Impacts of crop-livestock organization on mixed crop-livestock systems sustainability

A model-based study

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✓ Specialization of territories and farming systems
  - Nitrogen losses
  - Loss of carbon sequestration
  - Loss of biodiversity
  - Dependence on inputs markets

(Tichit et al. 2011, Bommarco et al., 2013, Soussana and Lemaire., 2014)

✓ Mixing crop and livestock production is more sustainable
  - Ecosystem services
  - Face climate change
  - Face volatility of input prices

(Bonaudo et al., 2014, Lemaire et al., 2014, Peyraud et al., 2014)
**HOWEVER** there is no consensus on the benefits of MC-L systems

(Perrot et al. 2012, Ryschawy et al., 2012, Veyesset et al., 2014)

**NEED FOR** better understanding mixed crop-livestock systems

(Parsons et al., 2011a, Bell and Moore, 2012)

**HYPOTHESES**

- Biophysical process levels **VS** farm scale
- Crop-livestock organization

![Diagram](image)

1. **Direct effect**: without interactions
2. **Indirect effect**: with interactions
Crop-livestock organization
- 20% crop – 80% livestock
- 80% crop – 20% livestock

Income
Productivity
MJ consumption
GHG Emissions
N balance

Crop-livestock interactions
- Crop self-consumption
- Introduction of pastures in crop rotations
- Introduction of forage intercrops
- Transfer of manure on crops
MAX GROSS MARGIN

Subject to constraints:

**FARM**
- Number of workers
- Farm size

**LIVESTOCK PRODUCTION**
- Demographic structure of the flock
- Fulfill feed needs

**VEGETAL PRODUCTION**
- Rotations schemes
- Fulfill fertilization needs
- Yields

**CROP-LIVESTOCK**
- Organization
- Interactions

Buildings & materials

Life Cycle Analysis (GHG, MJ)

Performances indicators
DIRECT IMPACT OF CROP-LIVESTOCK ORGANIZATION
Gains permitted by 80% of crop in comparison with 20% of crop

Net income (€/worker)
60%
40%
20%
0%
-20%

Crop
Crop GHG
(CO₂/Kg veg protein)
Crop MJ
(MJ/Kg veg protein)
Crop productivity
(Kg veg protein/ha)

Livestock
Livestock productivity
(Kg carcass/ha)
Livestock MJ
(MJ/Kg carcass)
Livestock GHG
(CO₂/Kg carcass)

N balance
(Kg N/ha)
→ **INCOME** :
  Crop production is more profitable than livestock production

→ **LIVESTOCK PRODUCTIVITY**
  Higher livestock intensification

→ **CROP GHG**
  N cycle

→ **LIVESTOCK MJ** :
  Livestock intensification (feeds)

→ **NITROGEN BALANCE** :
  Crop-livestock organization
  Livestock intensification (feeds)
Crop-livestock interactions have beneficial impacts

**BUT AN INDIRECT IMPACT OF CROP-LIVESTOCK ORGANIZATION IS OBSERVED**

- Integrated 20% Crop
- Integrated 80% Crop
- Zero Performance Gain
1. **Trade-off**: the direct effect of crop-livestock organization

   → Consistent with scientific literature
   
   *(Parsons et al. 2011, Bell and Moore, 2012, Perrot et al., 2012)*

   → **NOVELTY**: crop-livestock organization is a key explaining factor

2. **Crop-livestock interactions are beneficial**

   → some controversial studies
   
   ▪ Production scale
   ▪ No consideration of interactions
   ▪ Technical or agronomic constraints

   → **NOVELTY**: significantly affected by crop-livestock organization

3. **Model limits and perspectives**

   → Consideration of the social pillar of sustainability

   → Economic context
Crop-livestock organization is key determinant of performance

TRADE-OFF

Ability of a farming system to benefit from crop-livestock interactions

Trade-off between performances of sustainability

Need for a compromise analysis
THANKS FOR YOUR ATTENTION