IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

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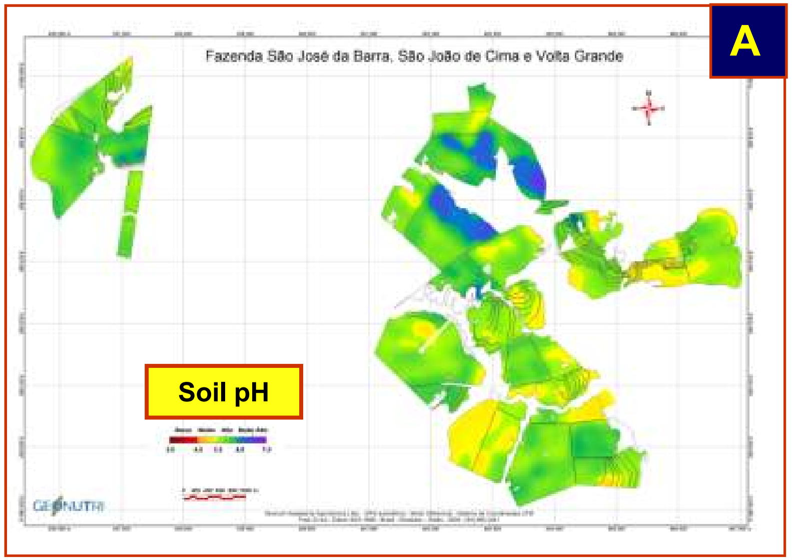
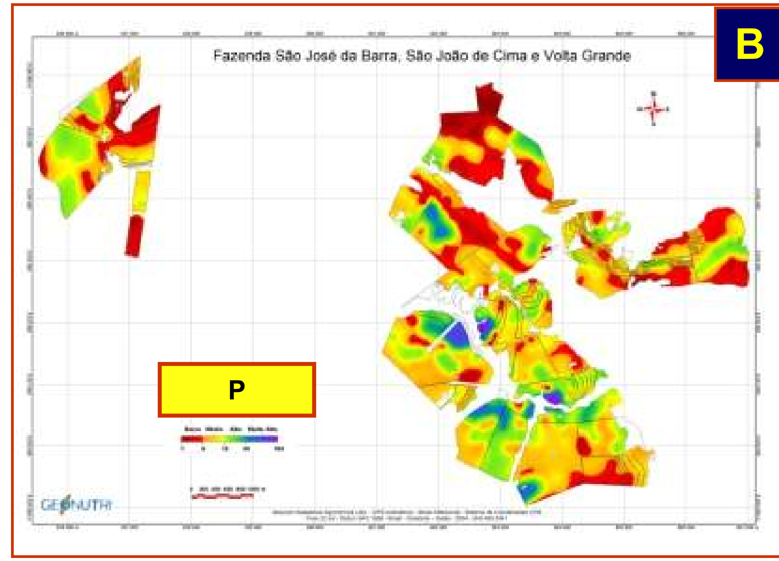
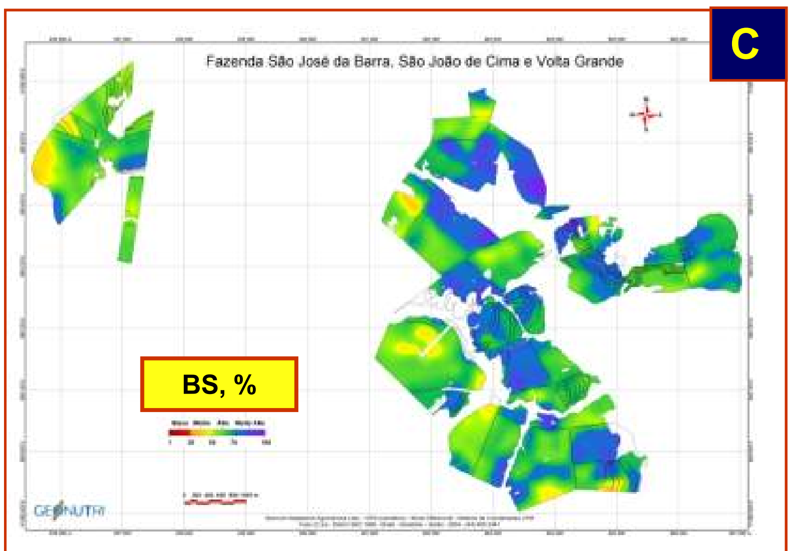
ION EXCHANGE RESIN FOR ACESSING THE BIOAVAILABILITY OF PLANT NUTRIENTS IN AGRICULTURAL SOIL SYSTEMS

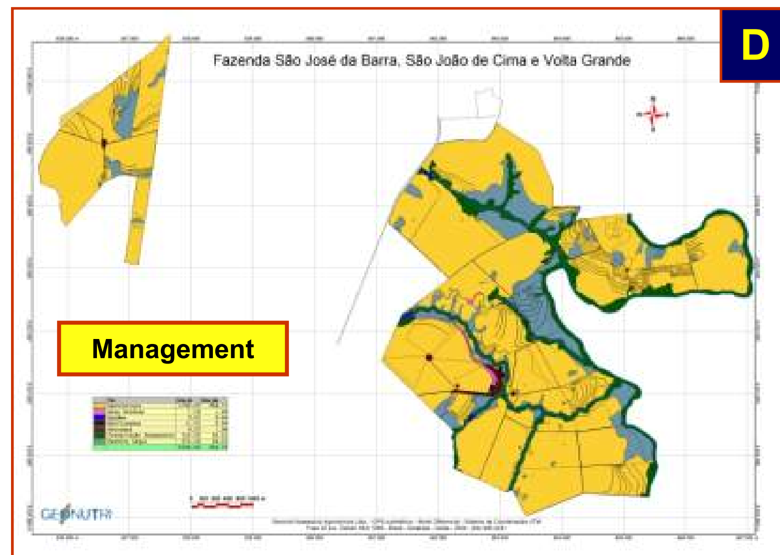
A GOOD PROGRAM UNDER PRECISION AGRICULTURE NUTRIENT MANAGEMENT SHOULD INITIALLY, AND ABOVE ALL, HAVE AN EFFICIENT METHOD TO PROPERLY EVALUATE THE BIOAVAILABILITY OF PLANT NUTRIENTS

Spatial distribution of pH $CaCl_2$ 0.01 mol L^{-1} (A). P (B). base saturation (C). and soil management recomendation (D) in farms São José da Barra. São João de Cima e Volta Grande (Sparovek & Cooper, 2003)









EXERCISE 1

The determination of P in a soil sample, using methodology "A", revealed an amount of 4 mg dm^{-3} (very low). The fertilizer recomendation to soybean in this case would be 100 kg ha^{-1} of P_2O_5. An experiment under this field site showed that the soybean crop did not respond to P (3.5 t ha^{-1}). Make comments regarding the effectiveness of methodology "A".

SEVERAL METHODS TO EVALUATE SOIL NUTRIENT BIOAVAILABILITY

ADVANTAGES OF SOIL CHEMICAL ANALYSIS

- ✓ Anticipates Chemical Management
- ✓ Reliable when properly adjusted
- ✓ Easily used on Routine Basis
- ✓ Generally Not Expensive

Rate of P_2O_5 application considering regular farmer practice versus when utilizing soil chemical analysis.

Area	Soil P [1]	Rate of P_2O_5		P_2O_5 balance
		Applied by farmer	Required [2]	
	mg dm^{-3}	---------------- kg ha^{-1} ---------------		
A	3	60	90	- 30
B	12	60	60	0
C	28	60	30	+ 30

(1) Soil P (mg dm^{-3}): 0 – 6 = very low, 7 – 15 = low, 16 – 40 = medium, 41 – 80 = high, > 80 = very high.
(2) According to maize calibration and response curve studies by the resin method to evaluate the bioavailable pool of P in the soil.

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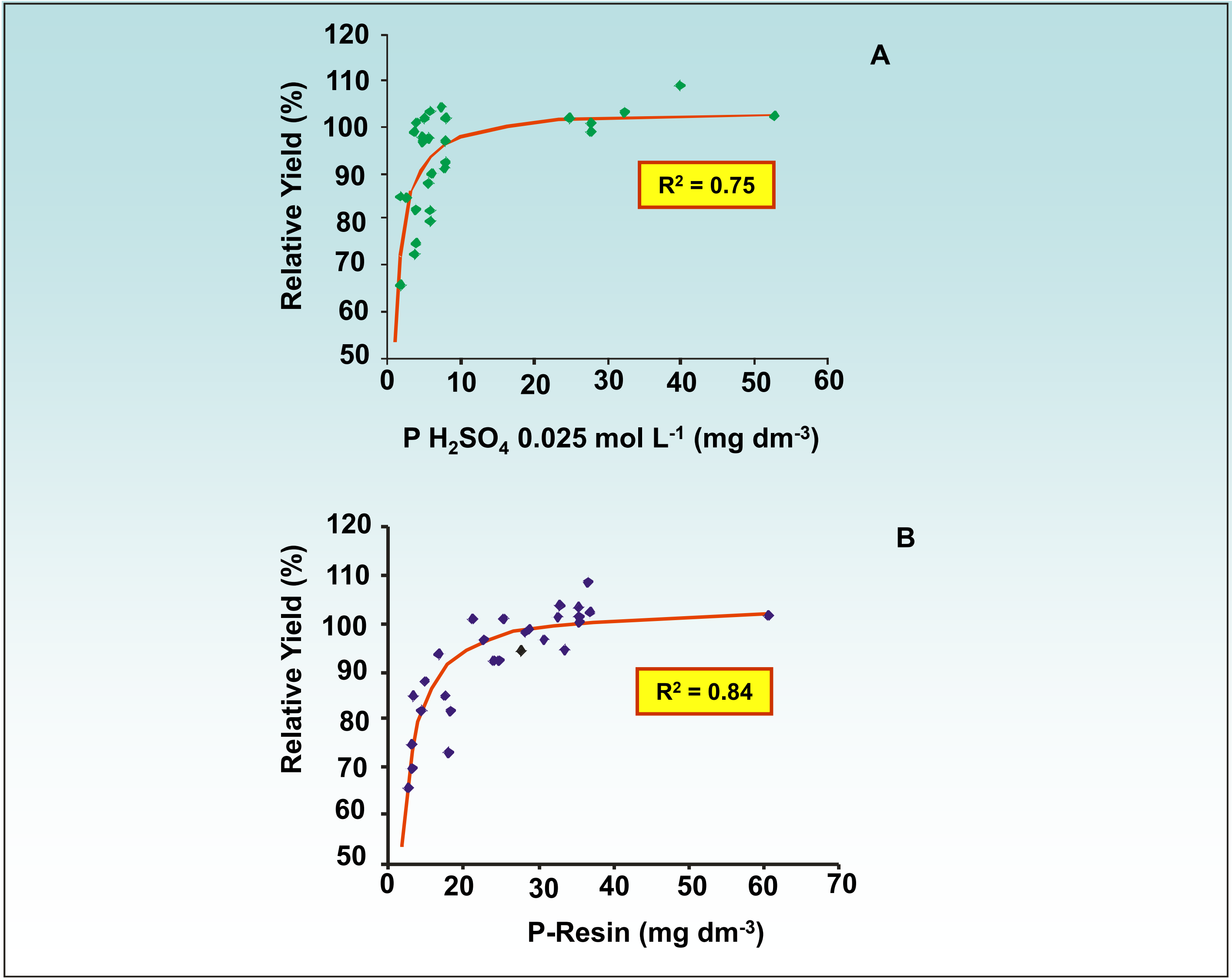
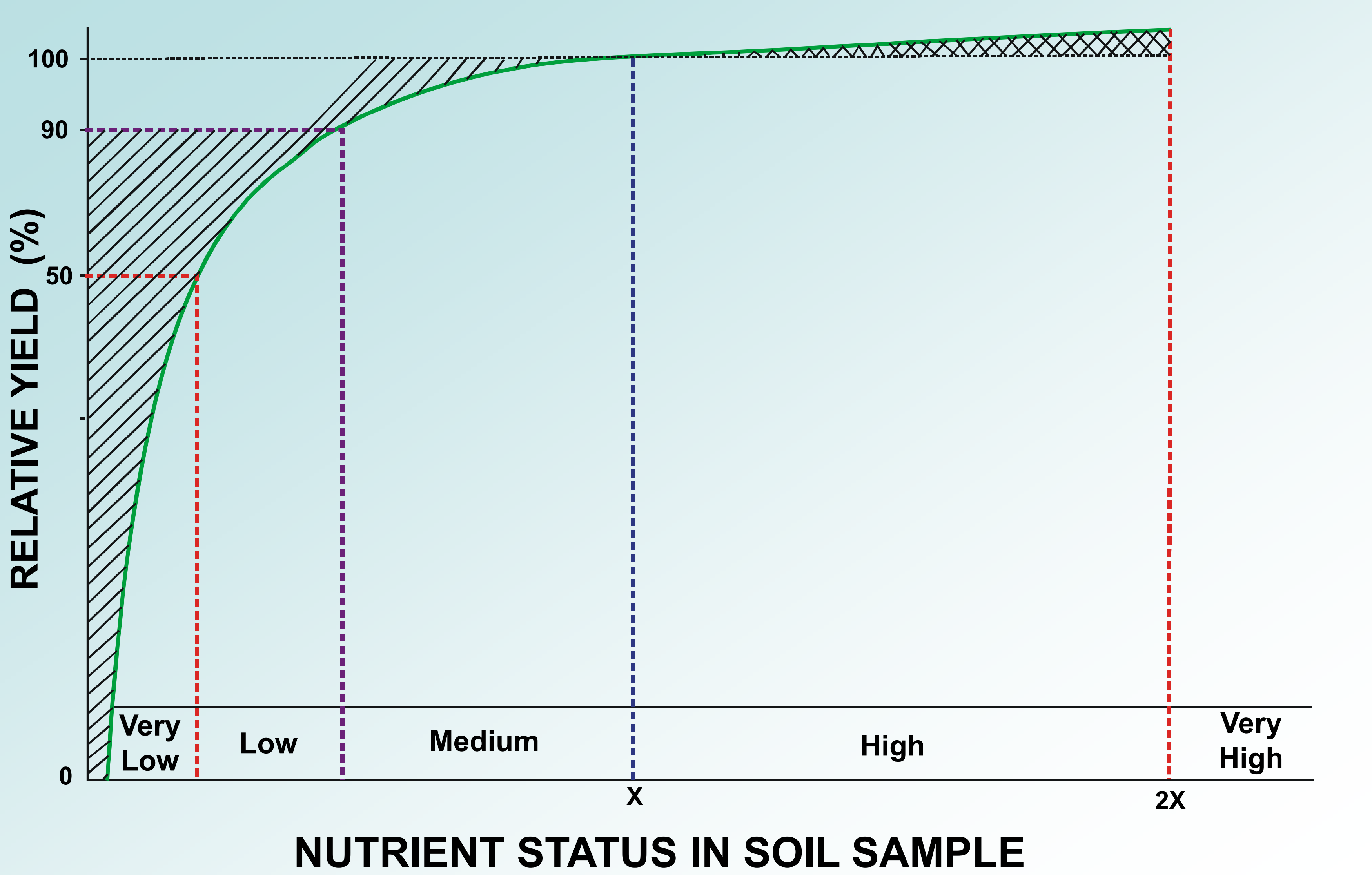
PROPERLY ADJUSTED TO LOCAL CONDITIONS

- ✓ Correlation (What Methodology?)
- ✓ Calibration (numbers versus plant requirements)
- ✓ Response Curves (What to Add?)

CORRELATION STUDIES



CALIBRATION STUDIES



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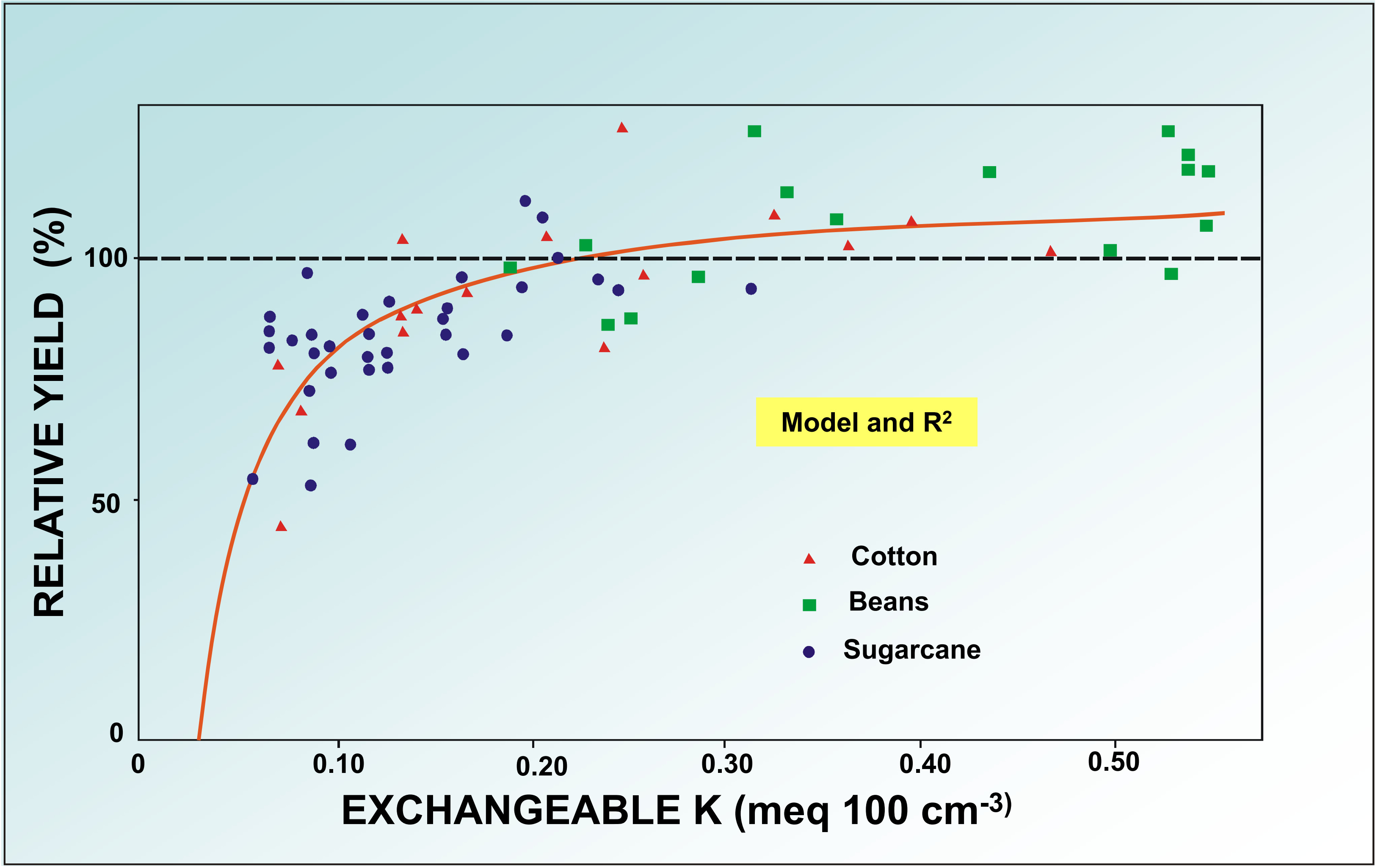
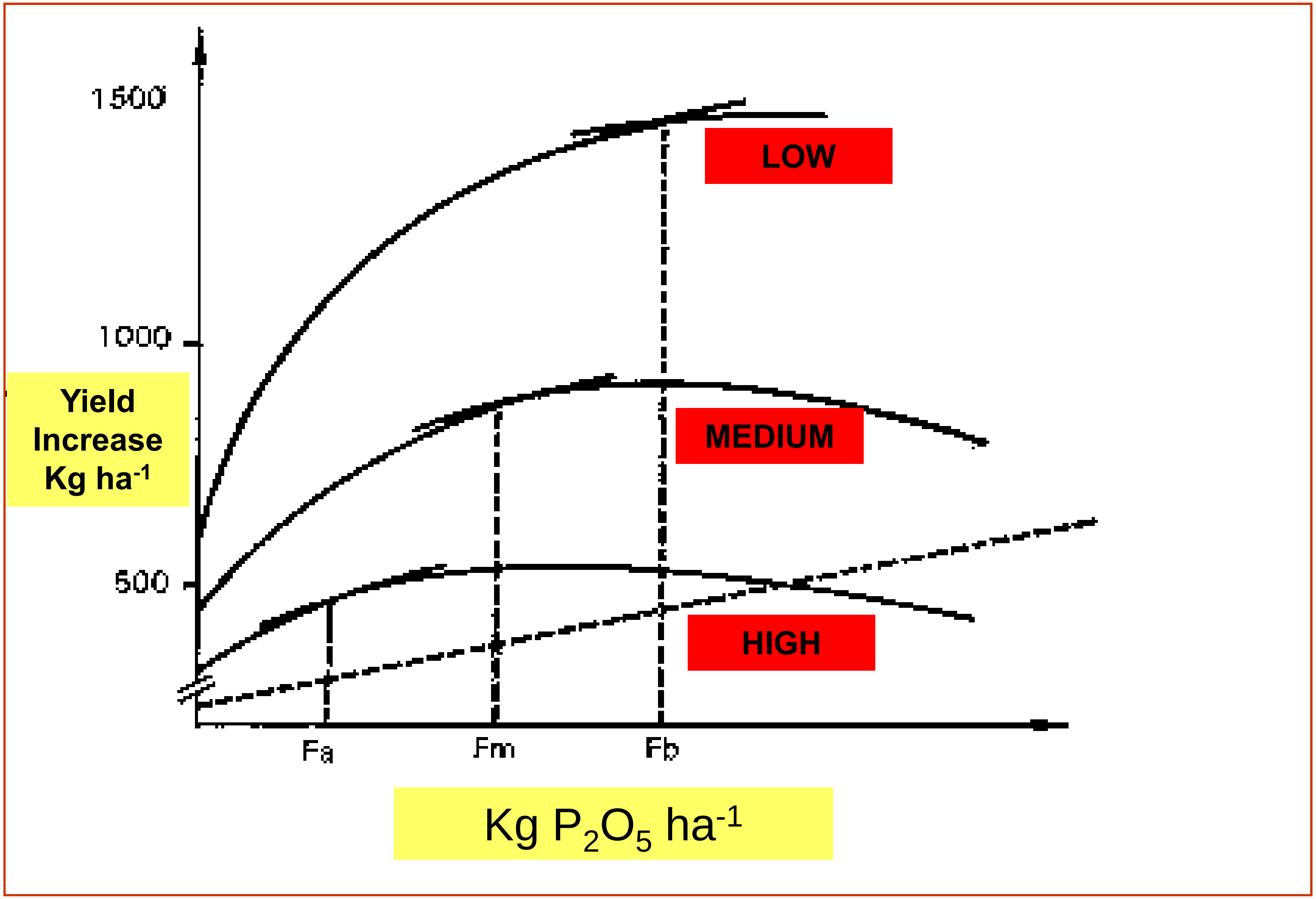
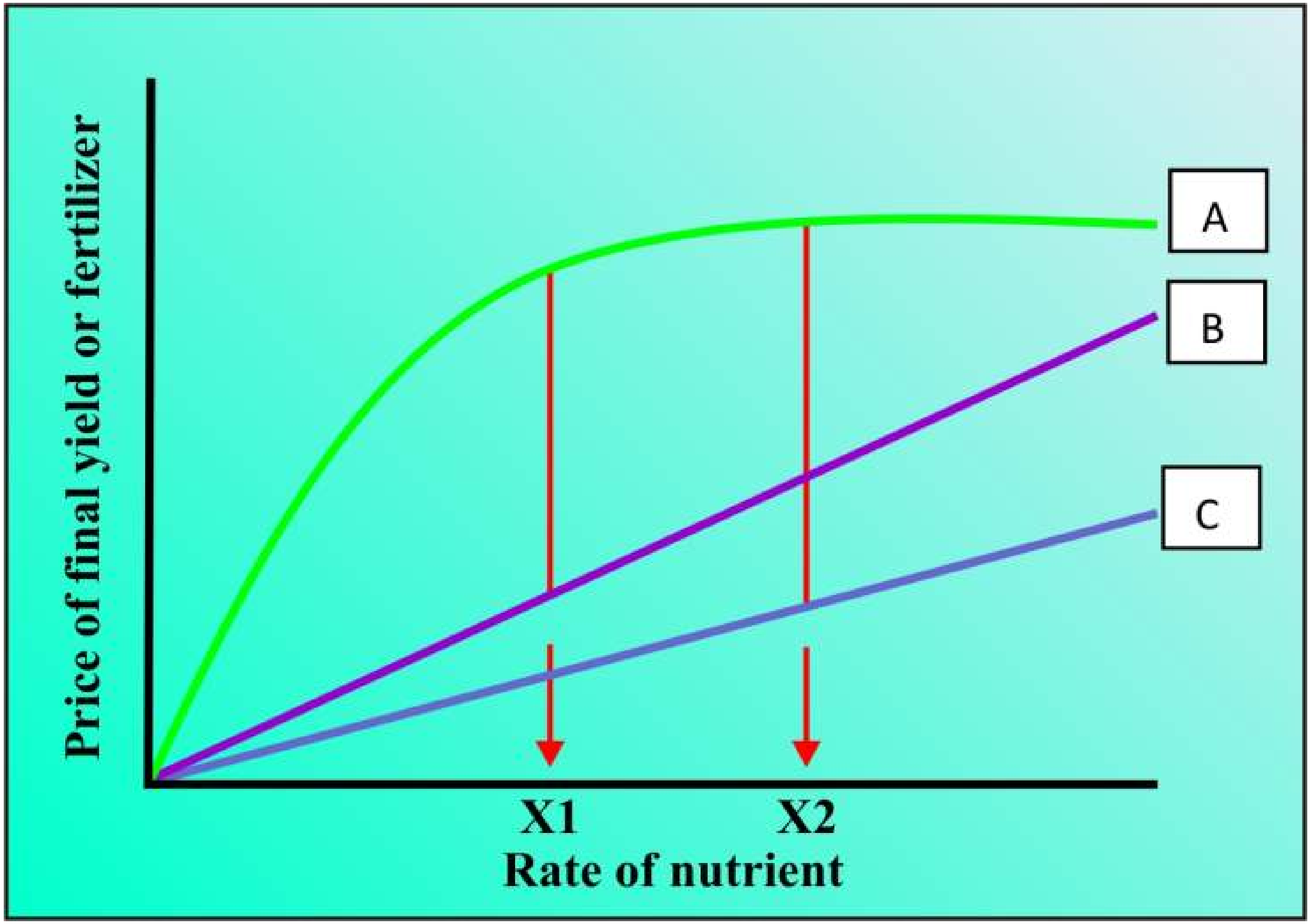
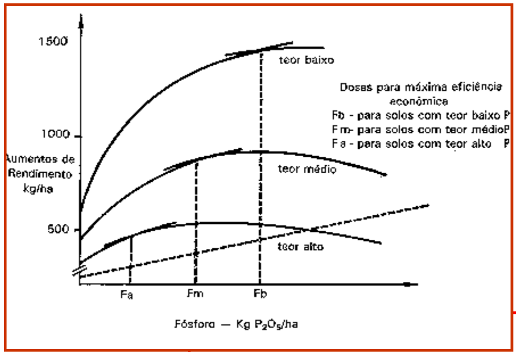



1500
1000
500
Yield Increase Kg ha-1
LOW
MEDIUM
HIGH
Fa
Fm
Fb
Kg P2O5 ha-1

RESPONSE CURVE STUDIES



A = Yield Response, B and C = Fertilizer



RECOMENDATION CHART

Adubação mineral de plantio: Aplicar de acordo com a análise de solo e a produtividade esperada, conforme a seguinte tabela:

YIELD	Nitro-gênio	P resina, mg/dm^3				K$^+$ trocável, mmol$_c$/dm^3			
		0-6	7-15	16-40	>40	0-0,7	0,8-1,5	1,6-3,0	>3,0
t/ha	N, kg/ha	P_2O_5, kg/ha				K_2O, kg/ha ([2])			
2- 4	10	60	40	30	20	50	40	30	0
4- 6	20	80	60	40	30	50	50	40	20
6- 8	30	90	70	50	30	50	50	50	30
8-10	30	([1])	90	60	40	50	50	50	40
10-12	30	([1])	100	70	50	50	50	50	50

([1]) É improvável a obtenção de alta produtividade de milho em solos com teores muito baixos de P, independentemente da dose de adubo empregada. ([2]) Para evitar excesso de sais, no sulco de plantio, a adubação potássica para doses maiores que 50 kg/ha de K_2O está parcelada, prevendo-se a aplicação em cobertura.

Maize – Raij et al, 1996

PROCEDURE HAS TO BE SPECIFIC FOR

- ✓ METHODOLOGY
- ✓ AREA/REGION AND SOILS CONSIDERED
- ✓ CULTIVATION SYSTEM
- ✓ SOIL DEPTH SAMPLING

IMPORTANT ISSUES

- ✓ PROPER SOIL SAMPLING
- ✓ USE OF RELIABLE LAB
- ✓ PRECISION AND ACCURACY
- ✓ CAREFULL INTERPRETATION
- ✓ CAREFULL RECOMMENDATION
- ✓ CAREFULL APPLICATION

Correct result = 10
Precise: 9, 10, 8, 9
Accurate: around 10
Precise but inaccurate: 22, 23, 21
Accurate (AV), not precise: 7, 13, 6, 14

THE ION EXCHANGE RESIN METHOD

- ✓ H-C ARTIFICIAL PHYSICAL PRODUCT
- ✓ HIGH EXCHANGE CAPACITY
- ✓ BIO-CHEMICAL-PHYSICAL METHOD
- ✓ RESIN WITH CEC OR AEC
- ✓ MIXTURE OF TWO (ex.: P, Ca, Mg and K)

SOIL P REACTIONS

NON LABILE P - LABILE P → SOLUTION P → PLANT

Forms and Functions of P in Plants 161

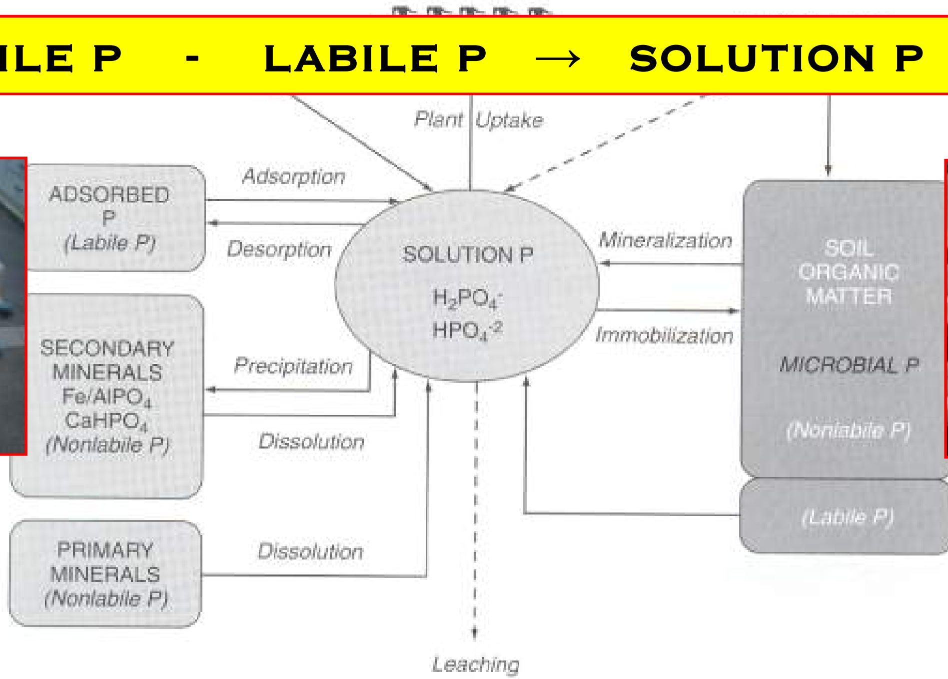


Figure 5-1 P cycle in soil.

Havlin, 2005

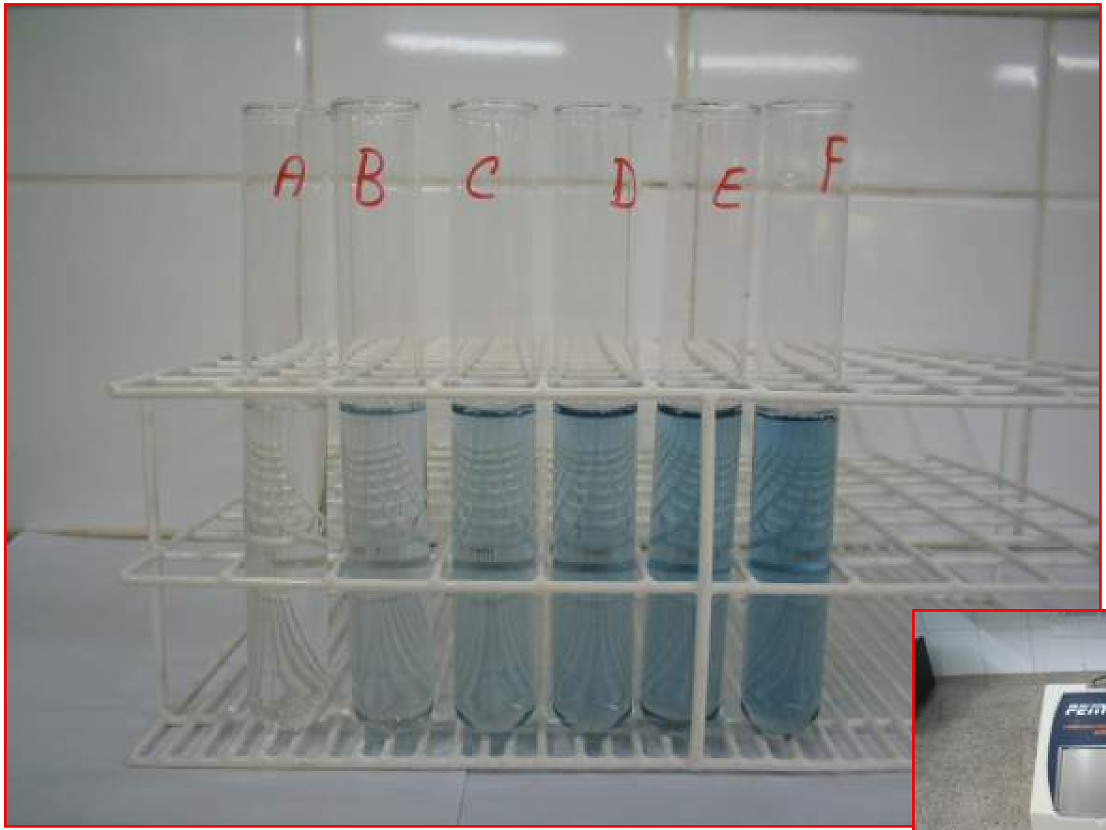
SOIL SAMPLE AND RESIN

16 h SHAKING

SEPARATION

1 h SHAKING

P QUANTIFICATION



NON LABILE P - LABILE P → SOLUTION P → PLANT

SOIL CHEMICAL ANALYSIS RESULT

Resultado de análise química de terra de rotina

Amostra	pH	M.O. g dm^{-3}	P mg dm^{-3}	K	Ca	Mg	Al	H+Al	S	SB	CTC	V%
				----------	----------	----------	----------	mmol$_c$ dm^{-3}	----------	----------	----------	
A(0-20)	5,4	20	7	1,0	36	14	0	25	2	51	76,0	67
A (20-40)	4,4	14	4	0,7	23	6	12	42	3	29,7	71,7	41
B (0-20)	5,3	28	42	4,4	48	16	0	35	12	68,4	103,4	66

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ADVANTAGES IER

- ✓ ACCURACY IN EVALUATING SOIL NUTRIENT BIOAVAILABILITY
- ✓ MULTI NUTRIENT EXTRACTION/EVALUATION (P, Ca, Mg, K)
- ✓ NEW POSSIBLE ELEMENTS (ex.: S)
- ✓ LOW COST
- ✓ AMPLIFIED RANGE FOR NUTRIENT INTERPRETATION (Sufficiency levels)
- ✓ P EVALUATON IN SOILS RECEIVING PR

EFFECTIVENESS OF P SOIL EXTRACTORS (70 SCIENFIC PAPERS)

METHOD	COEFICIENTT OF DETERMINATION (%)		
	ACID	ALCALINE/NEUTRAL pH	NOT SPECIFIED
Resin	84	83	69
Olsen	47	52	58
Mehlich 1	56	39	41
Bray 1	53	25	48

Source: Adapted from SILVA e RAIJ (1999).

EFFECTIVENESS OF THE PRE TREATMENT OF THE RESIN

SOIL	COTTON (Kg ha^{-1})		RESIN-HCl		RESIN-NaCl		RESIN-$NaHCO_3$	
	NO P	WITH P	pH (mg dm^{-3})	P	pH (mg dm^{-3})	P	pH (mg dm^{-3})	P
1	3.678	3.673	3.37	3	5.58	5	6.78	36
2	2.058	2.244	3.34	2	5.29	1	6.79	12

Source: RAIJ et al. (1986).

EFFECTIVENESS OF DIFFERENT P METHODOLIGIES

Evaluation of P bioavailability	TSP Before Seeding (STANDARD)		Fertilizers Applied 75 Prior to Seeding					
			TSP		Low Reactive PR		Calcined Al-P	
	Valor	Index	Value	Index	Value	Index	Value	Index
P uptake by soybean (mg pot^{-1})	4.26	100	2.25	53	1.13	27	1.72	40
P resin (mg dm^{-3})	12.7	100	7.9	62	1.70	11	4.9	39
P Bray 1 (mg dm^{-3})	37.9	100	39.6	104	7.90	21	39.4	104
P Mehlich 1 (mg dm^{-3})	27.9	100	24.6	88	42.8	153	15.0	54

Source: Raij & Quaggio, 1999

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EFFECT OF SOIL pH IN THE AMOUNT OF P IN PLANT LEAF AND SOIL P BY DIFFERENT METHODOLOGIES

Crop and Location	pH $CaCl_2$	Leaf P ($g\ Kg^{-1}$)	Soil P ($mg\ dm^{-3}$)			
			Mehlich 1	Bray 1	Olsen	Resina
Beans Pariqüera-Açu	3.8 d *	2.44 b	17 a	20 a	41 a	33 b
	4.2 c	3.21 a	18 a	21 a	33 b	36 ab
	4.7 b	3.25 a	18 a	20 a	26 c	38 ab
	5.1 a	3.26 a	19 a	18 a	19 d	43 a
	5.2 a	3.25 a	20 a	19 a	21 d	43 a
Sunflower Mococa	4.3 c	2.79 c	12 b	24 a	17 a	22 b
	4.6 c	3.27 b	12 b	22 a	17 a	26 ab
	5.3 b	3.81 a	16 a	25 a	16 a	33 ab
	5.5 ab	3.87 a	15 a	20 a	12 a	35 a
	5.7 a	3.80 a	16 a	20 a	12 a	37 a
Soybean Mococa	4.3 a	1.85 c	6 a	15 a	10 a	13 c
	4.8 d	2.06 bc	7 a	16 a	11 a	16 c
	5.5 c	2.44 ab	5 a	13 a	7 a	17 bc
	6.1 b	2.26 a	7 a	17 a	8 a	22 ab
	6.4 a	2.55 a	7 a	15 a	8 a	27 a
Soybean Ribeirão Preto	4.5 d	2.35 b	9 a	20 a	18 a	16 c
	4.9 c	2.69 ab	8 a	22 a	15 ab	19 bc
	6.1 b	2.88 a	8 a	20 a	13 ab	23 b
	6.6 a	2.85 a	10 a	24 a	12 b	34 a

Source: RAIJ e QUAGGIO (1990).

EXERCISE 2

The determination of P in a soil sample revealed an amount of 4 (low) and 24 (medium) mg dm^{-3} for methodologies "B" and "C", respectively. An experiment under this field site showed that the adition of 100 kg ha^{-1} of P_2O_5 increased maize yield from 3.8 to 7.5 ton ha^{-1}. respectively. Which of the two methodologies was more effective to evaluate soil P bioavailability?

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WE SHOULD NOT MAKE OURSELVES CONFORTABLE. NEW AND BETTER POSSIBILITIES MAY EXIST.

TEST THE EFFECTIVENESS OF CURRENT METHODS UNDER SITE FIELD CONDITIONS

HOW ARE THE METHODS FOR SOIL ANALYSIS EVALUATING THE BIOAVAILABILITY OF NUTRIENTS IN YOUR REGION ?

SUCCESS TO PA,
SUCCESS TO AGRICULTURE,
AND THANK YOU VERY MUCH FOR YOUR KIND ATTENTION

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