

EPITAG – EPIdemiological modelling and control for Tropical AGriculture

LIRIMA team 2017–2019



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BIOCORE, Inria Sophia Antipolis
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LIRIMA Scientific Days, Tunis, September 12th 2017

Who are we?



BIOCORE

- Suzanne TOUZEAU (INRA)
- Jean-Luc GOUZÉ
- Frédéric GROGNARD
- Ludovic MAILLERET (INRA)
- Samuel NILUSMAS (INRA, PhD 2016-19)

Other participants

- ▶ Yves DUMONT (CIRAD)
- ▶ Gauthier SALLET (emeritus)



Cameroon

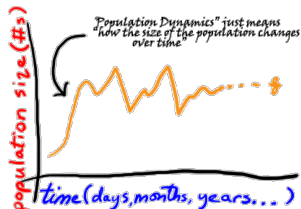
- Samuel BOWONG (Douala)
- Jean-Jules TEWA (Yaoundé 1)
- Berge TSANOU (Dschang)
- Joseph MBANG (Yaoundé 1)
- Émile MINYAKA (Douala)
- Myriam DJOUKWE TAPI (Douala, PhD 2014-17)
- Israel TANKAM (Yaoundé 1, PhD 2016-19)
- Yves FOTSO FOTSO (Dschang, PhD 2016-19)

In short



French & Cameroonian researchers

with a background in **dynamical systems**
and **control**



D. Coyne

and an interest in **crop diseases**

Before EPITAG

2010–2015 GRIMCAPE – Modeling, Analysis and Simulation in Epidemiology and Immunology, LIRIMA team, Univ.Yaoundé 1 (S. BOWONG) & MASAIE (G. SALLET)



2013–2017 Joint PhD supervision (S. BOWONG, J.-J. TEWA, Y. DUMONT): Myriam DJOUKWE, Alexis TAMEN TCHUINTE, Valaire YATAT DJEUMEN

April 2015 Samuel BOWONG invited in the BIOCORE team

Sept. 2016 **CIMPA–CETIC research school** on Mathematical modelling in life sciences, Yaoundé
EPITAG members among the organisers and lecturers

➔ **EPITAG**, with a focus on **crop epidemiology**

Why EPITAG?

Context

- Pests destroy 40% of the food supply and cash crops every year
- 50% of the world production is lost before or after harvest
- ➔ *Controlling crop pests is a major issue*
Cameroon: agriculture is a major sector for revenues and employment

Control methods

- ▶ **Pesticides:** high financial and environmental cost, health issues
- ▶ **Alternatives:** cropping practices, biological control, plant resistance

Why models?

- ▶ complement field studies (costly and time-consuming)
- ▶ formalise and integrate knowledge
- ▶ help design efficient strategies for integrated pest management

What do we do?

Aims

Study the epidemiology and management of tropical crop diseases, with a focus on Cameroon and Sub-Saharan Africa

Approach

Developing and analysing **dynamical models** to:

1. understand the plant–parasite interactions
2. identify relevant parameters
3. predict the evolution of damages
4. provide efficient and sustainable control strategies to limit damages

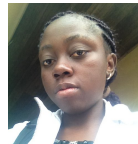
Challenge = **relevance of our models**

➡ Collaborations with field experts and involvement of “end users”

Applications

T1. Cocoa plant mirids

(S. BOWONG, L. BAGNY-BEILHE, Y. DUMONT)



T2. Plantain plant-parasitic nematodes

(J.-J. TEWA, F. GROGNARD, S. TOUZEAU)



T3. Coffee berry borers

(S. BOWONG, B. TSANOU, L. MAILLERET,
S. TOUZEAU)



T1. Cocoa plant mirids



- Major cash crop – Cameroon: 5th largest producer
 - Mirids (*Sahlbergella singularis*) feed on and damage young pods and shoots, most dangerous insects
 - Control: insecticides ↔ mating disruption, trapping
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- Complex production model [Zuidema *et al.* 2005], no dynamical models for mirids
 - Partners: CIRAD and IRAD

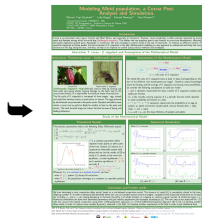
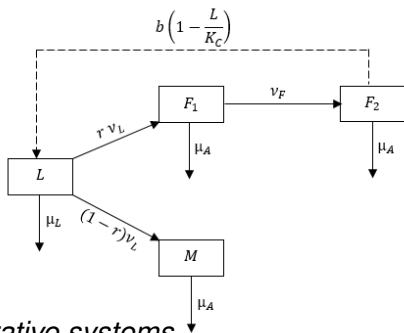
T1. Achieved in 2017

Mirid population dynamic model

(**L**arvae, **M**ales & **F**emales: 1 immature, 2 mature – K_c carrying capacity depending on pod availability)

with time-delays

- *Model analysis based on cooperative systems (conditions for mirid persistence)*
- *Implications in terms of control*

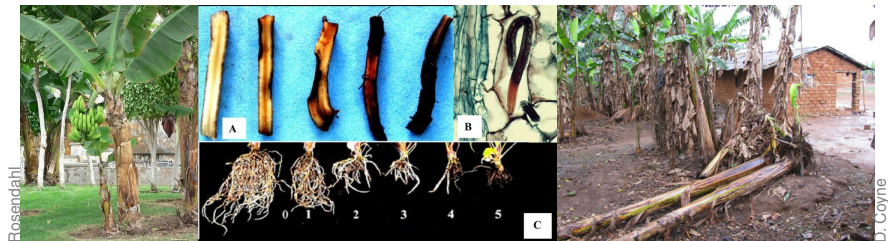


BIOMATH 2017

+

M. Tapi Djouke, L. Bagny Beihle, S. Bowong, Y. Dumont, Modeling Miridae population, a Cocoa Pest. Analysis and Simulation. Submitted to *Mathematical Methods in the Applied Sciences*, 2017.

T2. Plantain plant-parasitic nematodes



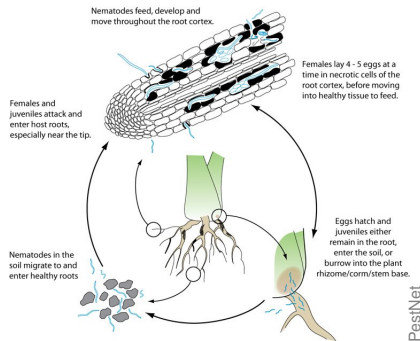
A: [Jesus, Agron Sustain Dev 2014]; B: M. MacClure, Univ. Arizona; C: [Zhang, EJPP 2012]

- Major staple food – Cameroon: 2% GDP
 - Nematodes (*Radopholus similis*) create root lesions and induce great damages (banana toppling)
 - Control: nematicides ↔ cropping practices (soil sanitation), tolerant or resistant banana varieties, biological control
-
- Complex interaction model for the West Indies [Tixier *et al.* 2006]
 - Partners: CIRAD and CARBAP

T2. Ongoing in 2017

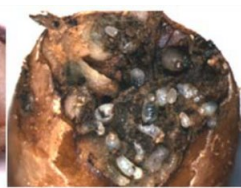
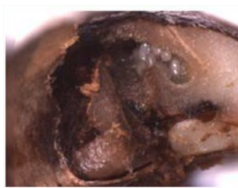
Israel had courses in 2016

Ongoing work: **plantain-nematode interaction model**,
including root growth, based on the nematode life-cycle:



► *Non autonomous ODE or hybrid model (inter-crop season)*

T3. Coffee berry borers



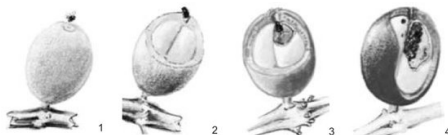
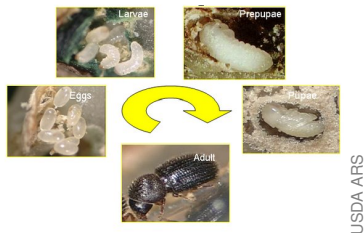
[Burbano, JIS 2011]

- Economic foundation for many countries in the tropics
 - Borers (*Hypothenemus hampei*) mostly develop in the coffee berries, inducing great crop losses (most important pest)
 - Control: insecticides ↔ cropping practices (removing all berries), trapping, biological control (parasitoids, fungi)
-
- Simulation model with crop growth and pest control [Gutierrez *et al.* 1998; Rodríguez *et al.* 2011; Rodríguez *et al.* 2013]
 - Partners: CIRAD and IRAD

T3. Ongoing in 2017

Yves had courses in 2017

Ongoing work: **coffee berry borer dynamic model**,
including berry availability, based on the insect life-cycle:

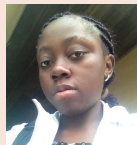


► *PDE or ODE model with impulse control*

[Jaramillo, B Entomol Res 2006]

Visits in 2017

May–July 2017 Myriam DJOUKWE TAPI
CIRAD Montpellier
+ seminars at Inria and INRA, Sophia Antipolis



Sep.–Dec. 2017 Israël TANKAM & Yves FOTSO
BIOCORE, Inria, Sophia Antipolis



*Partial funding from **IRD** via **UMMISCO** (Unité Mixte Internationale de Modélisation Mathématique et Informatiques des Systèmes Complexes)*

What next?

Ongoing PhD theses

- ▶ represent crop damages
- ▶ design efficient and sustainable control strategies to limit damages
- ▶ assess the model relevance, confront the model to field data

Visits

- ▶ New **stays in BIOCORE** in 2018 (4 months) for Israël TANKAM & Yves FOTSO
- ▶ Visits to Cameroon : Suzanne TOUZEAU, Samuel NILUSMAS, Ludovic MAILLERET...
- ▶ Visits to France : Samuel BOWONG, Jean-Jules TEWA, a new master student...

That's all... for now!