Coltivare con il biogas per ridurre l'impronta di carbonio ed aumentare sostenibilità e resilienza ai cambiamenti climatici.

CONVEGNO DI APERTURA
Venerdì 5 luglio 2019
Centro “E. Avanzi” - Aula “A. Benvenuti”
San Piero a Grado, Pisa

Tecniche e tecnologie per l’Agricoltura di Precisione a servizio della Agricoltura Conservativa

Marco Vieri, Daniele Sarri
The new paradigm: from drawbar an manual labour to motorization and digitalization - connectivity

Technological evolution will be profitable with a balanced inclusive and deep rooted social evolution ... from 90% to 5% of agricultural employers. ... motorization was effective with the rinsing of services and infrastructures
At the end of 1700 were born agricultural schools, new machines were invented and new best rational practices were disseminated in rural areas.
AFTER WORLD WAR II – WITH A DEEP INTRODUCTION OF INDUSTRY IN AGRICULTURE

GREEN REVOLUTION of the ‘50
It produces in 50 years a simplification of agronomic management with the use of:

1. Chemistry
2. Mechanics
3. Irrigation
4. Genetics
From hoe to satellite: two centuries of young age of humans in their mother earth

- 800 times more productivity on ploughing
- 400 times more productivity on growing and harverting

EQUAL DIGNITY AND IMPORTANCE OF TECHNOLOGIES
WHY GOOD PRACTICES & PA

THE RURAL ENVIRONMENT HIGHLIGHTS THE DELICATE BALANCE OF THE COMPLEX STRUCTURE AND BIOCENOSIS IN WHICH MAN IMPLEMENTS PRODUCTIVE ACTIVITIES
in the 90s the damages due to the loss of fertility of the soil, to their physical and biological erosion appear evident
1990
the “Brainpower” model
Precision Agriculture

.. PA is not technology
it is an innovative paradigm of punctual
management of spatial variability
Technology makes it possible to apply it
on large quantities (*surfaces, individuals, frequencies, number of parameters, ..*)

Actions:
- Determines Punctual Variability
- Evaluate the Causes
- Indicates the improvement actions
- It evaluates the economic and environmental effects
- Implement specific operations
- It tracks the flow

What innovations
- Digitalization
- Connectivity
- Automation
- Traceability...

AGRICOLTURE 3.0
The scientific technical reference framework - the STOA document with a milestone in the state of the art on Precision Agriculture

Precision Agriculture and the Future of Farming in Europe

September 2016

http://www.ep.europa.eu/stoa/
environmental and economic effects

Up to 15 % less time, fuel consumption, GHGs emissions with AUTOMATIC GUIDANCE
Up to 70 % saving in crop protection chemicals use with DSS and Automation in VRT
15 times reduction in soil losses and nutrients waste

<table>
<thead>
<tr>
<th>No.</th>
<th>Process</th>
<th>Technique</th>
<th>Expected environmental gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Avoid overlap of pesticide or fertilizer application</td>
<td>- Section control of sprayers and fertilizer distribution</td>
<td>Reduce/avoid excessive chemical input in soil and risk of water pollution</td>
</tr>
<tr>
<td>6</td>
<td>Variable rate manure application</td>
<td>On the go manure composition sensing Depth of Injection adjustment</td>
<td>Reduced ground water pollution Reduced ammonia emissions into the air</td>
</tr>
<tr>
<td>7</td>
<td>Precision irrigation</td>
<td>Soil texture map</td>
<td>Avoidance of excessive water use or water logging Reduction of fresh water use</td>
</tr>
<tr>
<td>8</td>
<td>Patch herbicide spraying in field crops.</td>
<td>Weed detection on line/weed maps</td>
<td>Reduction of herbicide use with map-based approach In winter cereals by 6-81% for herbicides against broad leaved weeds and 20-79% for grass weed herbicides* Reduction of 15.2-17.4% in the area applied to each field was achieved with map-based automatic boom section control versus no boom section control** 24.6% average herbicide savings was achieved in tramline spraying field trials</td>
</tr>
<tr>
<td>9</td>
<td>Early and localized pest or disease treatment</td>
<td>Disease detection - Multisensor optical detection - Airborne spores detection - Volatile sensors</td>
<td>Reduction of pesticide use with correct detection and good decision model (84.5% savings in pesticides possible. (Moshou et al., 2011))</td>
</tr>
<tr>
<td>10</td>
<td>Orchard and vineyard precision spraying</td>
<td>- Tree size and architecture detection - Precision IPM</td>
<td>Reduction in pesticide use up to 20 – 30 % Reduction of sprayed area of 50-80%</td>
</tr>
<tr>
<td>11</td>
<td>Variable rate nitrogen fertilizer application according to crop requirements and weather conditions</td>
<td>Crop vegetation index based on optical sensors Soil nutrient maps</td>
<td>Improvement of nitrogen use efficiency Reduction of residual nitrogen in soils by 30 to 50 %</td>
</tr>
<tr>
<td>12</td>
<td>Variable rate phosphorous fertilizer application according to crop requirements and weather conditions</td>
<td>Crop vegetation index Soil nutrient maps</td>
<td>Improvement of phosphorous recovery of 25 %</td>
</tr>
<tr>
<td>13</td>
<td>Crop biomass estimation</td>
<td>Crop vegetation index</td>
<td>Adjust the fungicide dose according to crop biomass (Jensen and Jørgensen 2016)</td>
</tr>
<tr>
<td>14</td>
<td>Mycotoxin reduction</td>
<td>Crop vegetation index and fungal disease risk</td>
<td>Optimisation of fertilizer dose and fungicide use on the basis of higher disease risk in areas with high crop density</td>
</tr>
</tbody>
</table>

Table 1. Expected environmental gains from main PA processes and techniques

<table>
<thead>
<tr>
<th>No.</th>
<th>Process</th>
<th>Technique</th>
<th>Expected environmental gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Timeliness of working under favourable weather conditions</td>
<td>Automatic machine guidance with GPS</td>
<td>Reduction in soil compaction Reduce carbon footprint (10 % reduced fuel consumption in field operations)</td>
</tr>
<tr>
<td>2</td>
<td>Leave permanent vegetation on key location and at field borders</td>
<td>Automatic guidance and contour cultivation on hilly terrain</td>
<td>Reduction of erosion (from 17 to 1 ton/m²/year and perhaps lower) Reduction of runoff of surface water and reduced runoff fertilizers Reduced flood risk</td>
</tr>
<tr>
<td>3</td>
<td>Reduce or slow down water flow between potato/vegetable ridges to slow water</td>
<td>- micro-dams or micro-reservoirs made between ridges (tied ridges”) - ridges along field contours</td>
<td>Reduced sediment runoff Reduced fertilizer runoff</td>
</tr>
<tr>
<td>4</td>
<td>Keep fertilizer or pesticide at recommended distances from water ways</td>
<td>Automatic guidance based on geographic information Section control of spraying and fertilizer distribution</td>
<td>Avoidance/elimination of direct contamination of river water</td>
</tr>
</tbody>
</table>
Precision agriculture in Europe
Legal, social and ethical considerations

EPRS | European Parliamentary Research Service
Author: Mihalis Kritikos
Scientific Foresight Unit (STOA)
November 2017 – PE 603.207

✓ ISOBUS
✓ AUTOMATIC
✓ DRIVEN
✓ PRESCRIPTION
✓ MAPs
✓ AUTOMATION
**VRA technologies available**

- Progettazione e realizzazione nuovi impianti
  - Fertilizzazioni
  - Defogliatura
  - Vendemmia
  - Trattamenti antiparassitari
  - Irrigazione
  - Tracciabilità
  - Controllo flotte
- **Web-Gis gestionali aziendali**

Giornata di studi | Milano 15/11/2013 | Paradigmi della sostenibilità
perception systems for sustainable and profitable applications

VRA – CAS
canopy management and adaptation of treatment

DCM
Innovative proximal perception systems

Innovative Ultrasonic Sensors

New generation LIDAR
The map is loaded on USB flash drive for use in the HQS machine. Equipped with the GPS technology, the grape harvester knows its position and reads the map to determine A and B quality grape areas. Automatically, the harvester moves its conveyor to the right or to the left according to the map information.
INTELLIGENT ARMS
Experiences in Tuscany - VRT by drone
- Spraying nutrinets anche chemicals
- Pollinating
- launch of predators
Telemetry, Fleet control, DDS, Traceability in management

Stage 1 (for n° Times)  
Pesticide mixture preparation

Stage 2  
transport

Stage 3  
distribution

Stage 4  
Tank refill

Areas to be treated

Risk of error in mixture preparation

Contamination risk for workers

Spillage risk

Risk of incorrect distribution

Farm centre

Areas to be treated
TERRITORIAL DIGITAL PLATFORM AND DIRECT PARTICIPATING COMPANIES

Farmers

<table>
<thead>
<tr>
<th>Farmers</th>
<th>Vineyards [ha]</th>
<th>Olive growing [ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Az. Agr. Casanova di Neri di Giacomo Neri</td>
<td>72,3</td>
<td>7,1</td>
</tr>
<tr>
<td>Az. Agr. Martoccia di Brunelli Luca</td>
<td>8,3</td>
<td>1,4</td>
</tr>
<tr>
<td>Az. Agr. Podere La Vigna di Rubegni Adriano</td>
<td>6,4</td>
<td>1,1</td>
</tr>
<tr>
<td>Az. Agr. San Filippo di R. Giannelli</td>
<td>9,4</td>
<td>0,7</td>
</tr>
<tr>
<td>Siro Pacenti di Pacenti Giancarlo</td>
<td>23,1</td>
<td>3,6</td>
</tr>
<tr>
<td>Soc. Agr. Canalicchio di Sopra di Ripaccioli Marco &amp; F.II s.s.</td>
<td>19,1</td>
<td>2,3</td>
</tr>
<tr>
<td>Talenti Riccardo</td>
<td>14,9</td>
<td>3,6</td>
</tr>
<tr>
<td>Tassi di Franci Franca</td>
<td>5,2</td>
<td>0,3</td>
</tr>
<tr>
<td>Tenuta di Sesta di Ciacci Giovanni</td>
<td>36,5</td>
<td>22,9</td>
</tr>
<tr>
<td>Tenuta Fanti di Fanti Baldassarre Filippo</td>
<td>51,4</td>
<td>36,4</td>
</tr>
</tbody>
</table>
System Architecture

**Monitoring**

- **Aerial surveys:**
  - RGB Camera
  - Multispectral camera
  - Hyperspectral Camera
  - Gamma rays

- **Data collections on crops:**
  - Physiological measurements
  - Vigour indexes NDVI - NDRE

- **Data collection on soil:**
  - Conductivity measurements with electromagnetic induction
  - Profiles and drills
  - Laboratory analysis

- **Data collection from weather stations:**
  - Atmospheric pressure
  - Temperature
  - Rainfall
  - Humidity of the area
  - Wind intensity
  - Solar radiation
  - Dew point
  - Leaf wetness

**Data processing**

- Digital maps for the management of parcels with 1 sqm mesh:
  - Orthophoto (4 cm / pixel)
  - Vegetational maps and NDVI
  - Pedological maps
  - Hydrological modeling:
    - Water at field capacity (FC)
    - Water at the point of withering (WP)
    - Water available for plants (AWC)
    - Saturated hydraulic permeability (Ksat)
  - Weather-weather maps
  - Prescription maps

**Field activities**

- Telemetry control of operations
- Field books
- DSS Services - Decision Support System for:
  - Crop protection alarms
  - Logistic decisions support for the collection of products

**Services to companies and stakeholders**

- Analytical accounting of georeferenced parcel
- Traceability
- Typicality
- Identification of biodiversity footprints
CROP VIGOUR INDEXING NDVI-NDRE
ARTEA DATA – PIANO COLTURALE
To ADD INFORMATION INTO A FARM SYSTEM MANAGEMENT
Farm dashboard with on time emission and consumption indexes compared with conventional practices

on time emission and consumption indexes compared with conventional practices

A communicative tachimeter to highlight sustainability indicators: ROS, WFP, CFP, LCA, ... Eternality
SMASH for VITICULTURE

SMASH
Smart Machine for Agricultural Solutions
Hightech

- Puntual detection and SPRAY
- Precise mechanical weed control on the row

AgroBot
SMASH for HORTICULTURE

- Soil control by PLANTOID
- Precise mechanical weed control on the row

SMASH
Smart Machine for Agricultural Solutions
Hightech
MISURARE, ANALIZZARE, CONOSCERE AGIRE APPROPRIATAMENTE

Alta tecnologia per l’Agricoltura Conservativa
IL RACCOLTO Società Cooperativa Agricola
Rete Imprese Terre del Reno
PRECISION FARMING DI SECONDO LIVELLO

RIEQUILIBRIO DELLA SOSTANZA ORGANICA, VARIABILIZZATA IN BASE ALLE ESIGENZE PEDOLOGICHE DEI TERRENI E NUTRIZIONALI DELLE COLTURE, RILEVATE DA SENSORI OTTICI SU MACCHINE, DRONI E/O SATELLITE
GESTIONE APPORTI SOSTANZA ORGANICA A BASSO COMPATTAMENTO

- Trattrice a basso compattamento e con tecnologie DSS
- Aratro per gestione sottoprodotti da combinarsi a trattrice con tecnologie DSS
- Erpice rotante per gestione sottoprodotti da combinarsi a trattrice con tecnologie DSS
- Carro spanditore per gestione sottoprodotti da combinarsi a trattrice con tecnologie DSS
- Carro botte per gestione sottoprodotti da combinarsi a trattrice con tecnologie DSS
Compattamento: cosa, chi, dove, quando, perché

Morris et al., 2010

Fig. 9. Estimated changes in soil stress at 0.4 m soil depth resulting from increasingly heavy machinery running on the soil surface (figure courtesy of Chamen (2009) adapted from Koolen et al. (1992)).
Superficie di appoggio di livello superiore

- Rispetto ai MegaXbib 1050/50R32 (gli pneumatici di dimensioni maggiori), la superficie di contatto al suolo è pari al doppio con i cingoli SmartTrax da 24” (i più strettì della gamma).
IL RACCOLTO Società Cooperativa Agricola
Rete Imprese Terre del Reno
MAKING ORDER IN A CHAOTIC UNIVERSE OF TECHNOLOGICAL PROPOSALS

- ISOBUS
- AUTOMATIC GUIDE
- PRODUCTION MAPS
- PRESCRIPTION MAPS
- AUTOMATION
- TELEMETRY
Precision sustainable Farming is Spatial Intelligence and Precise Management. High Technology Farming is a way that makes it possible to clearly define the areas in which the technologies become "enabling" and profitable.
Integrated multicompetencies multiactor approach in effective and profitable innovation development – COLLABORATIVE ECOSYSTEM

- Automatic guidance in tractors operating on open field: a mature integrated innovation system
- High technologies for farming: caotic scenario to be proper developed in actuating steps and appropriate competencies and actors.

<table>
<thead>
<tr>
<th>Element</th>
<th>Product type</th>
<th>Problems and needs</th>
<th>Who does what</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite, aerplane, drone, terrain station, onboard system</td>
<td>vector</td>
<td>Resolution, frequency</td>
<td>Engineering competencies</td>
</tr>
<tr>
<td>FOTONICS</td>
<td>Sensors</td>
<td>Direct or Indirect measure or index</td>
<td>Physics researchers</td>
</tr>
<tr>
<td>Digital Data</td>
<td>Raw Data</td>
<td>interconnettivity</td>
<td>Informatics competencies</td>
</tr>
<tr>
<td>Data Comunication</td>
<td>Telecommunicazioni</td>
<td>Broad Band</td>
<td>Engineers researchers</td>
</tr>
<tr>
<td>Data mining</td>
<td>dati normalizzati</td>
<td>App</td>
<td>Informatics competencies</td>
</tr>
<tr>
<td>Informative digital systems</td>
<td>GIS + Digital Hubs territoriali</td>
<td>Hubs and Services</td>
<td>Agro-informatic &amp; Informatics systems</td>
</tr>
<tr>
<td>Data analysis</td>
<td>Biological and environmental models</td>
<td>Agronomic, Biological and Environmental Science Knowledges</td>
<td>Agronomous researchers</td>
</tr>
<tr>
<td>Decision support systems</td>
<td>Manager interface</td>
<td>Development of effective Decision Support System</td>
<td>Agronomous Agroinformatic</td>
</tr>
<tr>
<td>Mission Plan for Variable Rate Treatment automatism</td>
<td>Data meaning and managing</td>
<td>Agro-electronics and agroinformatics training</td>
<td>Agricultural machinery engineers Agroinformatics &amp; Agroelectronics</td>
</tr>
<tr>
<td>AVT machinery set up</td>
<td>Automation</td>
<td>Agro-electronics and agroinformatics training</td>
<td>Agricultural machinery engineers, Agroinformatics</td>
</tr>
</tbody>
</table>

TRL - Technological Readiness Level:
- 9 Commercial
- 8 Pre-Commercial
- 7 Field
- 6 Prototype
- 5 Beta
- 4 Beta
- 3 Pre-Beta
- 2 Concept
- 1 Basic
The evolution of agricultural mechanics has become profitable when:

- the machines have become appropriate and reliable *(historic failures of the Borello tractor and Bonmartini tire tracks)*;
- retailer, motorist, mechanic and gum services have become present in the territory *(within 100 km)*;
- training centers have been established **Famous in Tuscany was the Agricultural Mechanization Training Center of Borgo a Mozzano (Lucca) financed by the Government and by the ESSO**.

**Tuscany first highlighted these needs and identified them as essential**

- The territorial approach of the **PRODUCTION ECOSYSTEM**. This had already been defined in the regional ROADMAP for RIS3, defining the INNOVATION support PLATFORMS
- The **BUSINESS CASE** in agriculture, which is a non-relocatable external rural activity, is the **CASE OF TERRITORIAL USE** and not the single product, service or activity.
Grazie for Your precious attention

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www.agrismartlab.unifi.it

to contact: marco.vieri@unifi.it