Regional workshop on Conservation Agriculture

Investing in Sustainable Agriculture:
The Case of Conservation Agriculture and Direct Seeding Mulch-Based Cropping Systems

Five years of “adaptative” research for upland DMC based cropping systems creation in Cambodia

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Five years of “adaptative” research for upland DMC based cropping systems creation in Cambodia

Plan

1st PART
Rapid highlights on climate and soils conditions and reference plow based cropping systems

2nd PART
Progressive design of diversified DMC based cropping systems

3rd PART
Future Evolutions in the next coming years
1st PART

Rapid highlights
on climate and soils conditions
and reference plow based cropping systems
1/ Rapid Highlights on climate and soil’s conditions ...

1.1/ Main characteristic of the Cambodian central plain’s climate

**Climate** of the Central plain

- **Hot** (average $T^\circ = 28^\circ C$) and **sunny** (> 2 400 hours)
- **6-7 months rainy season** (from $\pm 4/15$ to $\pm 11/1$)
  5-6 months dry season
- **abundant rainfalls** (1200-1600 mm/year)

But 3 climatic hazards randomizes the rain repartition (irregularity and variable)

<table>
<thead>
<tr>
<th>Scattered rains</th>
<th>Heavy-regular rains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mars</td>
<td>Avril</td>
</tr>
<tr>
<td>Mai</td>
<td>Juin</td>
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<td>Juillet</td>
<td>Août</td>
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<td>Sept.</td>
<td>Octob.</td>
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<td>Nov.</td>
<td>Dec.</td>
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</tbody>
</table>

1st “hazard”
Rains arrival

2nd “hazard”
“Small dry season”

3rd “hazard”
Last useful rain
1.2/ Main location of Upland cultivation on Red and Black basaltic soils
### 1/ Rapid Highlights on climate and soil’s conditions …

### 1.3/ Key features of red basaltic oxysol (“ferralitique”)

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Soil 1</th>
<th>Soil 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td>10-20</td>
<td>3.9</td>
<td>3.9</td>
</tr>
<tr>
<td>20-40</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td>40-60</td>
<td>7.9</td>
<td>7.9</td>
</tr>
<tr>
<td>% Sand</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>% Silt</td>
<td>12.9</td>
<td>12.9</td>
</tr>
<tr>
<td>% Clay</td>
<td>83.3</td>
<td>83.3</td>
</tr>
<tr>
<td>C organic</td>
<td>26.4</td>
<td>13.9</td>
</tr>
<tr>
<td>Organic matter</td>
<td>3.2</td>
<td>2.7</td>
</tr>
<tr>
<td>pH CaCl2</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td>H + Al cmol/dm³</td>
<td>7.11</td>
<td>9.12</td>
</tr>
<tr>
<td>Al exchangeable cmol/dm³</td>
<td>0.41</td>
<td>0.35</td>
</tr>
<tr>
<td>Ca exchangeable cmol/dm³</td>
<td>2.63</td>
<td>0.55</td>
</tr>
<tr>
<td>Mg exchangeable cmol/dm³</td>
<td>1.13</td>
<td>0.45</td>
</tr>
<tr>
<td>K exchangeable cmol/dm³</td>
<td>0.55</td>
<td>0.15</td>
</tr>
<tr>
<td>P exch. mg/dm³</td>
<td>7.2</td>
<td>7.2</td>
</tr>
<tr>
<td>CTC at pH 7.0 cmol/dm³</td>
<td>11.2</td>
<td>11.2</td>
</tr>
<tr>
<td>CTC effective cmol/dm³</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Sat. for bases (V) %</td>
<td>36.5</td>
<td>36.5</td>
</tr>
<tr>
<td>Sat. for Al (m) %</td>
<td>9.6</td>
<td>9.6</td>
</tr>
<tr>
<td>Sat. for Ca %</td>
<td>23.3</td>
<td>23.3</td>
</tr>
<tr>
<td>Sat. for Mg %</td>
<td>10.1</td>
<td>10.1</td>
</tr>
<tr>
<td>Sat. for K %</td>
<td>3.1</td>
<td>3.1</td>
</tr>
</tbody>
</table>

- **80% CLAY**
  - Medium to high C contain
  - Low to very low pH
  - Low saturation rate by bases
  - High degree of saturation by Al
  - Low Ca contain
  - Medium to high Mg contain
  - V. low to v. high K contain
  - Low to high Pexch contain

- **Unbalanced saturation by bases:** pronounced relative deficiencies in K and Ca compared to Mg
1/ Rapid Highlights on …reference plow based systems

1.3/ Main Plow based cropping systems on Kampong Cham’s upland

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<tbody>
<tr>
<td>1st “hazard” Rains arrival</td>
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<tr>
<td>2nd “hazard” “Small dry season”</td>
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<tr>
<td>3rd “hazard” Last useful rain</td>
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- Scattered rains
- Heavy-regular rains

Sesame disc → Soybean

Cassava Monoculture

High technical and economical randomization + soil’s degradation
irregular and decreasing profit margins
progressive shifting to perennial
2nd PART

Progressive design of diversified DMC based cropping systems
2/ Progressive design of diversified DMC based systems

2.1/ First DMC based, using short term biomass production
### 2/ Progressive design of diversified DMC based systems

#### 2.1/ First DMC based, using short term biomass production (Photos)

<table>
<thead>
<tr>
<th>The “bio pumps”</th>
<th>The main crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eleusine coracana</td>
<td>Mulch of Eleusine + Cajanus</td>
</tr>
<tr>
<td>Sorgho pool preto at 65 DAS</td>
<td>Riz on Eleusine</td>
</tr>
<tr>
<td></td>
<td>Maize on Eleusine</td>
</tr>
</tbody>
</table>

Photos of crops and mulches highlighting the integration of diversified crop management systems (DMC).
2/ Progressive design of diversified DMC based systems

2.2/ The “second” generation, using long term biomass production

Step 1: association of Bio-pump lc with Maize

Year 1
- Bio-pump sc
- Maize + Bio-pump lc
- Bio-pump lc

Year 2
- ...Bio-pump lc
- Maize + (Brachiaria + Cajanus)

"scattered" rains
heavy rains

2/ Progressive design of diversified DMC based systems

2.2/ The “second” generation, using long term biomass production

Step 2: association of Bio-pump lc with Rice and Soybean

- **Year n**: Rice + Stylosanthes
  - Stylosanthes is oversown by no till planter at # 40 DAS

- **Year n + 1**: Rice + Stylosanthes
  - Year n + 1: Maize + …

- **Year n**: Soybean + Brachiaria

- **Year n**: Soybean + Stylosanthes
  - Year n + 1: Soybean + …
  - Year n + 1: Rice + Stylosanthes
  - Year n + 1: Maize + …

Stylosanthes or Brachiaria is broadcast sown at first

Soybean’s yellow leaves appearance
2/ Progressive design of diversified DMC based systems

2.2/ The “second” generation, using long term biomass production
“LEGOLAND”, an unlimited possibility for permanent cropping

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**Year 1**

- **Bio-p. sc**
  - Maize + *Brach.*
  - *Brach.*

- **Bio-p. sc**
  - Maize + *Stylo.*
  - *Stylo.*

- **Bio-p. sc**
  - Maize + *Stylo.*
  - *Stylo.*

**Year 2**

- **Bio-p. sc**
  - Maize + *Stylo.*
  - *Stylo.*

- **Bio-p. sc**
  - Maize + *Stylo.*
  - *Stylo.*

- **Bio-p. sc**
  - Maize + *Stylo.*
  - *Stylo.*

- **Soybean + *Stylo.***
  - *Stylo.*

- **Rice + *Stylo.***
  - *Stylo.*

- **Maize + *Stylo.***
  - *Stylo.*

- **Maize + *Stylo.***
  - *Stylo.*

- **Maize + *Stylo.***
  - *Stylo.*

- **Maize + *Stylo.***
  - *Stylo.*

- **Maize + *Stylo.***
  - *Stylo.*

- **Soyb. + *Brach.***
  - *Brach.*

- **Soyb. + *Brach.***
  - *Brach.*

---

Legend:
- **"scattered" rains**
- **heavy rains**

Soybean and maize in bi-annual rotation
Maize mono-cropping with DMC technologies:
« Maize + Stylosanthes // Maize + Stylosanthes »
Upland rice based cropping systems....
SEBOTA 68 on red soils, Bos khnor, 2007
2/ Progressive design of diversified DMC based systems

2.3/ Economical comparison between DMC Maize // Soybean rotation and Plow based Sesame / Soybean succession

Evolution of the GPM ($/ha) according to the cropping system (DMC/ploughing)

Foreseen difference after 10 years : > 500 USD/ha/y
2/ Progressive design of diversified DMC based systems

2.4/ The case of Cassava

(in french: “le cas cassava” !)

Year 1

- "scattered" rains
- heavy rains

Cassava + Stylo.  Stylo.

Year 2

- "scattered" rains
- heavy rains

Cassava + Stylo.  Stylo.

Reduced growth of the Stylo.
due to shade, dry soil’s conditions at Cassava’s harvest and early replanting in Year 2

Active growth of the Bio-pump lc
Other attempt under assessment:
alive cover of Stylosanthes guianensis
2/ Progressive design of diversified DMC based systems

2.4/ The case of Cassava

Economical comparison between DMC Cassava and Plow Cassava

Evolution of the GPM ($/ha) according to the DMC management years

Foreseen difference after 10 years: > 1000 USD/ha/y
3rd PART

Future orientations of the cropping systems’ design
3/ Future orientations of the cropping systems’ design

3.1/ The 2 cycles temptation

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;scattered&quot; rains</td>
<td>&quot;scattered&quot; rains</td>
</tr>
<tr>
<td>heavy rains</td>
<td>heavy rains</td>
</tr>
</tbody>
</table>

|------|-------|-----|------|------|------|-------|------|------|------|------|------|

|-------|--------|---------------|-------|

Brach | V. radiata | Maize + Brach | Brach. |
|------|------------|---------------|-------|

2nd “hazard” small dry season 3rd “hazard” last useful rain

Re-introduction of a high climatic risk

dependence on uncertain rainfall vs securisation by soil’s water reserve

Document obtained from the site http://Agroecologie.cirad.fr
3/ Future orientations of the cropping systems’ design

3.2/ Other technical evolutions

1/ Safrinhas

2/ Livestock association

Year 1

- "scattered" rains
- heavy rains

Year 2

- "scattered" rains
- heavy rains

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>heavy rains</td>
<td>heavy rains</td>
</tr>
<tr>
<td>&quot;scattered&quot;</td>
<td>&quot;scattered&quot;</td>
</tr>
<tr>
<td>rains</td>
<td>rains</td>
</tr>
</tbody>
</table>

- Brach.
- Soybean sc
- Sorgho + Stylo
- Stylo.

- Maize + Brach.
- Brach.
- Soybean + Stylo.
- Brach.

- Brach.
- Soybean mc
- Brach.
- Stylo.

- Maize + Brach.
- Brach.

- Brach.
- Maize + Brach.

- Brach.
- Maize + Brach.

- Brach.
- Soybean + Stylo.

- Brach.
- Maize + Brach.

- Brach.
- Maize + Brach.

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- Brach.
- Soybean + Stylo.

- Brach.
- Maize + Brach.

- Brach.
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- Brach.
- Soybean + Stylo.

- Brach.
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- Brach.
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- Soybean + Stylo.

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- Brach.
- Soybean + Stylo.

- Brach.
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- Maize + Brach.

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- Maize + Brach.

- Brach.
- Maize + Brach.

- Brach.
- Soybean + Stylo.
### 3/ Future orientations of the cropping systems’ design

#### 3.3/ Medium term agronomical evolutions

**Back to annual crops as Bio-pump sc**

#### Year 1

<table>
<thead>
<tr>
<th>Month</th>
<th>&quot;scattered&quot; rains</th>
<th>heavy rains</th>
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</thead>
<tbody>
<tr>
<td>Mar.</td>
<td></td>
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<tr>
<td>April</td>
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<td>May</td>
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<td>June</td>
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<td>July</td>
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<td>Nov.</td>
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<td>Dec.</td>
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#### Year 2

<table>
<thead>
<tr>
<th>Month</th>
<th>&quot;scattered&quot; rains</th>
<th>heavy rains</th>
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<tbody>
<tr>
<td>Mar.</td>
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<td>Dec.</td>
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#### Crop rotations

- **Mix sp.**
- **Soybean sc**
- **Sorgho + mix sp.**
- **Mix sp. regrowth**
- **Maize + mix sp.**
- **Mix sp.**

**Mix sp.**

**Soybean mc**

**Sorgho + mix sp.**

**Mix sp. regrowth**

**Maize + mix sp.**

**Mix sp.**

**Increase the sp.-diversity in the cropping systems**

**Integrate “functionalities” (ecological engineering)**

**Work toward agro-chemicals reduction**

**in order to**

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## Conclusion

Parallel between DMC Creation and DMC Adoption sequences

<table>
<thead>
<tr>
<th>STAGE 1</th>
<th>STAGE 2</th>
<th>STAGE 3</th>
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</thead>
<tbody>
<tr>
<td><strong>CREATION</strong></td>
<td><strong>ADOPTION</strong></td>
<td><strong>DMC farmer</strong></td>
</tr>
<tr>
<td><strong>Bio-pump sc</strong></td>
<td><strong>Year 1</strong></td>
<td><strong>Transition to No Tillage</strong></td>
</tr>
<tr>
<td>Weak &amp; uncertain C input</td>
<td>Year 1</td>
<td>Transition to No Tillage</td>
</tr>
</tbody>
</table>
| Simple management | Entrance in DMC | Rapid improvement of soil’s condition (weeds, physical, chem)
| High & secured C input | Year 2 to # 5 | Diversified & flexible management |
| Weak diversity in the rotation | Rapid improvement of soil’s condition (weeds, physical, chem) | High quality product in fully protected environment |
| Simple management | Rapid improvement of soil’s condition (weeds, physical, chem) | High quality product in fully protected environment |
| Mix annual sp. | Year 6 … | High quality product in fully protected environment |

Limited choice of technical proposal to farmers

Thank you for your attention