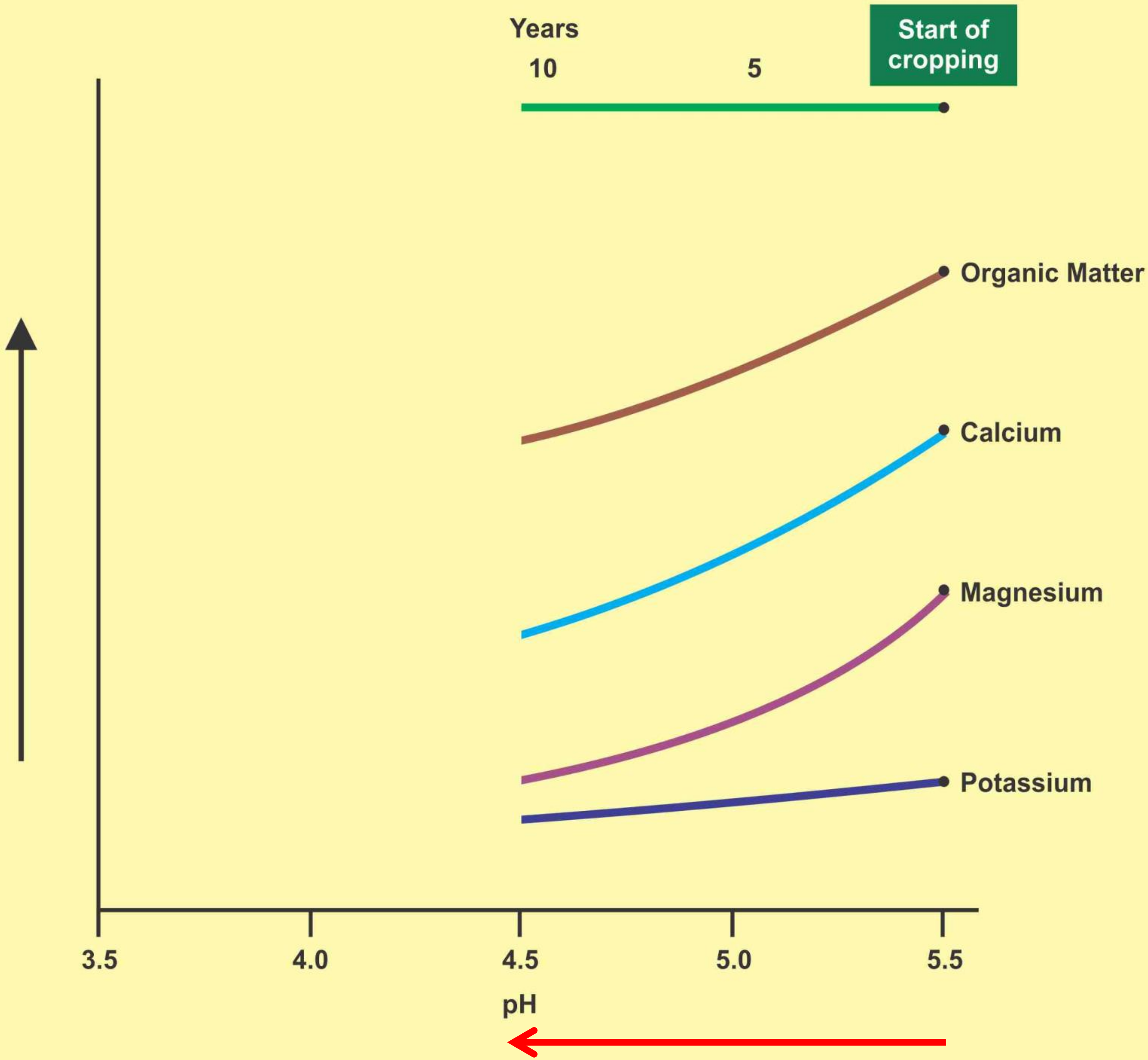
…so what <u>exactly</u> is the problem ?

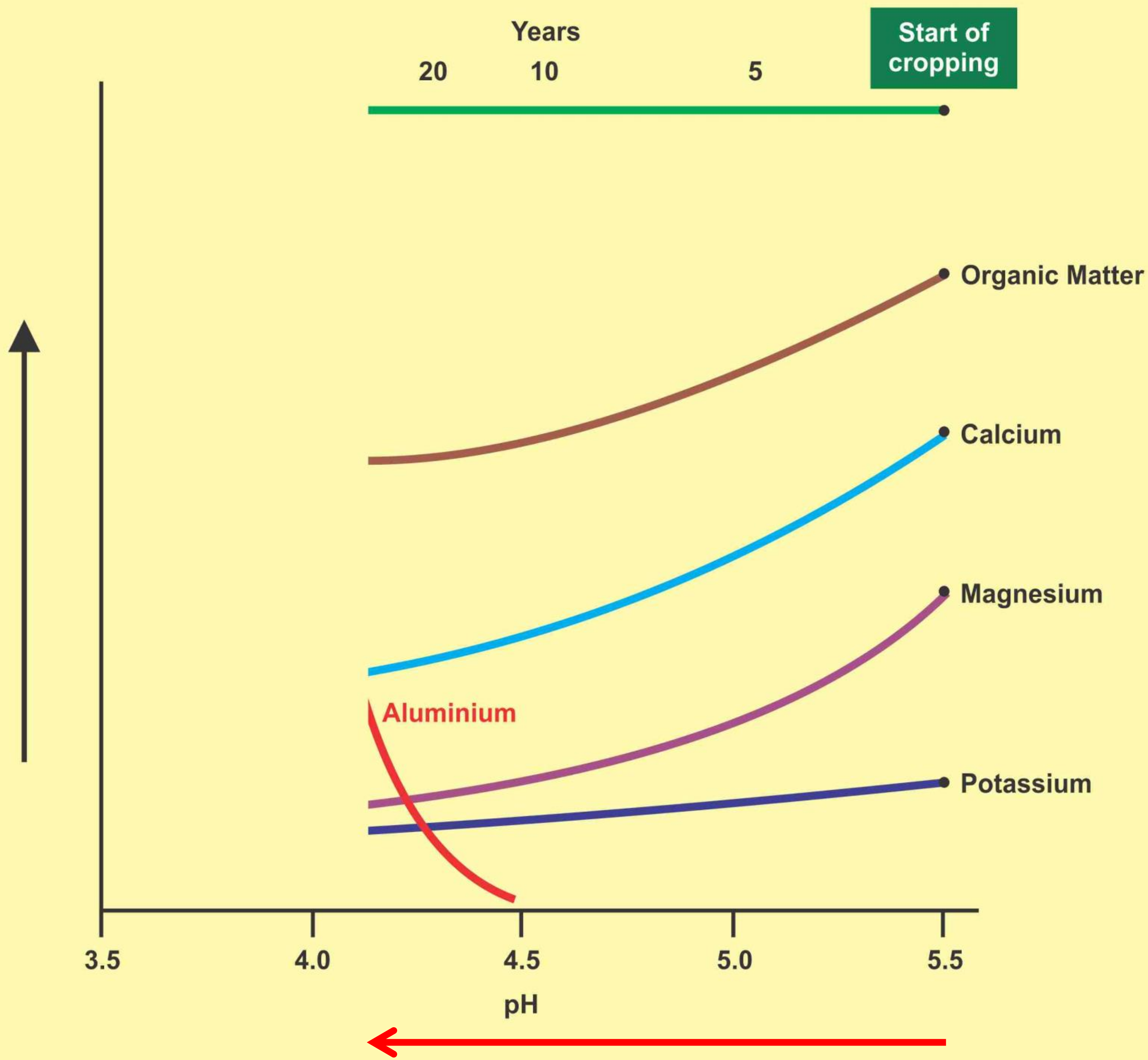
Start of cropping
Organic Matter
Calcium
Magnesium
Potassium
3.5
4.0
4.5
5.0
5.5
pH

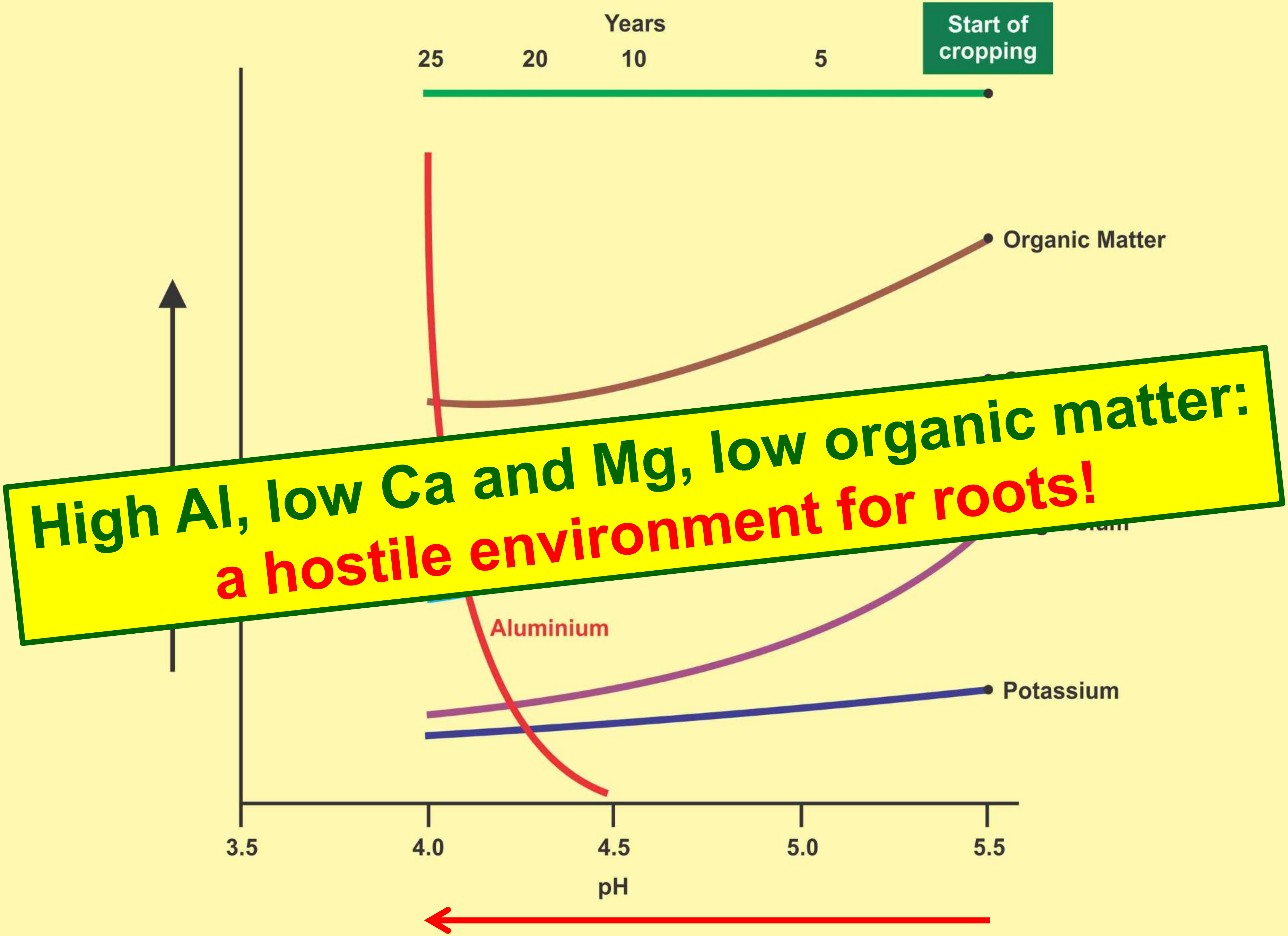

KAN28
Kalksteenammoniumnitraat
28%N
50 kg
UREA
UREUM /UREA
STORE INSIDE


Years
Start of cropping
5
Organic Matter
Calcium
Magnesium
Potassium
5.0
5.5



Years
10
5
Start of cropping
Organic Matter
Calcium
Magnesium
Potassium
3.5
4.0
4.5
5.0
5.5
pH


Years
20
10
5
Start of cropping
Organic Matter
Calcium
Magnesium
Aluminium
Potassium
3.5
4.0
4.5
5.0
5.5
pH


Years
25
20
10
5
Start of cropping
Organic Matter
Aluminium
Potassium
3.5
4.0
4.5
5.0
5.5
pH
High Al, low Ca and Mg, low organic matter:
a hostile environment for roots!

Aluminium as the primary factor in soil acidity effects on plant growth….

- First reported in **1918** (Hartwell and Pember, 1918. *Soil Science*)
- But…Beckman’s breakthrough (1934) with pH electrode technology detracted from further Al research!
- Role of Al ‘rediscovered’ by Reeve & Sumner (South Africa) and Kamprath (USA) in the 1970’s.
- Superiority of Al saturation as an index of soil acidity highlighted in field trials of Farina (1970 – 1990).
- Brazilian work from 1970’s to date – similar findings.
- Australian research on wheat confirmed that Al superior to pH as a predicative index.

Diagnostic criteria using soil tests

Ratio of exchangeable Al to total cations (a convenient *'proxy' for Al activity*) most reliable predictor

$$\text{Acid Sat \%} = \frac{Al+H}{Ca + Mg + K + Al+H} \times 100$$

What about <u>manganese</u> toxicity?

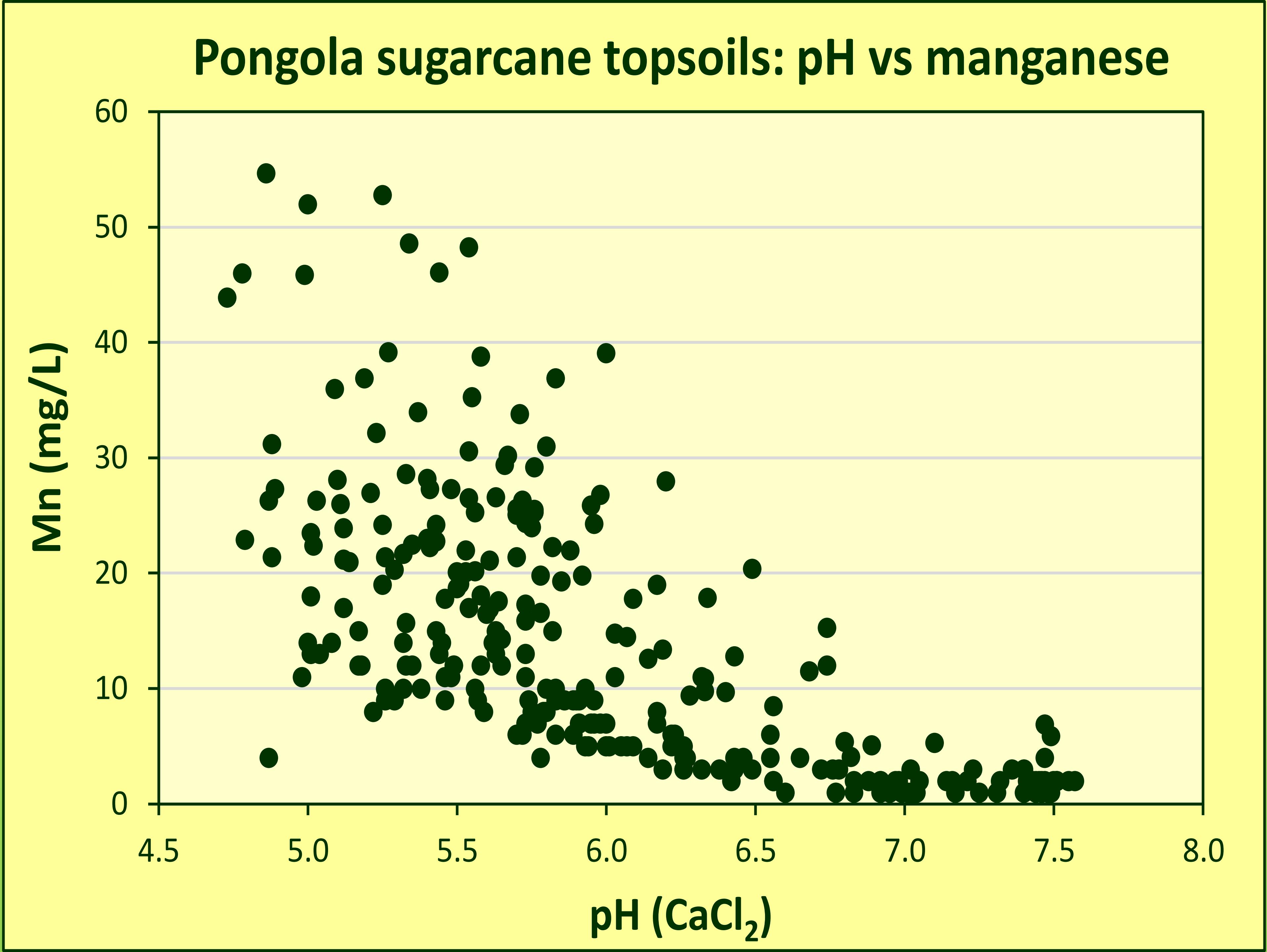
A frequent problem <u>in soils that are not inherently acidic</u> following acidification by agricultural practices!

Manganese Toxicity

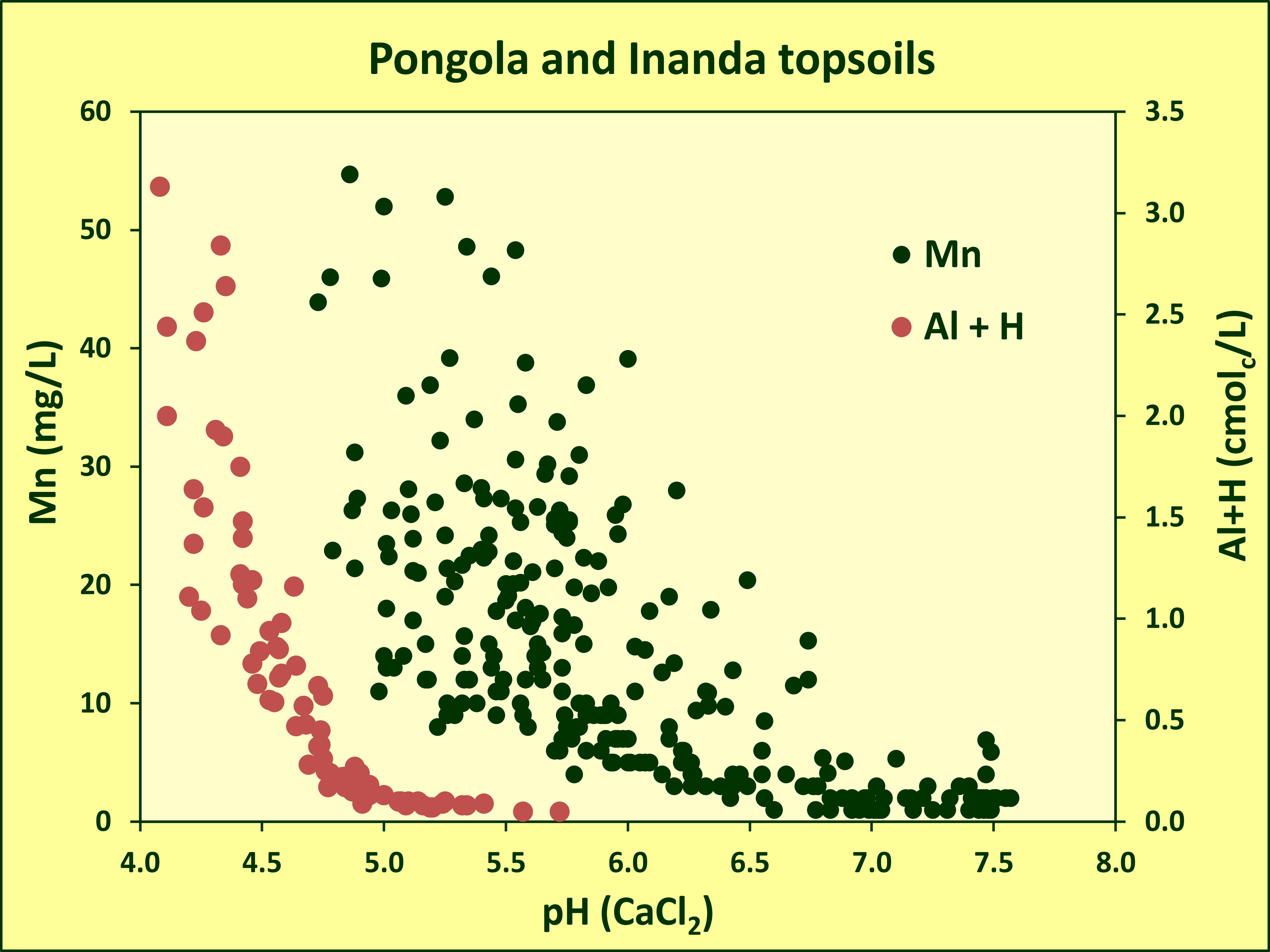
- Less widespread than Al toxicity.
- May occur at higher pH's than Al toxicity.
- Usually not a problem on highly weathered, naturally acidic soils (Mn leached out!)

Dr Mart Farina

Mn toxicity - most severe under reducing conditions created by water-logging and compaction



Pongola sugarcane topsoils: pH vs manganese
Mn (mg/L)
0
10
20
30
40
50
60
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
pH ($CaCl_2$)


Pongola and Inanda topsoils
Mn (mg/L)
60
50
40
30
20
10
0
Al+H (cmolc/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Mn
Al + H
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
pH (CaCl2)

2. Effects of acidity factors on plant growth

highly sensitive

moderately sensitive

moderately tolerant

highly tolerant

Pastures

lucerne / white clover

perennial ryegrass

red clover, barley

Italian ryegrass

cocksfoot

tall fescue

Digitaria eriantha, oats

kikuyu

Eragrostis curvula

Crops

sunflower

dry bean, cotton

sorghum

maize, lupin

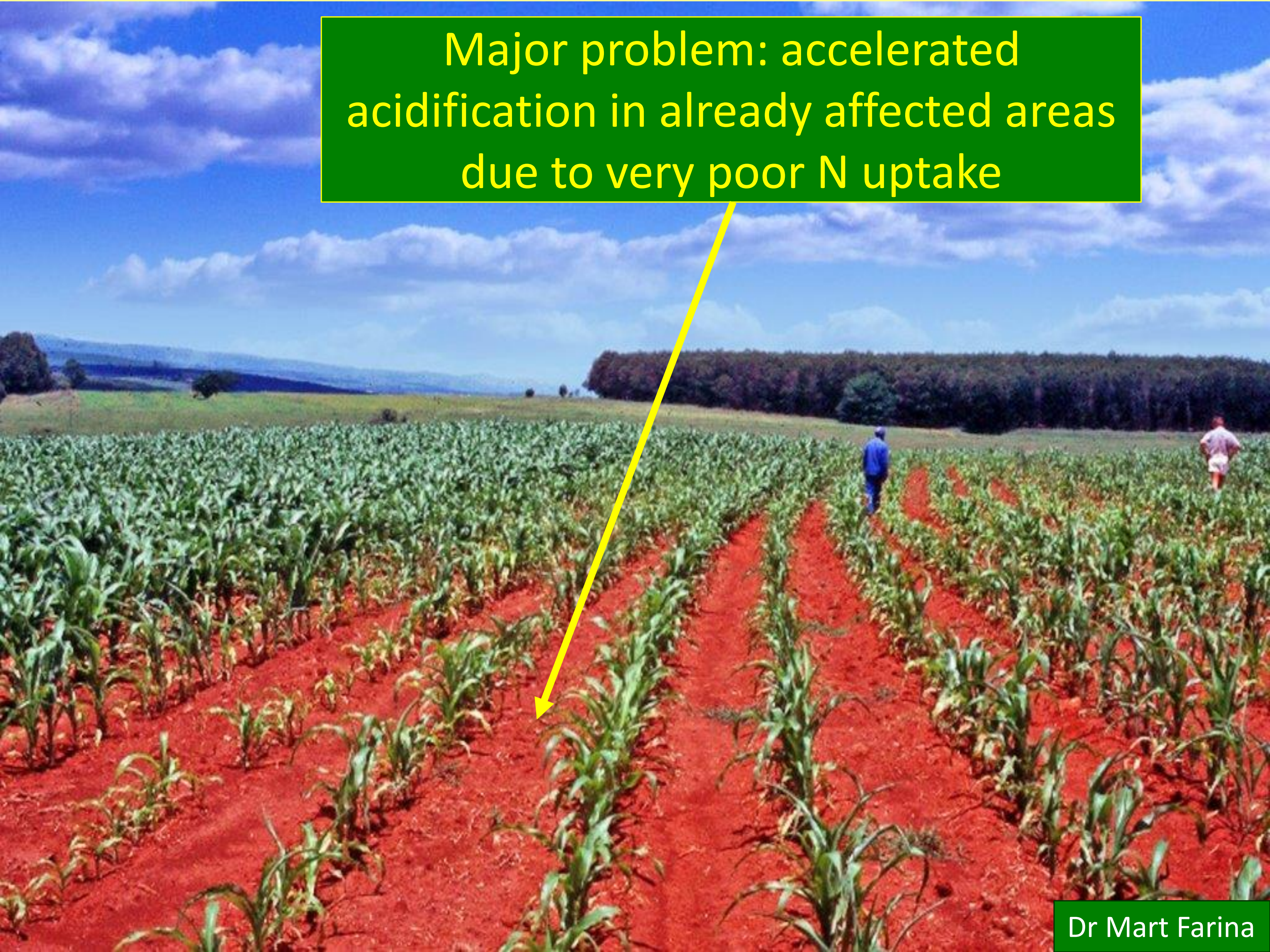
soyabean

potato

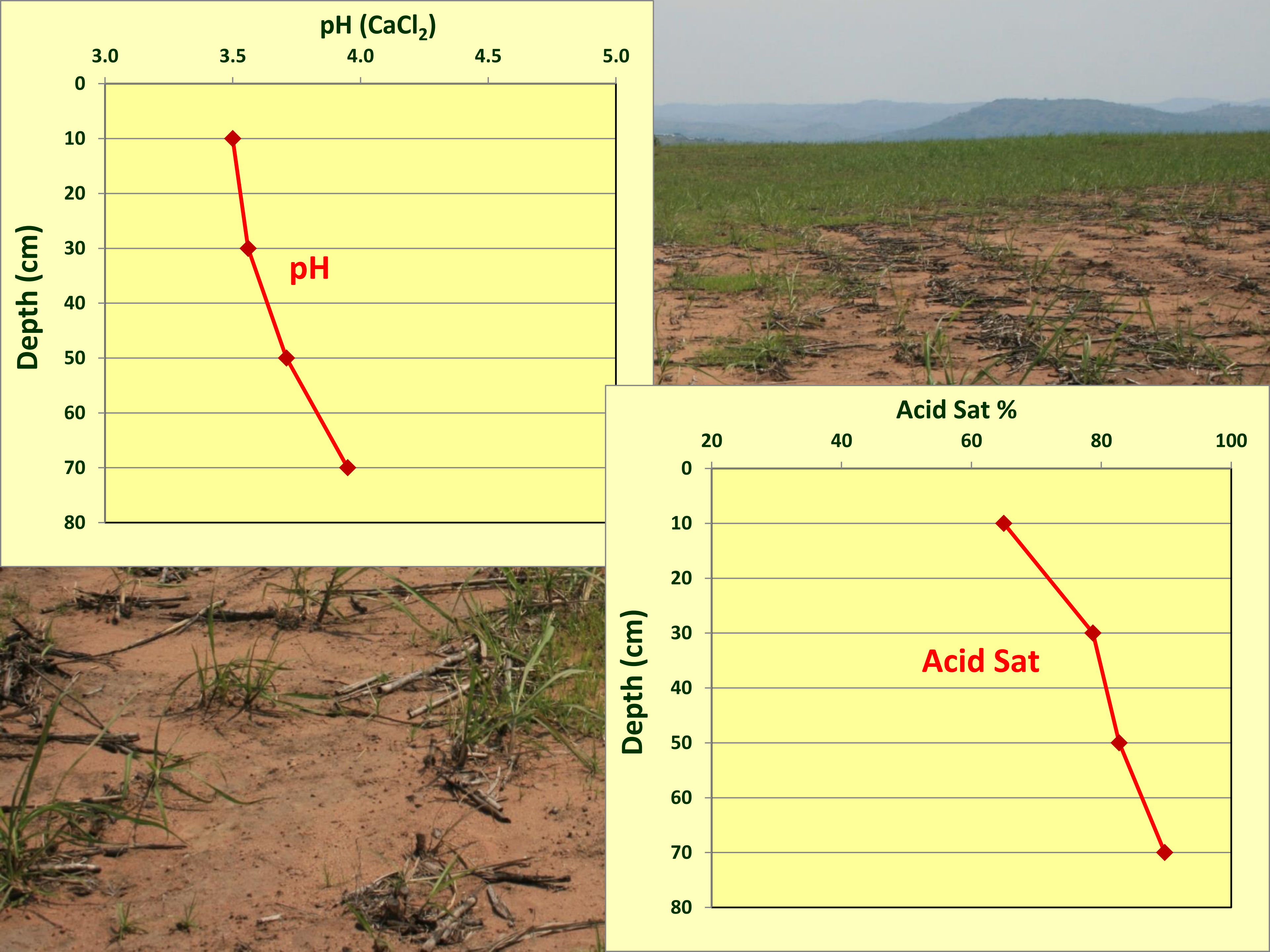
sweet potato

cow pea

sugar cane


Major problem: accelerated acidification in already affected areas due to very poor N uptake
Dr Mart Farina


Mart Farina



pH ($CaCl_2$)
3.0
3.5
4.0
4.5
5.0
0
10
20
30
40
50
60
70
80
Depth (cm)
pH
Acid Sat %
20
40
60
80
100
0
10
20
30
40
50
60
70
80
Depth (cm)
Acid Sat

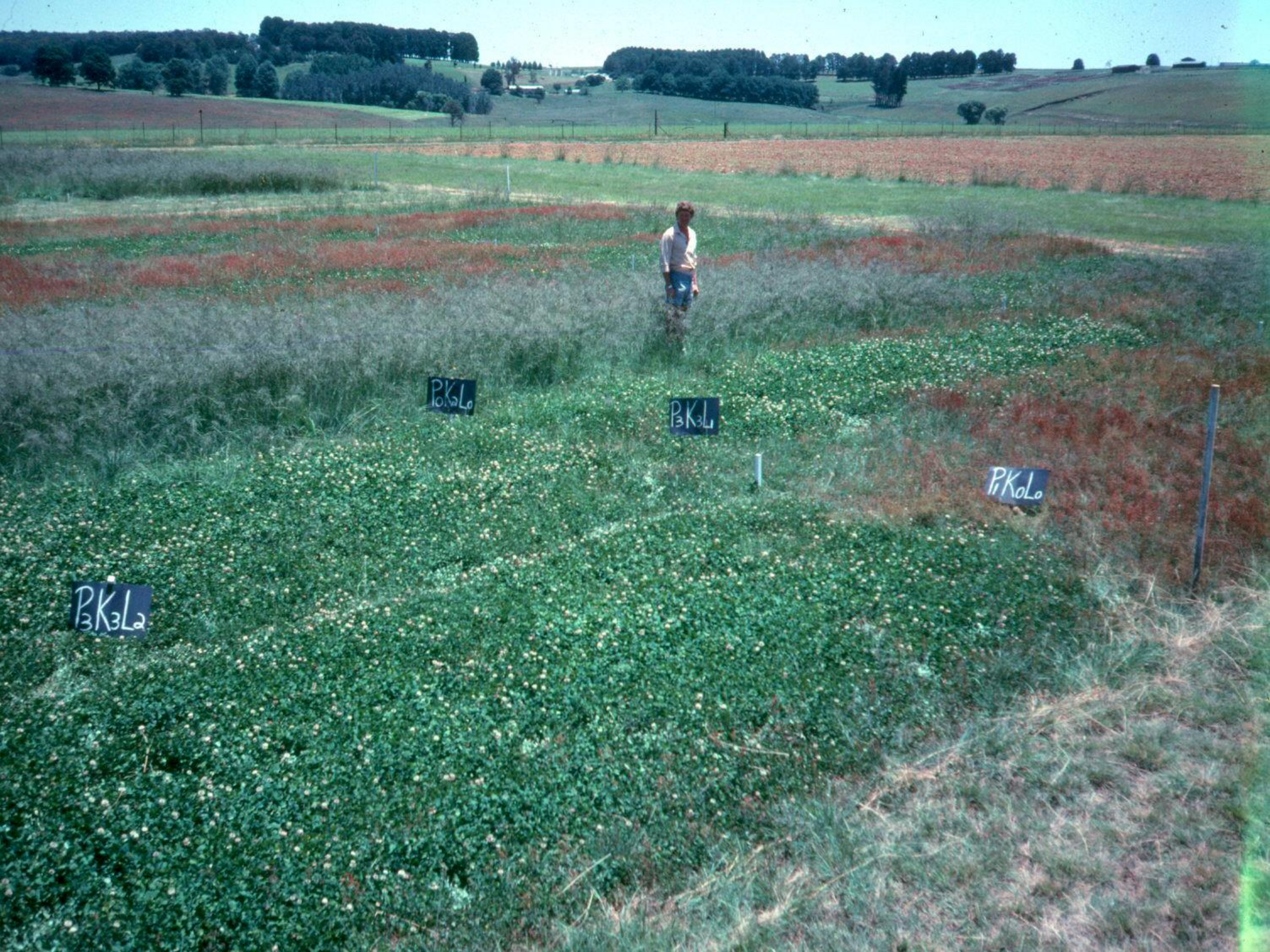
No lime

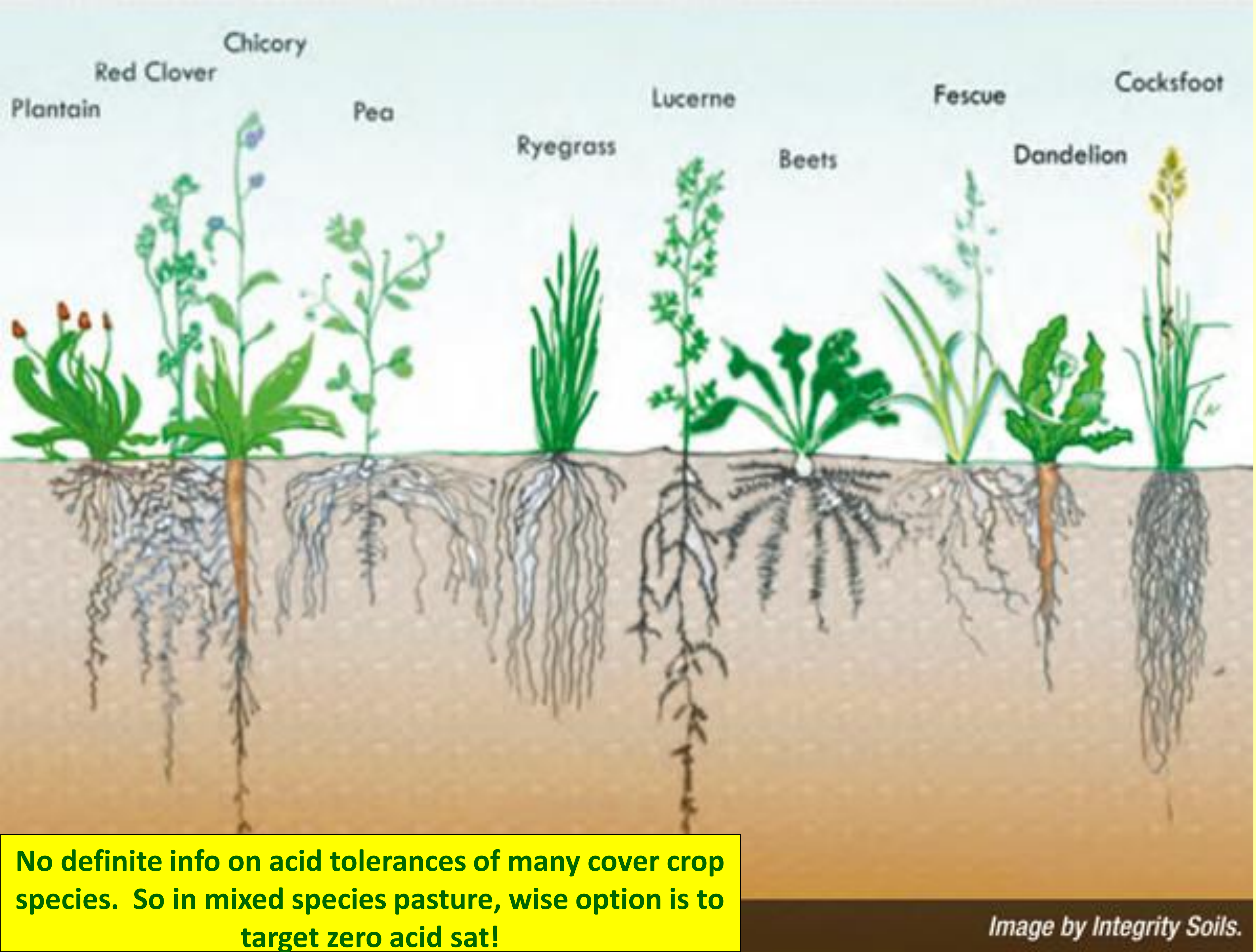
6 t/ha lime


Clover S.A

P3K3L2
P0K2L0

$P_2K_3L_3$
$P_3K_3L_2$
$P_0K_2L_0$
$P_0K_1L_0$
$P_1K_0L_0$
$P_3K_3L_1$


P0K2L0
P3K3L1
P1K0L0
P3K3L2



No definite info on acid tolerances of many cover crop species. So in mixed species pasture, wise option is to target zero acid sat!


Acid sat
= 30%
Acid sat
= 46%
Gavin Moore

Tentative ranking of tolerances to excess

Manganese

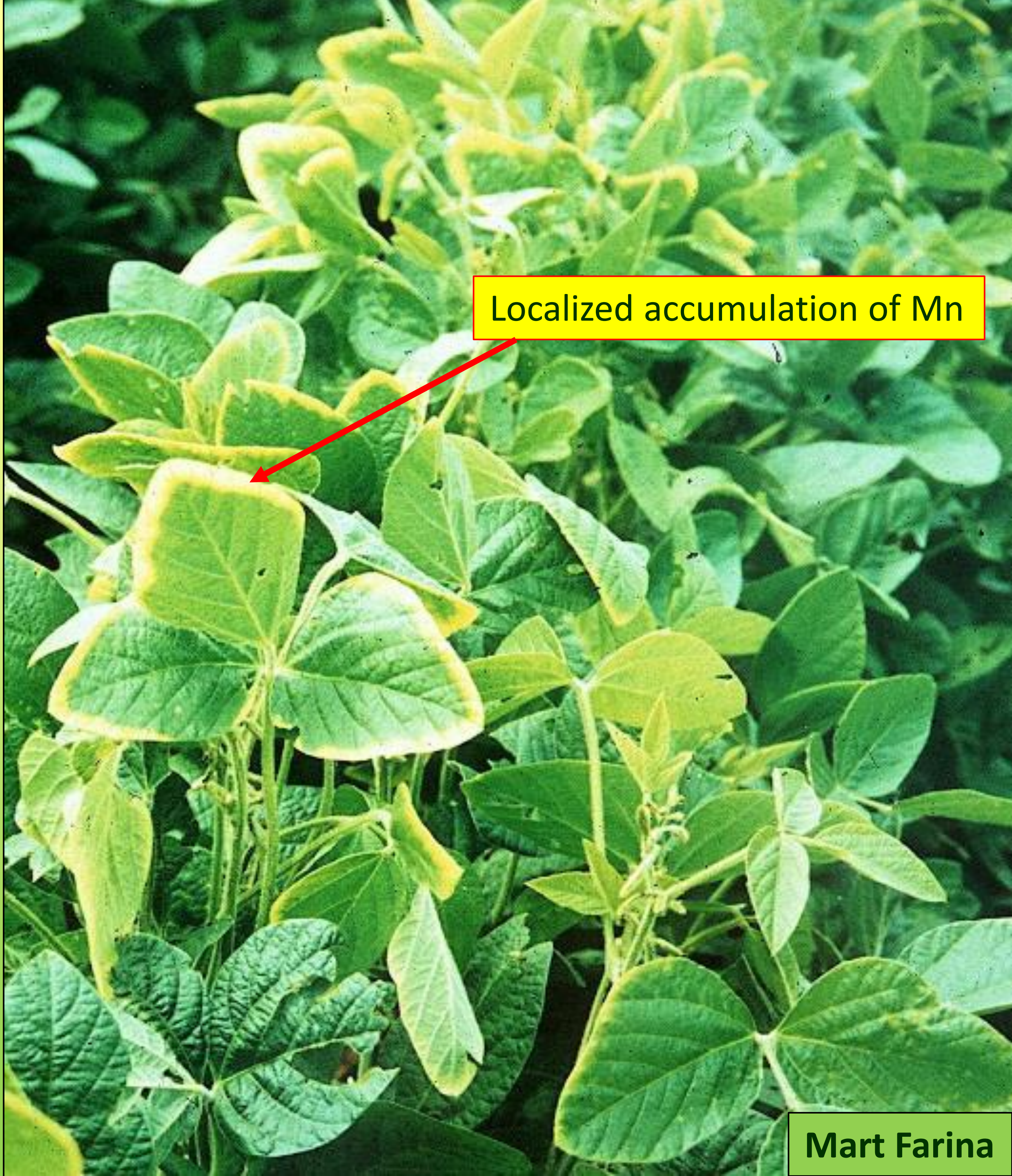
(based on literature reports)

Note: large cultivar differences occur

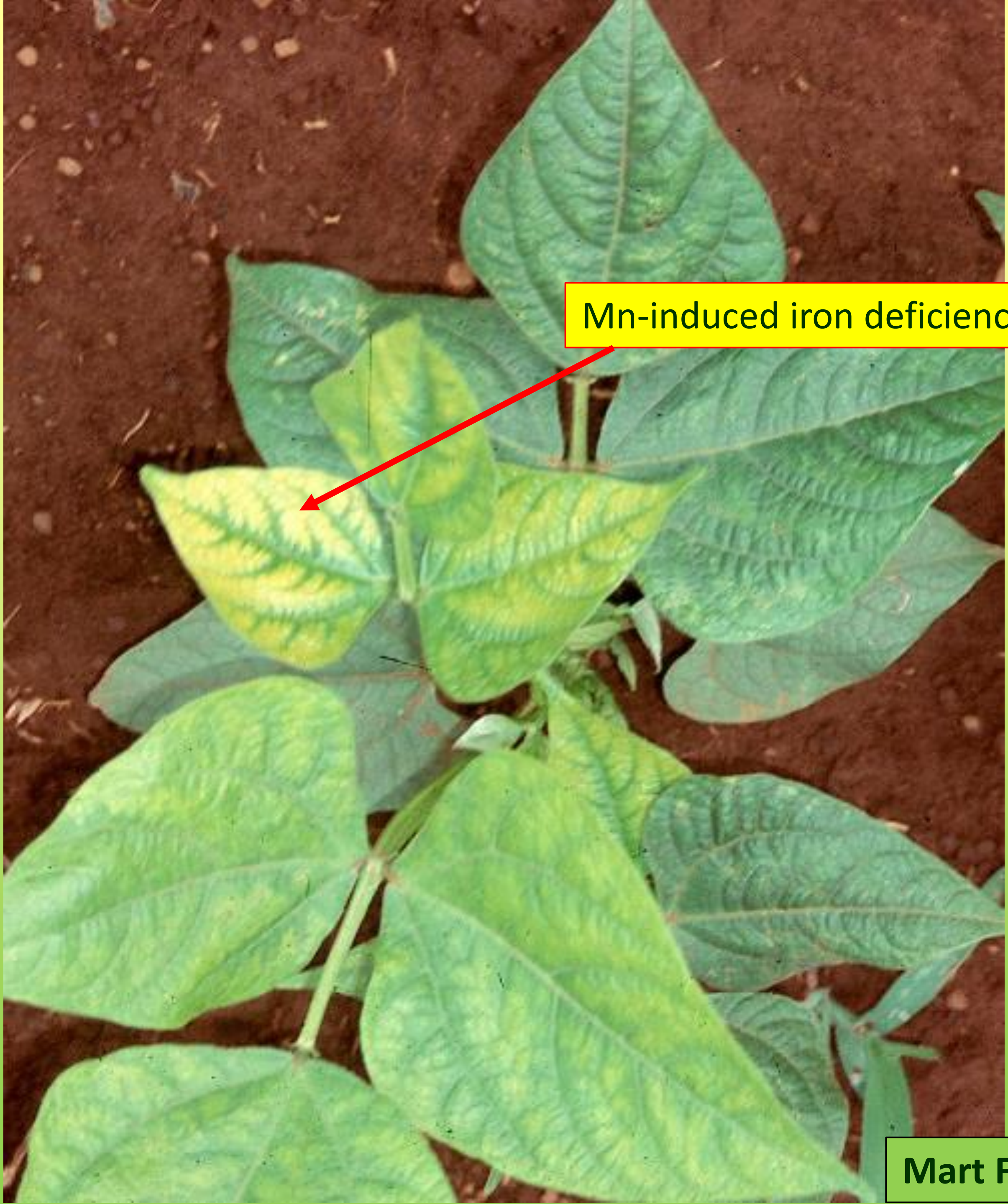
Highly sensitive	lucerne, cabbage, tobacco, potato, pineapple, beans
	soyabean, peanuts wheat
Moderately sensitive	barley maize
	cotton
Moderately tolerant	sweet potato
	sunflower
Highly tolerant	carrot, white lupin


Mart Farina

Manganese Toxicity



Manganese Toxicity



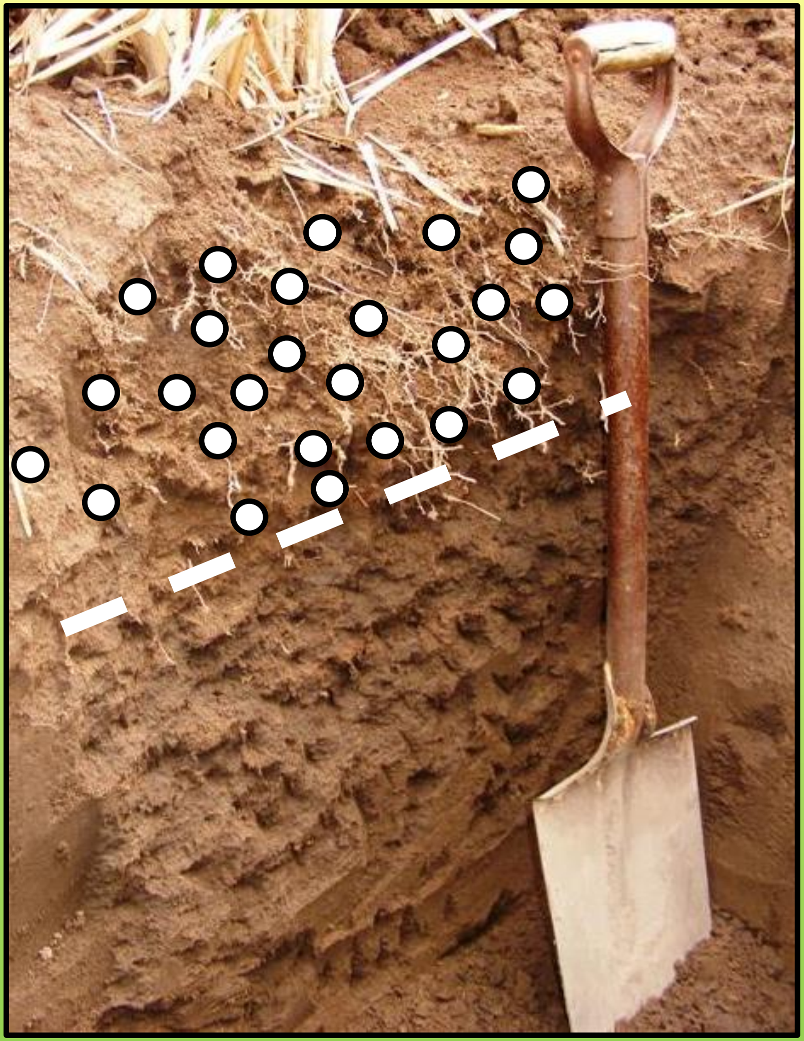
Mart Farina

3. Correction of soil acidity problems

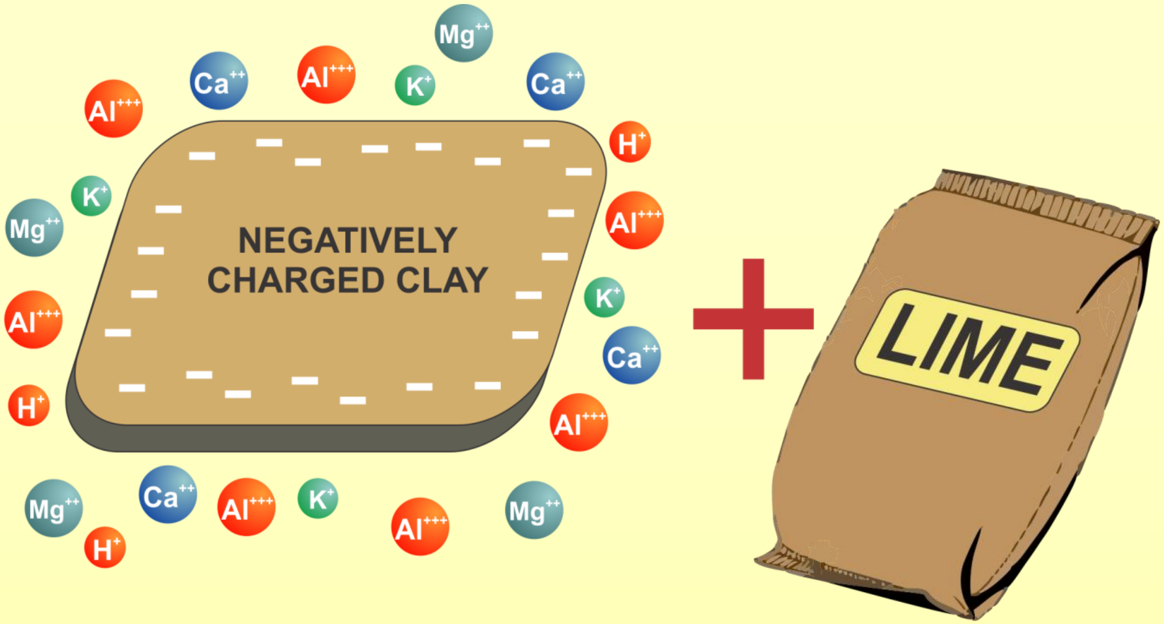
1. Roles of lime and gypsum
2. 'Alternative and new' products

(Calcitic or Dolomitic)

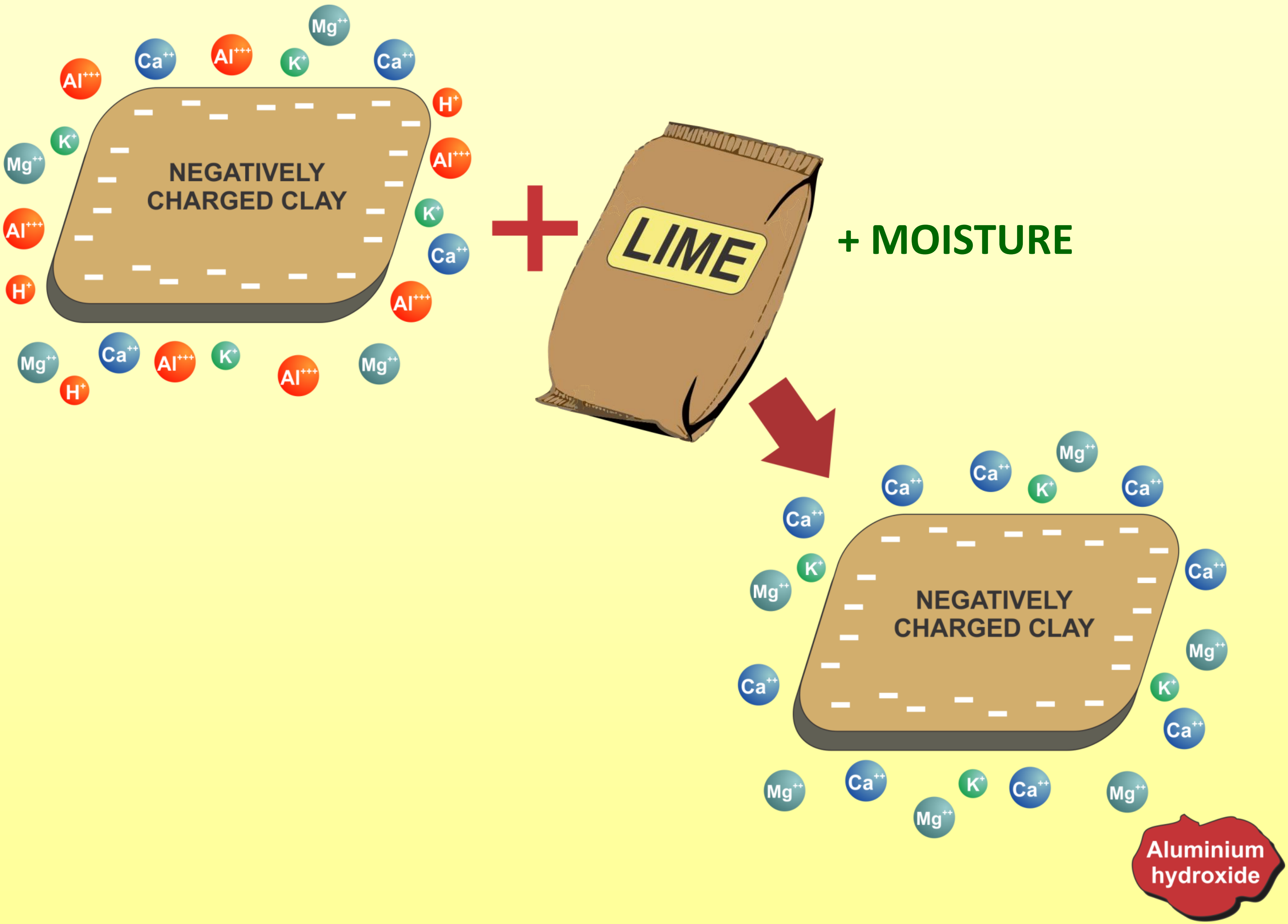
LIME

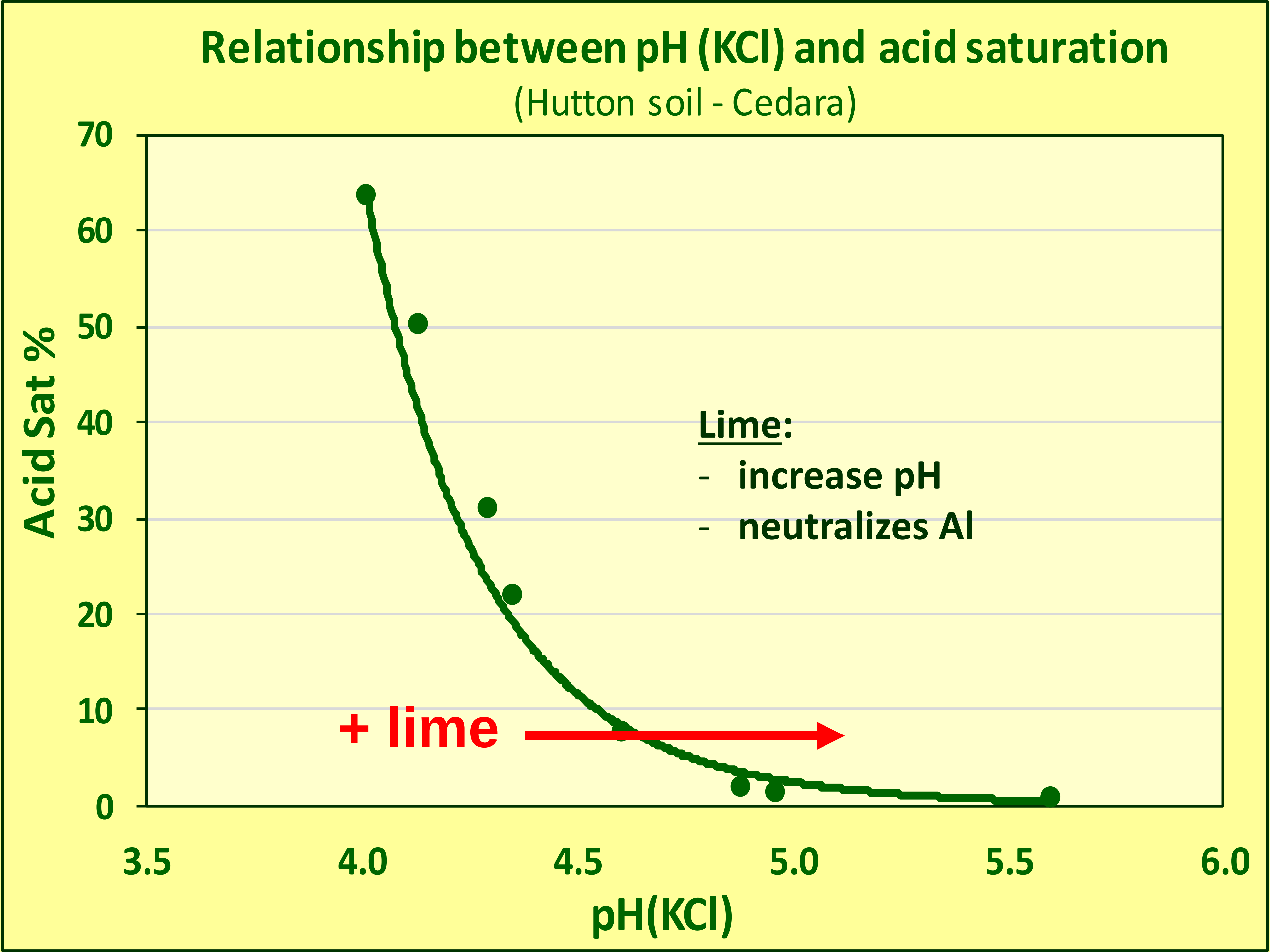


GYPSUM

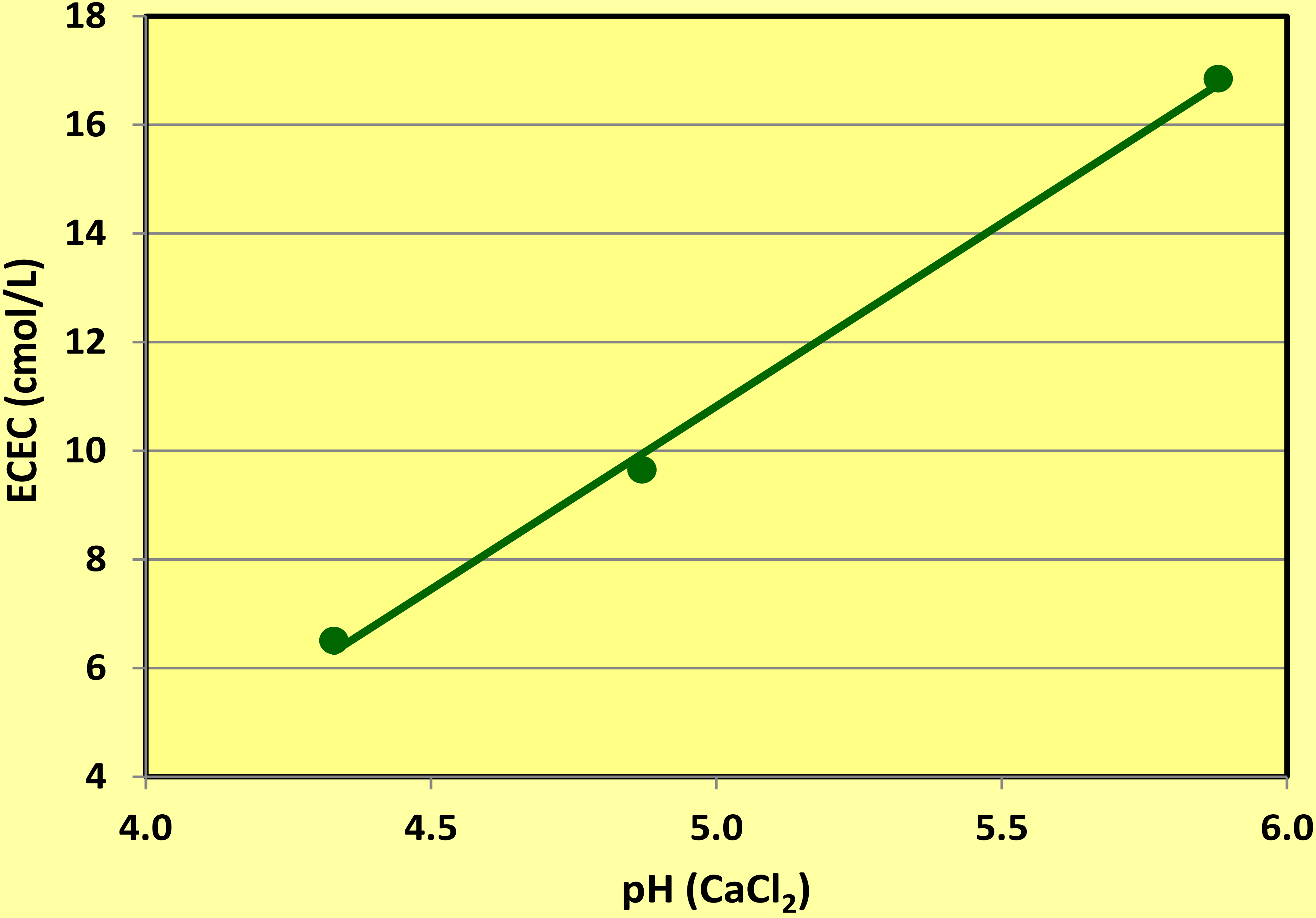


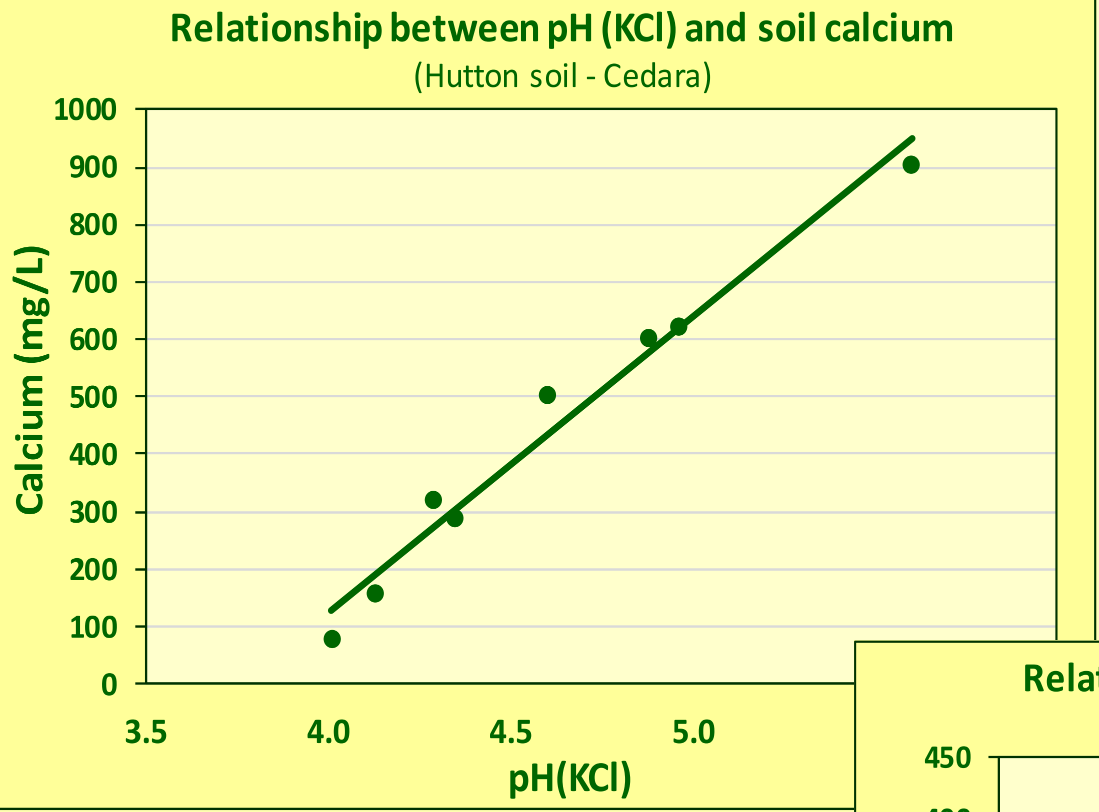
+ MOISTURE

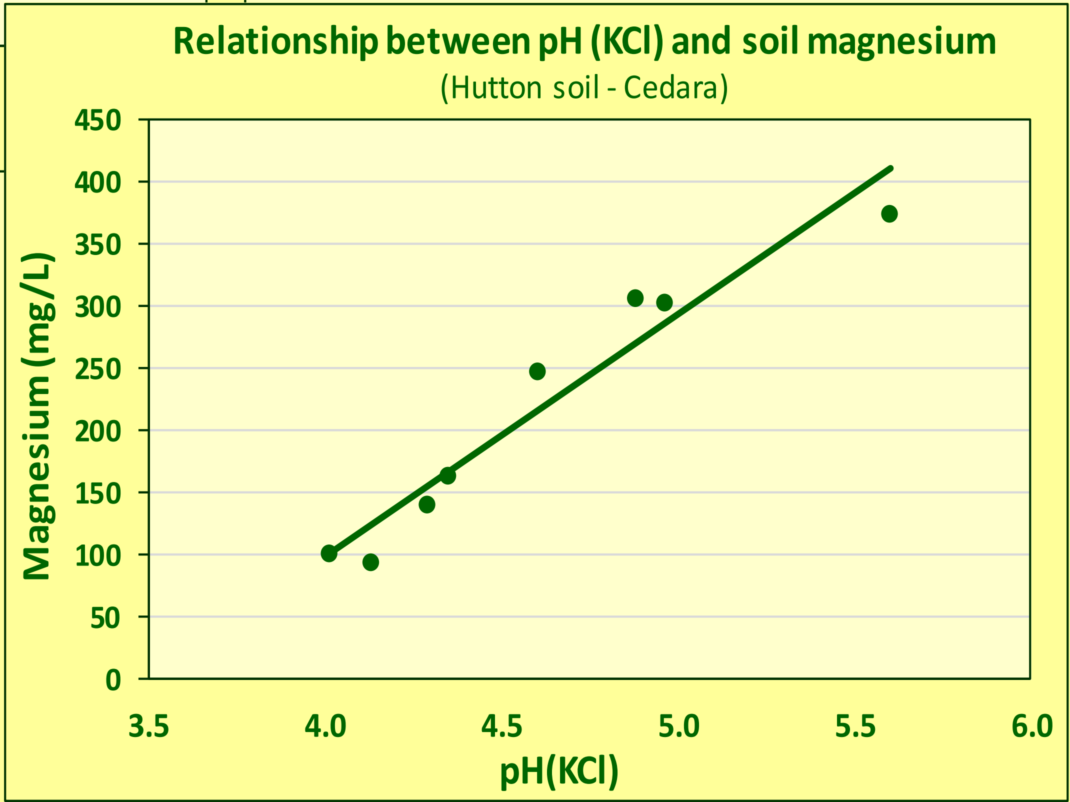

NEGATIVELY CHARGED CLAY
LIME
+ MOISTURE
NEGATIVELY CHARGED CLAY
Aluminium hydroxide


Relationship between pH (KCl) and acid saturation
(Hutton soil - Cedara)
Acid Sat %
70
60
50
40
30
20
10
0
3.5
4.0
4.5
5.0
5.5
6.0
pH(KCl)
Lime:
- increase pH
- neutralizes Al
+ lime

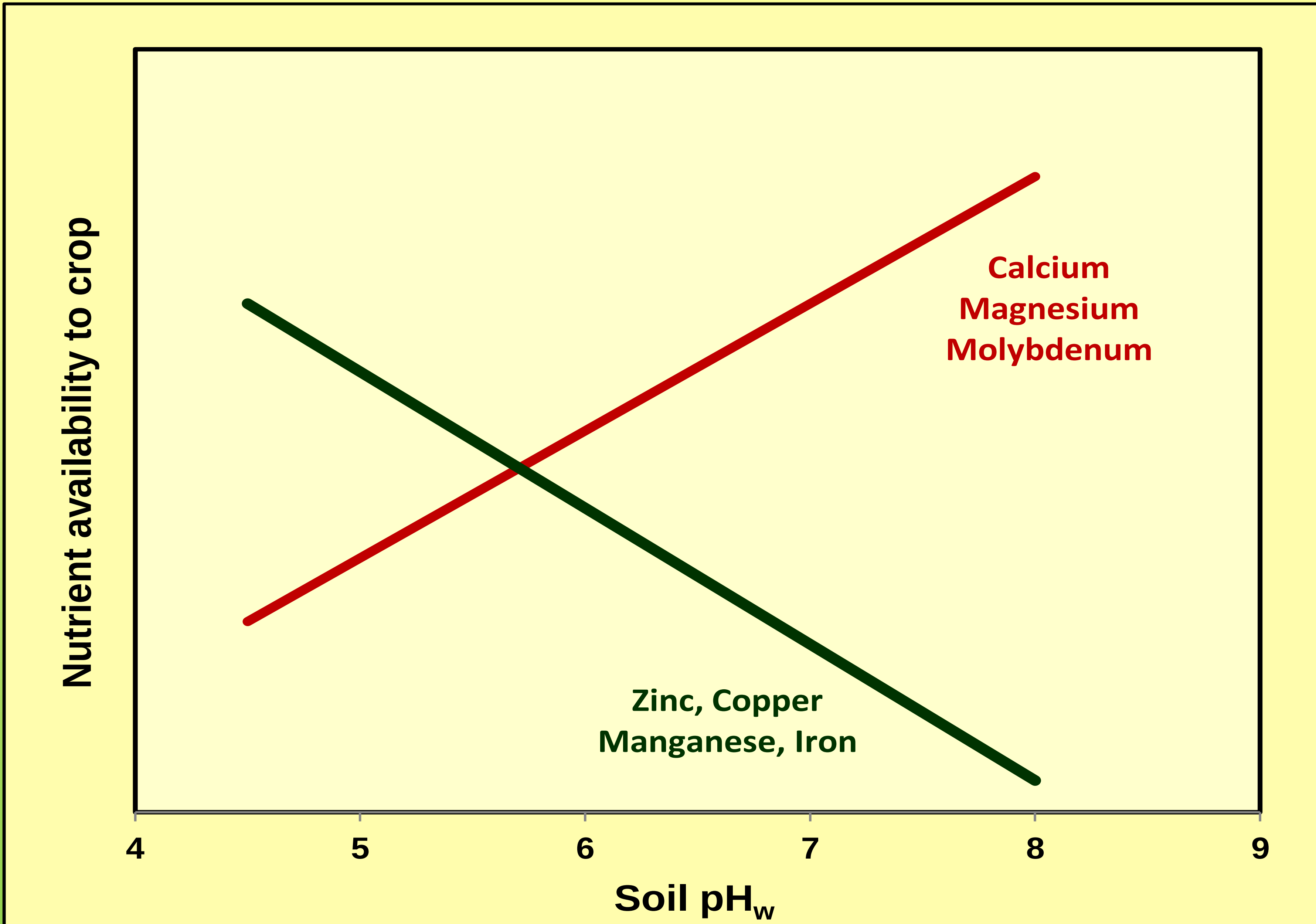
Variation in ECEC with pH in a Griffin soil (60% clay)




Relationship between pH (KCl) and soil calcium
(Hutton soil - Cedara)
Calcium (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
3.5
4.0
4.5
5.0
pH(KCl)

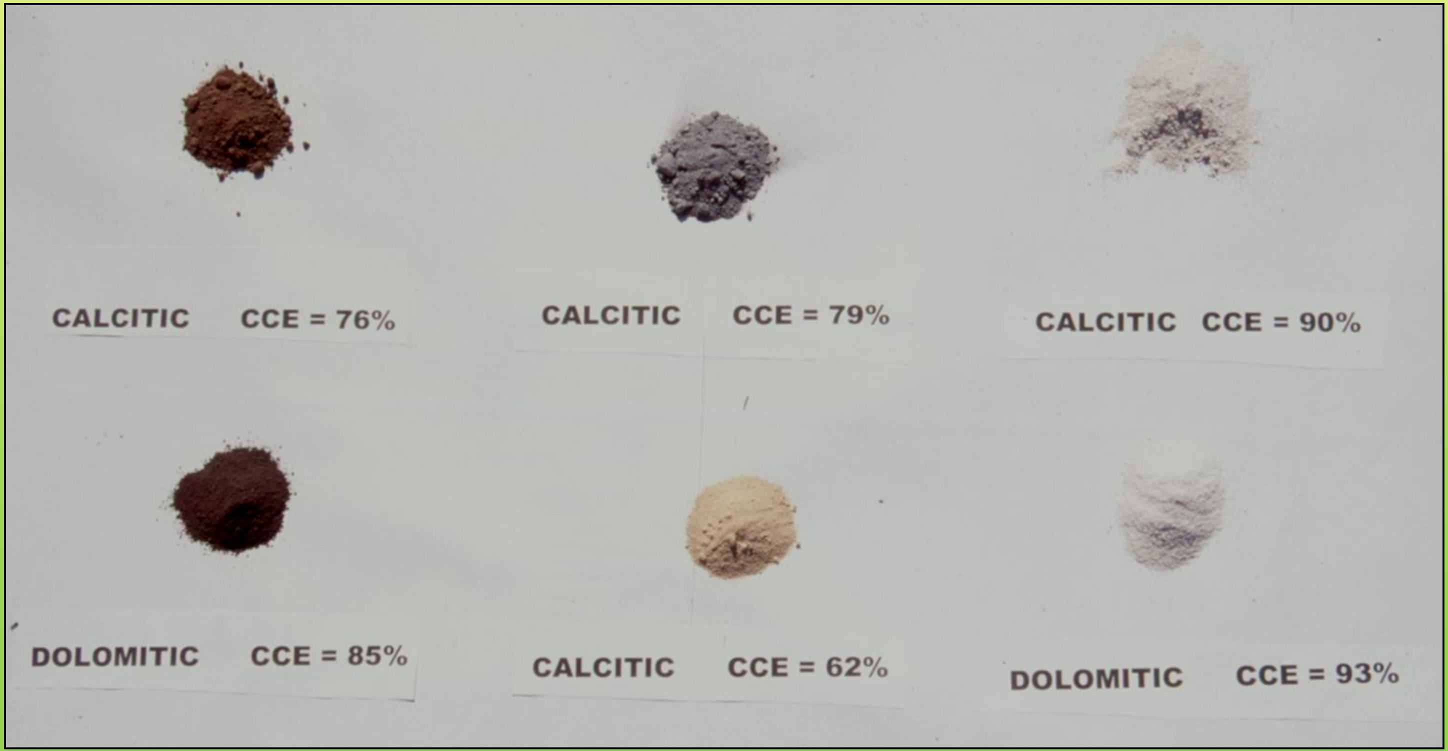

Relationship between pH (KCl) and soil magnesium
(Hutton soil - Cedara)
Magnesium (mg/L)
450
400
350
300
250
200
150
100
50
0
3.5
4.0
4.5
5.0
5.5
6.0
pH(KCl)

Nutrient availability and soil pH

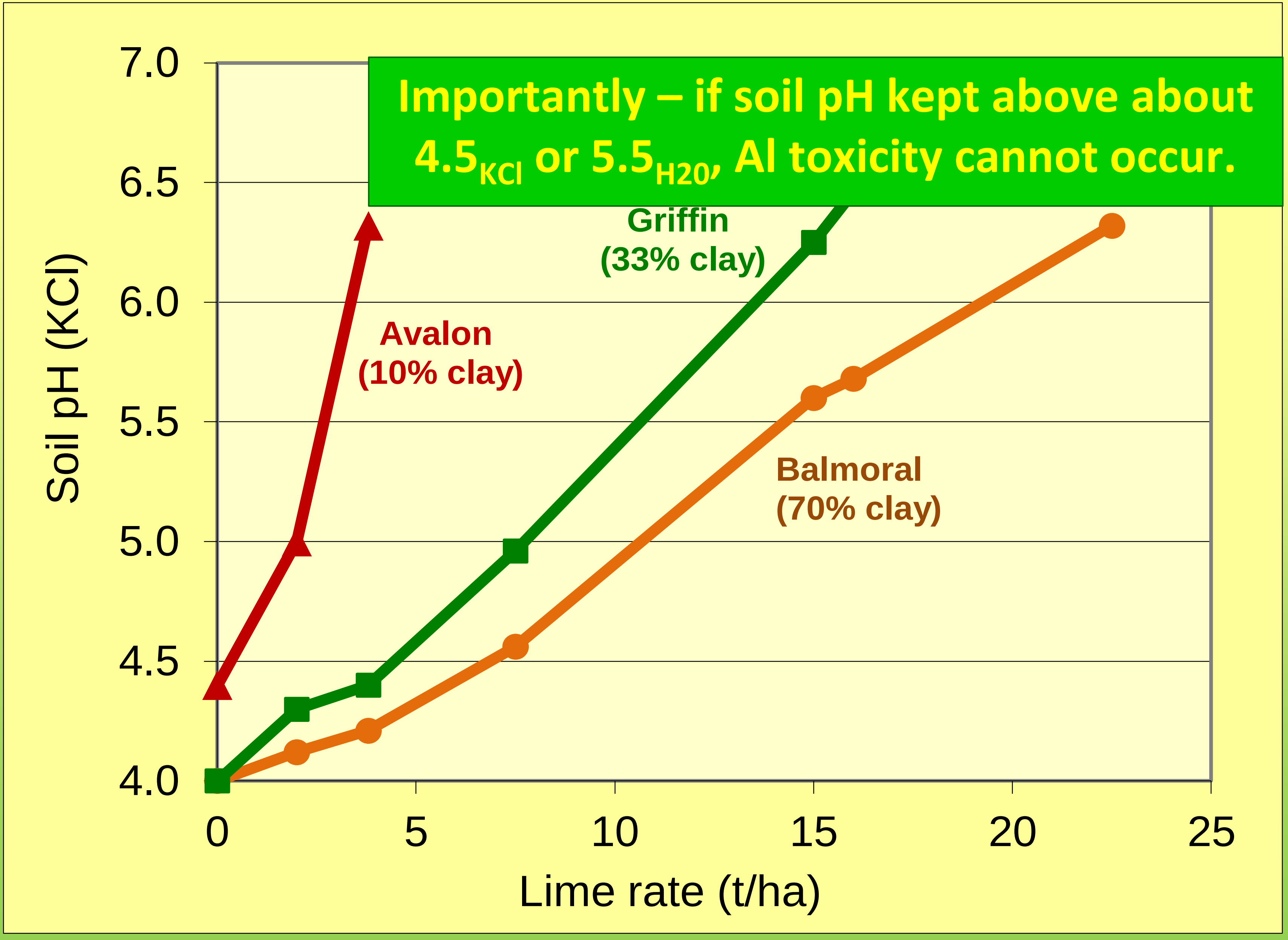


Important lime requirement considerations

- Lime quality (physical and chemical)
- Soil buffering (clay and organic matter contents)
- Depth of incorporation
- Crop species requirement



Variable soil response to liming (buffering capacity effects)



Economics of soil acidity correction

R3 500

Significant increases in sugarcane yields in Australia were still being recorded **18 years** after a single application of **5 t/ha of lime**, which resulted in approximately **366 t of additional cane** relative to the unlimed treatment over the 18 year period!

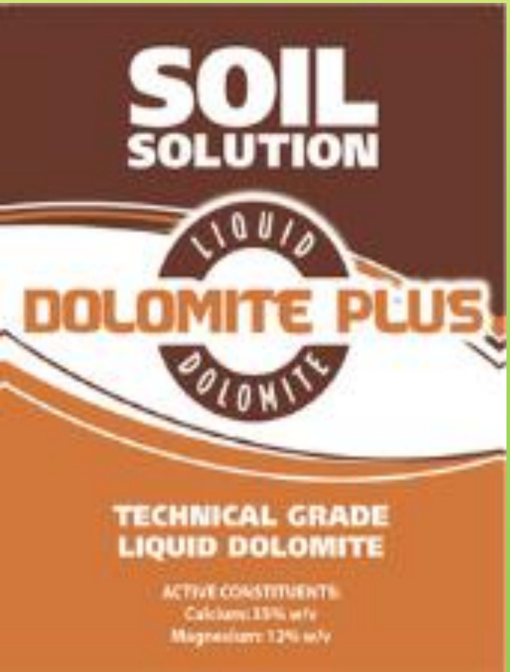
(Noble and Hurney, 2000)

R146 400

= R4083% return
(227% /yr)

'Enhanced efficiency' liming and gypsum products

- Granular
- Liquid
- Microfine



Micro-fine liquid and pelletized (granular) limes

Liquid Lime

One gallon of liquid lime = 1340 pounds of ag lime. Liquid Lime is a super high concentration of limestone that is easy to use.

<u>Frequent claims</u>

- Faster reaction ✓
- Application advantages ✓
- Mobile through the soil profile x
- Vastly lower rates have the same effect as tons of conventional lime on pH etc x
- Ca highly available relative to conventional limes x

Evidence is that lime granules remain intact in the soil for very long periods after application.

Pelletized / granular lime research reports….

Reference	Conclusions
Lollato et al., 2013 Soil Sci Soc Amer J.	• pellets intact more than 220 d after application • failed to significantly increase soil pH • failed to decrease soil Al
Murdock, 1997. Univ of Kentucky	Pelletized lime reacts no faster than conventional lime.
Damon et al.,2018. Australia	Pelletized lime: no effect on pH and Al
Dreyer, unpublished report, NW University, SA	• granular not as effective at increasing soil pH as conventional lime. • granular not mobile. • granules undissolved after 3.5 months in moist acid soil.

<u>Worrying</u>: the naïve (dishonest?) marketing approaches frequently used…

1. <u>Dairy farmer, KZN</u>: use granular lime at ¼ rate as substitute for conventional lime!

2. <u>Maize/soya farmer in Mpumalanga</u>: limed to zero acid sat, spent R200000 on granular lime 'to supply Ca'.

3. <u>Sugarcane farmer in Komati</u>: soil Ca levels of 4000 ppm, supplying liquid lime through drippers 'to correct Ca deficiency…' (Clogged drippers..!!!)

Concluding thoughts

Soil Acidity …..serious or not?

- Serious? Yes, impact on yields can range from moderate to devastating

BUT

- Cause: well known and understood
- Diagnosis: easy and reliable (soil tests)
- Correction: highly effective correction with mostly natural and benign products
- Economics of correction: gene favourable

So let's get on with sorting it out!!!