



Within the “Mazorquero Cacao” Project:

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

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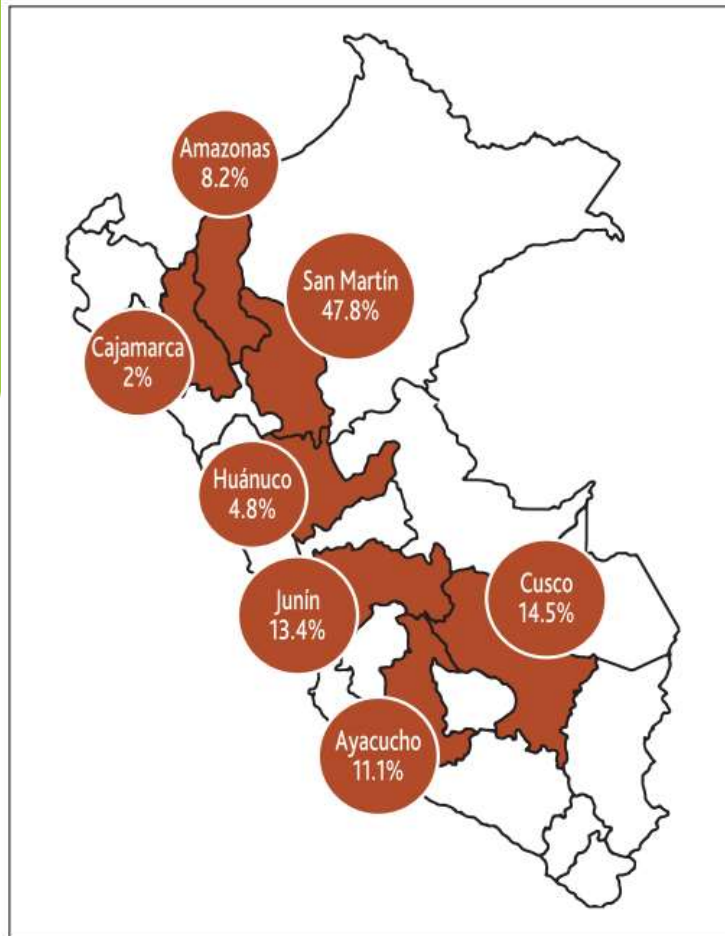


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Eau



Cocoa Production in San Martín

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



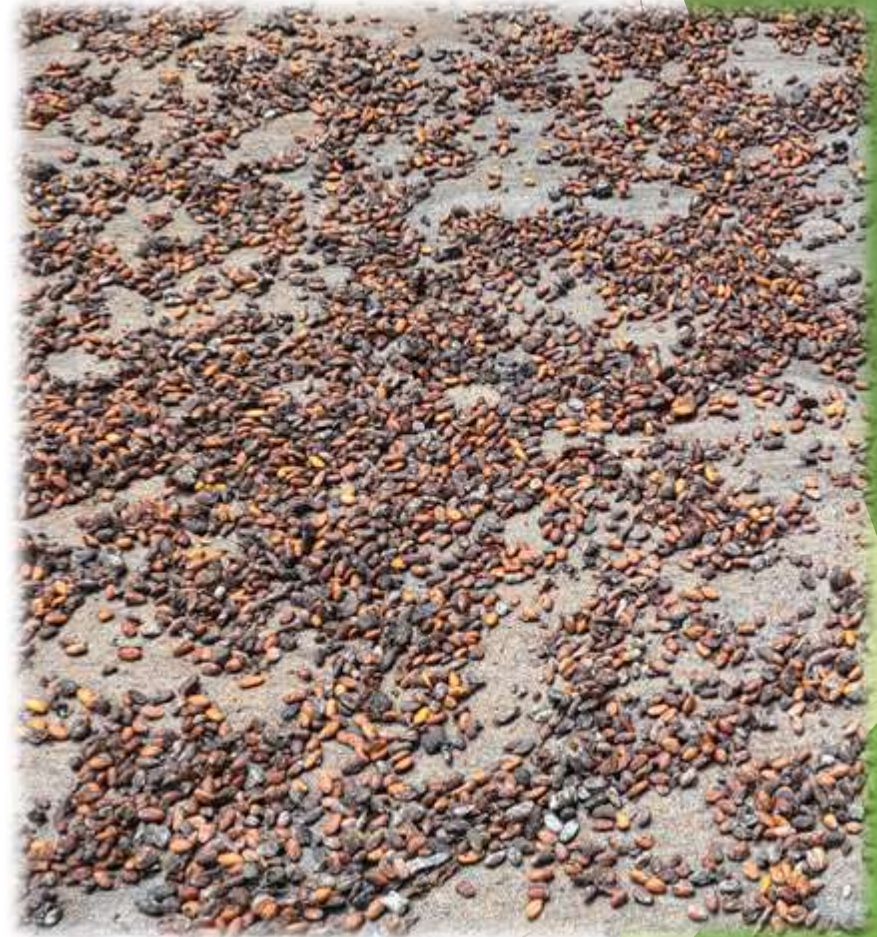
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Cocoa Markets in San Martin

Local Conventional & Organic Markets



Local “Black” Market

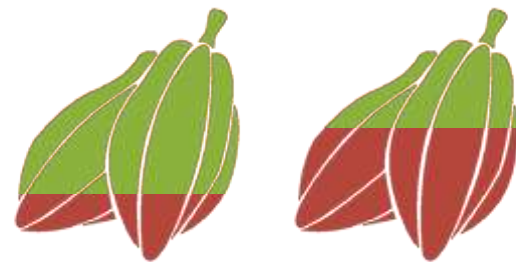


As affected seeds are still exploitable, estimating the damage can help in decision making

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

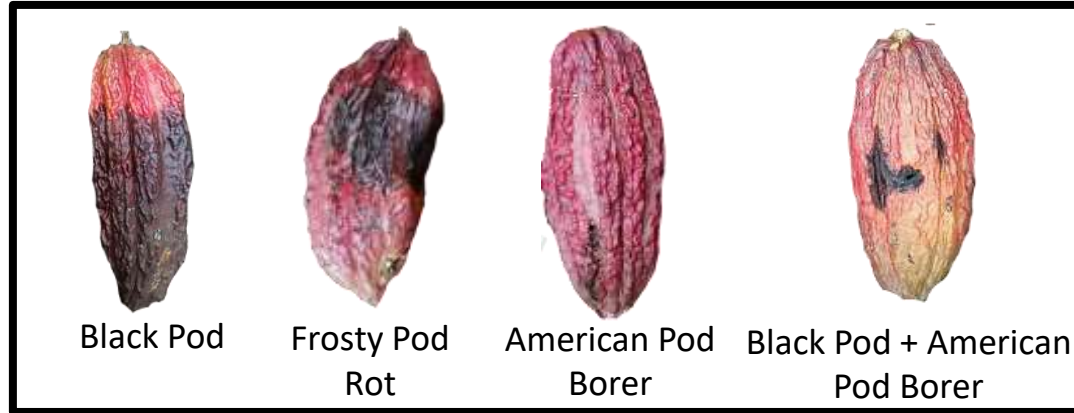
Develop a mathematical model to estimate yield loss related to cocoa pods P&Ds

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

Affected Seeds (AS)

Destroyed Seeds (DS)

Healthy Seeds (HS)



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

$$SDR_i = ASR_i + DSR_i$$

AS_i = Total number of affected seeds in evaluated pod

S_i = Total number of seeds in evaluated pod

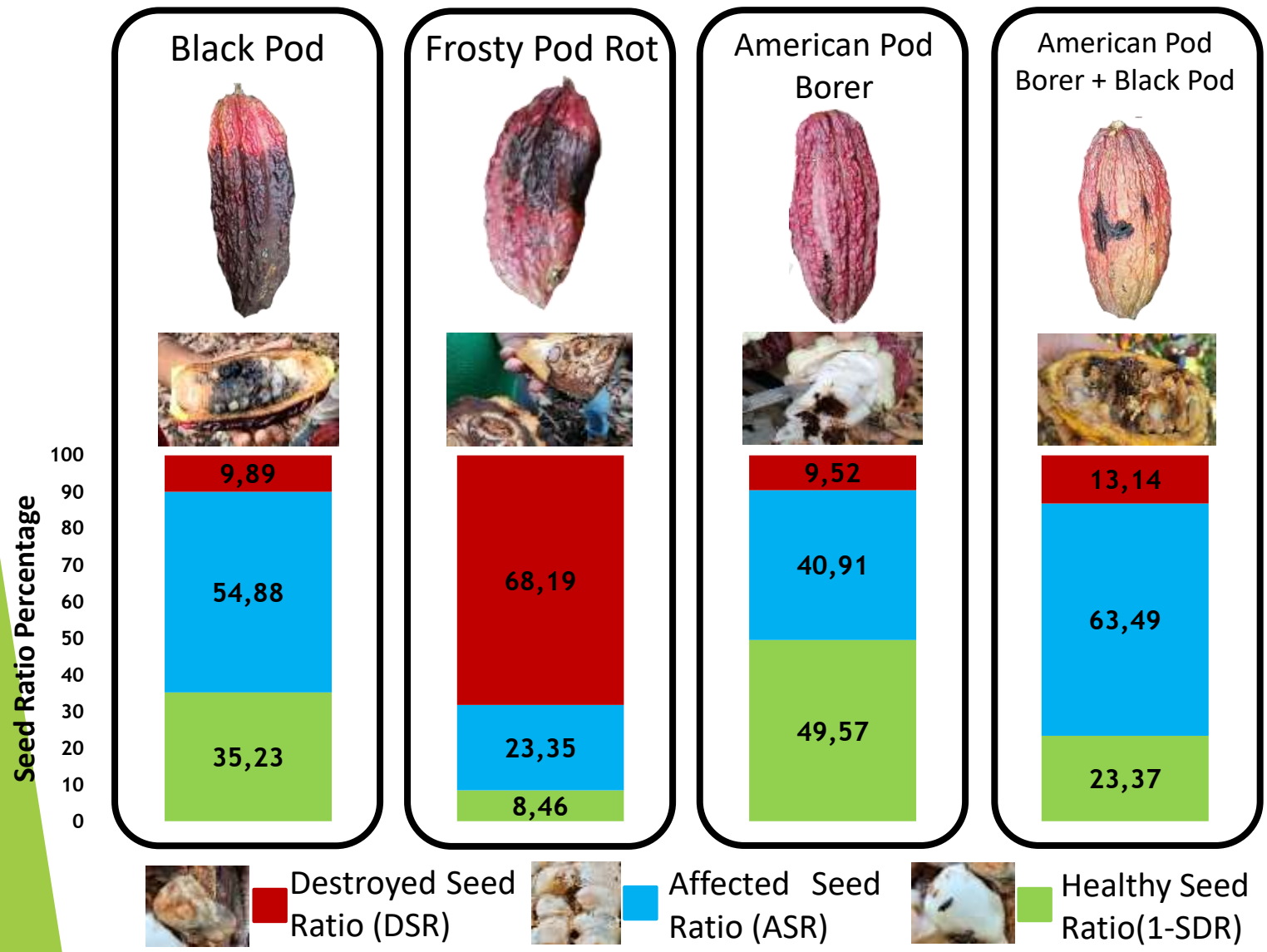
n = Total number of evaluated pods with evaluated P&D Combination

DS_i = Total number of destroyed seeds in evaluated pod



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

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

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	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(Π_L) - 1.83€/kg	CL	X	X			
Local Organic(Π_L) - 1.93€/kg	CL	X	X			
Local Black(Π_B) - 1.63€/kg				X		

Π_L = Local Market Index - Product of (meanS * SW * MV_{Local}) to calculate the gain in the Conventional and Organic Markets

P = Total number of pods

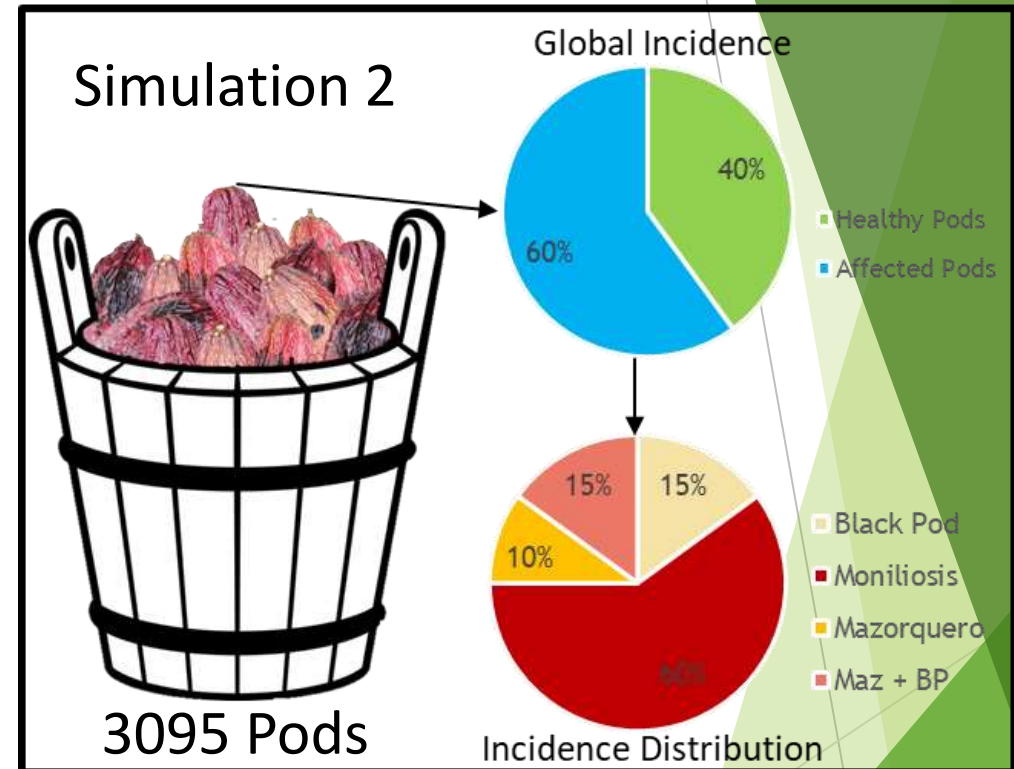
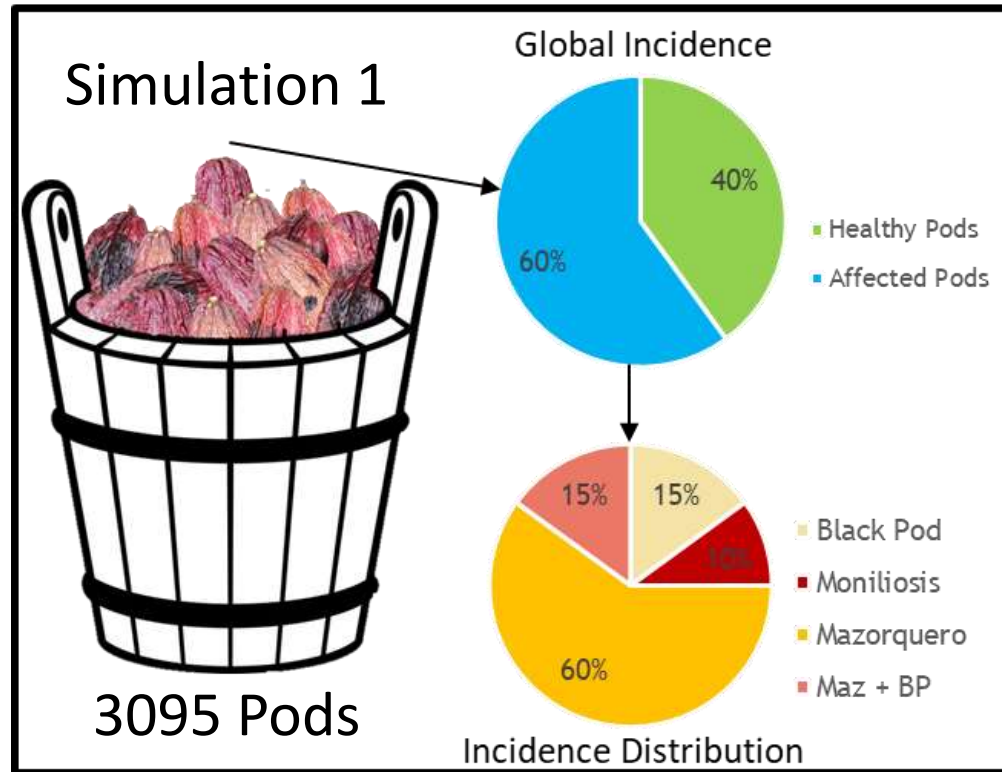
AP = Total affected number of pods

IC_i = Incidence of each P&D Combination

Π_B = 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

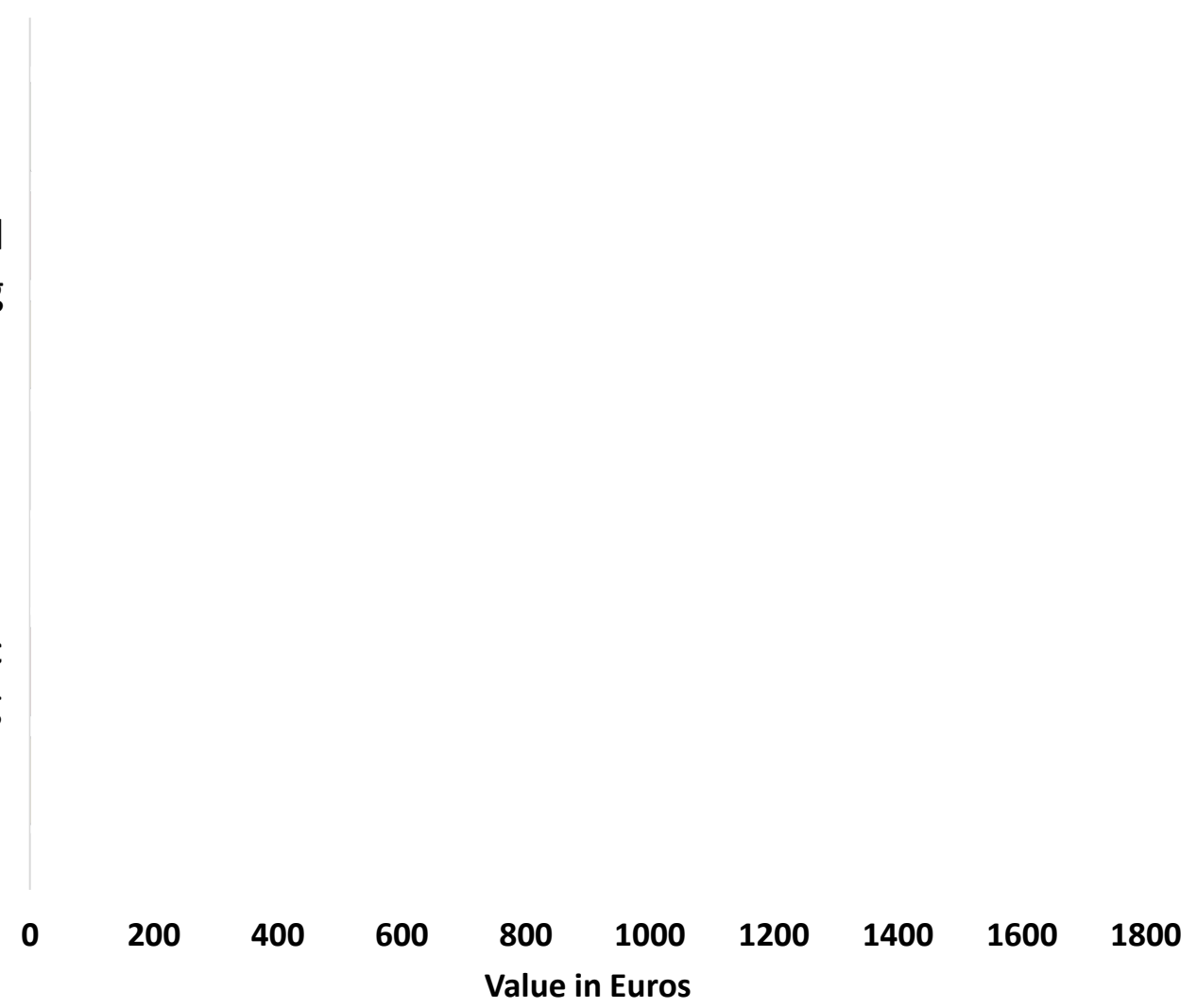
Model allows crop loss estimation through incidence of each P&D combination

Local Conventional
Mk = 1.83€/kg

Local Organic
Mk = 1.93/kg

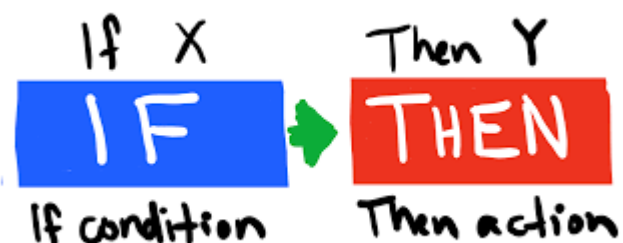
Profitability Comparison Between Local Cocoa Markets in San Martin

■ Potential Gain ■ Crop Loss for Simulation 2 ■ Crop Loss for Simulation 1



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**



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Thank you for your attention!!
Questions? (marcos-javier.ramos@cirad.fr)