Mixed crop-livestock farming systems: a sustainable way to produce beef?

Patrick VEYSSET, Michel LHERM, Didier BEBIN, Marielle ROULENC
veysset@clermont.inra.fr

VEYSSET Patrick, INRA Clermont-Theix, UMRH, F-63122 Saint-Genès Champanelle
• Mixed crop-livestock farming system: usually seen as ideal, a virtuous farming system

• Conceptual models, core concepts in agronomy and economics, model-based studies: MC-L advantages and potential gains highlighted

• Experiments: one question at the field or animal scale

• What about the productive, economic and environmental gains at the commercial MC-L farm scale?
Method (1)

- Charolais suckler-cattle farms network (INRA)
  - 66 farms, years 2010 & 2011: 59 conventional + 7 organic

- 2 sort variables:
  - % Main Forage Area (MFA) in Utilized Agricultural Area (UAA)
  - % Area dedicated to the cattle (haCatt=MFA + annual crops for feed)

<table>
<thead>
<tr>
<th>4 groups: 3 conventional 1 organic</th>
<th>100% Grassland Farms (GF) n=7</th>
<th>Integrated Beef + crops for feed (IB) n=31</th>
<th>Mixed crop-livestock (MC-L) n=21</th>
<th>Organic Farms (OF) n=7</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFA % UAA</td>
<td>100</td>
<td>89</td>
<td>68</td>
<td>87</td>
</tr>
<tr>
<td>haCatt % UAA</td>
<td>100</td>
<td>96</td>
<td>77</td>
<td>95</td>
</tr>
</tbody>
</table>

- Results comparisons (average 2010-2011)
  - Structure, technical, economics, environment
Method (2)

- Techno-economic data base
  - Annual survey => 300 data collected / farm / year
  - Techno-economic appraisal => 3000 technical-economic variables / farm / year

- Environmental performances
  - Apparent nitrogen balance at the farm scale
  - Gross GHG emissions, carbon sequestration, net GHG emissions (LCA)
  - Non renewable energy (fossil energy) consumption (LCA)

- Analysis of results
  - 2010 & 2011 not significantly different => pooled into a single sample for each group
  - Observations/group: GF=14, IB=62, MC-L=42, OF=14
  - Pairwise sample comparisons test: non-parametric Kruskal-Wallis
Structural factors

- **Farm size (ha UAA)**
  - 4 groups not significantly different

- **Herd size (Livestock Units)**
  - IB farms: the biggest herds
  - OF: the smallest herds

- **Labour productivity**
  - UAA/worker: highest on MC-L and lowest on IB and OF.
  - LU/worker: biggest on GF and smallest on OF.
Animal performances

- **Numerical productivity**
  - 4 groups not significantly different (≈85%)

- **Livestock productivity (kglw/LU)**
  - OF: the lowest productivity (-23%)

- **Type of animals sold**
  - OF and IB fatten more males
  - MC-L do not fatten their males

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EAAP, Copenhagen, 25 / 08 / 2014
Forages area and cropland

- **Forages**
  - Grass: staple forage for the 4 groups. Grazed and conserved grass
  - Conserved grass: hay for GF and OF; silage for IB and MC-L

- **Cereal yields**
  - 5 to 5.5 t/ha for conventional (not different); 3.2 t/ha for OF (-40%)

- **Live weight production / ha**
  - Not different for the 3 conventional-system groups

- **Mineral N / ha**
  - MC-L uses more mineral N both on MFA and cropland (for same yield and stocking rate)
Feeding: concentrates

- Kg concentrates / Kg live weight

- Despite having (theoretically) better-quality stored forage, IB and MC-L groups are the heaviest consumers of concentrate per kg of beef produced.
- MC-L group distributes the highest amount of self-produced concentrates and do not buy less concentrate than the IB group.
- The use of concentrates is more efficient for GF that have to buy in all concentrates and for OF (price of OF concentrates: +35%)
- OF use less concentrates
Economic performances

- **Economic results € / ha UAA**
  - **Gross farm product / ha UAA**
    - Similar across conventional groups
    - Lowest for OF (-20%)
  - **Farm income / ha UAA**
    - Lowest for MC-L (costs/product=80%)
    - Highest for OF (costs/product=65%)

- **Farm income € / worker**
  - 20% higher on OF than on conventional systems
  - MC-L: labour productivity offset the per ha income gap
Environmental performances: GHG emissions

- **Gross GHG emissions kg CO₂e /kg lw**
  - GF
  - IB
  - MC-L
  - OF

- **Net GHG emissions kg CO₂e / kg lw**
  - GF
  - IB
  - MC-L
  - OF

- **Carbon offset (% gross GHG)**
  - GF
  - IB
  - MC-L
  - OF

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Environmental performances

- N balance kg N / ha UAA
- GHG and energy / ha UAA
- Energy consumption MJ / kglw

**N balance kg N / ha UAA**
- GF: a
- IB: a
- MC-L: b
- OF: c

**Energy consumption MJ / kglw**
- GF: a
- IB: ab
- MC-L: b
- OF: ab

**GHG and energy / ha UAA**
- GHG CO2e
  - GF: a
  - IB: a
  - MC-L: a
  - OF: b

- Energy MJ
  - GF: a
  - IB: a
  - MC-L: b
  - OF: c

Note: Bars with different letters indicate statistically significant differences.
Sum-up

❖ Grassland Farms
  ✓ Less concentrates/LU, less mineral N/ha and same live-weight production/LU and per ha

❖ Mixed crop-livestock Farms
  ✓ More grass silage, more mineral N/ha, less fattened animals, more concentrates and same live-weight production/LU
  ✓ Higher mechanization costs

❖ Organic Farms
  ✓ Lower animal productivity, lower stocking rate, but higher self-sufficiency

❖ Beef Farms with cereals for feed (on-farm concentrates)
  ✓ Intermediate between grassland farms and organic farms

 другими
  With higher labour productivity, higher inputs use, and not higher production => mixed crop-livestock farms are not more profitable and post lower environmental performances
Discussion

Conventional beef cattle farms appear unable to translate a mixed crop-livestock strategy into economies of scope

❖ Feed self-sufficiency and feed resources diversification
  ✓ Economic necessity for GF and especially for OF
  ✓ No productive and economic gain to produce its own concentrates for MC-L farms => energy and inputs are not quite expensive!

❖ Input efficiency and economies of scope
  ✓ Organic Farms: integration of crop and livestock and good system efficiency => agroecology
  ✓ Lower efficient inputs use and higher mechanization costs for large MC-L farms => economies of scale? (limits of this dogma)

❖ Encouraging a complex farming system
  ✓ High labour productivity, simplification of practices => incompatible with an efficient management of complex farming systems

❖ OF and agroecology
Conclusion

A gap between the conceptual model and the real world

- From biophysical process to whole-farm approach
  - Optimisation of a biotechnical process ≠ efficiency of the system
  - Research, higher education, vocational training, and learning: need to long-term systemic cross-disciplinary approaches

- Public policy
  - Incentives that support integrated farm production systems and efficient use of factors of production rather than incentive to further expansion (regressive subsidies with the farm size, agro-environmental scheme payments)

- Knowing and improving reality
  - Collect and data analysis: diversity of the farming systems, diversity of the territories => importance of the technical-economic performance monitoring farms networks
Agroecology: integrating animals in agroecosystems