CoLosses: Assessment of primary and secondary coffee yield losses due to pests and diseases

DEVELOPING A METHODOLOGY FOR PERENNIAL CROPS

ALLINNE CLÉMENTINE, AVELINO JACQUES, CERDA ROLANDO, ESTHER LECHEVALLIER, LOUISE KROLCZYK, CHARLIE MATHIOT, EUGÉNIE CLÉMENT

Séminaire SMACH – 1er septembre 2015
Assessment of primary and secondary coffee yield losses due to pests and diseases

Titre long : Developing a methodology for the assessment of primary and secondary yield losses due to pests and diseases on perennial crops: the case of coffee

 Coordinateurs du projets, chercheurs et équipes impliqués :

- Allinne Clémentine (CIRAD UMR SYSTEM),
- Avelino Jacques (CIRAD UR106)
- Cerda Rolando (CIRAD UMR SYSTEM)
- Rapidel Bruno (CIRAD UMR SYSTEM)
- De Melo Elias (CATIE)
- Luis Salazar (UCR)

Partenaires impliqués : CIRAD, CATIE (Costa-Rica),
Why modelling and estimating yield losses of coffee?

- Quantifying and valuing pest and disease control services as a function of crop losses and economic losses = avoided crop losses
What is the contribution of CoLosses?

- For coffee, the assessment of yield losses is difficult due to:
  - The biennial production cycle of the crop
  - The complexity of agroecosystems where coffee is grown
  - The existence of primary and secondary yield losses (Zadoks & Schein, 1979)

→ A better understanding of the impact of P&D on primary and secondary coffee yield losses

→ A conceptual model to identify the main factors that determine coffee yield losses.
Materials and Methods: trial

- full sun exposure (5000 plants ha-1)
- six treatments x four replicates (40 m2)
- different sequences of fungicide applications are compared, with a duration of three years
Materials and Methods: measurement

- In each of coffee plot six coffee plants were marked for measurements:
  - Number of fruiting nodes per plant
  - Number of fruits per node
  - Number of branches per plant
  - Number of dead branches per plant
  - Yield: Coffee yield (grams of coffee cherries per plant)
  - Severity of diseases in leaves (scale 0-6) (each month)
  - Incidence = % affected leaf (each month)
Materials and Methods: Microclimatic data collection

- Plot temperature and relative humidity measurement
- Leaf temperature and leaf wetness measurement
Materials and Methods: Studied variables

- Studied variables
  - NFNPlant: Number of fruiting nodes per plant
  - NFNode: Number of fruits per node
  - FL: Fruit load (=NFNPlant x NFNode)
  - PDeadB: Percentage of dead branches
  - DeadB: Number of dead branches per plant
  - Yield: Coffee yield (grams of coffee cherries per plant)
  - Max_Sev: Maximum of severity of diseases in leaves
  - sAUDPC_R: standardized Area Under the Disease Progress Curve (% day-1)

- at the end of each year we obtain the attainable yields (Yatt) and the actual yields (Yac)
- yield losses, whose differences represent primary or secondary losses
- Yield loss = ((Yatt – Yac)/Yatt)*100%
Preliminary results: Yield losses assessment

Primary and Secondary Losses:

Primary Losses:
$$\frac{(3397-1931)}{3397} \times 100 = 43\%$$

Secondary Losses:
$$\frac{(3397-2125)}{3397} \times 100 = 37\%$$

Primary Losses + Secondary Loss = 0

(co-variable: Fruiting load 2013 and soil acidity)

Primary and Secondary Losses:
$$\frac{(3397-1823)}{3397} \times 100 = 46\%$$
Preliminary results: Yield losses assessment

% Dead branches

# Fruits/plant

INRA
SCIENCE & IMPACT
Results: Cumulated Pests and Diseases

- Primary and secondary yield losses dynamic depend on the initial state of the plant
  → Microclimat
  → Taking into account the Y (n) x Y (n+1) interaction

- Problem to assess losses by chemical treatment comparison
  → modelling
Preliminary results: Correlations and conceptual model

Matrix of correlations (Spearman) among variables that determine yields

- Fruit load in 2013 influenced negatively the fruit load in 2014
- Higher yield components caused higher sAUDPC
- Yield ~ yield determinant - dead branches
- Dead branches had positive correlations specially with severity of diseases
- Dead branches of 2013 influenced negatively the yield components in 2014

→ Dead branches are an indicator of primary and secondary yield losses
Preliminary results: Correlations and conceptual model

- Conceptual model to assess primary and secondary yield losses of coffee.

![](image-url)
Preliminary results: Correlations and conceptual model

- Conceptual model to assess primary and secondary yield losses of coffee.

Yield determinant and injury profile depend on the previous year

Next step: Structural equation modeling
Results: Model representing coffee actual yield

- **model with 5 variables:**
  \[
  \sqrt{\text{Yield}} \sim \text{NFN}_{\text{plant}} + \text{NFNode} + \text{DeadB} + \text{PDeadB} + \text{AUDPCc}_\text{cerc} + \text{AUDPCc}_\text{ins}
  \]

- **model with 3 variables:**
  \[
  \sqrt{\text{Cosecha}} \sim \text{NFN}_{\text{plant}} + \text{NFNode} + \text{DeadB}
  \]

\[
Y_{ac} = \left(16.464 + 0.04359 \times \text{NFN}_{\text{plant}}\right) + \left(3.24156 \times \text{NFNode}\right) - \left(0.11284 \times \text{DeadB}\right)
\]

\(Y_{ac}\): actual yield (grams of coffee cherries per plant); \(\text{NFN}_{\text{plant}}\): number of fruiting nodes per plant; \(\text{NFNode}\): number of fruits per node; \(\text{DeadB}\): maximum number of dead branches
Results: Estimation of yield loss by modelling

- Model to estimate actual yield (Yac):

\[ Y_{ac} = (16.464 + (0.04359 \times NFN_{plant}) + (3.24156 \times NFN_{node}) - (0.11284 \times \text{DeadB})^2 \]

- Model to estimate attainable yield (Yatt):

\[ Y_{ac} = (16.464 + (0.04359 \times NFN_{plant}) + (3.24156 \times NFN_{node}) )^2 \]

- Estimation of yield loss (YL):

\[ YL = \frac{(Y_{att} - Y_{ac})}{Y_{att}} \times 100\% \]
Yield losses assessment to compare the performance of agroecosystems
International dimension of CoLosses

- Conservation International
- CATIE

The CASCADE Project
Ecosystem-based Adaptation for Smallholder Subsistence and Coffee Farming Communities in Central America

In Central America, smallholder farmers are at the heart of the agricultural sector, and many of them depend directly on natural ecosystems for the provision of water, soil conservation, pest control and other services.

- Better understanding of the climate change impacts and the vulnerability of ecosystem services, agricultural production and livelihoods
- Identification of strategies used by smallholder farmers to adapt to climate variability
- Better understanding of the effectiveness of EbA strategies
- Development of training materials on EbA approaches and on its application to smallholder farming communities
- Improvement in the capacity of relevant institutions to promote EbA strategies
- Political and economic analysis to help promote EbA strategies
- Dissemination of project results to a wide set of stakeholders and decision-makers at various levels
CASCADE project: network of 69 plots

2 topoclimatic levels: LOW: <850 msnm/HIGH: >850 msnm

\[ \times \]

4 shade types

\[ \times \]

2 management intensity levels: HIGH/LOW

\[ = \]

69 plots

2014-2015
Common issues with the other DAMAGE projects

- MODQUAL, COLOSSES, QMPV
  - Losses assessment on perennial crop
  - Quantity and quality evaluation
  - How valuate the economic losses?

- Pesticide use reduction → program of payment for ecosystem services
For more information

Contacts:
Clementine ALLINNE
Jacques Avelino
Rolando cerda

Mails:
clementine.allinne@cirad.fr
jacques.avelino@cirad.fr
rcerda@catie.ac.cr

Site Web: CASCADE project
http://www.conservation.org/projects/Pages/cascade-program.aspx