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INTERNATIONAL
PLANT NUTRITION
INSTITUTE

Understanding the role, requirements and options for micronutrient – copper, manganese

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Better Crops, Better Environment … through Science

Cummins & Kimba, South Australia, August 2014.

Micronutrients *(rather than trace elements)*

- Required in low amounts by plants (g/ha).
- Essential for healthy growth.
- Difficult to pick up in soil tests
- Often by association & history

Copper (Cu)
Iron (Fe)
Manganese (Mn)
Zinc (Zn)
Boron (B)
Molybdenum (Mo)
Chloride (Cl)
Nickel (Ni)
Silicon (Si)
Colbolt (Co)
Selenium (Se)

Nutrient	Soil Levels mg/kg	Wheat Grain mg/kg	Removal 4 t/ha	Canola Grain mg/kg	Removal 2.5 t/ha
Nitrogen	**0.14%**	**23**	**94 kg**	**45**	**110 kg**
Copper	**2-400**	**5**	**20 g**	**4**	**10 g**
Manganese	**100-10,000**	**44**	**176 g**	**49**	**125 g**
Molybdenum	1-7	<0.8		<0.8	
Zinc	20-600	25	100 g	34	85 g

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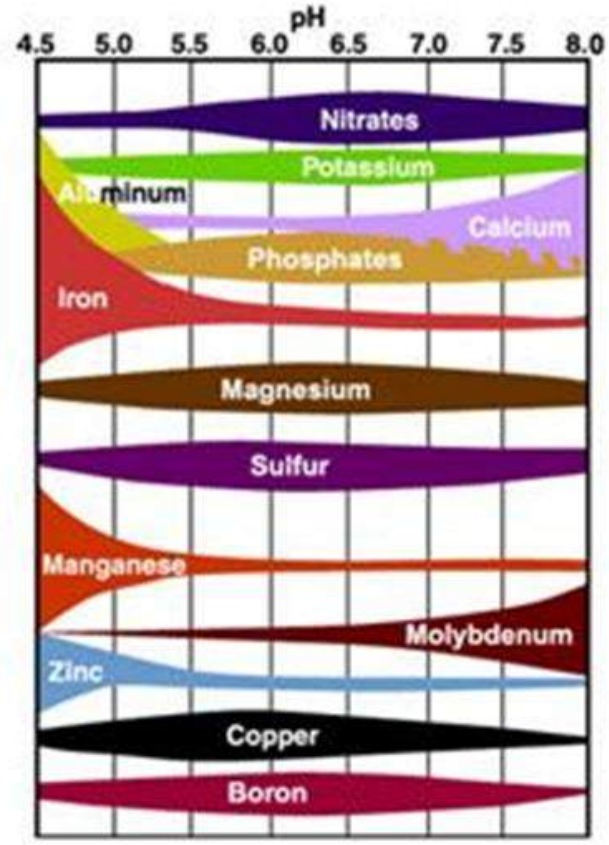
Availability – *not amount* – is important

- **Factors influencing availability of micronutrients in soils**

	Cu	Fe	Mn
pH > 7.0	---	---	---
pH < 5.5	++	+++	+++
water-logged soil	+	--	+
drought	---	---	---
high humus content	---	++	++
high P-content	-	---	-
sand	---	---	--
compaction	+	++	+

--- low availability high +++



It is a chemical jungle in the soil – soil/plant compete for metals

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Soil Test Values – NVT surveys

Region	pH ($CaCl_2$)	HWS B (mg kg^{-1})	DTPA Cu (mg kg^{-1})	DTPA Mn (mg kg^{-1})	DTPA Zn (mg kg^{-1})
Lower EP	7.1±0.1	5.6±0.8	1.9±1.0	14.8±54.2	3.9±3.8
Mid North	6.9±0.1	2.7±0.7	0.5±1.0	1.1±54.3	0.3±3.8
Murray Mallee	7.4±0.2	2.3±1.3	-	-	-
South East	7.1±0.1	3.1±0.6	0.8±0.1	1.7±7.0	0.9±0.5
Upper EP	7.7±0.1	5.1±0.8	-	-	-
Yorke P	7.4±0.1	3.7±0.7	-	-	-
Critical Values*		<0.12	<0.2-0.3	<10	<0.8(?)
All zones	6.3±1.3	3.5±13.3	1.1±1.0	24±43	1.0±2.9

- DTPA is common extractant used
  - Cu critical values very low & unreliable **4/10**
  - Mn values values very variable & unreliable **0/10**
- Grain nutrient concentrations
  - SA LEP Cu 4.4±0.3; Mn 25±3; Zn 19±2 **Cu 1.5; Mn 10; Zn 15**
  - SA UEP Cu 4.9±0.2; Mn 49±2; Zn 26±1 **Cu & Mn 3/10; Zn 5/10**

Diagnosis of micronutrient deficiency

- Situations (soil & season & crop) – probably most reliable
  - LEP long history of Mn, Cu and Zn responses.
  - Different reasons on different soils – fixed (pH) or low parent or washed out.
- Soil tests – for the reasons above soil tests tend to be unreliable
  - Use DTPA (chelating agent) and then assayed
    - eg DTPA Zn, critical value crop dependant (around 0.5 mg/kg)
  - No soil test for Fe or Mo.
  - Use an ASPAC lab & Fertcare advisors
- Plant tissue tests
- Visual symptoms

FERTCARE®

ASPAC

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Which is the copper deficiency?

Too easy?

Copper deficiency

- High OM soils & sandy alkaline soils, acidic
- Rolling/curling YEB
- Chlorophyll & pollen (timing)
- Wheat most likely.
- No confirmed Cu deficiency fo canola reported
- Interaction with N.

B Holloway SARDI

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- Classic on carbonate soils
- Washed out acid sands
- Coincident with Zn and Cu
- Mild wilting to water soaked patches – streaks or grey spots at leaf base
- Split seed in lupin
- Canola more tolerant

Risk & Reality

- Risk of Cu and Mn deficiency high
- Low soil mobility (distribution/response)
- Contribution factors to getting a response to added Cu or Mn
  - Paddock history
    - Cu supplemented basal fertilizer has a long residual life (>5 y)
    - Mn almost no residual activity
  - Carbonate - >60% lime almost certain Mn
  - Wet compacted soils, lower risk of Mn

Micronutrient	Susceptible Crops
Copper	Oats, Sunflower, Lucerne & canola more tolerant.
Manganese	Oats, Legumes. Lupins & canola more tolerant than cereals. Variety differences.

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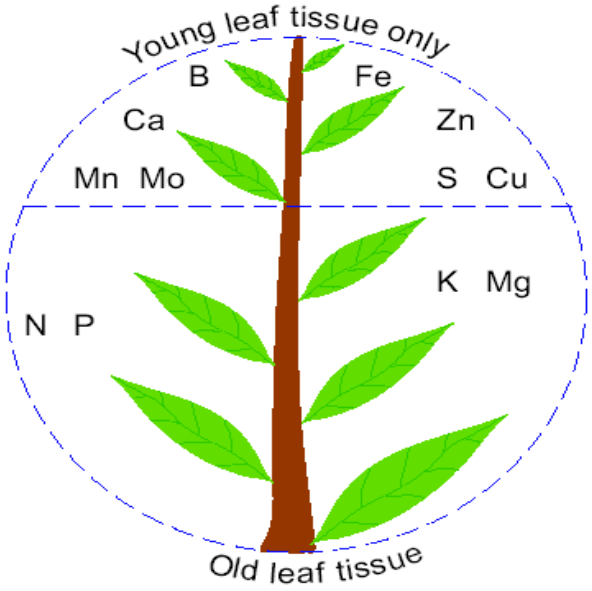
Diagnosing trace element deficiencies *confirm using tissue testing*

- Nutrient mobility in the plant
- Determines if seen in older or younger leaves
- Symptoms in older leaves occur with mobile nutrients (eg Nitrogen)
- Symptoms in younger leaves occur with less mobile nutrients (eg Sulphur).
- 100 random YEB/YML



	Cu	Mn
Wheat (YEB)	<1.5 mg/kg	<12 mg/kg
Lupin/Lentil (YMG)	<1.5 mg/kg	<20 mg/kg
Canola (YML)	2-3 mg/kg	<25 mg/kg

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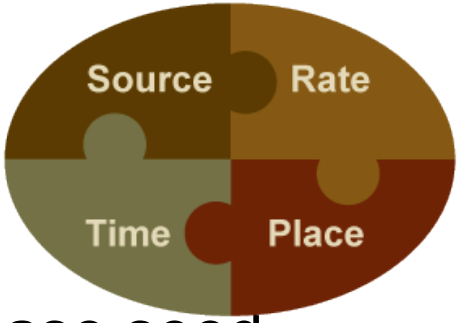
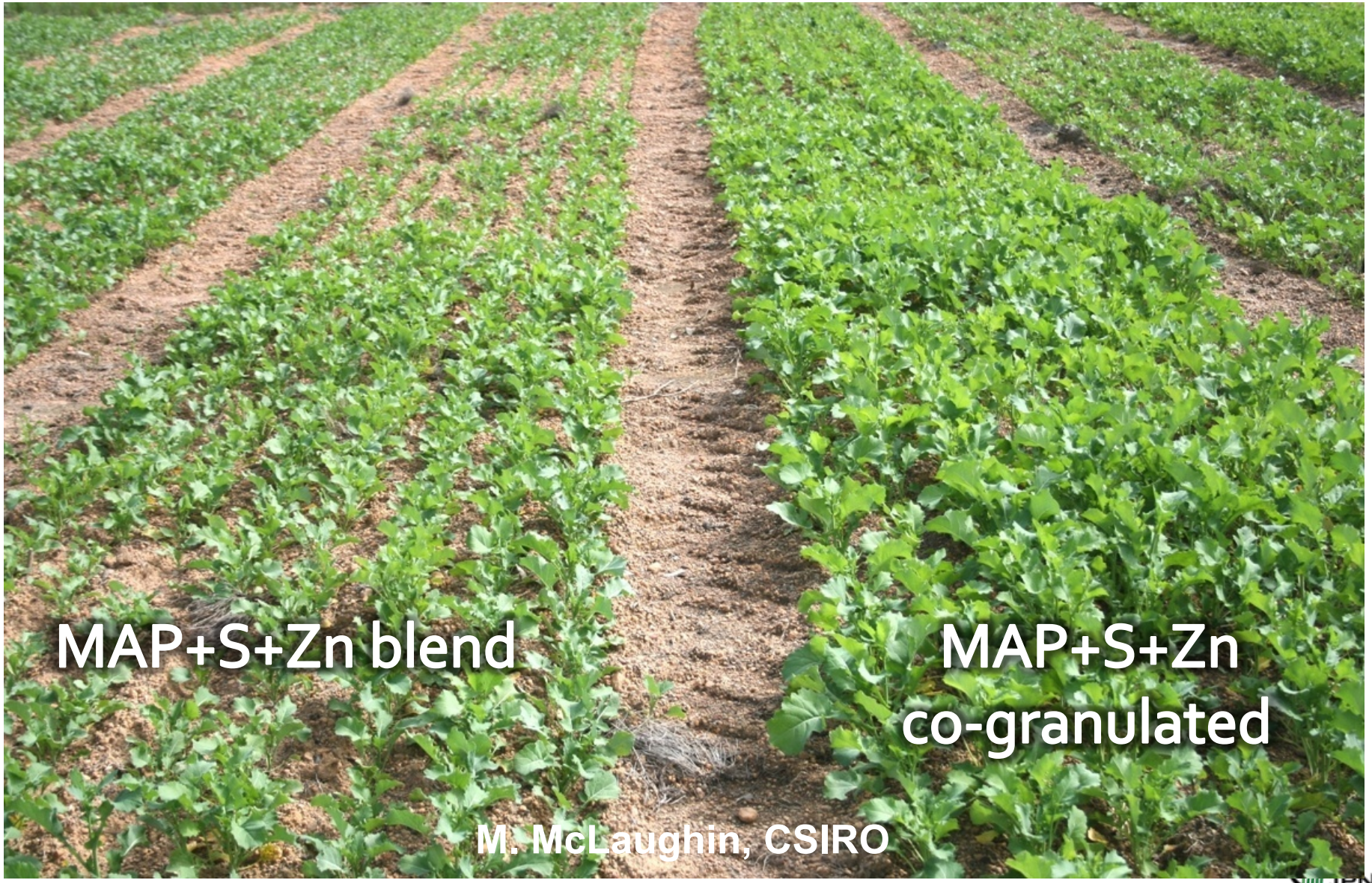
Delivering micronutrients

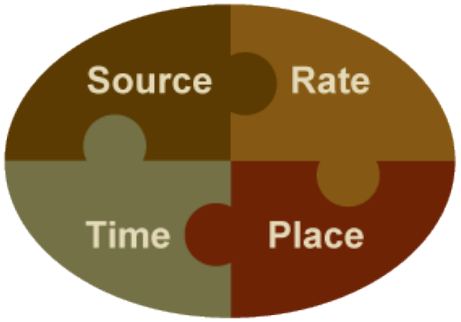


- Seed supplemented – late Cu, Zn to increase seed reserves. Maybe not enough added for Mn
- Seed dressing – Cu, Zn added (a range of formulations). Not able to load up enough to meet all Mn demands
- Dry blended – Co-granulated (ie in the MAP melt)
  - Copper sulfate and/or copper oxysulfate – 2-10 kg/ha
  - Manganese sulfate (soluble) or oxysulfate – 10-20 kg/ha.
  - Acidification around granule – enhanced uptake
  - Residual response.
- Fluid applied in-furrow
  - Foliar

Co-granulation of TE with NPK(S) is beneficial



Delivering micronutrients



- What is the right source?

- Chlorides – high solubility (foliar damage)
- Oxysulfates – suitable only for dry blending
- Sulfates (esp. Cu)– generally moderate solubility - corrosive
- Oxides– low to very low solubility
- Chelates – protected

- Low solubility not all bad, high solubility not all good.
- Match products on cost and active delivered

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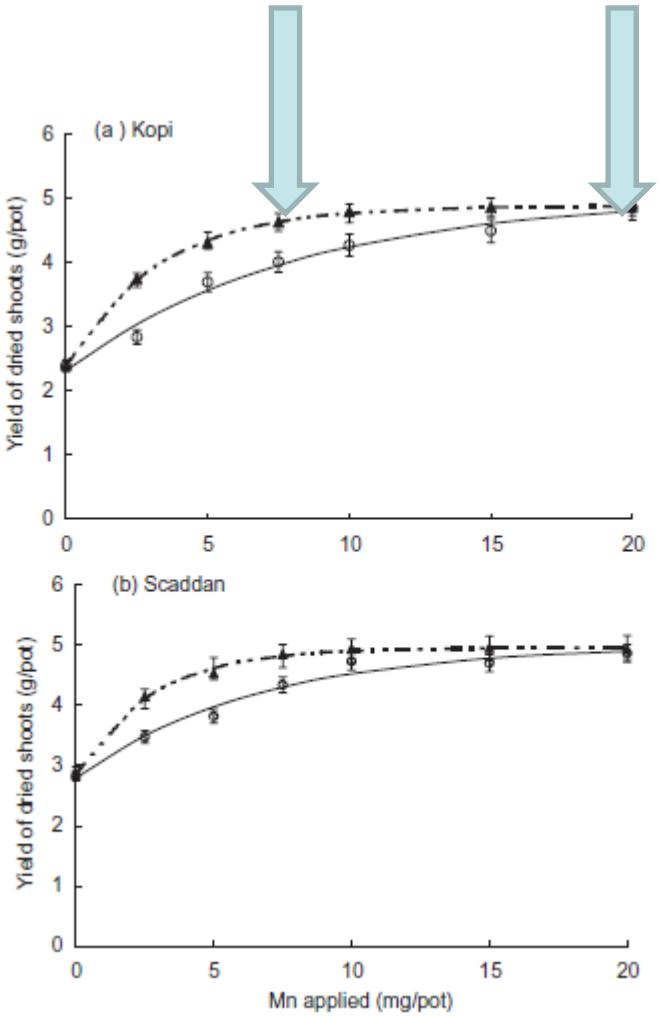
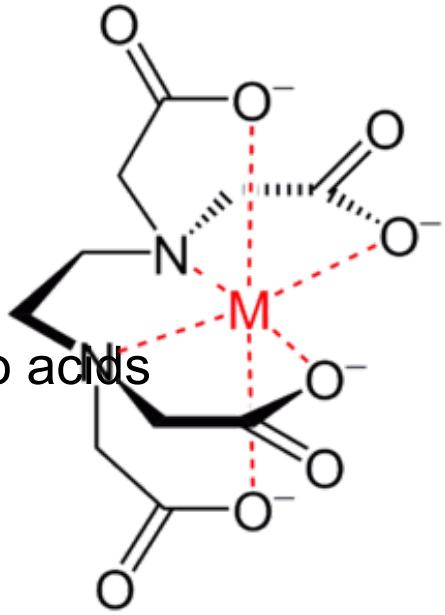
Source comparisons

- Soil applied MnO v $MnSO_4$ mixed through the soil
- Range of rates, 2 soils
- Compare the shape of the curve – rate to reach maximum yield.
- Oxide 40% as effective as sulphate form.



Fighting the chemical battle

- Chelating agents form bonds with metallic ions (ligands)
  - Synthetic *eg* EDTA, Humic and fulvic acids, Organic acids *eg* citric acid (divalent cations), Amino acids
  - New chemistry coming for trace element chelates
    - Rhamnolipids, Polyethyleneimine



- Prevent interaction with soil
- Protect micronutrient in spray tank
- Reduce canopy damage

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As a foliar?

- Little or no residual value
- For Cu and Mn, recovery from early deficiency is OK.
- Generally need more at seeding than as a foliar – residual Cu response
- Cost per kg nutrient
- Product Efficacy comparisons
- Supplements, adjuvants, magic potions.
  - Need proper data on the efficacy – field trials.
- *Key selection criterion is the potential for immobilization in soil*

- *Ignorance more frequently begets confidence than does knowledge.*
  - *Charles Darwin*

Species	Foliar Uncertain ~1 kg Zn/ ha	Soil >5 kg Zn/ ha	Source
Wheat	2-29	22	Duncan, 1967a
Wheat	16	39	Takkar 1989

% response over control

Copper Sources

- Foliar application products compared.
- WA a long time ago.
- Relative effectiveness
  - Sulfate = 1 (250 g/ha)
  - Chelate = 1.72-2.24 (150 g/ha)
  - Oxychloride = 0.47 – 0.63 (520 g/ha)
  - RATE VERSUS FORMULATION
- Timing
  - Most effective was the chelate applied early (2-3 leaf).

Cu source	A (t/ha)	A_0 (t/ha)	C ($10^2 \times C$)	RE[A]
	Experiment 1a			
Chelate	2.27 ± 0.02	1.56 ± 0.09	2.581	1.77
Sulphate	2.25 ± 0.03	1.56 ± 0.08	1.457	1.0
	Experiment 1b			
Chelate	2.14 ± 0.02	1.56 ± 0.06	2.248	1.97
Sulphate	2.14 ± 0.01	1.56 ± 0.04	1.140	1.0
	Experiment 2a			
Oxychloride	2.59 ± 0.05	0.66 ± 0.02	0.705	0.49
Chelate	2.53 ± 0.01	0.63 ± 0.01	2.476	1.72
Sulphate	2.53 ± 0.02	0.64 ± 0.01	1.442	1.0
	Experiment 2b			
Oxychloride	2.32 ± 0.05	0.61 ± 0.02	0.610	0.49
Chelate	2.27 ± 0.02	0.60 ± 0.01	2.265	1.81
Sulphate	2.28 ± 0.04	0.63 ± 0.02	1.252	1.0
	Experiment 3			
Oxychloride	1.93 ± 0.02	0.35 ± 0.05	0.934	0.63
Chelate	1.94 ± 0.07	0.32 ± 0.02	3.015	2.02
Sulphate	1.94 ± 0.04	0.33 ± 0.01	1.490	1.0
	Experiment 4			
Oxychloride	2.15 ± 0.09	0.33 ± 0.02	0.407	0.47
Chelate	2.05 ± 0.04	0.35 ± 0.01	1.925	2.24
Sulphate	2.08 ± 0.03	0.35 ± 0.01	0.860	1.0

[A] C_x/C_s is the RE where C_x is the curvature coefficient for any of the three Cu sources while C_s is the curvature coefficient for $CuSO_4$.

Brennan, 1990, AJEA.

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Is there a magic formula for success?

Copper

- At-sowing – more residual, formulation, delivery 1-5 Cu kg/ha.
- Copper as foliar – do the sums on sulfate/chelate $, 50-100 g Cu/ha, foliar damage
- Apply earlier rather than later.

Manganese

- As foliar as symptoms appear
- ~200-500 g Mn/ha
- May need two applications.

COMPATIBILITY

YIELD RESPONSE

Mn product comparison

GRDC
Grains Research & Development Corporation
Your GRDC working with you

- Streaky Bay - Mn foliar source on wheat
  - Mn sulphate; Mn EDTA chelate; Mn Lignosulphate chelate; Mn Amino acid chelate (all label rates), as well as at 150 g Mn/ha
- One of a series of experiments on deployment of micronutrients
  - Large emphasis on fluid-in-furrow rate comparisons against foliar and granular.
  - Residual values of Cu/Mn/Zn products on SA soil types.
  - Building on the great work of Holloway et al. using fluid micronutrients (mixtures) and deep placement.

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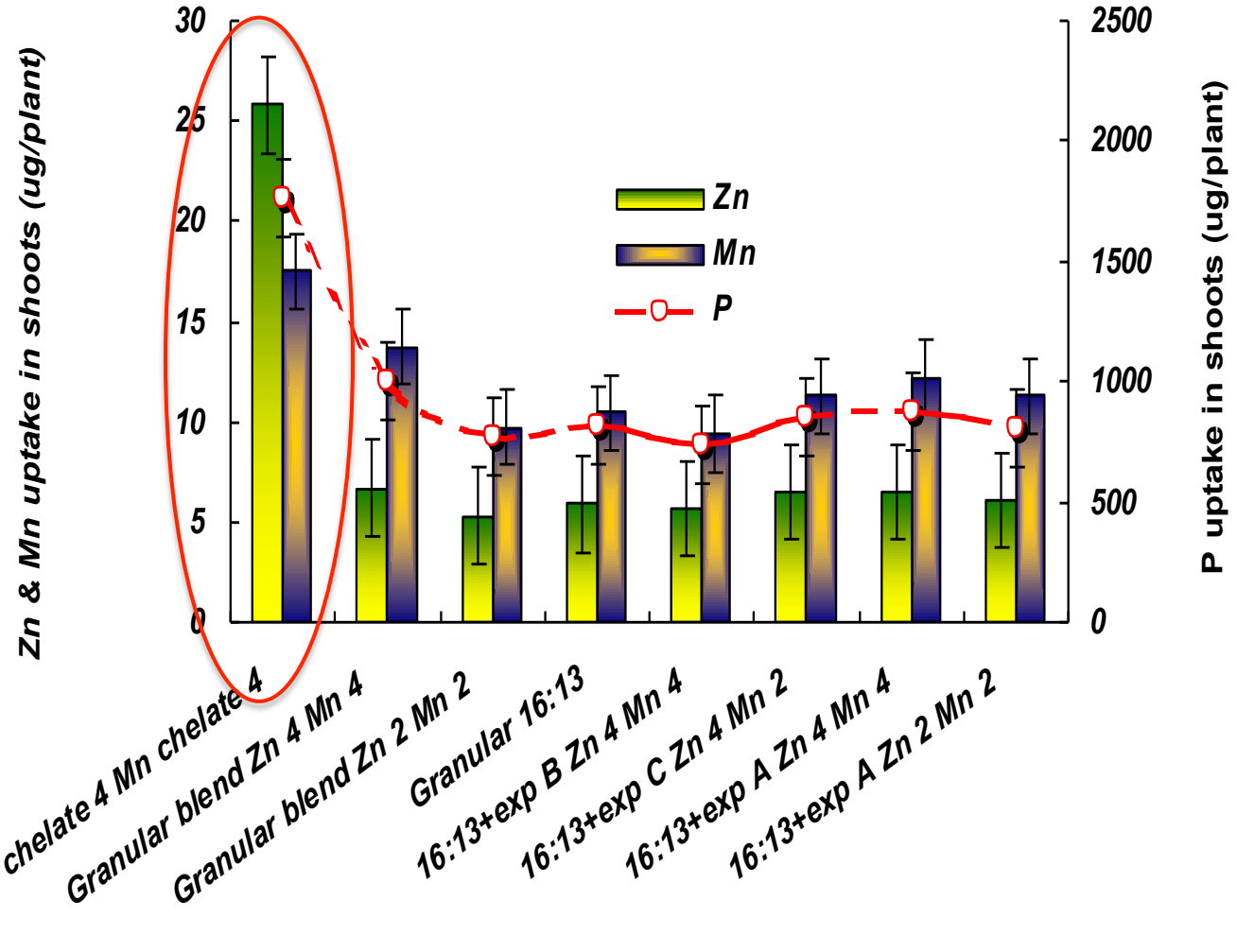
Improving TE fertilizer efficiency – fluid fertilizer field trials



Holloway, B., Brace, D., Richter, I., McLaughlin, M., Hettiarachchi, G., Armstrong, R. 2006. Improving micronutrient availability with fluids. Proceedings of 2006 Fluid Forum "Fluids: Balancing Fertility and Economics", Scottsdale AZ, USA, 12-14 February 2006.

Summary and take home

- There are areas where micronutrients will give benefits.
  - Sometimes it is obvious
- The tools for identifying specific risks are not so good.
  - Tissue testing (timing)
- Products on the market vary in efficiency and price.
  - Very little efficacy data in the public domain.
  - Demand that information from the supplier – from proper trials.
  - At sowing requires more product but is usually cheaper
  - Foliar is generally more expensive per kg supplied, but more efficient.
    - **$ for $ - do the sums**
    - **At sowing 5 kg @ $5/kg = $25**
    - **Foliar 2 kg @ $12/kg = $24**

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