Structure of Cocoa-based Agroforestry Systems and their Productivity in Talamanca, Costa Rica

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ESA 2010
August 29th – Sept. 2nd
Montpellier, France
Cocoa-based Agroforestry systems: how the variability of their high structural complexity...

- Low input & based on workforce
- High specific diversity
- High intra and inter heterogeneity
- Differenciate management of the components
- High diversity of man uses

...is affecting their productivity?
Performances of cocoa based AFS: a controversial topic

• Until recently (1990’s), NOT considered as an acceptable option regarding cocoa productivity, especially compared to that obtained in cocoa monocropping systems (Ruf, 2009)

• Highlighted today for their productive performances (Malezieux & al., 2008; Harvey & Villalobos, 2007; Harvey et al., 2006; Schroth et al., 2004; Dahlquist et al., 2007)

• But extremely few papers try to understand the impact that structure variability has on agronomical performances (Steffan-Dewenter & al., 2007)

Our objectives:

Link a given cocoa orchard structure with its cocoa yield
Be able to rank cocoa agroforests according to their trade-offs between Productivity and Structure complexity
The Talamanca region, Costa Rica

- 36 cocoa AFS selected to maximize contrasts in terms of associated plant species and density, topographical context and landscape context.
- Aged 4 to 57 years – Area: 0.5 to 5 ha
- All under organic certification scheme

- Average T°C = 27°C
- P=3500–4500 mm/year
- Altitude 70 to 500 m
- Deep fertile soils (Winowiecky, 2008).
Cocoa agroforest border

Sampling unit

Estimated center of the cocoa agroforest

<table>
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<tr>
<th>Subplot 1</th>
<th>Subplot 2</th>
<th>Subplot 3</th>
<th>Subplot 4</th>
<th>Subplot 5</th>
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<tbody>
<tr>
<td>Subplot 9</td>
<td>Subplot 8</td>
<td>Subplot 3</td>
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<th>Subplot 10</th>
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20 m

50 m

10 m
- Canopy layer
- Cocoa trees layer
- Ground cover

- Associated plants ≥ 2.5 m were identified, counted and measured for dbh and height,
- Shade % at 1m height with densiometer on each subplot during dry and rainy season.
- Cocoa trees counted and measured for Ø 30cm and height
- Pods counted on all cocoa trees within the 1000 m² plot before each main harvest (April & October).
- 1 m² area on each subplot.
- 4 times / for: % of Ligneous, Grasses, Mosses, Ferns, and Litterfall
COCOA TREES LAYER

- Cocoa trees density / ha [**]
- Cocoa trees basal area (m²) [*]

% of SHORT cocoa trees [**]
% of HIGH cocoa trees [**]

ST1
ST2
ST3
ST4
The diagram illustrates the composition of the canopy layer across different sites (ST1, ST2, ST3, ST4). The data is categorized into three primary groups:

- Tall associated plants [**]
- Medium sized associated plants [**]
- Short associated plants [**]

Additionally, there are three subcategories indicated by color:

- Green: Palmacea associated to cocoa [*]
- Yellow: Musacea associated to cocoa [**]
- Brown: Trees associated to cocoa [**]

The percentages for each category at each site are as follows:

- **ST1**: Tall associated plants [**] - 90%, Medium sized associated plants [**] - 10%, Short associated plants [**] - 0%
- **ST2**: Tall associated plants [**] - 80%, Medium sized associated plants [**] - 20%, Short associated plants [**] - 0%
- **ST3**: Tall associated plants [**] - 70%, Medium sized associated plants [**] - 20%, Short associated plants [**] - 10%
- **ST4**: Tall associated plants [**] - 60%, Medium sized associated plants [**] - 25%, Short associated plants [**] - 15%
CANOPY LAYER

- Richness
- Shannon-Wiener index
- Simpson index

ST1, ST2, ST3, ST4
CLUSTERS    DESCRIPTION

ST 1

• High density of associated plants distributed in low and middle strata with a high stratum almost empty (65-25-10).
• High proportion of trees and Palmacea
• Average proportion of Musacea.

• Extremely high shade level at 1m height.

• Ground covered with litterfall and young tree seedlings. Very little grasses.

ST 2

• Very low density (247) of thin associated plants distributed mainly in high stratum (25-25-50).
• Extremely high proportion of trees (86%)
• Very low proportion of Musacea and Palmacea

• Very high shade level at 1m height.

• High density of young, very high and thick cocoa introduced varieties mixed with “local” ones (75/25).

• Ground covered with litterfall and young tree seedlings. Low prop. of grasses.
**ST 3**

- Very high density (470) of associated plants distributed mainly in low stratum (75%).
- High proportion of Musacea (62%).
- Low proportion of Trees and Palmacea.
- Ground covered with litterfall and high % of weeds. Almost no ligneous plants.
- High shade level at 1m height.

**ST 4**

- Low density (295) of associated plants distributed mainly in low and high strata (45-20-35).
- High % of Trees and Palmacea.
- Low % of Musacea.
- Ground covered with litterfall and high % of trees and weeds. Floodplain pattern.
- Very high shade level at 1m height.

- High density (560) of low, medium aged unpruned cocoa introduced varieties mixed with local ones (75/25).
Trade-offs between Yield and Structure in cocoa based AFS?

- Biodiversity gradient ($H'$)
- Yield (Pods / cocoa tree / year)

Legend:
- ST1
- ST2
- ST3
- ST4

Graph showing the relationship between biodiversity and yield for different structure types (ST1, ST2, ST3, ST4).
Thank you…

… for your attention.

… to the Bribri indigenous people of Talamanca.

… to the Central American Cocoa Project (PCC),

… to CATIE and CIRAD for financial support.