Multi-pest regulation for the compensation of the yield losses due to competition in bananas

A theoretical modelling approach to design sustainable management strategies

Charlotte Poeydebat, Dominique Carval, Luc De Lapeyre De Bellaire, Philippe Tixier

Banana Pineapple & Plantain Cropping Systems Research Unit, CIRAD

OBJECTIVES

- To understand the **interactions between pest regulation and the competition for the resources** at the plant scale in multi-species cropping systems
- To test the interest of a **theoretical modelling approach** :
  - To **quantify the pest regulation service** that multi-species cropping systems should provide to compensate for the competition
  - To **design sustainable pest management strategies**

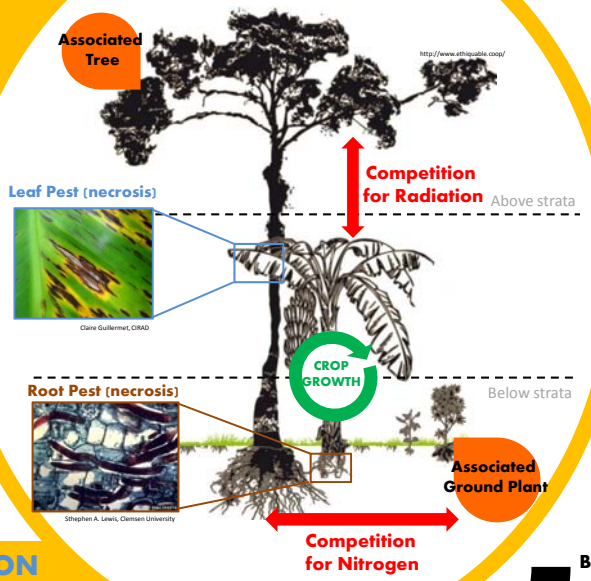
PESTS & ASSOCIATED PLANTS INTERACTIONS

Pests and associated plants both have negative impact on the **biomass production,** through the **reduction of light or nitrogen crop potential uptake**

Shading and leaf necrosis cause a ↘ of intercepted light which in turn cause a ↘ of biomass and thus a ↘ of N demand
This can lead to a **delay in nitrogen stress occurrence** or a **minor nitrogen stress, paradoxically reducing yield losses**

Simulation of different **scenarios of cropping system diversification**

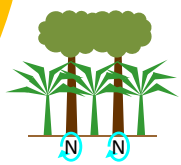
MULTI-STRATA SIMPLE THEORETICAL MODEL



Different profiles of resource interception

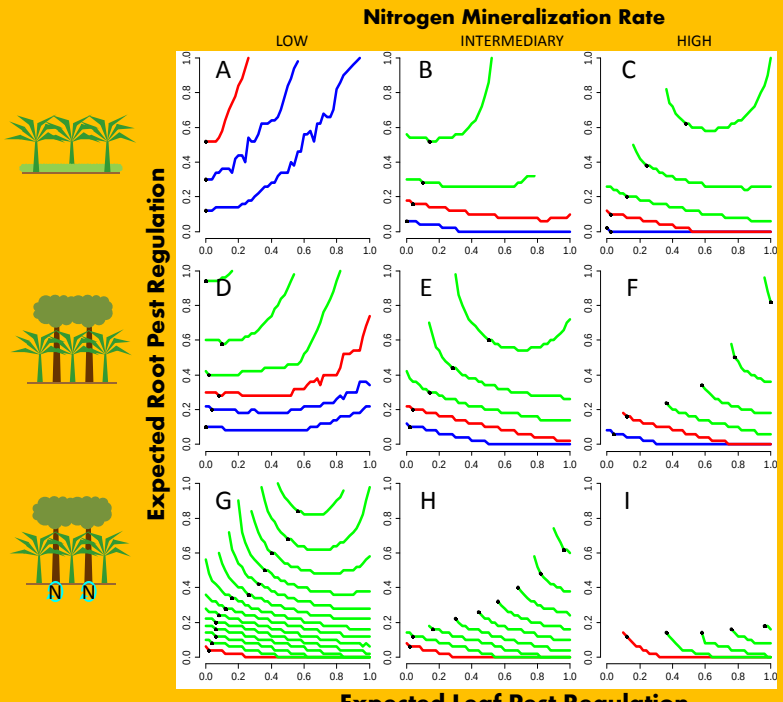
Banana with Ground Plant
Interception of Nitrogen

Banana with Tree
Interception of light and Nitrogen



Banana with N fixing Tree
Interception of light

COMBINATIONS OF LEAF AND ROOT PEST REGULATION LEVELS EXPECTED TO REACH A GIVEN YIELD LEVEL

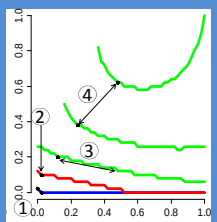


Comparison with the banana monoculture under **different Nitrogen mineralization rates**

RESULTS

- The most often, leaf and root pest regulations are negatively correlated ➔ possible **trade-offs between ecosystem regulation services**
- In high fertility conditions (C, F and I) or in the case of the highest yield levels (in C, E, F and G), the two pest regulations can become positively correlated ➔ **no possible trade-offs**, poorly interesting strategies
- In A (low mineralization rate, nitrogen competition and no growth reduction by shading), Yref is achievable only at a high cost and higher yield levels are impossible to reach ➔ **association with ground plant very costly in terms of pest regulation**
- To reach a given yield level, the three cropping systems perform differently when considering the strategy of minimizing both pest regulations ➔ **N fixing tree is the most efficient** (smallest pest regulation levels), followed by Tree and ground plant
- N fixing tree is the association **the most sensitive to pest regulation levels** (smallest pest regulation change to reach upper yield level)

How to understand the figure ?



● Corresponds to the combination minimizing both leaf and root pest regulation levels (minimum Euclidean distance with reference to the origin or the plot = no regulation as in the reference scenario)

The isoclines represent all the possible combinations of leaf and root pest regulation levels expected to reach :

- Monoculture without regulation yield level Yref
- Higher yield levels + 40% Yref each time
- Lower yield levels – 40 % Yref each time

1. Zero Pest regulation = Reference = Monoculture without pest regulation
2. Strategy = **Minimizing both pest regulation levels to reach the yield of the monoculture** without pest regulation
3. Moving the point along the isocline = **Choosing a pest management strategy**
4. Gap between isoclines = pest regulation effort needed to increase yield by 40%

CONCLUSIONS

Our theoretical modelling approach enables :

- To generate **knowledge** about the **generic rules of interaction between associated plant and pest regulation**
- To **quantify the expected pest regulation service** to reach a given yield level

Furthermore, it can help :

- To **evaluate the regulation needs remaining at farmer's expense**, if the service is not entirely provided by the cropping system itself
- To **determine the most appropriated strategy of multi-pest management** reflecting the technical, economical or bio-physical constraints and the targeted yield level

CAEC
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
cirad
LA RECHERCHE AGRONOMIQUE POUR LE DÉVELOPPEMENT

Contact : charlotte.poeydebat@cirad.fr