Agro-ecological integration of shade tolerant and drought tolerant food/feed crops for year-round productivity in banana-based systems under rain-fed conditions.

Banana is mainly intercropped with annual (predominantly legumes) or perennial (e.g., coffee) crops in **rain-fed cropping systems** on **small-scale farms** in east DR Congo and Burundi.

These banana-based systems mainly focus on food crops, and to a lesser extent on fodder crops.
• Land is limiting for most households in east DR Congo and Burundi.

• Practices such as shifting cultivation and fallowing are no longer feasible for most farmers.

→ There is need to use the available land space more efficiently.
Sustainable intensification of rain-fed banana-based systems with focus on various constraints:

• Drought (dry seasons)
• Shade (from the banana leaf canopy)
• Biotic constraint (Xanthomonas wilt of banana; XW)
Drought (dry seasons; lack of irrigation options) and shade (from the banana leaf canopy) are constraints to year-round and optimum whole farm productivity.

- Optimum use of space (layers) in time (across rainy and dry seasons) for optimum year-round/whole farm productivity, improve soil fertility and moisture retention in the dry season and reduce the weed burden.
In order to reduce shade levels, banana leaves are often cut at the onset of the rainy season (for annual cropping).

Dense banana plantation at the onset of the rainy season in North Kivu. Most banana leaves had been cut to provide sunlight for the legume intercrop.
Farms in the dry season

Perennial: various tree species (multipurpose, coffee, ...)

Few food crops (e.g., sweet potato, yam, taro, cassava) remain in the field during the dry season. Gradually harvested according to HH needs.
Xanthomonas wilt of banana is a serious constraint to banana production in east DR Congo and Burundi.

Most XW diseased plants are cut at soil level before annual cropping starts.
A package of control options is available, comprising whole mat uprooting and SDSR.

As a result of applying whole mat uprooting or SDSR, mats or plants are removed from the plots, creating open space and increased ground level light penetration favourable for annual crop cultivation.

Integration of annual crops during the recovery phase of the banana plots with the aim to maintain/increase whole farm productivity.
Experience from on farm trials in South Kivu:

- During how many annual cropping seasons can annual crops be planted in a developing banana plot (with gradual increase in canopy size).
- How does banana planting density (2x2, 2x3, 3x3, 3x4 m) influence this?
- Examples for legumes (bush bean ‘HM21-7’ and climbing bean ‘Namulenga’).
PAR (micromole m$^{-2}$s$^{-1}$) at 50 cm from a banana mat

PAR (micromole m$^{-2}$s$^{-1}$) in the middle of the plot

Full light (micromole m$^{-2}$s$^{-1}$)
Figure: Legume yield across 3 annual cropping seasons under different banana planting densities (2x2, 2x3, 3x3) in Katana, South Kivu, DR Congo.

Grain yields dropped to near zero as of the 3rd cropping season (2x2, 2x3 and 3x3 m).
Banana leaf pruning needed.
How does banana leaf number influence annual crop cultivation?

**Table.** Yield of legumes according to retained number of banana leaves


<table>
<thead>
<tr>
<th>Legume type</th>
<th>Banana leaf treatment</th>
<th>2010B (planted 3 months after banana field planting)</th>
<th>2011A (planted 9 months after banana field planting)</th>
<th>2011B (planted 15 months after banana field planting)</th>
<th>2012A (planted 21 months after banana field planting)</th>
<th>2012B (planted 27 months after banana field planting)</th>
<th>Average legume biomass yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Bush bean</em> (MLB49)</td>
<td>Monocrop</td>
<td>2070a</td>
<td>3542a</td>
<td>658 a</td>
<td>422 a</td>
<td>1118a</td>
<td>1565a</td>
</tr>
<tr>
<td></td>
<td>4 leaves</td>
<td>2170a</td>
<td>1362b</td>
<td>255 b</td>
<td>325 ab</td>
<td>778b</td>
<td>978a</td>
</tr>
<tr>
<td></td>
<td>7 leaves</td>
<td>2442a</td>
<td>1100bc</td>
<td>220 b</td>
<td>248 ab</td>
<td>390c</td>
<td>880a</td>
</tr>
<tr>
<td></td>
<td>All leaves</td>
<td>1365a</td>
<td>955 c</td>
<td>212 b</td>
<td>210 b</td>
<td>370c</td>
<td>622a</td>
</tr>
<tr>
<td></td>
<td>LSD</td>
<td>1077</td>
<td>373</td>
<td>161</td>
<td>169</td>
<td>326</td>
<td>1239.6</td>
</tr>
<tr>
<td></td>
<td>CV</td>
<td>34</td>
<td>13</td>
<td>30</td>
<td>35</td>
<td>31</td>
<td>91.5</td>
</tr>
</tbody>
</table>

* Means in a column followed by the same letter are not significantly different from each other according to Tukey’s HSD test (P<0.05).
Table. Effect of different banana leaf pruning levels and legume intercrop types on banana bunch traits and yield

<table>
<thead>
<tr>
<th>Intercropping treatment</th>
<th>Banana leaf treatment</th>
<th>Banana plant crop</th>
<th>First ratoon crop</th>
<th>Yield (t/ha)</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean (SB24)</td>
<td>4 leaves</td>
<td>26.64 e</td>
<td>31.46c</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 leaves</td>
<td>40.26 b</td>
<td>42.02b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All leaves</td>
<td>44.23 a</td>
<td>44.35ab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climbing bean (AND10)</td>
<td>4 leaves</td>
<td>25.89 e</td>
<td>29.83c</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 leaves</td>
<td>39.88 b</td>
<td>42.41b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All leaves</td>
<td>43.57 a</td>
<td>44.17a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bush bean (MLB49)</td>
<td>4 leaves</td>
<td>27.64 e</td>
<td>32.29c</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 leaves</td>
<td>41.79 b</td>
<td>41.97b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All leaves</td>
<td>46.23 a</td>
<td>45.93a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banana monocrop</td>
<td>4 leaves</td>
<td>35.73 c</td>
<td>31.64cd</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 leaves</td>
<td>39.78 b</td>
<td>42.58b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All leaves</td>
<td>44.84 a</td>
<td>42.72b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lsd (005)</td>
<td></td>
<td>3.75</td>
<td>2.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td>24.6</td>
<td>18.20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#: NH: number of hands; FL: finger length; 2HW: second hand weight (kg); BW: bunch weight (kg)

*: Means in a column followed by the same letter are not significantly different from each other according to Tukey’s HSD test (P<0.05)
Bottlenecks in the system

**Shade:**
Banana canopies eventually close, making it hard for annual crops to grow and produce good yields, hence the need for shade-tolerant crop options to make optimal use of available space.

**Drought** (2 dry seasons of 3 months each; June-September; January till March):
Solution: Food or feed crops that can be planted during the latter phase of the rainy season and can continue growing in the dry season.
• There are differences in shade or drought tolerance according to cultivar/genotype.

• Focus on crops in general.
Use of shade tolerant crops (examples from Asia):

In Malaysia, Pueraria phaseoloides, Calopogonium caeruleum and Centrosema pubescens are widely cultivated as **cover crops** (to prevent weed growth, moisture loss and soil erosion) in young rubber and oil palm plantations with low shade levels.


Only shade-loving and shade-tolerant crops can be grown in mature oil palm since the availability of light is less than 30 per cent.

**Table.** Intercrops grown in mature oil palm gardens in India.

<table>
<thead>
<tr>
<th>State</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>Cocoa, banana, <strong>black pepper, long pepper and</strong> elephant foot yam.</td>
</tr>
<tr>
<td>Karnataka</td>
<td>Banana, coffee, vanilla, medicinal and aromatic plants, arecanut and annatto.</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>Banana</td>
</tr>
<tr>
<td>Orissa</td>
<td>Banana, <strong>turmeric, arrow root</strong> and pine apple</td>
</tr>
<tr>
<td>Gujarat</td>
<td>Banana</td>
</tr>
</tbody>
</table>
Search for shade and drought-tolerant crops:

Drought and shade tolerant annual crops currently grown in the South Kivu and Burundian rain-fed banana-based Systems.

**Shade:**

- **Taro** (*Colocasia esculenta*) (shade-loving)
- **Yam** (copes with shade)
- **Red Bird Eye Chilli pepper** (*Capsicum frutescens*)
  (in very small numbers; for home consumption, Chilli sausage; excellent growth under shade)
Shade

Cassava for leaves
(eastern DR Congo)

Drought:

Taro and yam
(harvested in the dry season according to HH needs)
Drought

Cassava

Harvested in the dry season according to HH needs.
Grown as intercrop with banana in east DR Congo (for leaves).
Grown as monocrop in western Burundi (for tubers)

Sweet potato

Harvested in the dry season according to HH needs.
e.g., in Burundi; planted in April and harvested in August/September; planted in October and harvested in March). Mainly grown as monocrop.
Options for system improvement (focusing on shade and drought tolerance):

**Mucuna** planted at the end of the rainy season with growth and ground cover during the dry season (being evaluated)

**Red Bird Eye Chilli pepper** (*Capsicum frutescens*)
Shade loving; currently in low numbers in farmer’s fields (industrial processing; e.g. to make teargas; screen for export markets in ECA and beyond; build new value chains);

Shade and drought tolerant: **Cocoyam** (*Xanthosoma spp*) *(Aroid)*
Chick pea (planted at the end of the rainy season)
Elephant foot yam (grown e.g. in India) (Aroid)

*Amorphophallus paeoniifolius*, the elephant foot yam, is a tropical tuber crop grown primarily in South Asia, Southeast Asia and the tropical Pacific islands. Because of its production potential and popularity as a vegetable in various cuisines, it can be raised as a cash crop.
Ginger (Zingiber officinale) is a flowering plant whose rhizome, ginger root or simply ginger, is widely used as a spice or a folk medicine. It is a herbaceous perennial which grows annual stems about a meter tall bearing narrow green leaves and yellow flowers. Ginger is in the family Zingiberaceae, to which also belong turmeric (Curcuma longa), cardamom (Elettaria cardamomum), and galangal. Ginger originated in the tropical rainforest in Southern Asia.
Turmeric or tumeric (Curcuma longa) is a rhizomatous herbaceous perennial plant of the ginger family, Zingiberaceae. It is native to southern Asia. When not used fresh, the rhizomes are boiled for about 30–45 minutes and then dried in hot ovens, after which they are ground into a deep-orange-yellow powder commonly used as a spice in Bangladeshi cuisine, Indian cuisine, Pakistani cuisine and curries, for dyeing, and to impart color to mustard condiments.
Sustainable intensification of Enset systems

• Which annual/perennial crops are grown in mature enset plantations?

• Very few annual crops.

• Sweet potato (for vine production) and rapeseed are sometimes planted under high shade levels in mature enset (Ensete ventricosum) fields in Ethiopia.

• Coffee
Sustainable intensification of Enset systems

- Testing of shade (and drought) tolerant forage legumes in mature enset fields (on station and on farm work)
- Which are the most promising shade tolerant forage legumes?, preliminary results.

<table>
<thead>
<tr>
<th>Legume variety</th>
<th>Above ground fresh biomass weight per plant (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On station, monocropped</td>
</tr>
<tr>
<td>Macrotyloma axillare</td>
<td>64</td>
</tr>
<tr>
<td>Desmodium intortum (green leaf)</td>
<td>36</td>
</tr>
<tr>
<td>Chamaecrista rotundifolia</td>
<td>42</td>
</tr>
<tr>
<td>Vici villosa</td>
<td>47</td>
</tr>
<tr>
<td>Vigna unguiculata</td>
<td>59</td>
</tr>
<tr>
<td>Lablab purpureus</td>
<td>58</td>
</tr>
<tr>
<td>Arachis pintoi</td>
<td>34</td>
</tr>
</tbody>
</table>
Lablab

*Lablab purpureus* (L.) Sweet

- Lablab is a dual-purpose legume.
- Flowers and immature pods also used as a vegetable.
- It is also used as a fodder legume, green manure, cover crop.
- As a dual purpose (human food and animal feed) legume, it is sown as a monoculture or in intercrop systems.

- Drought tolerant when established, and will grow where rainfall is <500 mm, but loses leaves during prolonged dry periods.
- Capable of extracting soil water from at least 2 meters depth.
- Moderately tolerant to heavy shading.
Questions to the audience:

➔ Which other shade and drought tolerant crops could be integrated into banana-based cropping systems in central Africa, with special focus on food crops?

➔ Which shade-tolerant feed crops could be integrated into mature enset plots in Ethiopia?

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