Incorporating Biodiversity in cropping systems: consequences on productivity, local nutrition and management in tropical countries

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Global context

Specialization and intensification (through chemical industry) have induced major environmental negative impacts (soils, water, climate, biodiversity) both in northern and southern agricultures.

How to increase productivity to face the growing demand for food?
Agronomy: Need for a shift from Agrochemistry to Agroecology

Setting up an **ecologically intensive** agriculture is now a major objective for providing more and better food to populations of both the southern and northern hemispheres.

The paradigm of **ecological intensification** is based on the **optimization of biological interactions and regulations** in agroecosystems.

- How to implement ecological intensification? Which mechanisms? Which systems?
- What are the impacts of introducing Biodiversity in Agroecosystems?
- How to set/promote innovation processes based on ecological intensification?
Main Hypothesis

Yes it is possible:

• To increase production in quantity and quality

• To decrease the dependancy to chemicals

• To get a better control of bioaggressors and a better management of natural resources

• By increasing biological diversity in cropping systems (plant associations, rotations, service plants, landscape organization, etc.)

• By optimizing biological interactions in cropping systems
Which trade-offs between productivity and biodiversity?

Production loss?

Biodiversity loss?
Vegetal diversification: the main pillar of ecological intensification

- Human & environmental health
- Beneficial organisms
- Pest & disease impact
  - Soil fertility
  - Biological soil activity
  - Farm production (quantity)
  - Farm production (quality)

Agrochemistry

- Chemical pesticide & fertilizer application

Agroecology / Ecological intensification

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How to implement biodiversity and ecological intensification?
Review article

Mixing plant species in cropping systems: concepts, tools and models. A review

E. Malézieux¹ *, Y. Crozet², C. Dupraz³, M. Laurans⁴, D. Makowski⁵, H. Ozier-Lafontaine⁶, B. Rapidel¹, S. de Tourdonnet⁵, M. Valantin-Morison⁵

Plant species diversity for sustainable management of crop pests and diseases in agroecosystems: a review

Alain Ratnadass · Paula Fernandes · Jacques Avelino · Robert Habib
A radical change of perspective

• Hypothesis: stability of complex systems

• Using complementary functional attributes in terms of resource captation

• Favour positive interactions

• Optimize food networks
Natural ecosystems vs. agroecosystems

- Specific diversity
- Spatial heterogeneity, numerous interfaces
- Perennial soil cover
- Functional redundancies
- Presence of trees

Towards a mimic of natural ecosystems?

Lefroy E.C., Hobbs R.J., O’Connor M.H. and J.S. Pate (editors), 1999
Agroforestry Systems Volume 45, 446p
Agriculture as a mimic of natural Ecosystems.

Natural systems agriculture: a truly radical alternative

Agronomy Sust. Developm.
DOI 10.1007/s13593-011-0027-z

REVIEW ARTICLE

Designing cropping systems from nature

Eric Malézieux

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More complex systems

Number of cultivated species
Various forms to incorporate specific diversity at the field scale

- Plant associations (mixed cropping, agroforestry, cover crops)
- Relay cropping
- Rotations
Mixing plants with production objectives
(Re)introducing trees in the fields
Introducing cover crops in annual cropping systems

Succession with mulching

Intercropping

Relay cropping
Main impacts of introducing biodiversity in Agroecosystems
Mixing to control bioaggressors
Evaluation of trap crops for the regulation of gombo and sorghum bioaggressors (Icrisat-Cirad/Inran/UAM, station Inran Birni N’Konni, 2008)

Trap crops to control tomato pest *Helicoverpa zea*

B. Rhino (Cirad)

(from A. Ratnadass)
Mixing for resource use efficiency

Water

Carbon

Nitrogen

Modelling crop residue mulching effects on water use and production of maize under semi-arid and humid tropical conditions
Eric Scopel*, Fernando A.M. Da Silva*, Marc Corbeels*, François Afifholder*, Florent Maraux*

Soil carbon storage potential of direct seeding mulch-based cropping systems in the Cerrados of Brazil
Marc Corbeels*, Eric Scopel*, Alexandre Cardoso†, Martial Bernoux†, Jean-Marie Douzet§ and Marcos Siqueira Neto§

Cover Crop and Nitrogen Effects on Maize Productivity in No-Tillage Systems of the Brazilian Cerrados
A. Maltas, M. Corbeels*, E. Scopel, J. Wery, and F. A. Macena da Silva
Specific role of cover crops for an integrated fertility management

- Controlling erosion
- Biological N fixation
- Recycling nutrients
- Increasing SOM stocks
- Stimulating biological activity
An improvement of global efficiency of the Agroecosystem

Relay cropping of fodder crops in no tilled Maize systems (Cerrados, Brazil)
Legumes Diversification for Maize systems in Malawi

Legumes Diversification for Maize systems in Malawi

**Limited N contribution**

- Maize/legume (groundnut, soya, pigeonpea) intercrops
- Legume-legume intercrop / Maize rotation (Maize rotated with ppea/peanut or soyabeans)
- Maize /Mucuna rotation
- Maize /Agro-forestry Tephrosia intercrop

**High N contribution**
Legumes Diversification for Maize systems in Malawi

Improved child growth

Child growth in first year participating villages, participating households vs non-participating households

How to set / promote innovation processes based on biodiverse agroecosystems?
From savannahs to agroforests (from Jagoret, 2010)

From savannahs to agroforests

- **S1**: Plantation d'arbres fruitiers, Élimination partielle des palmiers, Semis de palmiers à haute densité

- **S2**: Plantation de palmiers et d'arbres fruitiers, Labour et semis de plantes annuelles

**Temps**
- T0
- -5 ans
- -2 ans
- 3 ans

**Cultures annuelles**

**Arbres forestiers**

**Arbres fruitiers**

**Cacaoyers**

**Palmiers**

**Savane**
From savannahs to agroforests (from Jagoret, 2010)

10 ans

Plantation des cacaoyers

3 ans

Redensification continue des cacaoyers et des palmiers

Réduction de la densité des arbres associés

Introduction/préservation d’arbres forestiers

S1

Savane

S2

Plantation de palmiers et d’arbres fruitiers

Labour et semis de plantes annuelles

Cacaoyers

Palmiers

Arbres forestiers

Arbres fruitiers

Cultures annuelles

Savane

From savannahs to agroforests (from Jagoret, 2010)
Main challenges for family farming:

- Agroecological systems are complex and knowledge intensive.
- They often require a transition phase before reaching a new beneficial equilibrium (long term investment).
- Family farmers need to be convinced, to be able to innovate and to face risks linked with changes.
- Technical changes have to fit with their own resources and with the dynamics of family farms in their context.
- Family farmers need to organize themselves to exchange experiences, to negotiate with private sector, markets or policy makers.
The development of EI systems needs to be progressive and participatory

Farmers should have the opportunity to share their own experience

Farmers should be direct protagonists of the EI systems development

Multiactors Co-innovation platforms
Conclusion: which Challenges for research?

- Global approaches and methods:
  - Develop systemic approach & framework
  - Develop participatory approaches and methods for co-conception and diffusion of AE innovations

- Plot and landscape level: Agroecological functioning of cropping systems
  - Optimize below and over ground regulations (competition, facilitation, predation, allelopathy)
  - Cropping system design and technical management

- Farm level:
  - Resource allocation and labour organization

- Institutional & policy issues, education and training:
  - How can policies favour EI innovation and transition?
Thank You for your attention...