

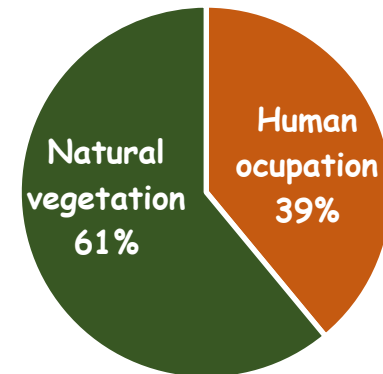
A Comprehensive Nutrient Budget of Brazilian Agriculture

Dr. Eros Francisco, IPNI Brazil





Land use in Brazil



- ✓ 1,871 conservation units
- ✓ 600 Indian reservations
- ✓ 2,471 protected areas
- ✓ 68 military areas

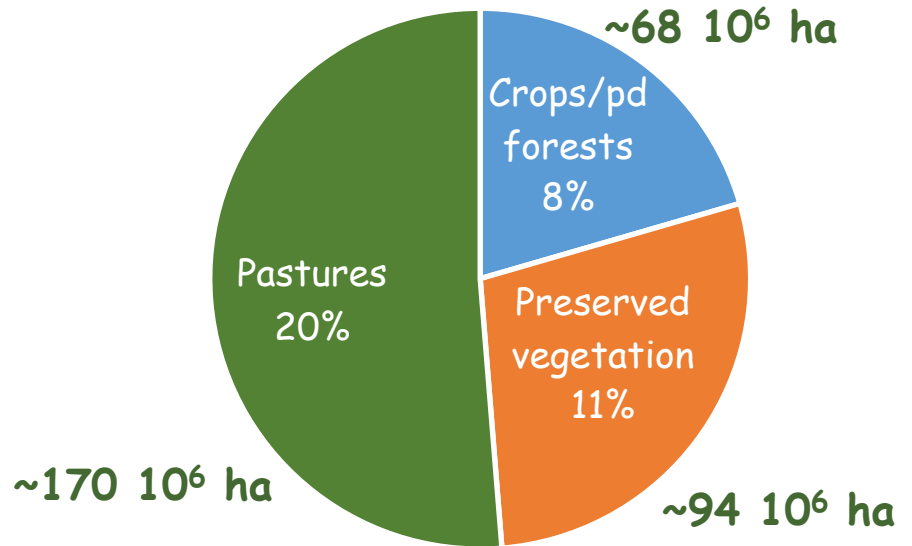
<http://www.aprosoja.com.br/storage/site/downloads/comunicacao/publicacoes/cartilha-de-sustentabilidade-em-ingles-e-mandarim58e3e27052fe6.pdf>



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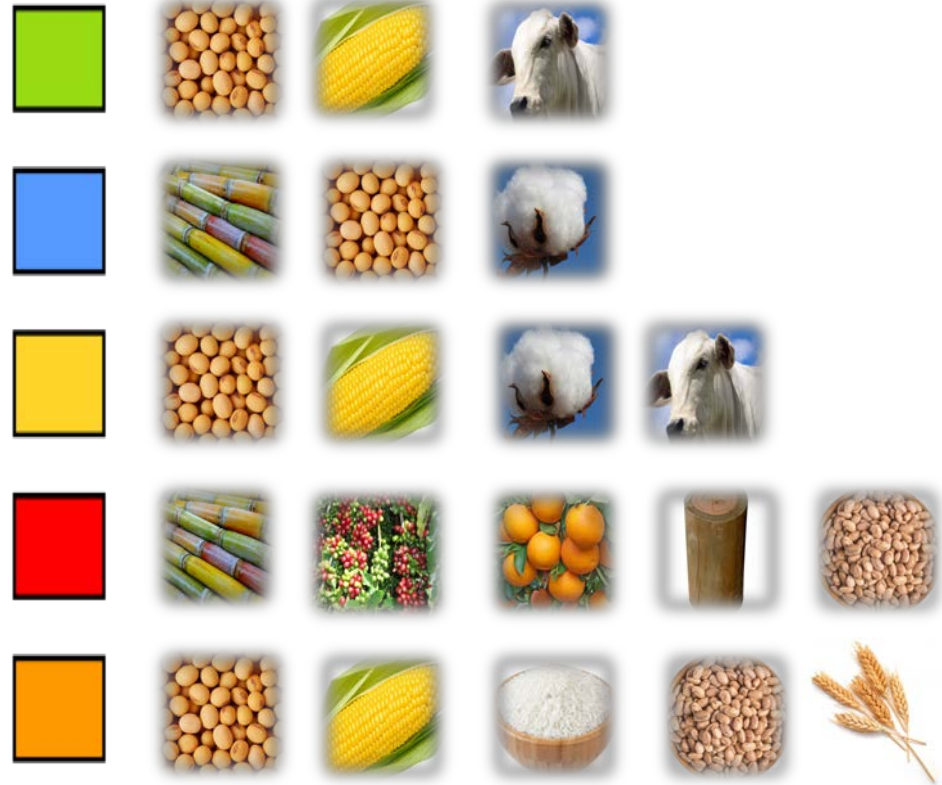


Land use in Brazil: *39% of human occupation*



<http://www.aprosoja.com.br/storage/site/downloads/comunicacao/publicacoes/cartilha-de-sustentabilidade-em-ingles-e-mandarim58e3e27052fe6.pdf>

Main crops in each region of Brazil



Harvested land, agricultural production and yield of crops in Brazil in the period of 2013 to 2016

Crop	Harvested land	Percentage	Production	Agricultural yield
	ha	(%)	(ton)	kg ha ⁻¹
Soybean	32,374,243	41.8%	395,490,231	3,054
Maize	15,073,126	20.1%	306,732,301	5,087
Sugarcane	10,148,028	14.2%	2,993,732,938	73,752
Coffee	2,002,765	2.9%	22,779,194	2,843
Cotton	1,025,142	1.3%	15,604,931	3,806
Rice	2,114,174	2.8%	47,566,510	5,625
Beans	2,946,949	4.1%	12,420,543	1,054
Tobacco	397,132	0.5%	3,276,569	2,063
Subtotal	72,956,311	97.5%	4,047,363,987	13,869
Other crops	1,927,553	2.5%	-	-
Grand total	77,689,240	100.0%		

Source: IBGE.



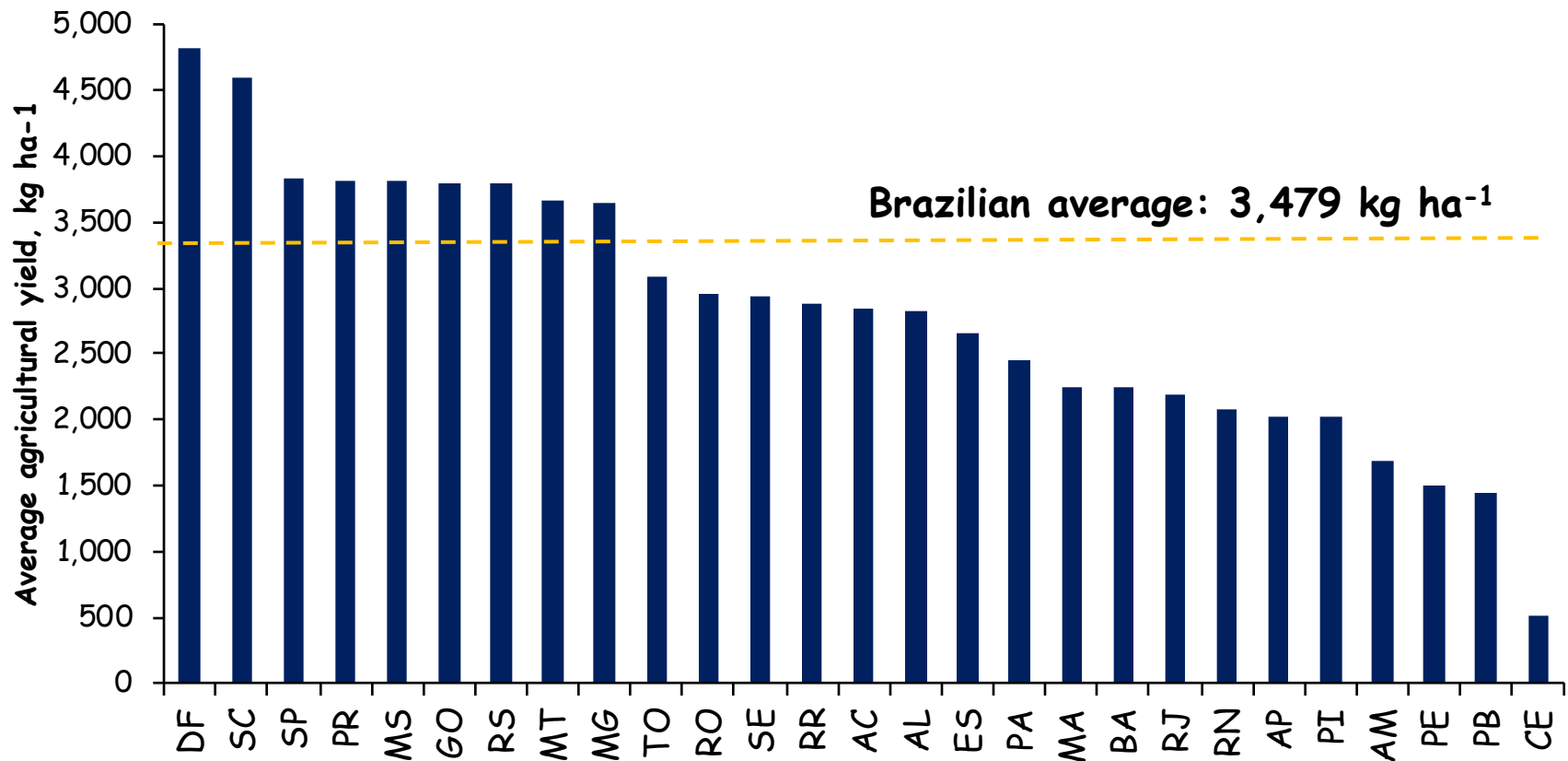
Harvested land, agricultural production and yield of crops in Brazil in the period of 2013 to 2016

Crop	Harvested land	Percentage	Production	Agricultural yield
	ha	(%)	(ton)	kg ha ⁻¹
Orange	678,012	1.0%	67,209,651	24,782
Wheat	2,419,922	3.1%	24,299,770	2,510
Potato	131,133	0.2%	15,264,413	29,101
Banana	477,327	0.7%	27,503,429	14,405
Sorghum	731,323	1.0%	7,664,537	2,620
Tomato	62,814	0.1%	16,647,320	66,257
Cocoa	697,824	1.0%	1,022,491	366
Cassava	1,473,950	2.7%	88,019,799	14,929
Peanut	148,426	0.2%	2,008,565	3,383
Castor bean	54,024	0.1%	120,795	559
Subtotal	72,956,311	97.5%	4,047,363,987	13,869
Other crops	1,927,553	2.5%	-	-
Grand total	77,689,240	100.0%		

Source: IBGE.



Average agricultural yield in Brazil during the period of 2013 to 2016: **by state**



Source: IBGE.

Nutrient budget in Brazilian agriculture is an on going project

1998



MANEJO DO SOLO DE ACORDO COM SUA MOBILIDADE NAS DIFERENTES CULTURAS*

A mobilidade do solo é um fator determinante para a produtividade agrícola. Este artigo discute as implicações da mobilidade do solo em diferentes culturas e apresenta estratégias de manejo para otimizar a utilização dos nutrientes.

PROF. DR. JOSÉ FRANCISCO DA CUNHA, INSTITUTO DE CIÊNCIAS EXATAS, UNICAMP

2010



BALANÇO DE NUTRIENTES NA AGRICULTURA BRASILEIRA*

Este artigo apresenta o balanço de nutrientes na agricultura brasileira, destacando a importância da fertilização adequada para garantir a sustentabilidade e a produtividade das culturas.

PROF. DR. JOSÉ FRANCISCO DA CUNHA, INSTITUTO DE CIÊNCIAS EXATAS, UNICAMP

2011



BALANÇO DE NUTRIENTES NA AGRICULTURA BRASILEIRA - DO PERÍODO DE 1990 A 2010

Este artigo analisa o balanço de nutrientes na agricultura brasileira ao longo do período de 1990 a 2010, avaliando as mudanças e os desafios para a sustentabilidade.

PROF. DR. JOSÉ FRANCISCO DA CUNHA, INSTITUTO DE CIÊNCIAS EXATAS, UNICAMP

2014



BALANÇO DE NUTRIENTES NA AGRICULTURA BRASILEIRA - 2009 A 2012

Este artigo apresenta o balanço de nutrientes na agricultura brasileira no período de 2009 a 2012, destacando as tendências e as necessidades de pesquisa.

PROF. DR. JOSÉ FRANCISCO DA CUNHA, INSTITUTO DE CIÊNCIAS EXATAS, UNICAMP

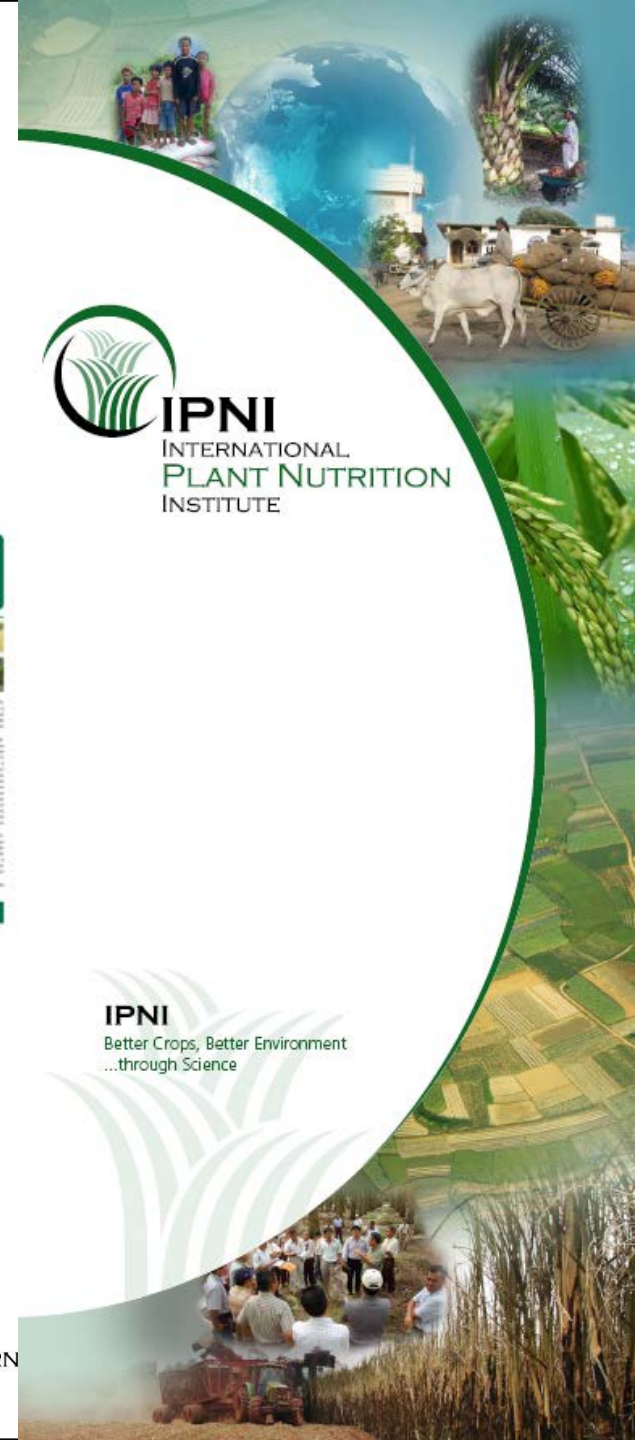
2018



Este artigo celebra os 40 anos de atuação do IPNI, destacando as conquistas e o compromisso com a sustentabilidade e a melhoria da agricultura brasileira.

PROF. DR. JOSÉ FRANCISCO DA CUNHA, INSTITUTO DE CIÊNCIAS EXATAS, UNICAMP

José Francisco da Cunha
IPNI Brazil Consultant



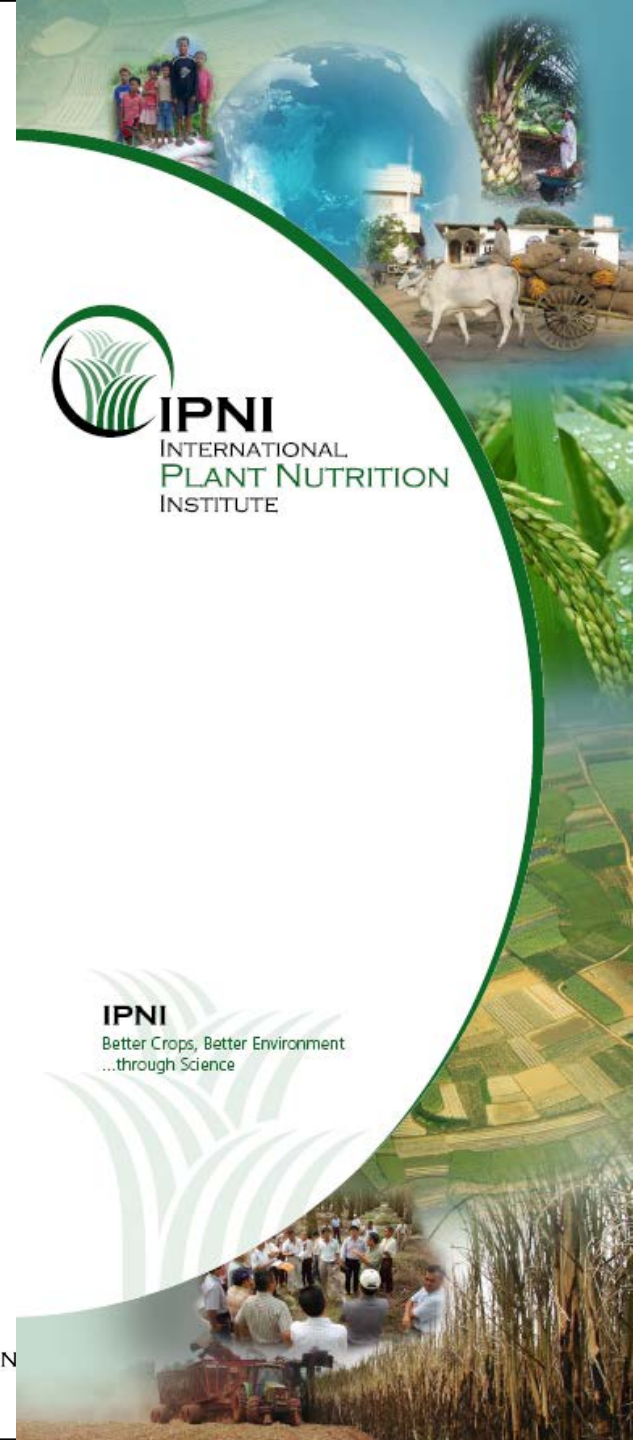
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What is nutrient budget?



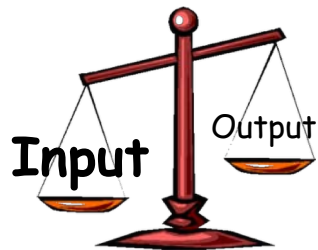
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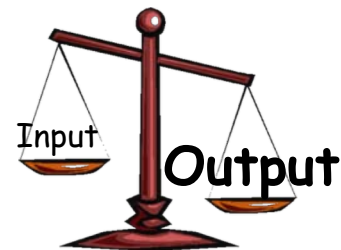
**Addition
(Input)**

**Removal
(Output)**

$$\text{Budget} = \text{input} - \text{output}$$



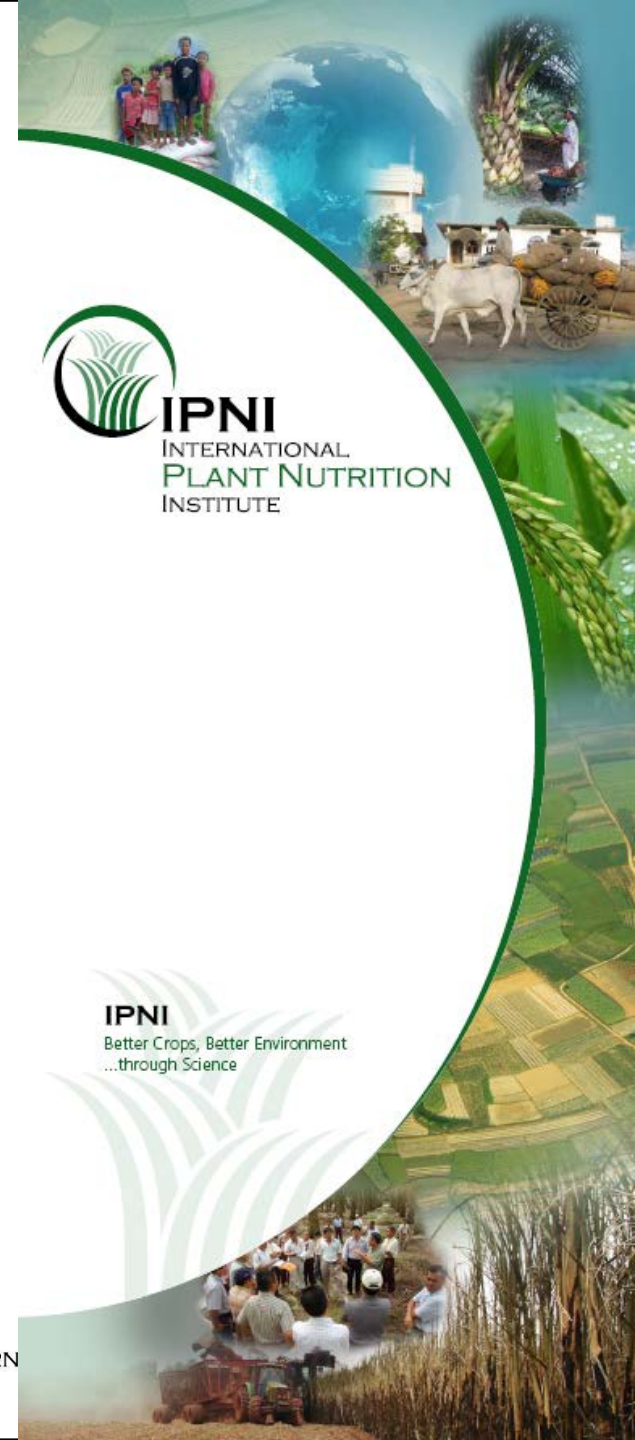
Excessive user of resources
Potential environmental impact



Mining soil fertility
Exhaustion of cropping system

Equilibrium means sustainable



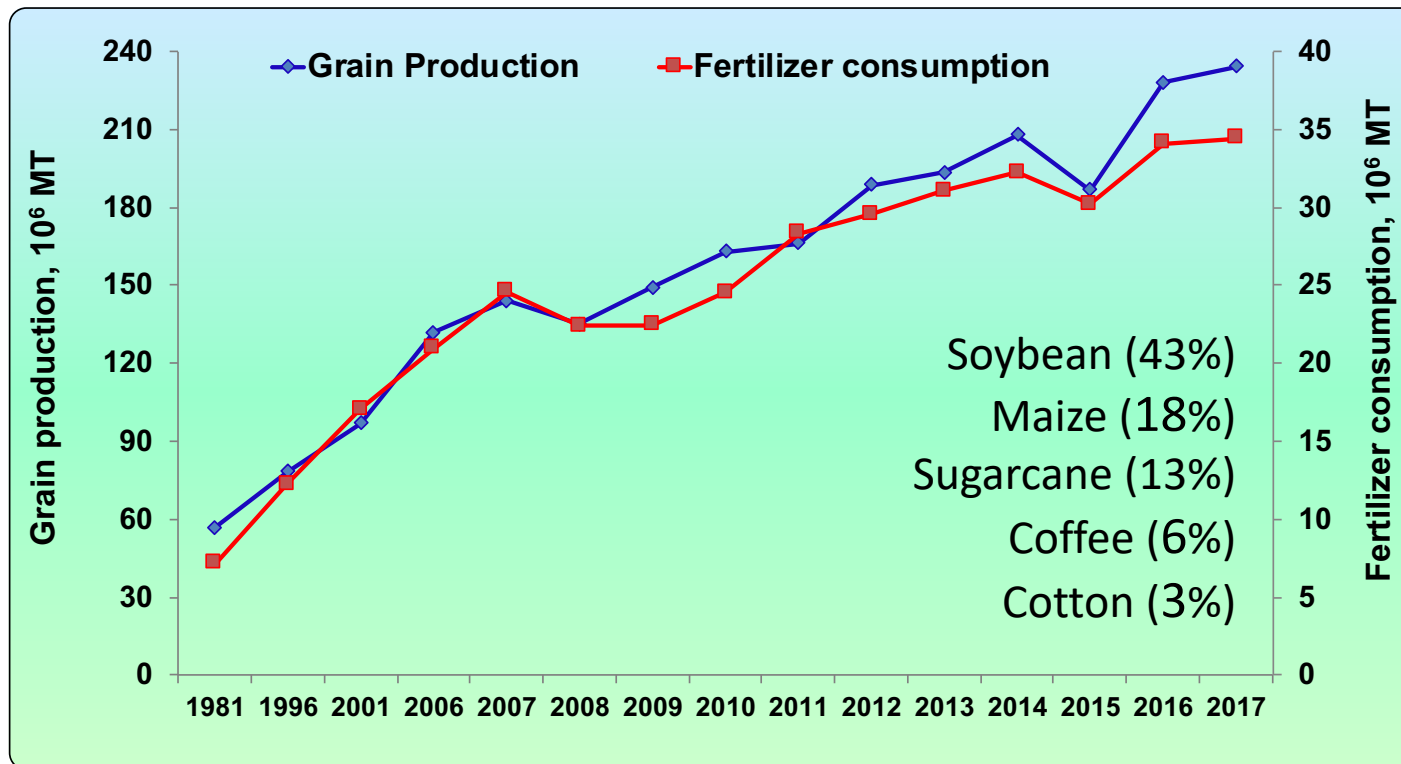


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What are the inputs in Brazilian agriculture?

Total grain production and fertilizer consumption in Brazil over the last three decades



Source: IBGE, ANDA.

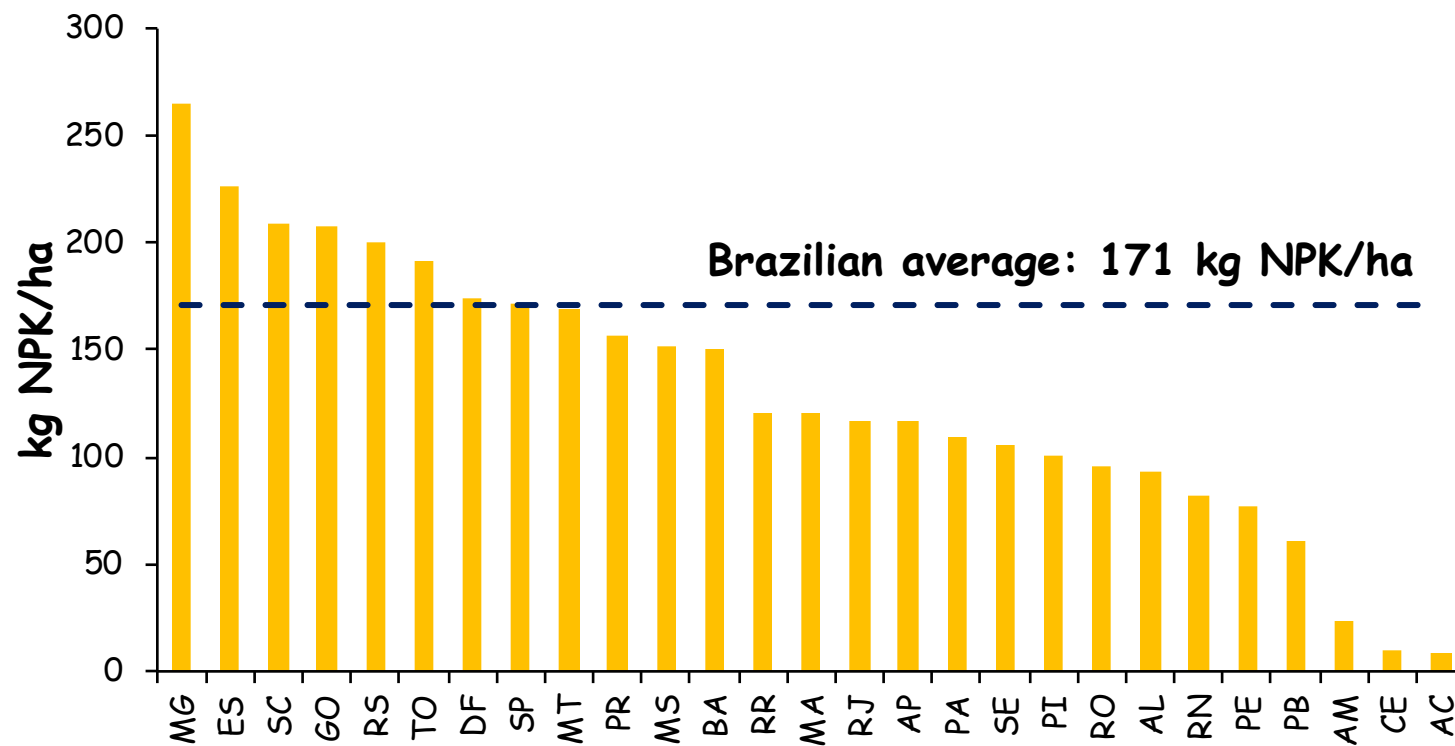
Total fertilizer and nutrient average annual consumption in Brazil in the period of 2013 to 2016: **by region**

Region	Total consumption			
	Product	N	P ₂ O ₅	K ₂ O
	ton			
South	8,746,791	1,141,459	1,403,874	1,418,287
Midwest	10,574,696	995,969	1,780,671	1,970,166
Southeast	8,038,345	1,321,370	853,007	1,201,671
Northeast	3,373,080	316,623	455,540	555,449
North	1,161,190	91,968	198,926	199,330
Brazil	31,894,102	3,867,387	4,692,018	5,344,902

Source: Cunha et al (2018).



Average NPK addition per hectare in Brazil during the period of 2013 to 2016: **by state**



Source: Cunha et al (2018).

*What are the outputs in
Brazilian agriculture?*



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Total nutrient removal yearly in Brazil during the period of 2013 to 2016: **by crop**

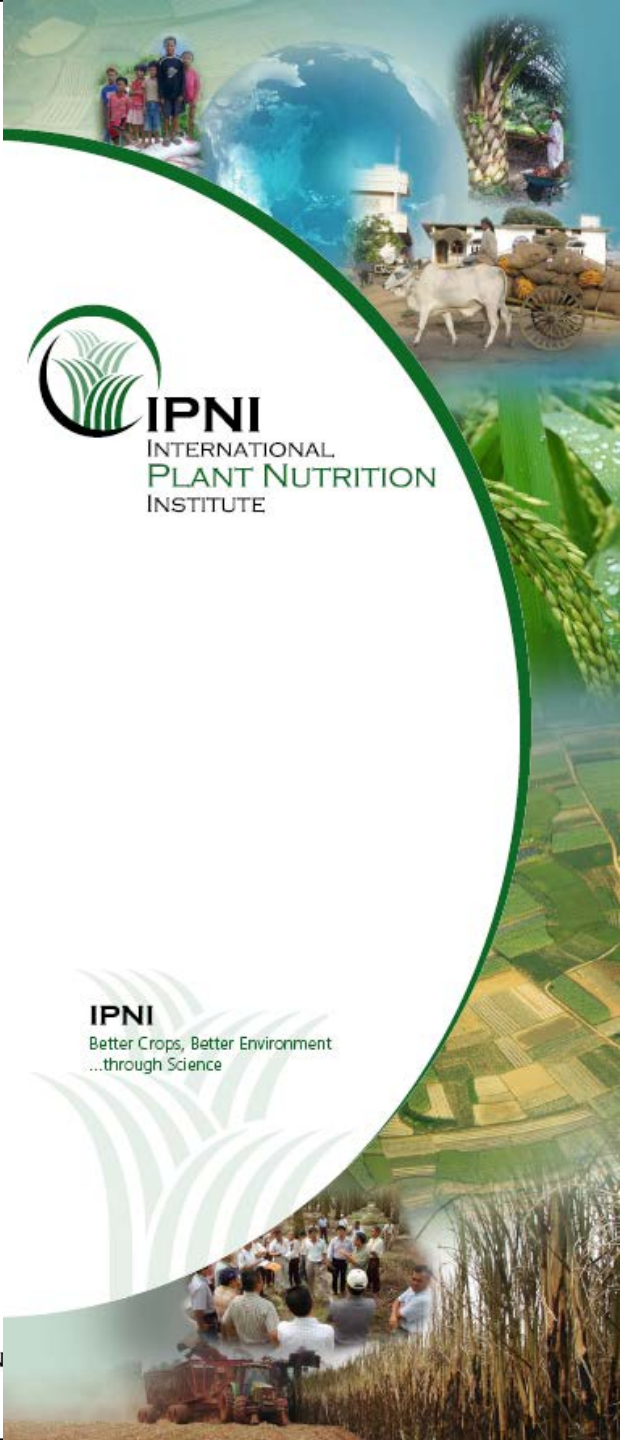
Crop	Macronutrients						Micronutrients					
	N	P ₂ O ₅	K ₂ O	Ca	Mg	S	B	Cu	Fe	Mn	Mo	Zn
	ton											
Soybean	5,853,255	1,246,045	2,239,118	286,730	227,407	296,618	2,393	1,285	13,279	3,332	494	3,727
Maize	1,073,563	456,844	341,778	7,668	84,351	76,683	383	153	1,150	383	46	1,380
Sugarcane	621,200	188,643	703,220	299,373	232,014	179,624	898	1,946	10,703	7,260	12	2,470
Coffee	99,374	15,659	181,789	19,362	7,973	7,688	95	94	598	142	0	233
Cotton	132,252	47,985	85,827	11,146	32,770	13,264	130	29	2,007	164	-	68
Rice	148,051	61,036	63,315	11,892	12,843	17,481	52	75	727	298	2	486
Beans	108,369	28,460	57,603	9,626	8,073	17,699	41	20	371	72	-	93
Tobacco	31,947	12,576	44,403	10,075	25,148	8,191	18	11	-	204	-	26
Orange	32,025	6,661	30,623	8,838	2,134	2,302	37	20	111	47	0	15
Wheat	122,106	44,544	25,613	1,215	4,860	7,290	18	18	84	79	-	90
Potato	13,738	1,924	15,170	572	687	1,526	8	8	76	76	4	15
Banana	13,202	4,175	68,084	1,877	1,939	440	15	6	63	73	0	12
Sorghum	28,742	32,929	9,071	479	2,395	2,721	6	3	23	21	1	24
Tomato	9,988	3,433	12,333	583	916	1,165	12	6	104	11	0	13
Cocoa	8,436	1,171	2,463	256	511	256	3	4	20	7	0	12
Cassava	45,110	10,589	51,689	13,863	7,042	1,760	40	18	528	35	-	101
Peanut	17,073	2,301	5,444	251	502	1,004	-	-	-	-	-	-
Castor bean	876	256	262	187	72	60	2	1	21	4	-	2

Source: Cunha et al (2018).

Total nutrient removal yearly in Brazil during the period of 2013 to 2016: **by region**

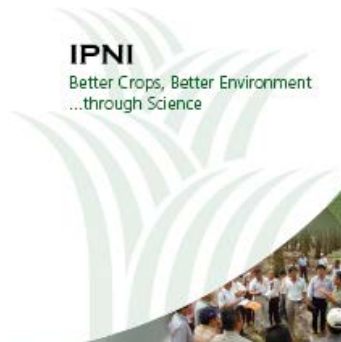
Region	Total nutrient removal											
	N	P ₂ O ₅	K ₂ O	Ca	Mg	S	B	Cu	Fe	Mn	Mo	Zn
	ton											
South	2,776,706	713,514	1,121,915	152,886	166,994	176,901	1,140	740	6,767	2,374	194	2,483
Midwest	3,435,065	879,286	1,402,493	201,183	212,007	219,767	1,547	1,047	10,135	3,188	251	2,912
Southeast	1,159,435	322,011	917,546	248,740	196,408	167,548	959	1,516	9,089	5,359	51	2,373
Northeast	668,538	173,467	346,481	59,869	58,641	53,067	361	308	2,923	1,037	42	706
North	319,563	76,953	149,371	21,317	17,587	18,491	143	88	951	249	23	297
Brazil	8,359,307	2,165,231	3,937,806	683,995	651,638	635,774	4,149	3,699	29,865	12,208	560	8,770

Source: Cunha et al (2018).



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Nutrient budget



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Nutrient budget in Brazilian agriculture in the period of 2013 to 2016: **annual average**

	N	P ₂ O ₅	K ₂ O	Ca	Mg	S	B	Cu	Fe	Mn	Mo	Zn
	ton											
Total removal	8,359,307	2,165,231	3,937,806	683,995	651,638	635,774	4,149	3,699	29,865	12,208	560	8,770
Deductions	6,288,787	4,567	204,956	-	-	-	-	-	-	-	-	-
Total net removal (I)	2,070,519	2,160,664	3,732,849	683,995	651,638	635,774	4,149	3,699	29,865	12,208	560	8,770
Total addition (II)	3,600,703	4,368,470	4,976,333	7,495,331	2,599,359	1,793,806	12,948	4,595	287,557	14,973	-	23,308
Budget (II - I)	1,530,184	2,207,806	1,243,484	6,811,336	1,947,722	1,158,033	8,799	895	257,692	2,765	(560)	14,538
Removal-to-use ratio	0,58	0,49	0,75	0,09	0,25	0,35	0,32	0,81	0,10	0,82	-	0,38

Source: Cunha et al (2018).

Deductions:

N: 100%, 50%, 50%, 40%, and 50% of soybean, common beans, maize 2nd crop, wheat, and sorghum removal, respectively, plus 30 kg N/ha from 30% and 20% of maize and cotton land in rotation with soybean.

P₂O₅: 50% from coffee shells that return to field.

K₂O: 50% from coffee shells that return to field, plus 20% of sugarcane removal in return from vinasse application.



Removal-to-use ratio in Brazil during the period of 2013 to 2016: **by region**

Region	Removal-to-use ratio		
	N	P ₂ O ₅	K ₂ O
South	0.53	0.55	0.84
Midwest	0.61	0.53	0.75
Southeast	0.56	0.40	0.69
Northeast	0.65	0.41	0.64
North	0.69	0.41	0.79
Brazil	0.58	0.49	0.75

Source: Cunha et al (2018).

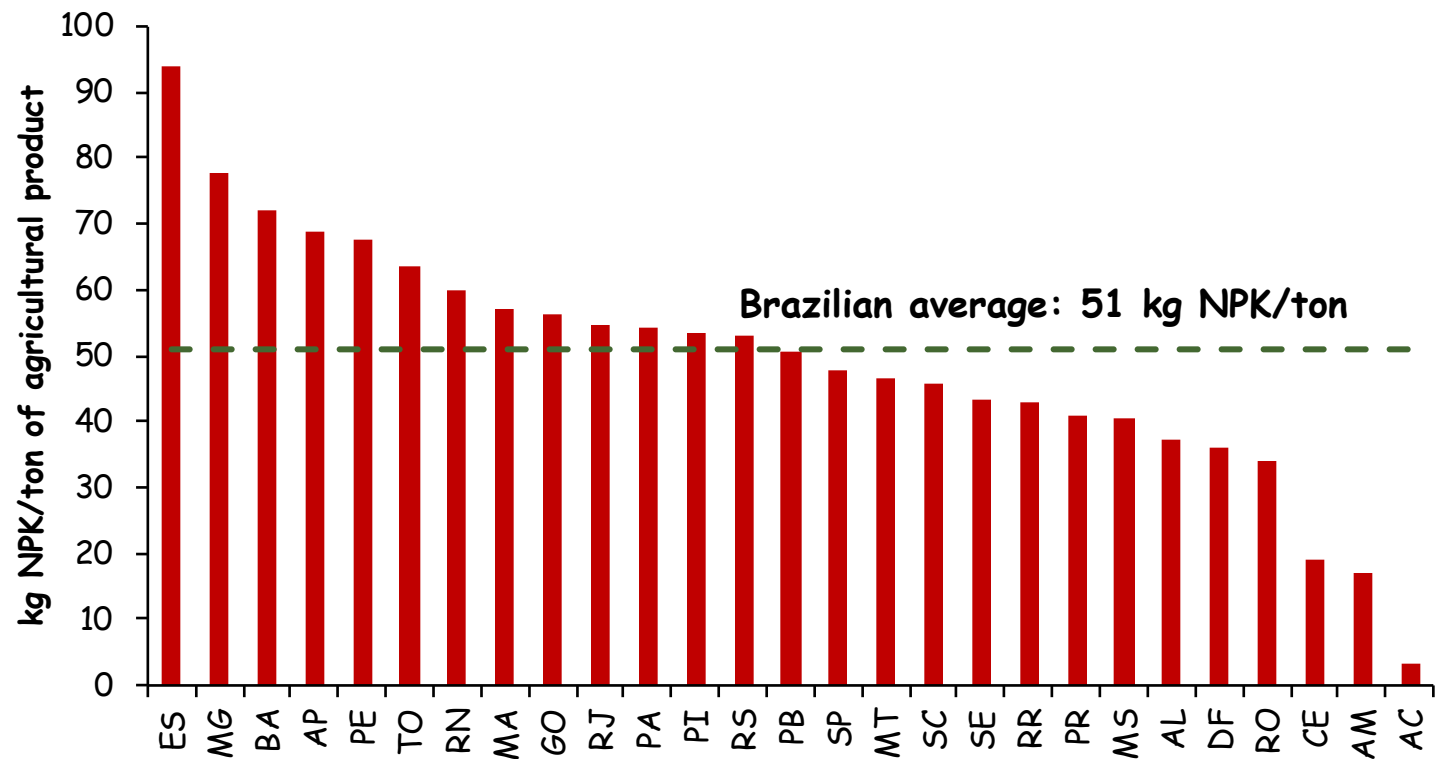


Removal-to-use ratio in Brazil during the period of 2013 to 2016: **by crop**

Crop	Removal-to-use ratio		
	N	P ₂ O ₅	K ₂ O
Soybean	-	0.47	0.90
Maize	0.64	0.80	0.57
Sugarcane	0.76	0.67	0.64
Coffee	0.20	0.12	0.42
Cotton	0.80	0.31	0.67
Rice	0.83	0.75	0.89
Beans	0.65	0.38	1.21
Orange	0.57	0.33	0.73
Wheat	0.49	0.43	0.33
Brazil	0.58	0.49	0.75

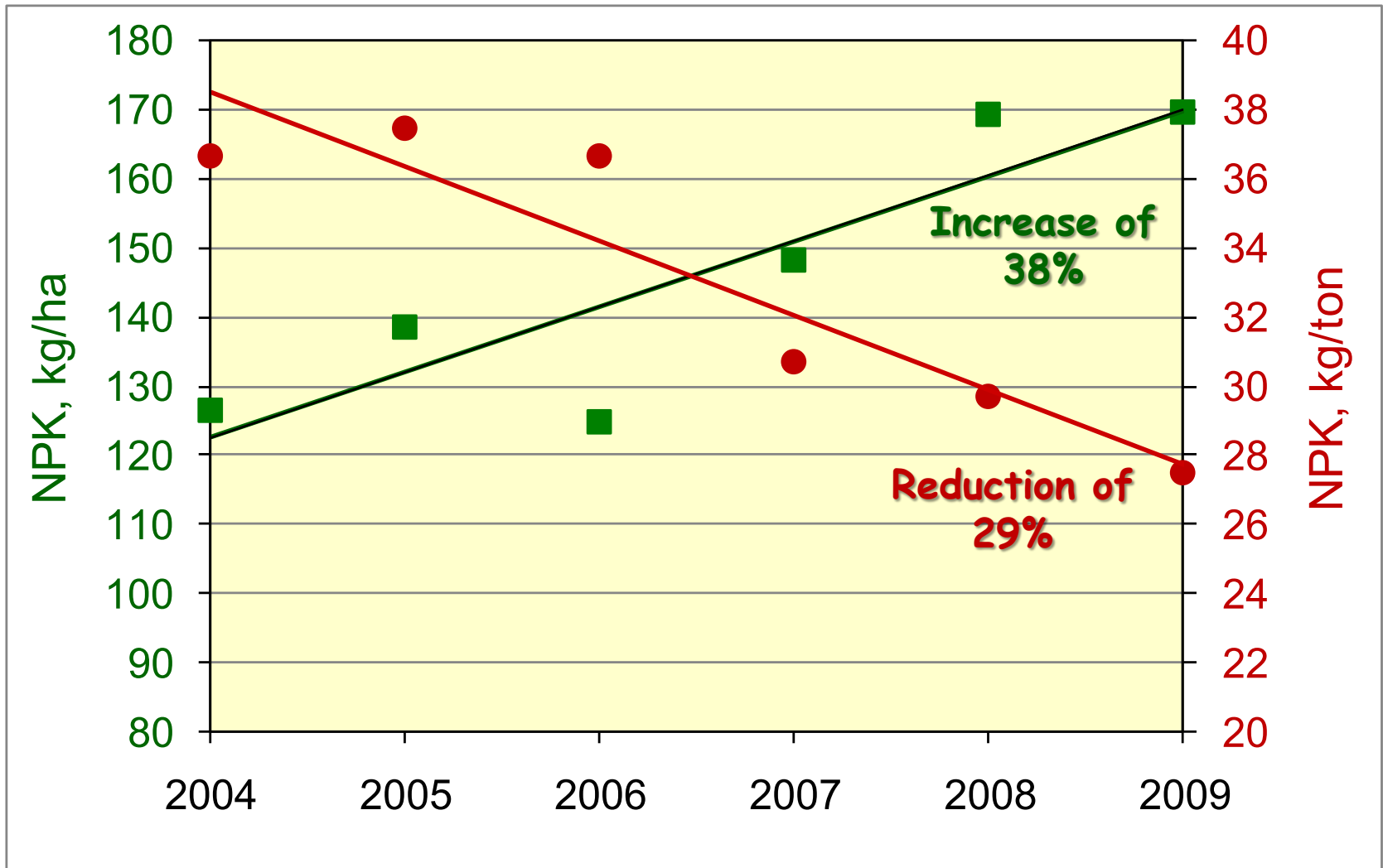
Source: Cunha et al (2018).

Average NPK addition per ton of agricultural product in Brazil during the period of 2013 to 2016: **by state**



Source: Cunha et al (2018).

Case study: soy/maize farm in Mato Grosso state

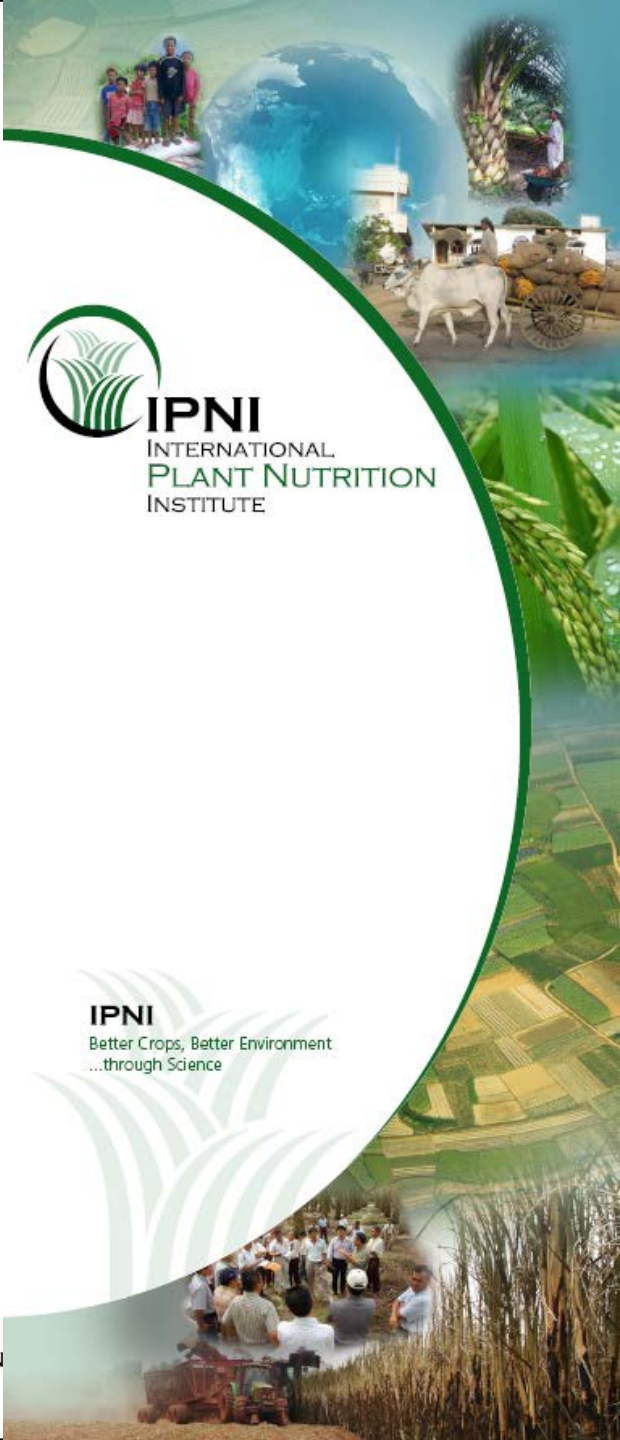


Source: Cunha et al. (2011).

Nutrient consumption, removal-to-use ratio and agricultural yield in Brazil during the period of 2013 to 2016

Year	Consumption (kg/ha)			Removal-to-use ratio			Agricultural yield (kg/ha)
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	
2009	39	51	47	0.72	0.55	0.97	3,066
2010	42	49	57	0.71	0.60	0.87	3,294
2011	49	57	65	0.58	0.48	0.70	3,074
2012	49	61	68	0.59	0.51	0.73	3,419
2013	48	61	67	0.61	0.47	0.73	3,394
2014	49	60	68	0.58	0.49	0.74	3,452
2015	45	56	66	0.62	0.52	0.76	3,467
2016	55	62	72	0.51	0.50	0.77	3,575
	Variation						
	+42%	+23%	+51%	-29%	-9%	+21%	+17%

Source: Cunha et al (2018).



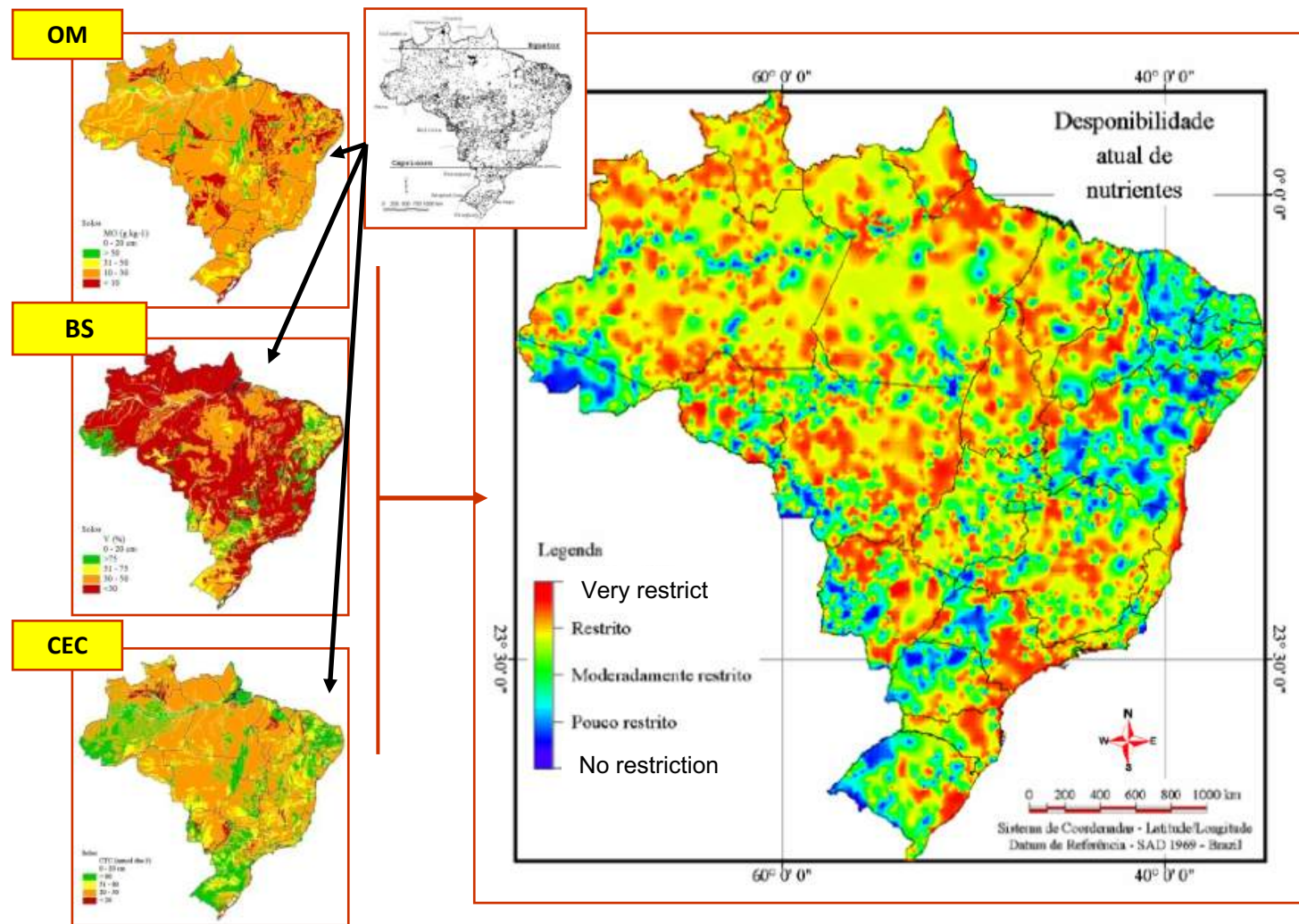
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Final considerations

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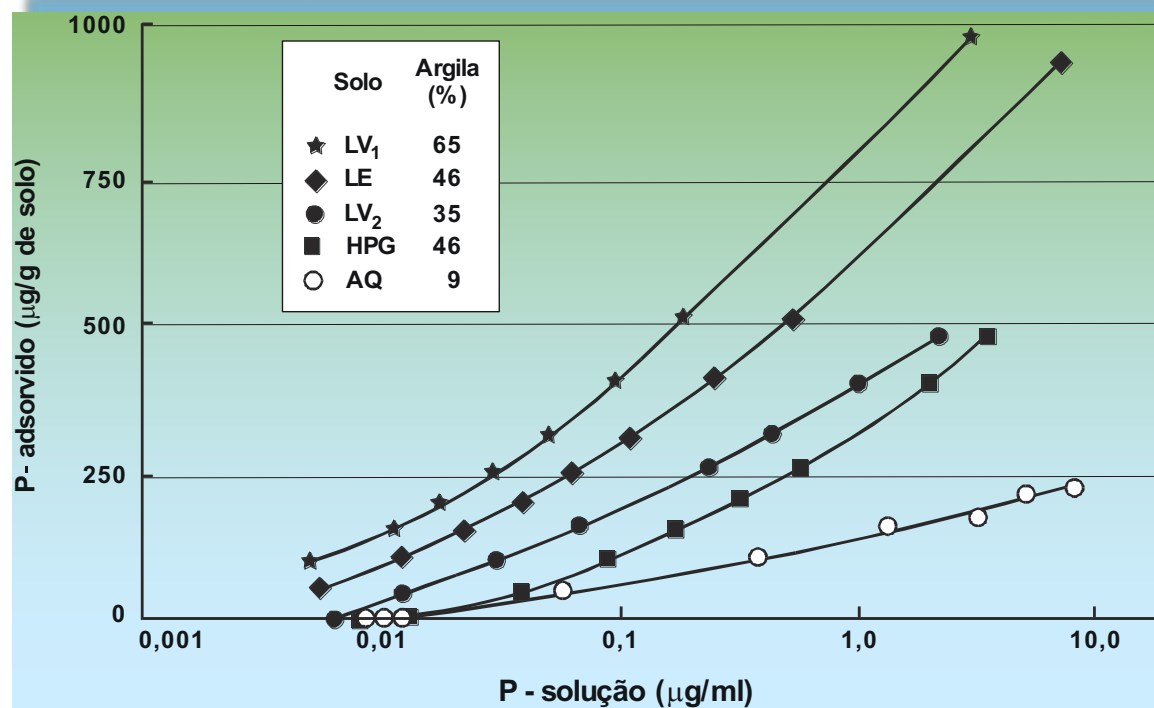


Soil fertility restrictions in Brazilian soils



Source: Sparovek et al.

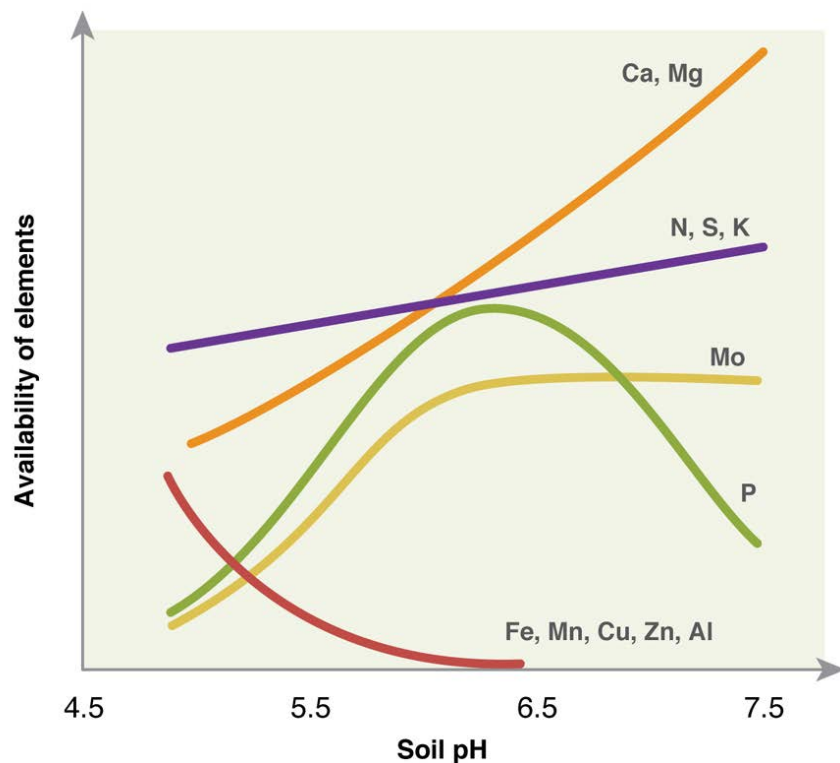
Soil P fixing capacity



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

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





A very complex cropping system



Soil Organic Matter



P recovery

long term study on a clay Oxisol

P rate (single superphosphate)	P recovery	
	Annual crops ¹	Annual crops + forage ²
kg/ha of P ₂ O ₅	----- % -----	
100	44	85
200	40	82
400	35	70
800	40	62

¹ 10 years of soybean + 1 year of maize + 4 years of soybean-maize (double crop) + 2 years of maize + 1 year of soybean.

² 2 years of soybean + 9 years of Brachiaria grass + 2 years of soybean + 2 years of soybean-maize (double crop) + 5 years of Brachiaria grass.

Source: Sousa et al., 2007.



Nutrient Budget Calculator

<http://brasil.ipni.net>

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Português



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10 Feb 2015



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.



Balanço de Nutrientes nas Culturas (BNC)



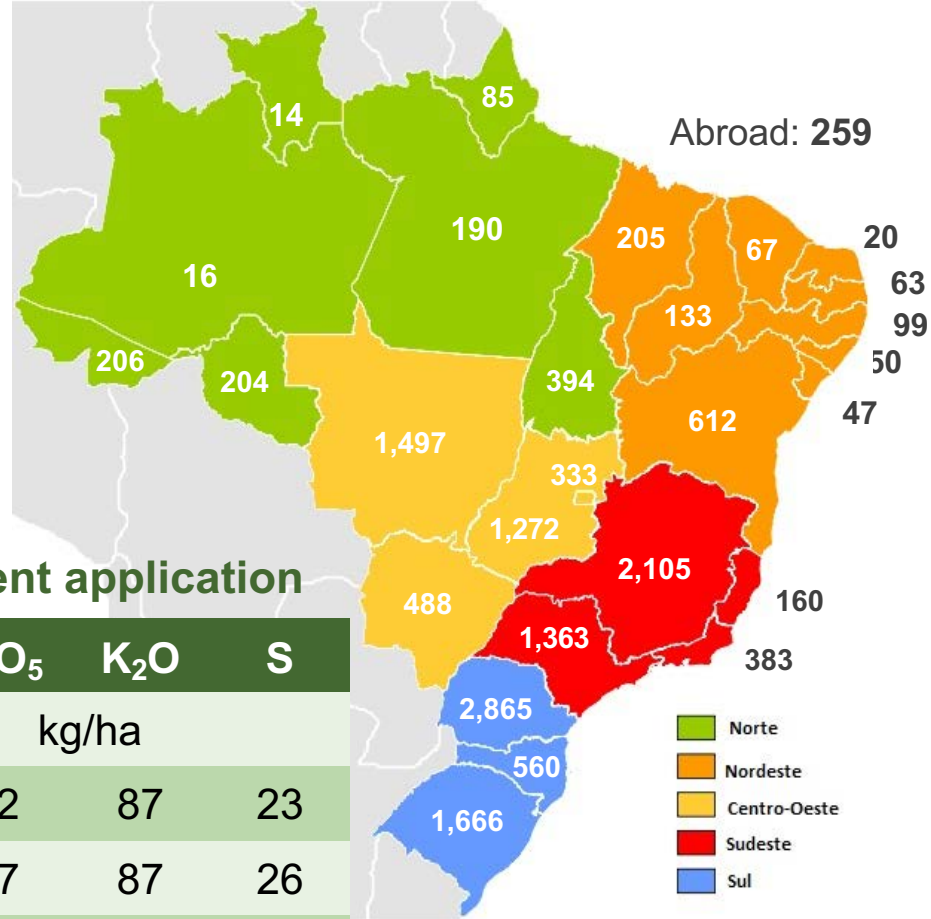
Most visited crops

Crop	%
Soybeans	46.0
Maize	21.0
Common beans	4.6
Sugar cane	4.0
Wheat	3.5
Coffee (shells)	3.5
Tomato	2.5
Rice	2.5
Banana	2.1
Coffee (beans)	1.5
Orange	1.5
Cotton (beans)	1.4
Sorghum	1.4
Cassava	1.3
Tobacco	1.1
Potato	1.0

**Over
16,000
access!!!**

Average of nutrient application

Crop	N	P ₂ O ₅	K ₂ O	S
	kg/ha			
Soybean	16	82	87	23
Maize	123	87	87	26
Sugarcane	94	77	104	43
Coffee	248	67	187	26
Cotton	124	78	118	42
Rice	77	62	74	22



Thank you!



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INTERNATIONAL
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INSTITUTE

Website:

<http://brasil.ipni.net>
efrancisco@ipni.net

Phone:

55 (66) 99932-8848
55 (19) 98723-0699