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

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Ur AIDA, Ur HortSys

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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 bioagressors and a better management of natural resources

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

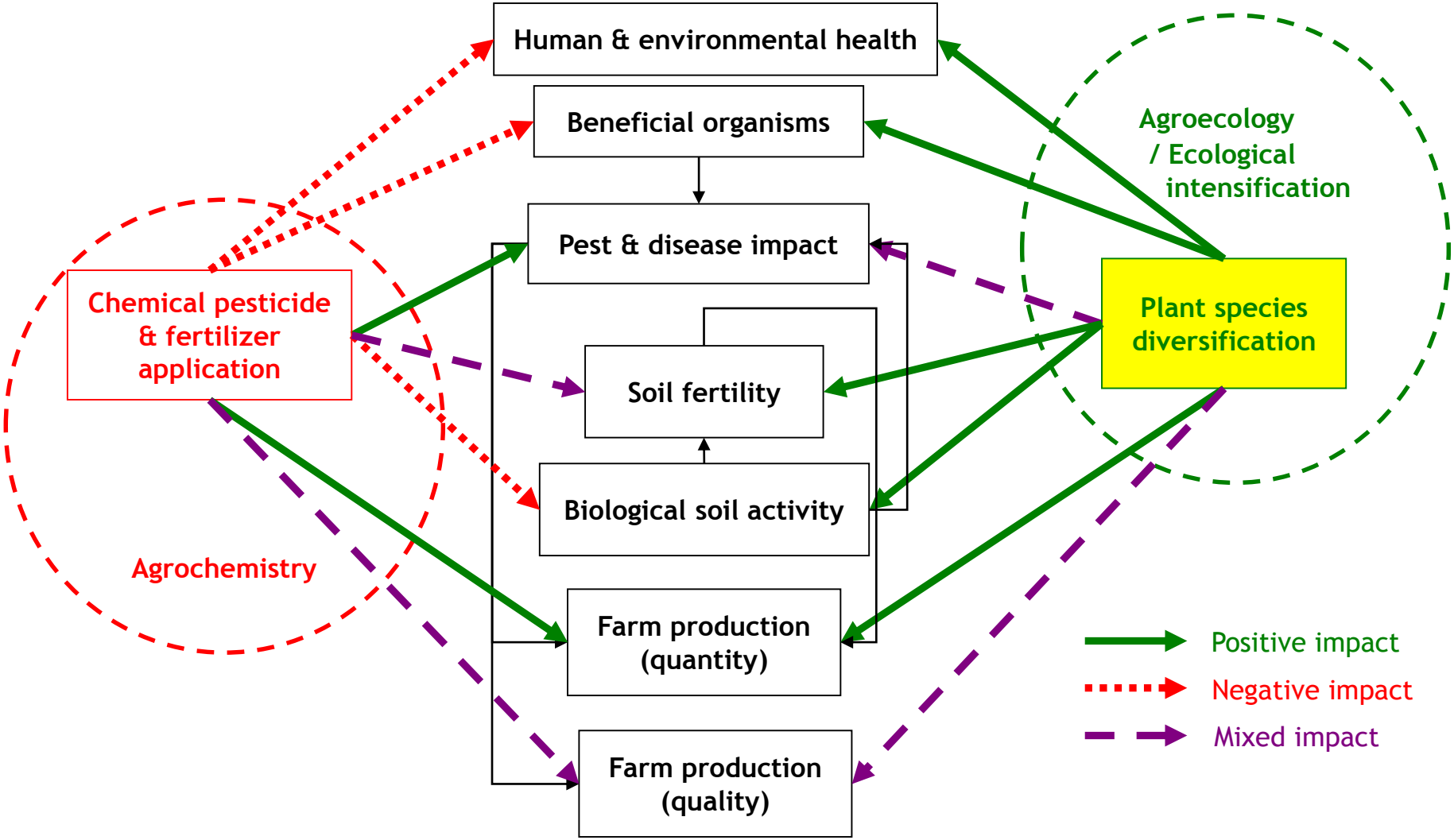
- **By optimizing biological interactions** in cropping systems

Which trade-offs between productivity and biodiversity ?

Production loss ?

Biodiversity loss ?

Vegetal diversification: the main pillar of ecological intensification



How to implement biodiversity and ecological intensification?

Agron. Sustain. Dev. 29 (2009) 43–62
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DOI: 10.1051/agro:2007057

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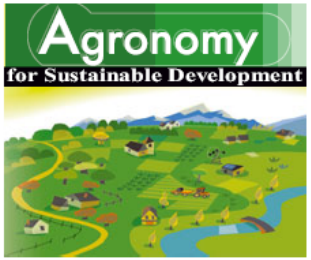


Review article

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

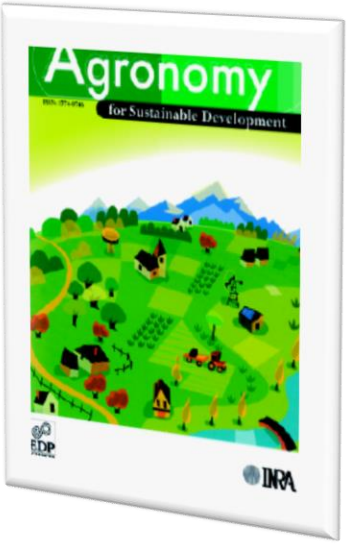
E. Malézieux[1]*, Y. Crozat[2], C. Dupraz[3], M. Laurans[4], D. Makowski[5], H. Ozier-Lafontaine[6], B. Rapidel[1,7], S. de Tourdonnet[5], M. Valantin-Morison[5]

Agronomy Sust. Developm.
DOI 10.1007/s13593-011-0022-4

REVIEW ARTICLE

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 redonduncies
- Presence of trees

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.

Wes Jackson, AEE 88 (2002) 111–117
Natural systems agriculture: a truly radical alternative

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

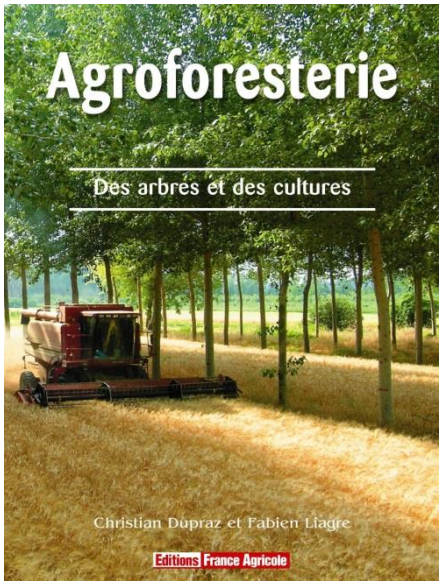
REVIEW ARTICLE

Designing cropping systems from nature

Eric Malézieux

Towards a mimic of natural ecosystems ?

More complex systems



Number of cultivated species

Various forms to incorporate specific diversity at the field scale

Space

Time

- 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

Main impacts of introducing biodiversity in Agroecosystems

Mixing to control bioagressors

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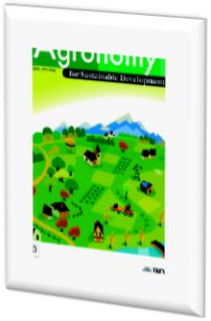
Accepted: 11 December 2010



Evaluation of trap crops for the regulation of gombo and sorghum bioagressors (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 ressource use efficiency

Water

Agronomie 24 (2004) 383–395
© INRA, EDP Sciences, 2004
DOI: 10.1051/agro:2004029

Original article

Modelling crop residue mulching effects on water use and production of maize under semi-arid and humid tropical conditions

Eric SCOPEL[a], Fernando A.M. DA SILVA[b], Marc CORBEELS[a]*, François AFFHOLDER[a], Florent MARAUX[c]

Carbon

Global Change Biology (2006) **12**, 1–15, doi: 10.1111/j.1365-2486.2006.01233.x

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¶

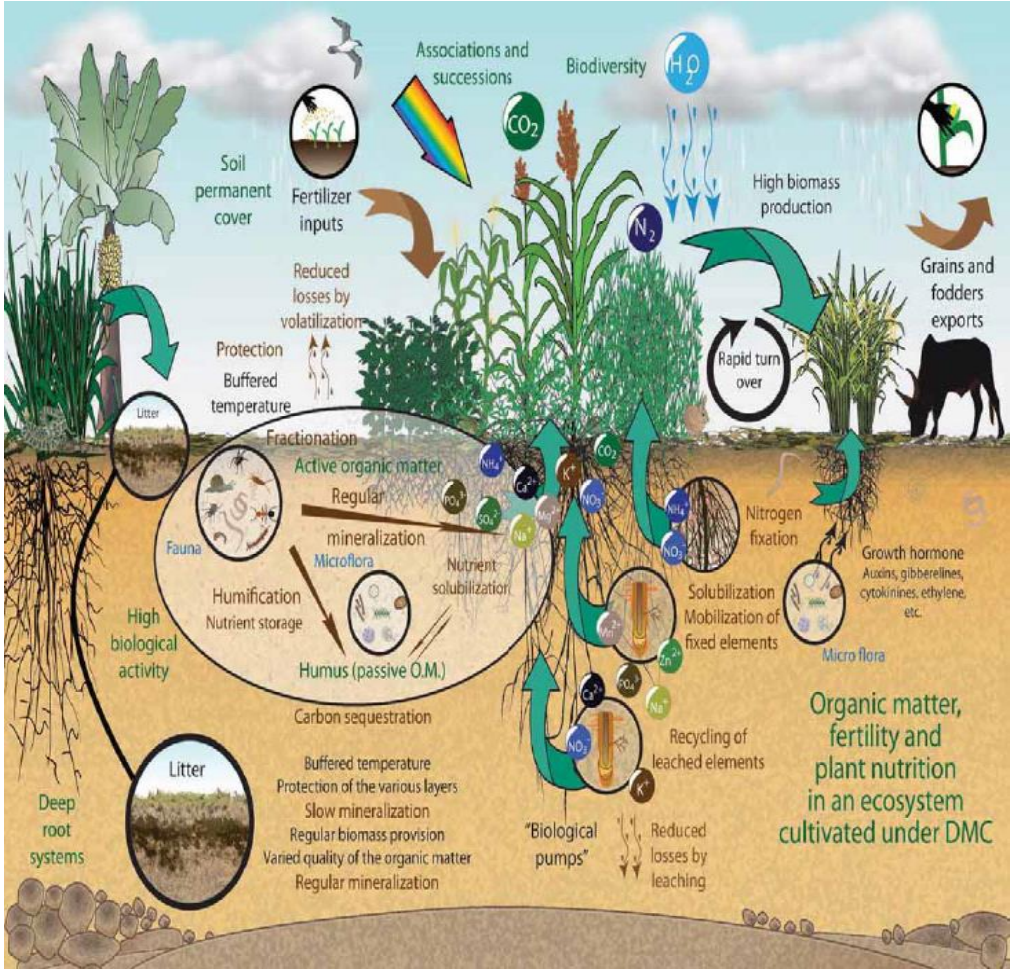
Nitrogen

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

AJ AGRONOMY JOURNAL since 1908

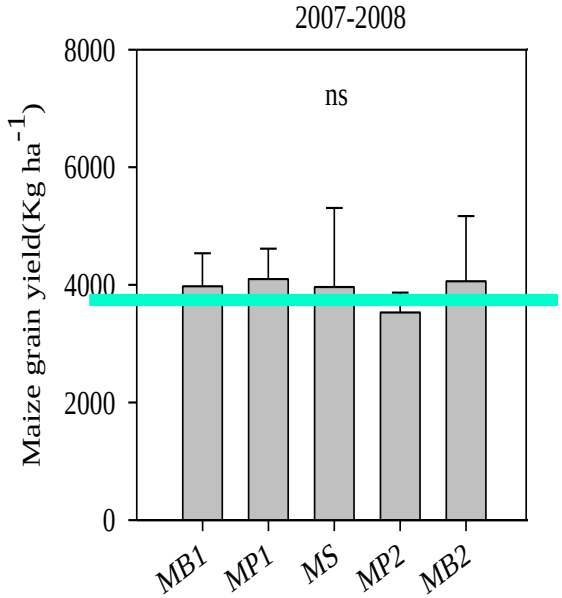
Specific role of cover crops for an integrated fertility management

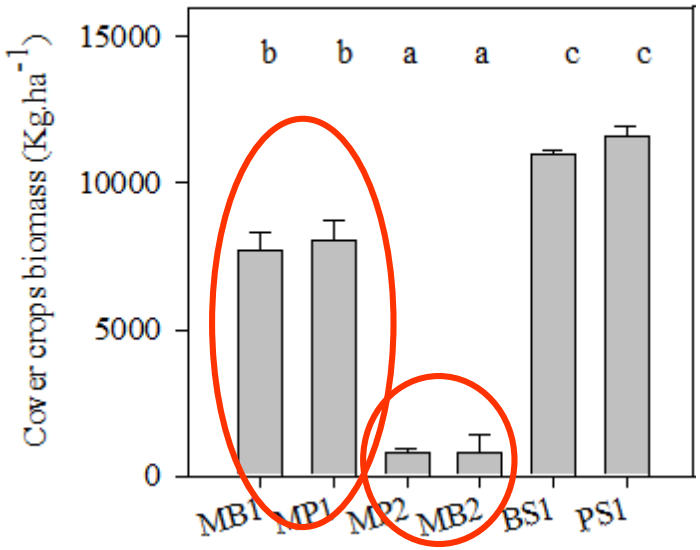


- Controling erosion
- Biological N fixation
- Recycling nutrients
- Increasing SOM stocks
- Stimulating biological activity

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

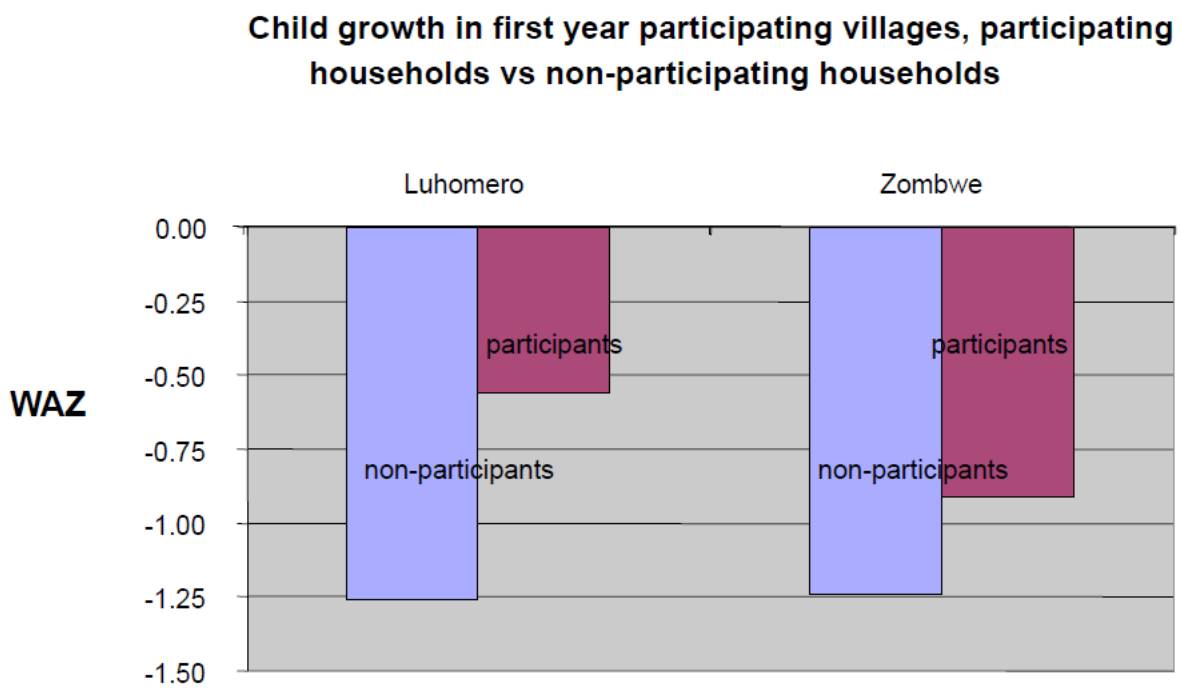
Limited N contribution

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

High N contribution

Legumes Diversification for Maize systems in Malawi

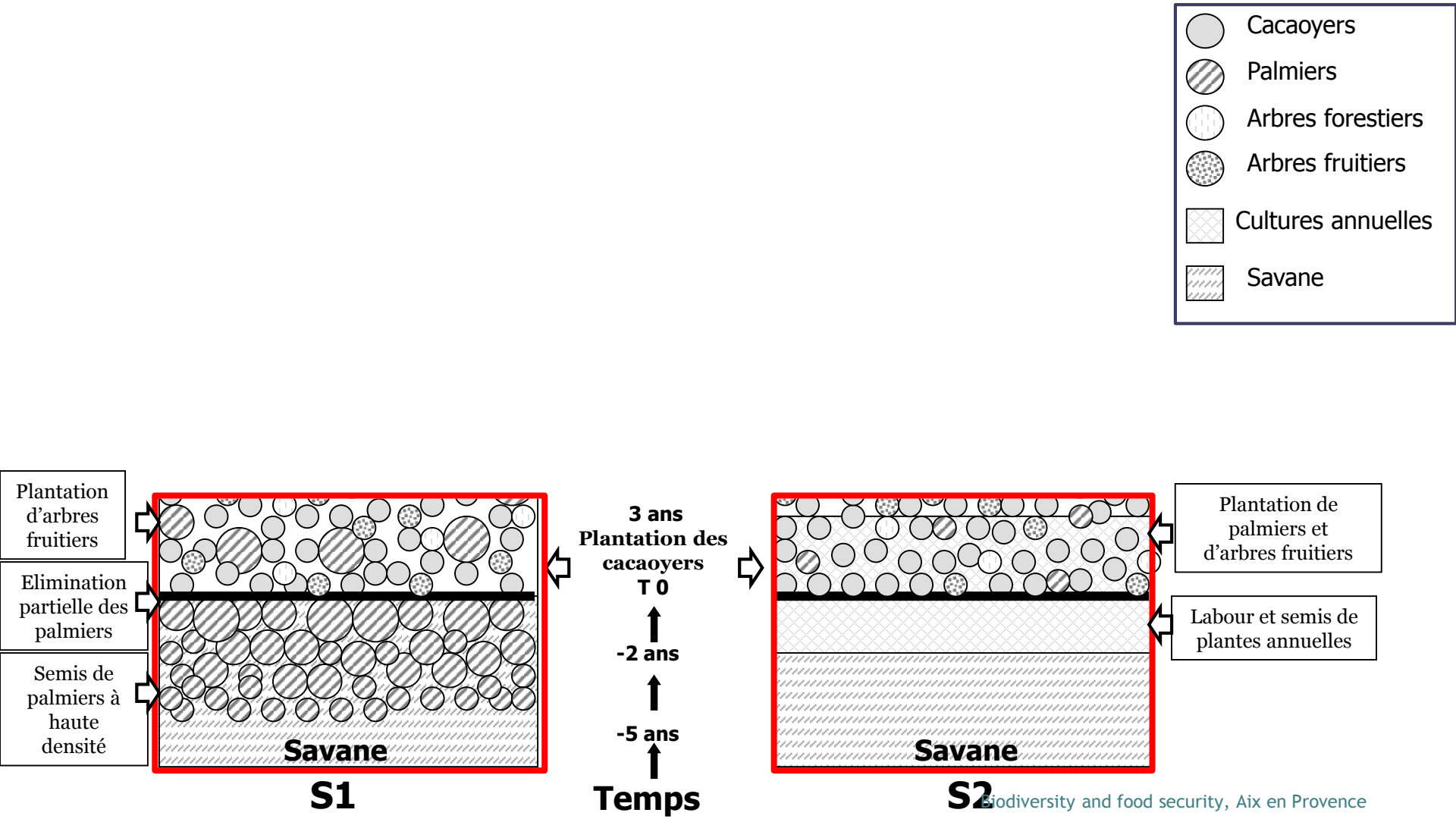
Improved child growth



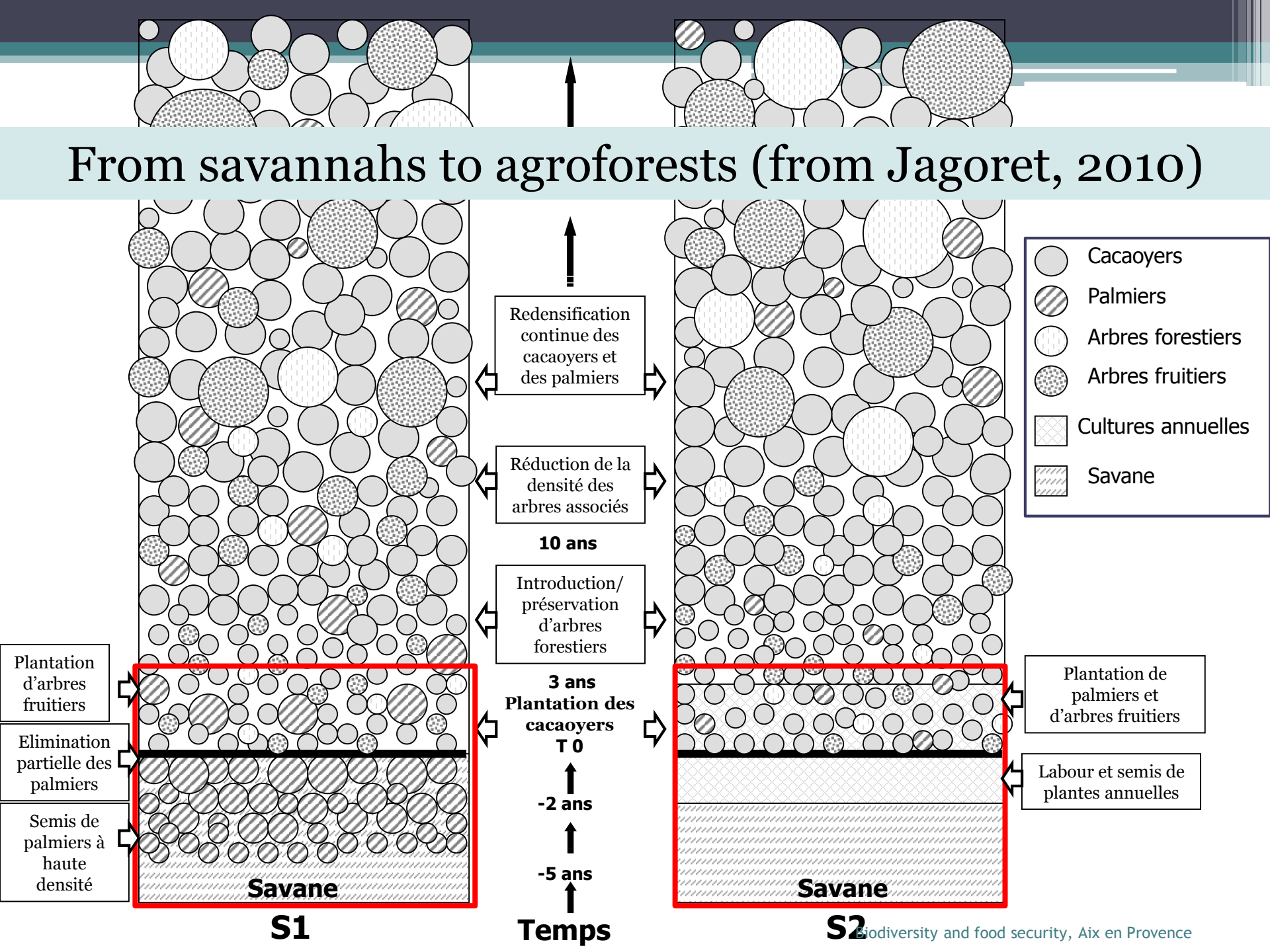
Source: Bezner Kerr, R., BerM, P.R. and Shumba, L. (2010) 'Effects of Participatory Agriculture and Nutrition Project on Child Growth in Northern Malawi' *Public Health Nutrition* 14(8):1466---1472

How to set / promote innovation processes based on biodiverse agroecosystems?

From savannahs to agroforests (from Jagoret, 2010)



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 be direct protagonists of the EI systems development

Multiactors Co-innovation platforms

Farmers should have the opportunity to share their own experience

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…