Conceptos y principios de la agricultura de precisión en el mundo: una aproximación a América Latina y el Caribe”.

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Mecanización agrícola
Embrapa Maíz y Sorgo

08 y 09 de setiembre del 2016
San José, Costa Rica
Topics

1. Introduction
2. Precision agriculture concepts
3. Evolution of precision agriculture in the world
4. Differences precision agriculture crops x livestock
5. Major constraints for adoption and success factors
6. Advances in Precision Agriculture
7. Tendencies in agribusiness
8. Final comments
1. Introduction
World Urbanization Trends - 2014

Less developed regions
Africa, Asia (excluding Japan), Latin America and the Caribbean, Melanesia, Micronesia and Polynesia.

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<tbody>
<tr>
<td>Urban population</td>
<td>5000</td>
<td>4000</td>
<td>3000</td>
<td>2000</td>
<td>1000</td>
<td>0</td>
</tr>
<tr>
<td>Rural population</td>
<td>3000</td>
<td>4000</td>
<td>5000</td>
<td>6000</td>
<td>7000</td>
<td>8000</td>
</tr>
</tbody>
</table>

Source: UN World urbanization prospects: The 2014 revision highlights

More developed regions
Europe, Northern America, Australia, New Zealand and Japan.

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</thead>
<tbody>
<tr>
<td>Urban population</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>3000</td>
</tr>
<tr>
<td>Rural population</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>3000</td>
<td>3500</td>
<td>4000</td>
</tr>
</tbody>
</table>
"Recent studies indicates that the world will need 70-100% more food by 2050 to feed 9 billion people!"
Population increase x Food demand

Increased income - classes C and D in developing countries

Demand for food, energy and water

AGRICULTURAL PRODUCTION $\times 2$

Maize, rice & wheat

Productivity Increase

Agricultural Expansion
World regions able to expand production

Available area

Global Context

Source: FAO
Introduction: Opportunities for Precision Agriculture

11 alternatives agricultural technologies to improve crop productivity, suggested by IFPRI* (2014).

1. No tillage
2. Integrated management of soil fertility or ISFM
3. Precision Agriculture (supply of agricultural inputs assisted by GPS, and simple technology management practices aimed at controlling all parameters of the field, from the supply of inputs to the spacing of plants and at water level)
4. Organic Agriculture
5. Water Collection
6. Drip irrigation
7. Sprinkler irrigation
8. Heat tolerance (improved varieties)
9. Drought tolerance (improved varieties)
10. Efficiency of nitrogen use
11. Crop protection

Food security in a world of growing natural resource scarcity.
The role Agriculture Technologies
Mark Rosegrant et al.
DETERMINANTS FORCES
PRECISION TECHNOLOGIES

WATER

FOOD

ENERGY

9 BILLION PEOPLE
2050
Introduction: new cycle of technology

Precision Agriculture development:

- Decade of 70/80
- Decade of 80/90
- End 80’s & beginning of 90’s
### Contributions (examples):

<table>
<thead>
<tr>
<th>University</th>
<th>Contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purdue University</td>
<td>• Precision Farming Profitability</td>
</tr>
<tr>
<td></td>
<td>• Jess Lowenberg – DeBoer - 2000</td>
</tr>
<tr>
<td>USDA/ARS &amp; UNIV. of Nebraska</td>
<td>• Agriculture Program of PA to solve problems of soil contamination of N – development of N sensor</td>
</tr>
<tr>
<td></td>
<td>• James Scheppers and – 1990-1996</td>
</tr>
<tr>
<td>University of Illinois</td>
<td>• Automation, Smart Systems e Artificial or Machine Vision</td>
</tr>
<tr>
<td></td>
<td>• Lei Tian - 2000</td>
</tr>
<tr>
<td>University of Minnesota</td>
<td>• In 1985, researchers at the University of Minnesota varied lime inputs in crop fields and the practice of grid sampling appeared</td>
</tr>
<tr>
<td></td>
<td>• The Precision Agriculture Center: Midwest water quality, Site Specific Mngt, etcPierre Roberts - 1995</td>
</tr>
<tr>
<td>And many others Universities in USA</td>
<td>• Modeling, soil sample instrumentation, sensors for process automation, etc</td>
</tr>
<tr>
<td></td>
<td>• Gainsville, Iowa, Auburn, etc</td>
</tr>
</tbody>
</table>
Meanwhile, in Latin America !!!

On receiving theses technologies:

We started

Against

To run against many obstacles

Time!!!!
Latin America: Technology Transfer!

Decade of 70/80/90

Development

Aplication

Latin America

Decade of 90/00

Europe USA

Decade of 70/80/90

Combines in the field
Precision Agriculture: "Farmer's expression!"

AGRICULTURE X SATELITE

"Confuse Situation"
2. **What is precision agriculture and what are its principles**

The concept of precision agriculture first emerged in the United States in the early 1980s.

- In 1985, researchers at the University of Minnesota varied lime inputs in crop fields. It was also at this time that the practice of grid sampling appeared (applying a fixed grid of one sample per hectare).

- Towards the end of the 1980s, this technique was used to derive the first input recommendation maps for fertilizers and pH corrections (Wikipedia, 2016).
The characteristics of the soil and crops vary in space (distance and depth) and also in time.

- The Precision Agriculture is a set of techniques designed to optimize the use of farm inputs (seeds, agrochemicals and lime) to quantifying the spatial and temporal variability of agricultural production.

- This optimization is achieved with a distribution process of the right amount of these inputs, according to the potential and the need for each point of management areas. (Mantovani et al; 2006)
What are its principles?

Traditional Agriculture → Average

Precision Agriculture → Variability
  • Espacial
  • Temporal
What is variability?

1. **Spatial Variability**: production differences in the same field.

2. **Temporal Variability**: production changes in the same field through the years.
1. Spatial Variability: production differences in the same field.
1. Spatial Variability: production differences in the same field.
2. Temporal Variability: production changes in the same field through the years.

Temporal Variability

Corn crop - Embrapa Mayse & Sorghum-2003
The application of the concept is only possible due to the evolution of these four technologies:

1. **Global Position System (GPS)**

2. **Geographic Information System (SIG)**

3. **Remote Sense**

4. **Onboard electronics (sensors, controllers, etc.)**
Precision Agriculture Phases

Source: AGCO 2005
Example 1:

Tea harvesting by hand in Tanzania

Figure 2. Tea harvesting by hand and estate yield maps
Exemplo 2

Japanese paddy field in Japan

Figure 3. Japanese paddy field and yield map from Kyoto University
Precision farming is the process of managing variability, which in turn, improves the overall efficiency of the agronomic process. (Blackmore, 2003)

- This improved efficiency will be beneficial to the farm both economically and environmentally.

- Many new information technologies are becoming available to assist in this process but without the adoption of coherent strategies and practices, the full benefit cannot be realized.

- The classified management map can be a very useful tool to help identify and manage spatial and temporal variability.

- A systems approach is needed to develop the methodology for adopting and using these new technologies in a recognized Best Management Practice for precision farming.
3. Evolution of precision agriculture in the world

Production Management

Environment

Chemical application

Increased Efficiency in the Use of Machinery and Implements

Optimization of Inputs Use

3. Evolution of precision agriculture in the world

Agriculture Fleet Management

3. Evolution of precision agriculture in the world

Autopilot or Light Bar

“Guides the machine in the path previously planned, with lights indicator (LEDs) and display map showing the shift to the left or right. The operator fits the correct direction.”
3. **Evolution of precision agriculture in the world**

Soil analyzes with faster and low cost methods

<table>
<thead>
<tr>
<th>Soil Fertility</th>
<th>Soil Texture</th>
<th>Soil Compaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="soil_fertility.jpg" alt="Image" /></td>
<td><img src="soil_texture.jpg" alt="Image" /></td>
<td><img src="soil_compaction.jpg" alt="Image" /></td>
</tr>
</tbody>
</table>
3. Evolution of precision agriculture in the world

Innovation and technology: management of production systems

- Image Processing
- Monitoring of pests, diseases and disabilities
- Environmental monitoring
- Production and yield estimates

High management technology: Precision Agriculture
3. **Evolution of precision agriculture in the world**

**Drones for mapping**

Drones presented by Embrapa: management of planting of different crops.


**Diagnostic of planting failures with drones: technology in support of agricultural production**

Mosaic Orthophoto Georeferenced generated by SX8

Variable-rate technology (VRT) for fertilizer, seed and irrigation was another popular topic at this year’s InfoAg conference.

- Variable-rate applications for nitrogen (N), potassium (K), gypsum and lime since 1997.
- One of the keys to their success has been well-defined management zones based on 17 years of consistent soil sampling, harvest data and other agronomic research.
- They make their applications using auto-guidance, boom height and swath control.
- They also supplement the map-based prescriptions with on-the-go, in-season NDVI measurements for fine-tuning N recommendations using a GreenSeeker crop sensor.
- In 2014, using precision ag technology to manage N application in cotton saved Baucom Farms $12.50 per acre, which is well on the way to realizing the internal objective of a $20 per acre total return on technology investment for the operation.
4. Differences between the development of precision agriculture crops x livestock activities?

- Early development of precision agriculture: greater emphasis to meet cultures requirements;
- Automation: the two areas of agriculture and Livestock were developing in a similar way;
- Now reached a point where it is not only possible to collect vast quantities of data, but also to use quite inexpensive, small processors to make use of this information to control different pieces of equipment or monitor individual animals.

Source: CEMA aisbl - European Agricultural Machinery
http://www.cema-agri.org/newsletterarticle/big-data-farm
The data is unstructured information

The structuring process adds value to the data and transforms them into information.

Knowledge is seen as an accumulation of various information, inserted in a context that defines their applicability.

So, knowledge is a cognitive process that needs the information as raw material to unleash it.

Knowledge Transfer

The great challenge today!
“We are gathering a lot of information that we are not able to move over to knowledge yet...it is a little frustrating...what are we doing about mining this big data to extract knowledge out of it?”

“...the industry spends a lot of time and effort doing more stuff and collecting more information, but can’t answer some basic questions farmers have...we can get the answers, but it’s still really complicated to do it”

“Farmers want to know what time it is, not how to build a clock...”

John Reifstock, CroplLife Precision, Summer 2013
5. Major constraints for adoption

PRECISION AGRICULTURE PHASES
Site specific management: “still a great challenge!”

Unknown problem - investigated later - found pH problem and corrected

Unknown problem - found compaction

Poor quality soil (stony)

Yield increase in the following year from applying lime

Soil erosion

Cattle broke through fence and damaged crop

Source: Mark Moore - Fieldstar – An integrated approach to reducing farm operating costs and increasing profitability
5. Major success factors

Production area history
- Temporal Maps: M1+M2+M3+M4

Local knowledge: maps
Weeds map  Old fields  Wet areas  Field trials

Stable resources field
Soil type  Soil depth  Topography

Seasonal conditions
Weather  Crop  Soil type/variety  Nutrients  Bugs & Disease

Farm Decisions
Qual é o cenário?  Personal Strategy  Local knowledge

Management Zones Identification

Management Zones establishment

Modifications of MZ with Seasonal Conditions

Recommendations & Analysis

Decision Implementations

Economical management of Production System

Yield Maps

Evaluation decisions
# Corn Production costs, in state of Goiás-Brazil (Data FAEG-2015)

## Corn - Conventional Seed

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>R$ 56,25</td>
<td>1,8%</td>
</tr>
<tr>
<td>Machine operation</td>
<td>R$ 640,63</td>
<td>20,2%</td>
</tr>
<tr>
<td>Fertilizer &amp; Lime</td>
<td>R$ 1,312,75</td>
<td>41,4%</td>
</tr>
<tr>
<td>Agrochemicals</td>
<td>R$ 294,32</td>
<td>9,3%</td>
</tr>
<tr>
<td>Seeds</td>
<td>R$ 350,00</td>
<td>11,0%</td>
</tr>
<tr>
<td>Others</td>
<td>R$ 514,30</td>
<td>16,2%</td>
</tr>
<tr>
<td><strong>Effective Operational Costs</strong></td>
<td><strong>R$ 3,168,25</strong></td>
<td><strong>100,0%</strong></td>
</tr>
</tbody>
</table>

### Yields (bags)
- Total: 160

### Cost/ bag
- R$ 19,80

## Corn - Transgenic Seed

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>R$ 61,62</td>
<td>1,8%</td>
</tr>
<tr>
<td>Machine operation</td>
<td>R$ 653,38</td>
<td>19,1%</td>
</tr>
<tr>
<td>Fertilizers &amp; Lime</td>
<td>R$ 1,312,75</td>
<td>38,3%</td>
</tr>
<tr>
<td>Agrochemicals</td>
<td>R$ 282,32</td>
<td>8,2%</td>
</tr>
<tr>
<td>Seeds</td>
<td>R$ 560,00</td>
<td>16,3%</td>
</tr>
<tr>
<td>Others</td>
<td>R$ 557,14</td>
<td>16,3%</td>
</tr>
<tr>
<td><strong>Effective Operational Costs</strong></td>
<td><strong>R$ 3,427,21</strong></td>
<td><strong>100,0%</strong></td>
</tr>
</tbody>
</table>

### Yield (bags)
- Total: 175

### Cost/bag
- R$ 19,58

![Pie charts comparing the cost distribution between Conventional and Transgenic seeds.](image-url)
## Corn Production costs, in state of Paraná (Dados SEAB-2015)

<table>
<thead>
<tr>
<th>Conventional maize seed</th>
<th>Value</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>R$ 270,76</td>
<td>13,4%</td>
</tr>
<tr>
<td>Machinery operations</td>
<td>R$ 498,42</td>
<td>24,7%</td>
</tr>
<tr>
<td>Fertilizer &amp; lime</td>
<td>R$ 500,50</td>
<td>24,8%</td>
</tr>
<tr>
<td>Agrochemicals</td>
<td>R$ 53,72</td>
<td>2,7%</td>
</tr>
<tr>
<td>Seeds</td>
<td>R$ 294,48</td>
<td>14,6%</td>
</tr>
<tr>
<td>Others</td>
<td>R$ 401,99</td>
<td>19,9%</td>
</tr>
<tr>
<td><strong>Effective Operational Costs</strong></td>
<td><strong>R$ 2.019,87</strong></td>
<td><strong>100,0%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maize No till planting</th>
<th>Valor</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>R$ 236,05</td>
<td>10,5%</td>
</tr>
<tr>
<td>Machinery operations</td>
<td>R$ 382,38</td>
<td>17,0%</td>
</tr>
<tr>
<td>Fertilizer &amp; lime</td>
<td>R$ 644,10</td>
<td>28,7%</td>
</tr>
<tr>
<td>Agrochemicals</td>
<td>R$ 99,17</td>
<td>4,4%</td>
</tr>
<tr>
<td>Seeds</td>
<td>R$ 417,96</td>
<td>18,6%</td>
</tr>
<tr>
<td>Others</td>
<td>R$ 465,75</td>
<td>20,7%</td>
</tr>
<tr>
<td><strong>Effective Operational Costs</strong></td>
<td><strong>R$ 2.245,41</strong></td>
<td><strong>100,0%</strong></td>
</tr>
</tbody>
</table>

- **Productivity (bags 60 kg)**: 100
- **Costs/bag**: R$ 20,20

- **Productivity (bags 60 kg)**: 120
- **Costs/bag**: R$ 18,71

![Pie charts showing cost breakdown for conventional and no till maize planting methods.](chart.png)

**Key Percentages**
- **Conventional Maize**: 64.1%
- **No Till Maize**: 65.3%
5. Major success factors

<table>
<thead>
<tr>
<th>Country</th>
<th>Key Success Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>- Corn and soybean crops: Yield maps&lt;br&gt;- Variable rate application: fertilizer&lt;br&gt;- Economic management crop system</td>
</tr>
<tr>
<td>Brazil</td>
<td>- Corn and soybean crops: Yield maps&lt;br&gt;- Economic management crop system&lt;br&gt;- Variable rate application: fertilizer and lime</td>
</tr>
<tr>
<td>Chile</td>
<td>- Grape and wine quality&lt;br&gt;- Fruit Quality&lt;br&gt;- Variable rate application</td>
</tr>
<tr>
<td>Paraguay</td>
<td>- Corn and soybean crops: Yield maps&lt;br&gt;- Variable rate application: fertilizer and lime</td>
</tr>
<tr>
<td>Uruguay</td>
<td>- Rice crop: Yield maps</td>
</tr>
</tbody>
</table>
"Hype Cycle", a time chart!

1. Trigger of Technology
2. Irrational consumption
3. Frustation
4. Maturity & profit

Source: Marc Vanach, InfoAg 2001
Innovations in release: every day a new technology

Georeferenced mapping pH, OM and EC

... and new sensors are being released for mapping K and P in soil!
What's new in release: every day a new technology of the Precision Farming!

New Chemical Applicator high efficiency self-propelled

**High application capability:** 230 g/min, tank of 1200g

**Speed Application:** 40 km/h

**Width:** 33 – 40 m
Precision planting: high demand to improve plantability of corn production areas.

Seedling speed: 16 km/h

What's new in release: every day a new technology of the Precision Farming!
5. Agribusiness Tendency

**Precision Seeder: Great demand to improve plantability.**

Current situation: Improvement of the genetic material of cultivars x population increase spacing x reduction

Simple hybrid, mostly!

![Graph showing the relationship between plant density and yield](image)

**Equations:**

- For 50 cm row space: $y = 0.0423x + 3487.7$, $R^2 = 0.992$
- For 80 cm row space: $y = 0.0605x + 2271.3$, $R^2 = 0.9922$

Source: Cruz et al., 2008)
Improving genetic material of cultivar

High density planting: 80,000 plants/ha

Good plant distribution

Planting depth

Planting speed
2015 Precision Agriculture Dealer Survey: Top Five Trends To Watch 2015 to 2018!

By: David Widmar, Dr. Bruce Erickson | June 1, 2015
Editor’s note: The 17th Precision Agriculture Survey

1. UAVs
2. Yield Monitor Analysis
3. Field mapping (with GIS)
4. VRT Seeding prescriptions
5. Satellite/aerial

6. Advances in Precision Agriculture

The 4th Industrial Revolution - "Industry 4.0"

Drivers
- Quality of life
- Engineering Sciences

Mobility

μElectronics

ICT

4th

1st

2nd

3rd

40 yrs

Computer, NC, PLC

Cyber Physical Systems

2015

Smart Automation

???

1954

Electronic Automation

1913

Industrialization

1782

Power generation

Mechanical automation

GB

US

US/EU

GB

US

EU

steam engine

conveyor belt

200 yrs

60 yrs

40 yrs
Big Data Comes to the Farm, Sowing Mistrust

Monsanto Co., DuPont Co. & others companies: they are rushing to launch technologies "under planting recipe" for farmers in the United States.

Big agricultural companies say the next revolution on the farm will come from feeding data gathered by tractors and other machinery into computers that tell farmers how to increase their output of crops like corn and soybeans.

At the same time:

Some farmers are preparing to collect themselves their data so they can decide what information to sell and at what price.

Other producers are joining small technology companies to try to prevent the agribusiness giants dominate the plantation segment data-driven.
7. Tendencies in agribusiness

Automatic Guidance Was The Tipping Point

Yield Mapping
1-2 meters

Parallel Tracking
< 1 meter

AutoTrac
Decimeter

AutoTrac RTK + iTec Pro
< 2.5 cm and full automation of turning

1998

2009

Source: Dr. John Reid, John Deere, CIGR 2012
8. Tendencies in agribusiness

Autonomous Worksite Solutions

Customer Value:
- Productivity of the worksite
- Efficient and convenient operations
- Increased profitability at the systems level

Source: Dr. John Reid, John Deere
Agricultural Automation: an actual fact!
7. Tendencies in agribusiness

NEW TECHNOLOGIES
8. Final Comments
8. Final Comments

Smart farming

Big data on the farm

*Driverless tractors, cows milked by robots – this is how agriculture works today*

‘Farming 4.0’ at the farm gates

8. Final Comments
8. Final Comments

Considering the large number of small farms in Latin America and Caribe, a common use of GPS in the communities for mapping the plots of production it can be a cheaper alternative to help farmers in decision-making.

Although there are limitations to the use of precision farming tools in the small farms, you can get the same success of medium and large farms, using the concept and making site-specific management.

So, much can be done with precision agriculture, achieving success at any scale of production.

The major success factor for use of precision agriculture, on any production scale, will be the technical ability to transform data collected in the areas into production information and convert them into knowledge for decision-making on the farm.
Muchas Gracias

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