Integrated Soil Fertility Management (ISFM) in Sub-Saharan Africa: Concepts and practice

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ISFM is...
ISFM is not...
This is not about ‘rocket science’…
... or dogma’s

**Conservation Agriculture**

**Evergreen Agriculture**

“Evergreen agriculture allows us to glimpse a future of more environmentally benign farming where much of our annual food crop production occurs under a full canopy of trees.”

Dr Dennis Garrity, Director General, World Agroforestry Centre

**‘Pull’**
Volatile chemicals from Napier border attract moths to lay eggs

**‘Push’**
Volatile chemicals from Desmodium intercrop repel moths

Chemicals (isoflavones) secreted by desmodium roots inhibit attachment of striga to maize roots and cause suicidal germination of striga seed in soil

**Organic**

**Conventional**
... but about applying good soil management principles derived through the application of the standard rules of scientific discovery!
Farming in sub-Saharan Africa is a complex venture
Old and degraded soils...
Poor infrastructure…
… expensive inputs!
Many factors affect crop yield...

- **Yield-defining factors**
  - Temperature
  - Radiation
  - Crop characteristics

- **Yield-limiting factors**
  - Nutrients
  - Water
  - Labour

- **Yield-reducing factors**
  - Pests, diseases and weeds
  - Pollutants

- **Production situation**
  - Potential yield
  - Attainable yield
  - Actual yield

- **Production level**
  - Available food
  - Post-harvest to marketing
  - Post-harvest losses
Small farms...  
... poor people!
Small farms…
… eternally poor people?

Land (hectare) required to produce 1 USD/day as a function of net returns from crop production

Harris et al, 2012
Variability in soil fertility...

Same farm...
Same variety...
Same inputs...
Same management...
Same weather...

Good soil

Poor soil
Variation in farmer’s resources, ambitions and risk-taking abilities

Tytonnell et al, 2011
Densely populated areas: Intensification
Forested areas: Intensification or expansion?
It is possible!

Maize in Kenya

Millet in Niger
ISFM: Potential solutions based on good practices
No fertilizer, no intensification…

India: Evolution of Fertilizer Consumption and Cereal Yields

SSA: Evolution of Fertilizer Consumption and Cereal Yields

IFA, 2001
Universal principles of nutrient management

Management intensity (planting date, crop density, time of P application); Tinfouga, Mali

Maize grain yield (kg/ha)

- Low management
- Medium management
- High management

- Control (no fertilizer applied)
- Fertilizer applied

Bationo et al., 1997
Improved germplasm: matching better nutrient supply with better demand

Maize yield in East DR Congo

Maize yield (kg ha\(^{-1}\))

- **SED\(^*\)** (variety effect)
- **SED\(^{**}\)** (fertilizer)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Without Fertilizer</th>
<th>With Fertilizer</th>
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<tbody>
<tr>
<td>Kasaï</td>
<td>SED(^*): 3.1</td>
<td>SED(^{**}): 3.2</td>
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<tr>
<td>Kuleni</td>
<td>SED(^*): 5.6</td>
<td>SED(^{**}): 5.6</td>
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<tr>
<td>BH140</td>
<td>SED(^*): 3.3</td>
<td>SED(^{**}): 3.3</td>
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<td>BH540</td>
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Co-application of fertilizer and organic inputs

Total millet dry matter yield as affected by long-term application of crop residues and fertilizer, Sadore, Niger

- Control
- Crop residues
- Fertilizer
- Crop residues + fertilizer

Year


Dry matter / N applied (kg kg⁻¹)

without crop residues

with crop residues

0 20 40 60 80 100 120
But fertilizer is often not enough...

Manure + N

N+P Fertilizer
Variability in response to fertilizer...

Non-responsive soils
Integrated Soil Fertility Management

‘The application of soil fertility management practices, and the knowledge to adapt these to local conditions, which maximize fertilizer and organic resource use efficiency and crop productivity. These practices necessarily include appropriate fertilizer and organic input management in combination with the utilization of improved germplasm’
Integrated Soil Fertility Management

Agronomic efficiency

Increase in knowledge

Responsive soils

Poor, less-responsive soils

Current practice

Germplasm & fertilizer

Germplasm & fertilizer’ + Organic resource mgt

Germplasm & fertilizer + Organic resource mgt + Local adaptation

‘Full ISFM’

Move towards ISFM

A

B

C
ISFM works for maize-based systems!

Vanlauwe et al, PLSO, 2011
ISFM works for maize-based systems!

Vanlauwe et al, PLISO, 2011
Long term trials as essential components of an intensification strategy

Is fertilizer used in the context of ISFM a valid entry point towards sustainable system intensification?
ISFM vs CA: Complementarity steps towards sustainable intensification?
Principles of Conservation Agriculture

1. Minimize soil disturbance by reduced or zero-tillage

2. Keep the soil covered with organic materials (crop harvest residues or cover crops) – at least 30% soil cover

3. Use crop rotations/associations

Important additional rule: No minimal tillage without mulch retention!
Transition Phases - Conventional to Conservation Agriculture

http://www.fao.org/ag/ca/5.html
## Potential benefits of CA

<table>
<thead>
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<th>SOM</th>
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<tbody>
<tr>
<td>Aggregation</td>
<td>↑</td>
</tr>
<tr>
<td>Compaction</td>
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<tr>
<td>Surface crusting</td>
<td>↓</td>
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<tr>
<td>Infiltration</td>
<td>↑</td>
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<tr>
<td>Porosity</td>
<td>↑</td>
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<tr>
<td>Runoff/Erosion/Sedimentation</td>
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<tr>
<td>Ion/water holding capacity</td>
<td>↑</td>
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<td>Nutrient loss/imbalance</td>
<td>↓</td>
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<tr>
<td>Pesticide carryover</td>
<td>↓</td>
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<tr>
<td>Biological activity</td>
<td>↑</td>
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<tr>
<td>Weeds, insects, pathogens</td>
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<tr>
<td>Air, water quality</td>
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Coordinated Research Project on CA, facilitated by IAEA (2005 – 2010)

[Various countries and continents, systems, climates, etc]

Overall conclusions:

1. CA does not necessarily improve crop yields in the short term
2. CA does not necessarily increase soil C stocks
3. CA systems appear to have more stable yields under varying rainfall conditions [climate change adaptation]
Niches for CA

Performance (well-being)

Resources (natural, social, human)

T1

‘Stepping out’

T2

‘Stepping up’

T3

‘Hanging in’

T4

T5

X
Niches for CA
Tillage x residue management in Central Kenya

Guto et al. (2011), Agron. J.
ISFM and Conservation Agriculture
The common quest for biomass...

- Current practice
- Germplasm & fertilizer
- Organic resource mgt
- Local adaptation

Agronomic efficiency

Increase in knowledge

Responsive soils
Poor, less-responsive soils

Move towards ISFM

‘Full ISFM’
Take-home messages
This talk…

1. Smallholder farming in SSA is complex – attempts to intensify need to work within that complexity

2. Literature and field evidence shows that ISFM addresses such complexity and provides immediate benefits to farmers (beware of non-responsive soils)

3. Long term ISFM trials are required to assess sustainability aspects of ISFM interventions

4. ISFM and CA could be considered as covering different phases along smallholder intensification pathways

And…

5. Creating an enabling environment for uptake of ISFM is certainly as important as developing ISFM interventions
The African Green Revolution is achievable!
Integrated Soil Fertility Management in Africa: From Microbes to Markets

hosted by CIAT-TSBF and the University of Nairobi

22-26 October 2012, Nairobi, Kenya

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