# Importance of micronutrients in crop nutrition

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## Outline

- Essential elements
- Classical approach for assessing micronutrient limitations
- Residual value of micronutrient fertilizers
- New evidence of micronutrient disorders
- Recalcitrant micronutrient problems
- Mapping location of micronutrient deficiencies
- Correcting market failure in the adoption of micronutrient fertilizers
- Conclusions

# Importance

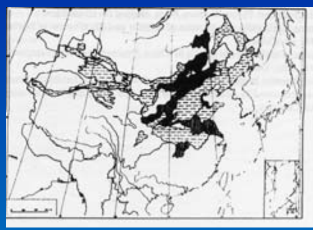
| Impact per unit area | x | Area affected |
|---|---|---|
| Yield | | Topsoil |
| Crop quality | | Subsoil |
| Seed vigour | | Residual value |
| N fixation | | Genotypes |
| Human/ animal nutrition | | |
| Inefficient use of inputs | | |


# Essential elements

- No new essential micronutrients discovered since Ni (1987)
- Continuing work on Si
- New understanding of behaviour of B in plants
- new evidence of B requirements in animal and human nutrition
- New emphasis on impacts for human health

Photos: B Wood, USDA

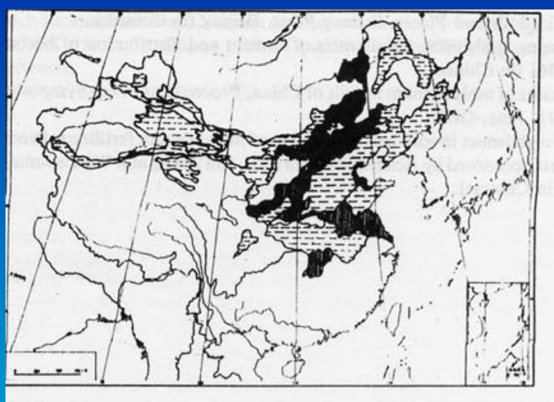
# Classical approach for assessing micronutrient limitations



- Soil analysis surveys
- Field trials
- Critical levels
- Fertiliser rates and types
- Crop species requirements

# Mapping location of micronutrient deficiencies

- Based on location of responsive sites
- Based on soil types



# Residual value of micronutrient fertilizers

Identification of deficiency

Rates, forms for correction

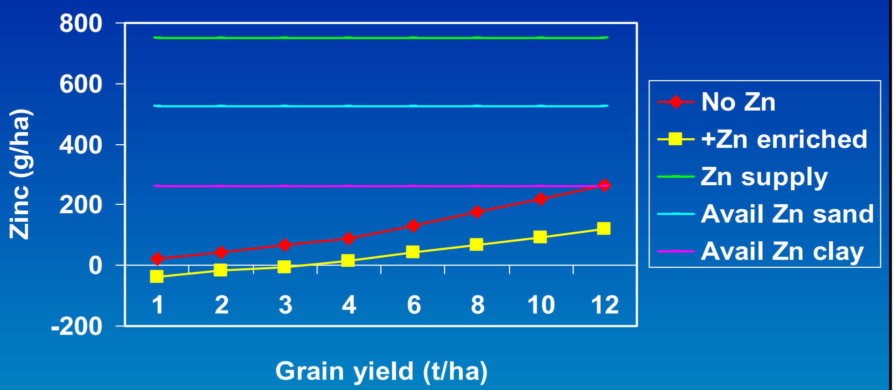
Residual effectiveness
- Soils
- Yield
- Element

# No. year production supported by 0.75 kg Zn /ha applied once

| | Yield (t/ha) | Zn removed (g/ha) | Zn added (g/ha) | Zn balance (g/ha) |
|---|---|---|---|---|
| Wool | 0.07 | 7 | 90 | 83 |
| Wheat | 3 | 66 | 0 | -66 |
| Lupin | 2.2 | 66 | 0 | -66 |
| Canola | 2.2 | 66 | 0 | -66 |
| No. years | | | | 18 |

Brennan, unpublished 2004

# Estimating residual Zn




Based on Brennan 2004

# Boron residual value

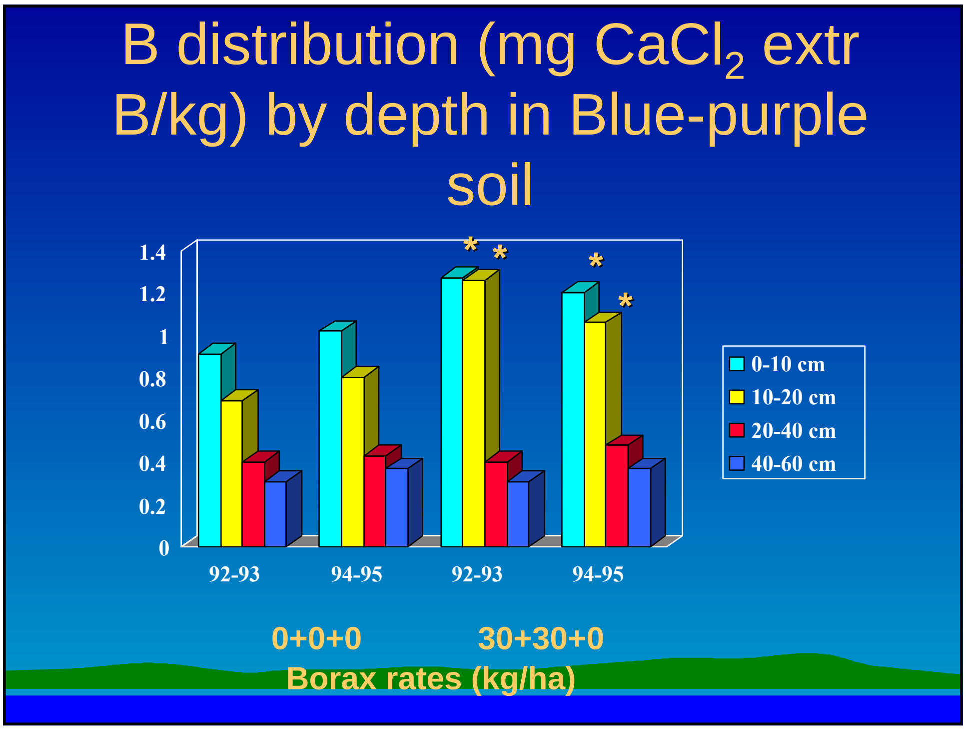
- B movement in soils
- B reactions in soils
- B toxicity risk from B fertiliser
- B inputs and outputs in rice-based cropping systems

# Soil properties

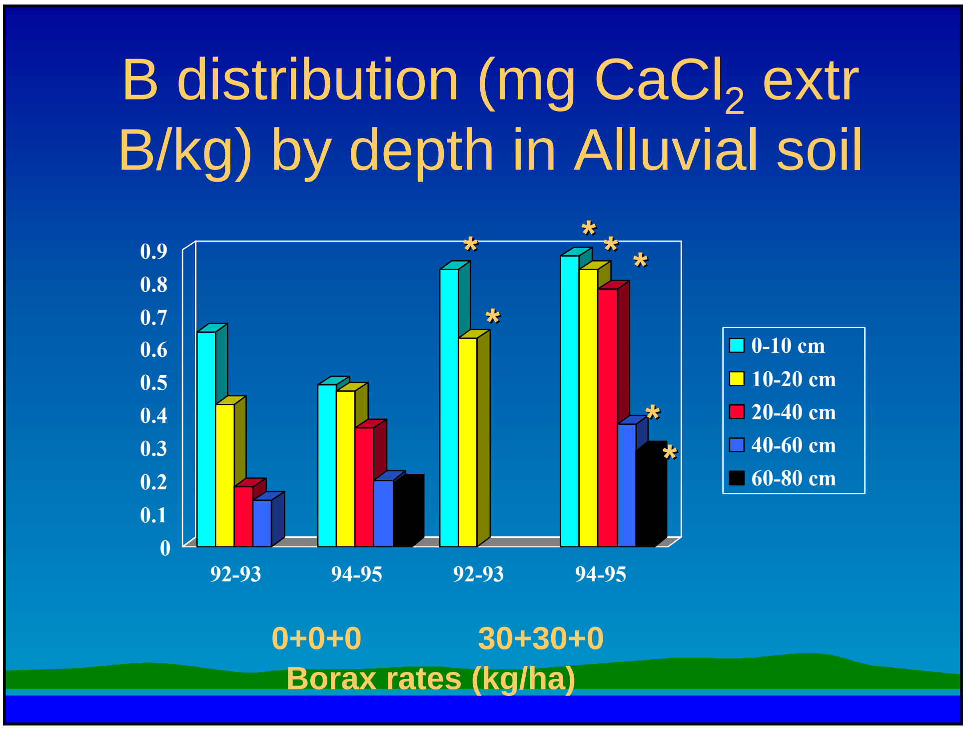
| | Alluvial Jiang-shan | Red Jiang-shan | Blue-purple Jiashan |
|---|---|---|---|
| Taxon-omy | Udi-fluvent | Hapl-udult | Aquent |
| pH (KCl) | 6.5 | 5.1 | 6.4 |
| OM g/kg | 27 | 26 | 43 |
| Clay g/kg | 200 | 260 | 220 |
| ECEC cmolc/kg | 13 | 7 | 22 |
| B mg/kg | 0.35 | 0.33 | 0.75 |

# B application rates (kg B/ha)

| Borax Treatments | Yr 1 | Yr 2 | Yr 3 |
|---|---|---|---|
| 0+0+0 | 0 | 0 | 0 |
| 15+0+0 | 1.65 | 0 | 0 |
| 30+0+0 | 3.3 | 0 | 0 |
| 30+30+0/30 | 3.3 | 3.3 | 0/3.3 |

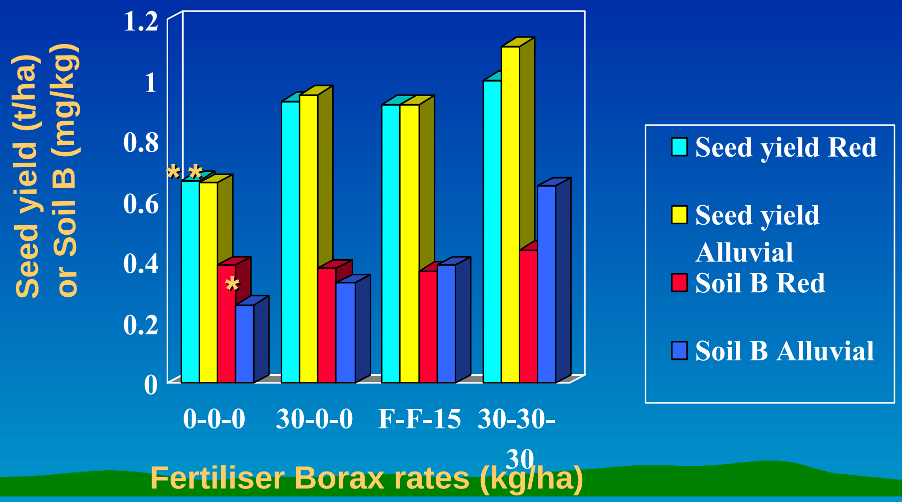


B distribution (mg $CaCl_2$ extr B/kg) by depth in Blue-purple soil
1.4
1.2
1
0.8
0.6
0.4
0.2
0
92-93
94-95
92-93
94-95
0-10 cm
10-20 cm
20-40 cm
40-60 cm
0+0+0
30+30+0
Borax rates (kg/ha)

B distribution (mg $CaCl_2$ extr B/kg) by depth in Alluvial soil
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
92-93
94-95
92-93
94-95
0-10 cm
10-20 cm
20-40 cm
40-60 cm
60-80 cm
0+0+0
30+30+0
Borax rates (kg/ha)

## Effect of repeated B application on oilseed rape yield




## B removal in grain and straw

| | |
|---|---|
| B removed in grain each year (g B/ha) | 50 |
| B removed in straw each year (g B/ha) | 200 |
| % of B in 15 kg borax removed after 3 years in straw and grain | 40 |

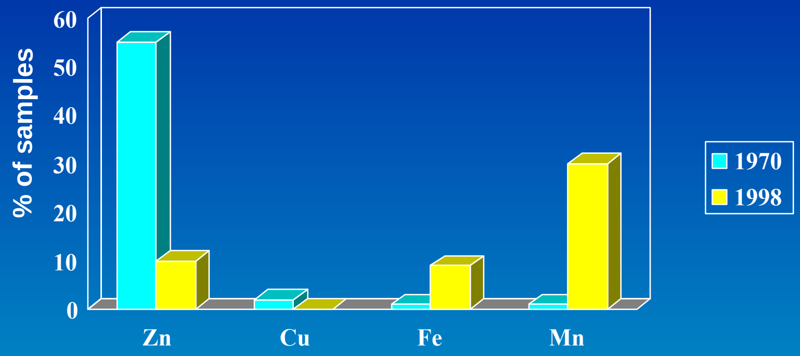
## Conclusions

- borax at 3-8 x recommended rates has low risk of inducing B toxicity
- low risk of B toxicity consistent with low extractable B levels in fertilised soils
- leaching loss of B is minimal
- B removal in harvested crop products is significant in triple cropping system
- single application of 1.65 kg B/ha effective on all soils for 3 years

## New evidence of micronutrient disorders

- Changing lowland farming systems
  - Intensification
  - Direct seedling
  - declining sub-soil levels
- Upland farming systems
  - Legumes, oilseeds
  - Plantation forestry
  - Hostile sub-soils

# Change in incidence of micronutrient deficiencies- Punjab




Nayyar et al. (1999)

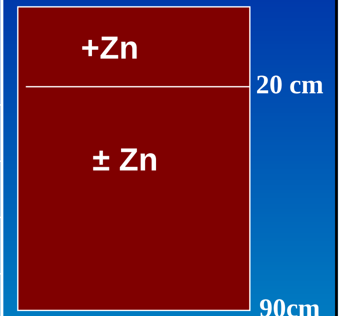
# Sub-soil

- Hostile sub-soils
  - Acidity
  - Alkalinity
  - Salinity
  - Physical constraints

- Low micronutrients in sub-soils
  - Zn, Mn, Cu, B

# Low micronutrients in sub-soil

| | Rape Seed yield (g/plant) | | Zn effic. (%) |
|---|---|---|---|
| | -Zn | +Zn | |
| ZY821 | 9 | 14 | 63 |
| XZ 2 | 11 | 17 | 68 |
| Naren. | 11 | 14 | 79 |
| CSIRO-1 | 18 | 19 | 92 |




Grewal et al. 1997

# Wheat sterility


- Gaping glumes
- Low grain set
- Low yield
- South Asia, Southeast Asia
- China
- Brazil

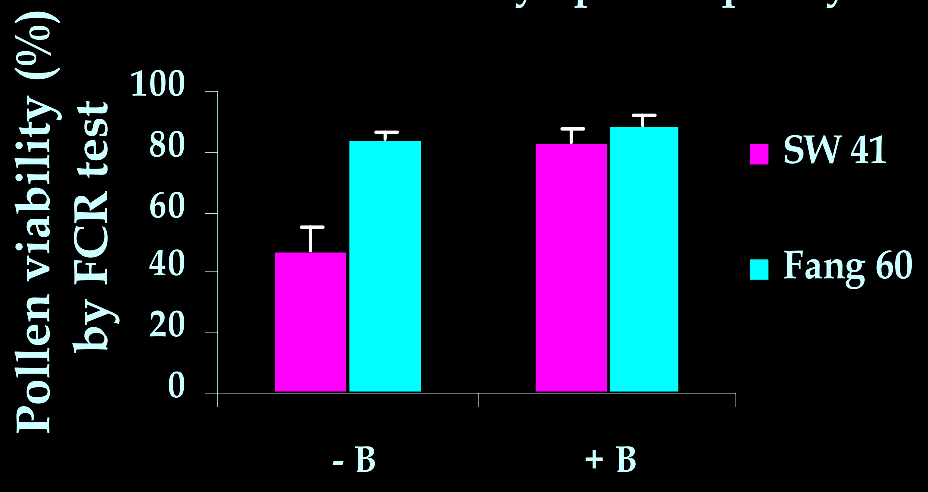

Figure 1. Scanning electron micrographs (a, b) and light micrographs (c, d) of wheat pollen towards anthesis. (a) Normal turgid grains with prominent germ pores (arrows) from B+ plant. (b) Shrivelled grains (arrows) inside anther tissue (A) from Bo plant. (c) Pollen grains from B+ plant mounted in iodine solution. The cytoplasm contains numerous small starch grains. (d) Pollen grains from Bo plant showing distorted shape and reduced cytoplasm.

## Effect of low B (3 days) on pollen viability in wheat

| Treatment stage | FCR test at anthesis (% +B) |
|---|---|
| -B (pre-meiosis to meiosis) | 61 |
| -B (meiosis to late tetrad) | 8 |
| -B (young microspore to mit-I) | 56 |
| -B (mit-I to mit-II) | 42 |

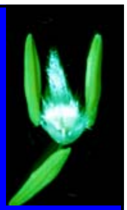
Huang et al. 2000

## Short term B deficiency - pollen quality




NaChiangmai et al. 2004

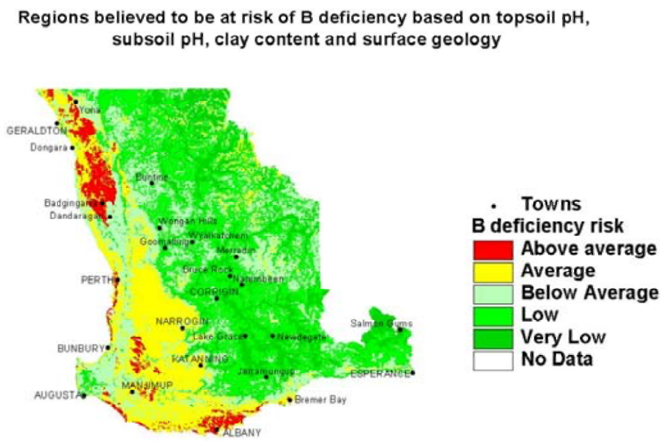
## Ear boron on D5



| B (µM) | B concentration (mg/kg) | | B distribution (%) | |
|---|---|---|---|---|
| | Fang 60 | SW 41 | Fang 60 | SW 41 |
| 0.1 | 6.8 | 3.8 | 1.9 | 1.1 |
| 10 | 12 | 7.8 | 1.6 | 1.5 |

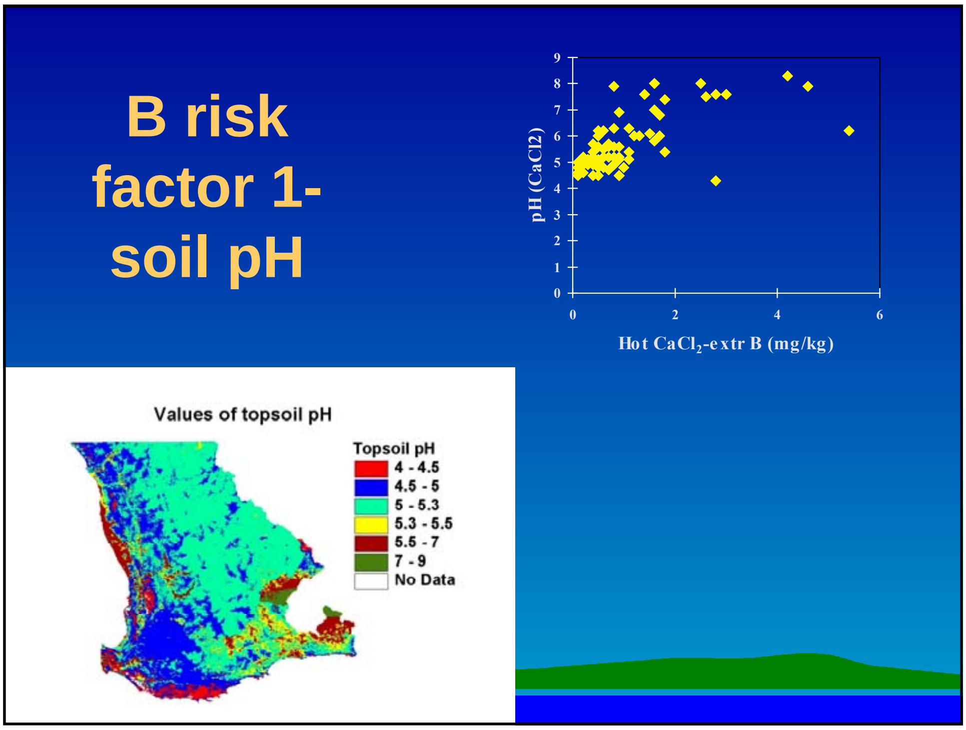
NaChiangmai et al. 2004

## New approaches weight of evidence modeling

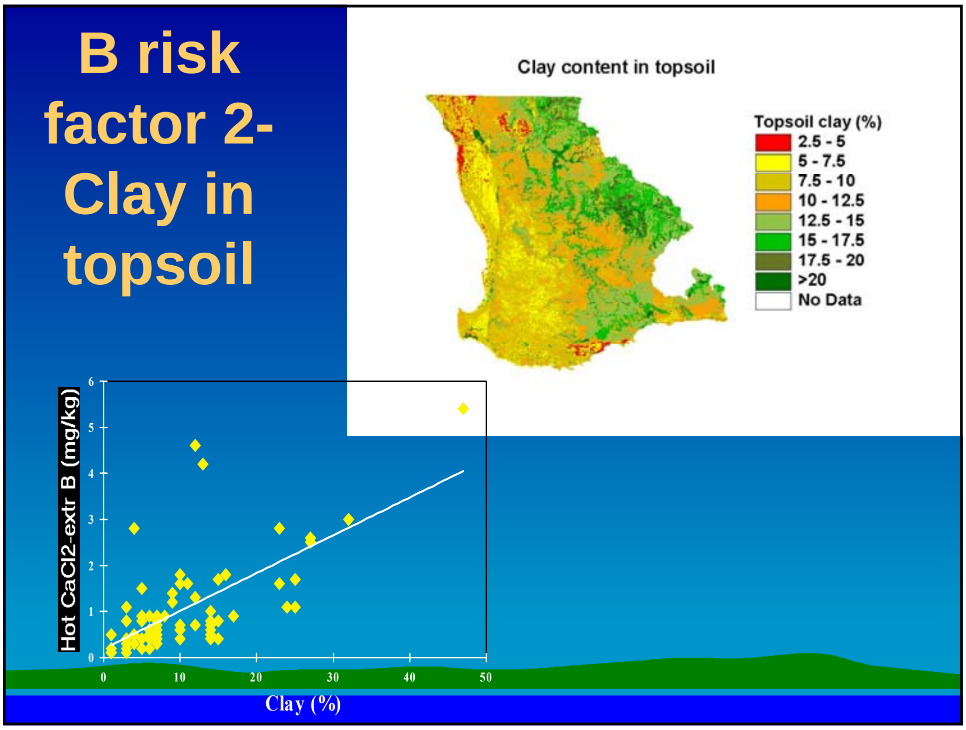



B risk map

Wong and Bell, unpublished



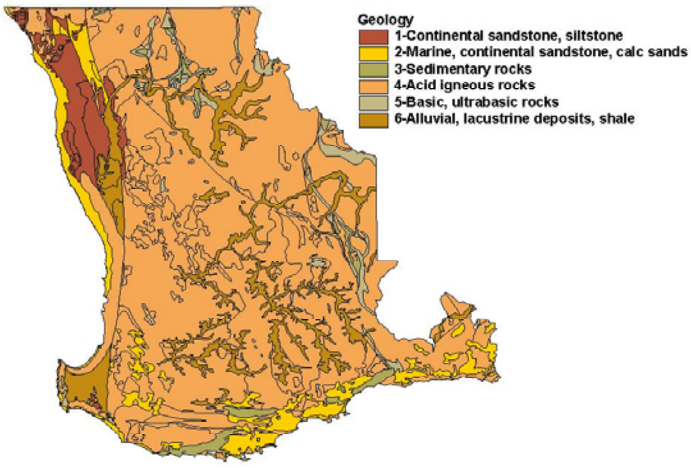
B risk factor 1- soil pH
pH (CaCl2)
Hot CaCl$_2$-extr B (mg/kg)
Values of topsoil pH
Topsoil pH
4 - 4.5
4.5 - 5
5 - 5.3
5.3 - 5.5
5.5 - 7
7 - 9
No Data

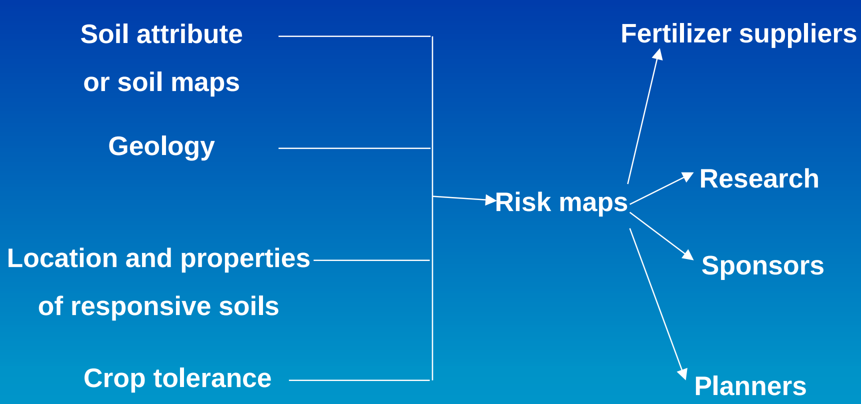
B risk factor 2- Clay in topsoil
Clay content in topsoil
Topsoil clay (%)
2.5 - 5
5 - 7.5
7.5 - 10
10 - 12.5
12.5 - 15
15 - 17.5
17.5 - 20
>20
No Data
Hot CaCl2-extr B (mg/kg)
Clay (%)

# B risk factor 3- Geology

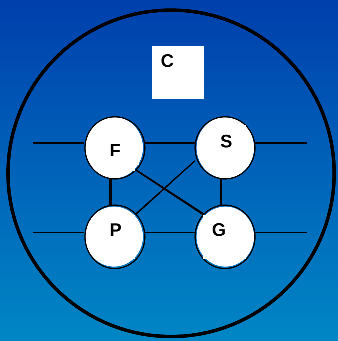
Reclassified geology of the south west of Western Australia




# Improved mapping



# Partnership- Correcting market failure in the adoption of micronutrient fertilizers




# Conclusions

- Assess extent and severity of sub-soil limitations
- Spatial technologies to define affected areas
- Quantify residual value
- Efficient cultivars
- Partnerships