A review of big data, smart and precision technologies in grass based dairying systems

Laurence Shalloo

L eso L.¹,², McDonagh A.¹, Geoghegan A.¹, Werner J.¹,³ and O’Leary N.¹

¹Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland
²University of Florence, Dept. of Agricultural, Food and Forestry Systems, 50145 Firenze, Italy
³Institute for Agricultural Engineering, University of Hohenheim, 70599 Stuttgart, Germany
Overview

- Drivers of efficiency in a pasture based systems
- State of the Art
- SWOT Analysis
  - Strengths
  - Weaknesses
  - Opportunities
  - Threats
- Future – Needs Driven Development
Grass utilised per ha and net margin per ha (National Farm Survey)
Grassland systems

\[ R^2 = 0.9074 \]

Dietary grass proportion (%)

Total costs of Production (€ c/l)

Source: Dillon et al. (2005)
Six Week Calving Rate > 90%

Each 1% increase in 6 week €8.22/cow
Overview

• Drivers of efficiency in a pasture based systems
  • State of the Art
• SWOT Analysis
  • Strengths
  • Weaknesses
  • Opportunities
  • Threats
• Future – Needs Driven Development
State of the art

- Precision dairy tech overview - what can be measured?

Production Performance
- Milk yield
- Milk quality

Health
- Mastitis
- Fertility
- Locomotion
- Metabolism

Behaviour
- Physical behaviour
- Feeding/rumination
- Spatial behaviour
- Social behaviour

Spectral analysis
- Biodiversity
- Growth
- Quality
Health
Mastitis
Locomotion
Lameness

Fertility

Metabolism
Overview

• Drivers of efficiency in a pasture based systems
• State of the Art
• SWOT Analysis
  • Strengths
  • Weaknesses
  • Opportunities
  • Threats
• Future – Needs Driven Development
Grazing behaviour and activity

**ITIN+HOCH RumiWatch**
- Noseband Sensor + Pedometer
  - Noseband pressure sensor
  - Jaw movements
  - Rumination, eating and drinking
  - Developed for research

**DAIRYMASTER MooMonitor +**
- Collar (Accelerometer)
  - Measures feeding, rumination, activity levels - 3-axis acceleration
  - Measures acceleration
  - Submits pre-processed data in 15-minute-summaries to base station

---

Multi-axis accelerometer-based pedometer
- Walking, standing, lying, amount of strides

---

EGF 2018

Agriculture and Food Development Authority

17th - 21st June 2018 | CORK, IRELAND
Grazing behaviour

Mean difference = 4.4 min/h
$r_s = 0.96$
CCC = 0.96

Mean difference = 1.0 min/h
$r_s = 0.94$
CCC = 0.97
Automated Body Condition Scoring

- INGENERA BodyMat
- BMF output in 0-5 point French scale
- Converted to 1-5 Irish scale (Decision Tree & Linear)
- A CCC of 0.7 with the average score of two observers
- Compares well to the agreement between those two observers (0.69)
Overview

• Drivers of efficiency in a pasture based systems
• State of the Art
• SWOT Analysis
  • Strengths
  • Weaknesses
  • Opportunities
  • Threats
• Future – Needs Driven Development
Sensor Development

126 published studies describing 139 sensor systems for animal health management (till 2013)

- Productivity did not change after investment in sensor systems on dairy farms (Steeneveld et al., 2015)

Source: Rutten et al. (2013)
AMS v’s conventional milking systems

Return on investment for additional investment associated with AMS technology on Irish farms <0%
Feed to Yield Milking systems

Return on investment for the additional investment associated with Feed to Yield technology on Irish farms <0%
Overview

• Drivers of efficiency in a pasture based systems
• State of the Art
• SWOT Analysis
  • Strengths
  • Weaknesses
  • Opportunities
  • Threats
• Future – Needs Driven Development
Proliferation of Smart-Phone/Internet

Fig. 1. The cyber-physical management cycle of Smart Farming enhanced by cloud-based event and data management (Wolfert et al., 2014).
Data analytics development

- Whole range of approaches newly develop which have not extensively been applied to agriculture
- Scope to embed algorithms within Databases
  - Machine Learning
  - Artificial Intelligence
- Potential for a continuous learning process
• Geo-referenced locations
• The user can input the influencing factors and calculate the next area to be grazed
• The tool measures the biomass
• The data is transferred to the smartphone.
• Data can be uploaded to Pasturebase ‘Decision Support Tool’
Linear measures

Body length
Back length
Chest width
Thurl width
Body depth
Chest depth
Flank depth
Length of rump
Height at wither
Height at rump
Rounding of ribs
Rump angle
Tail set
Width at hips

• Wiidth at pins
• Muscularity shoulder
• Back width
• Thickness of lion
• Thigh rounding
• Thigh width
• Thigh length
• Muzzle width
• Top line
• Front legs
• Fore pasterns
• Rear legs set
• Claw angle
• Thickness of bone
LOCOMOTION:

HEAD APPLITUDE
HEAD FREQUENCY
GAIT ANALYSIS
STRIDE LENGTH
SPEED
Sustainability Assessment

Environmental

- GHG emissions
- Nutrient use efficiency
- Water use
- Energy Use
- Biodiversity
Overview

• Drivers of efficiency in a pasture based systems
• State of the Art
• SWOT Analysis
  • Strengths
  • Weaknesses
  • Opportunities
  • Threats
• Future – Needs Driven Development
Threats

- If the technology doesn’t work
- Focus on technology rather than solution
  - Technology provider working in isolation
- Unwillingness to share Data – Business Model
  - Perceived Monetary value
  - GDPR – Data Ownership
  - Loss of Control
- Early adopters get their fingers burned
- Lack of vision around the big picture
  - Sum of the parts greater than the individual parts - ICBF
Overview

• Drivers of efficiency in a pasture based systems
• State of the Art
• SWOT Analysis
  • Strengths
  • Weaknesses
  • Opportunities
  • Threats
• Future – Needs Driven Development
Future – Needs Driven Approach

• Move away from development because the technology can be developed to development for an industry need
Short term decision making

### Farm Cover (kg DM/ha)

<table>
<thead>
<tr>
<th>Farm Cover</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover / LU</td>
<td>164</td>
</tr>
<tr>
<td>Growth / ha</td>
<td>103</td>
</tr>
<tr>
<td>Demand / ha</td>
<td>57</td>
</tr>
<tr>
<td>Demand / day</td>
<td>5593</td>
</tr>
<tr>
<td>Days ahead</td>
<td>10</td>
</tr>
<tr>
<td>Kg LWT / ha</td>
<td>0</td>
</tr>
</tbody>
</table>

### Total LU

<table>
<thead>
<tr>
<th>Total LU</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LU / ha</td>
<td>3.38</td>
</tr>
<tr>
<td>Grazing Area</td>
<td>92.57 ha (25)</td>
</tr>
<tr>
<td>Silage - Cut Later</td>
<td>23.31 ha (6)</td>
</tr>
<tr>
<td>Silage - Cut Now</td>
<td>4.72 ha (1)</td>
</tr>
<tr>
<td>Reseed</td>
<td>0.00 ha (0)</td>
</tr>
<tr>
<td>Other</td>
<td>0.00 ha (0)</td>
</tr>
<tr>
<td>Rotation Length Back (Days)</td>
<td>17</td>
</tr>
</tbody>
</table>
Medium term decision making - actions

Solutions
Soil Fertility?
Drainage?
Variety?

Costing €250/Ha
Costing €30k annually this farm
Long term

$y = 1.0718x^{0.6143}$

$R^2 = 0.3167$

Growth Rate (kg DM/Ha)

Individual Paddock Cover kgDM/Ha

Growth 33kgDM/Ha

Growth 75kgDM/Ha

Growth 115kgDM/Ha
Integrated solutions – future development
Conclusion

- Huge scope to increase sustainability in pasture based systems
- Precision technologies will have a significant role
- Need to provide integrated solutions
  - Timely information
  - Interpreted decisions
  - Appropriate medium