Precision in conservation agriculture: first results of an experimental study

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Introduction

- High working capacity
- More efficiency use of soil
- High efficiency of the input
- Economic benefit
- Environmental benefit

- Soil tillage modulation
- Conservation tillage optimization
- Managing and modeling tool support of crop production
- Soil compaction mitigation

- Increase in soil features
- Decrease soil erosion
- Decrease CO2 emission
- Soil as carbon sink
LIFE13 ENV IT 0583 AGRICARE
Introducing innovative precision farming techniques in Agriculture to decrease Carbon Emissions

- Decrease GHG emission
- Enhance soil features and crop yield
- Assess the economic feasibility
- Define the best approach reaching highest net energy value
Experimental plan

LIFE13 ENV IT 0583 AGRICARE

3 years duration

2014 - 2017

4 crops

2 input managing system

4 soil tillage techniques
Demonstrative and pilot farm Vallevecchia

**Study area:** 23.6 ha divided in 16 plots

**Crop rotation:** wheat, rapeseed, corn, soybean

**Soil tillage:**
- Conventional tillage (CT)
- Minimum tillage (MT)
- Strip-tillage with inter-row 55 cm (ST)
- No tillage (NT)
Soil tillage techniques compared

**CT**

**MT**

**ST**

**NT**
<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite guidance system with RTK differential correction</td>
<td>Analysis of soil variability (historical yield maps, georeferentiated soil analysis)</td>
<td>Study of soil variability and homogeneous zone characterization</td>
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<td>Variable rate nitrogen fertilizer application</td>
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<tr>
<th>Precision Farming technologies</th>
<th>CT</th>
<th>Conservation Agriculture</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
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</table>
Analysis instruments: Historical data

Satellite images

UAV (unmanned aerial vehicle) images

Basic information about the field
Analysis instruments: Historical data

Moisture and yield sensor

YIELD QUANTIFICATION

GPS system

INFIELD POSITIONING

On board computer

DATA RECORDING

Yield map
Analysis instruments: Soil data

Automatic Resistivity Profiling  *(ARP – Geocarta, France)*

- Electrical data derives from a succession of electrodes represented by 4 toothed metal wheels (electrodes are inserted into the soil through the movement of rotation).

- 1° axle enters a stabilized current to the subsoil

- 2°, 3°, 4° axle measure the potential that derive from the injected current at 0-0.5, 0-1, 0-2 m.

- Data (expressed in Ohm·m) were real-time referenced by differential global positioning system (DGPS).
Analysis instruments: Soil data

- Sampling points definition
- Soil samples collected at different depth level

Contributes to define soil spatial variability through:
- Physical features
  a) Texture
  b) Soil organic matter
  c) N,P,K availability
- Chemical features
  a) Electrical conductivity
  b) pH
  c) Cation exchange capacity (CEC)
Phase 1: Historical yield maps

Yield maps elaboration
1. Row maps
2. 2011 corn map
3. 2012 soybean map
Phase 1: ARP analysis and soil sampling analysis

● Sampling point

**Soil’s data collection**
- Soil resistivity measurement carried out considering parallel transects at 5 m apart
- 20 sampling points obtained by ARP data (3 depth level: 0-10cm; 10-30cm; 30-60cm)
- Optimization of number of soil samples
- Statistical analysis to define homogeneous classes

<table>
<thead>
<tr>
<th></th>
<th>ZONE A</th>
<th>ZONE B</th>
<th>ZONE C</th>
<th>ZONE D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric conductivity (dS/m)</td>
<td>1,82</td>
<td>aA</td>
<td>2,01</td>
<td>aAB</td>
</tr>
<tr>
<td>SAR (Sodium Adsorption Ratio)</td>
<td>0,46</td>
<td>ns</td>
<td>0,5</td>
<td>ns</td>
</tr>
<tr>
<td>pH</td>
<td>7,25</td>
<td>aA</td>
<td>7,53</td>
<td>bB</td>
</tr>
<tr>
<td>Active lime (%)</td>
<td>4,07</td>
<td>aA</td>
<td>3,83</td>
<td>aB</td>
</tr>
<tr>
<td>Total Nitrogen (%)</td>
<td>0,06</td>
<td>aA</td>
<td>0,06</td>
<td>bA</td>
</tr>
<tr>
<td>Soil Organic Matter (%)</td>
<td>1,22</td>
<td>aA</td>
<td>1,23</td>
<td>aA</td>
</tr>
<tr>
<td>Assimilable phosphorus (mg/kg)</td>
<td>32,83</td>
<td>ns</td>
<td>30</td>
<td>ns</td>
</tr>
<tr>
<td>Exchangeable potassium (mg/kg)</td>
<td>115,83</td>
<td>aA</td>
<td>121,67</td>
<td>aA</td>
</tr>
<tr>
<td>Clay (% t.f.)</td>
<td>15,17</td>
<td>aA</td>
<td>16,33</td>
<td>aA</td>
</tr>
<tr>
<td>Silt (% t.f.)</td>
<td>25,33</td>
<td>aA</td>
<td>24,67</td>
<td>aA</td>
</tr>
<tr>
<td>Sand (% t.f.)</td>
<td>59,5</td>
<td>aA</td>
<td>59</td>
<td>aA</td>
</tr>
</tbody>
</table>
Phase 2: Study of soil variability

Data interpolation:
1. Management zone analyst (MZA)
2. Homogeneous zones characterization
3. Final experimental plan
Phase 3: Soil managing strategy and VRT

Identify the best way to manage soil variability using a predictive model

SALUS (System Approach to Land Use Sustainability) is a program designed to simulate the production response of herbaceous and woody crops under different agronomic management strategies.
Phase 3: Soil managing strategy and VRT

Zone C: 8,5 plants/m²

Expected yield (t/ha) vs. kgN/ha (CT, MT, NT, ST)

Zone D: 9,5 plants/m²

Expected yield (t/ha) vs. kgN/ha (CT, MT, NT, ST)

N-leaching (kg/ha) vs. kgN/ha (CT, MT, NT, ST)

Zone C: 8,5 plants/m²

Zone D: 9,5 plants/m²
Phase 3: Soil managing strategy and VRT

- Rapeseed and wheat: seed rate influenced by soil tillage technique but not by soil variability; N application changes between homogeneous zones.
- Corn: different seed and N rate due to spatial variability and soil tillage techniques requirements.
- Soybean: Variable rate seed application; N fertilization not required by the crop.
Phase 3: Soil managing strategy and VRT

Prescription maps

Maps transfer and work performing

Application maps implementing data collection

Deviations < 10%
The economic balance assessment

Machines costs assessed using ASABE standard

- **Machines**
  - Power (kW)
  - Purchase price (€)
  - Economic duration (years)
  - Interest rate (r)
  - Year usage (h/year)
  - Fixed costs (€/year)
  - Quota restoration and maintenance (€/h)
  - Diesel cost (€/l)
  - Workers payment (€/h)

- **Input**
  - Price schedule of 2015 crop season (€/u.m.)

These items are connected to the economic value of the agricultural product.
The energetic balance calculation

The applied inputs, the agricultural operations carried out during the crop cycle and the crops production (excluded the energy of environmental origin) have been divided into different classes:

- Engine/operator machines
- Seeds (main cultivation + cover-crops)
- Fertilizers
- Pesticides
- Exsiccation
- Crop yield

The amount of each class have been converted in “energetic value” using average coefficients found in literature (more reliability of the valuation).
Preliminary results: Crops yield

- **Rapeseed**
- **Wheat**
- **Corn**
- **Soybean**
Preliminary results: Gross revenue and total costs

<table>
<thead>
<tr>
<th>Thesis</th>
<th>Gross revenue (€/ha)</th>
<th>RAPESEED</th>
<th>WHEAT</th>
<th>CORN</th>
<th>SOYBEAN</th>
<th>TOTAL COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>1590.3</td>
<td>752.7</td>
<td>868.0</td>
<td>500</td>
<td>1041.6</td>
<td>2034.7</td>
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<tr>
<td>MT</td>
<td>1361.9</td>
<td>956.7</td>
<td>1041.6</td>
<td>500</td>
<td>800.0</td>
<td>2006.1</td>
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<tr>
<td>MTv</td>
<td>1889.8</td>
<td>953.4</td>
<td>953.4</td>
<td>500</td>
<td>936.2</td>
<td>2083.6</td>
</tr>
<tr>
<td>ST</td>
<td>440.4</td>
<td>337.1</td>
<td>1451.2</td>
<td>500</td>
<td>914.2</td>
<td>1529.7</td>
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<tr>
<td>STv</td>
<td>1556.7</td>
<td>1556.7</td>
<td>1556.7</td>
<td>500</td>
<td>1907.1</td>
<td>1556.7</td>
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<tr>
<td>NT</td>
<td>1588.5</td>
<td>747.2</td>
<td>747.2</td>
<td>500</td>
<td>1483.8</td>
<td>1588.5</td>
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<tr>
<td>NTv</td>
<td>1555.4</td>
<td>1274.2</td>
<td>1274.2</td>
<td>500</td>
<td>1963.2</td>
<td>1555.4</td>
</tr>
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Thesis: CT, MT, MTv, ST, STv, NT, NTv

Legend:
- RAPESEED
- WHEAT
- CORN
- SOYBEAN
- TOTAL COSTS
Preliminary results: Economic balance

- MT supported by PF obtains gross income higher of 80% than CT
- PF allows ST to get approximately 75% higher gross income than ST Without PF
- NT implemented with PF technologies mitigates low crops yield characterizing this soil tillage techniques
Preliminary results: Total energetic input and output

<table>
<thead>
<tr>
<th>Thesis</th>
<th>Gross energy (MJ/ha)</th>
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</thead>
<tbody>
<tr>
<td>CT</td>
<td>171,899</td>
</tr>
<tr>
<td>MT</td>
<td>169,483</td>
</tr>
<tr>
<td>MTv</td>
<td>176,024</td>
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<tr>
<td>ST</td>
<td>79,281</td>
</tr>
<tr>
<td>STv</td>
<td>80,684</td>
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<tr>
<td>NT</td>
<td>82,327</td>
</tr>
<tr>
<td>NTv</td>
<td>165,860</td>
</tr>
</tbody>
</table>

- RAPESEED
- WHEAT
- CORN
- SOYBEAN
- TOTAL INPUT
Preliminary results: Net energy

- MT and NT supported by PF reach net energy values Higher than CT respectively of 6% and 3%
- PF increases net energy of about 15% in ST compared with the same URA technique
Preliminary results: Energetic maps

- **Rapeseed**
- **Wheat**
- **Corn**
- **Soybean**
Conclusions

- Precision Farming increases crops yield in all Conservation tillage techniques enhancing the input use efficiency.

- Minimum tillage and No tillage supported by Precision Farming got higher gross income and net energy than Conventional tillage.

- First year adoption of Strip tillage shown technical complications, but it was observed ample room for improvement.

- At the end of second year of experimentation a CO$_2$ balance will be performed also considering the mid-long term carbon fixed in the soil.
Thanks for the attention