Relationship between sward height and herbage mass for silvo-pastoral systems

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1. Context:

1.1. Advantages of integrated crop-livestock systems with trees:

- land use systems that allow more income **diversification**, without causing environmental degradation;
- to increase potential attainment of **ecosystem services**, such as improving soil structure, soil organic C sequestration, C sequestration in woody biomass of trees, nutrient cycling and animal welfare;
1. Context:

1.2. Incentives:

- COP 15 + COP 21: ↓ GHG emissions by 43% until 2030, compared to 2005 levels!

- The label **Carbon Neutral Beef** is a brand-concept developed by Embrapa (2016). It aims to certify that beef under this label was produced under high standards of animal welfare, through systems with trees;

  A new concept for sustainable beef!
1. Context:

1.3. Resource competition between trees and the understory crop community:

**Leaf level**
- Leaf length
- Specific leaf area
- Chlorophyll content

**Plant level**
- Root-shoot ratio
- Leaf inclination angle
- Seed mass
- Specific root length
- Root diameter
- N content

**Community level**
- Tiller production
- Clonal growth

Morphology: constitute the leaf area index → Light interception-efficiency

Plant features associated to shade

Physiology: related to photosynthetic potential → Light use-efficiency

Nutrients availability

Relationship between sward height and herbage mass

SH is an important management variable, since it is easily measured and highly correlated to HM!
2. Objective:

- to investigate the SH and HM relationship for a continuously stocked mixed black oat (*Avena strigosa*) x ryegrass (*Lolium multiflorum*) pasture, in two non till-integrated crop-livestock system, i.e. with and without trees, combined with two levels of nitrogen.
2. Materials and methods:

2.1. Local:

- Agronomic Institute of Paraná (IAPAR), Ponta Grossa-PR, Brazil;
- the local climate is classified as subtropical humid (Cfb), with frequent occurrence of frosts;
2. Materials and methods:

2.1. Local:

- October 2006;
- Species: eucalyptus, *Eucalyptus dunnii*; pink pepper, *Schinus terebinthifolius*; silver oak, *Grevillea robusta*;
- Trees were planted in rows running crosswise in relation to the slope, at 3 x 14 m spacing (237 trees/ha);
Integrated crop-livestock system

Integrated crop-livestock system with trees
2. Materials and methods:

- During the winter (i.e. livestock phase):
  - black oat (*Avena strigosa*) x ryegrass (*Lolium multiflorum*);
  - the paddocks were managed in order to maintain a target surface sward height of 20 cm by adjusting the number of grazing animals weekly, i.e. put and take approach.
  - animals used were Purunã beef breed heifers that were approximately 10 months old and 232 kg;
2. Materials and methods:

- During the summer (i.e. crop phase):
  - the production system integrated corn or soybeans crops;
  The total experimental area is managed since 2007 as an integrated crop-livestock systems using no-till.
2. Materials and methods:

2.2. Treatments and experimental design:

- **Four treatments** = two N fertilization levels (90 and 180 kg N ha$^{-1}$) and two integrated crop-livestock systems (with vs. without trees), and with three replicates;
2. Materials and methods:

2.3. Pasture measurements:

- **Sward height** (SH): measured at 100 randomized points in paddocks every 15 days using a sward stick;
- **Herbage mass** (HM, kg/ha of dry matter): estimated every ~21 days with 5 cuts (0.25 m²) at the ground level per paddock;
- **Tiller density**: estimated by counting tillers in 50 cm linear in 3 randomly areas per paddock;
- **Weight per unit of tiller length** (mg/cm): measured in 10 tillers per species and per paddock;

These measures were done during the winter of 2014 and 2015 = 8- to 9-years-old trees = ~50% of light reduction

Before this study = 237 trees/ha
2014 = 158 trees/ha (by thinning pink pepper)
2015 = 79 trees/ha (by thinning silver oak)
3. Results:

Figure 1. Sward height average and herbage mass within each treatment \((n = 3)\), for each date and in each experimental year.

CL, integrated crop-livestock system; CLT, integrated crop-livestock system with trees. N90, 90 kg N ha\(^{-1}\); N180, 180 kg N ha\(^{-1}\).
3. Results:

**Figure 2.** Relationships between sward height and herbage mass within each system.

- **Treeless system**: ~600 kg/ha
- **Silvopastoral system**: = 698 kg of dry matter/ha

\[ r^2 = 0.69^{**} \]
3. Results:

- Lower herbage production in shaded areas:
  - ↓ weight per unit of tiller length:
    - $\text{CLTrees} = 5.6 \pm 0.45 \text{ mg cm}^{-1}$
    - $\text{CL} = 8.7 \pm 1.74 \text{ mg cm}^{-1}$
  - ↓ tiller density:
    - $\text{CLTrees} = 102 \pm 3.58$
    - $\text{CL} = 172 \pm 3.22$

Adapted from Gommers et al. (2013)
4. Conclusions:

- Important differences in the relationship between SH and HM were caused by shading, but only differences in order of magnitude (different intercepts) and not in the rate of change (equal slopes);
- The high shading percentage (~50%) during the experimental period, despite a thinning have been realized in the previous year, intensified the negative effect of trees, reducing drastically the HM;
- The target mean SH used at full sun systems as an index for management might not apply for systems under trees;
4. Conclusions:

- Silvicultural interventions should be intensified to minimize tree-crop competition, in order to have acceptable levels of tree competition, and making possible the maintenance of a target SH of 20 cm, recommended at full sun systems as an index for management of C₃ grass species, as well as ensuring high animal performance and adequate residual HM as soil cover for the succeeding crop;
These systems could be designed to:

- protect and enhance C sequestration, particularly, on sensitive landscape locations such as with greater land degradation and water pollution potential;
- > flexibility to the production system (e.g. with tropical species);
- premium prices on products;
Thanks for your attention!