PSP5 2014 – Facing Phosphorus Scarcity

HOW TO OPTIMIZE THE USE OF PHOSPHATE RESOURCES BY PRODUCING ALTERNATIVE TOTALLY ACIDULATED PHOSPHATE FERTILIZERS

Dr. Luís Ignácio Prochnow
IPNI Brazil Program Director

APATITE

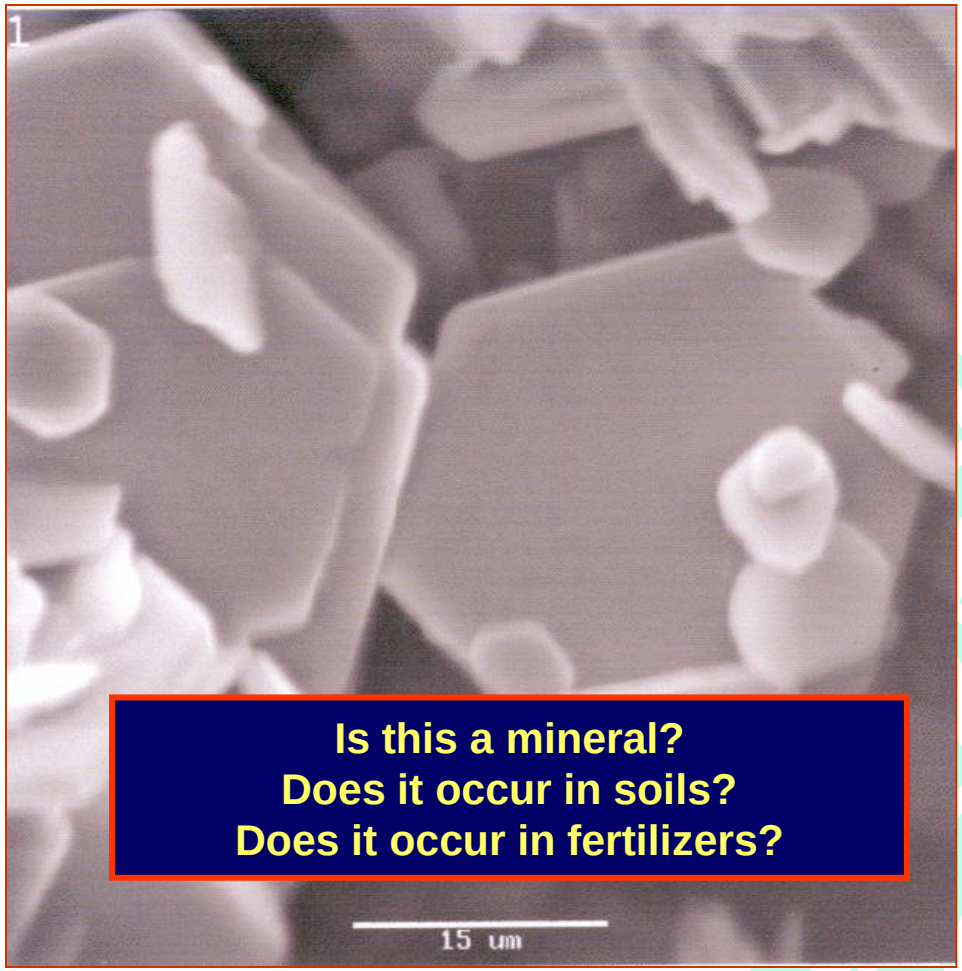
INITIAL CONSIDERATION

- ✓ **This presentation challenges researchers and the nutrient stakeholders to think differently regarding P sources.**

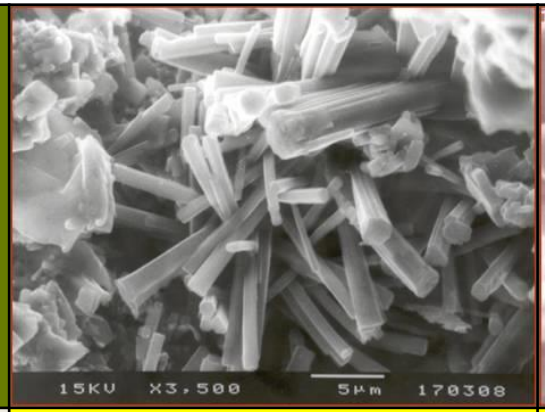
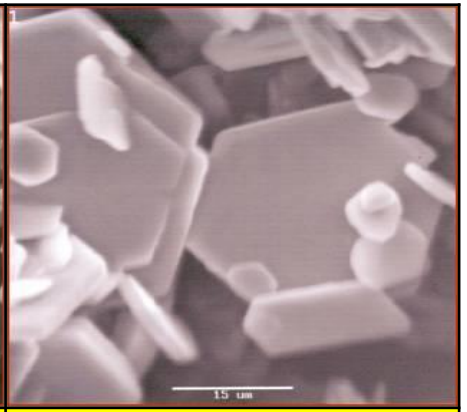
WHAT IS THIS?

Is this a mineral?
Does it occur in soils?
Does it occur in fertilizers?

WHAT IS THIS?



Is this a mineral?
Does it occur in soils?
Does it occur in fertilizers?

QUESTION/ COMPOUND CHARACTERIZATION		
Chemical Formula	$Fe_3KH_8(PO_4)_6.6H_2O$	$Fe_3KH_{14}(PO_4)_8.4H_2O$
Is it a mineral?	No	No
Where does it precipitate?	P Fertilizer, Generally in SSP	P Fertilizer, Generally in TSP
Total P (TP)	20.4	23.8
NAC Soluble P (CSP)	19.3	22.8
Water Soluble P (WSP)	0.03	0.2
(WSP/CSP) * 100	0.2	0.9
RAE(MCP; Upland Rice)	33	73
RAE (MCP; Flooded Rice)	75	104

Both compounds are much avoided by the P fertilizer industry because of their low water solubility. Does science prove this to be always necessary?

BACKGROUND INFORMATION

- ✓ **Totally acidulated P fertilizers (SSP, TSP, MAP, DAP) have high water solubility (WSP).**
- ✓ **Premium Grade PR to produce such fertilizers is decreasing worldwide.**
- ✓ **High amounts of energy and money are spent in order to always produce P fertilizers with high contents of WSP.**
- ✓ **To produce high WSP P sources part of the apatite concentrates are discarded, which means lost and potential environmental problems.**
- ✓ **Is it really necessary for totally acidulated P sources (not PAPR) to always have high water solubility?**
- ✓ **Interest and momentum exist to consider maybe such requirement is not necessary, leading to a better use of PR?**

STUDY 1

Characterization and agronomic evaluation of single superphosphates varying in iron phosphate impurities

P Source	P				Fe	fi
	Total	Available	Water	2% C.A.		
	%					
MCP	55.8	55.3	54.6	54.3	1.3	99
SSP1	20.8	19.6	16.8	17.6	2.2	86
SSP2	17.2	16.1	12.8	14.1	4.3	80
SSP3	17.7	16.4	7.5	10.2	5.8	46

46% of WSP

N.	Compound	SSP1	SSP2	SSP3
1	Fe3KH8(PO4)6	0.4	0.4	0.6
2	Fe3NaH8(PO4)6	5.02	3.35	6.36
3	Fe3H9(PO4)6	0.4	6.19	12.34
4	Na2SiF6	0.25	0.41	0.33
5	Ca10(PO4)6OH0.97F1.03	2.82	2.6	3.09
6	Ca4SiAlSO4F13	2.18	0.4	2.1
7	SiO2	0	0	0.73
8	CaF2	0.25	1.44	0
9	MgSO4	0.35	0.4	0.45
10	SrSO4	1.53	1.32	1.17
11	ZnSO4	0.07	0.1	0.15
12	Ti2(SO4)3	0.92	1.4	1.88
13	BaSO4	1.92	1.14	1.28
14	Al2(SO4)3	0.25	1.27	1.08
15	Ba(H2PO4)2	0.19	0.41	0.28
16	CaSO4	49.15	49.7	46.87
17	Ca(H2PO4)2	34.19	19.08	12.81
	TOTAL	99.89	89.61	91.52

P Source	Dry-matter yield	P uptake
	Upland Rice	
MCP	100	100
SSP1	98	88
SSP2	96	93
SSP3	88	76
	Flooded Rice	
MCP	100	100
SSP1	97	91
SSP2	111	110
SSP3	102	85

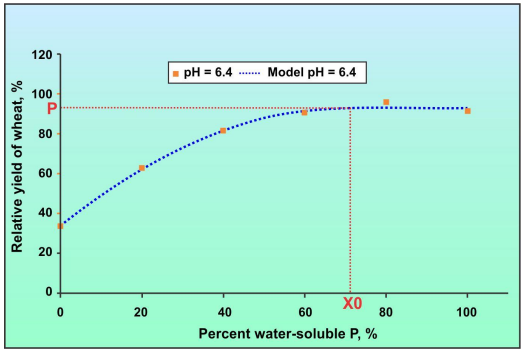
mcp: Standard source of P

RAE = (bi/bMCP)*100, *i* = other SSP

Source: PROCHNOW, L.I.; CHIEN, S.H.; TAYLOR, R.W.; CARMONA, G.; HENAO, J. & DILLARD, E.F. Agronomy Journal. 95:293-302, 2003.

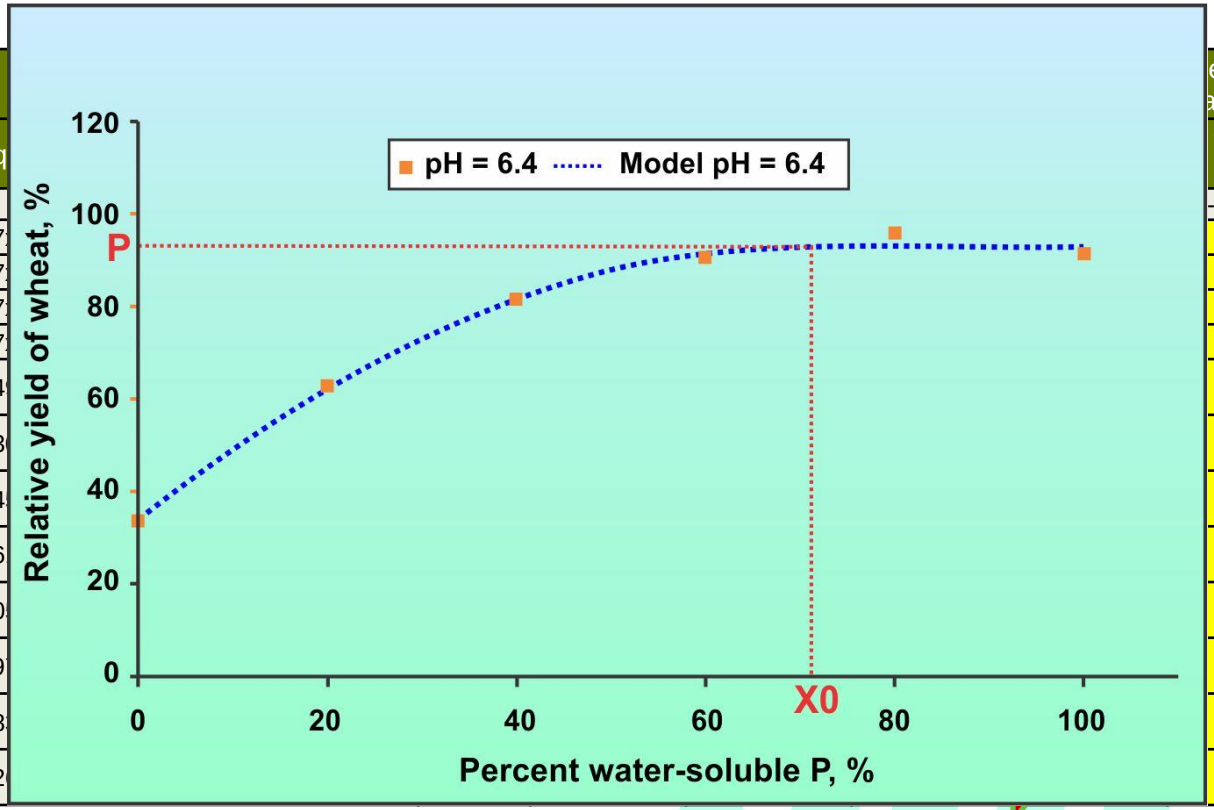
STUDY 2

Plant Availability of Phosphorus in Four Superphosphate Fertilizers Varying in Water-Insoluble Phosphate Compounds



Fonte de P[a]	pH	Eq	erido para ar [c] 90% do plateau

MCP-DMY	5,2	y = 0,94 + 0,957	
MCP-RY	5,2	y = 3,27 + 3,337	
MCP-DMY	6,4	y = 0,70 + 1,447	
MCP-RY	6,4	y = 2,44 + 5,047	
TSP 1-RY	5,2	y = 35,44 + 1,24	46
TSP 1-RY	6,4	y = 34,13 + 1,83	36
TSP 2-RY	5,2	y = 47,98 + 0,74	49
TSP 2-RY	6,4	y = 42,97 + 1,16	48
SSP 1-RY	5,2	y = 17,93 + 1,70	48
SSP 1-RY	6,4	y = 24,42 + 1,89	46
SSP 2-RY	5,2	y = 58,76 + 0,68	31
SSP 2-RY	6,4	y = 60,97 + 0,92	31



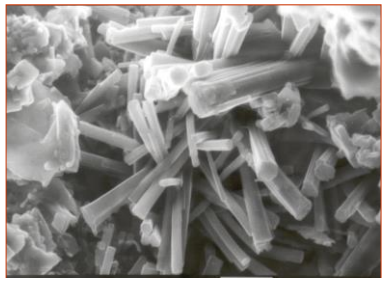
Source: PROCHNOW, L.I.; CHIEN, S.H.; CARMONA, G.; HENAO, J.; DILLARD, E.F.; AUSTIN, E.R. Soil Science Society of America Journal, 72:462-470, 2008.

STUDY 3

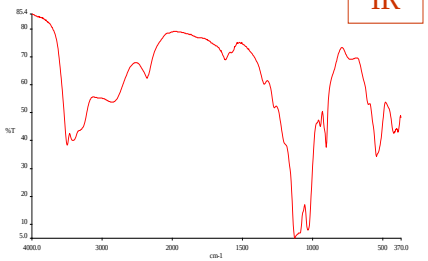
Synthesis, characterization and agronomic evaluation of iron phosphate impurities in superphosphates

$Fe_3KH_8(PO_4)_6.6H_2O$

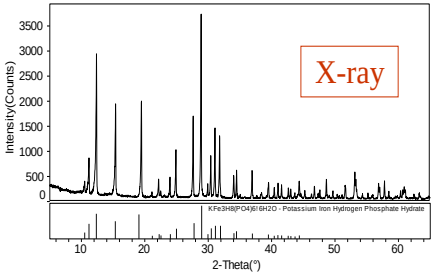
SEM



IR



X-ray



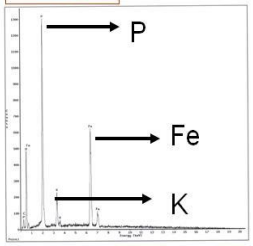
Chemical Analysis for total P, Fe, K, S and water of hydration ✍

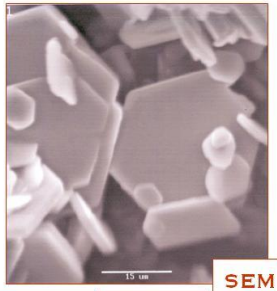
Calculated Formula:

$Fe_{2.8}K_{1.1}H_8(PO_4)_6!6.1H_2O$

$Fe_3KH_{14}(PO_4)_8.4H_2O$

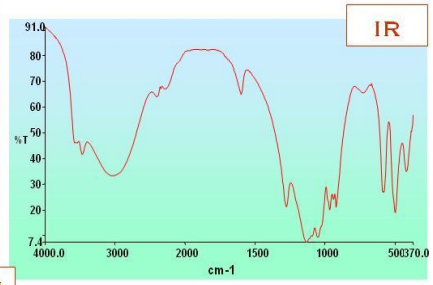
EDX



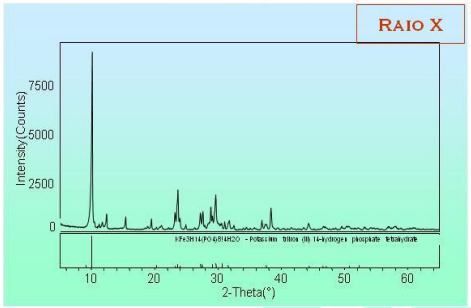


SEM

IR



RAIO X



Análise química para P total, Fe, K, S e água de hidratação

Fórmula calculada:

$Fe_{3.0}K_{0.9}H_{14}(PO_4)_8.4.3H_2O$

Source: PROCHNOW, L.I.; CHIEN, S.H.; et al. Soil Science Society of America Journal. 67:1551-1563, 2003.

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STUDY 3

Synthesis, characterization and agronomic evaluation of iron phosphate impurities in superphosphates

P Source	Crop	Segmented Regression Model			WSP (%) required to reach §	
		Quadratic Equation	SE†	Plateau	Plateau	90% of Plateau
H8-syn	Upland Rice	$Y=7.81+0.28X-6.2x10^{-3}X^2$	1.59	35.3	66.6	42.7
H14-syn	Upland Rice	$Y=22.83+0.398X-2.8x10^{-3}X^2$	2.36	36.9	70.9	34.6
H8-syn	Flooded Rice	$Y=14.52+1.168X-20.0x10^{-3}X^2$	2.15	31.6	29.3	16.7
H14-syn	Flooded Rice	$Y=25.08+0.299X-3.8x10^{-3}X^2$	1.45	30.9	39.1	10.6

† Standard error for comparing predicted values.
§ Percentage water-soluble P needed to obtain the plateau or 90% of the plateau of the segmented model.

Source: PROCHNOW, L.I.; CHIEN, S.H.; et al. Soil Science Society of America Journal. 67:1551-1563, 2003.

DOESN'T IT SOUND FUNNY ?

The fertilizer industry spends energy and money to transform phosphate rock, which has very low water solubility, in highly soluble P sources, like SSP, TSP, MAP, DAP, and then, because it is too soluble, many try to somehow protect it for lower water solubility ?

Isn't there another possibility ?
Isn't there a more logical possibility?

WHAT IS THE PRACTICAL MEANING OF HAVING TOTALLY ACIDULATED P FERTILIZERS WITH LOWER WSP BUT WITH HIGH AGRONOMIC EFFECTIVENES ?

- ✓ **Decrease in disposal of part of certain P resources.**
- ✓ **Lower WSP sources = lower potential environmental problems.**
- ✓ **Higher efficiency.**
- ✓ **Optimization in the use of P Resources.**
- ✓ **Anyone interested?**

Statistical Group Experiment Analysis
- 16 Field Experiments -

Treatment	P SOURCE	AVERAGE RAE	
1	SSP GCA (High WSP)	96.1	A
2	SSP RCA (Low WSP)	95.3	A
3	SSP GCA/RCA	94.5	A
4	SSP Patos (Low WSP)	95.5	A

Source: PROCHNOW, L.I. Unpublished. Scientific Report.

GENERAL CONCLUSIONS

- ✓ **Research has showed not to be necessary to always have high water-solubility in fully acidulated phosphate fertilizers. Data obtained indicated that the WSP requirement should be related to the soil system, the crop and the chemical composition of the fertilizer.**
- ✓ **Some Fe-P compounds, now avoided by the industry, can be good sources of P in some circuntances and can be agronomically more effective as a source of P under flooded soil systems than for upland crop systems.**
- ✓ **This all translates into possibilities for specific sources for different agro-climatic conditions, with a better use of P Resources.**

Lehr (1980)

Are water-insoluble phosphates to be avoided at all cost?

The need for a more realistic set of product specifications is one of the most important problems confronting phosphate producers to seek relief from unnecessary and costly purification steps. Only agronomic research can provide the necessary guidance.

QUESTION

Some have been repeating the same message, now with more data, that Lehr stated decades ago. Why no action to optimize the use of PRs by producing alternative totally acidulated P fertilizers with lower water solubility ?

- ✓ **No credibility.**
- ✓ **More studies needed.**
- ✓ **People resist to change.**

I invite you to think about this possibility

THANKS FOR YOUR ATTENTION!

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Website: http://brasil.ipni.net
Telephone/fax: 55 (19) 3433-3254