Slow-release micronutrient fertilizers

Biorelease Smart Fertilizers

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Innovator

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Recognitions

Fellow, National Academy of Agricultural Sciences, India

Fellow, State Academy of Science & Technology

Awards

Young Scientist Award, Indian National Science Academy

Young Scientist, Department of Scientist & Technology

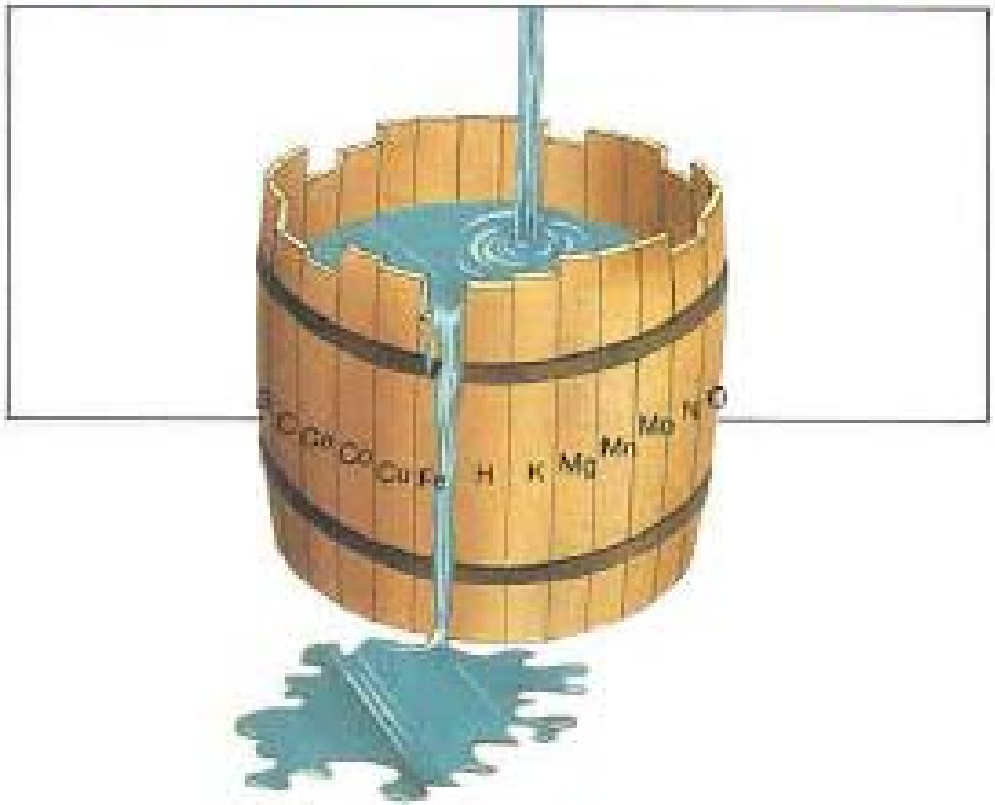
UNESCO-ROSTCA Award

Lockheed Martin India Innovation Gold Medal

Micronutrient fertilizers

- Necessary building blocks that plants require, e.g., iron, zinc
- Micronutrients improve yield & nutrition
- Micronutrient fertilizers needed in addition to NPK fertilizers

Why Crops Need Micronutrients?



Liebig's barrel: Yield-Limiting Factors

PRESENT STATE OF TECHNOLOGY

Limitations Of Water Soluble Fertilizers

- Conversion to non-available forms due to reactions with soil
- Ground water pollution due to leaching.
- Low use-efficiency.
- Low economic returns
- Usage is very limited and crop yields are poor

CONSEQUENCES

- High input costs
- Low usage for food crops
- Yields not optimized – Global food shortages
- Lower nutrient levels in cereals, grains, vegetables
- Water pollution

IMPROVED TECHNOLOGIES

	Polymer coated	Zeolite based	Gel based	Frits (glasses)	Oxides
Nutrients	NPK with traces of micronutrients	NPK with traces of micronutrients	NPK with traces of micronutrients	Micronutrients + phosphate	Micronutrient
Markets	Home gardens, Turfs, Golf courses	Golf course, flowers, turfs, etc	Agricultural crops, nursery, etc.	Very limited, mainly for boron	Mainly for zinc, for long term treatment
Applicability	Customized for soil & crop types	Non-commercial crops	Customized for soil & crop types	Sandy soils	Acidic soils

MECHANISMS OF SLOW-RELEASE

- By diffusion through a membrane or gel
- By hydrolytic solubilization
- Ion exchange
- Slow dissolution of insoluble materials

Biorelease Smart Micronutrients

✓ Bio-release smart fertilizer is a new category of slow-release fertilizer

➢Molecules designed so that nutrient release is governed by organic acids secreted by plants and microbes

➢The fertilizer effectively acts as a store from which crops can extract nutrients as and when they need it.

➢ They mimic the natural form of nutrients in soils. Nutrient release is under the control of the plant itself.

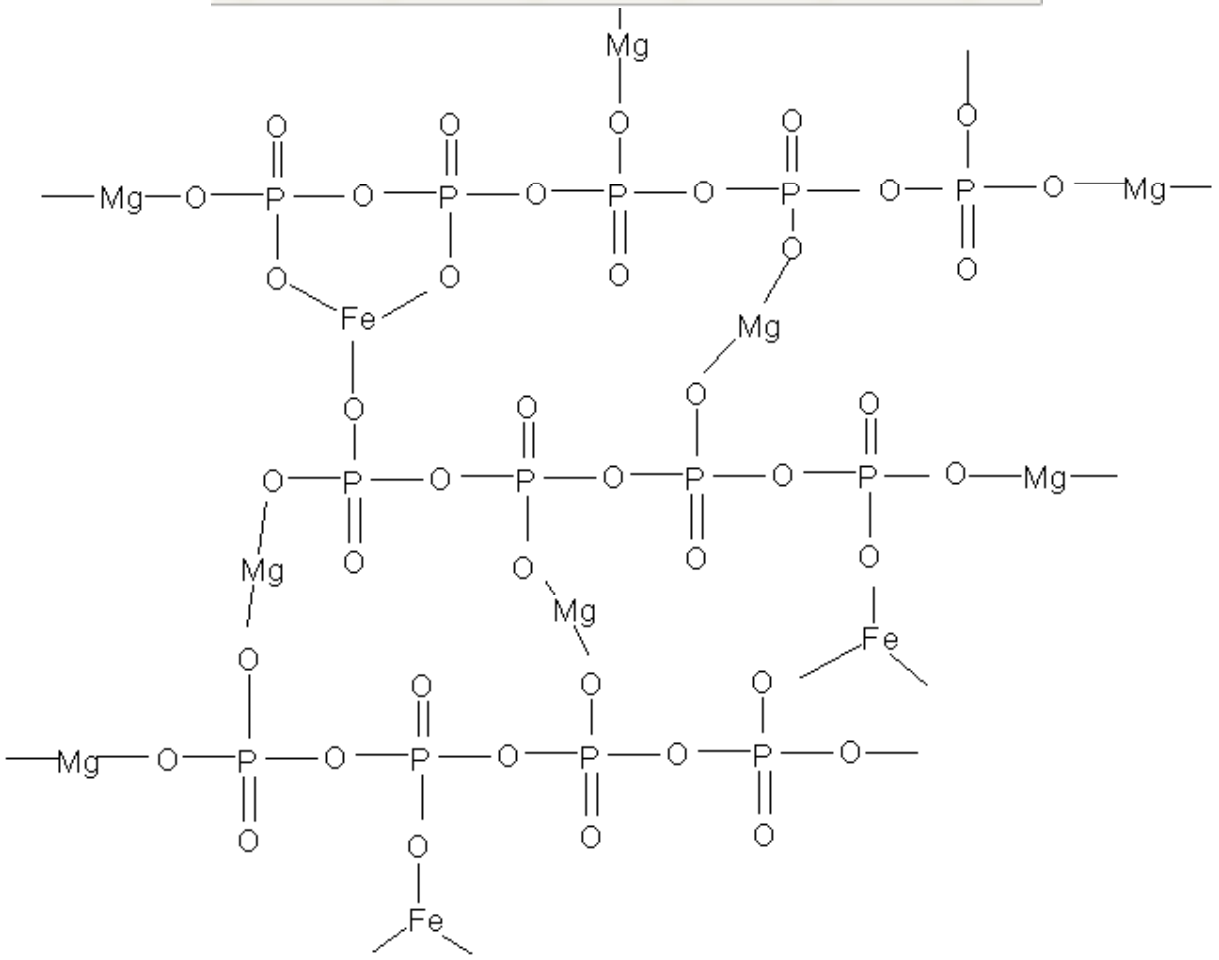
Characteristics

- ✓ Inorganic chemical compounds
- ✓ All constituents are plant nutrients
- ✓ Insoluble in water
- ✓ 100% soluble in citrate and DTPA
- ✓ Micronutrients in available form
- ✓ Powdery & non-hygroscopic

Chemical nature

- Inorganic polymers based on polymeric phosphates
- Major chemical constituents are micronutrients, P, Mg
- Have -P-O-P- linear chains that function as cation exchangers for micronutrient cations
- Crystalline

Typical Structure



From : A new slow-releasing iron fertilizer : Chemical Engineering Journal Volume 155, Issues 1-2, 2009, pp 451-456

Smart fertilizers developed

- Zinc
- Iron
- Manganese
- Copper

Any combinations of these in different ratios, with or without B and Mo (as compounds not mixtures)

- Iron-manganese-copper
- Zinc-iron-manganese-molybdenum
- Zinc-iron-manganese-copper-boron

Process outline

Phosphoric acid in reactor

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Add solids

↓

Heat with agitation to polymerize

↓

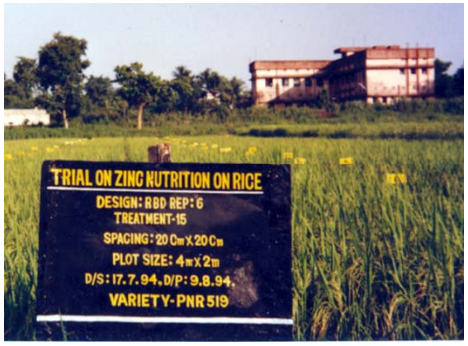
Neutralise

↓

Dry

↓

Pulverize



Raw materials

Phosphoric acid

With micronutrient source :

Zinc oxide / Iron ore fines / Iron oxide/ Manganese carbonate / Copper carbonate / Boric acid / Molybdenum trioxide

& base for neutralization

Magnesia / lime / ammonia

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Field trials

- About 20 field trials all over India
- With 10 different crops
- In 6 different types of soils
- In 7 states of India
- Eight of these conducted & certified by Agricultural Universities and Institutes
- Statistically designed trials with 6 replicates in Randomized Block Design

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Field trial results with zinc fertilizer

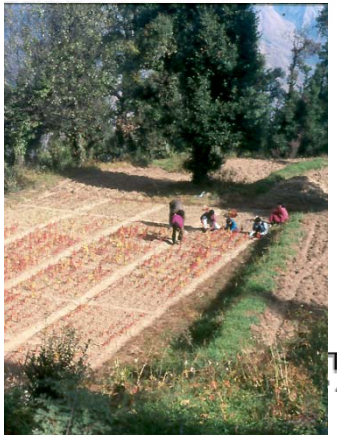
Location	Bio-release fertilizer dosage in kg/ha	Crop	Yield increase over control in kg/ha (no Zn)	Increase over control (no Zn)	Reduction in dosage compared to $ZnSO_4$	Increase over $ZnSO_4$
State Rice Research Station, West Bengal	2.27	Rice	637	14 %	60%	7 %
-do-	Residual	Rice	717	30 %	-	31 %
Rajendra Agricultural University, Pusa, Bihar	2.27	Rice	400	11 %	60%	10 %
-do-	Residual	Wheat	738	22 %	-	6 %
University of Agricultural Sciences, Bangalore, Karnataka	1.14	Corn	2378	59 %	75%	36 %
State Government Research Farm, Nagpur, Maharashtra	1.14	Wheat	1092	38 %	75%	28 %
Farmer's field, Murshidabad, WB	0.64	Green gram (pulses)	324	16 %	36%	6 %

Field trial results with multinutrient (Zinc-Iron-Manganese-Copper) fertilizer

Location	Bio-release fertilizer (dosage)	Crop	Yield increase over control in kg/ha	Increase over control (no micronutrient)	Reduction in dosage compared to sulfates	Increase over sulfates
Farmer's field, 24 Parganas	1 kg/ha Zn, 0.33 kg/ha Fe, 0.17 kg/ha Mn, 0.08 kg/ha Cu	**Rice**	**1405**	**43 %**	**75%**	**24 %**
Farmer's field, Hooghly	2 kg/ha Zn, 0.66 kg/ha Fe, 0.34 kg/ha Mn, 0.16 kg/ha Cu	**Rice**	**699**	**19 %**	**50%**	**15 %**
Farmer's field Hooghly	1 kg/ha Zn, 0.33 kg/ha Fe, 0.17 kg/ha Mn, 0.08 kg/ha Cu	**Potato**	**4175**	**42 %**	**75%**	**28 %**
Farmer's field, Murshidabad,	0.75 kg/ha Zn, 0.375 kg/ha Fe, 0.19 kg/ha Mn, 0.09 kg/ha Cu	**Red cabbage**	**9730**	**22 %**	**25%**	**9 %**
CRIJAF, ICAR, UP	2 kg/ha Fe, 1 kg/ha Mn	**Cauliflower**	**4452**	**40 %**	**0%**	**54 %**
DARL, Auli,Uttarakhand	1.2 kg/ha Zn, 0.9 kg/ha Fe, 0.45 kg/ha Mn, 0.6 kg/ha Cu,1.2 kg/ha B	**Radish**	**3290**	**61 %**	**-**	**-**

Performance benefits

Yield responses	Cost per acre	Protein content (green gram)	Vitamin C in vegetables	Zn & Fe in vegetables / cereals	Environment friendliness
Good	Reasonable	Significant increases (16%)	Significant increases (>30%)	Significant increases (>20%)	Good



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1) Chandra PK, Ghosh K and Varadachari C (2009) A new slow-releasing iron fertilizer, ***Chemical Engineering Journal [Elsevier],*** **155** 451-456.

2) Bandyopadhyay, S., Bhattacharya, I., Ghosh, K., and Varadachari, C. (2008) A New Slow-Releasing Molybdenum Fertilizer, ***Journal of Agricultural & Food Chemistry [American Chemical Society]***, **56** 1343-1349.

3) Bhattacharya I, Bandyopadhyay, S, Varadachari C and Ghosh K (2007) Development of a novel slow-releasing iron-manganese fertilizer compound, ***Industrial & Engineering Chemistry Research [American Chemical Society]*** **46** 2870-2876.

4) Ray S K, Varadachari C and Ghosh K (1997) Novel slow-releasing micronutrient fertilizers 2. Copper compounds, ***Journal of Agricultural & Food Chemistry [American Chemical Society]*** **45** 1447-1453.

5) Ray S K, Varadachari C and Ghosh K (1993) Novel slow-releasing micronutrient fertilizers. I. Zinc compounds, ***Industrial & Engineering Chemistry Research [American Chemical Society]*** **32** 1218-1227**.**

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IP Status

- Five US patent applications
- Nine Indian patents / applications

Economic, effective, environment-friendly

A new generation micronutrient fertilizers for the millennium

Winner of
Lockheed Martin India Innovation Award 2008

Judged by an International Team of Experts from IC2 Institute, University of Texas at Austin & Federation of Indian Chamber of Commerce & Industry (FICCI)

as the best out of over 350 technologies that competed from IITs, IISc, Companies,Government Institutes, Universities, etc

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Soil Information

Location	Soil type	pH	Texture (sand,silt,clay)	OM (g kg^{-1})	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
SRRS, West Bengal	Haplustalf	4.8	36, 34, 30	7.1	0.2	-	-	-
RAU, Pusa, Bihar	Ustifluvent	8.4	10, 40, 50	4.8	0.1	-	-	-
UAS, Bangalore, Karnataka	Haplustalf	5.6	83, 5, 12	4.1	1.1	-	-	-
SGRF, Nagpur, Maharashtra	Chromustert	8.0	9, 20,71	6.9	1.9	-	-	-
Farmer's field, Murshidabad	Haplustept	7.2	72, 7, 21	4.2	1.0	35	-	-
Farmer's field, 24 Parganas	Endoaquept	5.7	52, 9, 42	9.1	4.2	52	50	1.1
Farmer's field, Hooghly	Haplustept	6.2	59, 8, 33	6.9	2.7	60	69	0.6
CRIJAF, ICAR, UP	Haplustept	8.1	59, 21, 20	4.8	-	12	9	-
DARL, Auli	Dystudept	4.9	Sandy loam	38	5	68	-	1.4