Evaluating the Effectiveness of Fertiliser & Lime Products and Services

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“The only antidote to pseudo-science is science itself”.

Carl Sagan

Background

- Pseudo-science[1] is a feature of today's PC society – esp. soil fertility/fertiliser industry
- Scientists need to develop the skills, processes, procedures and questions to combat its ongoing development.

[1] Pseudo-science is false science: it uses the language of science to gain credibility but its claims are not based on evidence.

Pseudo = not genuine, sham, spurious

Questions

The key questions:

- Can the product or service work?
  - what is the active ingredient?
  - what is the claimed mode/mechanism of action?
  - 1st principles/basic chemistry
- Does the product or service work?
  - empirical (field/glasshouse) evidence

Case Study 1: Liquid fertilizers

- Typically applied at low rates (20 l/ha)
- Contain nutrients/plant growth regulators/organic matter
- Many claims made for them

NZ examples: Maxicrop, Seasol, Nitrosol, AgriSea

Example: Maxicrop

Can it work? Mode of action?

- Source of nutrients?
  - Need to apply 1,000 to 10,000 x label rate!
- Source of Organic Matter?
  - 500 gm OM /ha
  - Soils contain 50-100 tonnes OM/ha!
- Source of PGR (cytokinin)?
  - Need to apply 95,000 l/ha!

Based on claimed mode of action it *cannot* work

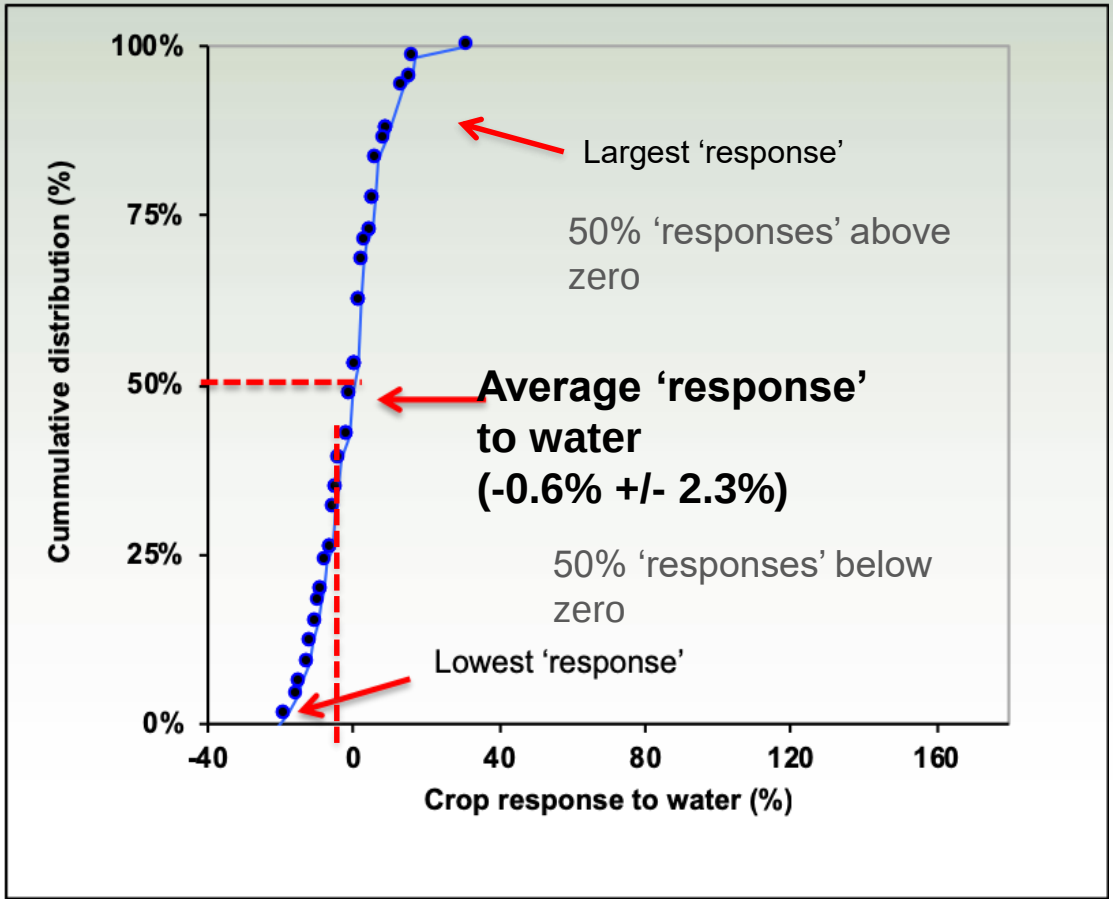
Question then becomes....

- Does it work?
  - What does the empirical field evidence show?
- Field trial results problematic
  - Measuring the effects of products against a background ‘noise’
  - Typical variation CV = 10%
  - Type I and II errors

Background noise: looks like..?

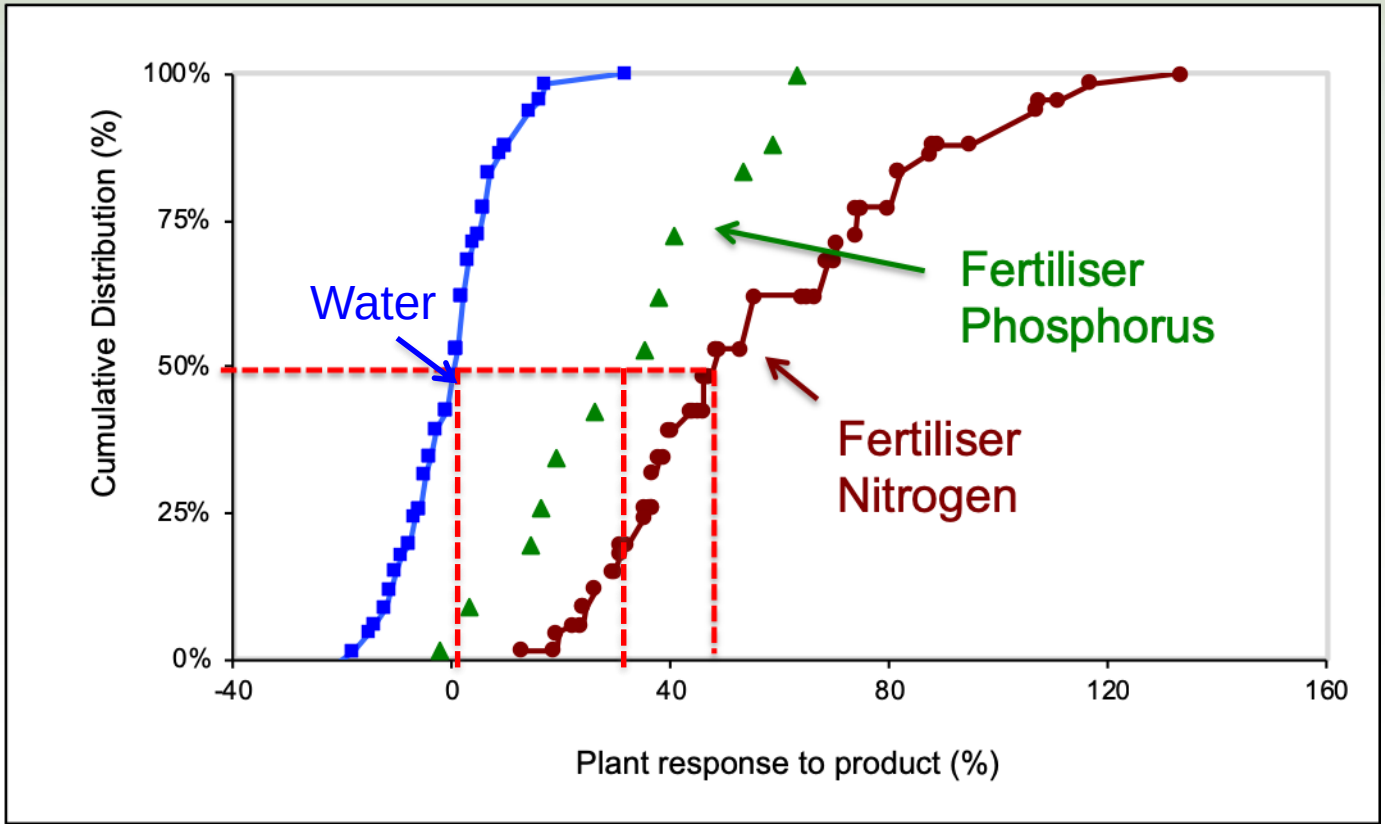
- UK scientist measured: control v water (225 l/ha) on crop production.
- This amount of water will have no agronomic effect on crop growth.
- There were 66 trial-years of data covering a range of crops.

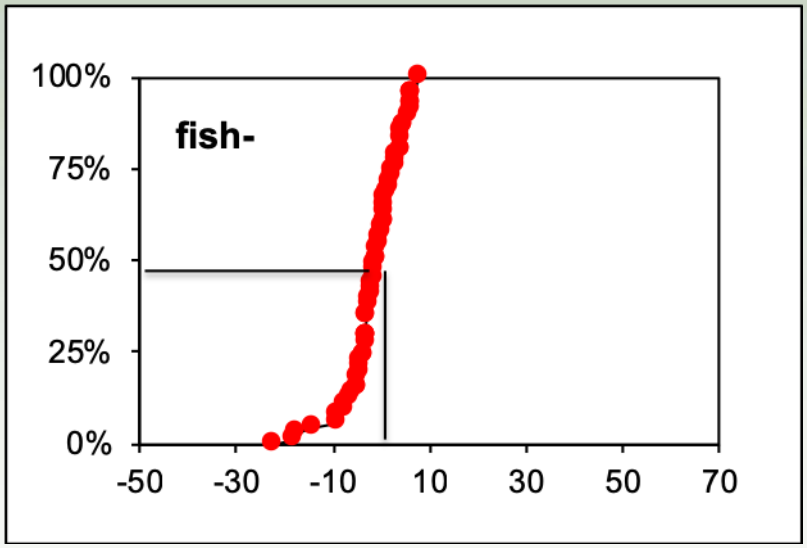
The range of ‘responses’ (-30% to +30%) reflects the background variation in crop yields.



Normal distribution centered on zero

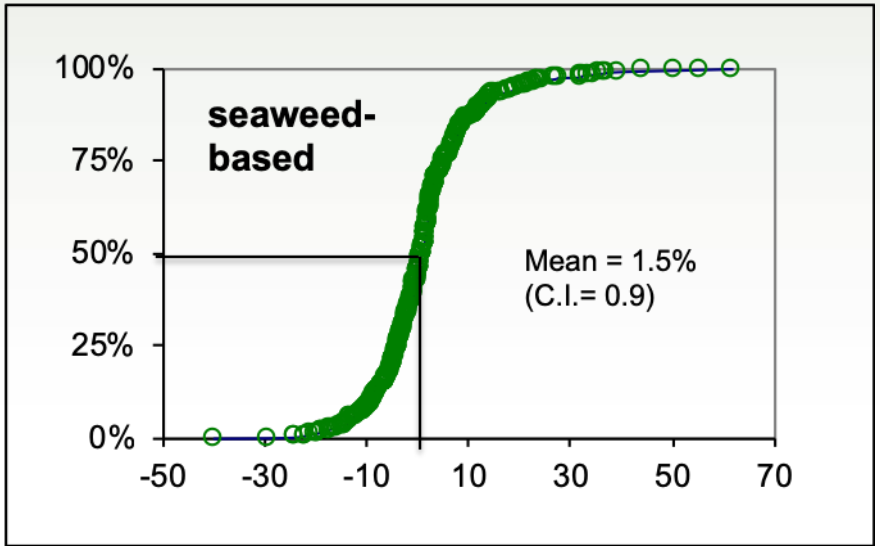
For products which increase production the distribution of responses moves to the right

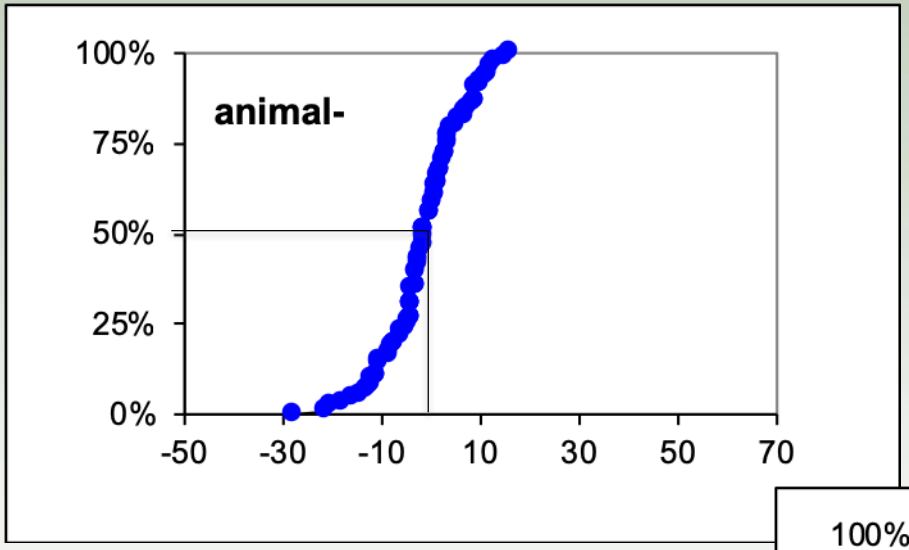




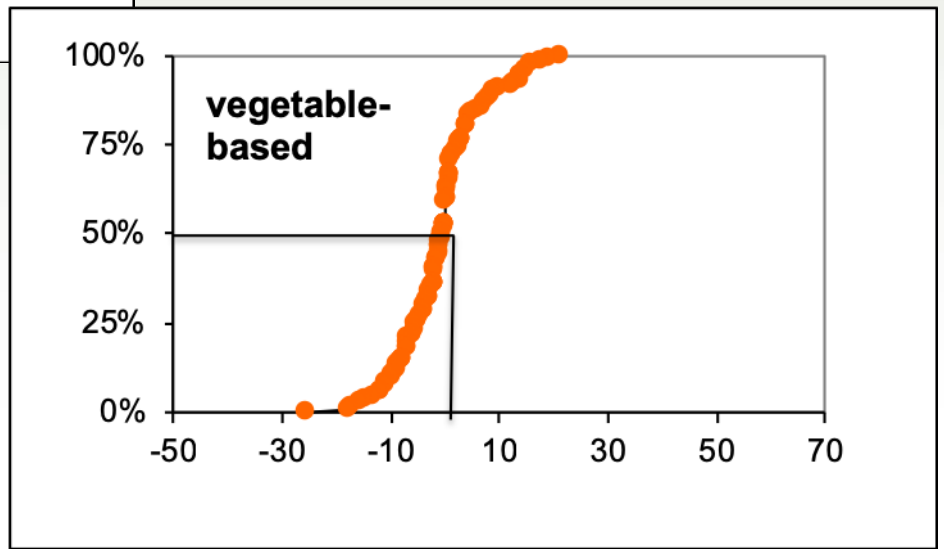
67 trials

543 trials

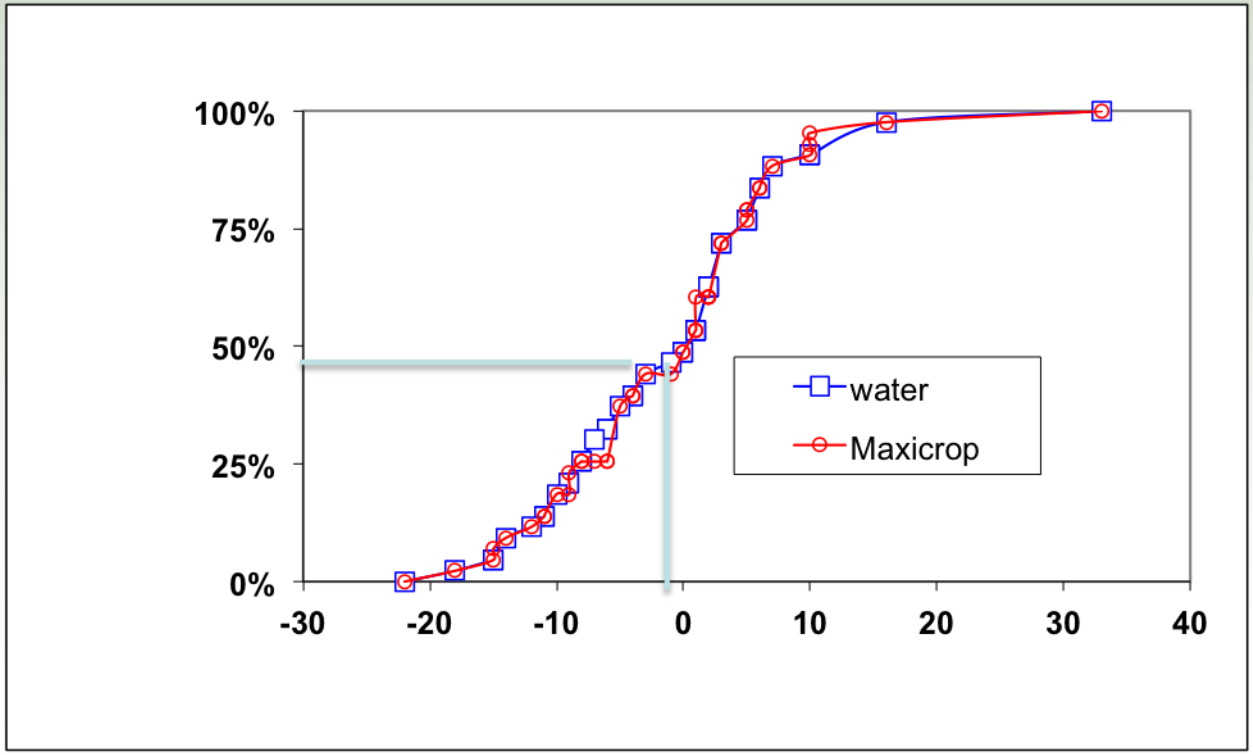



100%
75%
50%
25%
0%
animal-
-50
-30
-10
10
30
50
70

107 trials


100%
75%
50%
25%
0%
vegetable-
based
-50
-30
-10
10
30
50
70

Maxicrop = Water!!!



Case Study 1: Liquid fertilisers

- Cannot work
  - based on the analysis & mode of action/active ingredient/chemistry and 1st principles
- Do not work
  - based on the field evidence

Note: these lines of evidence are independent

“Keep the drum - it is the most useful part!”

Prof Walker

Example 2: Avail

- Polymer coated soluble P
- Claim: increase P use efficiency
- Claim: increase crop growth by **10-12%**

$m's sold in USA

Avail: Claimed Mode of Action

"the maleic–itaconic acid copolymer can be used with soluble granular P fertilizers, such as MAP and DAP, as P enhancer …

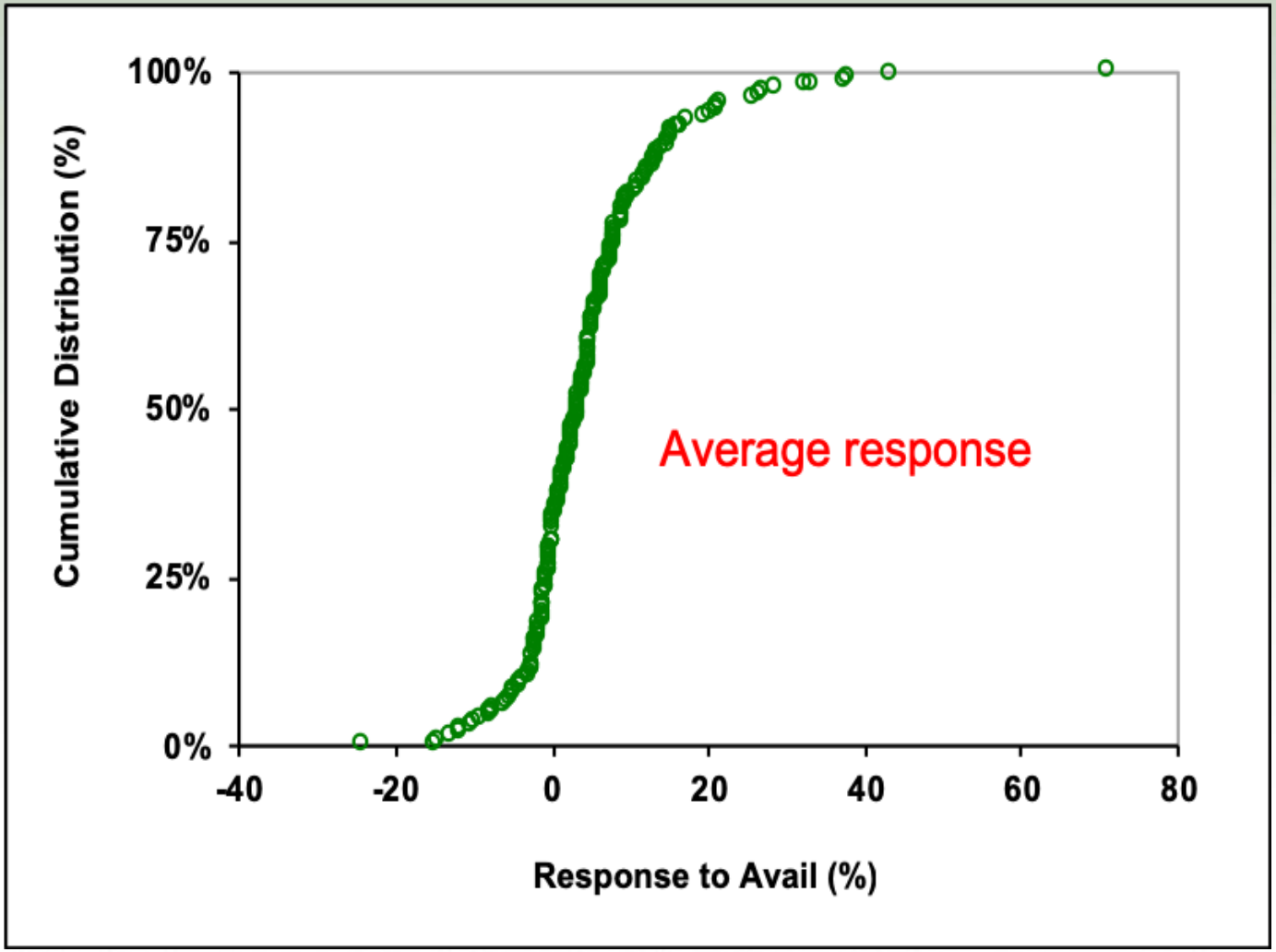
… the very high cation-exchange capacity of the copolymer (1800 $cmol_c\ kg^{-1}$) can bind with soil Fe, Al, and Ca ions, and thereby prevent soluble P from being retained (fixed) by the soil"

Does it work?

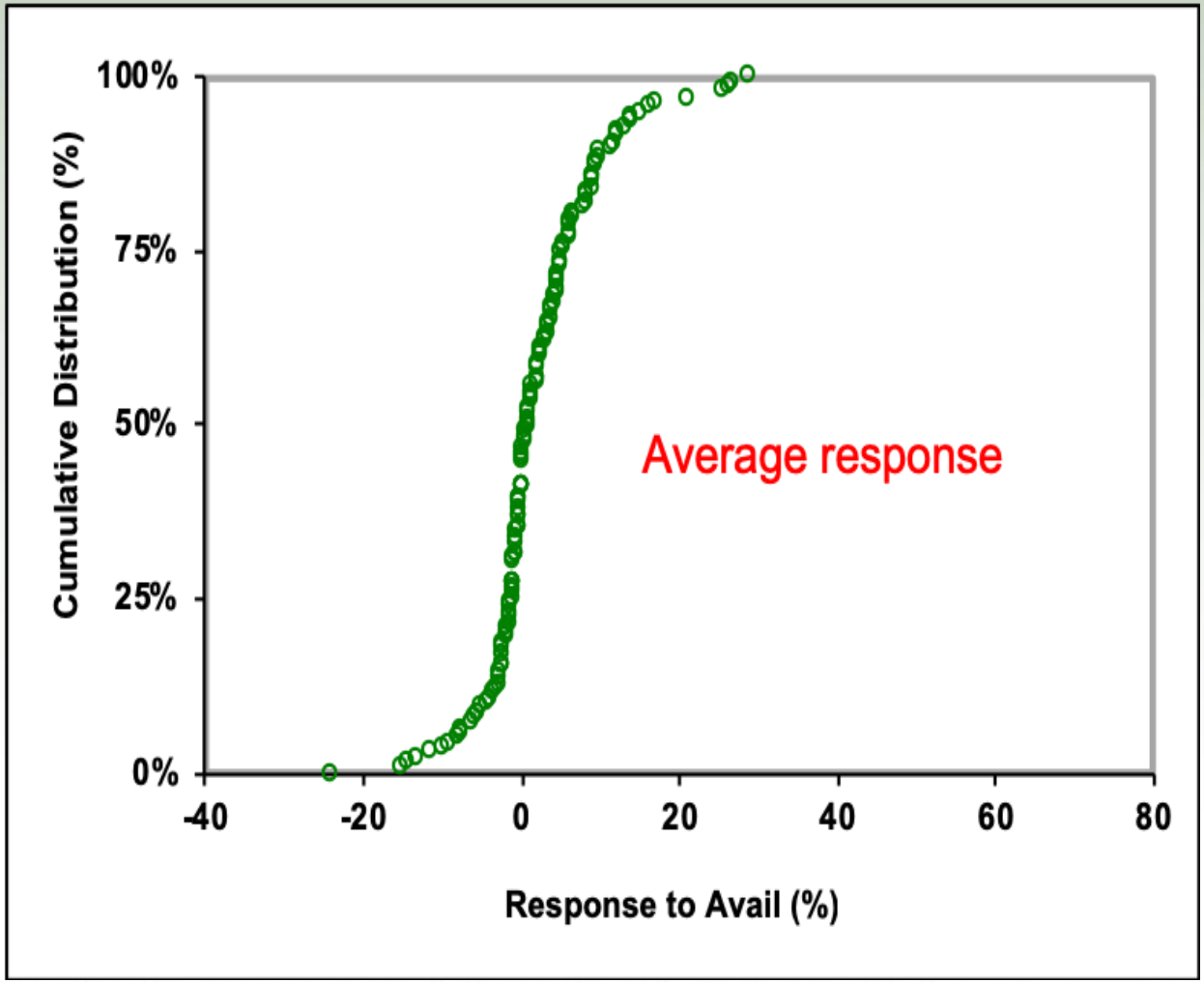
Field Trials: 3 categories

1. Very reliable
    - Trial design and statistics available
2. Reliable
    - No info. re trial design but stats. available
3. Not Reliable
    - Trial design unknown and no stats.

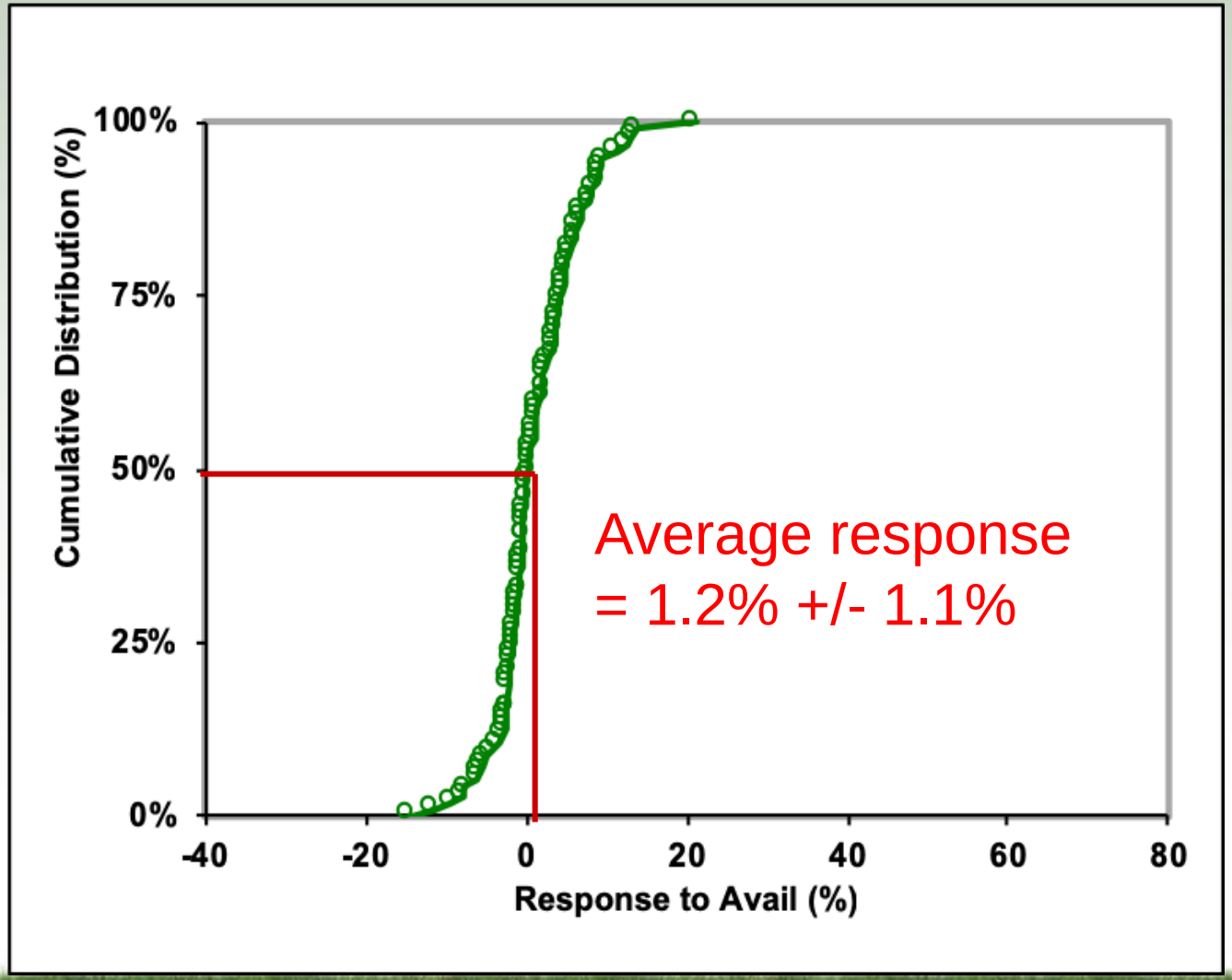
Avail: all trials (n= 210)



Avail: Reliable and Very Reliable trials (n= 140)

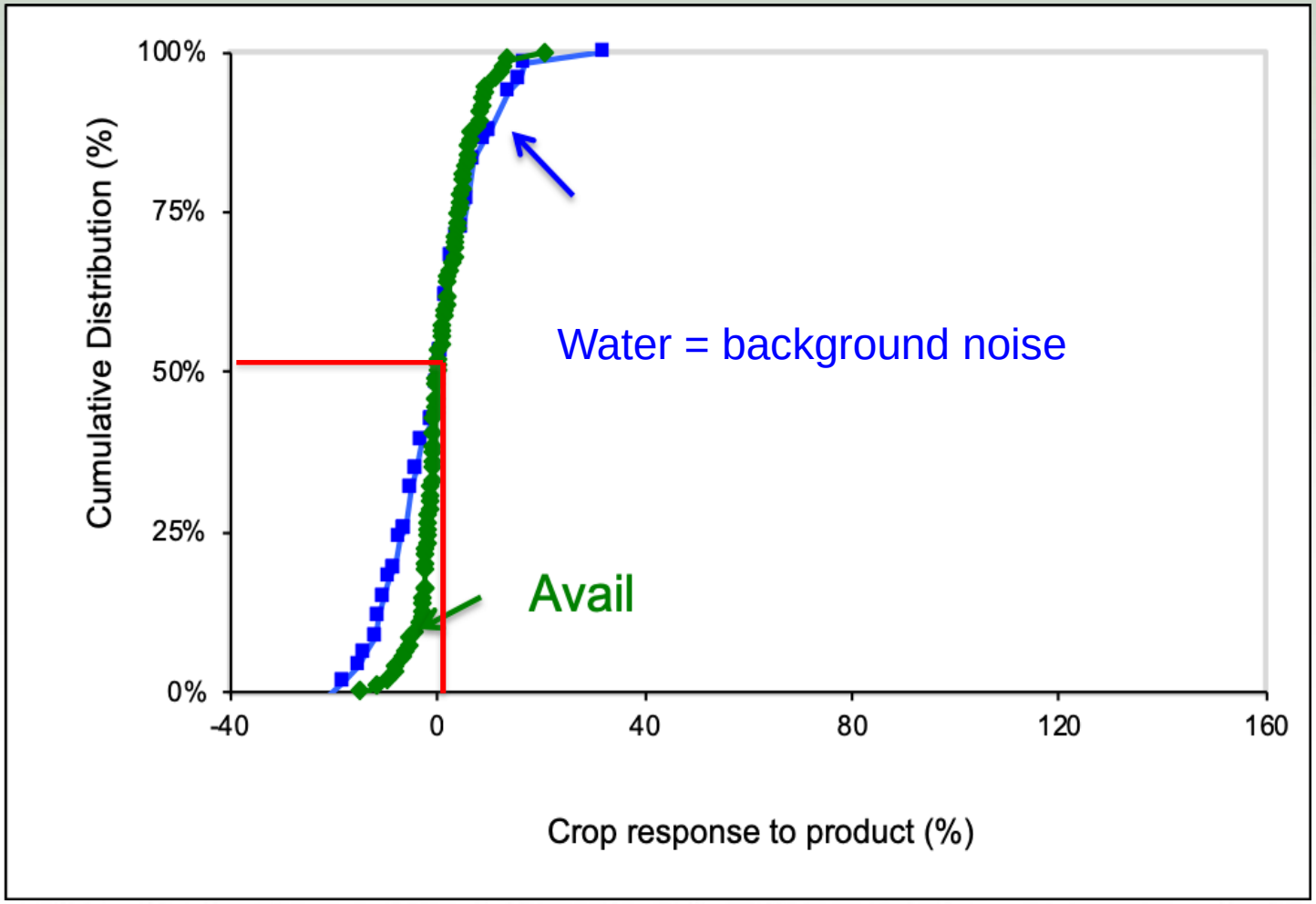


Avail: Very reliable trials (n= 95)



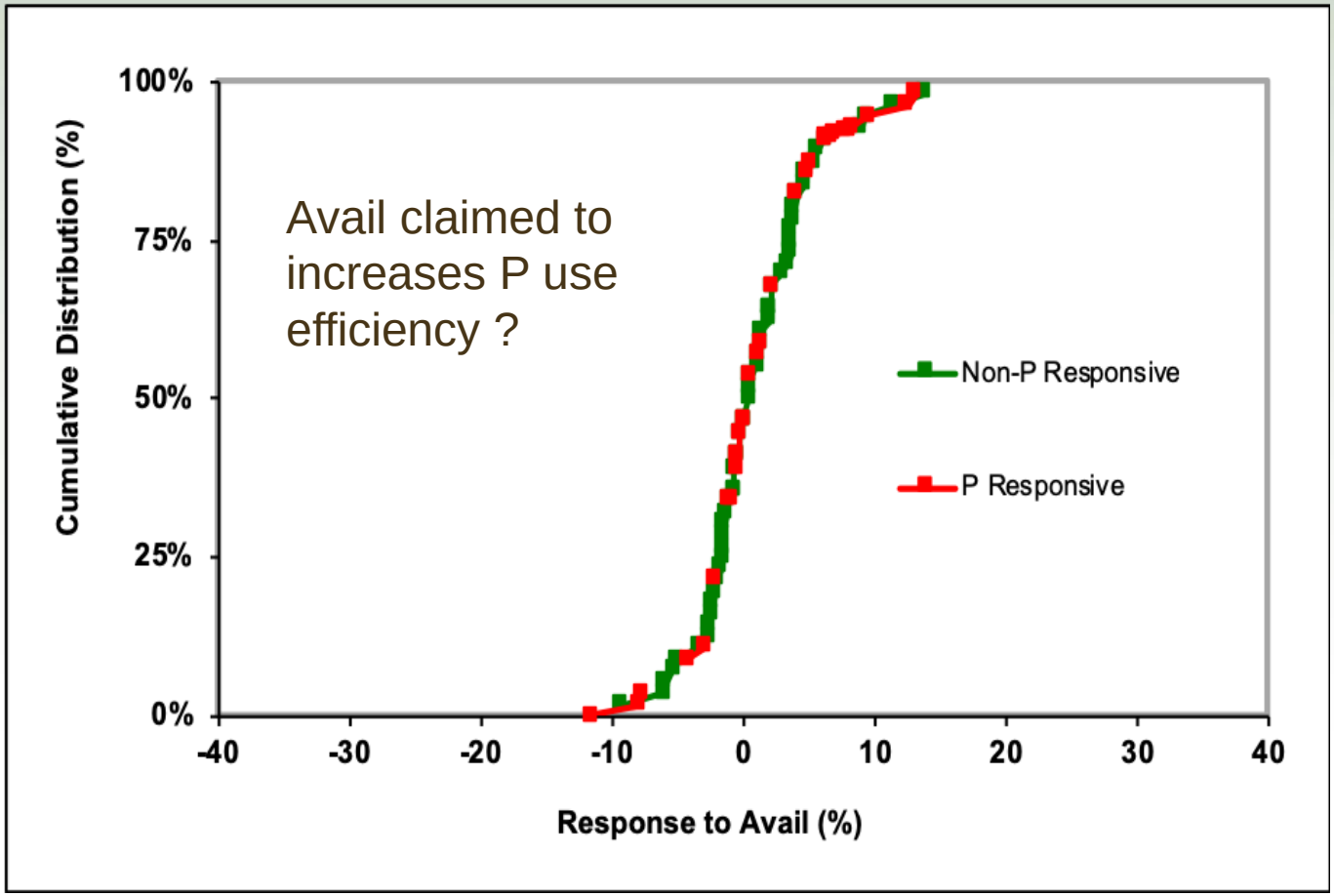
The more reliable the trials the more accurate the result

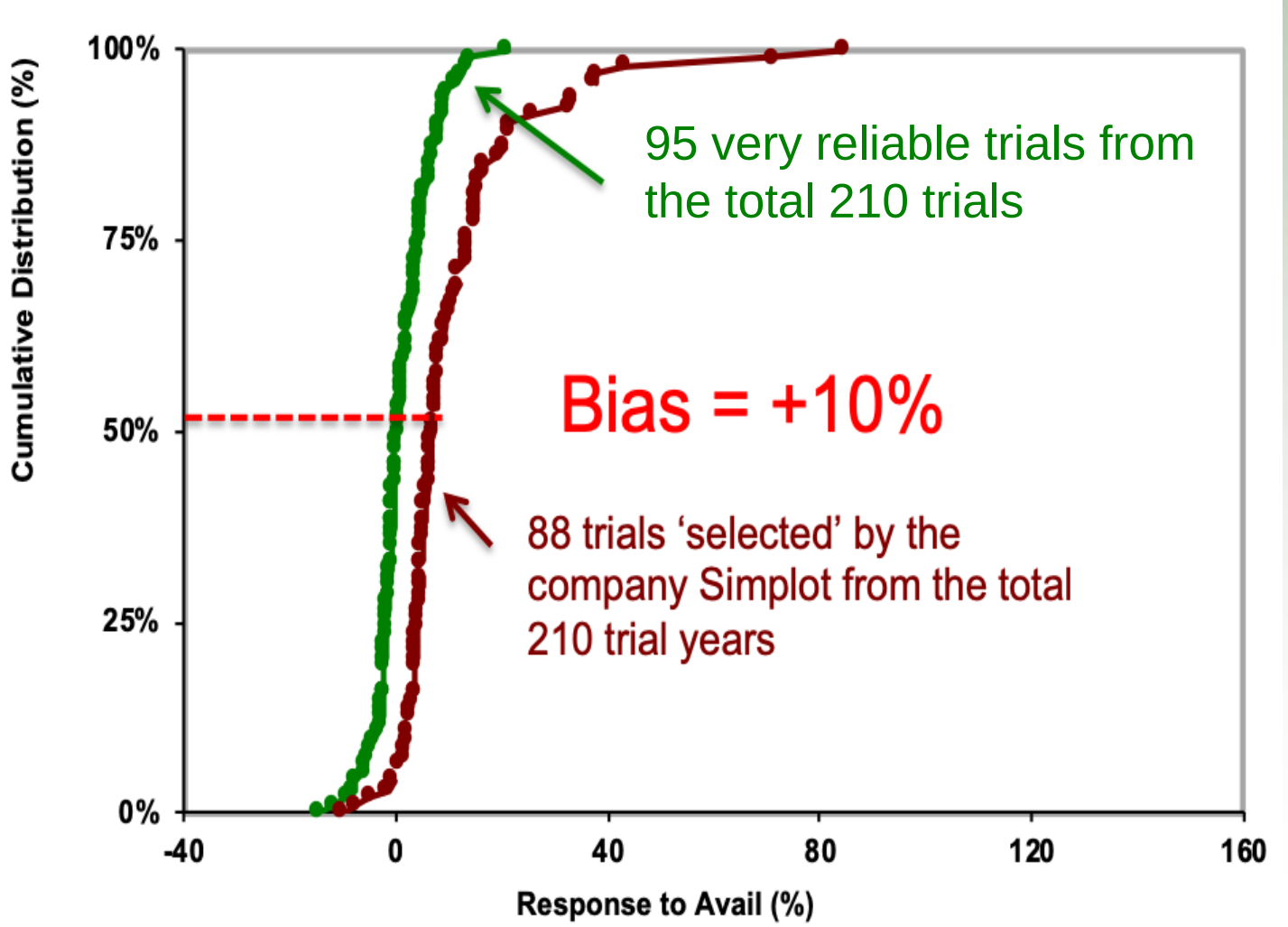
Compare: Water with Avail



Test of the mechanism

Should work better of P responsive sites





Beware of the salesman's bias

Can it work? No!

Basic chemistry/1st principles

"Theoretical calculations found that the amount of copolymer recommended for commercial use (0.25% of P fertilizer) is too small to have any significant effect on soil P chemistry"

Review of Maleic–Itaconic Acid Copolymer Purported as Urease Inhibitor and Phosphorus Enhancer in Soils. 2014: S. H. Chien,* D. Edmeades, R. McBride, and K. L. Sahrawat

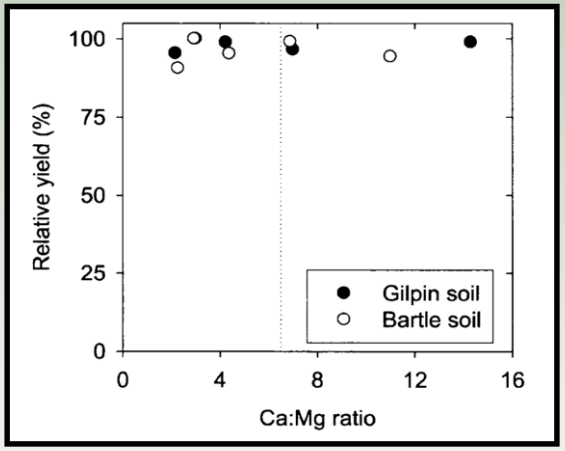
Exhibit 2: Avail

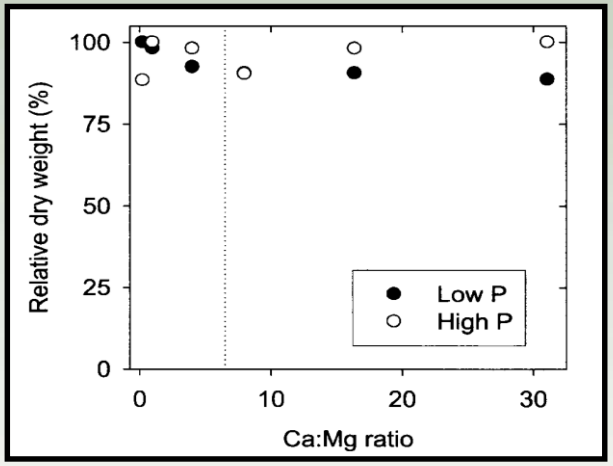
- Cannot work
  - based on the analysis of mode of action/active ingredient/chemistry and 1st principles
- Does not work
  - based on the field evidence

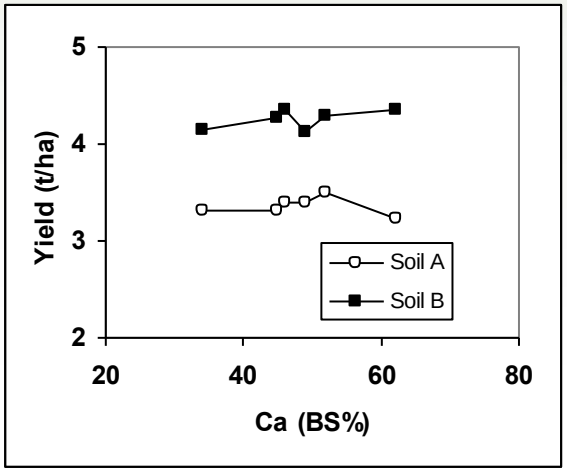
Note: these lines of evidence are independent

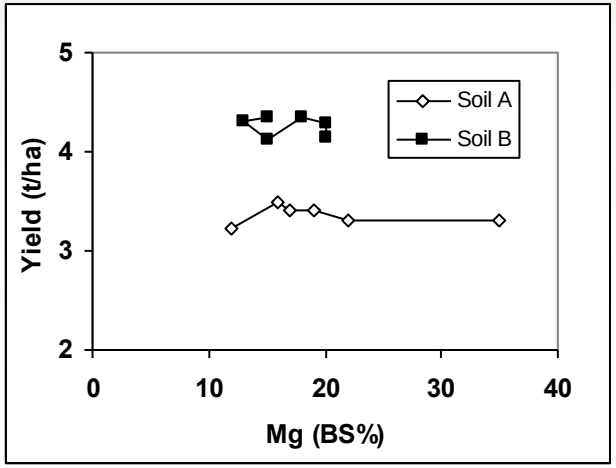
Case Study 3: Albrecht Base Cation Ratio Theory

- Does it work?
  - Field evidence
- Can it work?
  - Theoretical considerations





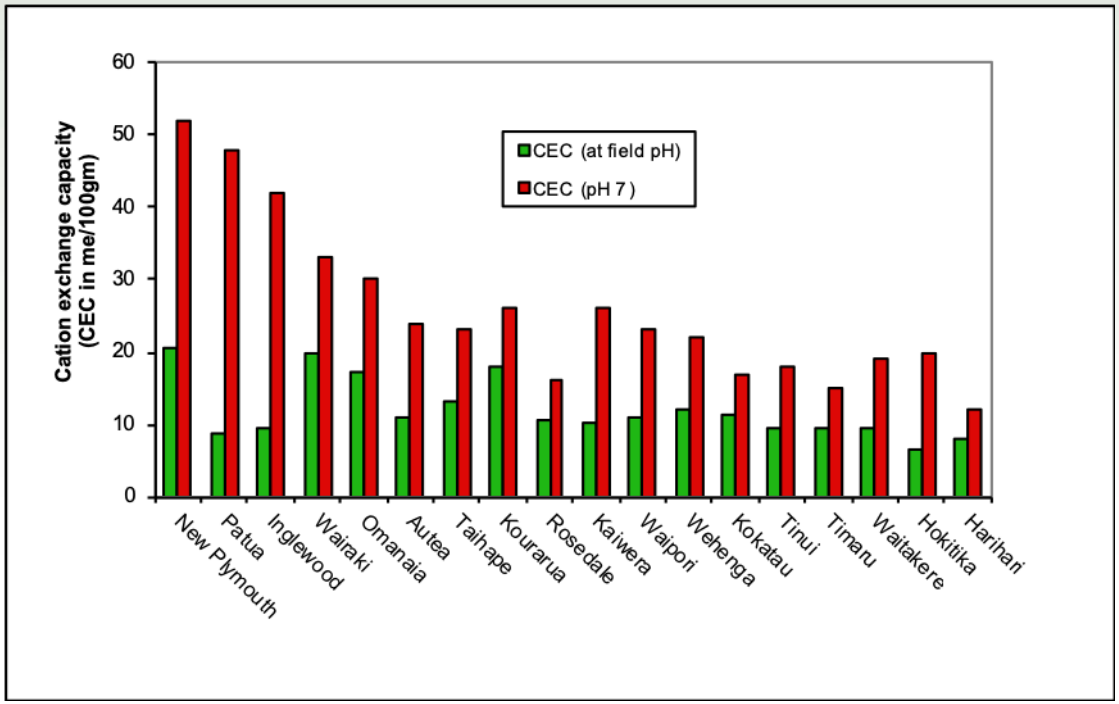




Empirical evidence: Does not work!

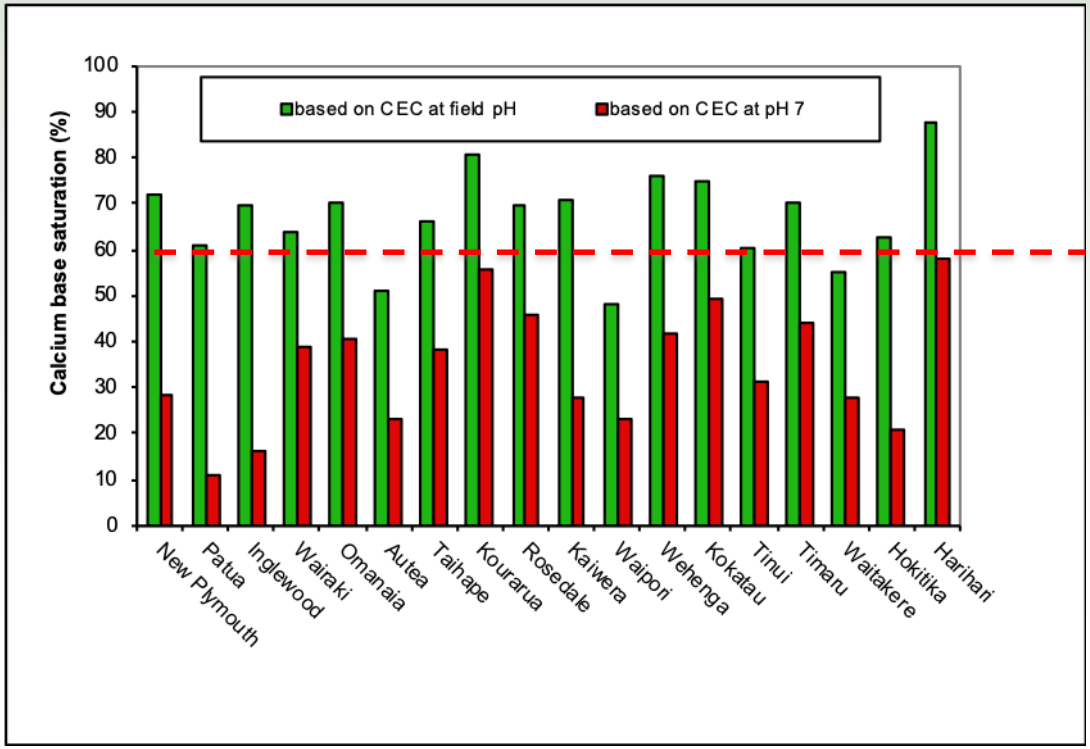
Theoretical Considerations

Effective CEC < CEC pH 7



Theoretical considerations

BCSRs underestimated using CEC @ pH 7



All soils
< 60% Ca BS and therefore need Ca fertiliser?

Ca deficiency unknown in NZ!!!

Theoretical Considerations

- Only deals with three (Ca, Mg, K) of the 16 essential nutrients (limited)!
- Advocates suggest that the soil pH can be ‘constructed’ by altering Ca/Mg ratio! (mechanism?)
- Advocates suggest changing Ca/Mg improves soil physical quality! (mechanism?)

Base Cation Ratio Theory

Does it work?

- Plant growth not affected by soil nutrient ratios providing the minimum amounts of nutrients are present.
- There is no such thing as an ‘ideal ratio’
- In practice results in *overuse* of some nutrients (Ca and Mg) otherwise not required, and *underuse* of (P) that are required.

Can it work?

- Theoretically implausible

Recent Review

"The data do not support the claims of the BCSR [the Base Cation Saturation Ratio theory], and continued promotion of the BCSR will result in inefficient use of resources in agriculture and horticulture."

Kopittke, P. M and Menzies, N.W. 2007: A Review of the Use of Basic Cation Saturation Ratio and the "Ideal' Soil. Soil Science Society of America. 71 (2) March-April 2007, 259-265)

See also: Letter to Editor South African Farmers Weekly: 24 May 2013 (19 signatories)

Case 4: Fine lime

- Can they work?
  - Active ingredient?
- Do they work?
  - Field evidence

Examples: Rapid lime (NZ), Cal-Lime-Flo (SA)
but many products in the market

Active ingredient: Liming Materials

Calcium or Magnesium carbonate

(Ca) (Mg) (CO_3)

Active ingredient

Neutralizes soil acids

$2H^+ + CO_3^{--} = H_2O + CO_2$

The change in soil pH is directly proportional to the amount of carbonate applied

Claims: Fine, Granulated, or Suspension Lime

Fine lime – greater surface area therefore faster acting

Fine lime – granulated or suspension – no dust

Fine lime – gets into subsoil quicker

Therefore: less lime required!!!!!!!

Examples #1

Rapid Lime (NZ granulated fine lime <150 micron)

Claim: 100 kg/ha fine lime = 1 tonnes/ha ag lime

Rule of thumb = 1 tonne/ha ag lime = 0.1 soil pH change

($ 30/tonne) ($300/1 pH unit)

therefore: 100 kg/ha = 0.01 soil pH change

($150-$200/tonne) ($2,000/1 pH unit)

Example #2

Cal-Lime-Flo: (suspension fine lime < 2-5 micron)

Claim: 25 litres/ha (13 kg lime @ 98% NV/ha) = 4 tonne/ha ag lime

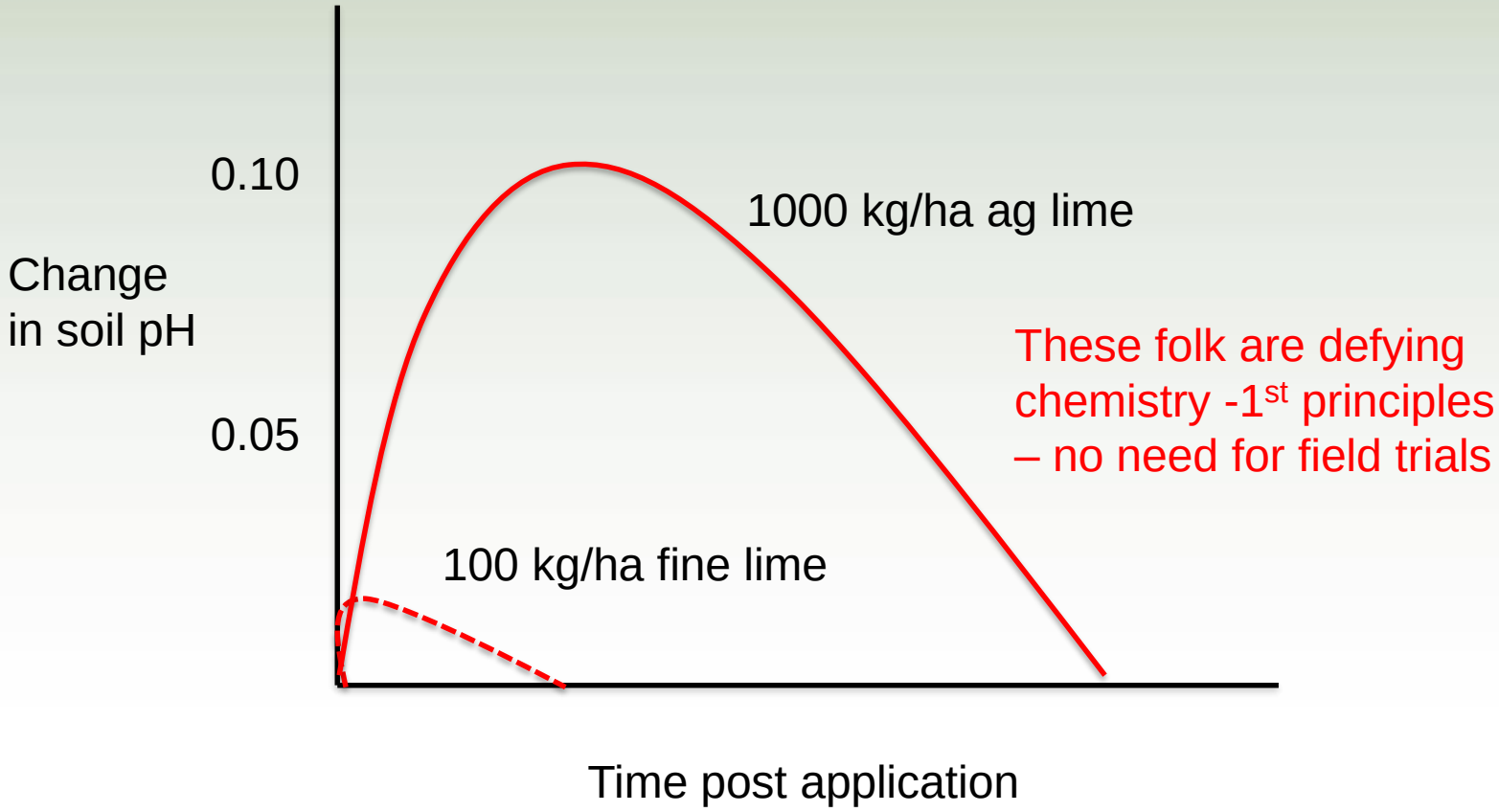
Rule of thumb (SA) = 4,000 kg lime/ha @ 75% NV/ha = 1 c mole acidity

Therefore: 3,000 kg lime/ha @98% NV) = 1 c mole acidity

Therefore: 13 kg Cal-Lime-Flo/ha = 0.004 c mole acidity

A factor of 250!!!!!!!!!

Confusing speed-of-liming-effect and quantity



My Hope

Can it work?

Does it work?

Its a useful framework to a vexing problem?

Your Challenge

"Those who are fortunate enough to have chosen science as a career have an obligation to inform the public about voodoo[1] science."

Robert Park 2000 "Voodoo science: The road from foolishness to fraud"

[1]voodoo science = bad science, junk science, pseudo science