Conservation tillage techniques for Tropical Agriculture

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Agriculture challenges: technology

Presentation topics

- Background
- Summary
- No Tillage System: 3 Phases
- Agriculture Challenges: 3 Cycles
- Conclusions
World - Evolution of Cultivated area of No Tillage

Period 1974 - 1979
Period 1979 - 1991
Period 1991 - 2006

Brazil - Evolution of Cultivated Area of No Tillage
1974 to 2006

PHASE I
PHASE II
PHASE III

Source: Adapted from FEBRAPDP (2007) by Denardin

Ministry of Agriculture, Livestock and Food Supply
Technology challenge: soil management system

Main Challenges: Tropical Agriculture
- Soil fertility correction
- Crop cultivar adapted to different conditions
- Biological Nitrogen fixation
- Inefficient pre seedling & high cost of herbicides
- Post emergence weed control with low selectivity
- Inefficient technology of herbicide application: 2X
- Operational limitation of equipment
- Crop production system

The most important facts are:
- Knowledge exchange
- ABC Foundation was created in 1984: to promote research in No Tillage associated with extension service and farmers.
- Agronomic and Seeders Tests were carried out by Embrapa Wheat Research Center.
- Process and equipment improvements.
Technology challenge: soil management system

Main reasons for adoption: Structural brake slope

- High efficiency of herbicide: selectivity
- Substantial price reduction: US$ 48  →  US$ 15  →  US$ 4
- High technology of herbicide application: 4L  →  0.6L
- Machinery equipment for all productions scales
- Livestock in the production system: Santa Fé System
- Production System for Tropical Agriculture: 2-3 crops/yr

Period 1981 - 2006
PHASE III

Source: Adapted from FEBRACAP (2007) by Denardin

Ministry of Agriculture, Livestock and Food Supply

BRAZILIAN GOVERNMENT

Brazil

TROPICAL REGION

SUB TROPICAL REGION

Equator

Tropic of Capricorn

Brazilian territory: 8,511,965 km²
- representing 20.8% of the American Continent
- as well as 47.0% of Latin America.

Source: Denardin et al. 2007
ANNUAL RAINFALL DISTRIBUTION

EROSIVITY
5,200 to 12,600 MJ mm ha\textsuperscript{-1} h\textsuperscript{-1}
CONCENTRATED IN SUMMER

Rainfall (mm)

Source: Denardin et all 2007

MAP OF BRAZIL SOILS

MOST FREQUENT SOILS

- Latosol - Red: 38.7%
- Latosol - Yellow: 38.7%
- Latosol – Brown: 6.0%
- Latosol - Red-Yellow: 20.0%
- Argisol: 20.0%
- Neosol - sand quartz: 14.6%
- Plinthosol: 6.0%
- Cambisol: 2.7%
- Nitosol: 1.4%
- Other: 16.6%

Source: Denardin et all 2007
SOIL PHYSICAL PROPERTIES

Latosols, Argisols, Neosols and Nitosols

- Deep
- Well-drained
- Distributed on slightly rolling to rolling landscape

No limitations for mechanization

Source: Denardin et al. 2007

SOIL PHYSICAL PROPERTIES

Soil Organic Matter

<table>
<thead>
<tr>
<th>SOIL TYPE</th>
<th>g/100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neosols - sand quartz</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Latosols</td>
<td>&lt; 4</td>
</tr>
<tr>
<td>Argisols</td>
<td>&lt; 4</td>
</tr>
<tr>
<td>Plinthosols</td>
<td>&lt; 4</td>
</tr>
<tr>
<td>Nitosols</td>
<td>&lt; 4</td>
</tr>
<tr>
<td>Cambisols</td>
<td>&gt; 5</td>
</tr>
</tbody>
</table>

Source: Denardin et al. 2007
SOIL PHYSICAL PROPERTIES

Most frequent soils

- Clay fraction
  1:1 ➔ (caolinite)
- Oxides ➔ Fe and Al

LOW WATER CLAY DISPERSION

HIGH AGGREGATE STABILITY

Source: Denardin et al. 2007

No Tillage System - PHASE I 1974-1979

Y = 11,901X - 2.34x10^7  R^2 = 0.84

Source: Adapted from FEBRAPDP (2007) by Denardin
Agriculture challenges: technology

1st Cycle

- **Impacts**
  - Rural-county development
  - Food supply stabilisation
  - Food prices decrease
  - Increasing exports

- **Assets**
  - Unproductive lands
  - Public investment

- **Products**
  - Grains, meat, milk, fruits, fibres, vegetables, and sugar cane.

---

Embrapa & National Agriculture Research System

Budget 2008: US $1.2 billion

Personnel: 8,632

- **Headquarters**
  - 9 Basic themes

- **13 Commodities**

- **15 Ecoregional**

- **3 Special services**

- **17 State research system**
Embrapa: Building research capability

Strong training program in centers of excellence around the world.

National Agriculture Research System

EMBRAPA  STATE RESEARCH SYSTEM  UNIVERSITIES

Ministry of Agriculture, Livestock and Food Supply
Innovation and technology: food production

Food security: 1\textsuperscript{ST} CYCLE

ECONOMIC

Agriculture challenges: Food Production

ECONOMIC

Ministry of Agriculture, Livestock and Food Supply
Soil Management Challenges: beginning of erosion problems

Monocropping and disc cultivation
Inadequate soil management

Negative environmental impacts
Crop yield decline
Soil Erosion

Source: Balbino 2008

Traditional Soil Management
Traditional and Conservation Soil Management

Technology challenge: soil management system

Soil losses: 30 to 40 ton/ha/year

Consequences: Erosion problem
Technology challenge: soil management system

Main Challenges: Tropical Agriculture

- Soil fertility correction
- Crop cultivar adapted to different conditions
- Biological Nitrogen fixation
- Inefficient pre seedling & high cost of herbicides
- Post emergence weed control with low selectivity
- Inefficient technology of herbicide application: 2X
- Operational limitation of equipment
- Crop production system

Agriculture challenges: Sustainable Agriculture

- Products and services
- Knowledge development

Food + Fiber + Energy

Sustainable production systems

- Climate changes

Source: Adapted from FEBRAPDP (2007) by Denardin
No Tillage System: PHASE II 1979-1991

\[ Y = 79,016X - 1.56 \times 10^8 \quad R^2 = 0.99 \]

Period 1974 - 1979
PHASE I

Period 1979 - 1991
PHASE II

Period 1991 - 2006
PHASE III

Source: Adapted from FEBRAPDP (2007) by Denardin

Agriculture challenges: Sustainable Agriculture

2nd Cycle

- **Assets**
  - Land
  - Technology
  - Logistics

- **Impacts**
  - Rural-county development
  - Economic, environmental & social

- **Products**
  - Grains, meat, fruits, fibres, vegetables, and sugar cane.

Products
- Grains, meat, fruits, fibre, biofuel.
Innovation and technology: production systems

Soil
- Traditional areas
- Expansion areas

Plant

Climate
- Arrangements
  - Food
  - Energetic fiber
  - Forestry
    - Perennial crops

Sustainability criteria

No Tillage System: PHASE II 1979-1991

\[ Y = 79,016X - 1.56 \times 10^8 \quad R^2 = 0.99 \]
Knowledge exchange

Process and equipment improvements

Mechanisms for opening furrows seedlings
Southern Region: erosion control no tillage system

Soil losses of 4-6 t/ha/year

Efficiency - post emergence herbicides for weed management

NO TILLAGE SYSTEM: SUBTROPICAL REGION

IDEAL PRODUCTION MODEL

<table>
<thead>
<tr>
<th>Area</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Corn</td>
<td>Sorghum</td>
<td>Oat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Soybean</td>
<td>Black Oat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>3</td>
<td>Corn + Brachiaria</td>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4</td>
<td>Soybean</td>
<td>Nabo</td>
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</tbody>
</table>
Harvest-planting Process

Ministry of Agriculture, Livestock and Food Supply

Harvest-planting Process
In the Subtropical region, mere coverage of the soil with straw doesn’t have a strong impact on soil structure.
BIOLOGIC ACTIVITY

MECHANIC ACTION

Ministry of Agriculture, Livestock and Food Supply
Technology challenge: soil management system

The most important facts are:

- Knowledge exchange
- ABC Foundation was created in 1984: to promote research in No Tillage associated with extension service and farmers.
- Agronomic and Seeders Tests were carried out by Embrapa Wheat Research Center.
- Process and equipment improvements.

Y = 1.709,957X - 3.40x10^9  \( R^2 = 0.98 \)

Source: Adapted from FEBRAPHDF (2007) by Denardin

R&D and TT: sustainable technologies
**The challenge of latosol management in the Cerrados was met using technology transfer from the Southern experience**

- Production Area (millions ha)
  - Total Area: 204
  - Farming Area: 127
  - Cultivated area: 80

The total area of this region is equivalent, in size, to the area of Spain, France, Italy, Germany, Portugal and England combined.

Innovation and technology: agriculture of the Cerrados.

**Typical Rainfall for the Cerrados**

Source: http://www.fao.org/docrep/004/Y2638E/y2638e08.htm#
Summer Crop Schedule

Decades 70 & 80

October  November  December/January  February  March

Placing

Cultivation/Pest control

Harvesting

Traditional Tillage

Traditional Soil Management
### Summer Crop Schedule

**Decades 90 & 00**

<table>
<thead>
<tr>
<th>October</th>
<th>November</th>
<th>December/January</th>
<th>February</th>
<th>March</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No tillage Planting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultivation/Pest control</td>
<td></td>
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</tr>
</tbody>
</table>

*Source: Balbino 2008*

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### Summer Crop Schedule

- **Grain crop production using No Tillage**

- No Tillage: sowing without previous ploughing or harrowing.

*Source: Balbino 2008*
Technology transfer: mechanization for the Cerrados

- Agronomy Technology
- Soil Management
- Machinery Technology

No Tillage Seeders technology: 27 manufactures

Chemical application technology
NO TILLAGE SYSTEM - BRAZILIAN CERRADOS

EXPANSION PRODUCTION MODEL

O N D J F M A M J J A S O

Soybean

Corn

Brachiaria & Livestock

EXPANSION PRODUCTION MODEL:

SOYBEAN

CORN

LIVESTOCK

Ministry of Agriculture, Livestock and Food Supply
CONSERVATION TILLAGE SYSTEM

HARVESTING-SOWING PROCESS
CROP ROTATION - FERTILE SOIL

- Flows of organic matter in productive agricultural systems are similar to the ones observed in ecosystems.
- Permanent and simultaneous flow: mineralization and nutrient absorption.
- The use of intensive rotation with high residue cover from crop production, under No Tillage, improves soil productivity.

Innovation and technology: Tropical No Tillage System

Technology challenge: soil management system

Main reasons for adoption: Structural brake slope
- High efficiency of herbicide: selectivity
- Substantial price reduction: US$ 48
  US$ 15
  US$ 4
- High technology of herbicide application: 4L 0,6L
- Machinery equipment for all productions scales
- Livestock in the production system: Santa Fé System
- Production System for Tropical Agriculture: 2-3 crops/yr

Source: Adapted from FEBRAPDP (2007) by Denardin
**Remark of Phase II**

Production costs of Corn under No Tillage System in 3 different regions of Brazil (R$/Hectare July - 2009*):

- Rio Verde
- Londrina
- Unaí

<table>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio Verde</td>
<td>2.600</td>
<td>2.800</td>
<td>2.000</td>
<td>2.200</td>
<td>2.400</td>
<td>1.600</td>
<td>1.800</td>
<td>2.000</td>
<td>2.200</td>
</tr>
<tr>
<td>Londrina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unaí</td>
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</tbody>
</table>

*Values considered using KIP-DI da FGV.

**Fertilizers Consumption in the Cerrados - 1986 e 2007**

<table>
<thead>
<tr>
<th>Region</th>
<th>Consumption (thousand tons)</th>
<th>Increment 1986-2007 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerrados Region</td>
<td>2.650</td>
<td>10.866</td>
</tr>
<tr>
<td>Other Regions</td>
<td>6.520</td>
<td>10.116</td>
</tr>
<tr>
<td>Total: Brazil</td>
<td>9.170</td>
<td>20.982</td>
</tr>
</tbody>
</table>

Fleet & sales of Tractors in the Cerrados Region

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerrados Region</td>
<td>52,459</td>
<td>228,832</td>
<td>336.21</td>
<td>7,494</td>
</tr>
<tr>
<td>Other Regions</td>
<td>270,654</td>
<td>559,221</td>
<td>106.62</td>
<td>24,241</td>
</tr>
<tr>
<td>Total: Brazil</td>
<td>323,113</td>
<td>788,053</td>
<td>143.89</td>
<td>31,735</td>
</tr>
</tbody>
</table>

Fonte: IBGE e Anfavea.

Fleet & sales of Combines in the Cerrados Region

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerrados Region</td>
<td>15,784</td>
<td>52,782</td>
<td>234.40</td>
<td>787</td>
</tr>
<tr>
<td>Other Regions</td>
<td>68,923</td>
<td>106,636</td>
<td>54.72</td>
<td>1,590</td>
</tr>
<tr>
<td>Total: Brazil</td>
<td>84,707</td>
<td>159,418</td>
<td>88.20</td>
<td>2,377</td>
</tr>
</tbody>
</table>


Innovation and technology: Tropical Agriculture
The Agribusiness in Brazil

One of the most dynamic sectors of the economy.
- 5 million rural properties - 18 million people.
- 23% GNP 2007 and 37% employment in the country.

Main source of International income
- 37% of Brazilian exports.

Commercial Balance Evolution of Brazilian Agribusiness (1989 to 2008 (US$ billions))

| Source: Agronorte/ Elektro-SECEX/MDIC |

**Products**

<table>
<thead>
<tr>
<th>Coffee</th>
<th>Sugar</th>
<th>Orange juice</th>
<th>Cattle meat</th>
<th>Tobacco</th>
<th>Alcohol</th>
<th>Soybean</th>
<th>Poultry meat</th>
<th>Mayze</th>
<th>Pork meat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1°</td>
<td>1°</td>
<td>1°</td>
<td>2°</td>
<td>2°</td>
<td>2°</td>
<td>2°</td>
<td>3°</td>
<td>4°</td>
<td>4°</td>
</tr>
</tbody>
</table>

**Commercial Balance Evolution of Brazilian Agribusiness (1989 to 2008 (US$ billions))**

- 1989: US$ 39 billion
- 2008: US$ 71.8 billion

**Production Growth of Agriculture Machinery**

- Minas Gerais: 33.14%
- São Paulo: 26.4%
- Rio Grande do Sul: 19.1%
- Rio de Janeiro: 7.4%
- Mato Grosso: 4.3%
- Pernambuco: 2.0%
- Goiás: 0.6%
- Paraná: 1.5%
- São Paulo: 0.6%

**Source:** Embrapa, Ministry of Agriculture, Livestock, and Food Supply

**Production and Exports of Brazilian Agribusiness**

- Coffee: 1°
- Sugar: 1°
- Orange juice: 1°
- Cattle meat: 2°
- Tobacco: 2°
- Alcohol: 2°
- Soybean: 2°
- Poultry meat: 3°
- Mayze: 4°
- Pork meat: 4°

**Source:** MAPA e USDA
**Innovation and technology: agriculture expansion**

**3rd Cycle**

**Urban and rural population**

![Graph showing Urban and rural population growth over time](image)

**Source:** IBGE

---

**Innovation and technology: agriculture expansion**

**Land availability**

![Bar chart showing land availability](image)

**Available**

**Occupied**

**The global context**

![Map showing global context](image)

**Population > 100 million**

**Area > 4 million km²**

**GDP > US$ 400 billion**

**Source:** FAO, Sacenco, N. 2006

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**Ministry of Agriculture, Livestock and Food Supply**
**Innovation and technology: agriculture expansion**

- Production Area (millions ha)
  - Total Area: 204
  - Farming Area: 127
    - Cultivated pastures: 35
    - Annual crops: 10
    - Perennial crop and cultivated forests: 2
    - Available area: 80

**Innovation and agriculture challenges: 3rd cycle**

*From small-scale agriculture... to precision agriculture...*

**Summary:**
- Institutional and RD&I challenges
- Partnerships: national and international
- Knowledge frontier: nanotechnology, integration functional genomics...
- Growth Acceleration Program (PAC): budget and modernization
- V Strategic Master Plan-2008-20011-2023: New Mission, Objectives, ...
Innovation and technology: new production systems

Integrated crop-livestock-forestry

- Recuperation of degraded pasture: 50 Million hectares

GOALS FOR DEGRADED AREAS WITH ICropPASTURE:

- 2006 - 3 million ha
- 2010 - 5 million ha (Public Policies)
- 2015 - 18 million ha
- 2020 - 25 million ha
- 2030 - 36 million ha

Source: Balbino 2008
CONCLUSIONS

1. Conservation Tillage in Sub Tropical and Tropical regions was implemented by the No Tillage system which showed to be the most appropriate technique for soil management for erosion control.

2. As a whole, No Tillage systems were responsible for most of the improvement of agriculture equipment, development of new short cycle cultivars, low price and efficiency of herbicide, their application technology, etc.

3. The change in concept was very significant and, at present, the No Tillage System comprehends a complex of technologies.

4. The use of No Tillage in the Cerrados allowed farmers to produce two or three crops per year, increasing planting efficiency by establishing proper seasonality for the sequence of crops.

5. The use of No Tillage showed favorable impact on nitrogen fixation, and biological(integrated) pest control associated to precision farming allowed for better natural resources management.

6. The magnitude and rate of adoption of the No Tillage System by farmers in all regions is considered, today, a great revolution in Brazilian Tropical Agriculture.
Thank you!
Grazie
Gracias
Dankeschön
Obrigado

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55-xx-61-34484306

Innovation and technology: tropical agriculture knowledge

- Tropical plants and animals:
  - Soybean (photoperiodism)
  - Tropical and temperate-adapted fruits
  - Zebu cattle, swine, poultry etc.
- Improved forages and pastures quality
- Fibers and wood (cotton, *Eucalyptus*)
- N fixation
- Biological control of pests and diseases
- No Tillage system
- Integrated crop-livestock-forestry (ILPF)
- Post-harvesting losses reduction
- Mechanization in agriculture – precision agriculture
- Agro-ecological zoning
- Integrated production systems
Innovation and technology: food production

Grains: Rice, beans, maize, soybean, wheat

Source: IBGE

Innovation and technology: food cost

Average: -5.20% / year

Real food price in the last 30 years.

Mendonça de Barros et al., 2009.
### International Investments

- **John Deere Brasil Ltda Horizontina (RS)**
  - Products: Tractors, Combines and Planters

- **AGCO do Brasil Canoas and Santa Rosa (RS)**
  - Products: Tractors & Combines

- **New Holland do Brasil Curitiba (PR)**
  - Products: Tractors & Combines

### Brazilian Wheel Tractors Fleet 1960-2007

<table>
<thead>
<tr>
<th>ANO YEAR</th>
<th>TRACTORES DE RODAS (unidade)</th>
<th>ÁREA CULTIVADA (HECTARES)</th>
<th>ÍNDICE DE MECANIZAÇÃO AGRÍCOLA (ha/tractor de rodas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>52,864</td>
<td>25,671</td>
<td>40,0</td>
</tr>
<tr>
<td>1965</td>
<td>66,091</td>
<td>33,847</td>
<td>41,3</td>
</tr>
<tr>
<td>1970</td>
<td>87,143</td>
<td>51,487</td>
<td>51,5</td>
</tr>
<tr>
<td>1975</td>
<td>279,032</td>
<td>41,811</td>
<td>53,3</td>
</tr>
<tr>
<td>1980</td>
<td>400,040</td>
<td>47,041</td>
<td>59,9</td>
</tr>
<tr>
<td>1985</td>
<td>681,195</td>
<td>69,134</td>
<td>90</td>
</tr>
<tr>
<td>1990</td>
<td>518,815</td>
<td>47,688</td>
<td>92</td>
</tr>
<tr>
<td>1995</td>
<td>492,246</td>
<td>50,022</td>
<td>104</td>
</tr>
<tr>
<td>2000</td>
<td>428,000</td>
<td>55,306</td>
<td>118</td>
</tr>
<tr>
<td>2005</td>
<td>381,085</td>
<td>66,839</td>
<td>157</td>
</tr>
<tr>
<td>2007</td>
<td>381,085</td>
<td>57,882</td>
<td>195</td>
</tr>
</tbody>
</table>

Fontes/Sources: Anfavea, IBGE.
Crop-Pasture-Forest Program

Source: Balbino 2008

Production costs of Soybean under No Tillage and Conventional System in 4 different regions of Brazil - (R$/Hectare July - 2009)

- Planto Direto Campo Mourão, PR
- Planto Direto Primavera do Leste, MT
- Planto Direito Rio Verde, GO
- Convencional Dourados, MS

Fonte: Conab

* Valores corrigidos pelo IGP-DI da

US$106.78/ha


Ministry of Agriculture, Livestock and Food Supply