The coffee rust (*Hemileia vastatrix*)
Some biological and epidemiological aspects

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Losses reported by the coffee institutes for the 2012-2013 harvest in Central America (data from February 2013)

<table>
<thead>
<tr>
<th>Country</th>
<th>2011/2012 exports (bags of 46 kg of green beans)</th>
<th>Estimated reduction of the 2012/2013 harvest (attributed to rust)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costa Rica</td>
<td>2 007 775</td>
<td>5 %</td>
</tr>
<tr>
<td>Honduras</td>
<td>7 100 000</td>
<td>15 %</td>
</tr>
<tr>
<td>El Salvador</td>
<td>1 500 000</td>
<td>37 %</td>
</tr>
<tr>
<td>Guatemala</td>
<td>4 800 000</td>
<td>15 %</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>2 000 000</td>
<td>20 %</td>
</tr>
</tbody>
</table>

~ Around M $ 345 for this harvest
Coffee rust jumps

Bordeaux mixture 1885

Nicaragua

Angola

Bahía, Brazil

Kenya

Ceylán (Sri Lanka)

Erradications 1869

1885
Coffee rust threatens again

Special climatic conditions (very rainy) which were propitious to fungus reproduction

Low coffee prices which caused a decrease of the number of fungicide and fertilizer applications
Severe outbreak of coffee rust in Nicaragua, in 1995-1996

40 % of incidence on average in Jinotega and Matagalpa at the end of 1995 and beginning of 1996

Severe defoliations and death of branches were observed

J. Avelino, 1996

Special climatic conditions (very rainy) which were propitious to fungus reproduction

+ 20 000 ha of coffee were producing for the first time (as we will see, fruit load is the main factor explaining coffee rust outbreaks)
In both cases the situation came back to normal in the next year.

But we cannot take the risk that such a severe epidemic occur again in 2013, even if the probabilities are low.
The 2012-2013 outbreak will cause losses over several years.

Severe defoliation caused by coffee rust
(February 2013, Costa Rica)

Stumping to rejuvenate coffee trees after the outbreak
(February 2013, Costa Rica)

These trees will produce normally in 2015-2016
If they don’t die: old coffee trees do not respond well to this practice.
Coffee tree phenology

Rainfall

Dry season
	nRainy season

Dry season
	nRainy season

Dry season
	nRainy season

Growth of year 1

Blossoming on nodes produced in year 1

Ripening of berries and harvest

Blossoming on nodes produced in year 2

Ripening of berries and harvest

Young leaves year 1
Old leaves year 2

Young leaves year 2
Old leaves year 3

Young leaves year 3
Old leaves year 4

Stem
First short internode
Second short internode

J. Avelino
Defoliations due to rust will negatively affect branch growth and decrease yield of the following year: secondary losses.

When defoliations are very severe, the consequence is a branch die back and losses from the current year: primary losses.
Coffee rust life cycle

1. Dispersed spores
2. Deposition
3. Germination
4. Host tissue penetration
5. Sporulation
6. Tissue colonization
7. Lesions
8. Colonies established
9. Spores produced

Steps involved in the life cycle of coffee rust: Dispersal of spores, deposition, germination, host tissue penetration, sporulation, tissue colonization, lesion formation, and colony establishment.
Main factor affecting coffee rust life cycle (Avelino et al., 2004)

- Deposition
- Germination
- Germinated spores
- Host tissue penetration
- Colonies established
- Lesions
- Tissue colonization
- Soil humidity
- Fruit load
- Temperature
- Complete resistance
- Partial resistance
- Parasitism
- Spores produced
- Sporulation
- Dispersed spores
- Deposition
- Radiation
- Temperature
- Leaf wetness
- Leaf area
- Rain
- Wind

Main factors affecting coffee rust life cycle:
- Parasitism
- Spores produced
- Dispersed spores
- Sporulation
- Lesions
- Tissue colonization
- Colonies established
- Soil humidity
- Fruit load
- Temperature
- Complete resistance
- Partial resistance
Epidemiology
Altitude, rainfall and harvest effects on the coffee rust progress curve

More rust at low altitude

More rainfall does not necessarily mean more rust (spore washing)

Coffee rust peak at the end of the harvest, during the dry season

Avelino et al., 2002, modificado de Avelino et al., 1990 (Chiapas, México)
Epidemiology
Fruit load effect on coffee rust progress

Ratio: number of berries in June/number of young leaves

Cumulative percentage of leaves with coffee rust at the end of the harvest

Avelino et al., 2002, modificado de Avelino et al., 1993
Datos de la finca La Libertad, Guatemala, 1990
Epidemiology
Fruit load and altitude effects on coffee rust progress

Similar attacks in different altitudes due to fruit load differences

Avelino et al., 2002, modified from Holguín 1987 (Chiapas, México)
Epidemiology
Simplified representation of the effect of shade on coffee rust

More coffee rust at full sun exposure
Shade effects on leaf temperature

- Intraday variations of leaf temperature (°C) as a function of rainfall and shade conditions (rainy season, 2009)

Dry days

Days with rainfall < 5 mm

Days with rainfall > 5 mm

Optimal range for germination and infection

Optimal range for latent period

Shade maintains temperature closer to the optimal range for coffee rust germination and life cycle in general

Lopez Bravo et al., 2012
A tool which helps to define risk domains and rationalize coffee rust control in Honduras (Avelino et al., 2006)

Fruiting nodes per tree

Yes

Fertilization

No

Altitude (m)

<1100

>1100

Shade %

<56

>56

Soil pH

<6

>6

Local factors more important than regional factors (rainfall is absent)

Recommendation domain

R : maximum annual incidences

R1 : [8.2%, 32.0%]

R2 : [32.0%, 53.4%]

R3 = [53.4%, 93.3%]
To conclude: what happened in Central America?

Our main hypotheses:

- "El niño" effect at the end of the year (just before and during the harvest period)
- Increase of temperatures
- Low rainfall (but enough for germination and no spore washing; free water from dew could help; dispersal is done by harvesters and wind)
- High altitude stands behaved as lower altitude plantations
- Decrease of coffee prices (-30% in 1 year)
- Fertilizer inputs reduced, and applications were not effective
- No preventive control; curative control was applied too late, when incidences were very high
To conclude: what happened in Central America? Our main hypotheses:

- Lower yield under shade
- Coffee rust impacts in shaded plots were lower as compared to those observed in plots at full sun exposure
- Dew interception by trees
- Spore interception by trees?
- Leaves less susceptible under shade (colonization phase)?
Muchas gracias
Thank you
Merci