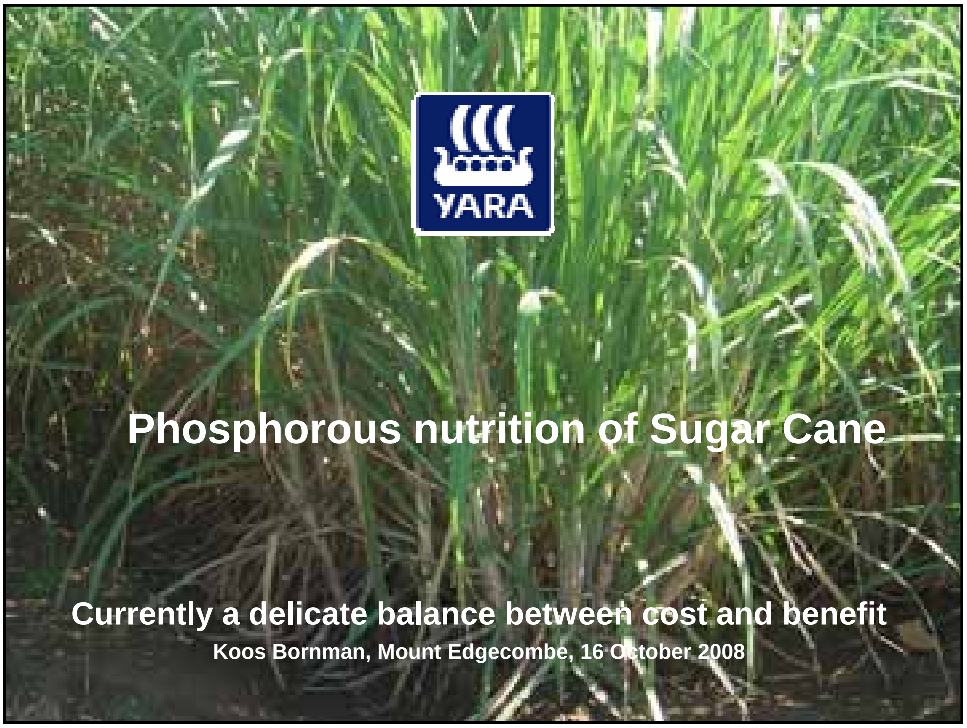


Phosphorous nutrition of Sugar Cane

Currently a delicate balance between cost and benefit

Koos Bornman, Mount Edgecombe, 16 October 2008

Content

- Why such high phosphorous prices?
- Current price ratios and economic optima for P and cane sugar production
- Lime and P interaction.
- Increasing the efficiency of P with organic material
- Use of rock phosphates
- “New” products and concepts

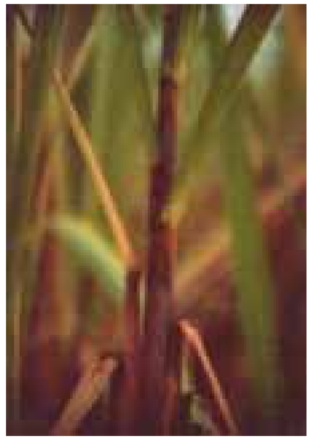
Phosphorus is essential for

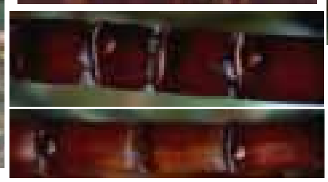
- Productive growth
  - More tillers
  - Quicker canopy closure
  - Stronger stalk development
  - Increased root mass
- Yield
- Sugar quality

- Adequate P levels (3 – 4 mg/l) are necessary in cane juice for proper clarification

  http://www.sugarcanecrops.com/agronomic_practices/fertigation/

P deficiency in Cane





Anderson and Bowen (1994 – INPOFOS)

Poor Tillering due to P deficiency

India

Phosphorus Deficiency

Brazil

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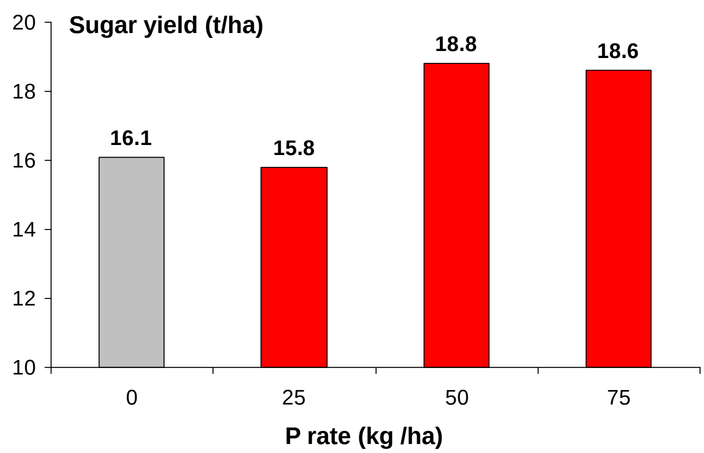
Phosphorus increases sugar yield

Maharashtra, India – planting crop



Fertilizer rates (kg/ha): N 180, K 100, S 20, + Zn, Fe, Mn

REF: Phonde et al. (2005)

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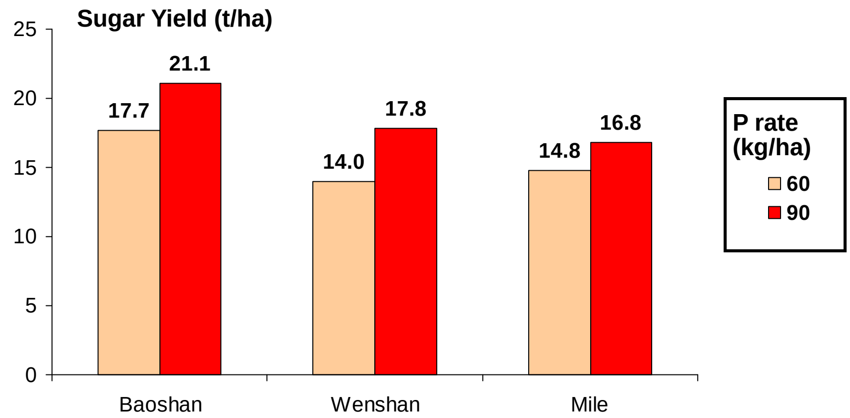
Phosphorus increases sugar yield

China (Yunnan province) – ratoon crop



REF: Hong Lifang et al. (2001)

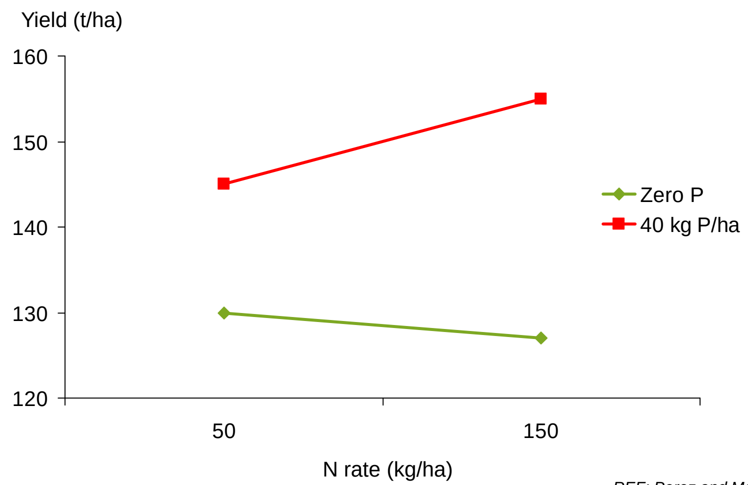
P increases cane/sugar yield and sucrose%

South Africa

	Site Inanda			Site Melmoth		
	Yield (t/ha)	Sucrose %	Sugar yield (t/ha)	Yield (t/ha)	Sucrose %	Sugar yield (t/ha)
No P	66.7	13.4	8.9	19.9	15.7	3.1
Superphosphate @1100 kg/ha	166.4	14.9	24.8	95.6	17.5	16.8

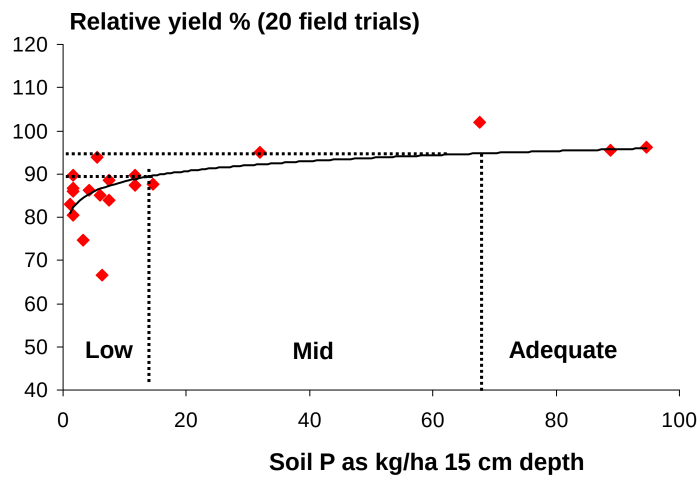
Wood (1990)

Effect of N on yield - with and without P
Guatemala – plant cane



REF: Perez and Melgar (1998)

Soil P levels and Cane yield
Guatemala

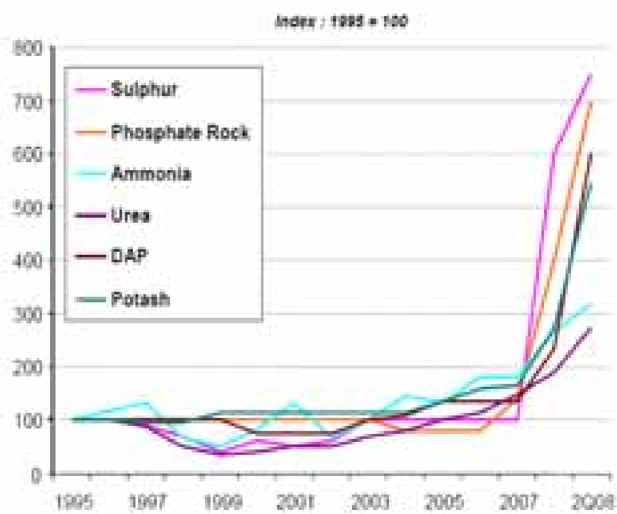


REF: Perez et al. (2003)

Average N mineralised versus soil organic matter

N mineralisation index	Organic matter%	Average N release Kg/ha/an
Very low	< 1	< 20
Low	1 to 2	20 to 40
Medium	2 to 3	40 to 60
High	3 to 4	60 to 80
Very high	> 4	>80

Fertilizers and Raw Materials : Historical Prices



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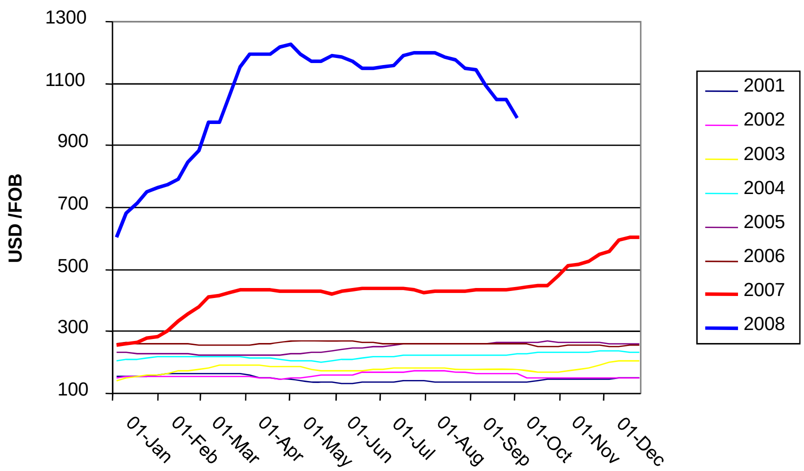
DAP prices - Tampa



Source: FMB

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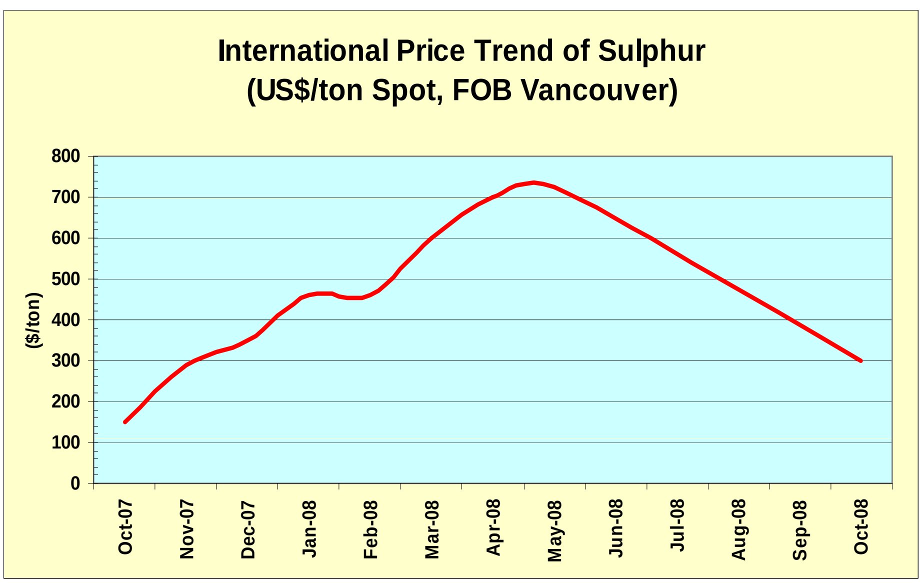

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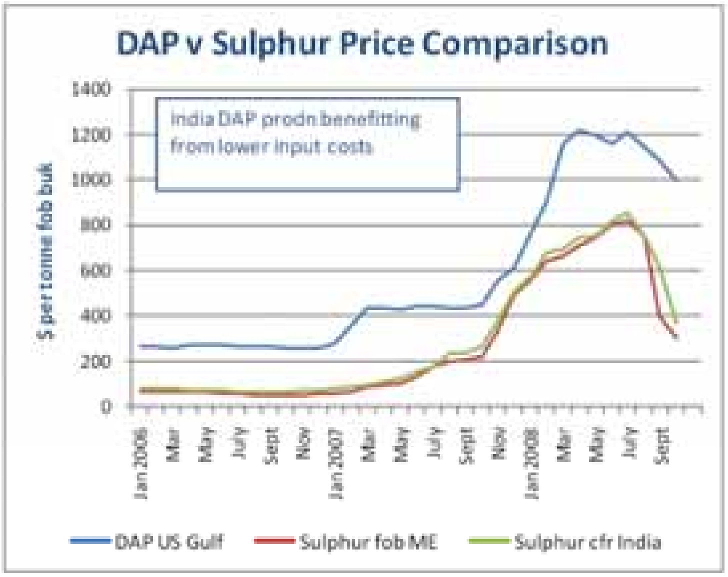
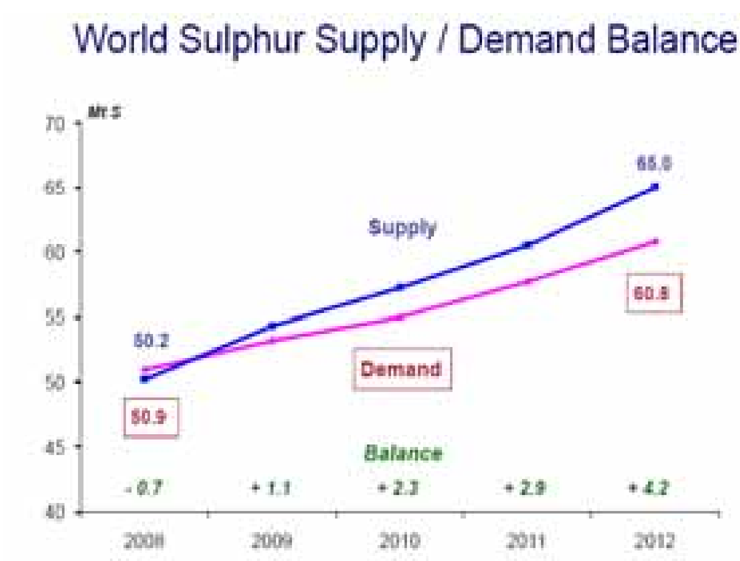
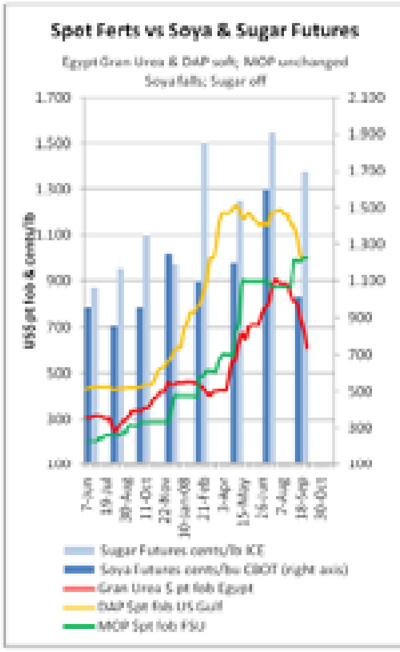


Source: FMB 2 Oct 2008



Source:- IFA

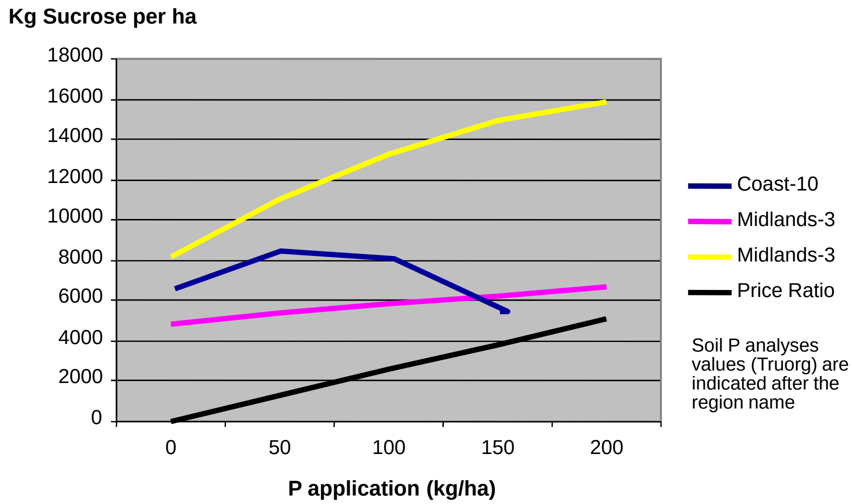


Source: FMB 2 Oct 2008

Calculation of P/Cane Economic Optima using SASRI data and current price ratios.

PRINS, A, BORNMAN, J J & MEYER, J H, 1997. Economic fertilizer recommendations for sugarcane in KwaZulu-Natal, incorporating risk quantification using the KYNO-CANE computer program. Proc. S Afr Sug Technol Ass 38-41.

Sugarcane response to P application (Plant Cane) – SASRI data



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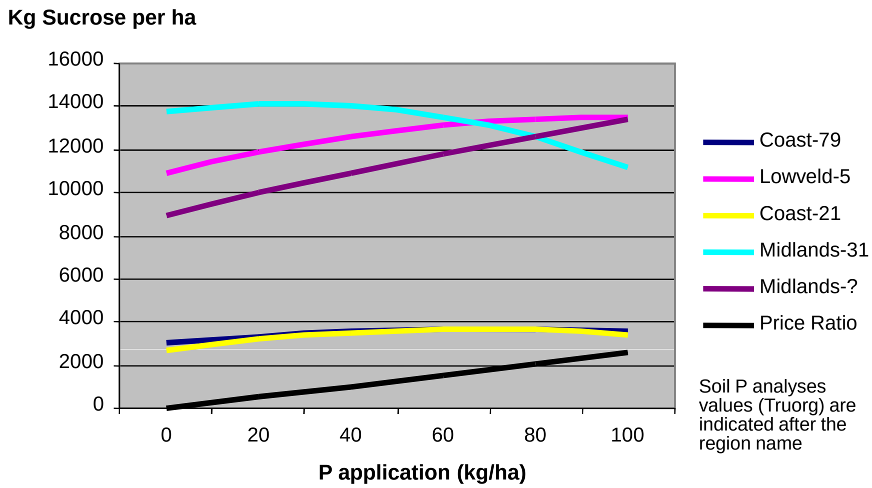
Sugarcane response to P application (1st to 3rd Ratoon Cane) – SASRI data



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Change of price ratio over the past three years

Year (Month of October)	Price of Phosphorus (P) Yara SA data Per kg	Price of Sugar (RV) SA Cane Growers Web Site Per metric ton	Price Ratio P:Sugar Price Kg base
2006	10.3	1702	6.1
2007	17.5	1702	10.3
2008	49.3	1922	**25.7**

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Calculation of Economic Optimum P application using production functions and Price Ratio. Values are in kg per ha (Plant Cane- all low Soil P).

Year	Coastal	Midlands Best	Average Midlands
2006	58.4	224.4	227.1
2007	53.2	208.2	196.9
2008	34.5	149.4	87.1

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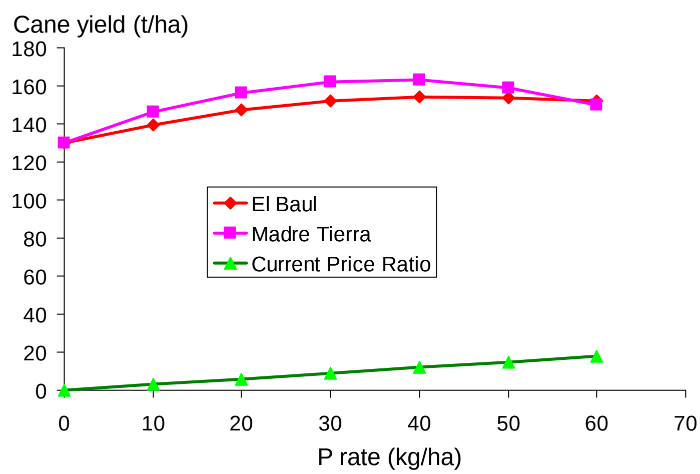
Calculation of Economic Optimum P application using production functions and Price Ratio. Values are in kg per ha (Ratoon Cane)

Year	Coastal Medium to High soil P	Midlands Best Low Soil P?	Average of Midlands	Average of Midlands + Lowveld
2006	50.3	318	55	65
2007	37.8	288	49	58
2008	-7.3	181	24	32

Phosphorus response

Guatemala – ratoon cane



REF: Perez and Melgar (1998)

Return on investment (percentage) regarding P input in current KZN Cane Production.

Note: Return in a single year of production.

Year	Plant Cane Coastal	Plant Cane Midlands	Ratoon Cane Coastal	Ratoon Cane Midlands
2006	730	524	240	790
2008	30	158	Negative	28

Liming reduces P fixation and enhances efficiency?

- "Many studies have investigated the effects of pH modification (usually by lime application to acid soils) on P retention and extractability, but consistent improvements in the availability of soil P have not been obtained" (from Isherwood, 2000 – IFA publication)
- Investigated by Haynes, 1982; Sumner and Farina, 1986; Mansell et al, 1984; Holford et al, 1994; Bornman et al, 1993, 1998; Curtin and Syers, 2001

Impact of liming on buffered soils (Aluminium and Iron rich soils)

pH (KCl) = <4 to 4.4

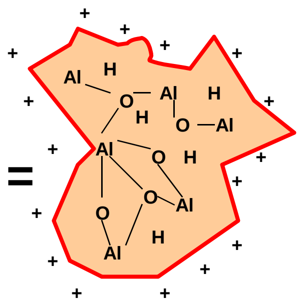
Al^{+++} Al^{+++}

Al^{+++} + OH^- (lime) =

Al^{+++} Al^{+++}

Al^{+++}

pH (KCl) = 4.5 to 5.3

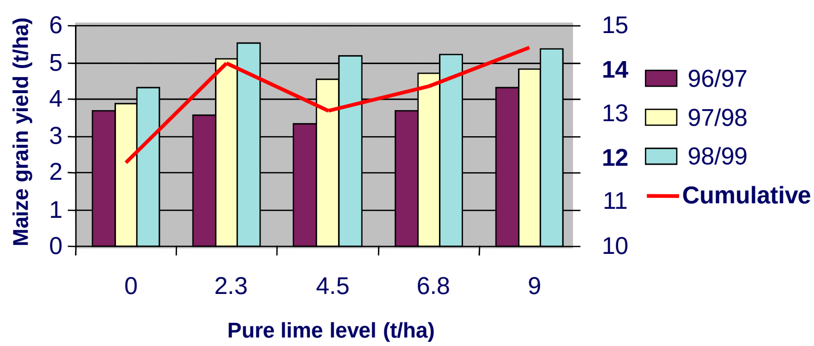


Amorphic aluminium oxide / hydroxide gel

Strongly absorbs anions like phosphate, molybdate and borate

Effect of liming on a P sorbing soil

Nooitgedacht (Mpumalanga)

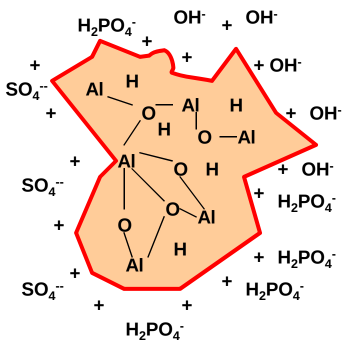


Clay % = 23%, EA 26%, pH (KCl) 3,9

Bray 1 P is 51 mg/kg

Remedy?

pH (KCl) = 4.5 to 5.3



Amorphic aluminium oxide / hydroxide gel

Saturate sorption sites with anions like;

hydroxide (lime) (pH KCl to 6)

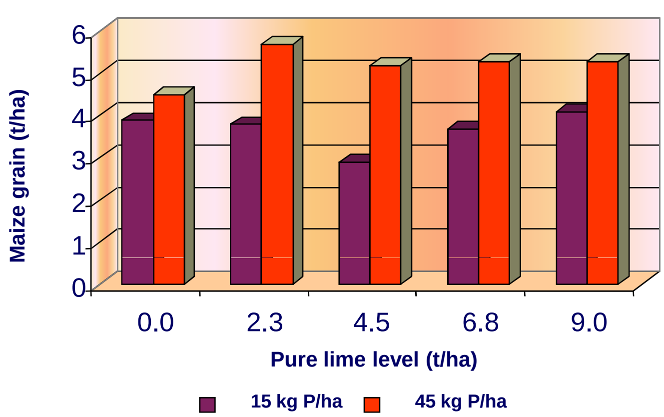
phosphate

sulphate (gypsum)

silicate (slags)

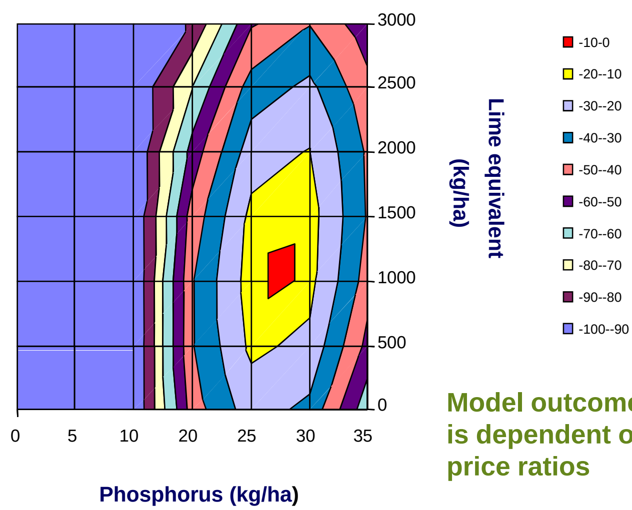
Liming and P interaction on a P sorbing soil

Nooitgedacht (Mpumalanga)



Date: 2007-07-20 - Pa

Potential margin loss (R/ha) due to lime and phosphorus application for first season of phosphorus and lime application in trial M265 (94/95)



Model outcome is dependent on price ratios

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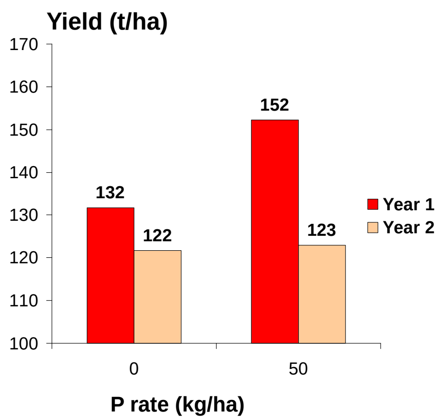
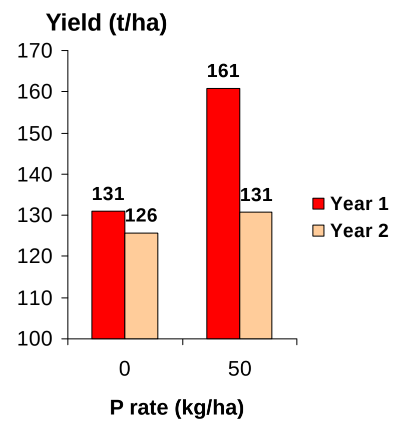
P fixation has major impact on cane yield

Guatemala, Andisols (low P containing volcanic ash soils)

Site: El Baul



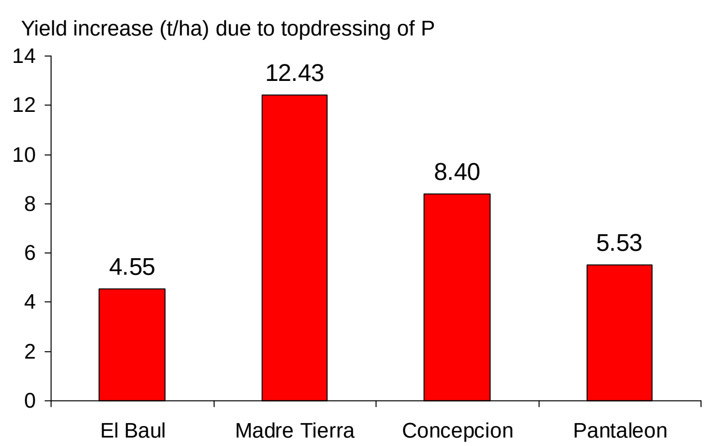
Site: Madre Tierra



REF: Perez and Melgar (1998)

Topdressing with P increases ratoon yield on P fixing soils

Guatemala – first ratoon



REF: Perez and Melgar (1998)

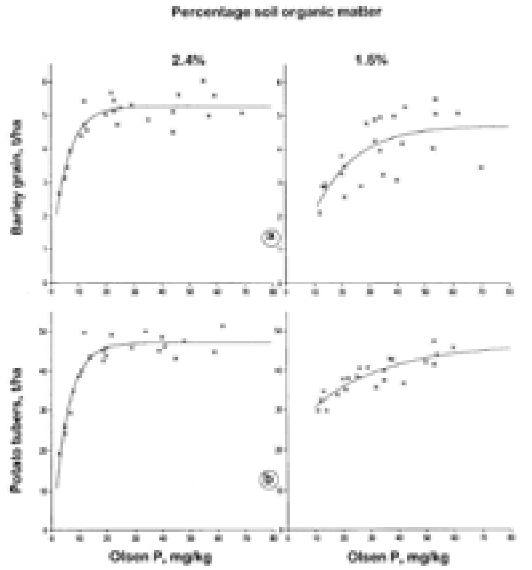
The value of cover crops, soil organic matter and rock phosphate sources

The value of soil organic matter to enhance P efficiency

Site	Treatment	% C	Total P mg/kg	Olson extractable P mg/kg	“Easily available” P (0.01 N $CaCl_2$ extractable) mg/kg
Barnfield	Control	0.8	670	18	0.5
	P	1	1215	69	3.0
	FYM	2.4	1265	86	12.8
	FYM + P	2.4	1875	145	22.3
Hoosfield	Control	0.93	630	6	0.3
	P	1.16	1175	103	14.4
	FYM	3.06	1340	102	25.4

Adapted from Johnston & Poulton, 1992

Organic matter lowers the soil P threshold value for optimum production (Johnston, 2000)



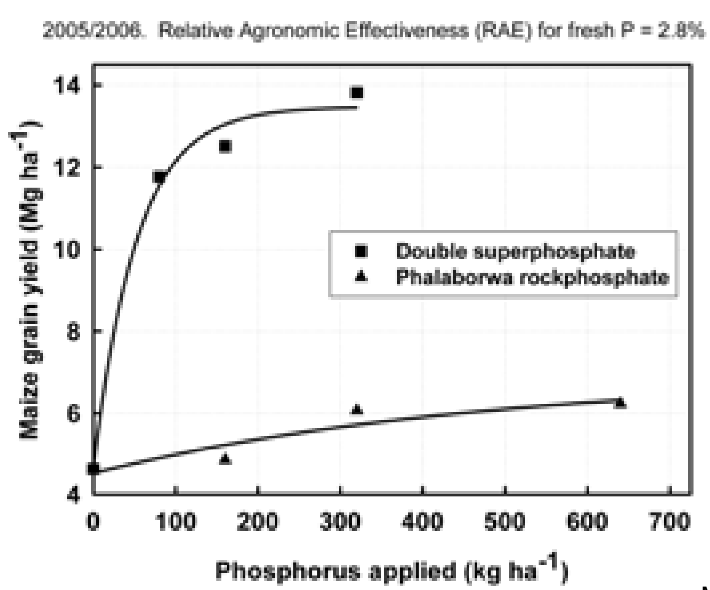
The value of soil organic matter to enhance fertilizer efficiency (Costa Rica)- Primarily ascribed to P efficiency

Treatment Compost/Fertilizer	Accumulated Cane Yield over 4 years t/ha
0/0	269
0/50%	352
0/100%	381
8 t/50%	363
8 t/100%	403

Adapted from Henriquez, 2004

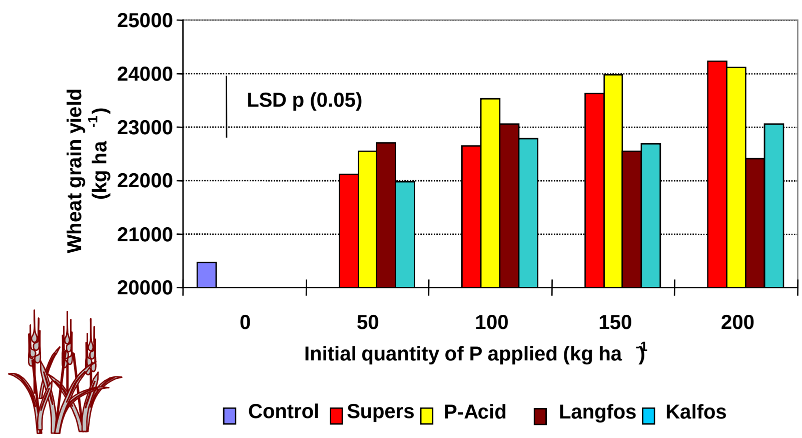
Use of Sedimentary Rock Phosphates

- Could be beneficial in acid soil – especially P fixing soils
- Needs to meet quality standards e.g. 70% of total P needs to be extracted with 4 sequential extracts with citric acid (standard procedure).
- Citric acid solubility (1st extract should preferably exceed 4% P)
- Carefully calculate the real cost per unit available P and analyze for heavy metals like cadmium.
- Beware of Vulcanic Rock Phosphates (e.g. paper by Theodoro & Leonardos, 2006, promoting such sources for smallholder cane production in Brazil)
- Alan Manson (Dept Agriculture KZN) has proven RAE of Phalaborwa rock to be between 3 and 7%



Manson, 2008

Total wheat grain yield over six seasons with different phosphorus sources at different levels of P initially applied (without topdressing). Malmesbury



“New” P fertilizer options?

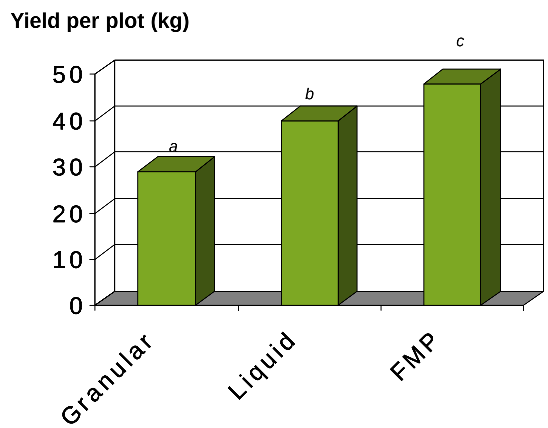
- Use of a Fused Magnesium Phosphate (High heat fusion of Apatite and Serpentine) – containing:

TYPICAL ANALYSIS

ELEMENTS	Concentration
Phosphorous	8.77%
Calcium	21.50%
Magnesium	8.00%
Silicon	12.00%
Sulphur	0.25%
Manganese	750 ppm
Zinc	50 ppm
Copper	1 ppm
Boron	12 ppm
Molybdenum	10 ppm
Nickel	250 ppm
Cobalt	60 ppm

- Sett treatment with flowable products containing P, Zn and Mo
  - (usually used for grain seed treatment)

Potato (BP1) response to different P sources (Sandveld, 2006) Winter Crop



Data: van Dyk, unpublished

Yields with different letters differ significantly at p = 0.05

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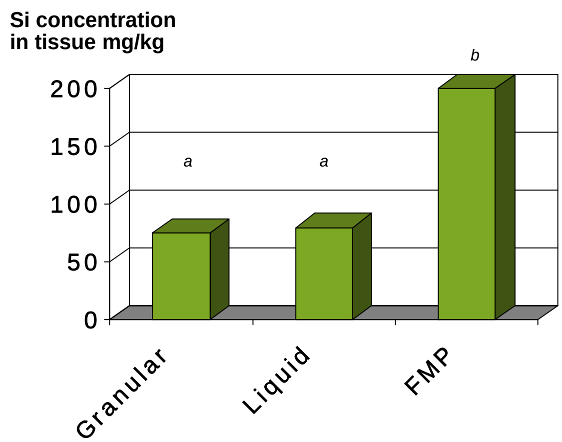
Potato (BP1) uptake of Silica from a Fused Magnesium Phosphate source



Data: van Dyk, unpublished

Uptake values with different letters differ significantly at p = 0.05

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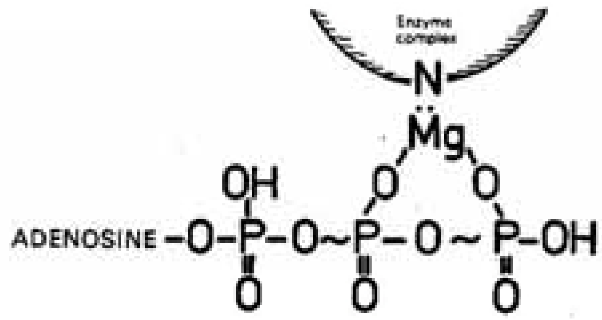
Magnesium plays a prominent role in enzyme/ATP bridging.



Marschner, 1995

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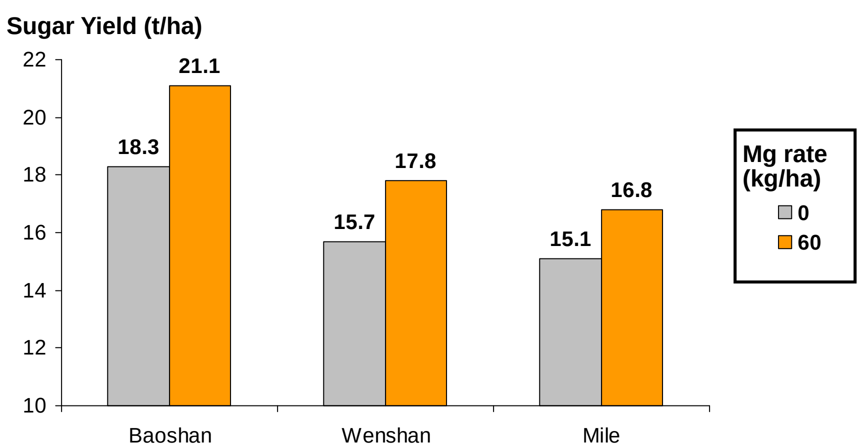
Magnesium increases sugar yield

China (Yunnan province)



REF: Hong Lifang et al. (2001)

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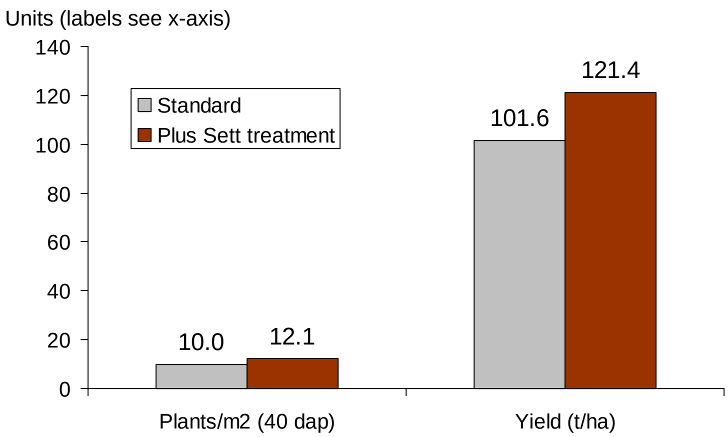
Sett treatment improves plant number & yield

Brazil Site: Usina Central de Alcool Lucelia Ltd



REF: Yara Brazil (2006)

Sett treatment improves plant development

Brazil, Antonio Eduardo Toniello e Outros; Usina Viralco (Sao Paulo)

- Evaluation 15 days after planting

REF: Yara Brazil (2006)

Sett treatment improves plant development

Brazil, Antonio Eduardo Toniello e Outros; Usina Viralco (Sao Paulo)

- Evaluation 40 days after planting

REF: Yara Brazil (2007)

Sett treatment improves plant development

Brazil, site Paulo Ferreira (Sao Paulo)

- Evaluation 50 days after planting
  - Better root development
  - Better vegetative growth

REF: Yara Brazil (2006)

Sett treatment improves plant development

Brazil, site Edilberto Meneguetti (Sao Paulo)

- Evaluation 50 days after planting
  - Better root development
  - Better vegetative growth

REF: Yara Brazil (2007)