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BRAZILIAN PRECISION AGRICULTURE IN PERSPECTIVE

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Country continues to have enormous potential for agriculture and livestock production. Among other advantages we have: area, possibilities for yield increase, possibilities to increase # of crops per year, available water and the necessary labour.

No need to interfere significantly with the Amazon forest.
Agriculture in Brazil

- Actual Area not Yet Explored: 100,000,000 ha
- Actual Area with Forage Grasses: 220,000,000 ha
Some concerns arising related to fertilizers and the environment (ex.: Parana state).

Restrictions are growing because of environmental protection.

Fastest growing country in terms of fertilizer consumption.

Still serious problems with logistics.

BRAZIL
## Main Crops Cultivated in Brazil
### Area, production, and yield information

<table>
<thead>
<tr>
<th>Crops</th>
<th>Cropped land (ha)</th>
<th>Total Production (ton)</th>
<th>Yield (ton/ha)</th>
<th>World ranking (production)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean (grains)</td>
<td>31,908,300</td>
<td>96,222,100</td>
<td>3.02</td>
<td># 2</td>
</tr>
<tr>
<td>Corn (grains)</td>
<td>15,569,600</td>
<td>81,811,400</td>
<td>5.26</td>
<td># 4</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>9,462,556</td>
<td>678,298,386</td>
<td>71.7</td>
<td># 1</td>
</tr>
<tr>
<td>Beans (grains)</td>
<td>2,977,500</td>
<td>3,151,200</td>
<td>1.06</td>
<td># 3</td>
</tr>
<tr>
<td>Wheat (grains)</td>
<td>2,458,800</td>
<td>7,011,600</td>
<td>2.85</td>
<td># 23</td>
</tr>
<tr>
<td>Rice (with rind)</td>
<td>2,292,300</td>
<td>12,499,900</td>
<td>5.45</td>
<td># 7</td>
</tr>
<tr>
<td>Coffee (grains)</td>
<td>1,939,351</td>
<td>2,602,696</td>
<td>1.34</td>
<td># 1</td>
</tr>
<tr>
<td>Cotton (seeds+lint)</td>
<td>976,200</td>
<td>2,320,400</td>
<td>2.38</td>
<td># 5</td>
</tr>
<tr>
<td>Orange</td>
<td>614,467</td>
<td>13,809,684</td>
<td>22.5</td>
<td># 2</td>
</tr>
</tbody>
</table>

### Yield Potential in the Cerrado Area of Brazil

<table>
<thead>
<tr>
<th>Crops</th>
<th>Area (Million ha)</th>
<th>Yield (t/ha/year)</th>
<th>Yield (Million t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfed</td>
<td>60,0</td>
<td>3,3</td>
<td>192</td>
</tr>
<tr>
<td>Irrigated</td>
<td>10,0</td>
<td>6,0</td>
<td>60</td>
</tr>
<tr>
<td>Beef Production</td>
<td>60,0</td>
<td>0,2</td>
<td>12</td>
</tr>
<tr>
<td>Perennial</td>
<td>6,0</td>
<td>15,0</td>
<td>90</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>136,0</strong></td>
<td></td>
<td><strong>354</strong></td>
</tr>
</tbody>
</table>

Assuming:
- a) 1/3 of area (71 million ha) for environmental preservation;
- b) availability of water to irrigate 10 million ha;
- c) increase in yield compatible with current available technology.

Extracted from Lopes, 2008

Source: Macedo, 1995
## Secondary Crops Cultivated in Brazil

### Area, production, and yield information

<table>
<thead>
<tr>
<th>Crops</th>
<th>Cropped land (ha)</th>
<th>Total Production (ton)</th>
<th>Yield (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava</td>
<td>1,605,500</td>
<td>23,572,900</td>
<td>14.7</td>
</tr>
<tr>
<td>Cocoa (almond)</td>
<td>704,780</td>
<td>286,790</td>
<td>0.41</td>
</tr>
<tr>
<td>Sorghum (grains)</td>
<td>783,750</td>
<td>2,259,750</td>
<td>2.88</td>
</tr>
<tr>
<td>Oats (grains)</td>
<td>201,400</td>
<td>469,560</td>
<td>2.33</td>
</tr>
<tr>
<td>English Potatoes</td>
<td>132,100</td>
<td>3,739,400</td>
<td>28.3</td>
</tr>
<tr>
<td>Castor bean (grains)</td>
<td>63,000</td>
<td>37,820</td>
<td>0.60</td>
</tr>
<tr>
<td>Peanuts (grains)</td>
<td>109,000</td>
<td>318,000</td>
<td>2.91</td>
</tr>
<tr>
<td>Barley (grains)</td>
<td>91,170</td>
<td>329,820</td>
<td>3.62</td>
</tr>
<tr>
<td>Onion</td>
<td>57,700</td>
<td>1,654,300</td>
<td>28.6</td>
</tr>
<tr>
<td>Triticale (grains)</td>
<td>38,970</td>
<td>119,150</td>
<td>3.06</td>
</tr>
</tbody>
</table>

Brazilian Agriculture

History of grain production and fertilizer consumption in Brazil

- Soybean (40%)
- Maize (21%)
- Sugarcane (18%)
- Coffee (7.5%)
- Cotton (4.5%)

Sources: ANDA e CONAB (2014),
Brazilian Agriculture

Soil fertility restrictions in Brazil

Legend:
- Muito restrito
- Restrito
- Moderadamente restrito
- Pouco restrito
- Sem restrição

Fonte: Sparovek et al.
Brazilian Agriculture
Equipaments are changing affecting how we apply inputs (ex.: fertilizers). Should not be the opposite?
Education – 4R NUTRIENT STEWARSHIP PROGRAM

Cropping system

APPLICATION OF THE RIGHT NUTRIENT SOURCE AT THE RIGHT RATE, TIME, AND PLACE
Precision Ag by Region

- **Southern region – Paraná and Rio Grande do Sul**
  - Small to medium farms, family operated, no-tillage and crop rotation
  - Skilled farm machinery operators
  - Cooperatives selling “applied fertilizer” – grid sampling + VRT broadcast

- **Sugarcane region – São Paulo**
  - Mills sold for worldwide companies (shell, raizen)
  - Large mills usually growing many small fields
  - Precision ag tools as ancillary tool for managing assets, not much on variability management

- **Central/Southern region – Mato Grosso do Sul, Goiás, Minas Gerais**
  - Medium to large farms, family management and hired labor
  - Grains, Pastures and integration: grains in rotation with pasture
  - Specialized companies selling grid sampling and prescription maps for fertilizer application

- **Central/Northern region – Mato Grosso, Bahia, Maranhão**
  - Medium to huge farms, family and investors (large groups with thousands ha)
  - Less skilled operators
  - Soybeans and second season corn
  - Specialized companies selling grid sampling and prescription maps for fertilizer application
  - Investors developing their own team for grid sampling aiming variable rate fertilizer application
Available Tools for PA

Machinery guidance

- Guidance is used by the majority of sprayers
- Broad range of technological solutions from U$5.000 to U$50.000

- **Light bars with autonomous GPS** – small farms (50ha and larger), for spraying and broadcast fertilizer application

- **Electric steering with correction through algorithm** – medium farms (200 ha and larger) for spraying and planting

- **Hydraulic steering with satellite DGPS** – medium to large farms (300 ha and larger) for planting, spraying and broadcast fertilizer application

- **Autopilot with satellite DGPS and RTK** – large farms (1000 ha and larger) for planting, harvesting, sugarcane is a big client

- **GPS signal correction** through local towers and radio are becoming common in region with intensive agriculture
Available Tools for PA

- **Rate controllers**
  - For uniform application – sprayers
  - Variable rate
  - Broadcast fertilizer and lime
  - Fertilizer and seeds for planters

- **Yield monitors**
  - Available for medium to large combines from the industry dealer
  - Available for almost any machinery from accessories dealers
  - Few farmers are using yield maps, less than 5% for grains

- **Key machinery companies**: Stara, John Deere, Jacto, CASE, AGCO

- **Key accessories companies**: Trimble, Arvus, Verion,
Available Tools for PA

- Worldwide companies are implementing electronics right after their release outside Brazil
- Local implement companies have partnership with local providers for replacing gearboxes by electro hydraulic mechanism
- Equipment is available, the cost is still high but the main restriction for its adoption is the lack of specialized labor and maintenance
Available Tools for PA
Broadcast Fertilizer Application Quality

Sulfate  Urea  KCl

Sulfate  Urea  KCl

Urea  KCl

KCI


CENTER  5 m  10 m  15 m
Broadcast Fertilizer Application Quality

Creating more variability…
Available Tools for PA

Responsive machinery industry but not always technical sounding...

2 tanks/rate controllers
1 spreading mechanism

 Powders (Lime + Gypsum) → ☑
 Ganulated fertilizers → ☹
Available Tools for PA

Pneumatic option for fertilizers and seeds

13 m boom for sugar cane
32 m boom under development for cereals
Sprayers with nozzle/nozzle control
Coffee harvester with yield monitor
Available Tools for PA

Machinery industry

Complete line of implements with VRT capability: planters, sprayers, fertilizer applicators, guidance, yield monitor, electrical conductivity
Available Tools for PA

Machinery industry

Electrical and hydraulic components that allow VRT in a large range of existing machinery, telemetry, guidance, yield monitor
Available Tools for PA

Soil Sampling

Soil sampling, penetrometer, software, chlorophyll meter, soil moisture sensors

Soil sampling, mechanical or handheld versions
The determination of P in a soil sample, using methodology “A”, revealed an amount of 4 mg Kg (very low). The fertilizer recommendation to maize in this case would be 100 kg ha\(^{-1}\) of P\(_2\)O\(_5\). An experiment under this field site showed that the crop did not respond to P (12.5 t ha\(^{-1}\)). Make comments regarding the effectiveness of methodology “A”.
A good program under agriculture nutrient management should initially, and above all, have an efficient method to properly evaluate the soil availability of plant nutrients.

We should not make ourselves comfortable. New and better possibilities may exist.

Test the effectiveness of current methods under site field conditions.

How are the methods for soil analysis evaluating the availability of nutrients in your region?
Precision Ag by Crop

- **Soybean**
  - Variable rate fertilizer and lime based on grid soil sampling.
  - Sampling density varying from 1 to 5 ha

- **Sugarcane**
  - Autopilot for planting and harvesting – avoid damaging shoots
  - Variable rate fertilizer and lime based on grid soil sampling

- **Corn and Wheat**
  - Variable rate fertilizer and lime based on grid soil sampling
  - Starting on the usage of reflectance sensors for nitrogen sidedressing
Precision Agriculture through Service Providers perspective

Source: Brazilian Association of Precision Agriculture Service Providers, Mr. Pedro Magalhães

- Specialized companies/contractors are responsible for the majority of PA operationalization in Brazil
- Questionnaires answered by several companies
- Average of 8 years in the market, 12 Brazilian states
- 280.000 ha/year of sampled/assisted area
Areas mainly in soybeans (80%) and corn (20%) cultivation,
Major part of services are provided for farmers which already used the technology and keep using it,
PA through SP perspective

Quality of equipment

✓ Overall perception: broadcast fertilizer and amendments application is improving but still an issue

Quality of the job done by selected equipment: 1 = poor, 5 = excellent

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section controllers on sprayers</td>
<td>3.8</td>
</tr>
<tr>
<td>Variable rate planting</td>
<td>3.3</td>
</tr>
<tr>
<td>Variable rate broadcast spreading</td>
<td>3.6</td>
</tr>
<tr>
<td>Automatized steering</td>
<td>4.2</td>
</tr>
<tr>
<td>Guidance through Light bar</td>
<td>3.8</td>
</tr>
<tr>
<td>Automatized soil samplers</td>
<td>3.0</td>
</tr>
</tbody>
</table>
Main difficulties when providing soil sampling services are:

1. Human resources/Labor issues
2. Seasonality
3. Equipment can’t adjust to varying soil conditions

Sampling details:

- Point grid sampling, 8 sub-samples/point
- 1 sample for each 2.0 ha (range: 1 to 5 ha/sample)
- 0 to 0.2 m layer (0-8 inch) majority, 0.2 to 0.4 m in some fields
Quality of equipment

☑ In your influence region what is the participation of the following precision ag tools in the farms?

- Soil sampling: 35%
- VRT of fertilizers: 32%
- VRT of lime: 32%
- Yield mapping: 7%
- Soil electrical conductivity: 7%
- Plant vigour maps (NDVI): 3%
- VRT agrochemicals: 0%
In your experience, which are the main constraints for the proper use of precision agriculture?

1 = not restrictive, 5 = very restrictive

- Humam resources
- Operational issues
- Education/understanding of farmer/hirer
- Lack of compounded benefits
- Equipment/tools for VRT
Future...

What do you think will be good opportunities for service providers within the next 5 years?

- Plant vigor mapping, UAVs or active sensors
- Management unit/directed sampling
- Variable rate plant population
- Soil Electrical conductivity
Precision Agriculture Use in Selected Agricultural Regions in Brazil

By Bernardi & Inamasu

12th International Conference on Precision Agriculture
Sacramento/CA, 2014

- 301 questionnaires
- Sep to Nov, 2012
- Main agricultural regions in Brazil: 9 states
- Public: farmers, extension agents, consultants, employees of agricultural enterprises, teachers, and students
# PA Use in Selected Agricultural Regions

## Farmers and managers (%)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Age</th>
<th>Gender</th>
<th>Education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Elem/ middle</td>
<td>High school</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Under Graduate</td>
<td>Graduate</td>
</tr>
<tr>
<td>Conv</td>
<td>141</td>
<td>39</td>
<td>11</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42</td>
<td>11</td>
</tr>
<tr>
<td>PA</td>
<td>160</td>
<td>35</td>
<td>9</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>43</td>
<td>19</td>
</tr>
</tbody>
</table>

## Farms and agricultural systems (%)

<table>
<thead>
<tr>
<th></th>
<th>Area</th>
<th>Soil texture</th>
<th>Relief</th>
<th>Crop rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sandy</td>
<td>Loam</td>
<td>Clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conv</td>
<td>977</td>
<td>9</td>
<td>43</td>
<td>45</td>
</tr>
<tr>
<td>PA</td>
<td>2357</td>
<td>14</td>
<td>46</td>
<td>39</td>
</tr>
</tbody>
</table>

## Technology access (%)

<table>
<thead>
<tr>
<th></th>
<th>Computer for farm management</th>
<th>Laptop in the field</th>
<th>Internet access</th>
<th>Mobile</th>
<th>Smart phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conv</td>
<td>47</td>
<td>20</td>
<td>46</td>
<td>90</td>
<td>28</td>
</tr>
<tr>
<td>PA</td>
<td>74</td>
<td>37</td>
<td>67</td>
<td>90</td>
<td>46</td>
</tr>
</tbody>
</table>
Main crops (A), adoption time (B), equipment (C) and activities in which the PA is used (D) implementation of PA services (E) and information sources (F) in the farms that adopt PA.
Implemention of PA services

- Contractors: 36%
- Maps by contractors, PA activities done with own team and equipment: 15%
- Contractors with their own equipment: 12%
- Specialized team with own equipment: 37%

Information sources

- Consultants: 5%
- Trainning courses: 3%
- Fair and expositions: 6%
- Dealers: 11%
- Internet: 11%
- Publications: 14%
- Magazines: 19%
- Neighbor: 23%
- Extension agents: 8%
What the Brazilian researchers are looking for...

- Development of models for variable rate nitrogen through active sensors
  - Wheat, Corn, Cotton
- Soil sensors validation/testing
  - VIS/NIR, pH, OM, K
- Management units creation
  - Through sensing: remote + soil
  - Though sampling: soil chemical parameters
Some important additional comments

- Electronics for improving machinery efficiency already accepted and growing year after year: guidance, rate controllers, section controllers.

- Management of variability partially accomplished:
  - Mainly focused on variable rate application of fertilizers – with inadequate sampling and machinery, poor broadcast spreaders.

- In the last two years remote sensing satellite and UAVs data is provoking dealers and customers to establish relations and better analyze their management actions like VRT.

- Some movements on variable rate corn plant population.

- Some movements on reflectance sensors.

- Industry focused on telemetry – allow better management of machinery/fleet.
“Farmers are very generally not well considered by several minority and noisy sectors of society. They are criticized by many: the left, the greens, the indians, the midia, famous “progressive” actors and actresses, from radicals of global warming, Bono Vox, Sting .... In summary .... this is a country where those that produce wealth are targeted by the fury of those that basically produce speech”
“One thing is sure: The Earth is more cultivated and developed now than ever before. There is more farming, but fewer forests. Swamps are drying up and cities springing up on an unprecedented scale. We have become a burden to our planet. Resources are becoming scarce and soon Nature will no longer be able to satisfy our needs. It will come to pass that disease, hunger, flood and war will reduce the excessively large numbers of the human species”.

Quintus Septimus Tertullianus, 200 BC
(by D. G. Johnson, Univ. of Chicago, 22 August 1998)
A computer technician is called by a company to evaluate a problem in a valuable computer.

After carefully studying the situation he turns off the machine, opens a specific part and turns a screw one and a half times.

Turns the computer on, which starts to work perfectly.

The company owner congratulates the technician and asks for the price.

He becomes very angry in finding out that the price is US$ 10,000 .... Says he will not pay unless an invoice is sent specifying everything done.

The next day the invoice arrives at the office and the company owner decides to pay immediately.

The invoice simply specified:

- Tighten a screw ........................................ US$ 20
- Know which screw to tighten ..................... US$ 9,980
Thank you for your attention!

Website: http://brasil.ipni.net
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Website: www.esalq.usp.br
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