SOIL CARBON SEQUESTRATION IN TROPICAL PASTURELAND: EVALUATION OF MITIGATION POTENCIAL IN THE LIVESTOCK

Ladislau Martin-Neto[1*], Aline Segnini[1], Odo Primavesi[2], Wilson T. L. da Silva[1], Debora P. Milori[1], Marcelo L. Simões[1]

[1]Senior Researcher at Brazilian Agricultural Research Corporation –Embrapa, Agricultural Instrumentation Center, São Carlos/SP, Brazil
*Vice-President/President Elected of International Humic Substances Society (IHSS)

[2]Senior Researcher at Embrapa- Southeast Cattle Research Center, São Carlos/SP, Brazil.

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OUTLINE

- 1- Brazilian Agribusiness
- 2- Anthropogenic GHG Brazil
- 3- Soil Organic Matter in Brazil
- 4- Carbon Sequestration Potential of Brazil
- 5- Experiments with grains areas
- 6- Experiment with brachiaria area
- *6*- Evaluation and Discussion of data
- *8*- Final Considerations

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Ranking 2005: Production and Exports

Main products	Brazil - World Ranking	
	Production	Exports
Ethanol *	1st	1st
Sugar	1st	1st
Coffee	1st	1st
Orange Juice	1st	1st
Soy Complex	2nd	1st
Beef	2nd	1st
Tabacco	2nd	1st
Broiler	3rd	1st
Corn	3rd	-
Fruits	3rd	-
Pork	4th	4th

Sources: USDA, F.O. Licht's

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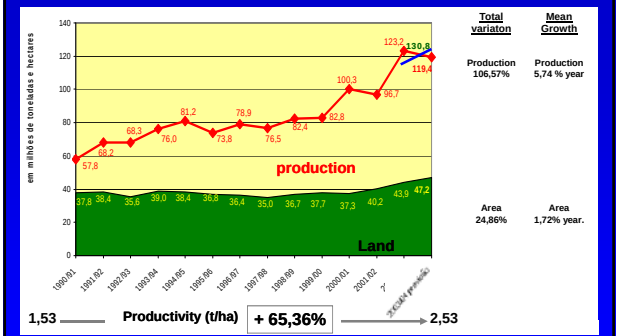
Evolution of Grains Production x Land Use



1,53 — Productivity (t/ha) + 65,36% → 2,53

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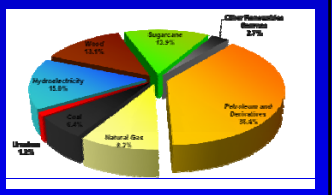
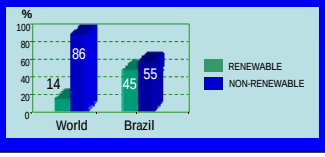
Brazilian Energetic Matrix - 2005

RENEWABLE SOURCES 44.7 %

218.6 MTOE





Source: Brazilian Energy Balance (2006)
Ministry of Mines and Energy

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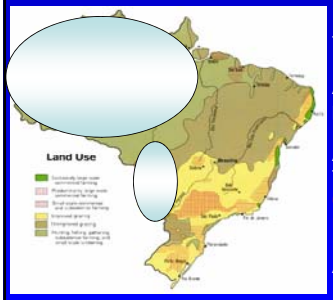
DATA OF BRAZIL'S AREA



Total area: 850 M ha

Amazonian, Pantanal and other preservation areas- 500 M ha

Agricultural Land- 350 M ha
Today- Grains and perennial- 60 M ha (sugarcane- 6 M ha; reforestation- 6 M ha)
Pasture- 190 M ha
Areas to be cultivated: 100 M ha

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TOTAL ANTRHROPOGENIC GREENHOUSE GASES (GHG) EMISSION IN BRAZIL- 1994

- TOTAL- 1,480 Tg CO_2 – equivalent
- 1,030 Tg CO_2
- 13.2 Tg CH_4
- 550 Gg N_2O
- 75% total GHG emission – agriculture and land-use changes- deforestation and biomass burning, mainly Amazonian rainforest (around 1 % of GDP)

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BRAZIL'S CH_4 EMISSION

- TOTAL- 13.2 Tg CH_4/year
- AGRICULTURE- 10.2 Tg CH_4/year
- LIVESTOCK- 9.8 Tg CH_4/year

(92% enteric fermentation and 4% animal manure)

- Correspond to 16% total GHG emission of Brazil or 12% total world livestock CH_4 emission and 2% of the global anthropogenic sources
- Bovine herd in Brazil- ~195 Mi

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SOIL ORGANIC MATTER (SOM) IN BRAZIL

- Tropical and subtropical regions (Brazil)- soil organic matter (SOM) - major factor to soil quality- fast turnover compared temperate areas, kaolinite (clay 1:1, low cation exchange capacity)
- Conventional tillage- erosion, reduction of soil fertility and structure, decrease of SOM (CO_2 emission)
- No-till (direct drilling)- maintain and/or increase SOM (CO_2 sequestration, other advantages

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SOIL CARBON SEQUESTRATION IN GRASSLANDS

- Some literature data showing tropical grassland (mainly African origin) capacity to carbon sequestration - Fisher et al., 1994 (Nature); South America- 250 M ha grassland- 0.1-0.5 Pg C $year^{-1}$ (deforestation and land-use changing- 1.2 Pg C/year)
- Total Brazilian pastureland : 190 Mi ha (*Brachiaria spp* 80 M ha)
- Conant et al., 2001- soil carbon sequestration rate in grassland in 17 countries, incluindo UK, NZ, Canada, Brazil and USA (26% of worldwide grassland)- rate 011 to 3.04 Mg C ha^{-1} $year^{-1}$ – mean value 0.54 Mg C ha^{-1} $year^{-1}$, dependence weather and biomes

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Potential of Carbon Sequestration in Brazil- Soil possibilities

- Brazilian Savanna area (Cerrado)- 200 M ha- 4% of agricultural land worldwide
- Mitigation of greenhouse effect - Lal, 2004 (Science)
  - Soil conservative procedures
  - No-tillage or direct drilling to grains and perennial cultures (no strong winter in Brazil)
  - Recuperation of degraded land (including degraded pastureland from a total 190 M ha)

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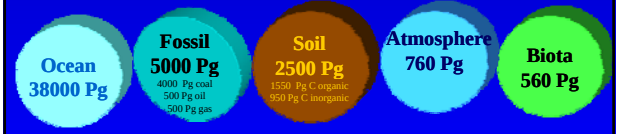
GLOBAL CARBON POOLS

♦ SOIL C- 3th higher pool



(Source: Adapted from Lal, 2004)

1 Pg = 10^{15}g

LAL, R. Soil carbon sequestration to mitigate climate change. Geoderma, v. 123, p. 1-22, 2004.

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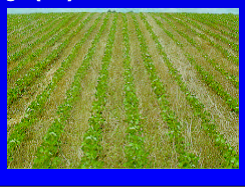
Conventional Tillage (CT)

No-Tillage (NT)



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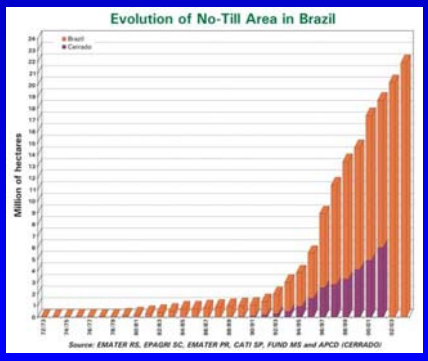

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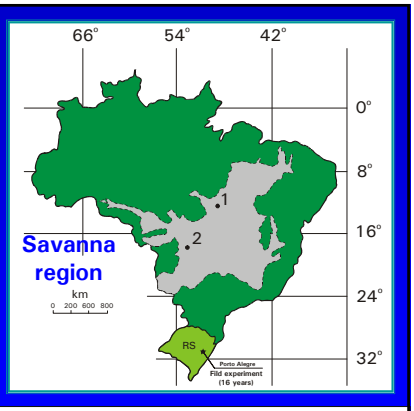
BRAZIL



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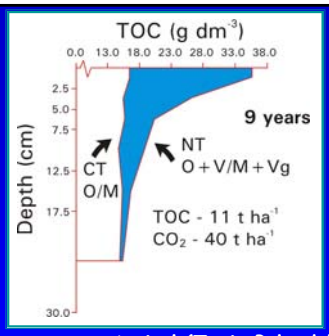

CT- conventional tillage
NT- no-tillage

Bayer, Martin-Neto et al., Soil & Tillage, 2000.

Acrisol (Typic Paleudult- USA)
540 sand, 240 silt, 220 clay g kg^{-1}
subptropical climate, temp.= 19.4 °C; rainfall= 1440 mm

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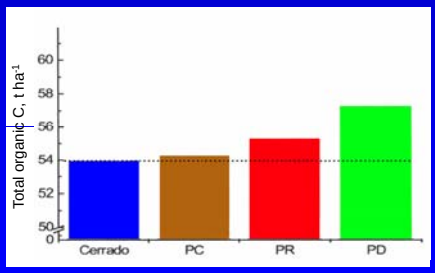
Oxisol- Costa Rica/MS, Brazil

5 years NT (0-20 cm) compared with Cerrado (no cultivated area):TOC 3.02 t/hectare CO_2 11 t/hectare



Soil Tillage
PD: no tillage
PC: conventional
PR: reduced
Cerrado: natural

BAYER, MARTIN-NETO et al., 2006- Soil & Tillage Research

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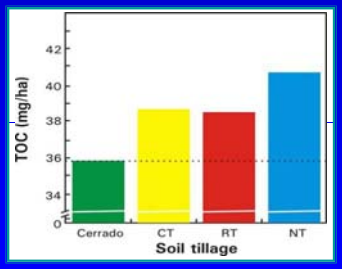
Oxisol - Lusiânia/GO (Brazilian Cerrado)

7 years NT (0-20 cm), increase COT 4,84 t/hectare, sequestration of CO_2- 17,9 t/hectare



Soil Tillage
Cerrado- no cultivated
CT- Conventional
RT- Reduced
NT- No-tillage

Bayer, Martin-Neto et al., Soil & Tillage Research, 2006.

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Mean value of soil carbon sequestration in Brazil in grain areas under no-till

- Data from Bayer, Martin-Neto et al., 2006 using own results and from several other published data from Brazil:
  - Savanna- 0.35 Mg C/ha year (variation= -0.03-0.60 MgC/ha ano) layer 0-20 cm, soils under no-till, soybean and corn mainly (sequestration- 1.26 Mg CO_2/ha $year^{-1}$)
  - Sub-tropical region BR= 0.48 MgC /ha year (variation= 0.19-081 Mg C/ ha year), layer 0-20 cm, soils under no-till, soybean, corn, wheat, and leguminous (cover plants) (winter- more rainfall than in the Savannah regions)

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Brachiaria decumbens experiment

- LOCAL: Embrapa- Southeast Cattle Research Center

São Carlos, São Paulo State- central region of Brazil

(21º58' S, 47º50' W)

- SOIL: Latosol red-yellow, with 25% of clay, pH 4
- Climate: **Mean annual temperature 20ºC, average annual rainfall 1360 mm**
- Period: 27 years

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TREATMENTS

- ***T00*** **(control): 27 years under pasture;**
- ***t0*****: no surface liming, but with mineral fertilization (400 kg y^{-1} N-ammonium sulfate and K_2O, after 1999);**
- ***t2m*****: 2 t ha^{-1} of surface limestone application, with NK fertilization and 1 t ha^{-1} y^{-1} reinforcement of limestone application, after 1999;**
- ***t4sa*****: 4 t ha^{-1} of surface limestone application without mineral fertilization, after 1999;**
- **Reference: Cerradão – Brazilian savanna area (dense Cerrado in transition to a native mesophyle semideciduous tropical forest)**

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Experimental sites- São Carlos

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CARBON STOCK (CS) - SOIL

Depth (cm)	CARBON STOCK (Mg ha^{-1})				
	cerradão (reference)	T00	t0	t2m	t4sa
0-10	25	31	64	57	56
10-20	25	24	27	44	42
20-40	25	42	41	41	41
40-60	22	32	34	29	27
60-80	15	25	24	28	21
80-100	17	20	22	24	28
TOTAL (0-100)	**129**	**174**	**212**	**223**	**215**

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CARBON SEQUESTRATION - soil

treatment	C sequestration rate (Mg C ha^{-1} ano^{-1})
T00	1.7
t0	3.1
t2m	3.5
t4sa	3.2

- **Layer 0-20 cm: C sequestration: 0,18 a 1,89 Mg C ha^{-1} $year^{-1}$**
- **Bayer et al. (2006)⇨ C sequestration in no-till areas in Brazilian savannah mean value: 0,35 Mg C ha^{-1} $year^{-1}$ (layer - 0-20 cm)**

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Mitigation Potential

- Carbon sequestration value of 1.7 to 3.5 Mg C ha^{-1} $year^{-1}$ (or 6.24 to 12.8 Mg CO_2 ha^{-1} $year^{-1}$) in the experimental site of São Carlos- Embrapa Southeast Cattle Res. Center;
- Probably main reason: very high net aerial primary productivity – 33 t/ha/year and net primary productivity below ground- 24 t/ha/year (total 57 t/ha/year) of African grasses (Fisher et al., 2007- Tropical Grassland- Australia)
- Potential estimate to Pastureland in Brazil (using our data):

80 Mi ha (Brachiaria spp)- 0.5 to 1.0 P g CO_2 $year^{-1}$

50 Mi ha (just ¼ of total pastureland area) - 312 Tg CO_2 $year^{-1}$ (using lowest sequestration rate of 6.24 Mg CO_2 ha)

Total Brazilian Agriculture CH_4 emission – 232 Tg CO_2-eq $year^{-1}$

OTHER FACTORS TO BE CONSIDERED DUE TO NITROGEN FERTILIZERS USE

- Nitrogen fertilizers – fossil derivative

  Production of 1 kg N generate 4 kg CO_2
- N_2O formation in soil- 296 times more effective to greenhouse effect than CO_2

Literature data on N_2O production

Crop	Local	Soil	Dose $kgNha^{-1}$	Emission $kgN\text{-}N_2O$ ha^{-1} day^{-1}
Brachiaria[1]	Rondônia/ Brazil	Oxisol	33-40	0.6-0.9
Grassland[2]	Rondônia/ Brazil	Oxisol	100	0.04-2.8
Maize[3]	Ohio/USA	Clay	150	1.8
Maize/peanut[4]	Malasia	Franco D	180	1.9
Maize/oat[5]	New Zealand	Silty DD	160	9.2-12
Mayze/wheat[6]	Germany	Silty DD	170 - 210	3.1-10.1

D: good drainage; DD: Deficient drainage

1-Passianoto et al., 2003; 2- Steudler et al., 2002; Jacinthe & Dick, 1997; Khalil et al., 2002; Choudhary et al., 2002; Sehy et al., 2003

N_2O in Brazil

- Data obtained in Brazil are generally smaller than results from other regions mainly temperate soils
- Probably main reason- Oxisol are well drainage soils – avoid soil water saturation and formation of N_2O (data from Alves et al., 2006)
- However additional research must be performed in the several biomes with different soils and climate characteristics to minimize uncertainty in data

FINAL CONSIDERATIONS

- Evidences of carbon sequestration in tropical grassland mainly from Africa origin (Brachiaria) in Brazil
- Next step: to increase number of field measurements in different biomes and livestock production systems in Brazil and include GHG fluxes analysis
- Soil carbon evaluation- high variability (space and time) – new tools to field measurements
- Certification procedures including to CDM and carbon footprint
- Qualitative (stability and lifetime estimate) carbon studies are also relevant (use of soil fractionating methods and spectroscopic techniques, as laser induced fluorescence- Milori, Martin-Neto et al., 2006- SSSAJ)

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Mitigation

SUSTAINABLE PRODUCTION SYSTEMS

GRAINS-CATTLE-FORESTRY INTEGRATION SYSTEM
Brazilian Cerrado (Savanna region)

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•Thanks for your attention!

martin@cnpdia.embrapa.br

Embrapa- Agricultural Instrumentation Center, São Carlos, BR

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