Potential of Carbon Sequestration in Brazilian No-till

Telmo Amado
Manhattan – KS
June 25, 2008

Brazil
Venezuela
Guyana
Paramaribo
Suriname
French Guiana
Colombia
Boa Vista
Atlantic Ocean
Macapá
Negro R.
Amazon R.
Belém
Manaus
São Luís
Fortaleza
Tocantins R.
Teresina
Natal
João Pessoa
Recife
Maceió
Aracaju
Rio Branco
Pôrto Velho
Araguaia R.
Miracema do Norte
São Francisco R.
Salvador
Xingu R.
Peru
Bolivia
Cuiabá
Brasília
Paraguai R.
Goiânia
La Paz
Paranaíba R.
Sucre
Belo Horizonte
Campo Grande
Grande R.
Vitória
Pacific Ocean
Paraguay
Paraná R.
Rio de Janeiro
Chile
São Paulo
Asunción
Curitiba
Argentina
Florianópolis
Pôrto Alegre
Paraná R.
Uruguay
©1997 MAGELLAN Geographix℠
(805) 685-3100 www.maps.com
750 km
500 mi
72°W
48°
0°
12°S
24°
N

(c) WWF-Canon / Juan PRATGINESTOS

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- Agribusiness overview – Brazilian No-till
- Carbon cycle under No-till system
- Innovate cropping system
- Final remarks

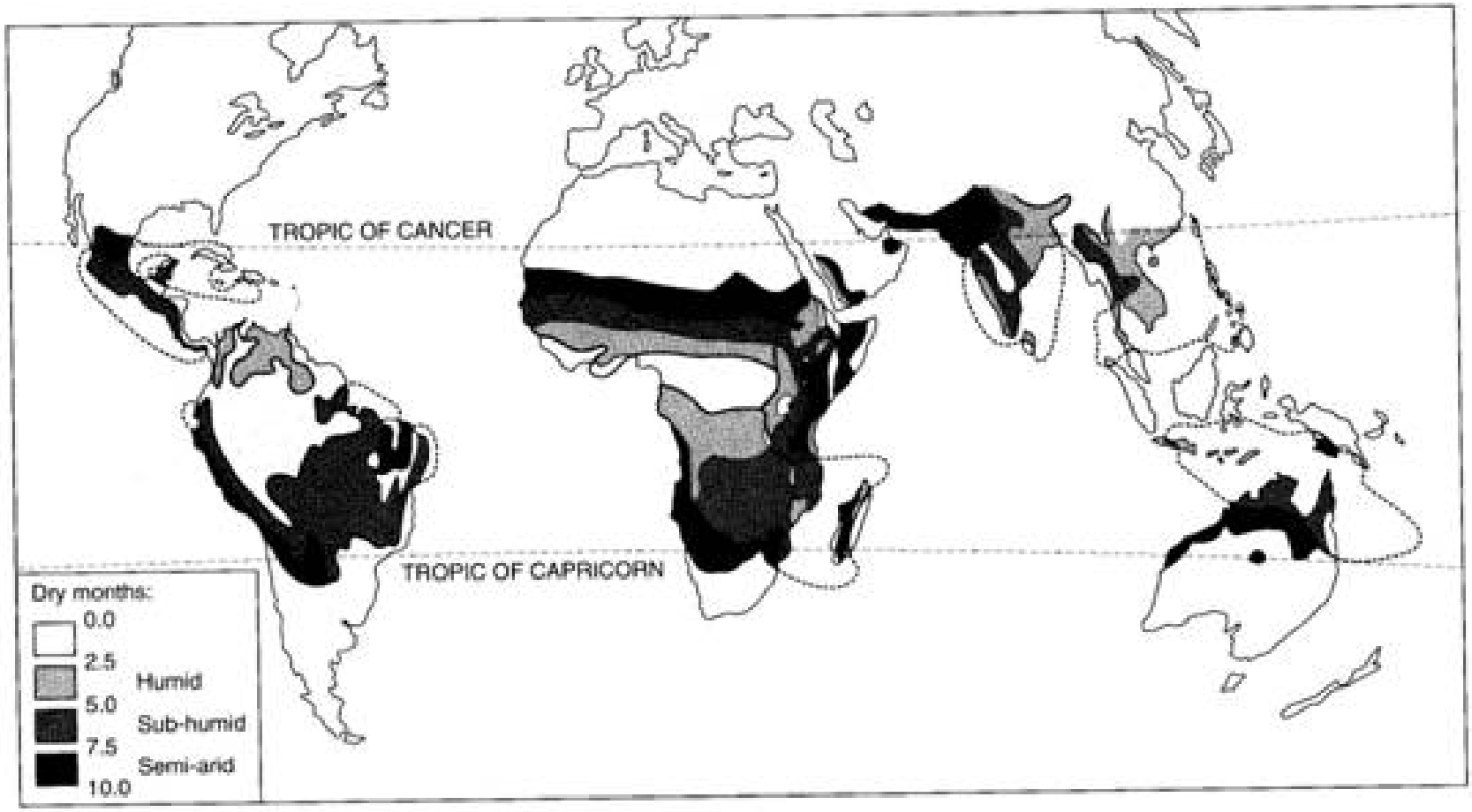
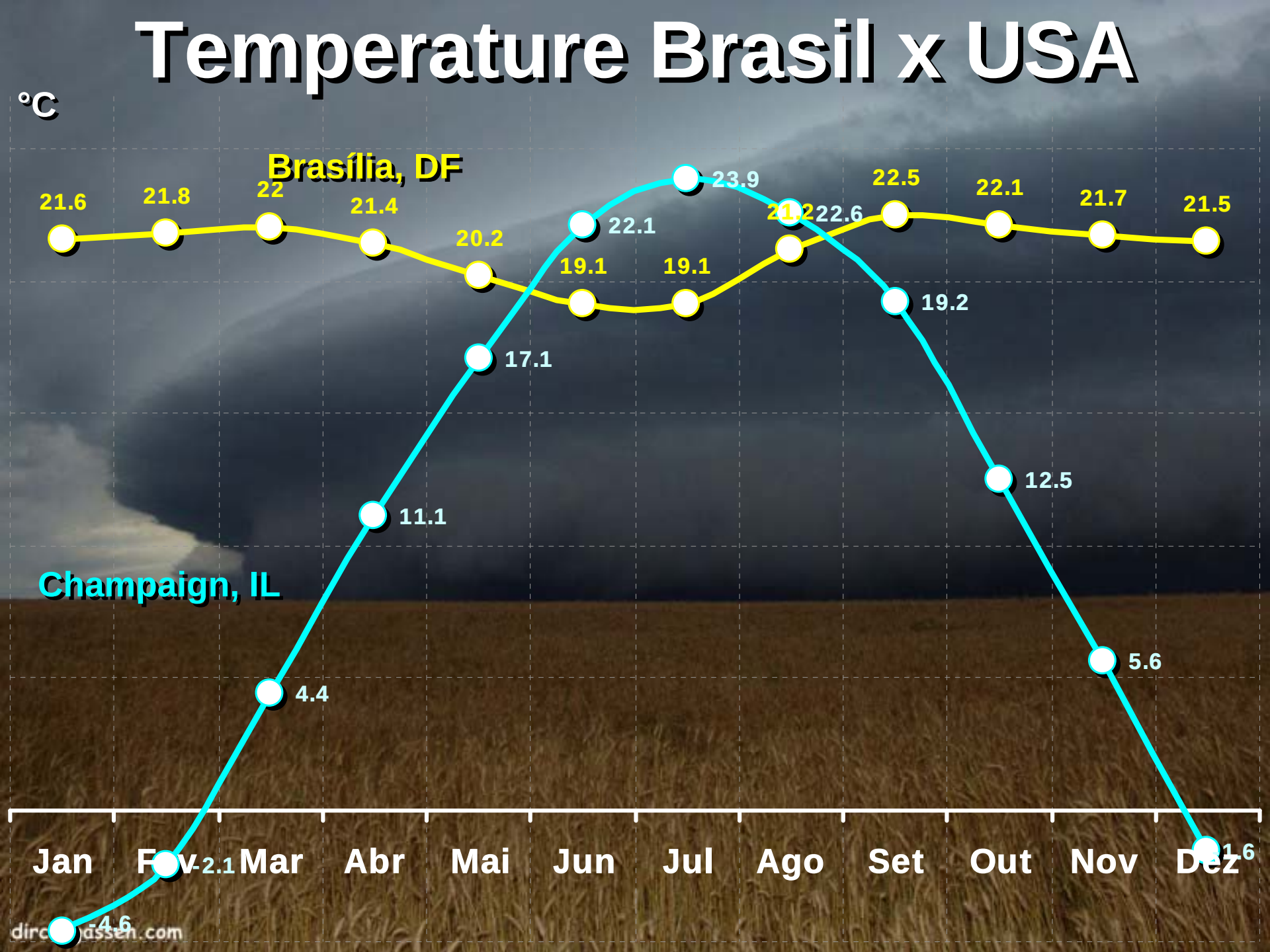
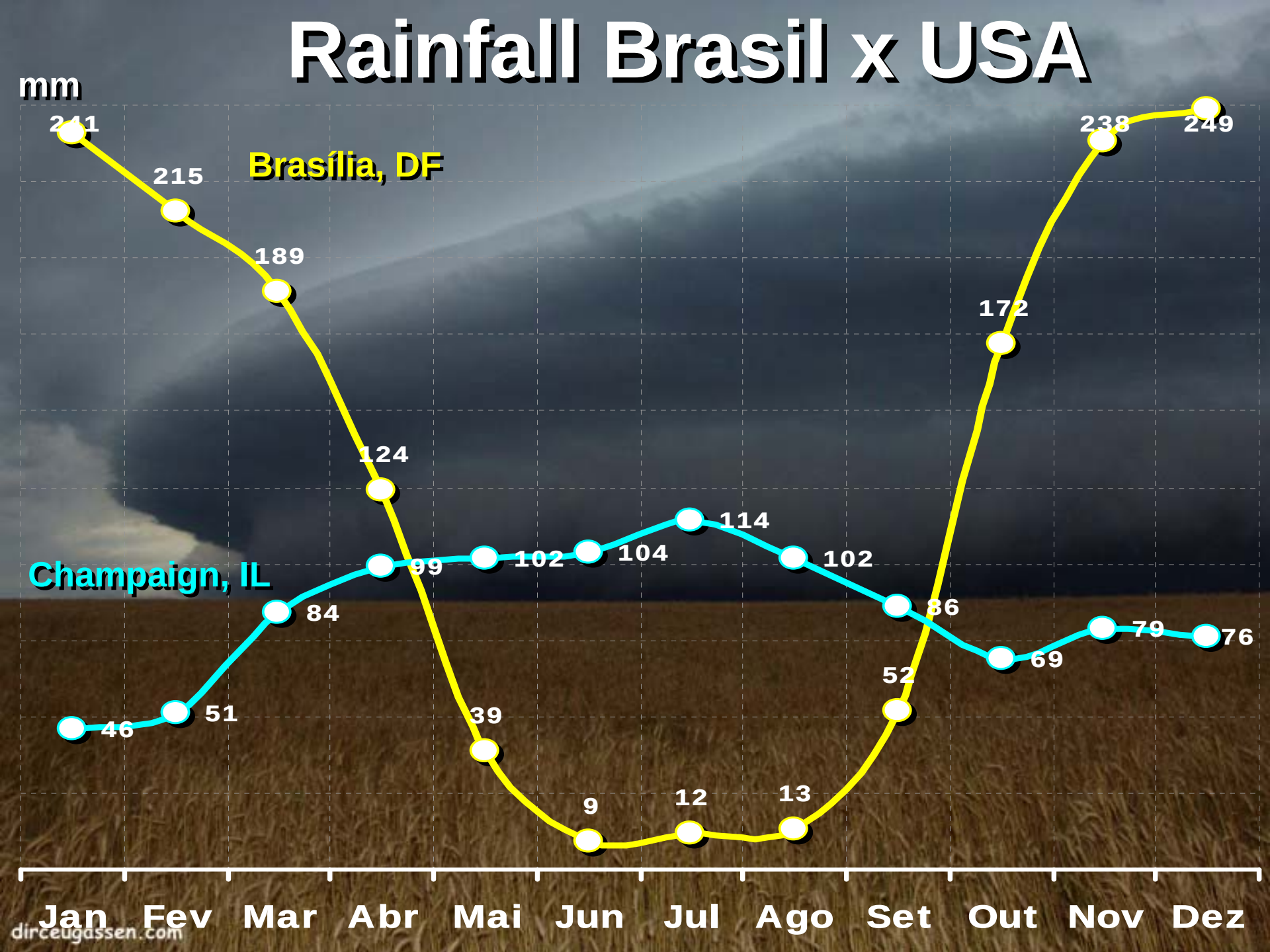


Figure 1-3 Map showing agro-climatic regions of the tropics. (Source: C. Barrow, 1987, *Water Resources and Agricultural Development in the Tropics*. Longman Scientific & Technical, Harlow, Essex, p. 22.)

Temperature Brasil x USA



Rainfall Brasil x USA



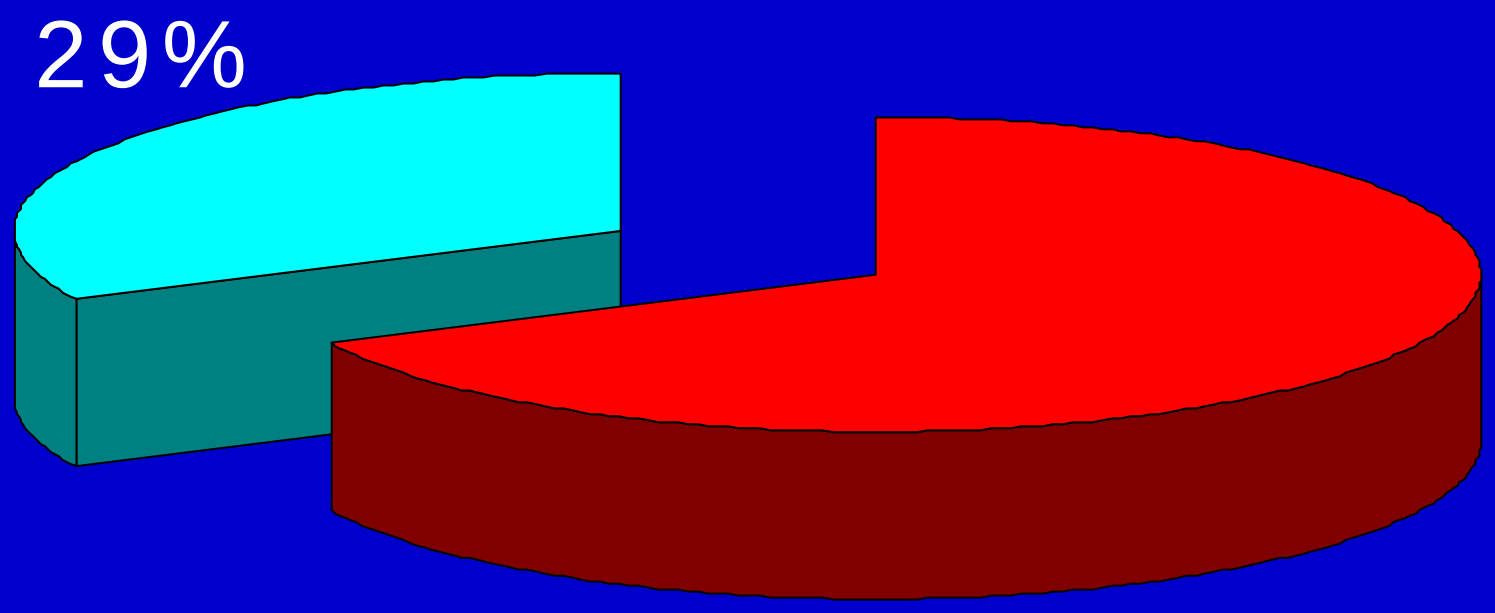
Brazilian agribusiness
General overview

Top 5 biggest world grain producers

Itens	Countries				
	China	USA	Brazil	Russian	Canadian
Total Surface (millions km²)	9,536	9,372	8,547	17,075	9,970
Population (millions)	1,300	278	175	147	31
Crop Area (ha – millions)	78	90	42	40	22
Grain production (ha – millions)	450	420	115	88	88

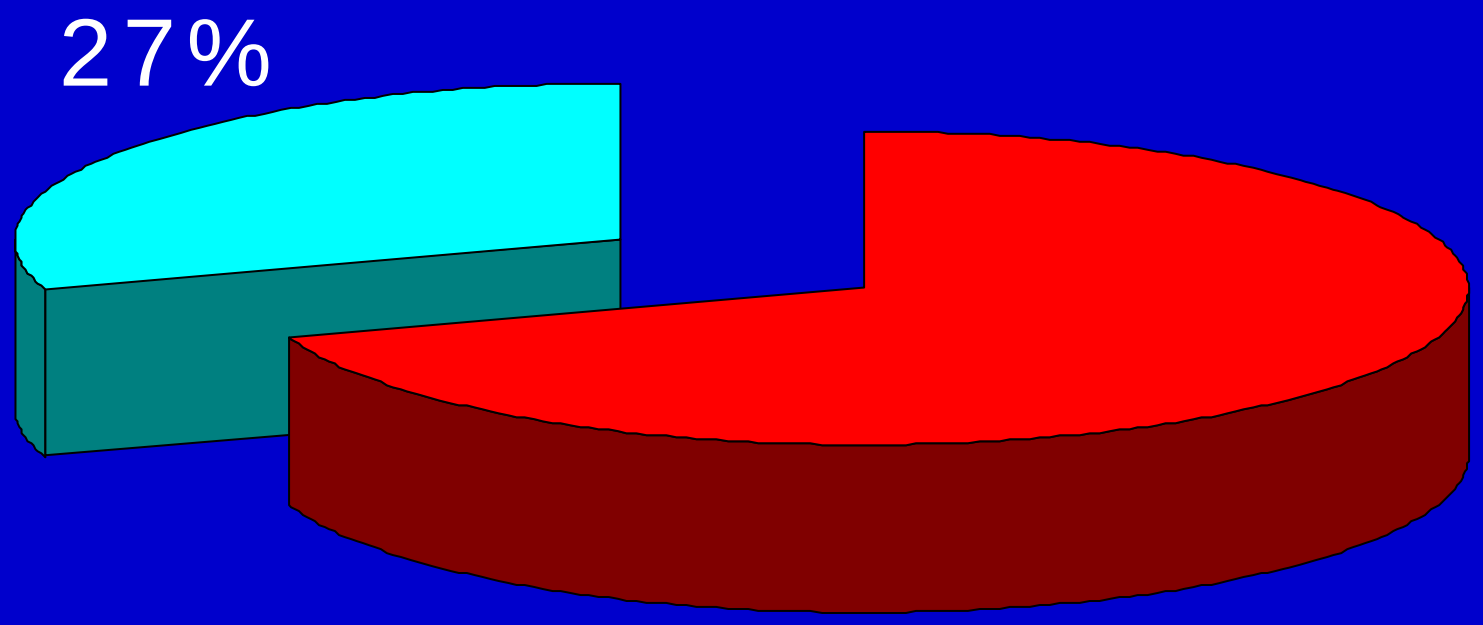
Source: Grolli, D., 2003 (Grãos Brasil, v. 10, p.12)

Contribution of the agribusiness in the Brazilian GDP



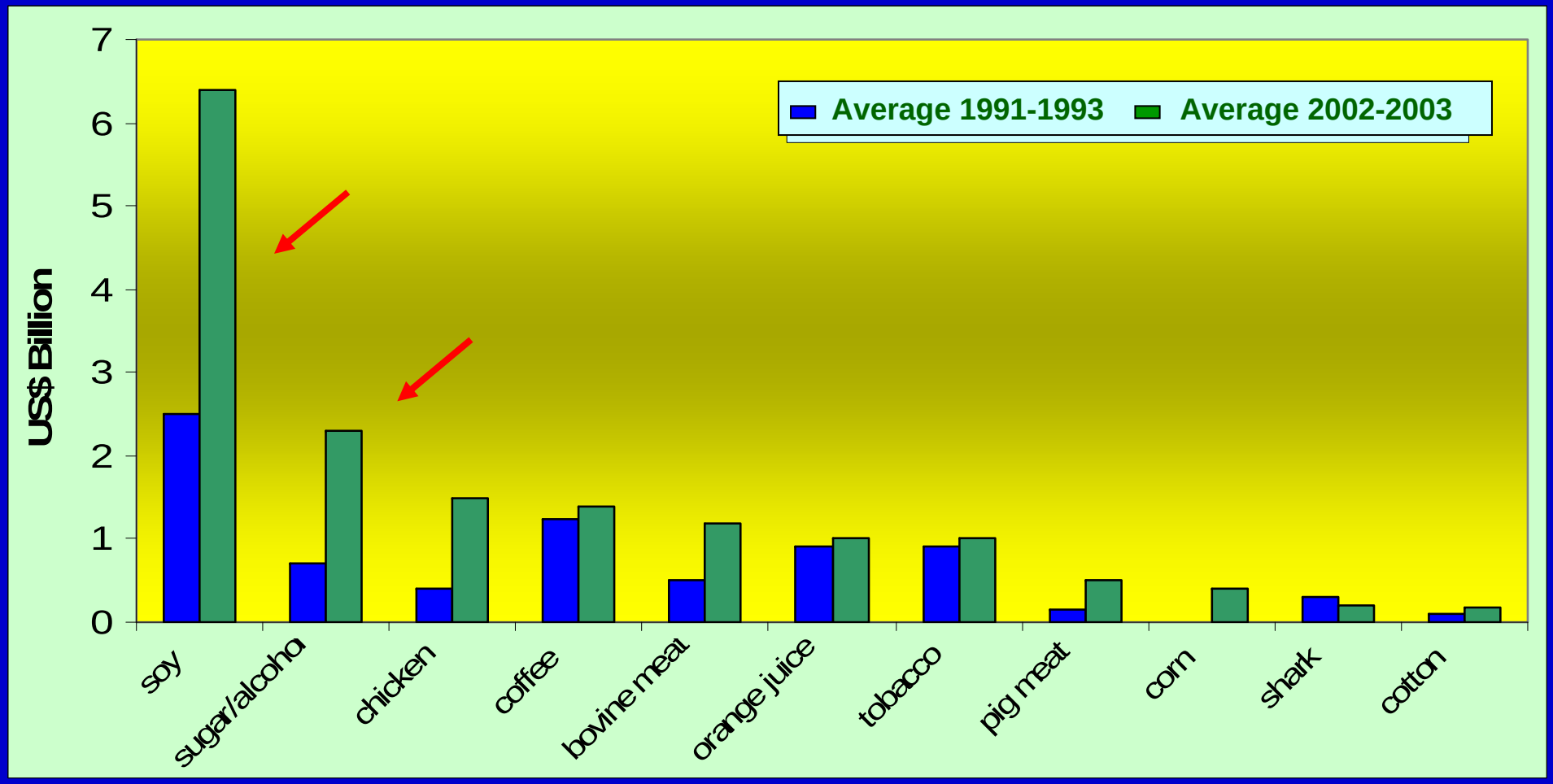
Source: IPEA, 2003

Agriculture contribution to the active economic population

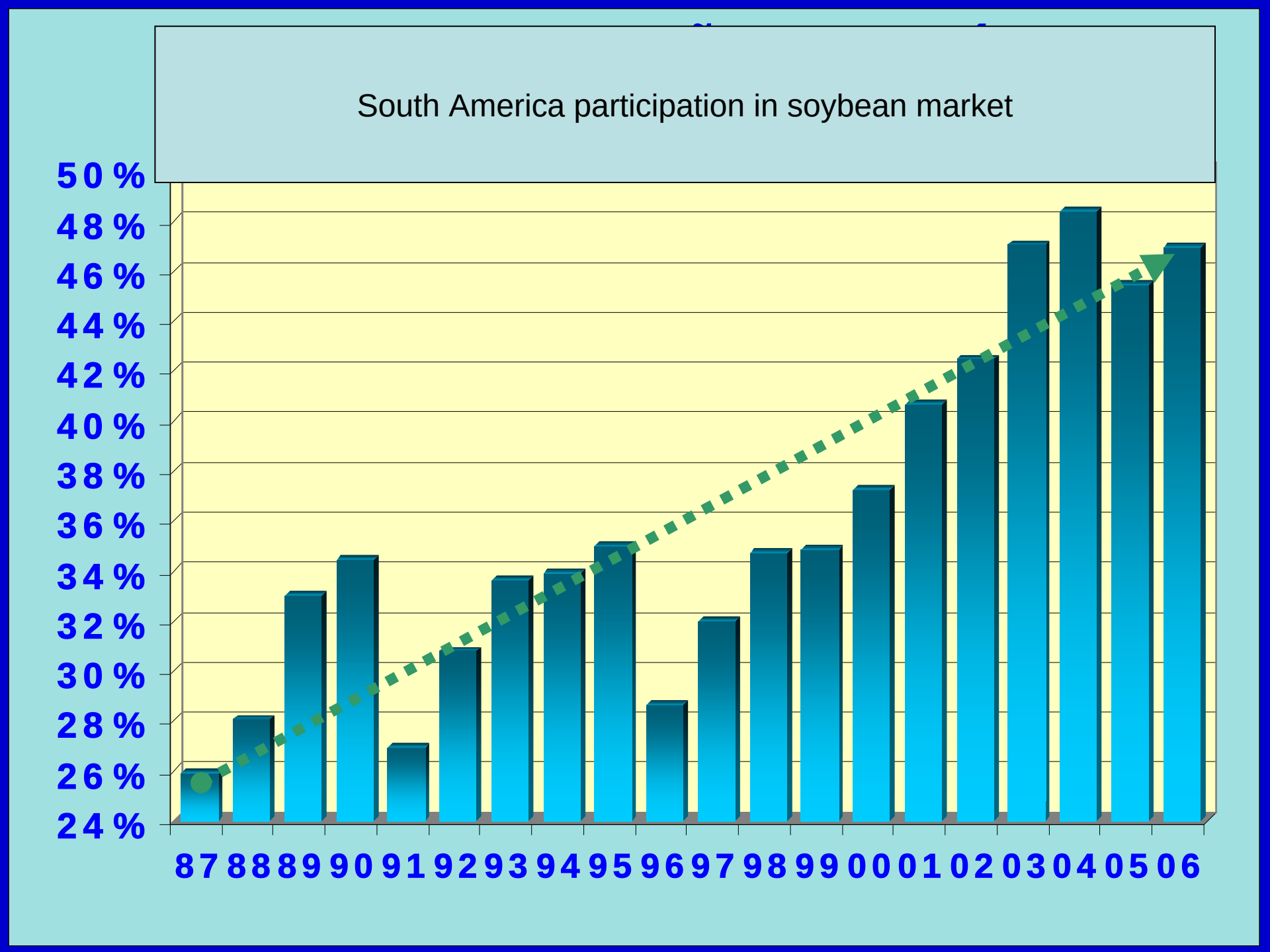


Source: IPEA, 2003

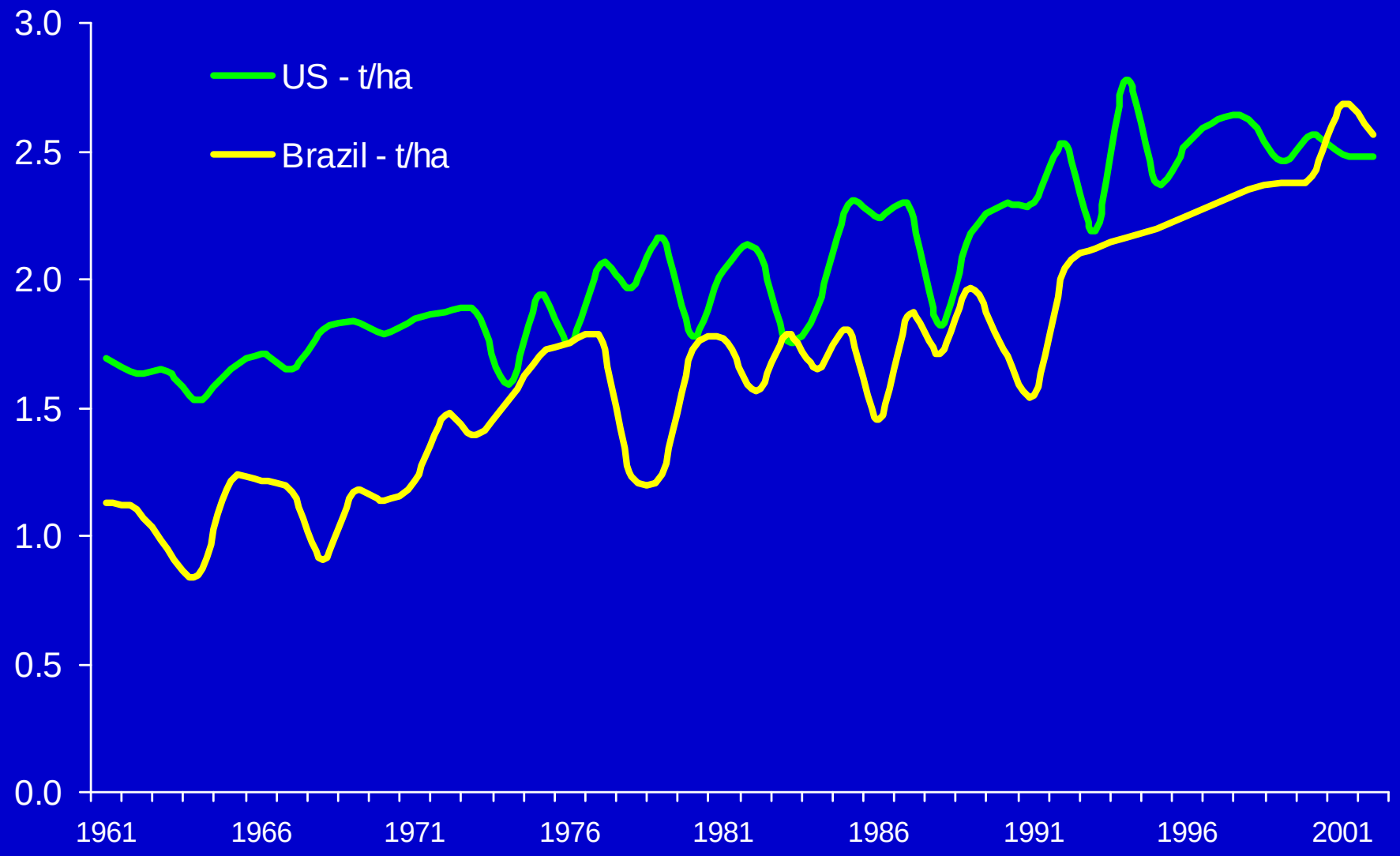
Main agricultural products exported.



Source: Ministry of the development, industry and external trade. MDIC, 2003.


South America participation in soybean market
50%
48%
46%
44%
42%
40%
38%
36%
34%
32%
30%
28%
26%
24%
87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06

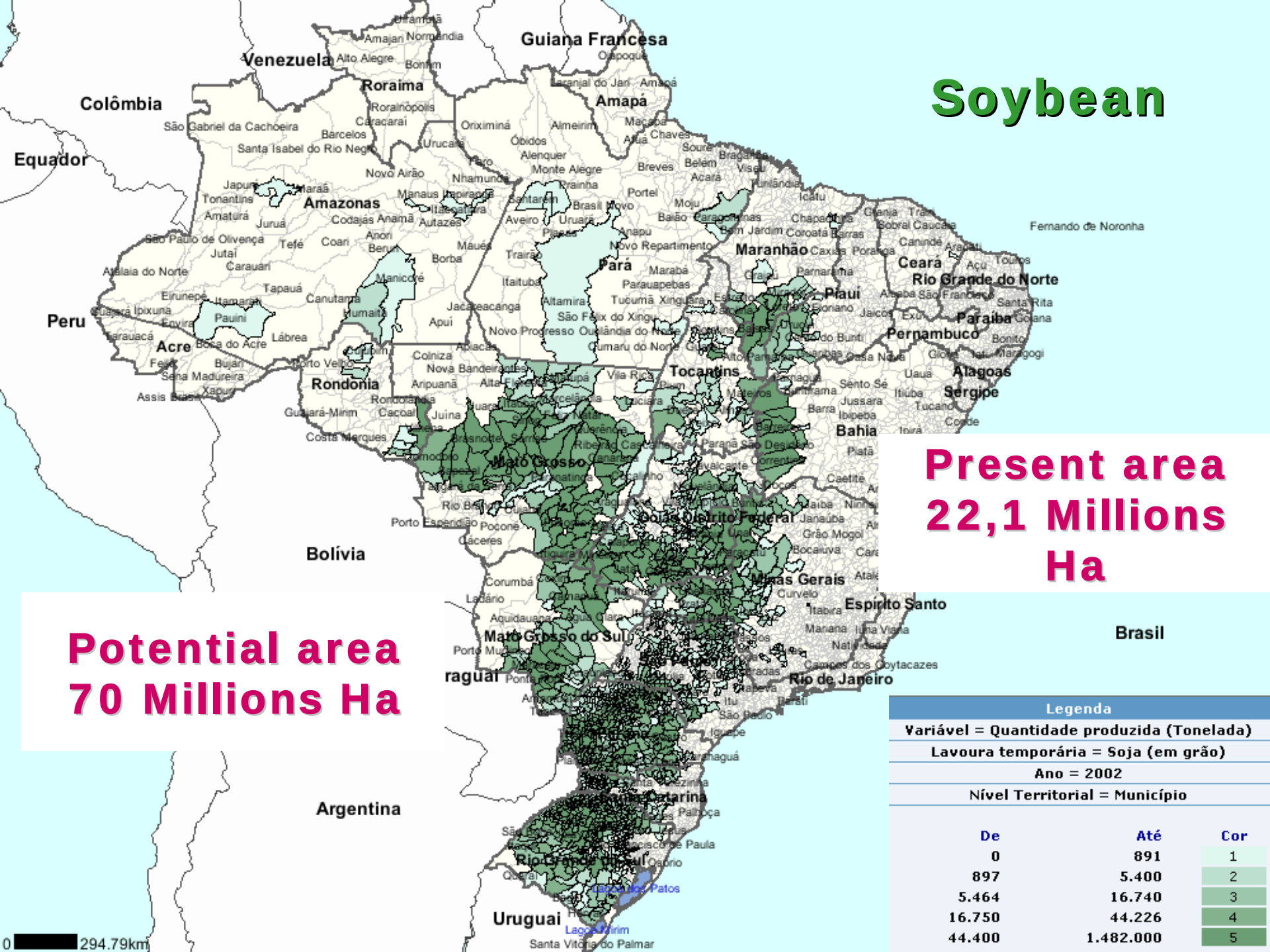
Soybean yields – US/Brazil



AgriStats, NASS

Brazilian agribusiness Future

Soybean



Present area 22,1 Millions Ha

Potential area 70 Millions Ha

Legenda
Variável = Quantidade produzida (Tonelada)
Lavoura temporária = Soja (em grão)
Ano = 2002
Nível Territorial = Município

De	Até	Cor
0	891	1
897	5.400	2
5.464	16.740	3
16.750	44.226	4
44.400	1.482.000	5

Center-West Brazil

BRAZIL: Next decade projections

CROPS	ÁREA HECTARES	ÁREA HECTARES	VARIATION (%)
YEAR	2006/2007	2014/2015	2015/2007
GRAIN *	45.837.100	59.479.305	29.8%
COFFEE	2.309.741	2.656.202	15.0%
SUGAR CANE	6.188.600	9.282.900	50.0%
VEGETABLES AND FRUITS	12.200.000	15.250.000	25.0%
TOTAL UTILIZADO	66.535.441	86.668.408	30.3%
ÁREA AGRICULTÁVEL DISPONÍVEL	388.000.000	388.000.000	
PASTURE	220.000.000	220.000.000	0.0%
COMERCIAL FOREST	6.000.000	12.000.000	100.0%
CROPS	66.535.441	86.668.408	30.3%
TOTAL AVAILABLE	95.464.559	69.331.592	

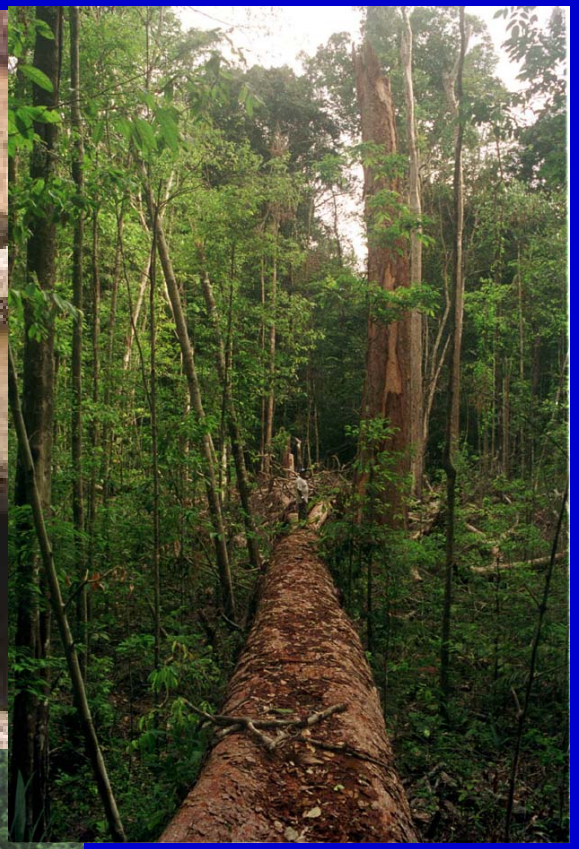
* INCLUSO ALGODÃO CAROÇO

Elaboração e Projeções: Carlos Cogo Consultoria Agroeconômica

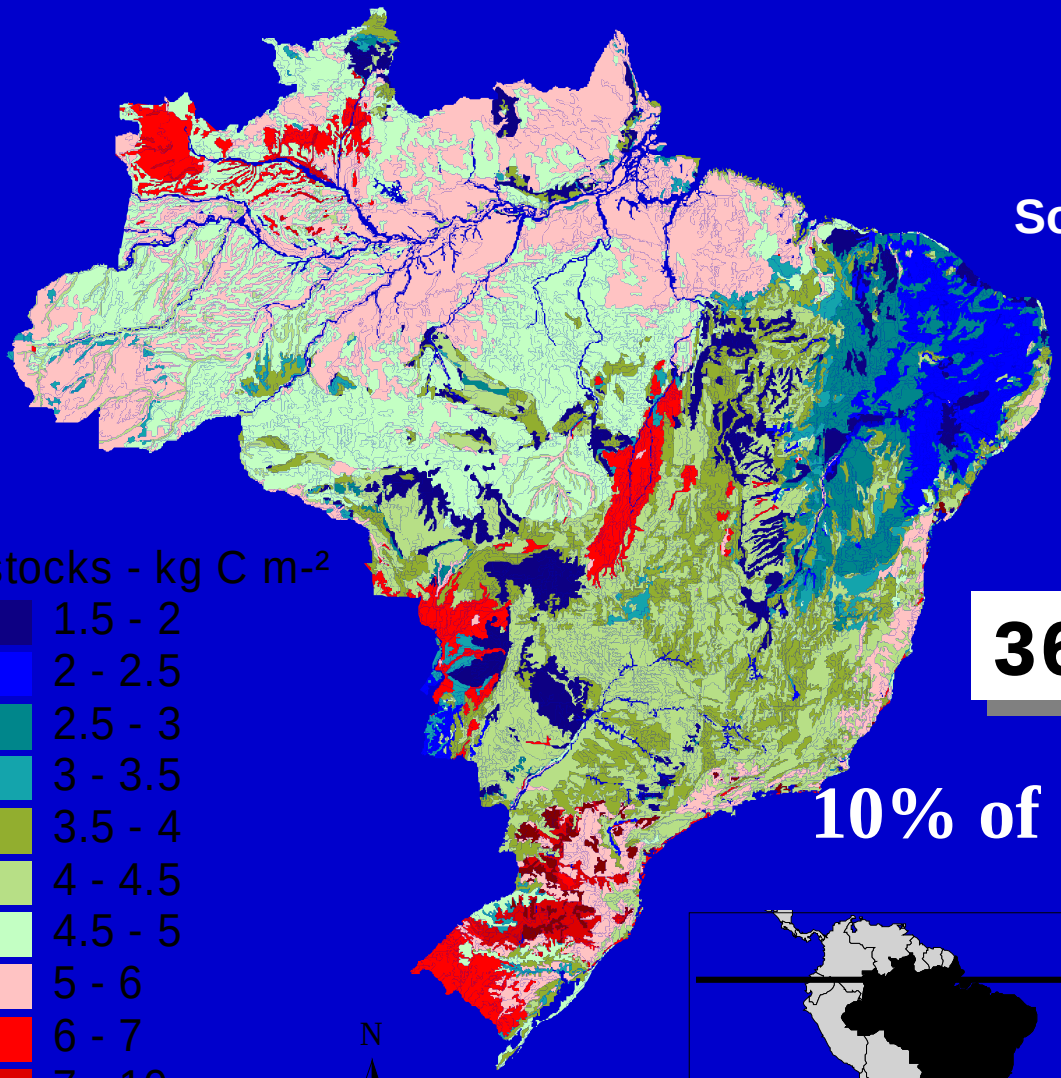
The rain forest...

Fire...

Selective logging...



Soil Carbon Stock



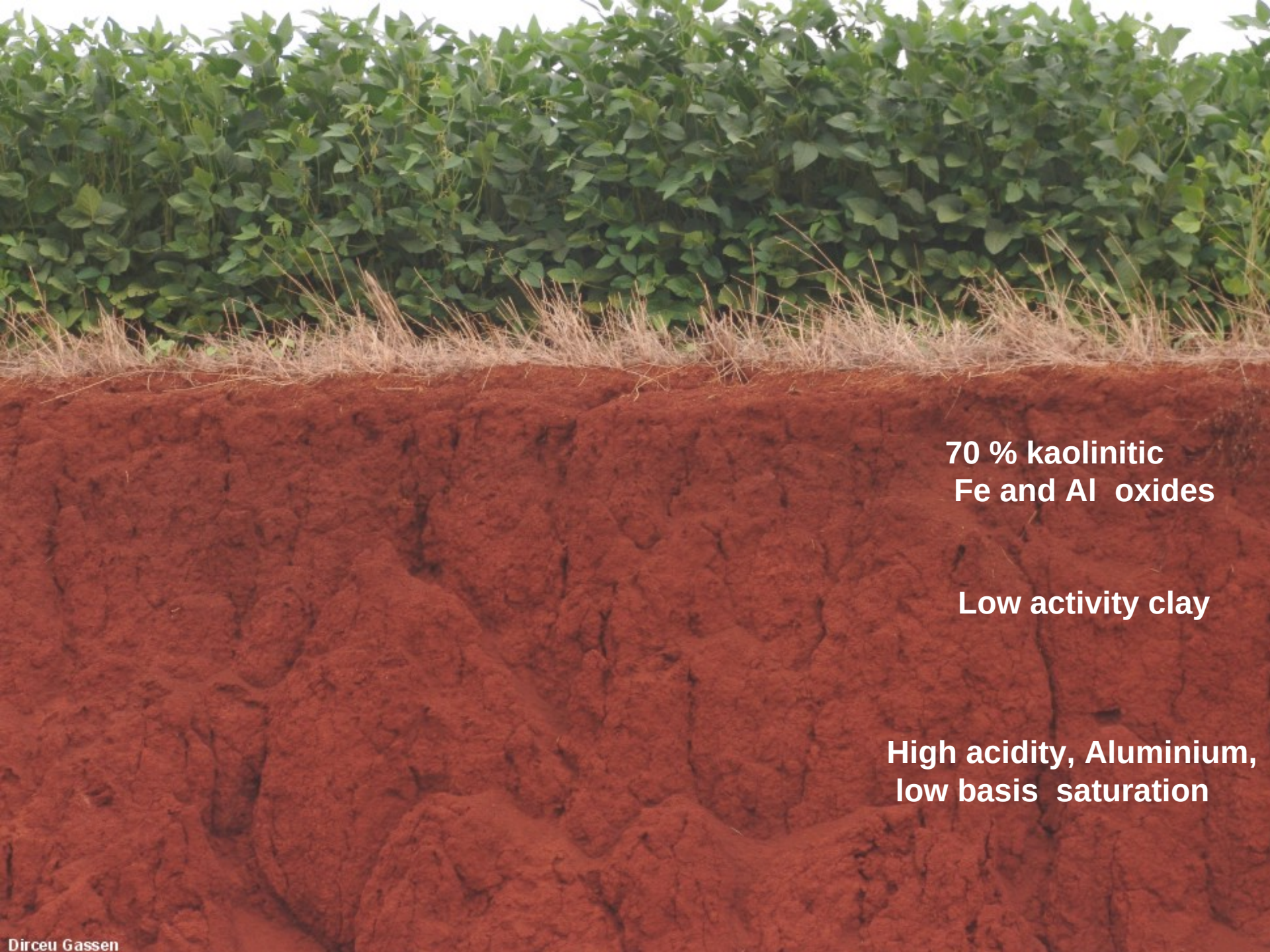
0-30 cm

Source: C. Cerri et al., 2003

36,4 ± 3,4 Pg C

10% of soil C in the world

1 Pg $=10^{15}$ g =
1 Bi. toneladas


70 % kaolinitic
Fe and Al oxides
Low activity clay
High acidity, Aluminium,
low basis saturation
Dirceu Gassen

EROSION

dirceugassen.com

dirceugassen.com

dirceugassen.com

dirceugassen.com

dirceugassen.com

Fonte: Moryja, 2005

16 1 2003

Erosion: 24 t/ha/year
Yield: 2.3 t/ha/year
1 t grain = 10 t soil
Werner Wünsche
Embrapa Trigo

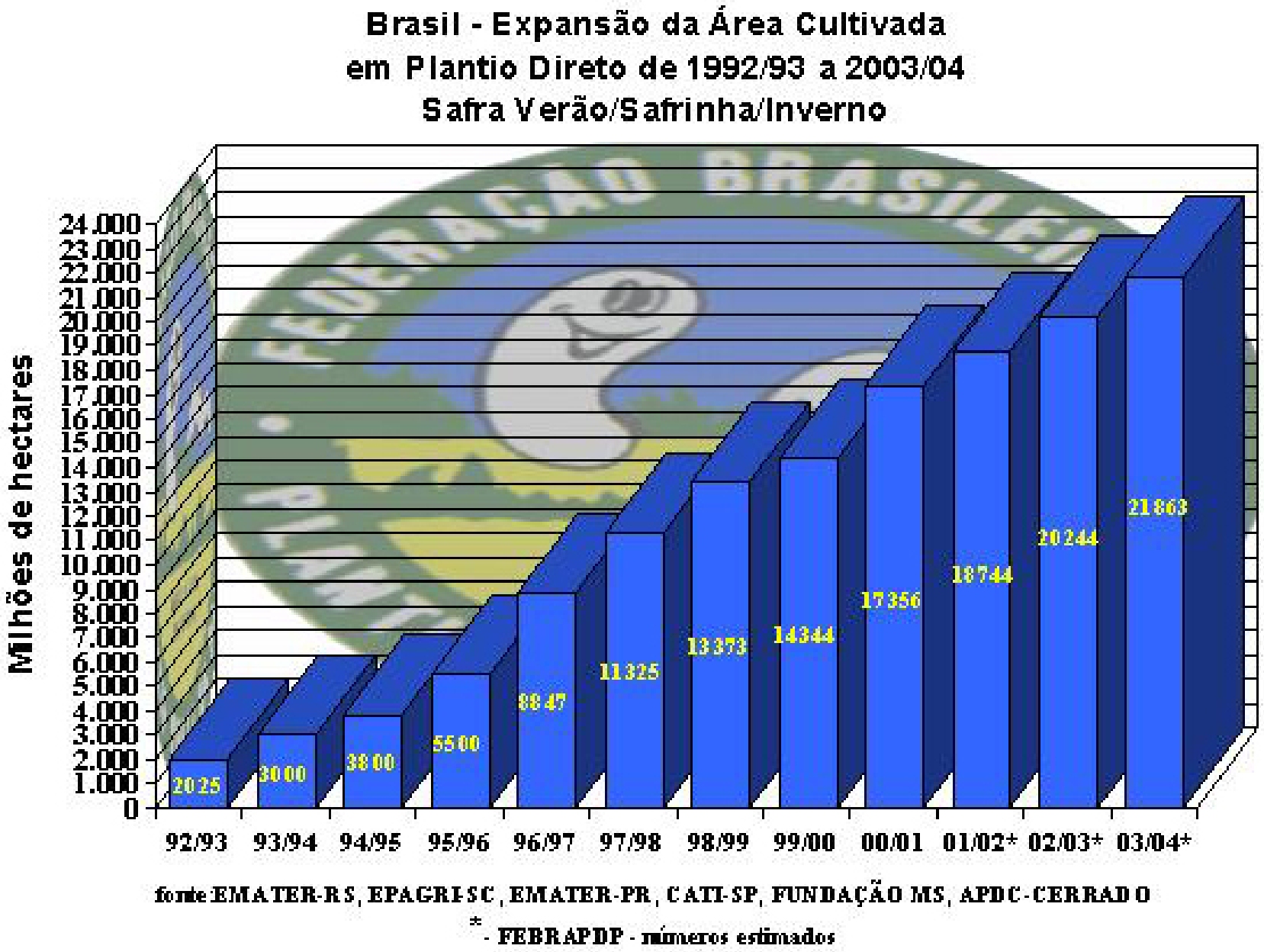
dirceugassen.com

NO-TILL

1962

Brazilian no-till farmers pioneer

Brazil NT area



Animal traction No-till

No-till animal traction

Fonte: Moryja, 2005

Fonte: Moryja, 2005

Fonte: Moryja, 2005

No-till smallholders

Country	Área (ha)	N° Farmers
Brazil	173.000	38.000
India	130.000	26.000
Pakistan	80.000	5.500
Ghana	45.000	100.000
Bangladesh	10.000	30.000
Paraguai	6.500	2.300

(Wall, P., 2002)

Ag Soil Carbon Sequestration

Sá, 2004

Some soil carbon sequestration rates

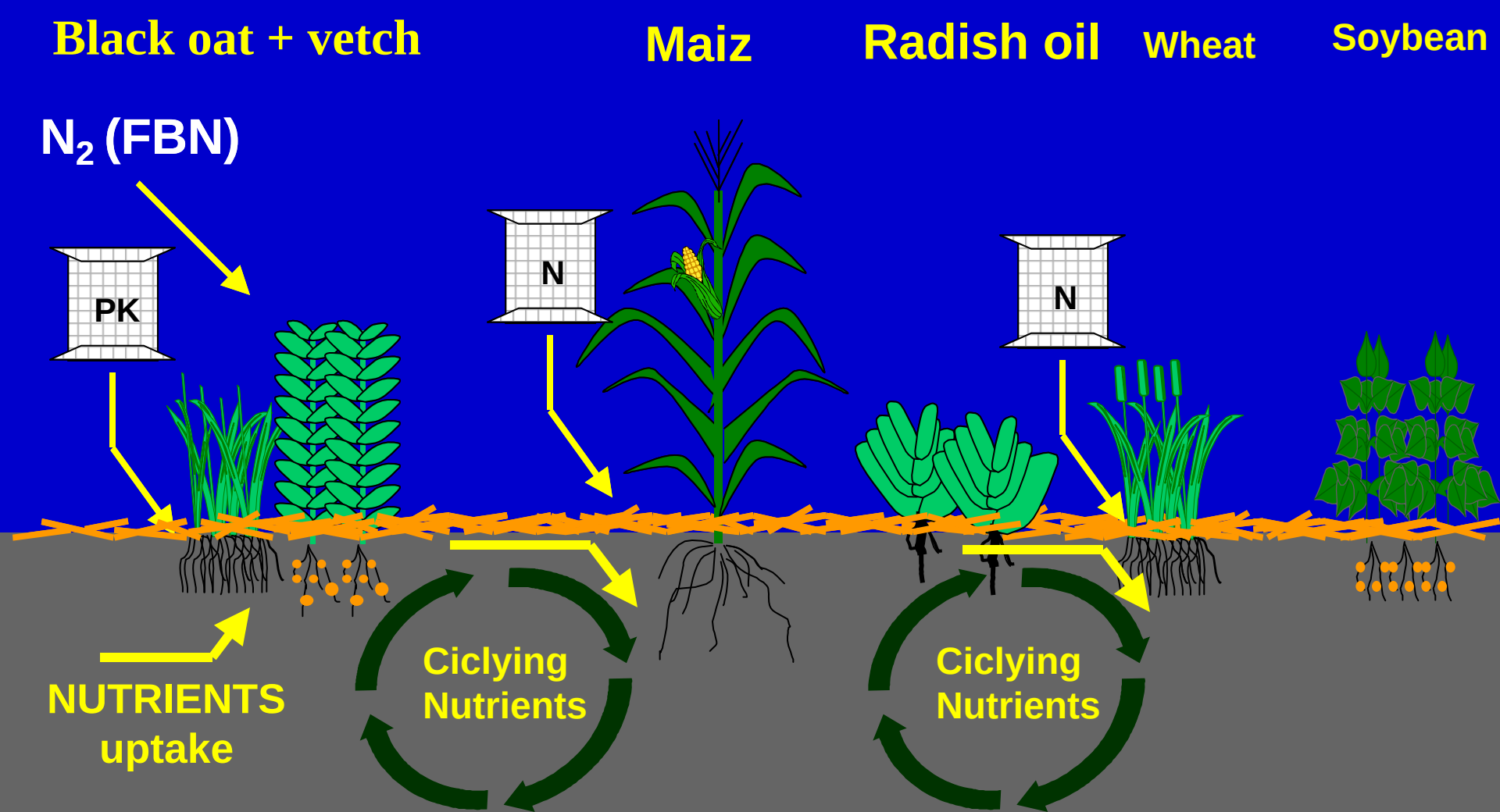
Brazil

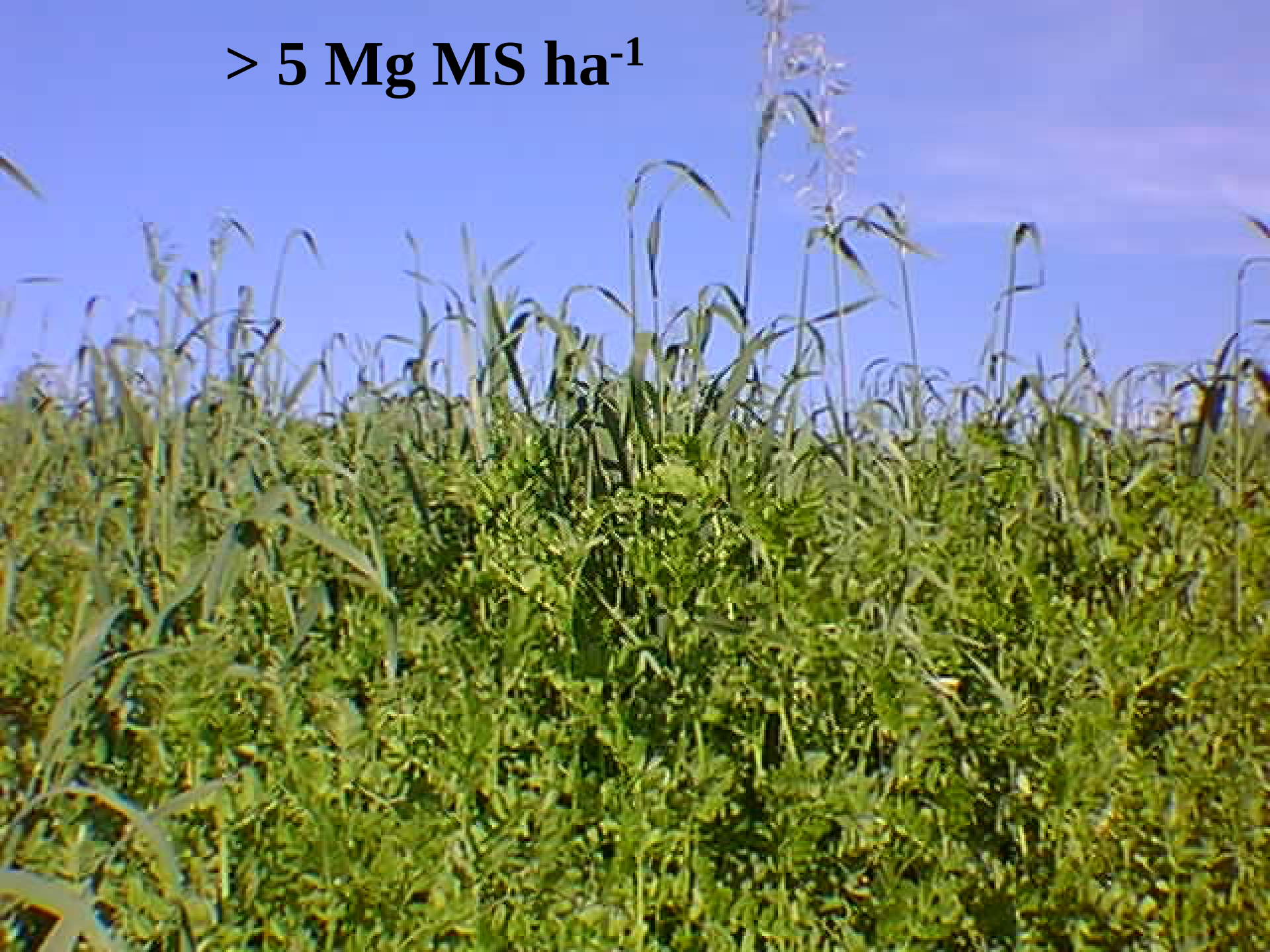
Region		Rate
		Mg ha^{-1} yr^{-1}
Tropical (West-Central BR)	Range	0.04 – 0.63
	Mean	0.39
Subtropical (Southern BR)	Range	0.04-0.97
	Mean	0.58
Temperate (USA)	Range	0.1-0.5
	Mean	0.34
GLOBAL	Mean	0.57

Tropical: Corazza et al. (1999), Silva et al. (2001), Leite et al. (2001)
Subtropical: Bayer et al. (2000a,b), Lovato (2001), Amado et al. (2001), Freixo et al. (2002)
Temperate: Lal et al. (1999); West & Marland (2002)
Global: West & Post (2002)

Bayer, 2007

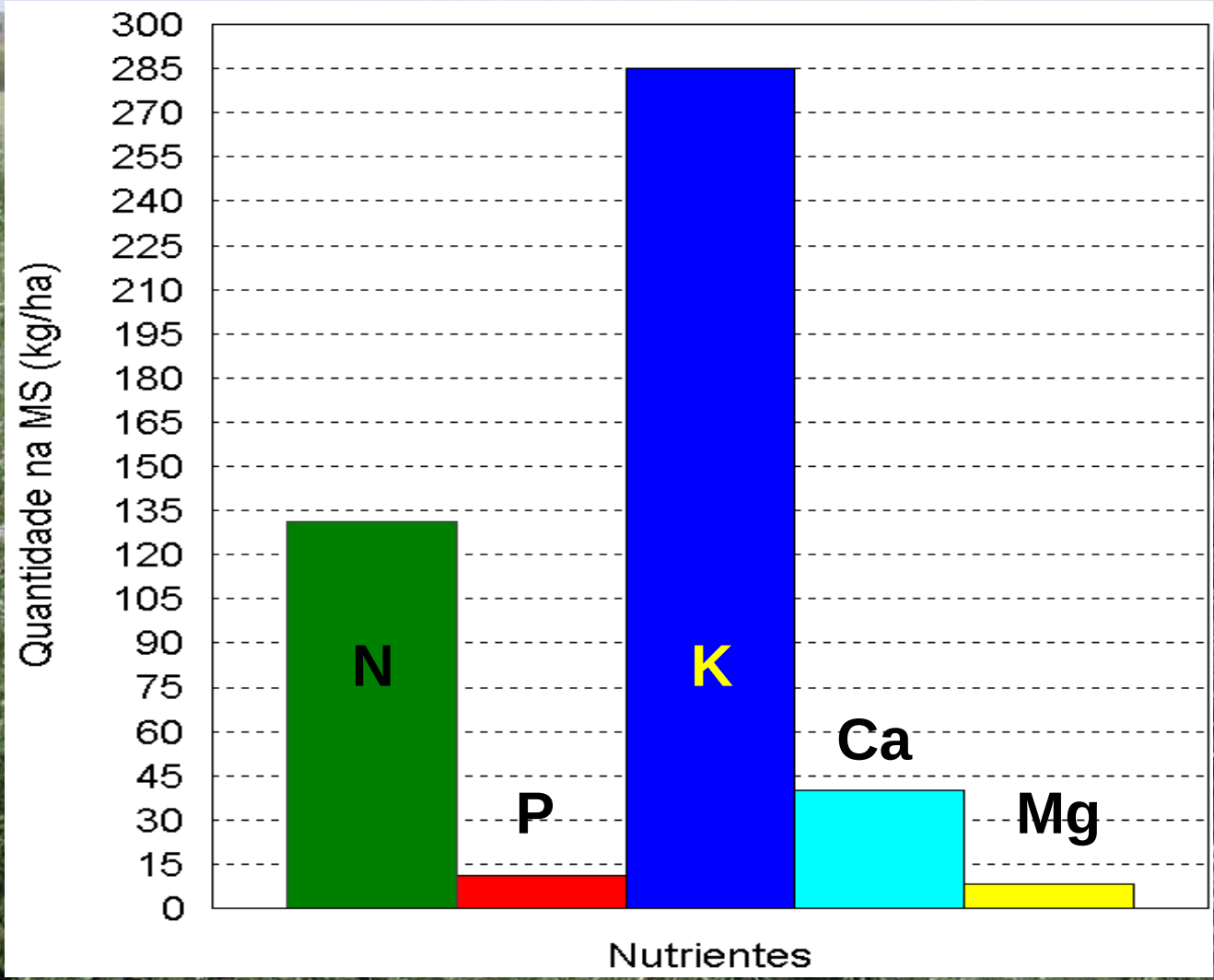
Soybean/Maiz Rotation



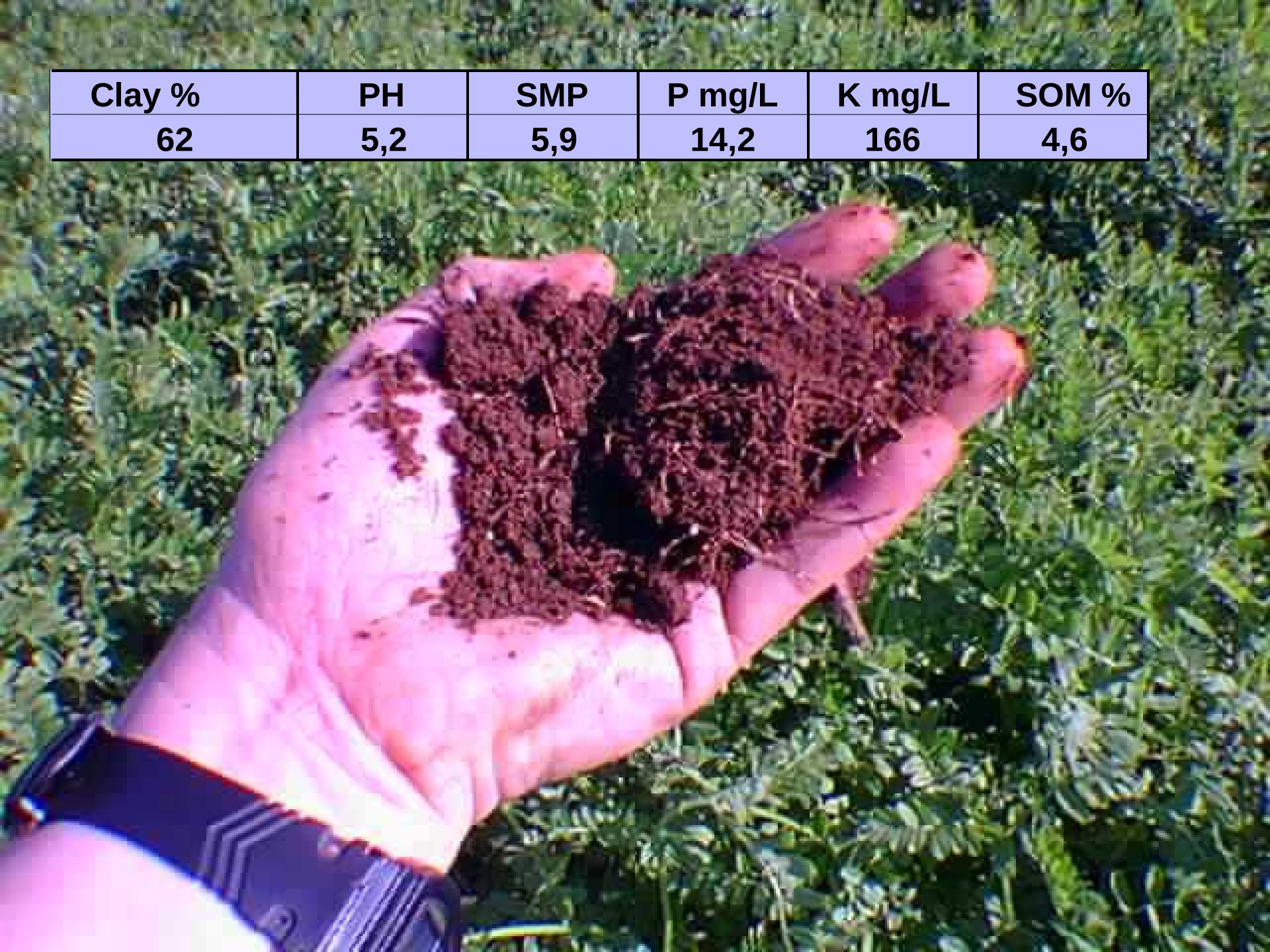

> 5 Mg MS ha-1

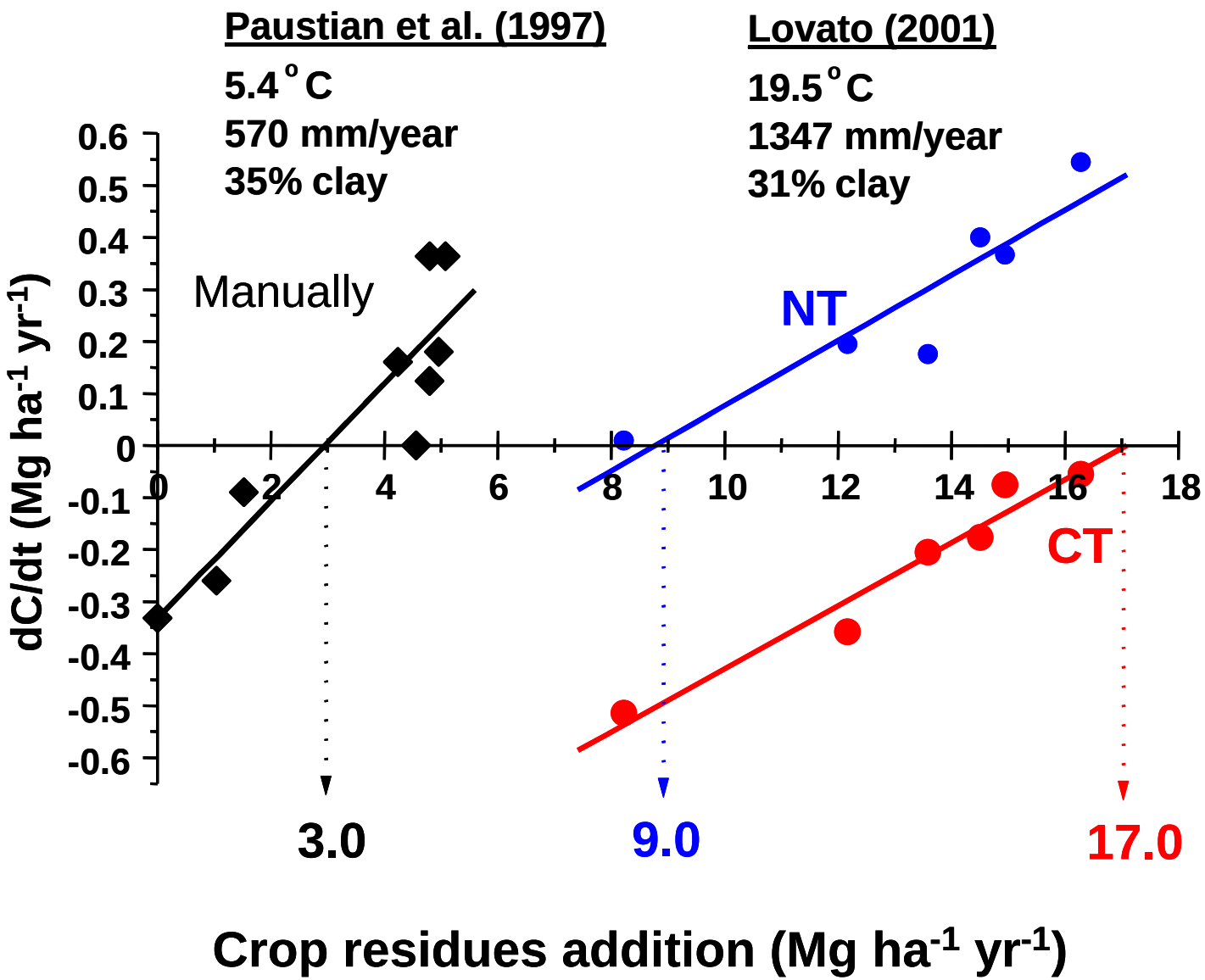
5 Mg MS ha^{-1}

Potassium recycling in radish oil



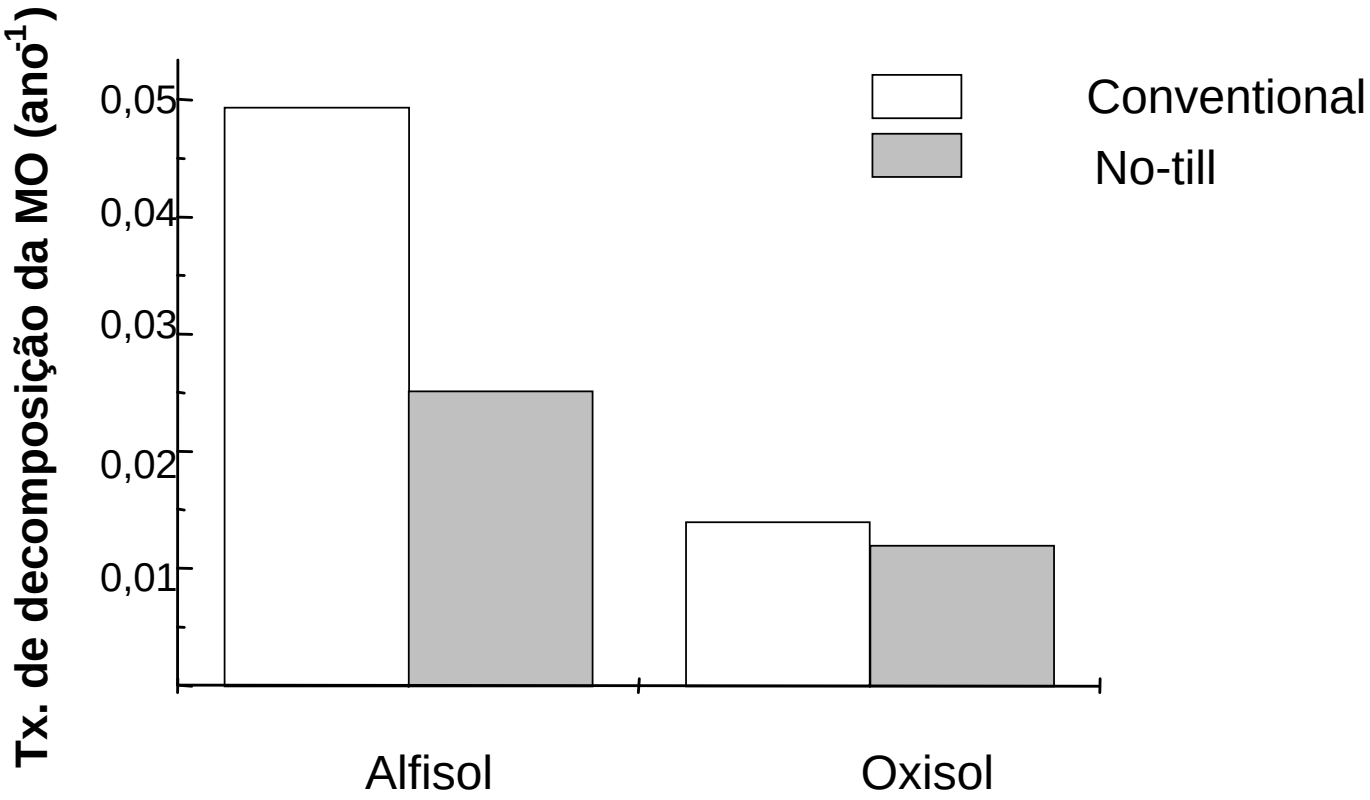
Clay %	PH	SMP	P mg/L	K mg/L	SOM %
62	5,2	5,9	14,2	166	4,6




Paustian et al. (1997)
5.4 °C
570 mm/year
35% clay
Lovato (2001)
19.5 °C
1347 mm/year
31% clay
Manually
NT
CT
dC/dt (Mg ha-1 yr-1)
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
2
4
6
8
10
12
14
16
18
3.0
9.0
17.0
Crop residues addition (Mg ha-1 yr-1)

Alfisol

Rate of SOM mineralization x Soil Type



Temperatura (ºC)	**19,4**	**21,2**
Precipitação (mm/ano)	**1550**	**1620**
Argila (g kg^{-1})	**220**	**620**
Fe_2O_3 (g kg^{-1})	**103**	**211**

C accumulation in subsoil layers of mature no-till

Soil	Reference System	C sequestration		Paper
		0-20	0-100	
		---- Mg ha^{-1} ano^{-1} ----		
No-till				
Alfisol	PC	0,65	1,05	*Zanatta et al. (2005)*
Alfisol	PC	1,22	1,95	*Dieckow et al. (2005)*
Oxisol	PC	0,52 *	0,98	*Sisti et al. (2004)*
Oxisol	PC	0,20	0,27	*Conceição et al. (2006)*
Oxisol	PC	0,82	1,36	*Jantalia et al. (2007)*
Oxisol	PC	0,83	2,28	*Corazza et al. (1999)*
Oxisol	PC	0,21 *	0,52	*Jantalia et al. (ñ pub)*
Pasture				
Alfisol	PC	0,91 **	3,23	*Omonode et al. (2006)*
Oxisol	PC	0,76 **	3,13	*Omonode et al. (2006)*
Oxisol	PC	0,43	1,92	*Corazza et al. (1999)*
Oxisol	Cerrado	1,14	2,53	*Silva et al. (2004)*

* 0-30 cm ** 0-15 cm

Mechanisms of C stabilization in no-tillage soils

-**Molecular recalcitrance**
-**Chemical protection**
-**Physical protection**

→ Very important in variable charge soils

Chemical and physical protection

Very important mechanisms in variable charge soils

Soil Quality Indicator

SOM fraction	Tillage Systems		Δ%	Δ Mg ha^{-1}
	CT	NT		
Particulate SOM	5.19	7.06	36	1.87
Mineral-associate SOM	25.22	30.90	23	5.68

75% of the total soil C sequestration

Bayer et al. (2003)

Brazil:

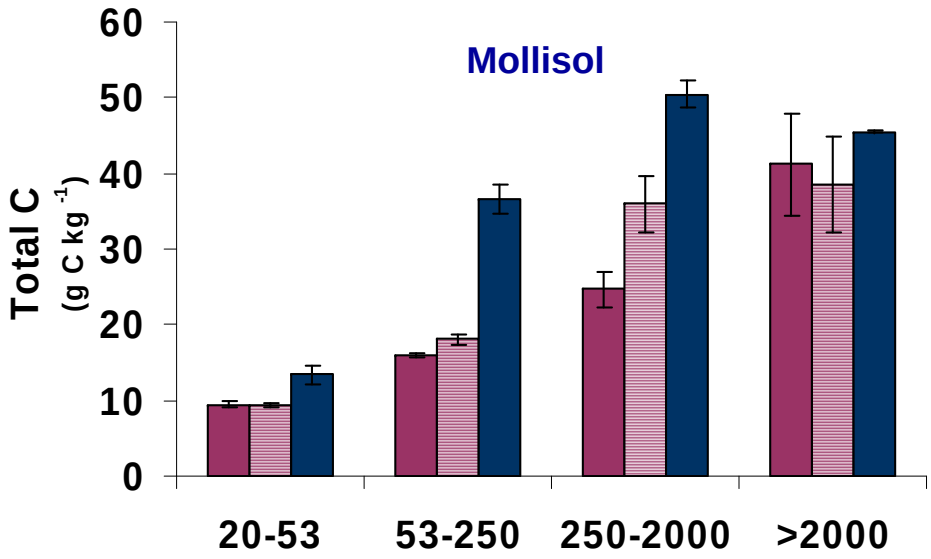
Soil: clay Rhodic Hapludox (Oxisol).

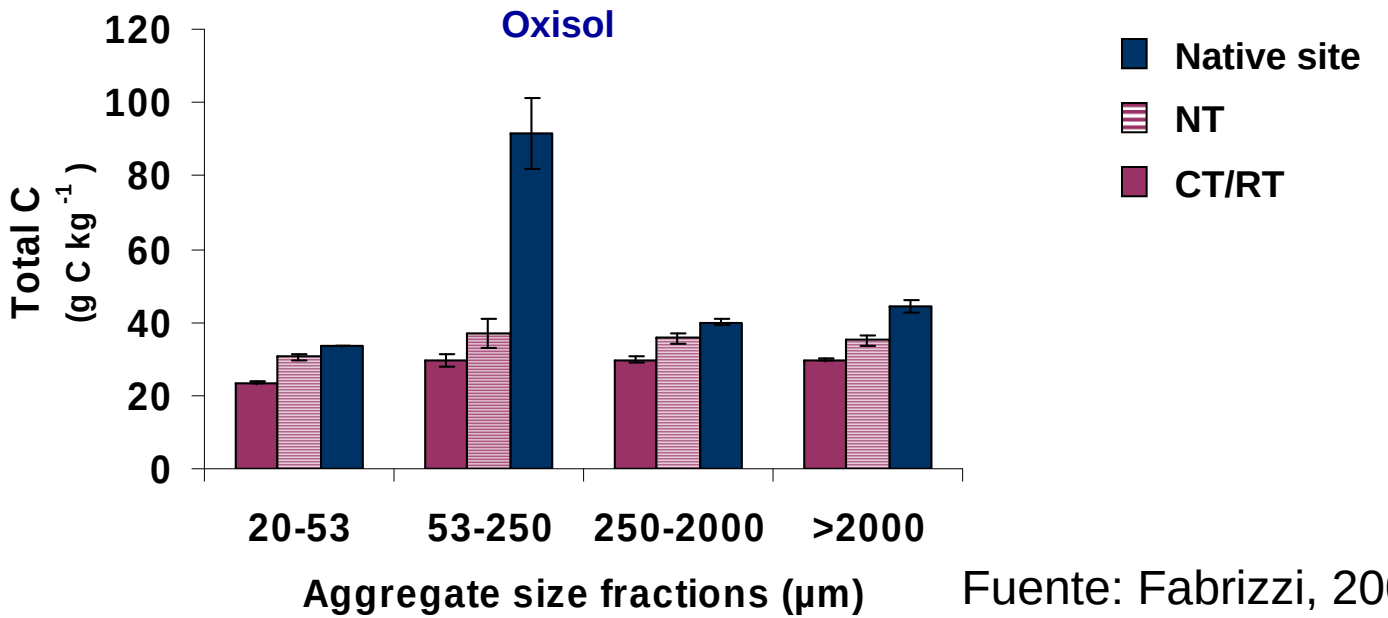
The treatments selected were:

1) Intensive crop system under CT and NT

Rotation: Black oat/soybean/black oat + vetch/maize/radish oil (*Raphanus sativus L.*)/wheat/soybean

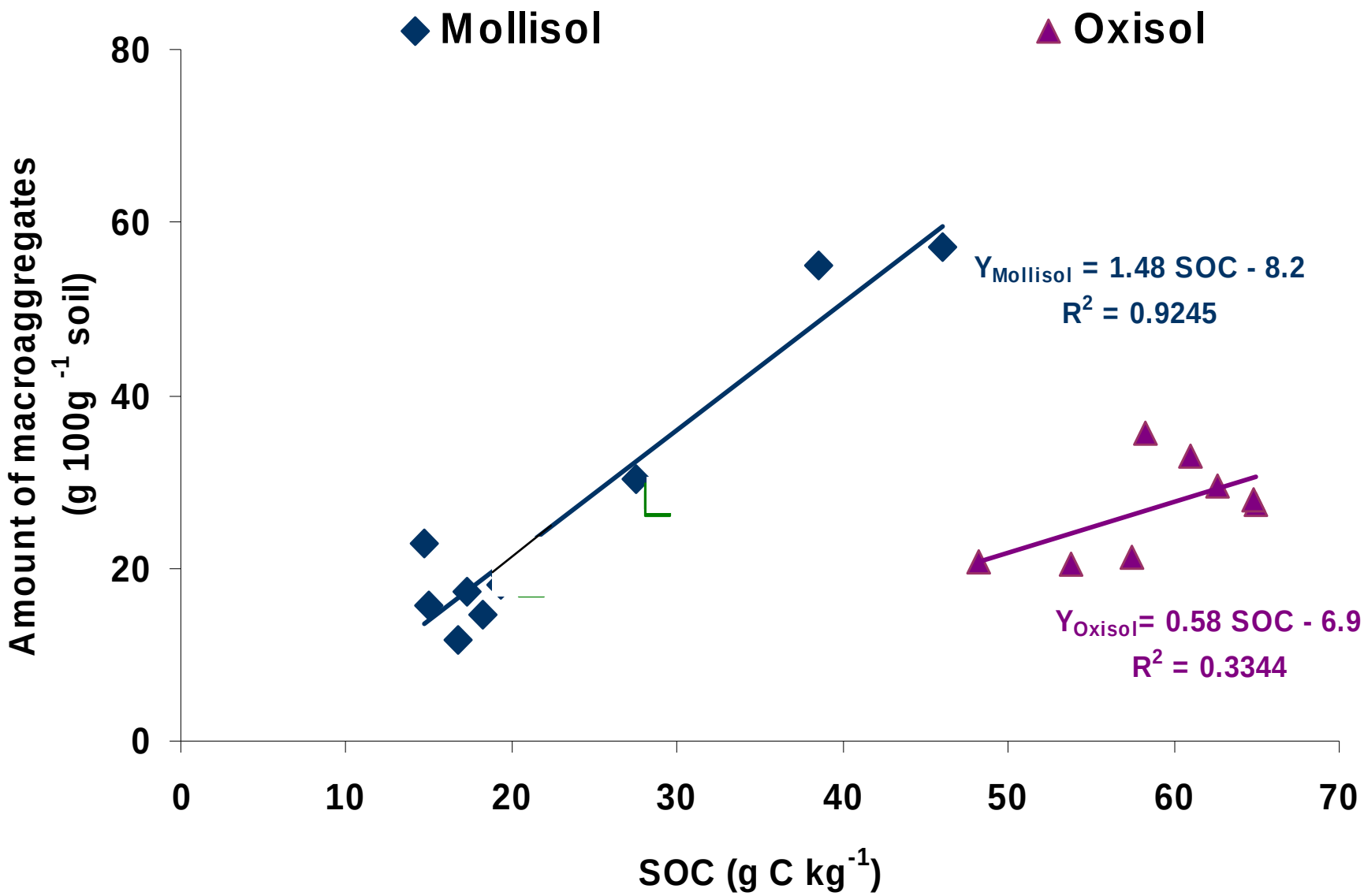
Aggregate-associated C





Fuente: Fabrizzi, 2006

Macroaggregates-SOC



Source: Fabrizzi, 2006 KSU

Soybean Ecosystem C Balance

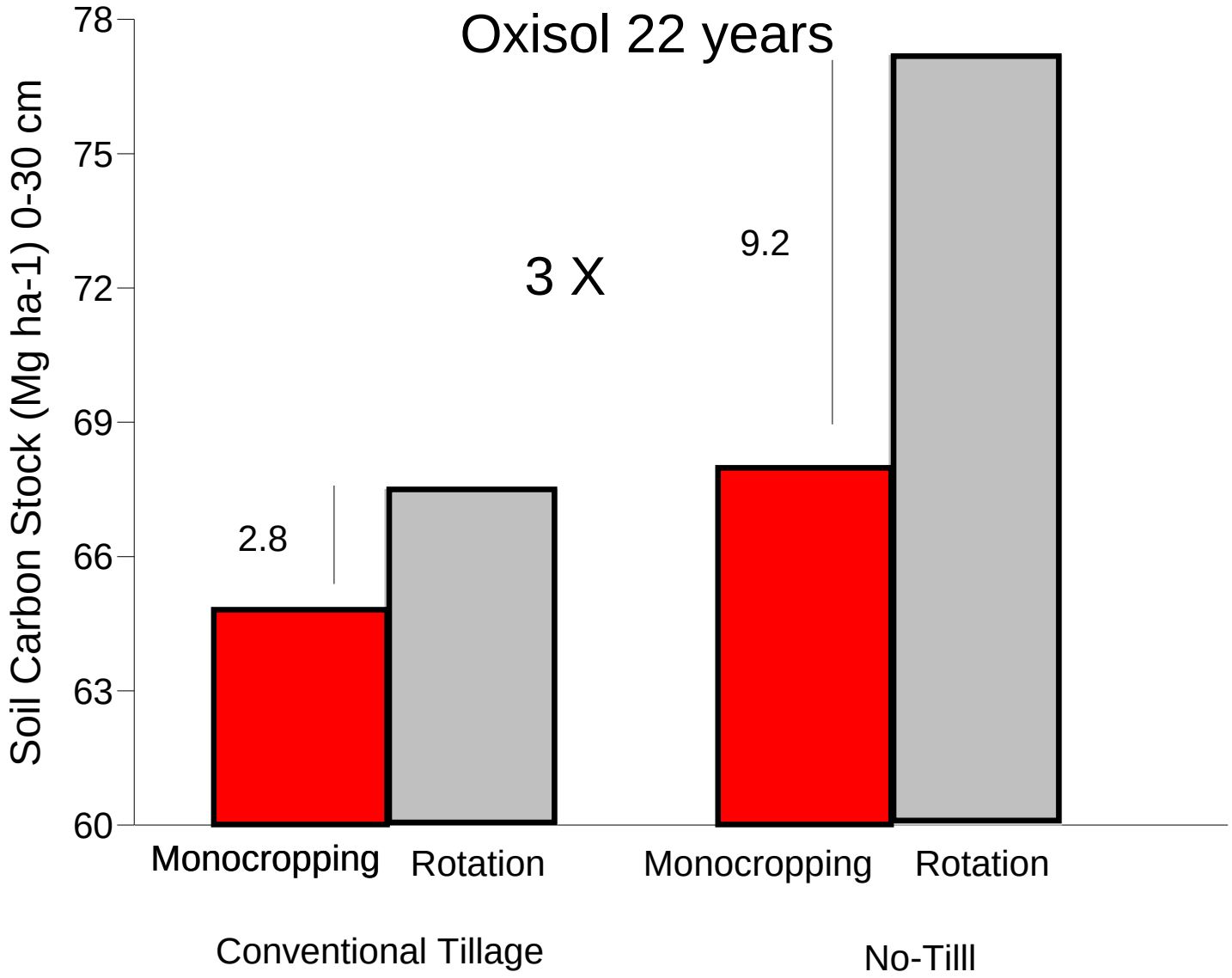
Soybean	Yield	C grain	CO2 Flux	CO2 flux-C grain
	---------- g m^{-2} ----------			
2006/07	321.3	150,95	-158.05	-7.10

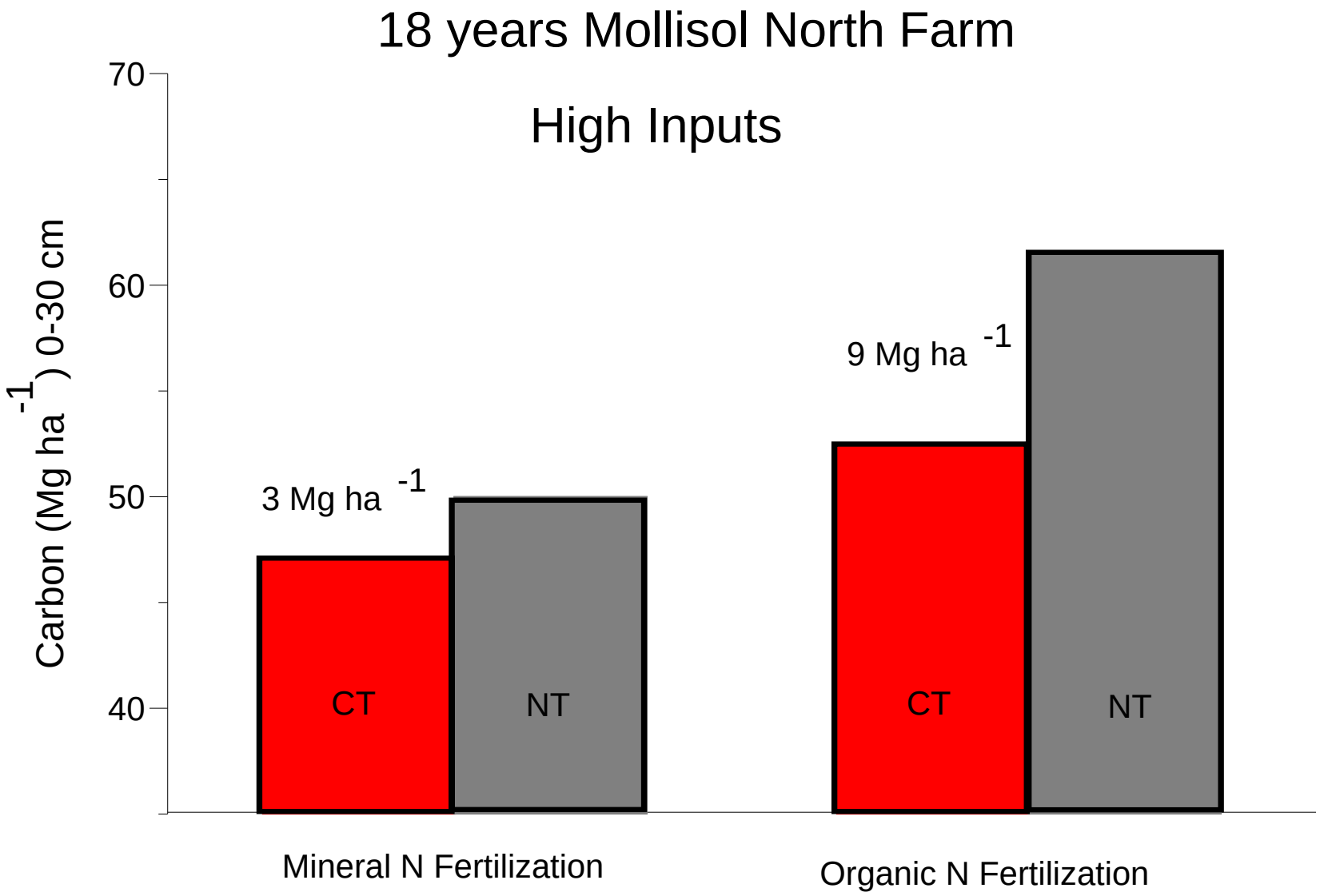
Verma et al. (2005) +/- 45 g C m^{-2}

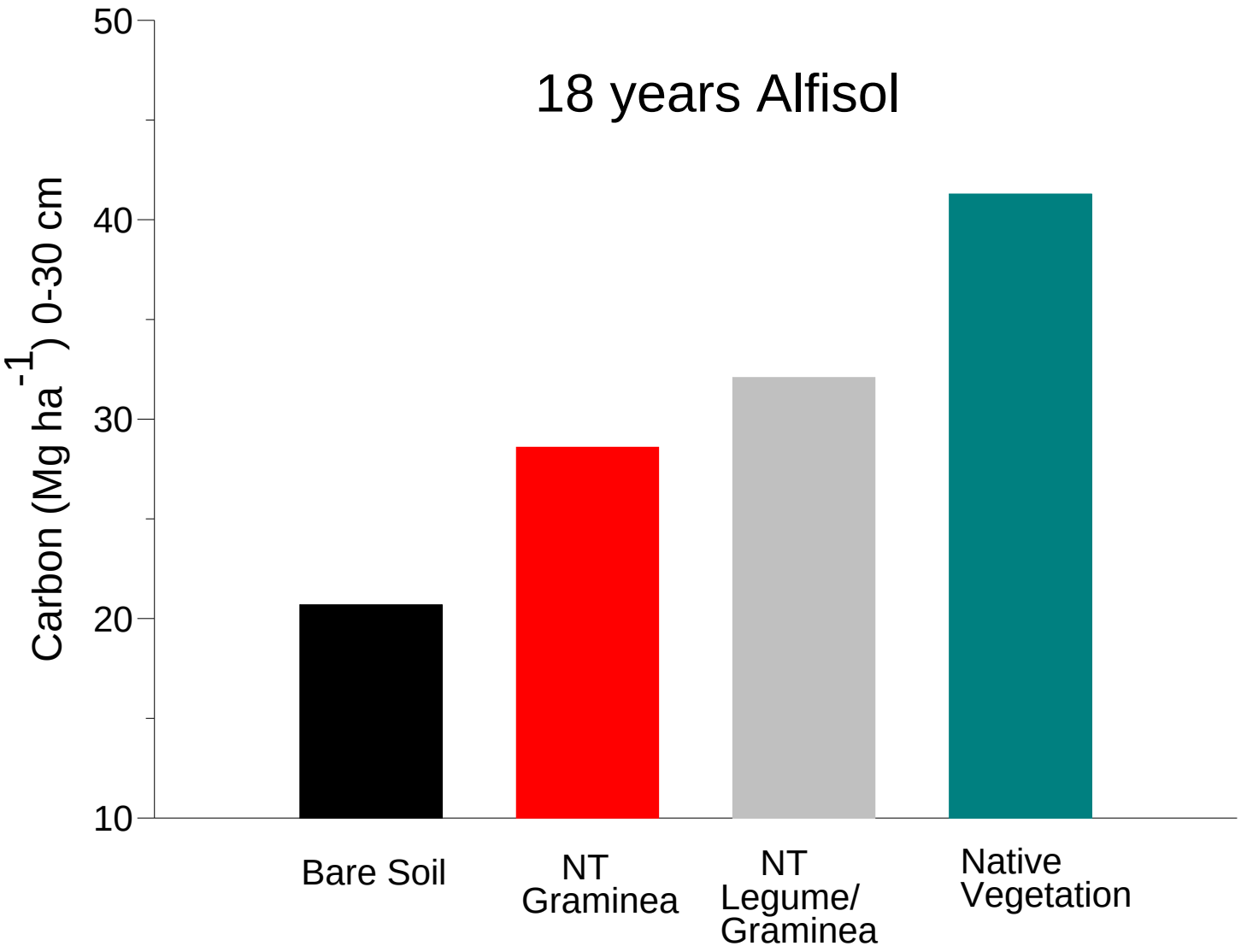
Conclusion: Carbon sequestration? Not with soybean

NT soybean neutral balance

Escobar, 2007

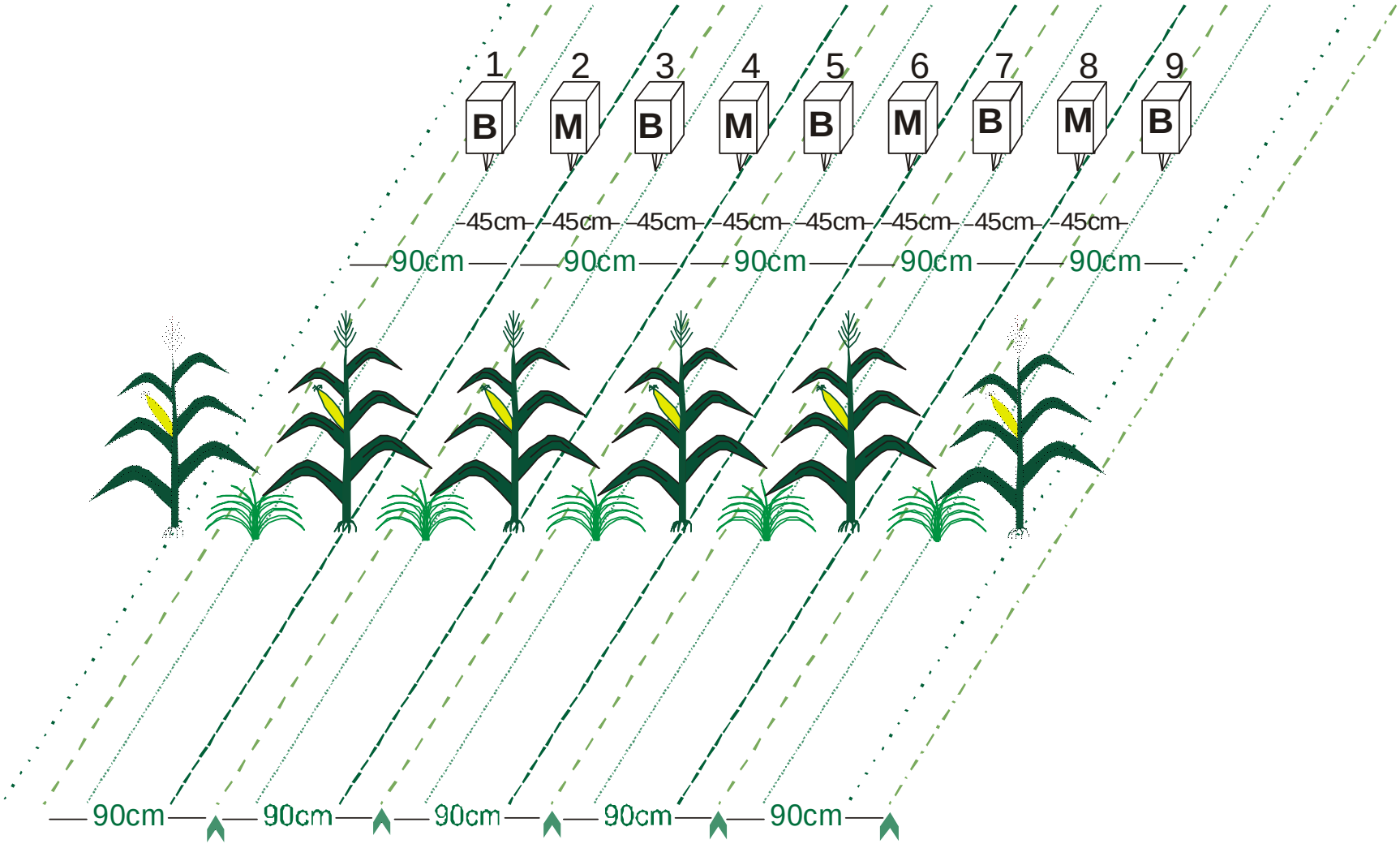

Oxisol 22 years
Soil Carbon Stock (Mg ha-1) 0-30 cm
78
75
72
69
66
63
60
3 X
9.2
2.8
Monocropping
Rotation
Monocropping
Rotation
Conventional Tillage
No-Tilll


18 years Mollisol North Farm
High Inputs
Carbon (Mg ha-1) 0-30 cm
70
60
50
40
3 Mg ha -1
9 Mg ha -1
CT
NT
CT
NT
Mineral N Fertilization
Organic N Fertilization


18 years Alfisol
Carbon (Mg ha-1) 0-30 cm
50
40
30
20
10
Bare Soil
NT Graminea
NT Legume/ Graminea
Native Vegetation

Innovate cropping systems

Consortium perenial pasture (Brachiaria) with Maize



7 14:05

25 14:45

7200
SLC
2 14:58

FORD