




**International Fertiliser Industry Association  
2006 Agricultural Conference, Kunming, China**  
International Workshop on Micronutrients - 27<sup>th</sup> February

**Main Micronutrient Forms/Products Available  
and  
Methods of Application**

Dr. Kevin Moran  
Group Technical Director  
Phosyn plc, UK

IFA Micronutrient Workshop, Kunming, China, February 27, 2006



**Essential Fertiliser Nutrients for  
Crops**

<b>PRIMARY NUTRIENTS</b>	<b>SECONDARY NUTRIENTS</b>	<b>MICRONUTRIENTS (Trace Elements)</b>
Nitrogen (N) Phosphorus (P) Potassium (K)	Calcium (Ca) Magnesium (Mg) Sulphur (S)	Boron (B) Copper (Cu) Iron (Fe) Manganese (Mn) Molybdenum (Mo) Zinc (Zn) *

\* Chlorine (Cl) and Nickel (Ni) have also been proposed  
Cobalt (Co) is required by root nodule bacteria in legumes (pulse crops)  
Selenium (Se) and Iodine (I) are also required by humans and animals

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## Main Micronutrient Forms/Products Available

### “Straight” Inorganics (1970’s)

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## Inorganic Sources of Micronutrients - “Straights”

Material	Element	Water Solubility (g/100g H <sub>2</sub> O)
<b>Sources of boron</b>		
Granular borax	11.3	2.5
Sodium tetraborate, anhydrous	21.5	1.3
Solubor®	20.5	22
<b>Sources of copper</b>		
Copper sulfate	25.0	24
Cuprous oxide	88.8	sparingly soluble
Cupric oxide	79.8	sparingly soluble

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## Inorganic Sources of Micronutrients - “Straights”

Material	Element	Water Solubility (g/100g H <sub>2</sub> O)
<b>Sources of iron</b>		
Ferrous sulfate	20.1	33
Ferric sulfate	19.9	440
<b>Sources of manganese</b>		
Manganous sulphate	24.6	105
Manganous carbonate	47.8	Sparingly soluble
Manganous chloride	43.7	63

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## Inorganic Sources of Micronutrients - “Straights”

Material	Element	Water Solubility (g/100g H <sub>2</sub> O)
<b>Sources of molybdenum</b>		
Sodium molybdate	39.7	56
Ammonium molybdate	54.3	44
<b>Sources of zinc</b>		
Zinc sulfate	36.4	89
Zinc oxide	80.3	sparingly soluble
Zinc oxysulfate (oxide + sulphate)	53.8	variable
Zinc nitrate	22.0	324

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## Application of “Straights”



**Mainly for Soil Application –**  
ploughed down,  
broadcast,  
or dry blended  
with NPK's


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## Main Micronutrient Forms/Products Available


**“Formulated” Inorganics**  
(Mid-late 1970's)

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## Benefits of “Wetters”

no wetter      **Increasing concentration of wetting agent** →




**LEAF SURFACE**


**Small area of contact meaning reduced uptake and possible localised scorch**

**Increased area of contact giving improved uptake and reduced risk of scorch**


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## Benefits of “Stickers”

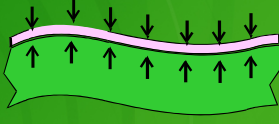


**Non formulated product**



**Product washed from leaf**

**Formulated product**



**Product stays on leaf**

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Foliar sprays of “formulated” inorganics are cost effective and safe micronutrient treatments -



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- and in very demanding conditions where rainfastness is critical to successful treatment



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## Main Micronutrient Forms/Products Available

# Complexes/Chelates (1980's)

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## “Complexes”

A group of substances consisting of a central ion bound by two or more “chemical” bonds of sufficient stability that the ion **does not undergo many of its typical reactions**

Adapted from: Official Pub. No. 57 (2004); Association of American Plant Food Control Officials (AAPFCO)

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## Chelates

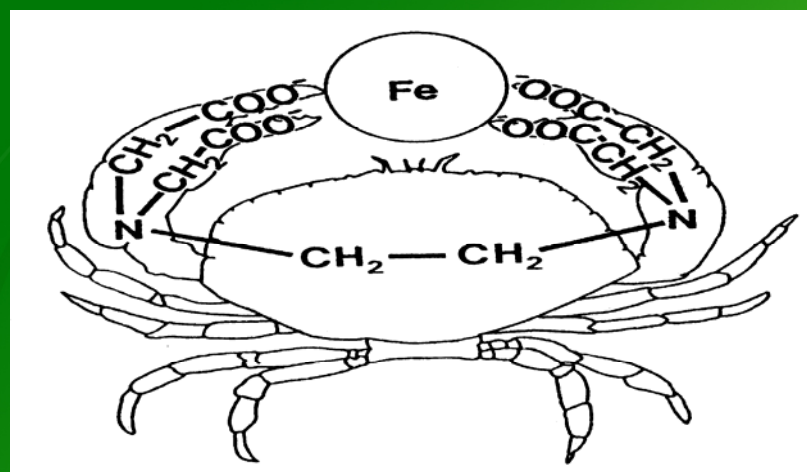
A special group of “complexes” in which the central metal micronutrient ions, Cu, Fe, Mn or Zn, are surrounded by a **cyclic (ring) structure which makes them particularly stable**

Adapted from: Official Pub. No. 57 (2004); Association of American Plant Food Control Officials (AAPFCO)

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## The chelate FeEDTA showing the cyclic, ring-like configuration



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## Micronutrient Content of Typical Chelates

Chelating Agent	Initial	% Micronutrient			
		Cu	Fe	Mn	Zn
EthyleneDiamineTetra – Acetic acid	EDTA	7-13	5-14	5-12	6-14
EthyleneDiamineDiHydroxyphenyl – Acetic acid	EDDHA	-	4-6 Lower % for liquids and higher for powders	-	-
DiethyleneTriaminePenta – Acetic acid	DTPA	-	10	-	-

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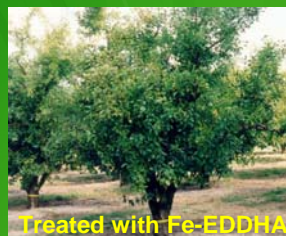
## Chelated micronutrients are best for hydroponics and fertigation -



- and soil applied EDDHA remains the best way to control Fe deficiency




Fe-deficient plum trees



Treated with Fe-EDDHA


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## Analysis of Different Types of Liquid Micronutrient “Complexes”

MICRONUTRIENT	“COMPLEX” TYPE	TYPICAL ANALYSIS
BORON (B)	Boron - alkanolamine	150 gm/litre
MOLYBDENUM (Mo)	Inorgano - molybdate	250 gm/litre
COPPER (Cu)	Cu – EDTA chelate	93 gm/litre
IRON (Fe)	Fe – EDDHA chelate	50 gm/litre

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- 
- ## Features to be Considered in Selecting a Micronutrient Treatment
- Amount (units) of micronutrient present
  - Cost per micronutrient unit – value for money
  - Rate of application per unit area per season
  - Ease, convenience and practicality of handling and use for trouble-free integration
  - Co-application characteristics
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## Features to be Considered in Selecting a Micronutrient Treatments - continued

- Control of deficiency
- Quality and consistency of performance
- Technical support and advice provided
- But the micronutrient treatments reviewed so far do **NOT** possess **ALL** of these features
- However in recent years an innovatively designed micronutrient product type has been developed that does possess **ALL**

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## Main Micronutrient Forms/Products Available

### Suspension Concentrates (1990's to date)

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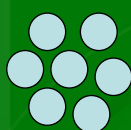
## Suspension Concentrates (SC's)

- Use very precise quality grades and specifications of inorganic micronutrient forms
- Highest micronutrient (unit) content of ANY available product developed so far
- Micronised particle sizes enable excellent performance and availability to crops...
- ...and provide controlled-release of micronutrients over an extended period
- Low treatment rates, very safe to use, superb co-application characteristics
- Extremely versatile for foliar, seed treatment and fertiliser "impregnation" applications

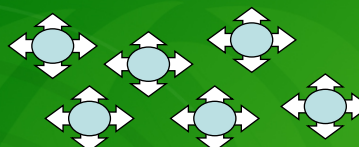
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## Dispersion Agents – Core Technology of Suspension Concentrates (SC's)



**No Dispersion Agents:** Particles in natural state are agglomerated or aggregated and "fall-out"



**With Dispersion Agents:** Particles remain dispersed after electrical or "steric" stabilisation



(2004; Capture from Phosyn Formulations Interactive CD-ROM)

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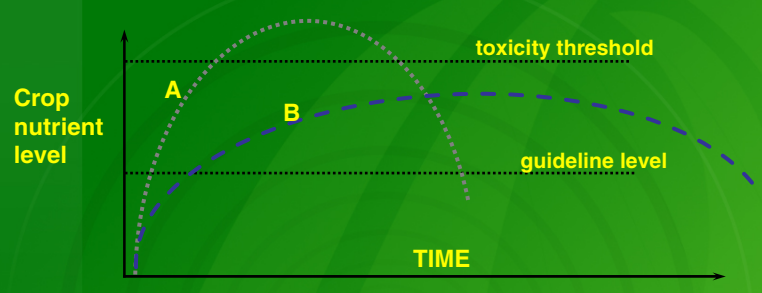
## Typical Micronutrient Content and Density Ranges of SC's

Micronutrient	Micronutrient Content (gm/litre)	Density (kg/litre)
Copper (Cu)	250 – 500	1.3 – 1.7
Manganese (Mn)	400 – 500	1.7 – 1.8
Zinc (Zn)	600 – 700	1.7 – 2.0

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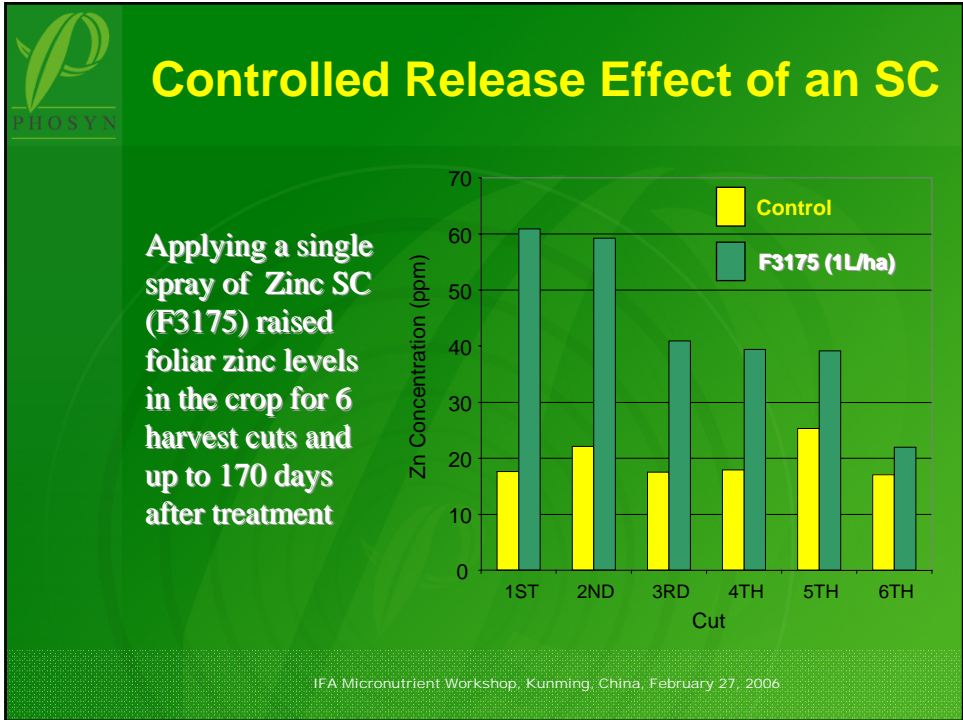
## SC's - Foliar Application



**A: Undesirable performance characteristics**

**B: Desired performance characteristics – typical SC**

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## Zinc Seed Treatment @ 4 litres/tonne (l/t) improves Crop Vigour (right) in Paraguay




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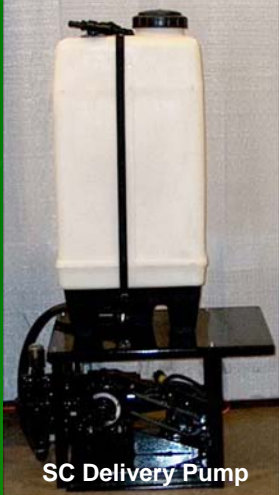
## Improved Root Structure (left) from Zinc Seed Treatment @ 4 l/t in France

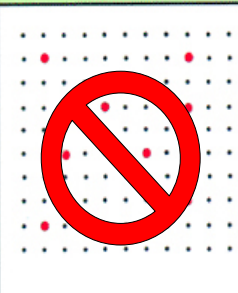
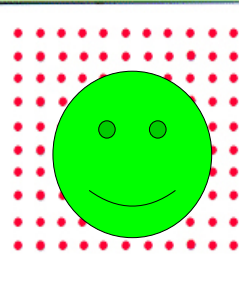


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# SC's - Fertiliser Impregnation




Blending	Impregnation
Heterogeneous Mix	Homogeneous Mix
	

- **Fertiliser granule**
- **Micronutrient**


SC Delivery Pump

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# Soil and Tissue Analysis are essential for Appropriate Micronutrient Applications

**Analysis removes guesswork ensuring the treatment fits requirement**



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