Nutrient Management for Soybeans in the Brazilian Cerrado

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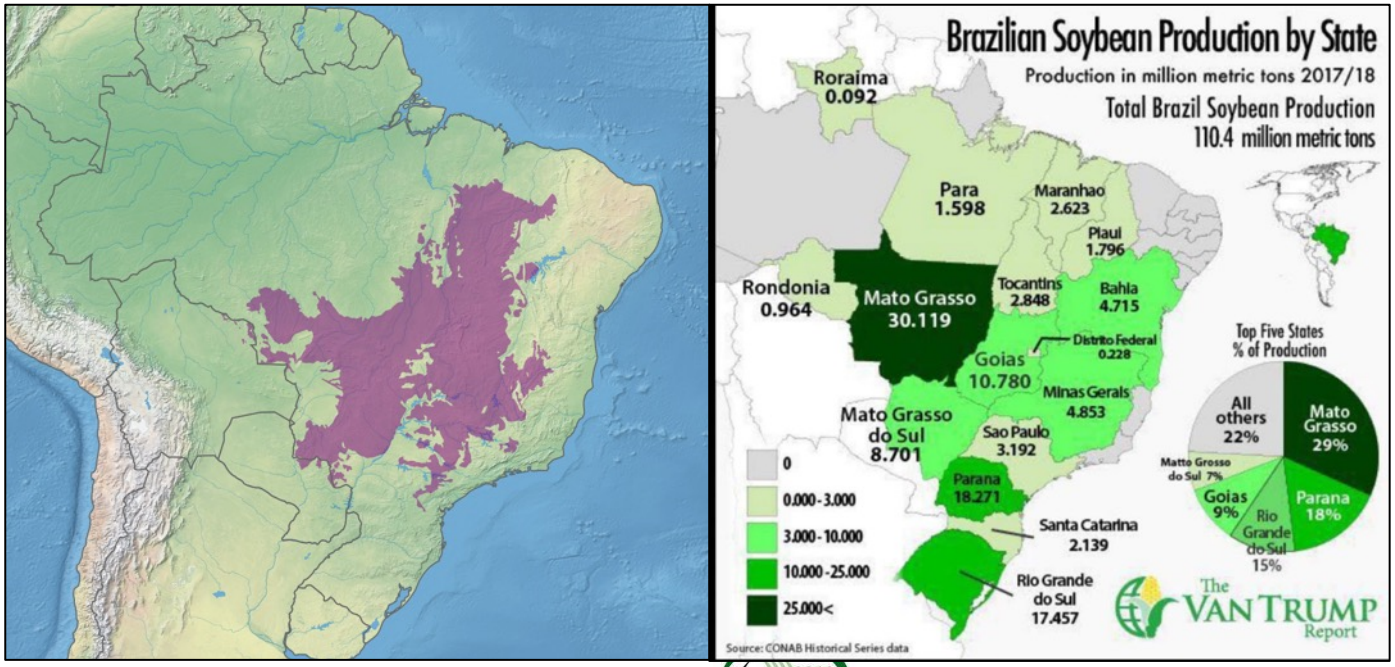
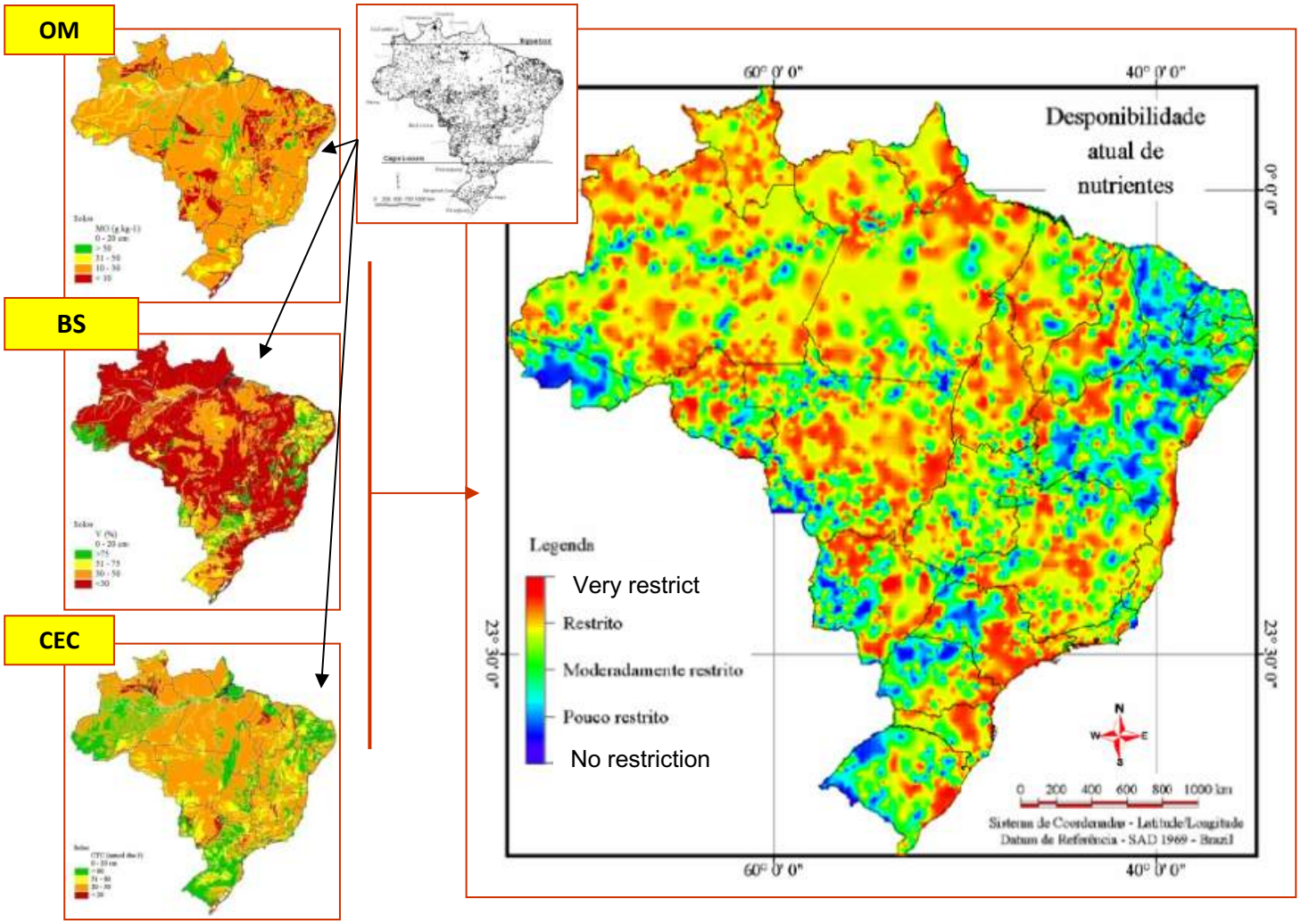
Cerrado: the Brazilian savannah

- Takes several states within four regions
- About 204 Million ha: 37.3 million ha of agriculture (grains, coffee, and sugarcane), 3.1 million ha of planted forests, and about 80 million ha of pastures
- Type of soils: Oxisols, Entisols, and Ultisols
- Climate: rainy summers and dry winters

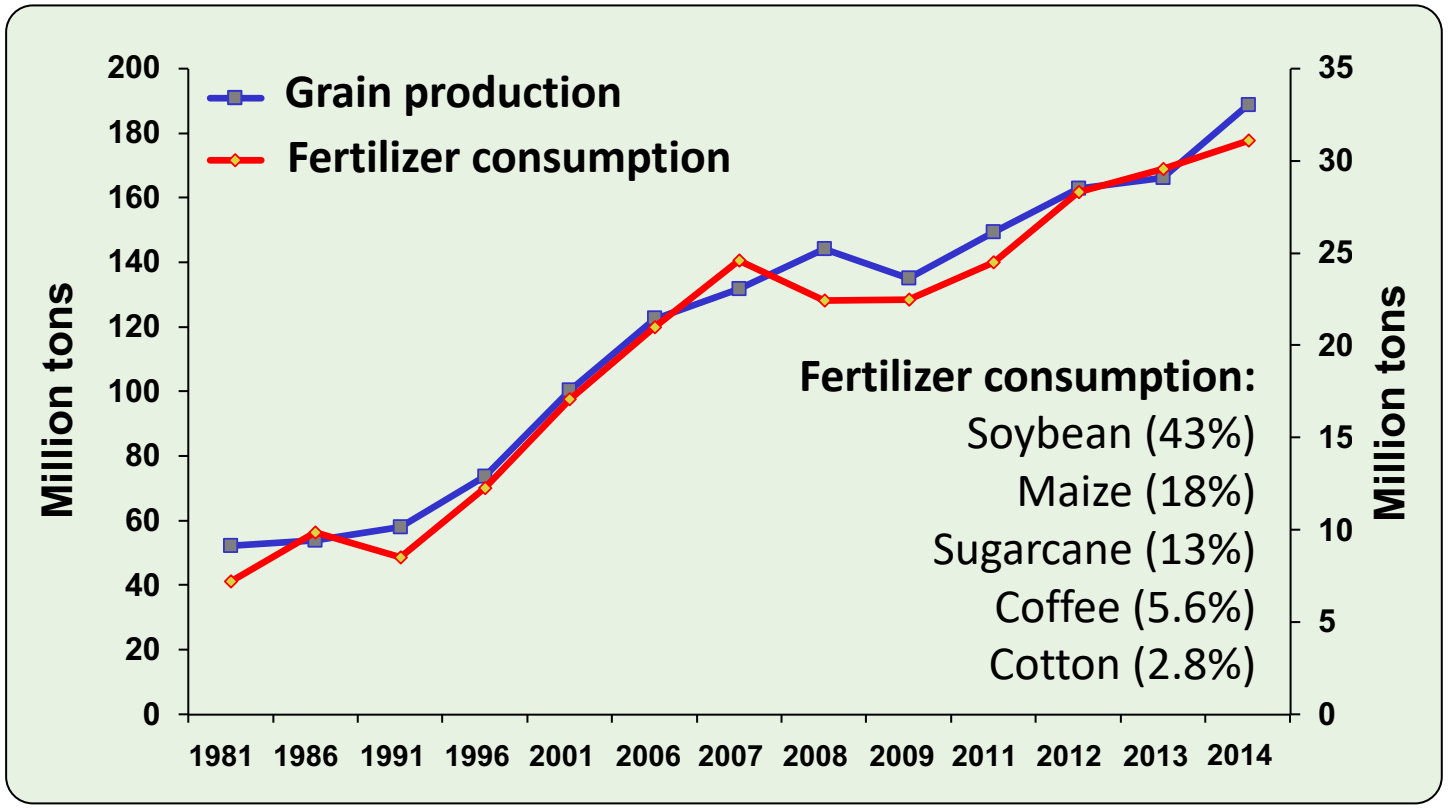


Soil fertility restrictions in Brazilian soils



Source: Sparovek et al.

Total grain production and fertilizer consumption in Brazil

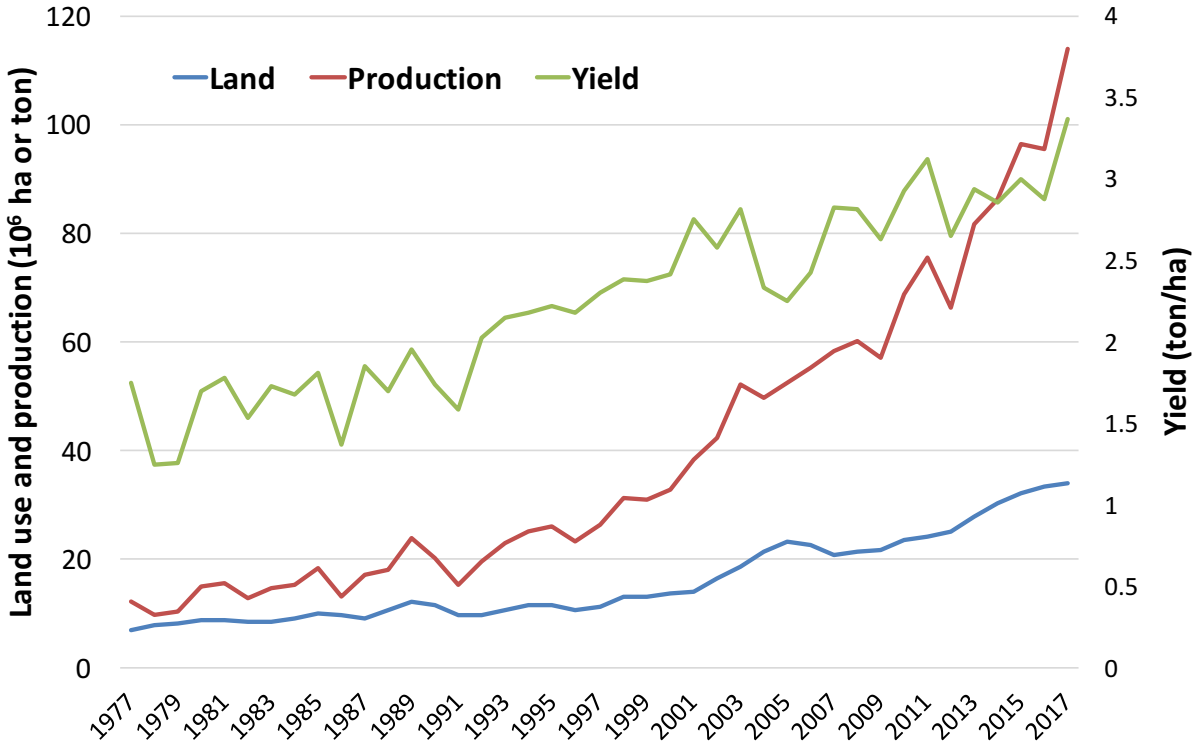


2017
237 M ton (grains)
34 M ton (fertilizer)

Source: ANDA e CONAB (2015),

Cotton seed, peanut, rice, barley, canola, rye, oak, beans, sunflower, castorbeans, maize, soybean, sorghum, and wheat.

Evolution of soybeans in Brazil



Source: Conab.

2017
34 M ha
114 M ton
3.4 ton/ha

Evolution of Cerrado's contribution (%) to soybean in Brazil

	Land	Production	Yield
1977	6.7	5.2	36.4
2017	63.5	61.7	96.2

Evolution of soybean systems in Brazil

Decade	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1980			SOYBEANS						FALLOW			
1990		SOYBEANS						Fallow, millet, maize				
2000		SOYBEANS					Millet, Maize,					
2010	SOYBEANS					MAIZE, millet, sun hemp						
2017	SOYBEANS					MAIZE, Brachiaria, sun hemp, millet						

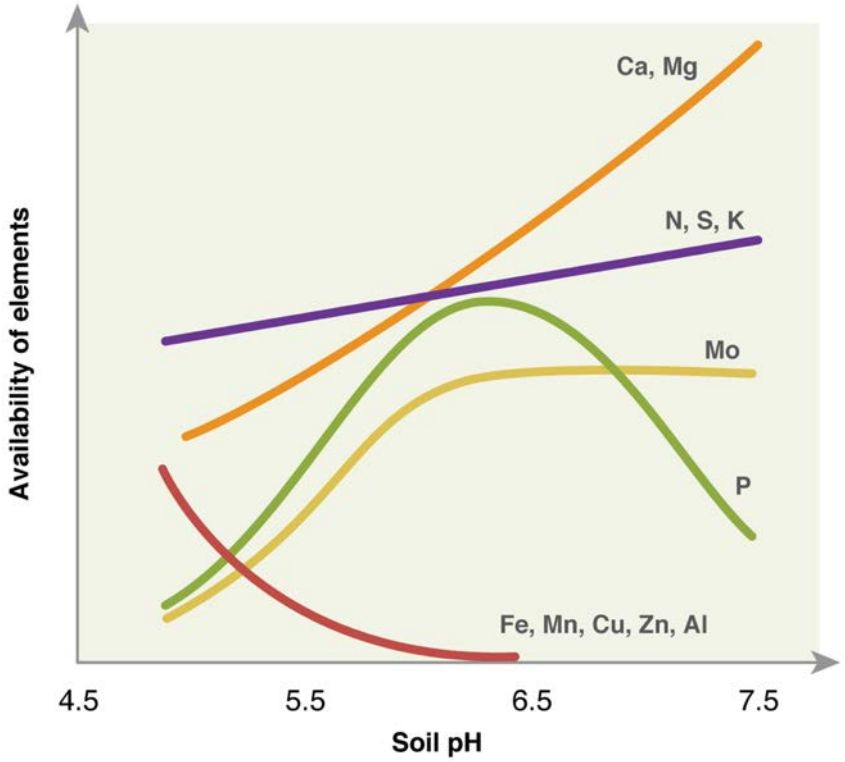
Source: Eros Francisco

Soybean harvest followed by Maize 2nd crop seeding


A very complex cropping system

Soil acidity management

Liming: the basis for high yielding soybeans



Liming recommendations

- BS > 50% (Midwest) or > 65% (South)
- Ca > 1.5 $cmol_c$/kg
- Mg > 0.7 $cmol_c$/kg

➢ Tillage systems (new operations): use BS formula

Source: Souza & Lobato

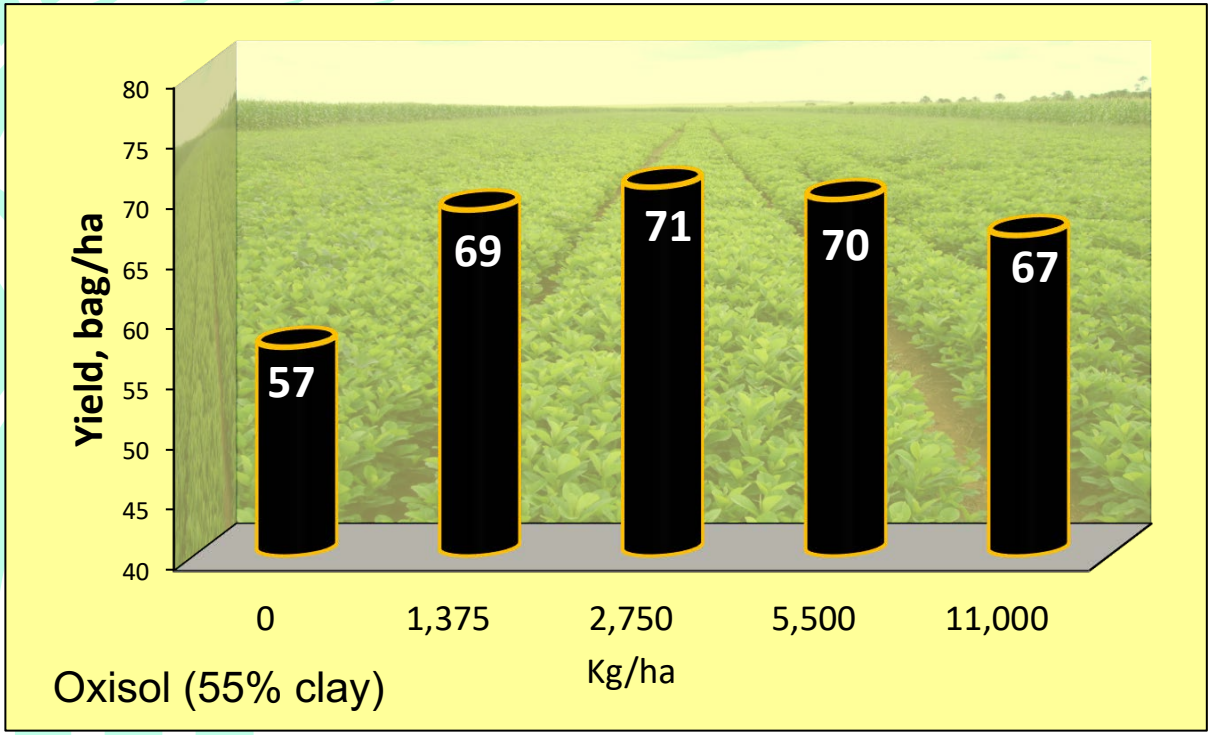
➢ No-tillage systems (pH <5.0 or BS < 65%, 0-5 cm):

- use BS formula to 70% (0-20 cm)
- at once or split in three years

Source: Caires

Subsoil acidity: phosphogypsum

- ✓ Reducing Al toxicity and supply Ca (18%) and S-SO_4 (15%);
- ✓ Decision to use: Al saturation > 20% or Ca <0.5 $cmol_c$/kg (20-40 cm)
- ✓ Recommendation rate: 50 kg per clay unit



Source: MT Foundation

Nitrogen

Biological N fixation

Important facts:

- ✓ Recommended inoculant rate (federal law): 1,200,000 viable cels/seed;
- ✓ Research data show 3 to 11% positive response in yield for yearly inoculation
- ✓ Great negative effect of soil acidity, compaction, and soil temperature (high) on nodules stablishment

Source: Zancanaro

Soil temperature in response to soil management and depth (Tukey , p>0.05).

Soil management	Depth (cm)									
	0		2		4		6		8	
No-till system	41.0	a	34.2	a	32.9	a	32.5	a	32.1	a
Conventional tillage	60.2	b	45.2	b	42.9	b	41.2	b	40.0	b

Source: MT Foundation

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Biological N fixation

Nitrogen balance in soybeans (kg N/ha). Source: Oliveira Junior et al.					
N-straw	N-BNF	N-root	N-soil	N-removal	N-net balance
228	194	11	35	-183	10

Tabela. Altura final de planta (AFP) e produtividade (PROD) de soja em função da inoculação das sementes com *Bradyrhizobium japonicum* e aplicação de nitrogênio. Fonte: Fundação MT/PMA (2011/12).

Tratamentos	AFP —— cm ——	PROD — sacas/ha —
Inoculação (I)		
Sem	95,7 b	52,5 b
Com	101,5 a	56,5 a
Modo de aplicação do N (M)		
Semeadura (lanço)	102,8	54,8
Cobertura (R1)	94,3	54,2
Dose de N (D)		
0 kg ha^{-1}	95,9	53,3
80 kg ha^{-1}	99,6	55,7
160 kg ha^{-1}	100,1	53,8
240 kg ha^{-1}	98,7	55,2

Tabela 1. Estande, altura final de plantas, número de grãos por vagem, peso de grãos e produtividade da soja em função dos tratamentos empregados na safra 2012/2013.

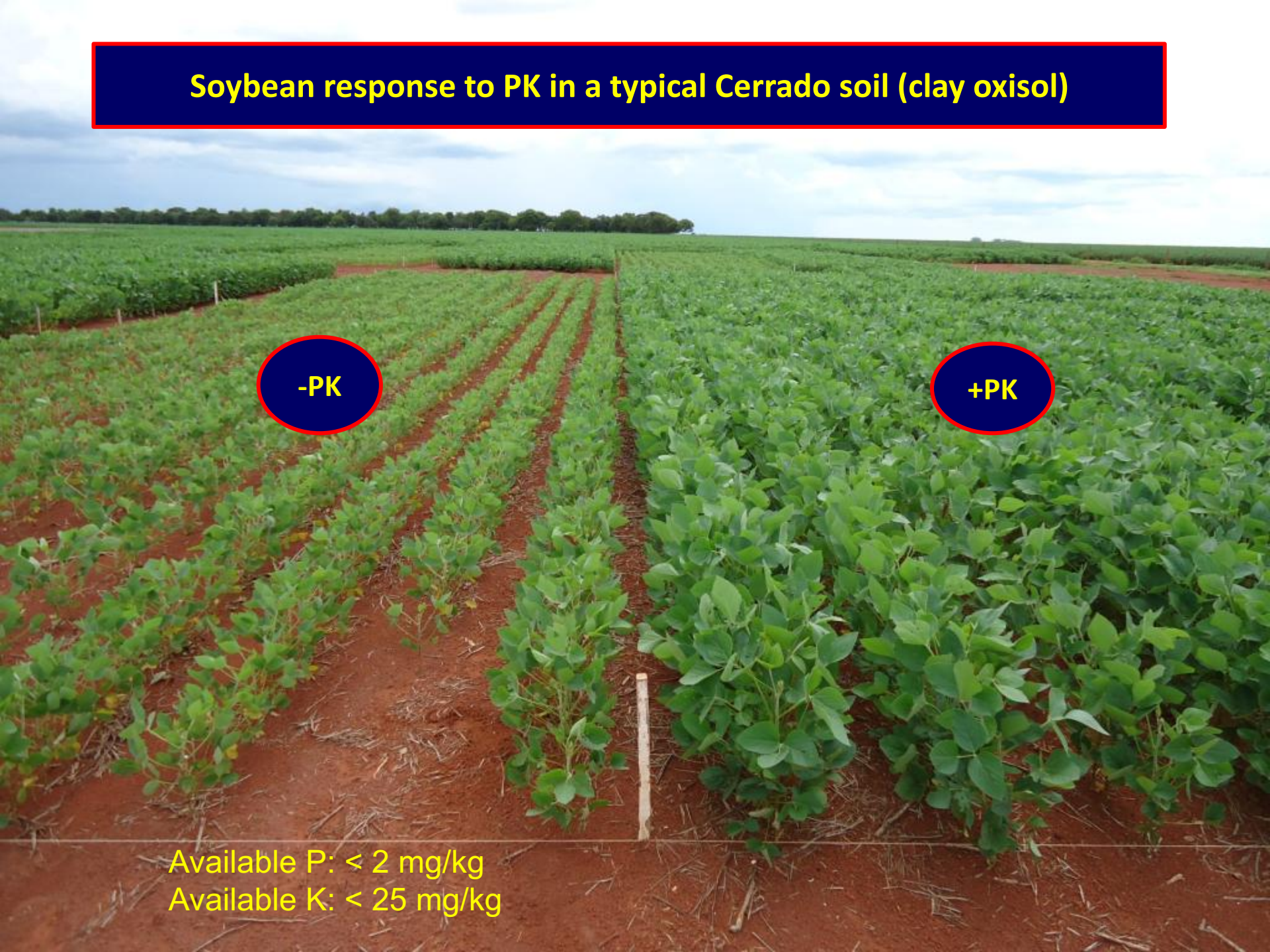
Trat.	Estande	Altura final	# pods/plant					Peso grãos	Yield	
	pl/m	cm	0	1	2	3	4	g	kg/ha	sc/ha
No N	11,2	59	1,0	5,8	20,3	29,2	0,0	161,2	3,750	62,5
N - starter	11,6	63	1,3	3,7	21,9	30,0	0,0	161,0	3,849	64,2

Estande e altura final de plantas: média de 3 amostragens
Número de grãos por planta: média de 9 amostragens
Produtividade: colheita mecanizada da área total

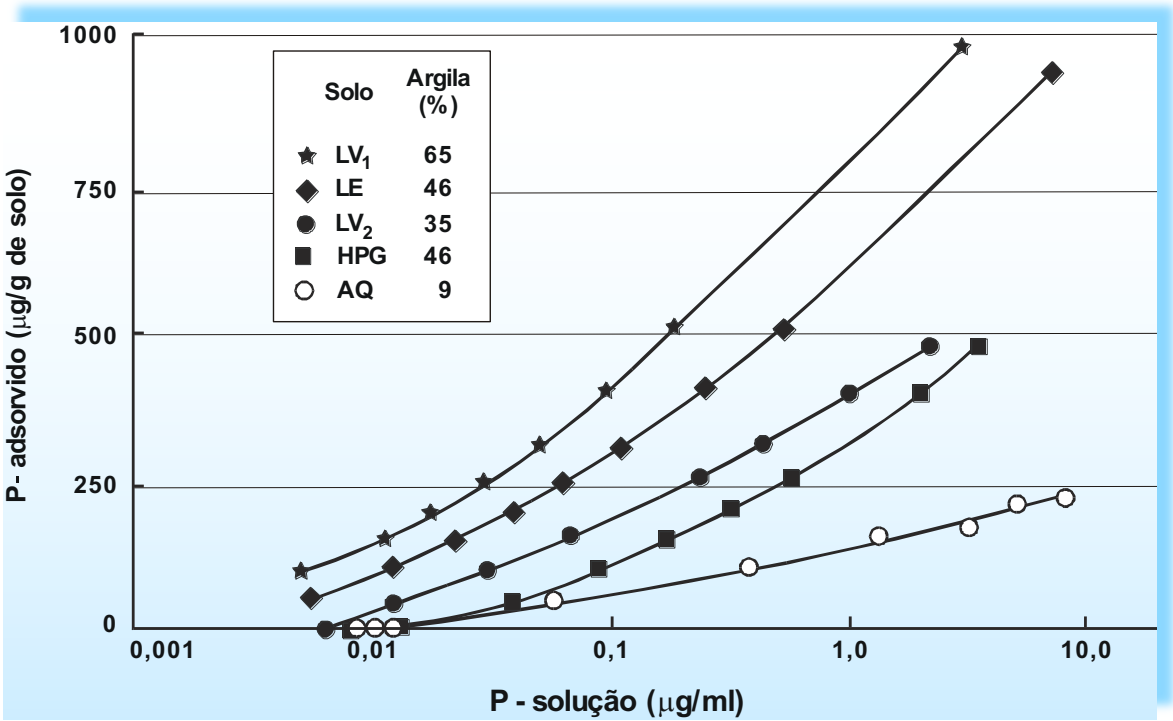
Source: IPNI

Phosphorus, Potassium, and Sulphur

Soybean response to PK in a typical Cerrado soil (clay oxisol)



Soil P fixing capacity



Practices to overcome soil fixation:

- ✓ Liming: keep soil pH adequately
- ✓ No-tillage: crop residues can help OM accumulation
- ✓ Promote biological activity: microryzha
- ✓ P placement: localize P application to reduce soil contact

PKS recommendations

Recommendation to correct PK soil levels in new operations

Clay	Increase P level				Increase K[3]	
	At once[1]		Gradually[2]			
	Very low P	Low P	Very low P	Low P	mg/kg	Kg K_2O/ha
	Kg P_2O_5/ha					
>60	240	120	100	90	<25	100
40-60	180	90	90	80	25-50	50
20-40	120	60	80	70	>50	0
<20	100	50	70	60		

1 Broadcast follow by incorporation to soil
2 In furrow application, yearly
3 Only for soils with clay content >20%

Source: Souza & Lobato

PKS recommendations

Recommendation based on yield expectation

Yield expectation	Adequate soil level		
t/ha	kg P_2O_5/ha	kg K_2O/ha	kg S/ha
3	60	60	
4	80	80	30
5	100	100	

- ✓ P rates applied at seeding
- ✓ K rates:
  - if > 50 kg K_2O/ha: split ½ at seeding and ½ 30 days after emergence, or
  - broadcast at the surface
- ✓ S via phosphate sources or phosphogypsum

Source: Souza & Lobato

Potassium on clay Oxisols

K management:

- ✓ Timing: application can be done at once (seeding or 15 days after emergence)
- ✓ Avoid high rates at seeding (< 50 kg K_2O/ha)
- ✓ Maize 2nd crop or cover crops in no-tillage will sustain K cycling
- ✓ Rates: 120 kg K_2O/ha in low K soils and 80-100 K_2O/ha in adequate K soil

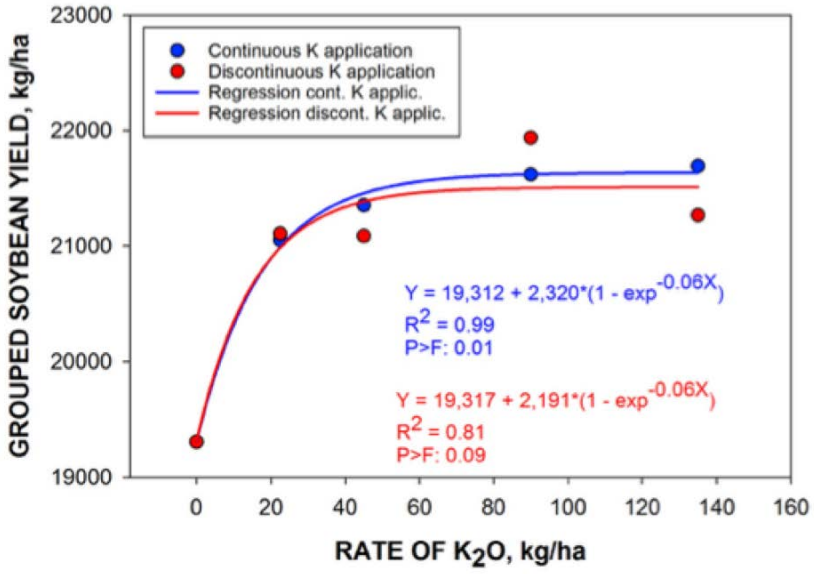


Figure 2. Grouped soybean yield response curves to K_2O rates with continuous and discontinuous K application (comparisons 1 and 2, Table 5). Crop seasons 2010-2016.

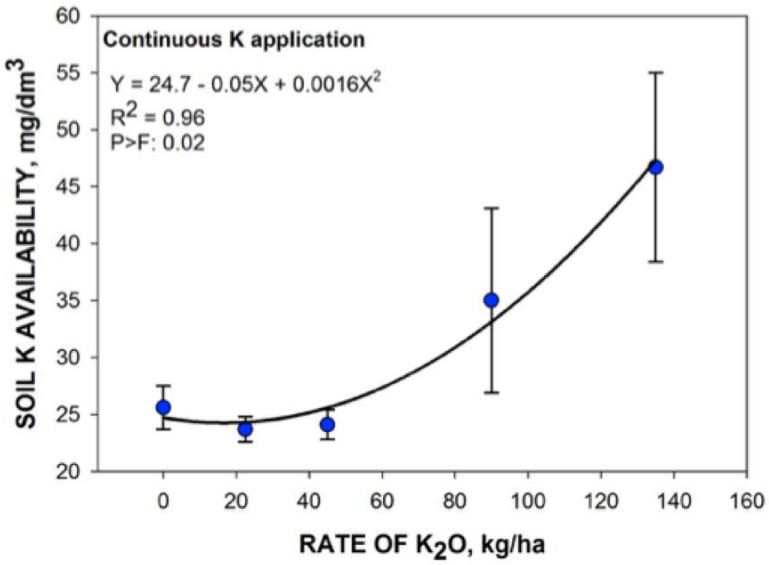


Figure 4. Soil K availability in response to K_2O rates with continuous K application (comparison 1). Crop season 2015-2016. Vertical bars represent standard deviation.

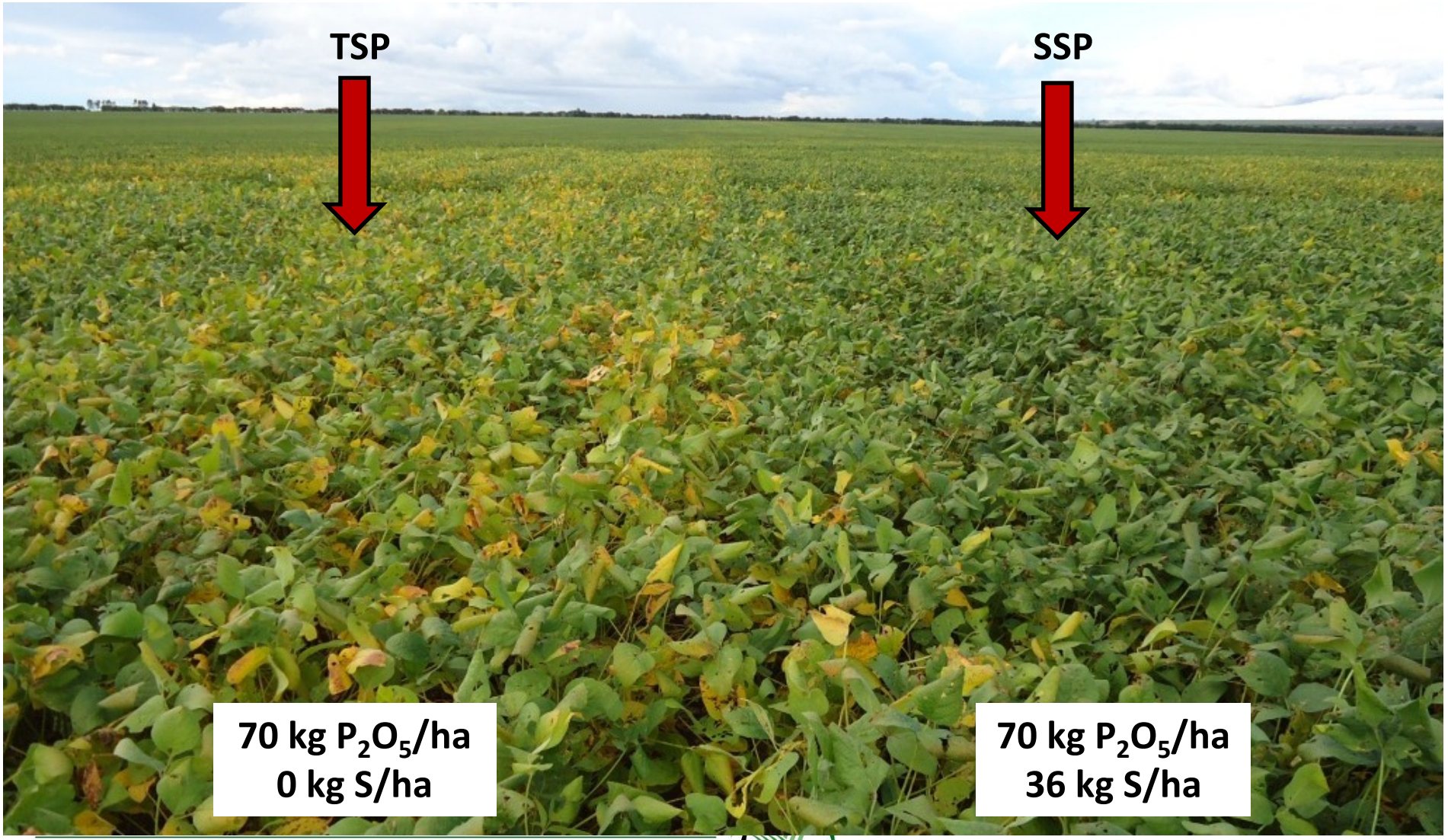
Source: IPNI

Potassium on sandy Entisols

K management:

- ✓ Timing: split K application in 2 or 3 (seeding, 30, and 60 days after emergence)
- ✓ Avoid high rates at seeding (< 50 kg K_2O/ha)
- ✓ Use of cover crops after harvest to increase K cycling
- ✓ Rates: 100-120 kg K_2O/ha in low K soils and 90-100 kg K_2O/ha in adequate K soils

Sulphur




Use of Elemental-S in pastilles:
- Higher rates
- Efficiency depends on soil bioactivity
- Not recommended as only source of S in soils low in S

Micronutrients

Micronutrients recommendations

Recommendation based on soil test

Soil level	B	Cu	Mn	Zn
		kg/ha		
Low	1.5	2.5	6.0	6.0
Medium	1.0	1.5	4.0	5.0
High	0.5	0.5	2.0	4.0

- ✓ Co: 2 to 3 g/ha via seed or foliar (V_3-V_5)
- ✓ Mo: 20 to 30 g/ha via seed or foliar (V_3-V_5)
- ✓ If Mn deficiency is visual: 350 g/ha via foliar

Source: Sfredo

Breaking yield barriers in soybean

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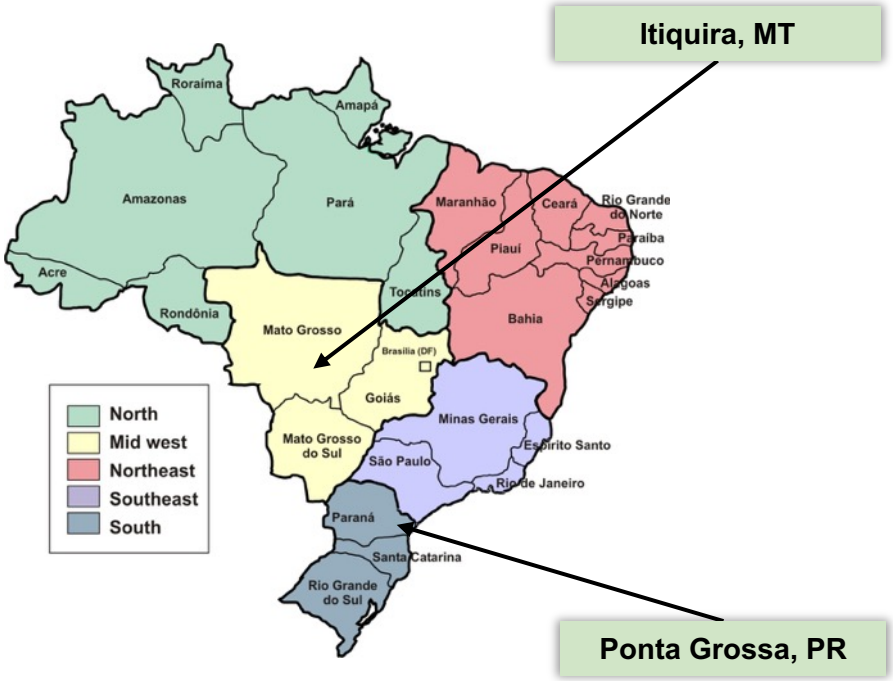
WG8 - Nutrient Decision Support for Soybean Systems

http://www.ipni.net/ipniweb/portal/soybean.nsf



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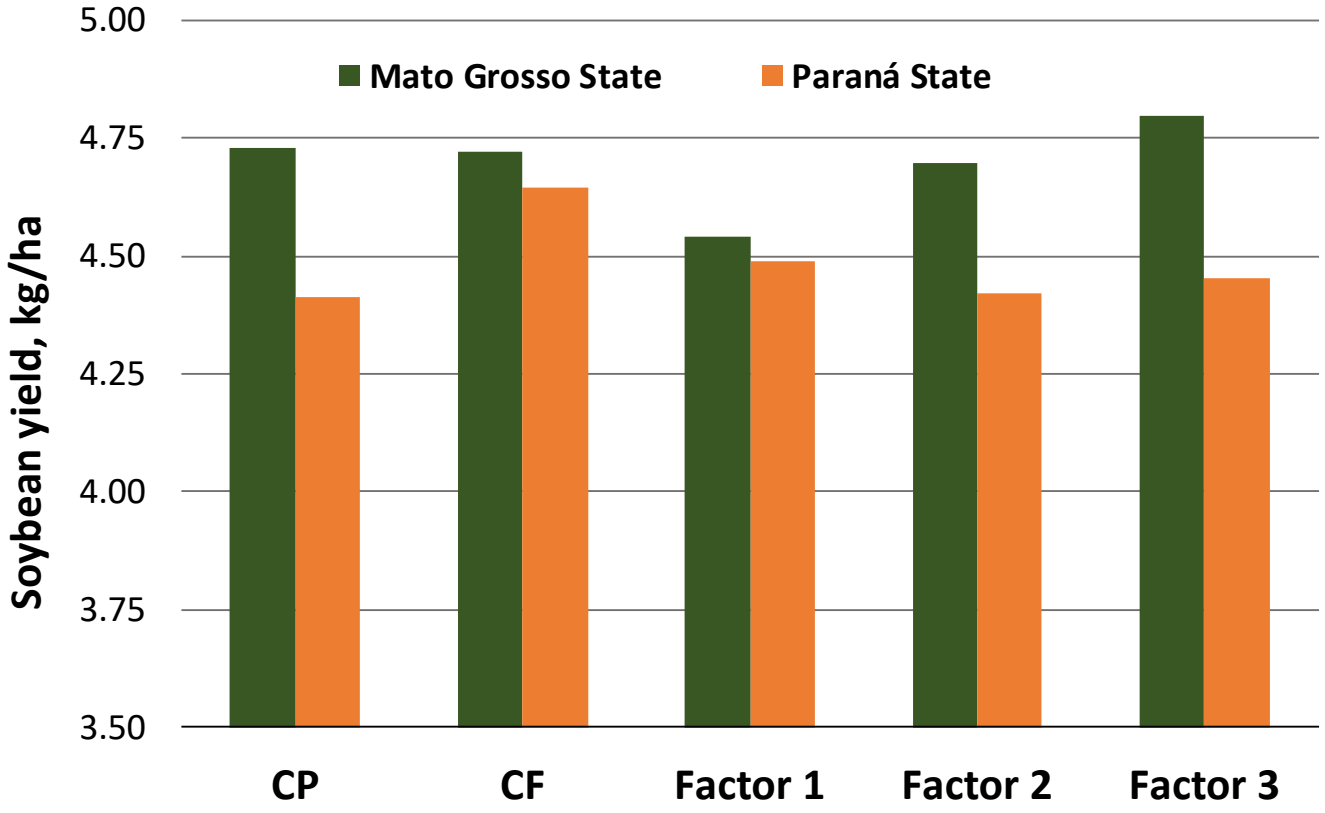

CP: common practice
CF: comprehensive fertilization
Factor 1: NPKS in soil
Factor 2: Micros in foliar
Factor 3: Extra liming

CP in MT: 50% BS, 26 kg P/ha, 60 kg K/ha, Mn foliar
CF in MT: 65% BS, 20 kg N/ha, 39 kg P/ha, 75 kg K/ha, 20 kg S/ha, Micros in foliar
CP in PR: 60% BS, 26 kg P/ha, 50 kg K/ha, Mn foliar
CF in PR: 75% BS, 20 kg N/ha, 39 kg P/ha, 75 kg K/ha, 20 kg S/ha, Micros in foliar

Source: IPNI (2017)

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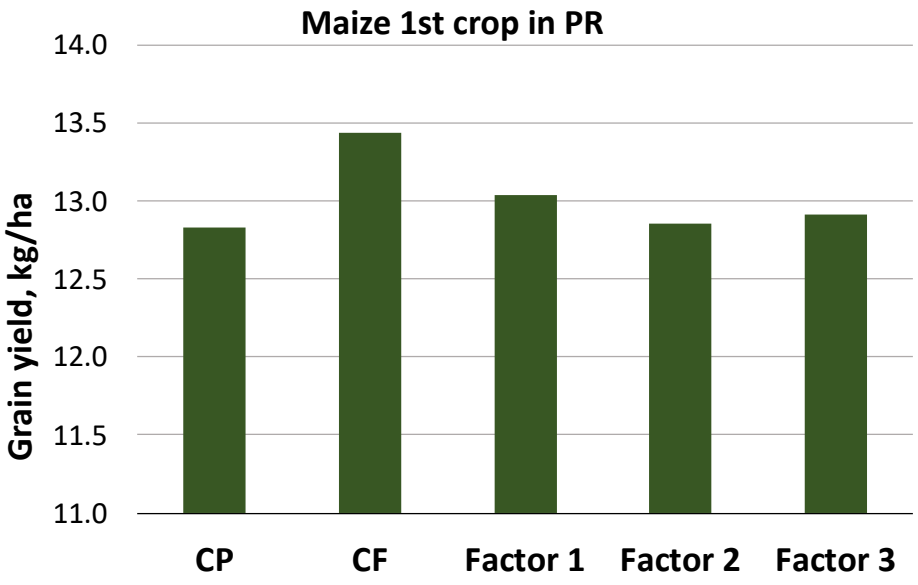

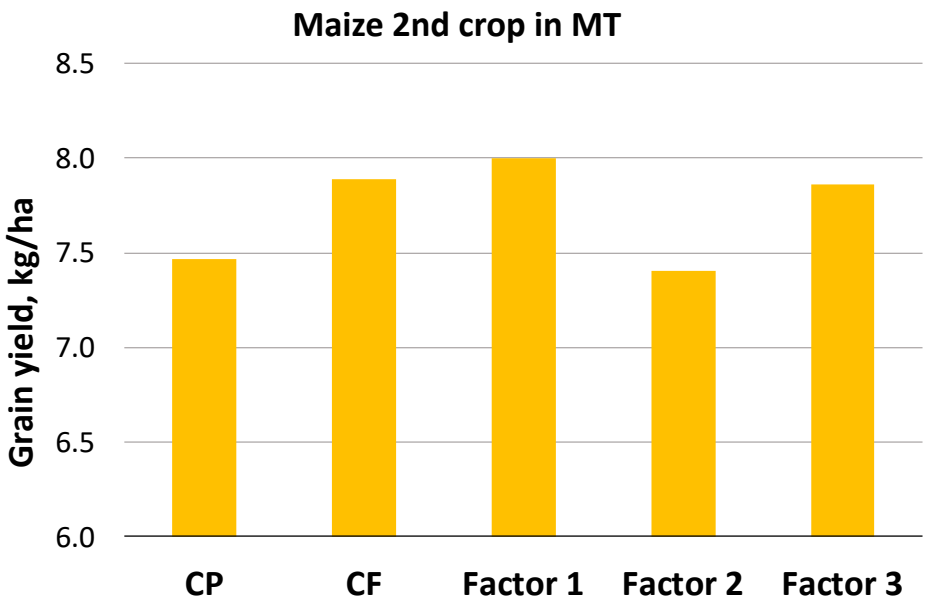

CP: common practice
CF: comprehensive fertilization
Factor 1: NPKS in soil
Factor 2: Micros in foliar
Factor 3: Extra liming

CP in MT: 50% BS, 70 kg N/ha, 22 kg P/ha, 33 kg K/ha, Zn foliar
CF in MT: 65% BS, 140 kg N/ha, 22 kg P/ha, 42 kg K/ha, 20 kg S/ha, Micros in foliar
CP in PR: 60% BS, 180 kg N/ha, 42 kg P/ha, 75 kg K/ha, Zn foliar
CF in PR: 75% BS, 191 kg N/ha, 53 kg P/ha, 75 kg K/ha, 55 kg S/ha, Micros in foliar

Source: IPNI (2017)

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WG8 - Nutrient Decision Support for Soybean Systems

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Crop	N	P	K	Ca	Mg	S
Nutrient uptake (kg/ha)						
Soybean	378	29	175	92	37	16
Nutrient removal (kg/ha)						
Soybean	273	20	80	19	11	9
Nutrient uptake (kg/ha)						
S+M2	658	76	422	145	77	35
Nutrient removal (kg/ha)						
S+M2	422	53	131	27	23	18
Nutrient budget with CP						
Soybean	-273	6	-20	-	-	-9
S+M2	-304	12	-10	-	-	-18
Nutrient budget with CF						
Soybean	-253	19	-5	-	-	11
S+M2	-214	25	5	-	-	22

S+M2: Soybean followed by Maize 2nd crop
CP: common practice
CF: comprehensive fertilization

Source: IPNI (2017)

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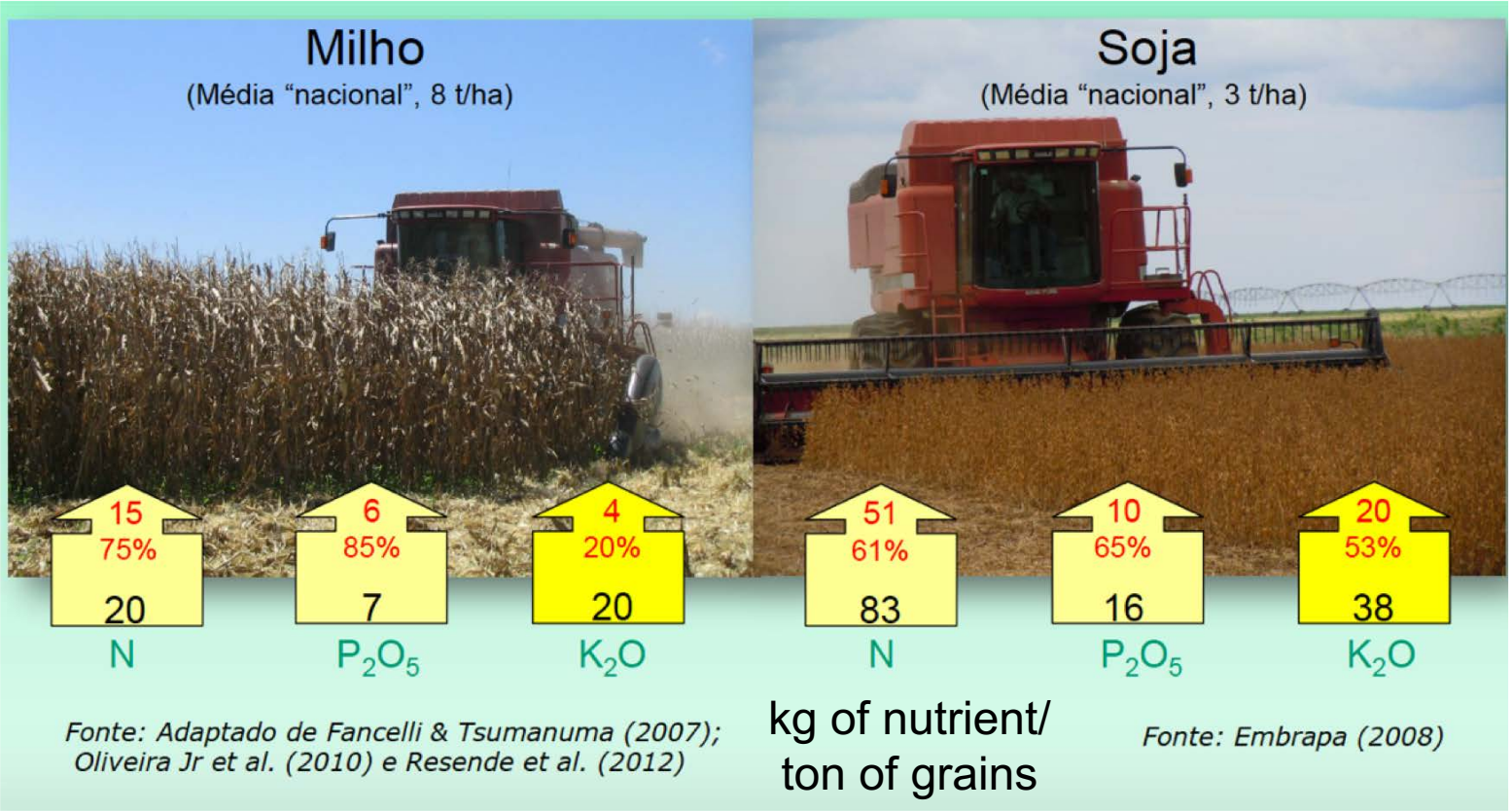
In high yielding cropping systems, crop removal must be followed closely

Removal

Uptake



Fonte: Adaptado de Fancelli & Tsumanuma (2007); Oliveira Jr et al. (2010) e Resende et al. (2012)

Fonte: Embrapa (2008)

Nutrient Budget Calculator

http://brasil.ipni.net

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10 Feb 2015

Balanço de Nutrientes nas Culturas (BNC)

Balanço de Nutrientes nas Culturas (BNC)

O **balanço de nutrientes nas culturas (BNC)** é uma das ferramentas para avaliação do uso de fertilizantes na agricultura e representa a diferença entre a saída de nutrientes pela colheita (exportação) e sua entrada no sistema (adubação). Saldos negativos, nos quais a exportação excede a adubação, levam à diminuição da fertilidade do solo e, eventualmente, à redução da produtividade, uma vez que a disponibilidade de nutrientes cai abaixo dos níveis críticos. Saldos positivos geralmente estão associados ao aumento da fertilidade do solo e podem, eventualmente, representar um elevado risco de perda de nutrientes para o ambiente.

Thank you!

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