Within the “Mazorquero Cacao” Project:

A novel method for estimating cocoa crop losses related to pest and diseases in the Peruvian Amazonia

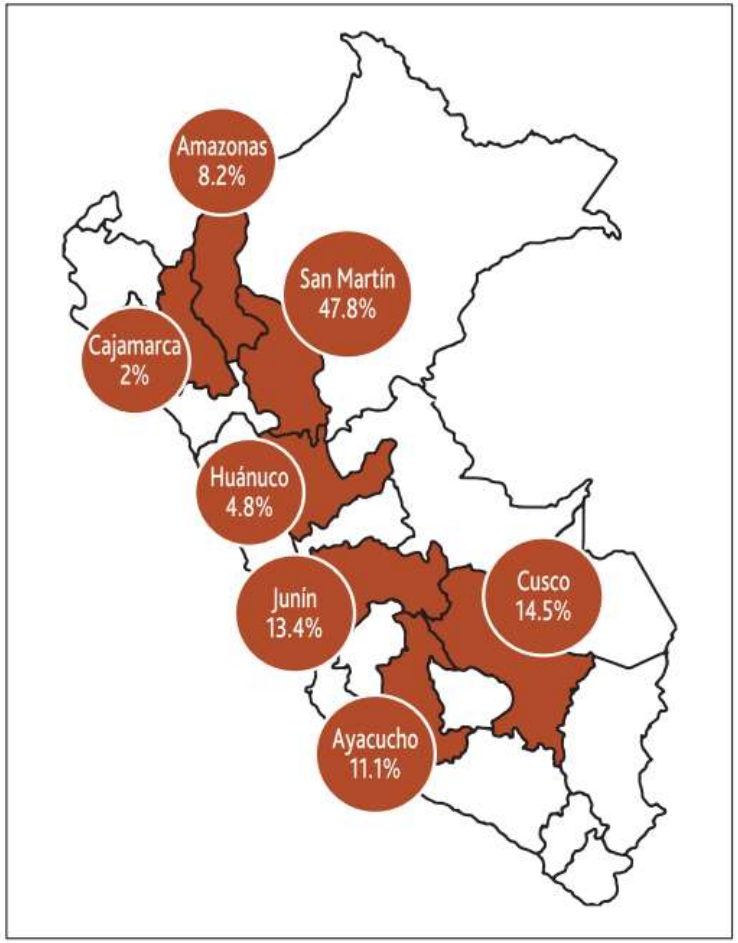
Presented by: Marcos J. Ramos

Authors:
Marcos J. Ramos (UMR ABSys, UMR PHIM, CIRAD – France; SENACYT – Panama – marcos-javier.ramos@cirad.fr),
Clémentine Allinne, PhD (UMR ABSys, CIRAD - France),
Jhoner Alvarado (FUNDAVI - Peru),
Bruno Rapidel, PhD (UMR Absys, CIRAD - France),
Leïla Bagny-Beilhe, PhD (UMR PHIM, CIRAD - France)

2022 International Symposium on Cocoa Research (ISCR), Montpellier, France

Cocoa Production in San Martin

Most productive cocoa zone of Peru



Cocoa crops have social, environmental and economic importance

90% of the cocoa varieties are CCN-51

P&Ds pose severe constraints

Ninnin 2020

Análisis Integral de la Logística en el Perú 2016

P&Ds Complex in San Martin

Up to 60% incidence of the most damaging P&Ds

Recent emergence of *Carmenta Foraseminis* (American Pod Borer “Mazorquero”)

Impact of these P&Ds is not necessarily additive

The Sanitary Harvest is a common practice

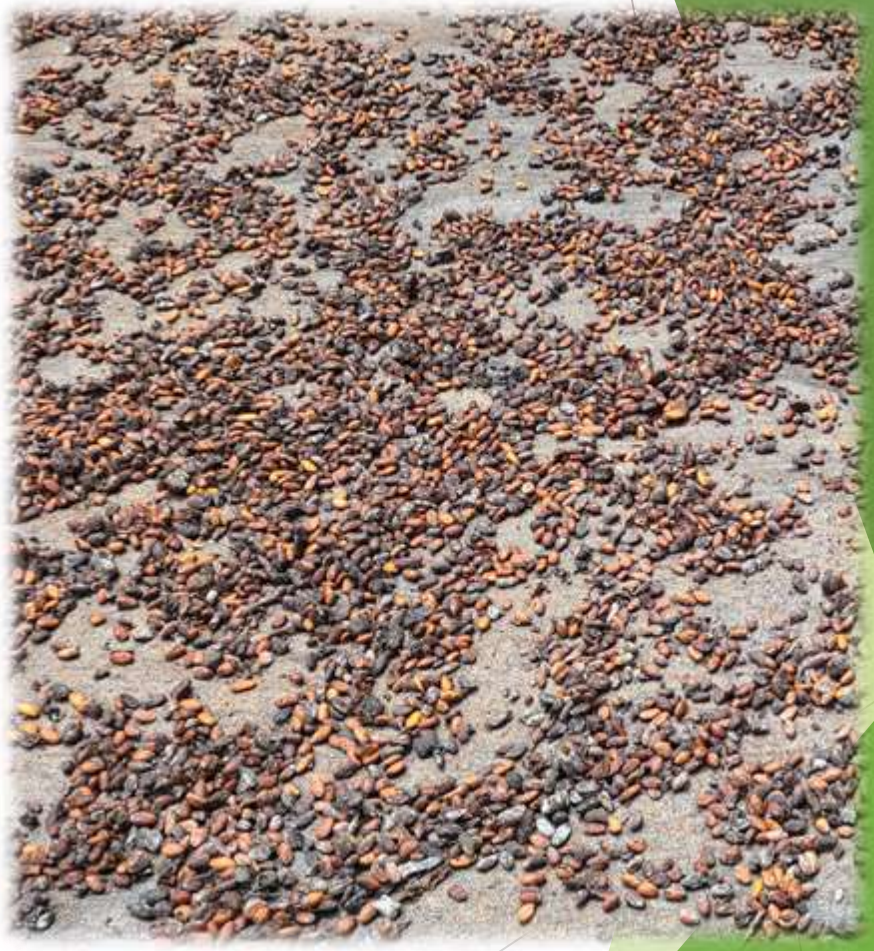
Available Markets differ in terms of the seed quality they purchase

Ninnin 2020

Cocoa Markets in San Martin

Local Conventional & Organic Markets

Local “Black” Market

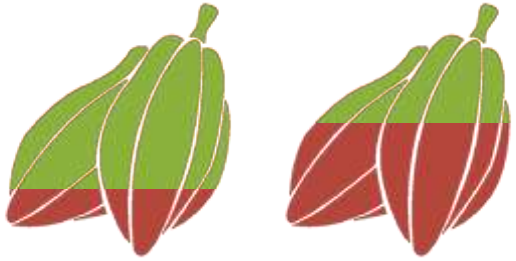


As affected seeds are still exploitable, estimating the damage can help in decision making

Research Question & Objectives

How can we estimate yield loss & crop loss related to P&D incidence?

Incidence to track presence of P&Ds



Severity not available

No integrative indicator

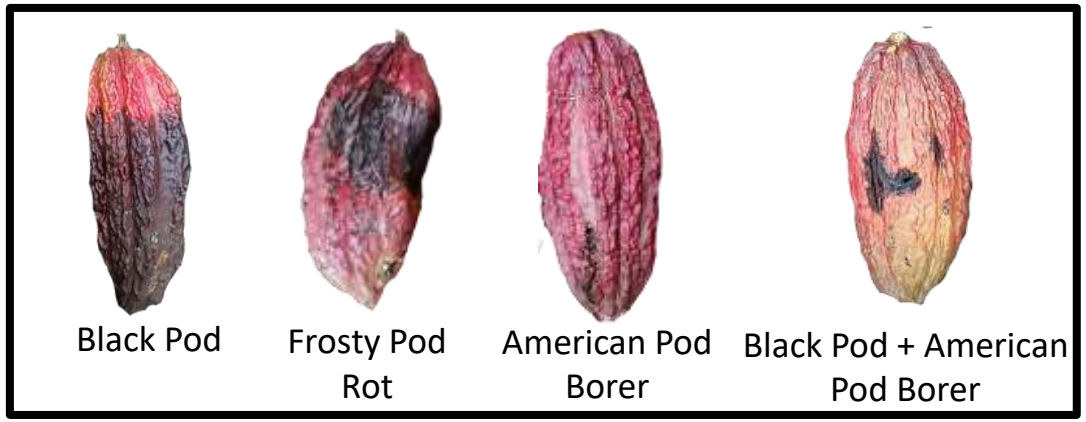
Develop a mathematical model to estimate yield loss related to cocoa pods P&Ds

Establish a yield loss due to individual and combined P&D incidence

Fit model for identified markets to estimate crop losses

Materials & Methods – Data Collection

a. P&Ds Combinations per pod



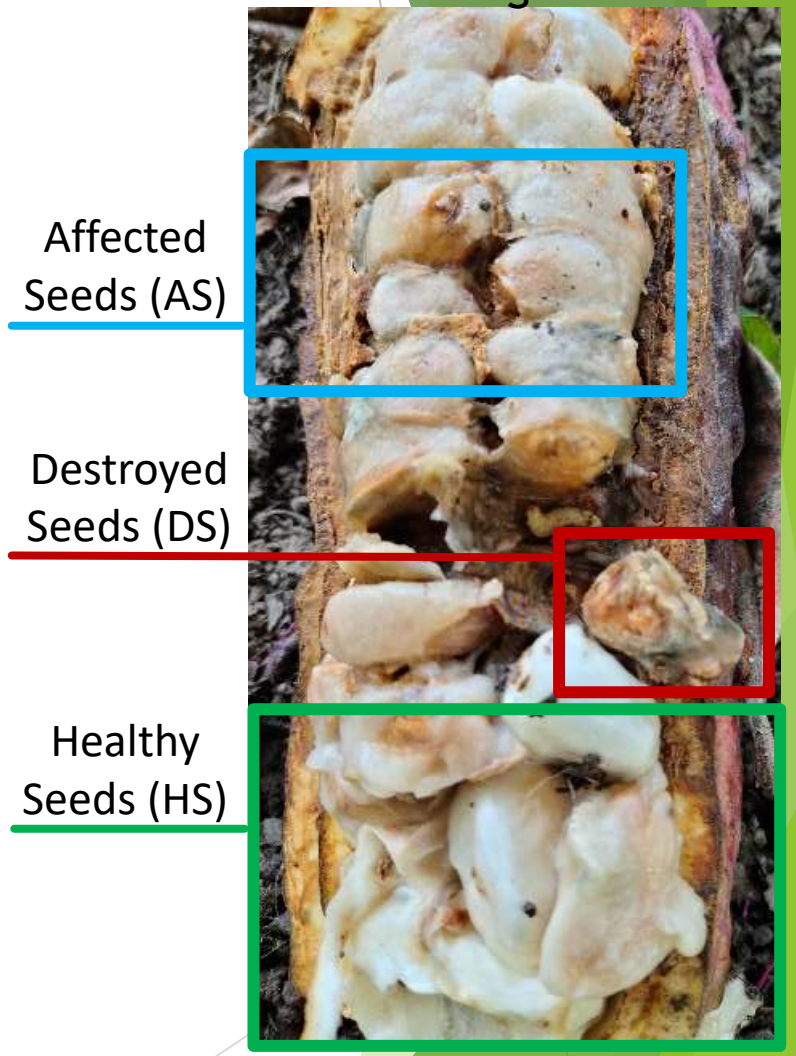
- 30 Pods per Combination, different cocoa plots

b. Pod's Phenological Stage for Harvest

→ On P&Ds symptoms appearance

→ Pods close to maturation

c. Seed Damage Classes



Materials & Methods – Data Analysis and Methodology Development

d. Seed's Damage Ratio per Pod (SDR) for each P&Ds Combination:

ASR_i = **Affected Seeds Ratio** for each P&D combination

$$ASR_i = \frac{\sum_{i=1}^{n}\left(\frac{AS_i}{S_i}\right)}{n} * 100$$

DSR_i = **Destroyed Seeds Ratio** for each P&D combination

$$DSR_i = \frac{\sum_{i=1}^{n}\left(\frac{DS_i}{S_i}\right)}{n} * 100$$

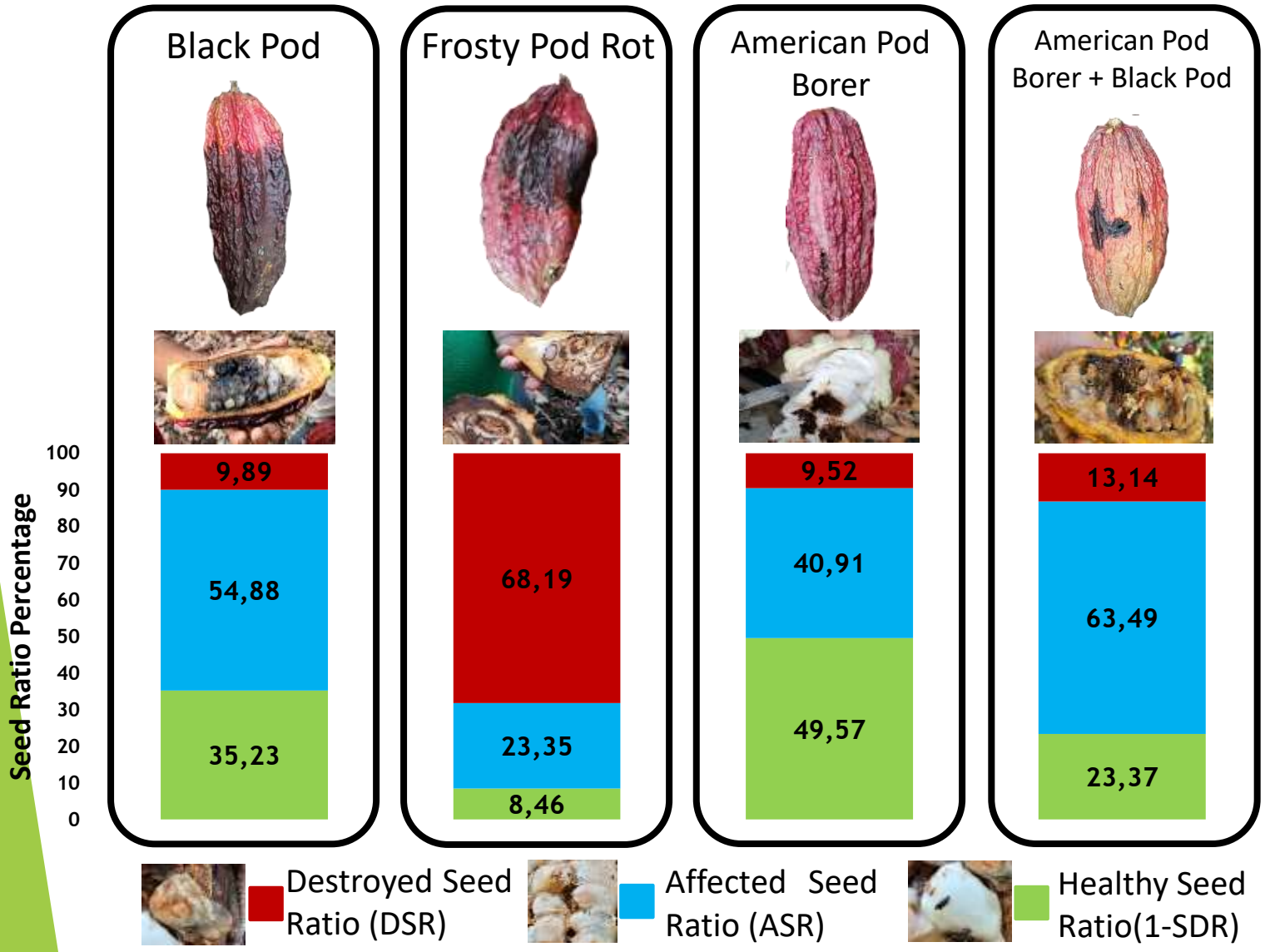
SDR_i = **Seed Damage Ratio** for each P&D combination

$$SDR_i = ASR_i + DSR_i$$

Average Seeds per Pod (meanS) for CCN-51 = 46

AS_i = Total number of affected seeds in evaluated pod
S_i = Total number of seeds in evaluated pod
n = Total number of evaluated pods with evaluated P&D Combination
DS_i = Total number of destroyed seeds in evaluated pod

Results - Seed Damage Ratios (SDRs) for each P&D



Frosty Pod Rot → Most damaging P&D in the zone

American Pod Borer → Least amount of damage caused

American Pod Borer + Black Pod → Appear to synergize, increasing damage

Materials & Methods – Data Analysis and Methodology Development

e. Yield Loss

$$\text{Yield Loss} = \sum_{i=1}^{n} (\text{AP} \times \text{IC}_i \times \text{meanS} \times \text{SDR}_i)$$

AP = Total Number of Affected Pods
IC_i = Incidence of each P&D Combination
meanS = Average Seeds per Pod (46)
SDR_i= Seed Damage Ratio per Pod of each P&D Combination
n = Number of P&D combinations

Modified versions of this equation were utilized to estimate the crop loss

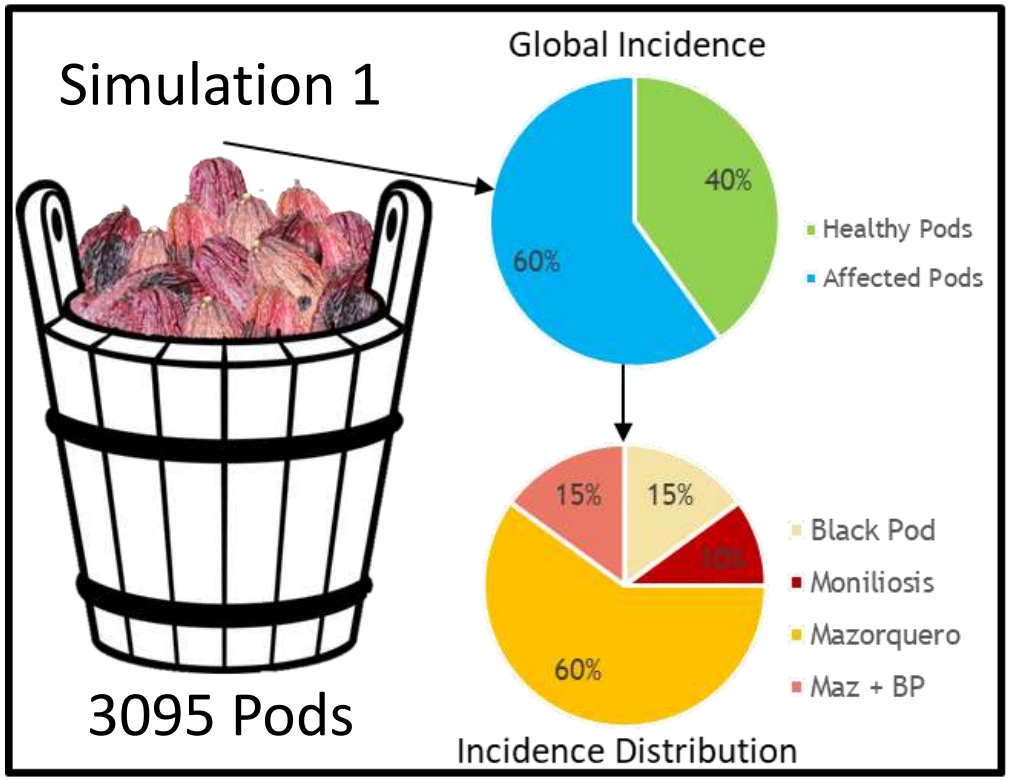
Materials & Methods – Model Application

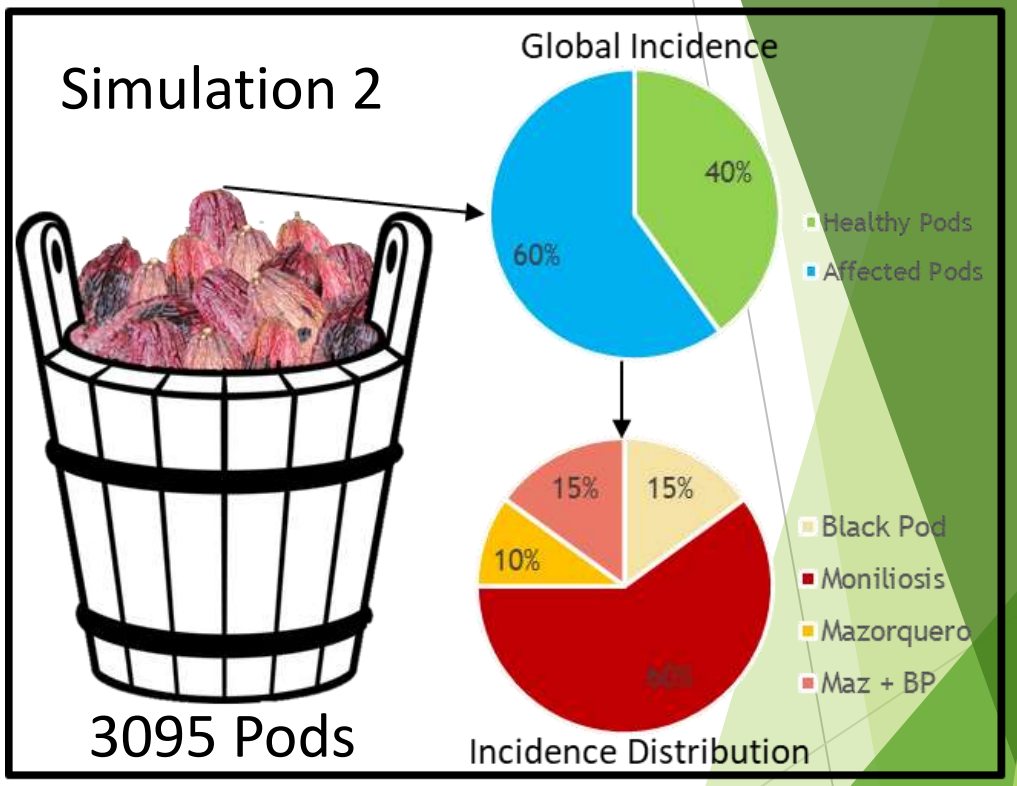
e. Market Simulations (Crop Loss - CL)

Market \ Seed Type	Crop Loss	Gain from Healthy Pods	Gain from Affected Pods		Destroyed Seeds
		Healthy Seeds		Affected Seeds	
	CL = $[P * \Pi L]$ - [Gain from Healthy Pods + Gain from Affected Pods]	$[(P - AP) * \Pi L]$	$\sum_{i=1}^{n}((AP * IC_i) * (1 - SDR_i) * \Pi L)$	$\sum_{i=1}^{n}((AP * IC_i * ASR_i) * \Pi B)$	
Local Conventional(ΠL) - 1.83€/kg	CL	X	X		
Local Organic(ΠL) - 1.93€/kg	CL	X	X		
Local Black(ΠB) - 1.63€/kg				X	

ΠL = Local Market Index - Product of (meanS * SW * MV_{Local}) to calculate the gain in the Conventional and Organic Markets
P = Total number of pods
AP = Total affected number of pods
IC_i = Incidence of each P&D Combination
ΠB = Black Market Index - Product of (meanS * SW * MV_{Black}) to calculate the gain in the Black Market
MV_{Black} = Black Market Value

Results - Simulation





Simulation - Results

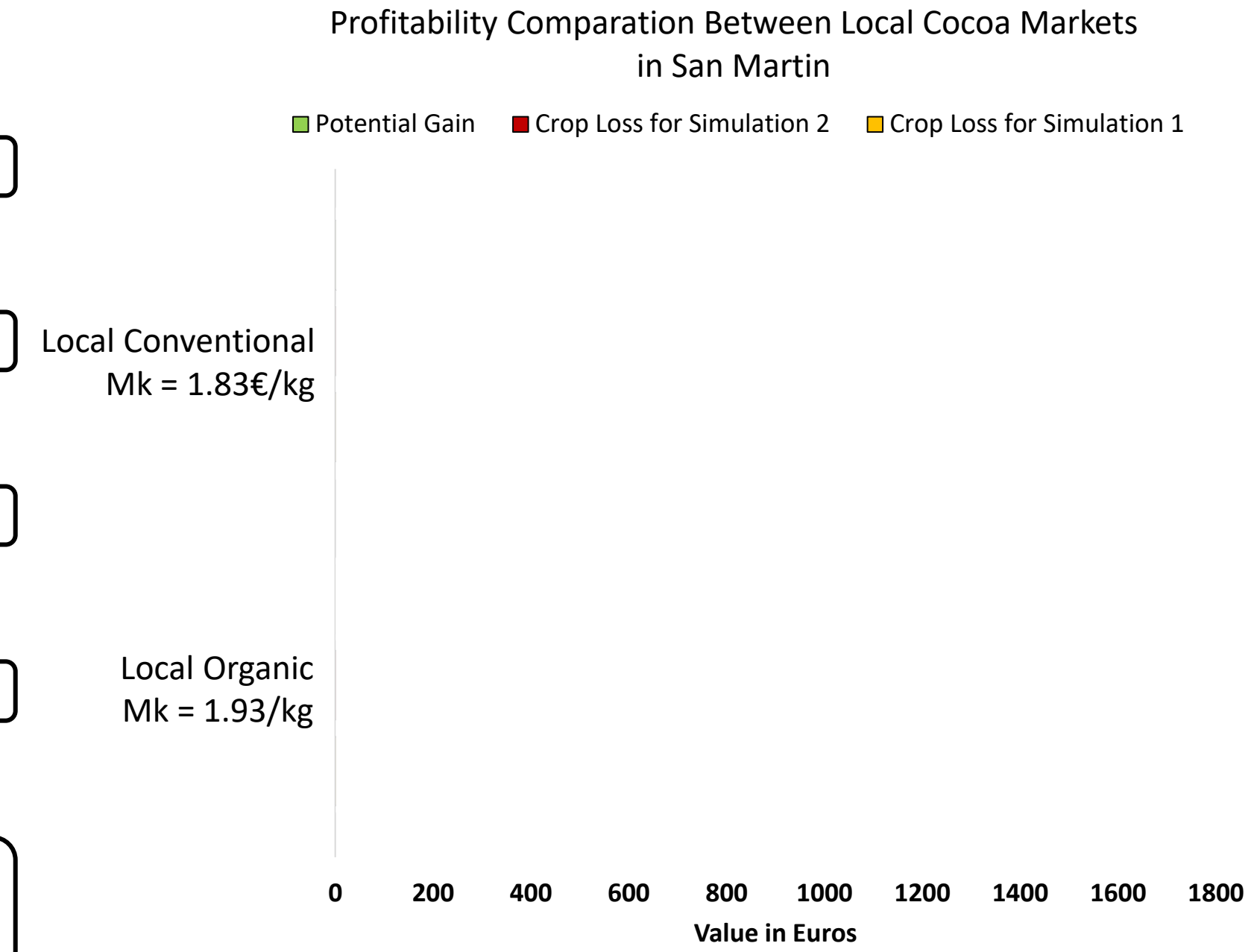
Potential gain Organic > Conventional

Crop Losses Organic > Conventional

Simulation 2 CL doubles Simulation 1 CL

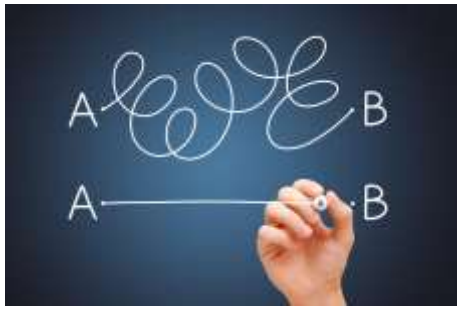
Crop Losses depend on P&D composition

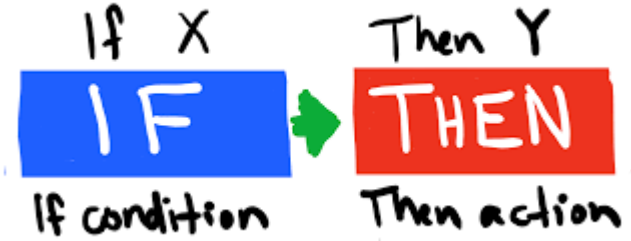
Model allows crop loss estimation through incidence of each P&D combination



Discussion & Conclusion

- The SDRs originate from a **simple model**, allow **easy yield loss quantification** and are **versatile**





- **Crop Loss Estimation** can support decision making. **This may help farmers & technical personnel to:**

- **Prioritize most damaging P&Ds**

- **Prioritize specific control practices**

- **Adjust investment strategies**

Acknowledgments

- All the Farmers
- Dr. Clementine Allinne
- Dr. Leila Bagny-Beilhe
- Dr. Bruno Rapidel
- Lic. Jhoner Alvarado
- My Colleagues at CIRAD

Thank you for your attention!!

Questions? (marcos-javier.ramos@cirad.fr)