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PA 254 COFFEE YIELD VARIATIONS AND THEIR RELATIONS TO RAINFALL EVENTS IN NICARAGUA

LARA, Leonel[1,2]*, HAGGAR, Jeremy[3], STOIAN, Dietmar[1], RAPIDEL, Bruno[1,4]

[1] Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica.
[2] Research Unit Sustainability and Global Change, University of Hamburg, Germany.
[3] Natural Resources Institute, University of Greenwich, UK.
[4] CIRAD, UMR SYSTEM, Montpellier, France.
* E-mail: Leonel.lara@zmaw.de

In order to predict the impacts of foreseen climate change on coffee production, one first step would be to check the impacts of past climate variations on coffee yields. Data on climate variables are relatively available, although sometimes of questionable quality; however, historical data on coffee yields and management are much more difficult to obtain. We developed a survey in coffee zones in Nicaragua to compile the historical registers made by farmers on yields, management and blossoming date, and analyze their relationship to specific climate events. The farmers' perceptions on climate risks and actual damages were also investigated. A simple model was then developed, that links coffee phenology, rainfall effects on flowering and soil water balance. Coffee yield data were obtained from 23 farms, over a span ranging from 6 to 78 years. The Pacific Zone, and the most ancient coffee zone, presented the longest series. Coffee yields are much more variable in this region than in the North Zone (variation coefficient 33% vs. 18%, resp.). Farmers' perceptions agreed with this finding, with much higher risks perceived in the Pacific Zone. Drought and rainfall excess alike were identified as causing the highest risks, temperature variations were not reported, possibly because they are much less easy to perceive than rainfall variations. The blossoming period was perceived, in both regions, as the most sensitive period, particularly to rainfall excess.
Very long series on blossoming dates and intensities allowed us to build and calibrate a model, based on rainfall and temperature, to estimate the rainfall during blossoming and the resulting yield loss. Rainfall over 40 mm during the blossoming could reduce the yield from 60 %(Figure 1). The water stress indexes during the different phonological stages did not show any effect in relation to coffee yields, even in the Pacific Zone that suffers from a 6 months-long dry season and high temperatures. Some alternative practices are discussed in order to mitigate the risks identified in the risk-prone Pacific zone.

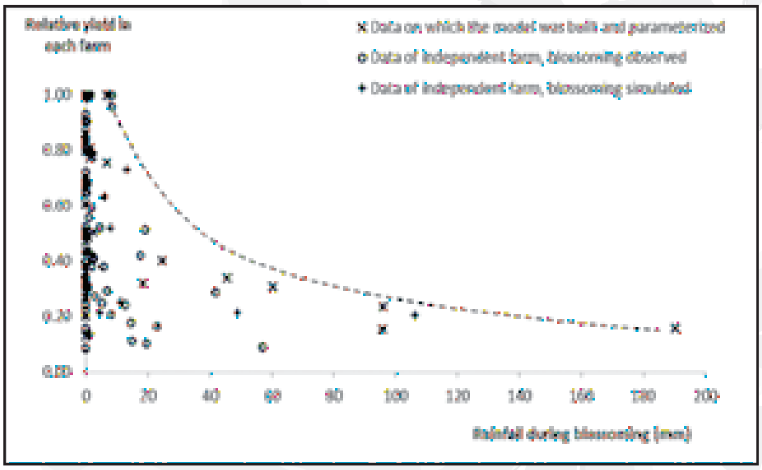

Figure 1. Relation between rainfall on flowering and coffee yield.

Coffee Yield Variations and their Relations to Rainfall Events in Nicaragua

L. LARA[1,*] , J. HAGGAR[1], D. STOIAN[1], B. RAPIDEL[2]
[1]Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica.
[2] CIRAD, UMR SYSTEM, Montpellier, France.

SUMMARY

In order to predict the impacts of foreseen climate change on coffee production, one first step would be to check the impacts of past climate variations on coffee yields. We developed a survey in coffee zones in Nicaragua to compile the historical registers made by farmers on yields, rainfalls and temperature daily, management and blossoming date, and analyze their relationship to specific climate events. The farmers' perceptions on climate risks and actual damages were also investigated. A simple model was then developed, that links coffee phenology, rainfall effects on flowering and soil water balance. Coffee yield data were obtained from 23 farms, over a span ranging from 6 to 78 years. The Pacific Zone, and the most ancient coffee zone, presented the longest series of yields and rainfalls. Coffee yields are much more variable in this region than in the North Zone (variation coefficient 33% vs. 18%, resp.).Farmers' perceptions agreed with this finding, with much higher risks perceived in the Pacific Zone. Drought and rainfall excess alike were identified as causing the highest risks, temperature variations were not reported, possibly because they are much less easy to perceive than rainfall variations. The blossoming period was perceived, in both regions, as the most sensitive period, to drought as well as to rainfall excess. Drought events are perceived as more frequent. Very long series on blossoming dates and intensities allowed us to build and calibrate a model, based on rainfall and temperature, to estimate the rainfall during blossoming and the resulting yield loss. Rainfall over 40 mm during the blossoming could reduce the yield from 60%. Alternative practices are discussed that could mitigate the risks identified in the risk-prone Pacific zone.

INTRODUCTION

Climate change is expected to impact heavily on coffee production in the next decades. However, these expectations are based on chains of models with significant uncertainties. One first step to ascertain these impacts would be to check the impacts of climate variation on coffee yield in the past. However, this work is rarely done due to the extreme rarity of historical coffee yields records in Central America, particularly at the finer scales. At higher scales, where data are more currently recorded, yields can only be calculated as a ratio of production per area, both variables having their own uncertainties, resulting in even higher uncertainties on yields.

The analysis of statistical series to extract the particular effect of climate on crops is always blurred by various factors: the evolution of cultivation practices, triggered by technical progress, current or past commodity prices, and sectorial policies and laws; the bi-annual productivity oscillation that affects on most perennial crops, and is further complicated by the multiannual cycle of coffee pruning; the evolution of other production factors, like soil fertility or plantations age. The extraction of the climate

* E-Mail address: Leonel@catie.ac.cr
Present affiliation: Research Unit Sustainability and Global Change. University of Hamburg. Germany.

effect from the scarce yields series is therefore easier at local scale, where these factors can be monitored and their effects removed from the signal.

Climate data also show information gaps in many countries in Central America: time gaps, when series are temporarily discontinued; space gaps, due to the combination of loose meteorological network and high spatial variability of certain meteorological variables, like rainfall or wind speed. Nevertheless, some individual farmers, or agricultural enterprises, for historical and personal reasons, keep long, unexpected records on the weather and productivity in their farms. Those farmers are usually among the richest ones, and some bias might exist when considering these records as representative of the whole sector. As long as we only address biophysical relationships between productivity and climate, these records are a very valuable tool.

This study aims at studying the effects of past variations of climate on coffee yields, based on local records. To this end, we set up a detailed survey looking for long term records for coffee yields and rainfall, the climatic variable that is measurable most easily in the field, and the perceptions of farmers on the climatic hazards affecting coffee production.

MATERIALS AND METHODS

The survey was developed on the coffee zones of the Pacific and North in Nicaragua. Coffee producers, agronomist, and companies related to coffee trade chain were interviewed. Each farm pre-identified was visited, in order to get historical registers of coffee yields and farm management, and any other historical observations. The farmers were interviewed about these registers, and their perceptions about the impact of climate on coffee productivity were recorded. Historical climate data were collected from coffee farms registers, local meteorological stations, and Grid-extractor database (Uribe 2011).

The registers of yield and management collected in the interviews were analyzed and carefully depurated. The longer yield registers were selected to the analysis. In some farms, for example, coffee was not harvested during some years in the midst of the coffee price crisis, and yields were recorded as zero. Total renovations of coffee plantations, abrupt changes in farm management were looked for and, if identified, excluded. To account for local differences and progressive improvement in coffee management, annual coffee productivities were divided by the running average over 10 years in the same farm. Rainfall data sets were equally selected and depurated, comparing each record with each other in the same region at various time scales to detect anomalities. The final records of yields and rainfall were matched based on closeness. Farmers were also asked for damages in coffee productivity related to climate, identifying the coffee stage most sensitive, the years that productivity was most affected, and their climatic causes, if any.

Simple models based on literature were developed to calculate water stress index (simple, FAO-based, water balance model), phenological phases, and to calculate the blossoming dates each year, based on water stress accumulation and a triggering rainfall.

RESULTS AND DISCUSSION

Longest registers of yield and rainfall were found in the Pacific Zone (since 1925). We found shorter registers in the North Zone, the oldest beginning in 1977 (Table 1).Coffee productivity varies more in the Pacific (VC 33%) than in the North (VC 18%).

Table 1: Yield and climatic registers found out at coffee farm level in each coffee zone.

Zone	Coffee Yield			Climatic variables		
	n	Years	Period	n	Years	Period
Pacific	16	6-78	1925-2010	7	8-84	1979-2010
North	16	4-33	1977-2010	9	2-11	2000-2010
		-		9*	2-36	1971-2007
Country		-		Grid-Extractor	30	1978-2008

* Meteorological stations.

The Pacific Zone presents the lowest historical mean of rainfall (1564 mm ± 321) and highest mean of air temperature (26 °C ± 0.5) than the North Zone (1917 mm ± 313; 22 °C ± 0.6). The variations on the coffee yield in the Pacific Zone could be related to adverse historical conditions. However, according to the interviews years of lowest yield are related with extreme climate events in both zones. In addition, observations on blossoming dates and intensity were obtained from various farms, the longest in the Pacific Zone covering 67 years, starting in 1936.

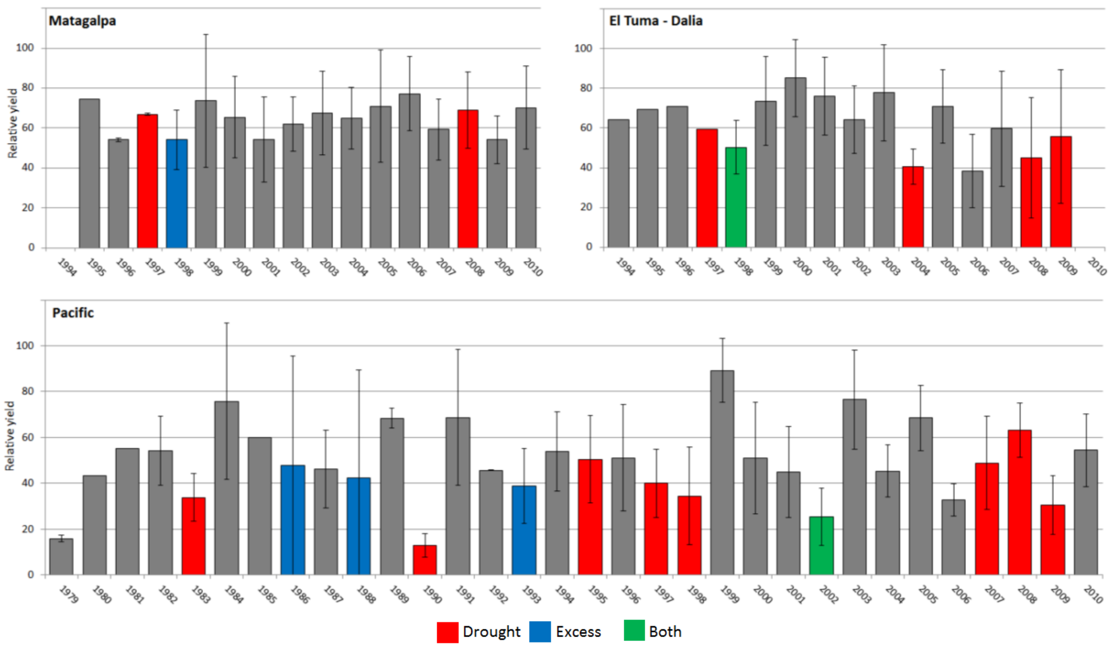

Figure 1: Yield relative of coffee farms and years identified by producers with affectations in the yield because drought, excess rainfall or both.

Most of the producers remembered the yield variations during the last 10 years or less. Only dramatic years were remembered earlier. The perceptions were improved where we could rely on written qualifying records, more frequent in the Pacific zone (figure 1). Excess rainfalls seem less frequent than drought events. Some years were consistently identified as bad climatic years (1997, 1998, 2008), but the causes can differ: 1998, was considered as a dry year in the Pacific, a wet year in Matagalpa, and a year that suffered from both in La Dalia (Hurricane Mitch).

Table 2: Farmers' perception of climate hazards on coffee productivity

Zone	Risks	Damage on phenological phases (%)			
		Blossoming	Pin head	Growth	Harvest
Pacific	Drought	29 (76)*	37 (41)	0	0
(n = 17)	Excess rainfall	43 (76)	0	0	23 (12)
North**	Drought	11 (22)	27 (44)	3 (6)	3 (6)
(n = 18)	Excess rainfall	0	3 (6)	7 (39)	3 (6)

* ( ) = % farmers. ** North Zone: La Dalia, Matagalpa, Jinotega.

The farmers' perceptions of damages related to rainfall were assessed in severity (calculated for the year in which the event were mentioned) and agreement (% of farmers mentioning the same particular events) in Table 2. The stronger risk mentioned was excess rainfall during blossoming in the Pacific region. Over 40% of producers mentioned losses between 27 – 37 % by drought on pin head phase in both zones.

Being blossoming a very short period very sensitive to rainfall excess, a model was build on an Excel sheet, based on water stress, thermal time and rainfall occurrence. The model was able to simulate correctly the blossoming timing and intensity, as recorded in a coffee estate in the Pacific zone (figure 2, left). Rainfall on blossoming presented a negative and significant correlation with relative yields in the Pacific region (-0.46, p= 0.007).

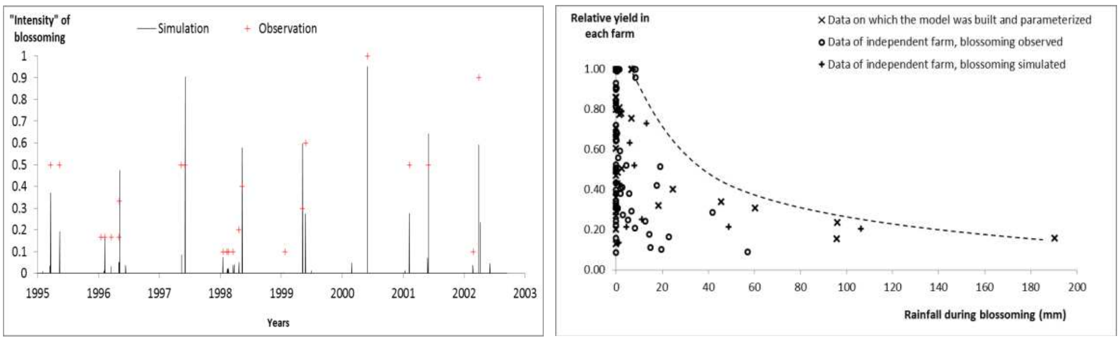

Figure 2: Left: Comparison between observations and blossoming simulations in a coffee farm in the Pacific. Right: Relation between coffee yield and rainfall on blossoming.

Some practices and strategies to reduce this particular risk can involve targeted irrigation (to trigger blossoming at dates where the risk of rainfall is very low), use of medium term climate forecasts. Drought events might be even more difficult to cope with, in a future climate where water will become a rare resource confronted to competitive uses. For all these non avoidable risks, financial tools like agricultural insurances could possibly be implemented, based on the sort of models we developed.

LITERATURE CITED

Lara, E., Rapidel, B., Stoian, D., Arguello, J., Gaitán, T., González, C. 2011. Estudio de factibilidad para la implementación de seguros basados en Índices climáticos en el cultivo de café en Honduras y Nicaragua. Proyecto Apoyo al Desarrollo del Mercado de Seguros Agropecuarios en América Central (WB/IBD/FIDES). CATIE. 95 p.
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COFFEE YIELD VARIATIONS AND THEIR RELATIONS TO RAINFALL EVENTS IN NICARAGUA

CATIE Solutions for environment and development / Soluciones para el ambiente y desarrollo

L. LARA[1,*], J. HAGGAR[1], D. STOIAN[1], B. RAPIDEL[2]
[1] Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)
[2] CIRAD, UMR SYSTEM, Montpellier, France.

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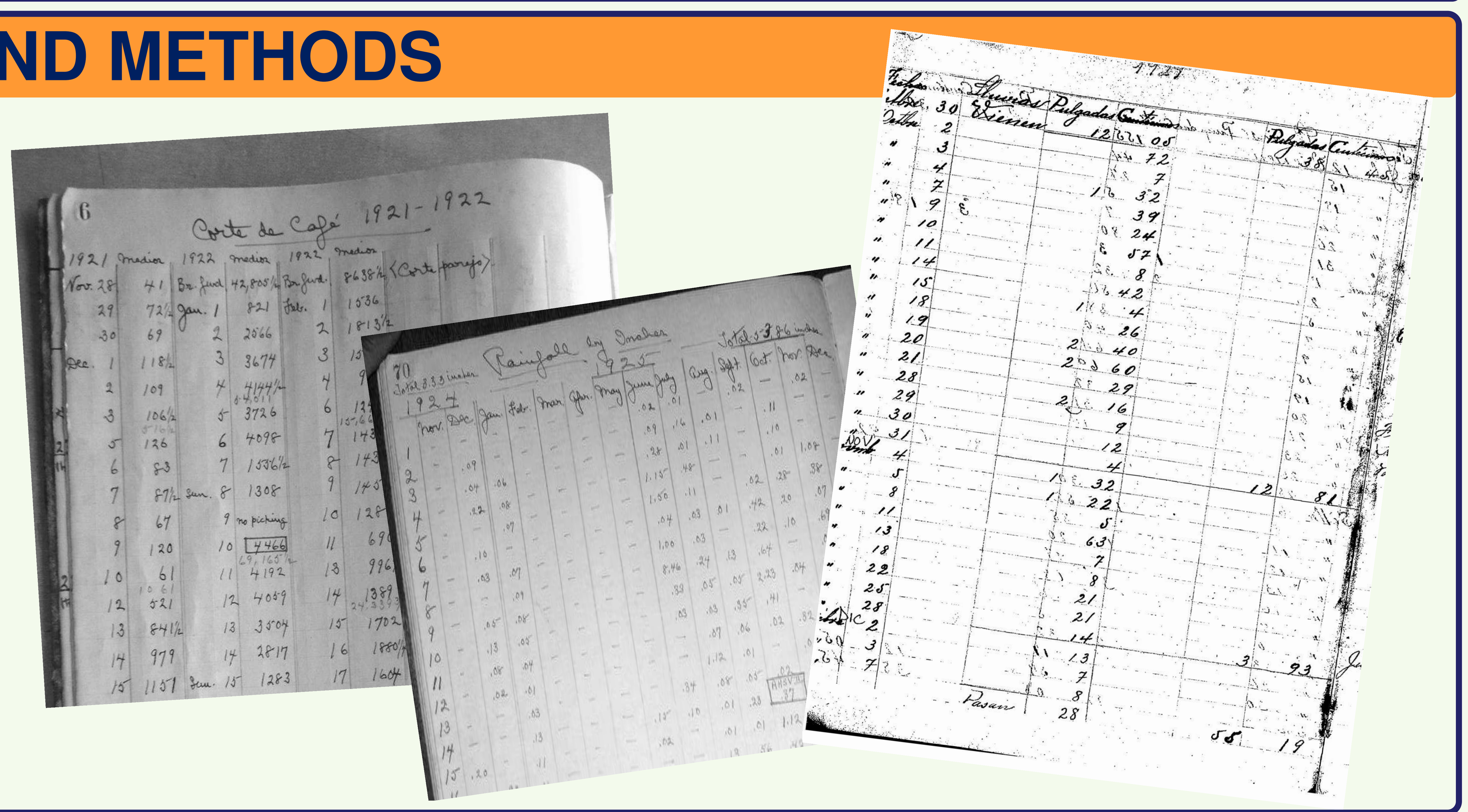
INTRODUCTION

Climate change is expected to impact heavily on coffee production in the next decades. However, the uncertainties are significant. One first step to ascertain these impacts would be to check the impacts of climate variation on coffee yield in the past. This study aims at studying the effects of past variations of climate on coffee yields, based on local records.

MATERIALS AND METHODS

- A survey was developed on the coffee zones in Nicaragua.
- Data collected: Historical registers on coffee yields, farm management, climate data; and risk perception and yield loss by climate events.
- Data were analyzed and carefully depurated.
- Simple models were developed to calculate water stress index, phenological phases, and a blossoming model based on water stress accumulation and a triggering rainfall.



RESULTS AND DISCUSSION

Yield and Climate Registers

- Longest registers of yield and rainfall: Pacific Zone (1921)
- Historical climate
  - Pacific: 1564 mm ± 321; 26 °C ± 0.5
  - North: 1917 mm ± 313; 22 °C ± 0.6

Table 1: Yield and climatic registers found out at coffee farm level in each coffee zone.

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* Meteorological stations. ** Grid-extractor database (Uribe 2011)

- Blossoming dates and intensity: Longest record in Pacific zone with 67 years (1936)
- Coffee productivity: Pacific (VC 33%) & North (VC 18%)
- Years of lowest yield related with extreme climate events in both zones.

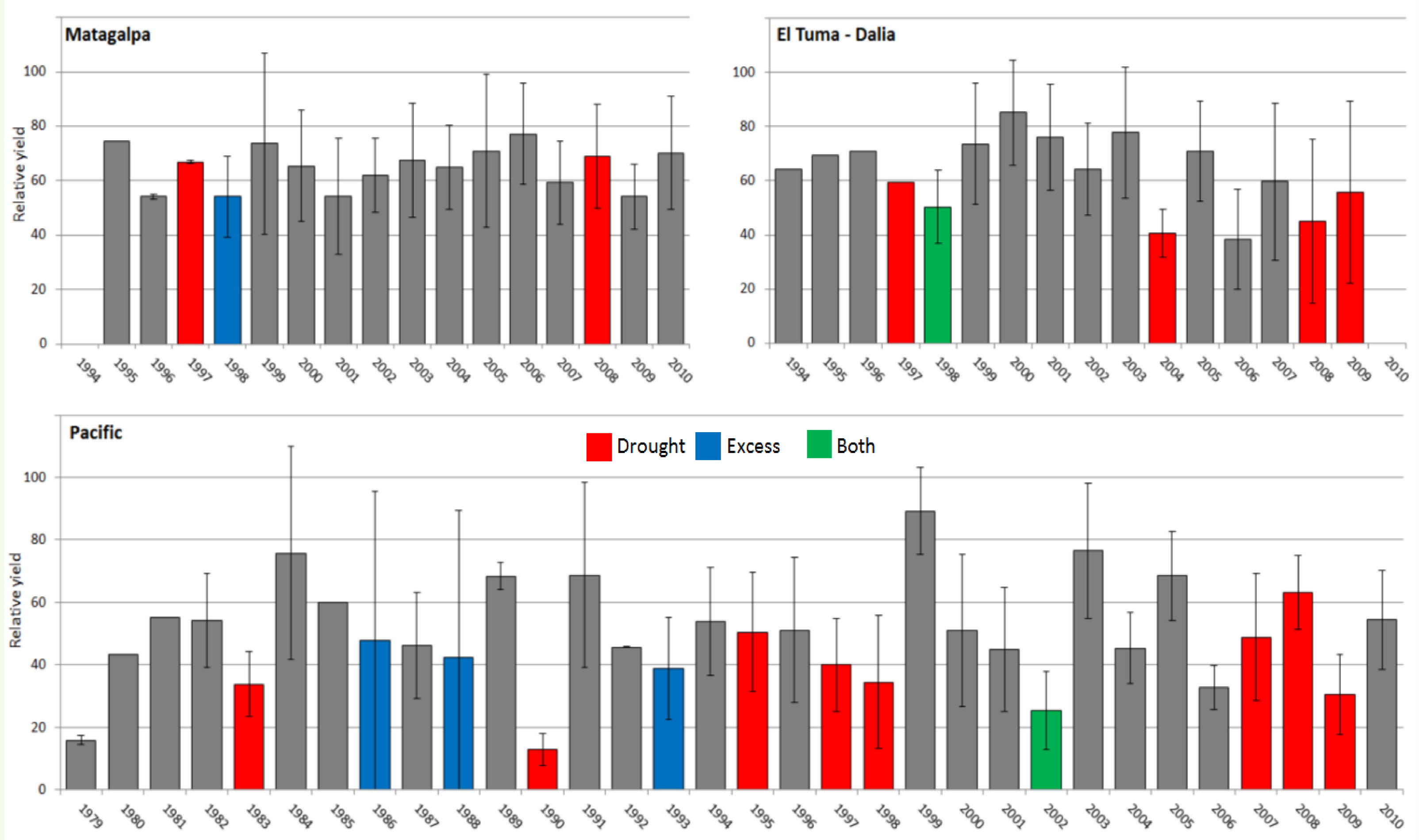

Figure 1. Yield relative of coffee farms and years identified by producers with affectations in the yield because drought, excess rainfall or both.

- Excess rainfalls seems less frequent than drought events.
- Bad climatic years in both zones (1997, 1998, 2008)
- Some years both event occurred (e.g. 1998)

Risks and damages

- The stronger risk was excess rainfall on blossoming in the Pacific Zone.
- Over 40% of producers reported losses between 27 – 37 % by drought on pin head phase in both zones.

Table 2: Farmers' perception of climate hazards on coffee productivity

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- The blossoming model was able to simulate correctly the blossoming timing and intensity, as recorded in a coffee estate in the Pacific zone (Figure 2, above).
- Rainfall on blossoming presented a negative and significant correlation with relative yields in the Pacific region (-0.46, p= 0.007).

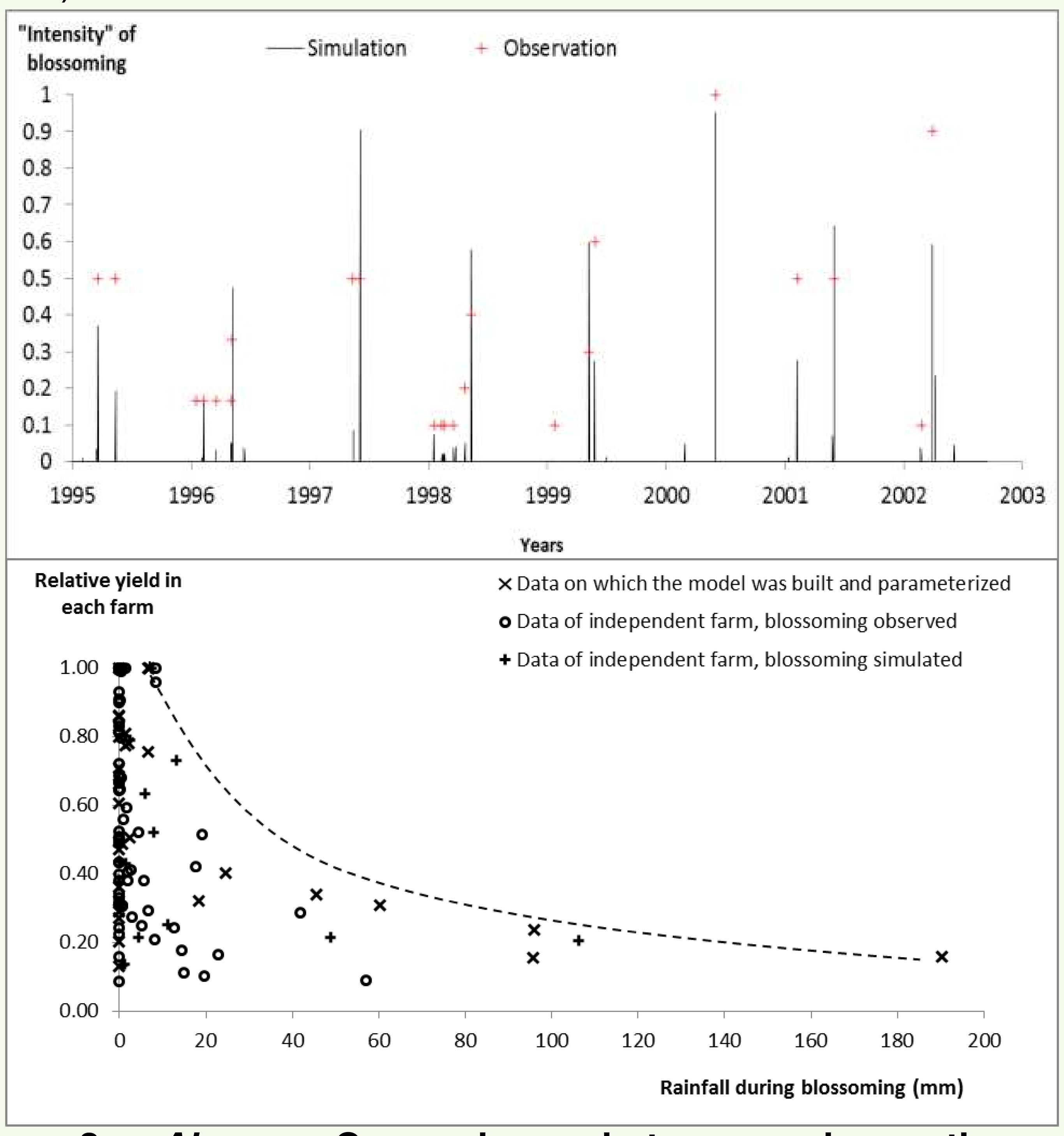

Figure 2: *Above:* Comparison between observations and blossoming simulations in a coffee farm in the Pacific. *Below:* Relation between coffee yield and rainfall on blossoming.

CONCLUSION

- Strategies to reduce rainfall risk on blossoming can involve targeted irrigation or/and use of medium term climate forecasts.
- Droughts are more difficult to cope with, in a future climate where water will become a rare resource confronted to competitive uses.
- Financial tools like agricultural insurances could possibly be implemented, based on the sort of models we developed.

REFERENCES

- Lara, E., Rapidel, B., Stoian, D., Arguello, J., Gaitán, T., González, C. 2011. Estudio de factibilidad para la implementación de seguros basados en Índices climáticos en el cultivo de café en Honduras y Nicaragua. Proyecto Apoyo al Desarrollo del Mercado de Seguros Agropecuarios en América Central (WB/IBD/FIDES). CATIE. 95 p.
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* Leonel@catie.ac.cr. Present affiliation: Research Unit Sustainability and Global Change. University of Hamburg. Germany.