Tree management in monocultures and agroforestry systems affect microclimatic growing conditions and fine-root growth

WIEBKE NIETHER¹, L. ARMENGOT², C. ANDRES², M. SCHNEIDER², G. GEROLD¹
¹UNIVERSITY OF GÖTTINGEN, GÖTTINGEN, GERMANY
²RESEARCH INSTITUTE OF ORGANIC AGRICULTURE, FRICK, SWITZERLAND (FiBL)
Tree management for cacao cultivation

- Production systems:
  - Monocultures $\rightarrow$ simple agroforestry systems $\rightarrow$ complex agroforestry systems

- Microclimate: incoming light, throughfall, temperature, humidity
  - Buffer function of shade trees $\rightarrow$ less stressful environmental conditions

- Biomass
  - Aboveground carbon sequestration
  - Root development

- Trade-off
  - Yield
  - Ecosystem services

- Tree management
  - Stem density
  - Species composition
  - Pruning
Study area

´Sara Ana´

- Alluvial terrace, 380 m a.s.l.
- Luvisols and Lixisols
- 25.2 °C
- 83% relative humidity
- 1439 mm, 78% from October to April
Long-term experiment and land-use systems

MONO CONV
Monoculture conventional

MONO ORG
Monoculture organic

AF CONV
Agroforestry conventional

AF ORG
Agroforestry organic

SAFS
Successional agroforestry system

BAR
Barbecho / Fallow

48 m x 48 m

FiBL
Plot structure

Data collection (2013-2015)

- **Stand structure**
  - Height (stratification), basal area
  - Canopy openness

- **Microenvironment**
  - Radiation
  - Precipitation / throughfall
  - Temperature, relative humidity

- **Root development**
  - *Theobroma cacao, Erythrina ssp.*
  - 0-25 cm; 25-50 cm

Plot: 48 x 48 m
- Cocoa trees
- *Musa*
- Woody trees
- Successional plants

Net-plot: 24 x 24 m
V-shaped transect: 52 m

Before + after pruning

Before pruning
Pruning effect on microclimate

<table>
<thead>
<tr>
<th>Canopy openness %</th>
<th>MONO</th>
<th>AF</th>
<th>SAFS</th>
<th>BAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+13</td>
<td>+21</td>
<td>+7</td>
<td>0</td>
</tr>
</tbody>
</table>

PPFD: photosynthetically active photon flux density
VPD: vapor pressure deficits of the air
Pruning: Effective tool to manage the system

→ Overlays the stand structure effect (rapid effect, but decreases over time)
→ Has to be adapted to season and in intensity to not increase environmental stress
Stand structure and root development

- **Stem density [stems ha\(^{-1}\)]**
  - 625
  - 1536
  - 2431

- **Stem basal area [m\(^2\) ha\(^{-1}\)]**
  - 7
  - 22
  - 23

- **Species diversity [number]**
  - 1
  - 2
  - 13
  - 15
  - > 20

- **Root growth increment (1 year)**

---

**MONO CONV**  **MONO ORG**  **AF CONV**  **AF ORG**  **SAFS**  **BAR**

---

12.12.2017  Tree management
Root quality

- **C:N-ratio**

  ![C:N-ratio chart](chart)

Biomass and rooting systems

- Highest stem density in SAFS but trees are smaller than in AF (stem diameter)
- 80% of cacao roots in the upper 25 cm
- MONO ORG > MONO CONV: cover crop!
- *Erythrina* still much in 25-50 cm

Root quality

- Cacao C:N-ratio increases with complexity
- More variable in 25-50 cm
- *Erythrina*: C:N-ratio not different between ORG and CONV
- CN-ratio: cacao > *Erythrina*
Thank you  Gracias  Merci