Several enemies at the same time: interaction between two cocoa pod diseases and a cocoa pod borer and their impact in Peruvian agroforestry systems

Mónica Arias, Marcos Ramos, Jhoner Alvarado, Clémentine Alline, Gerben Martijn Ten Hoopen, Leïla Bagny-Beilhe

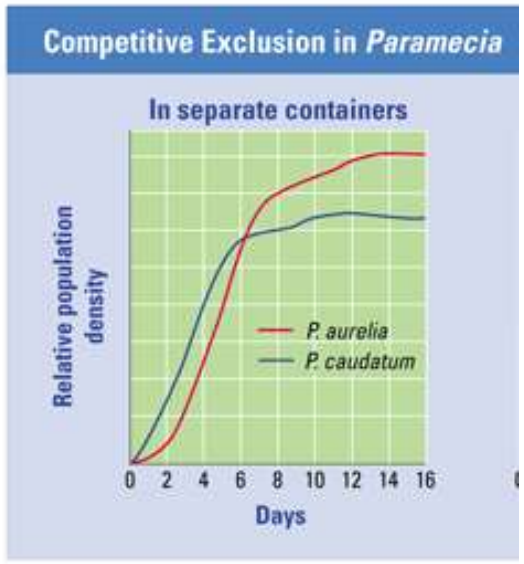
Cirad

France

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

Simultaneous infection of multiple diseases

- Classically one pathogen and one host



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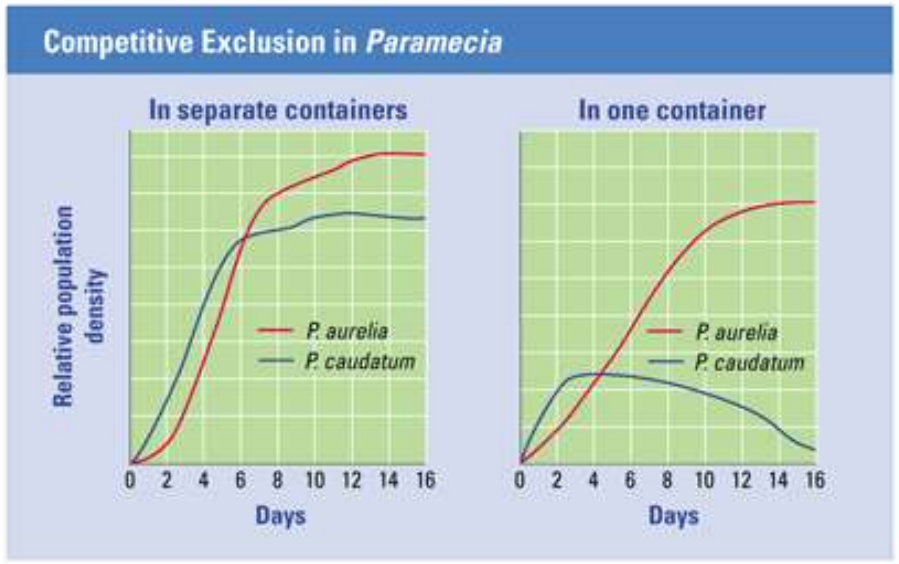

Simultaneous infection of multiple diseases

- Classically one pathogen and one host
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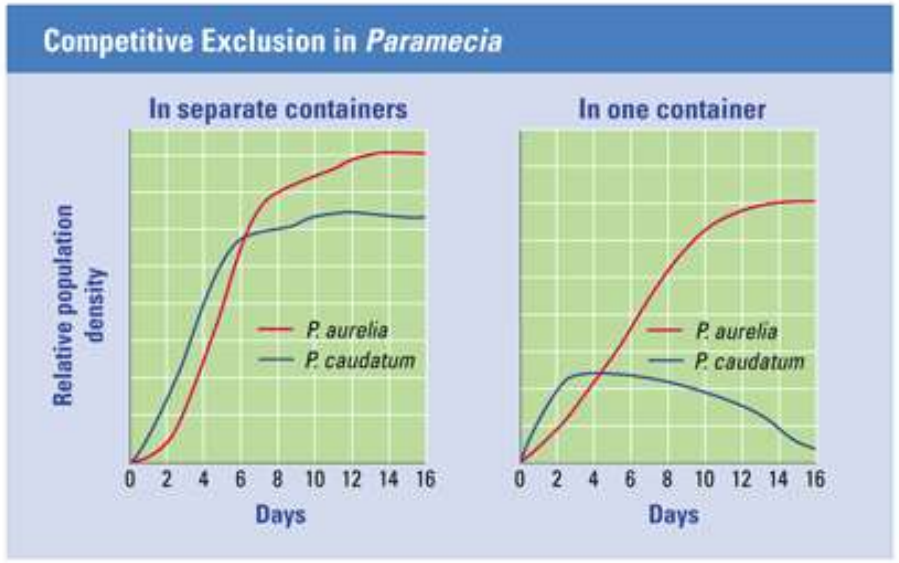
  - resource-mediated
  - host-mediated
  - interference



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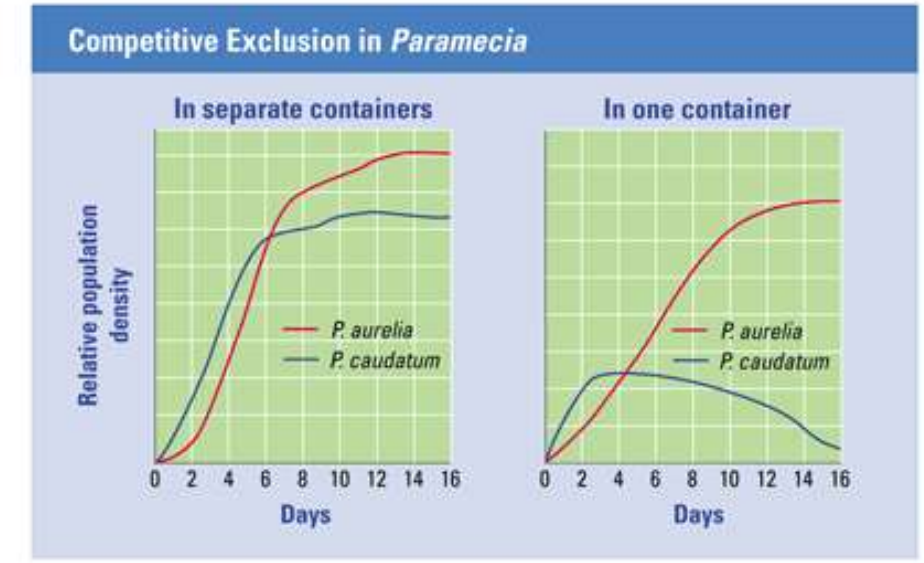
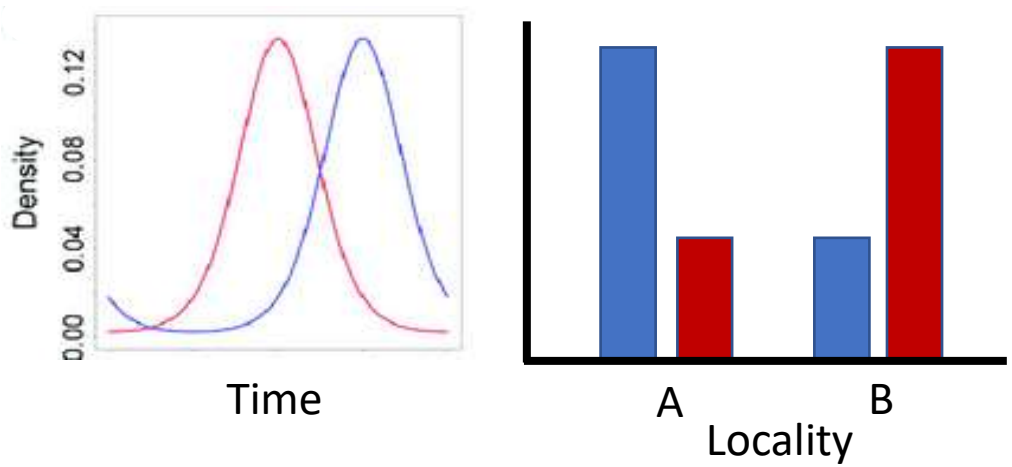


competition



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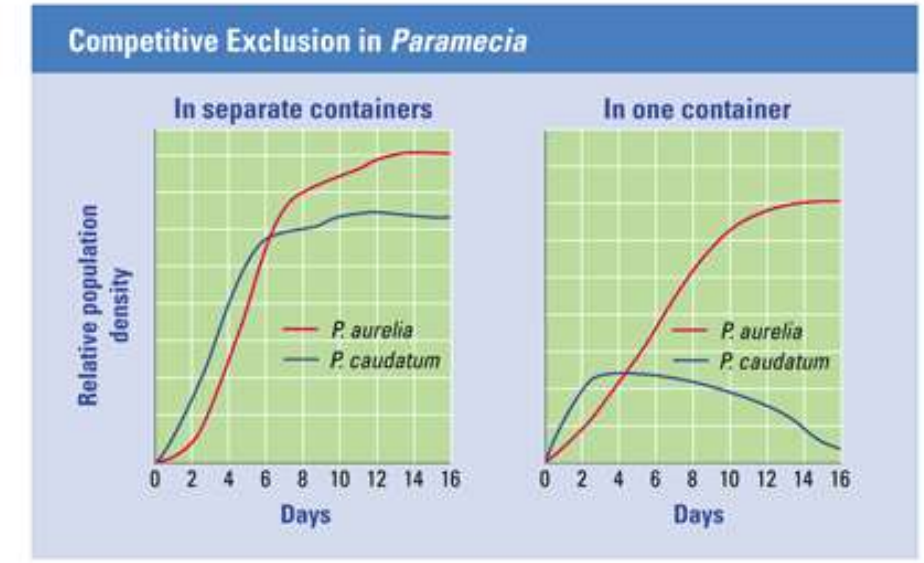

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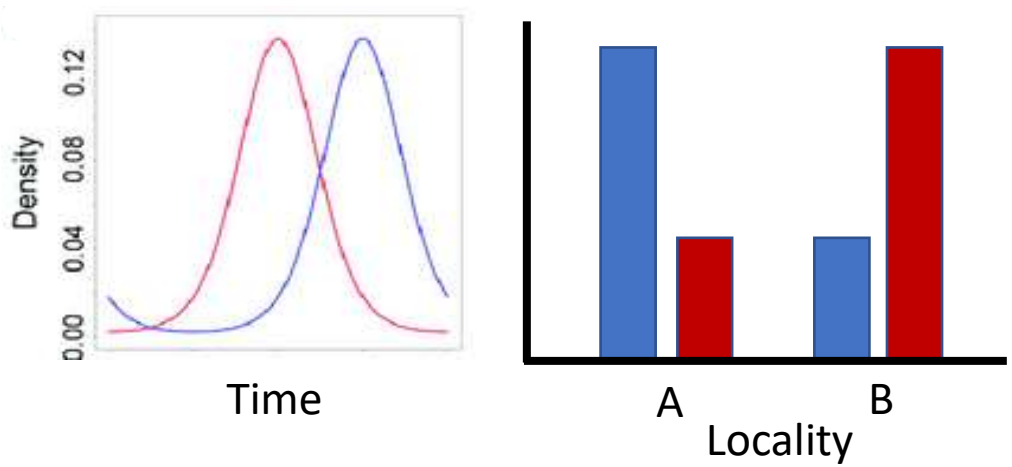
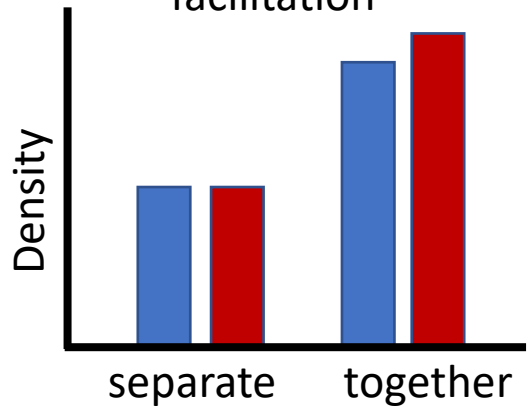


facilitation



Cocoa pests and diseases in South America

-Multiple pest simultaneously
-Only 22% of cocoa pods are healthy when harvesting
    -58% infected
    -20% affected by other agents

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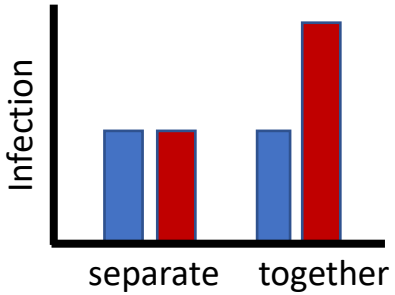
Mazorquero +
Mazorca negra



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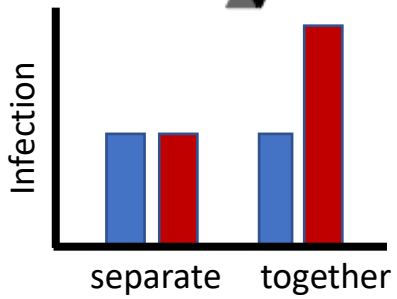
Otros (roedores, aves)

Mazorquero +
Mazorca negra



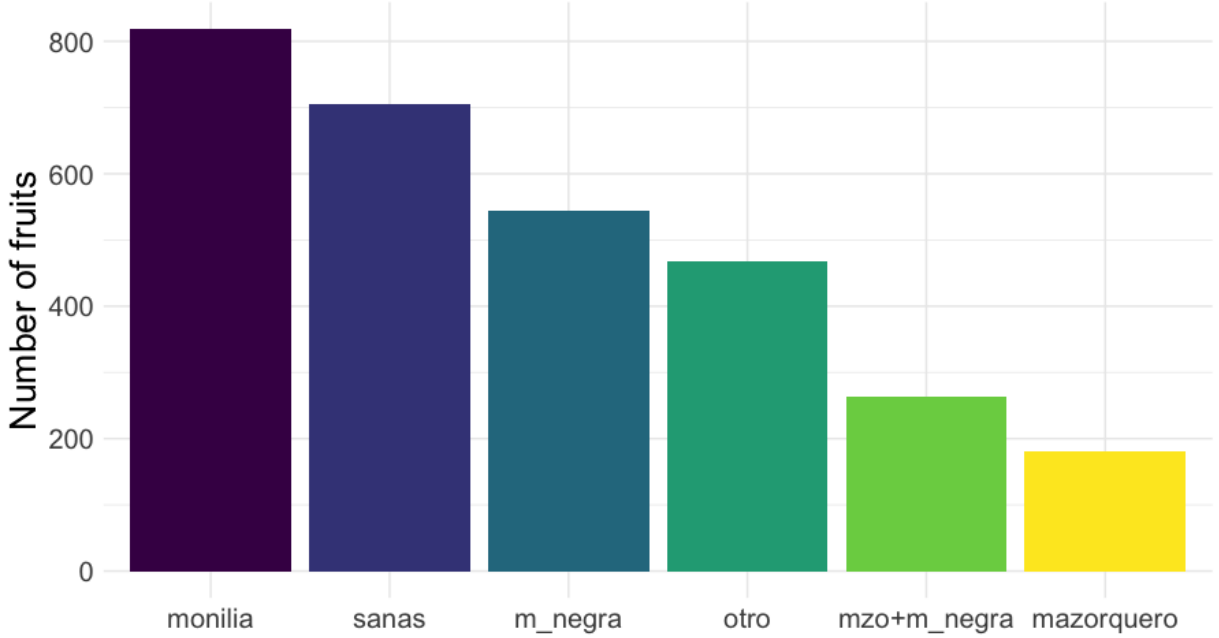
18 months of monitoring in the Peruvian Amazon

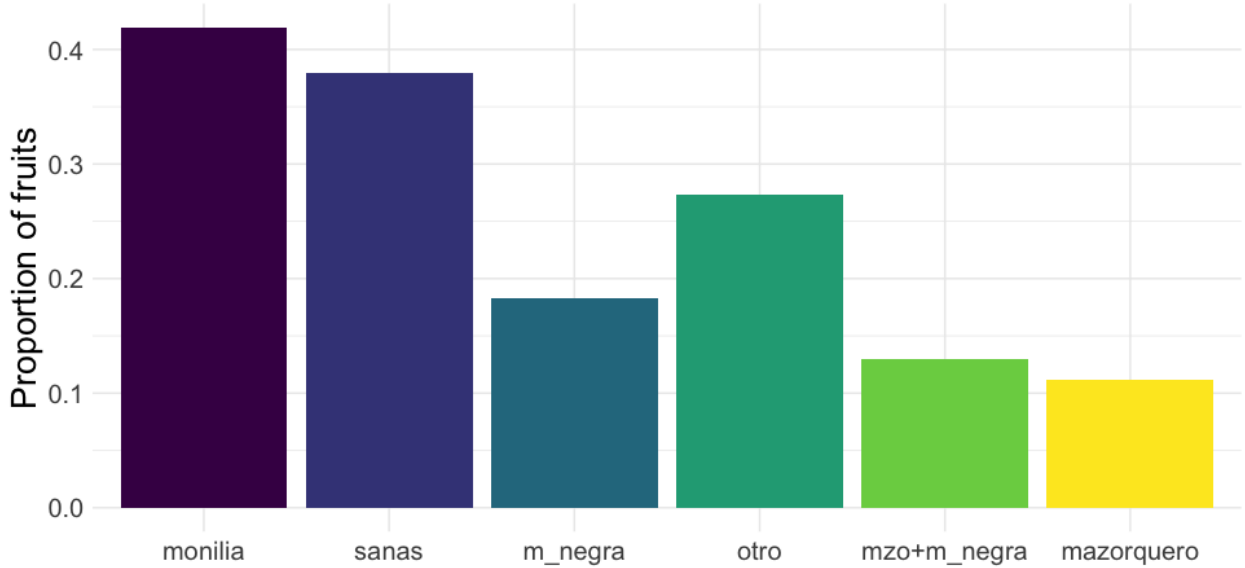
Upper Huallaga river
8 plots with differences in shade and managing practices
40 trees per plot
Measurements each 15 days
Fruits removal if infected
Data : total # healthy and infected pods per date per tree

Multipest spatio-temporal dynamics

1. Is there a prevalent disease?
2. Do disease infections follow a geographical pattern?
3. Are there differences in infection through time? If so, are these differences related to resource availability? To climate oscilations?
4. Are coinfection events promoted by season and/or by spatial differences?

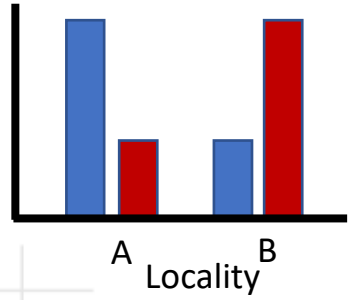
1. Is there a prevalent disease?

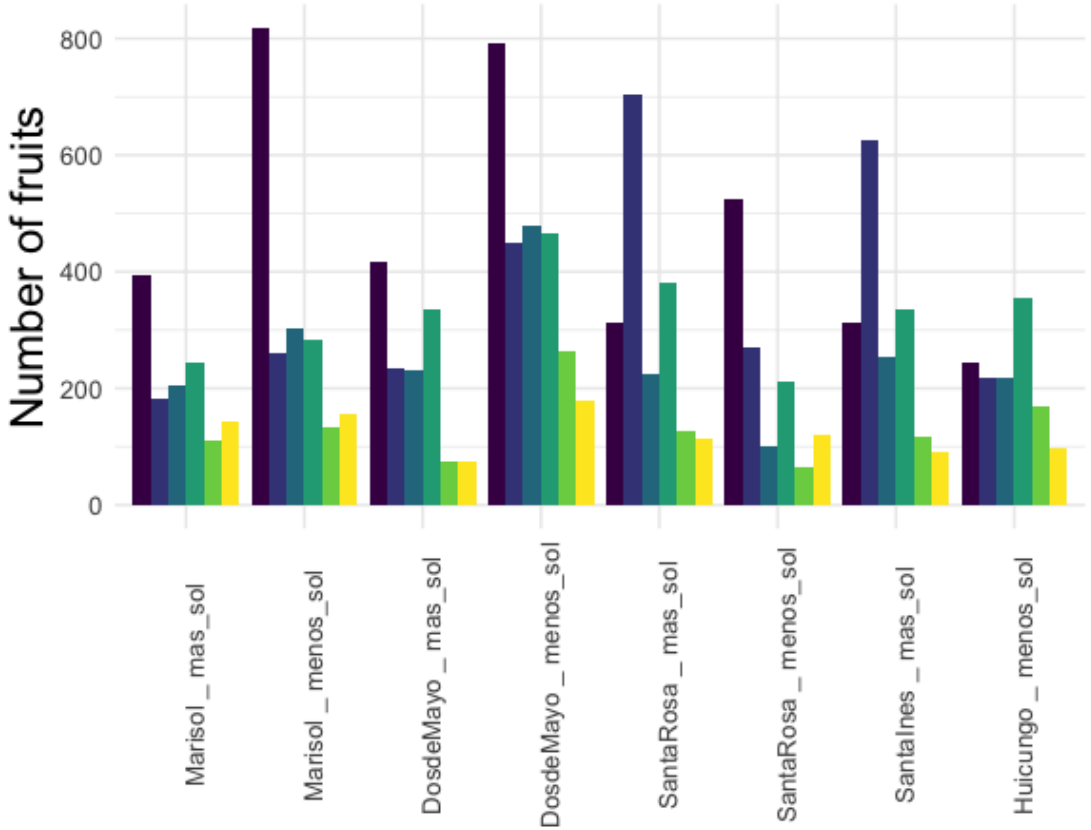


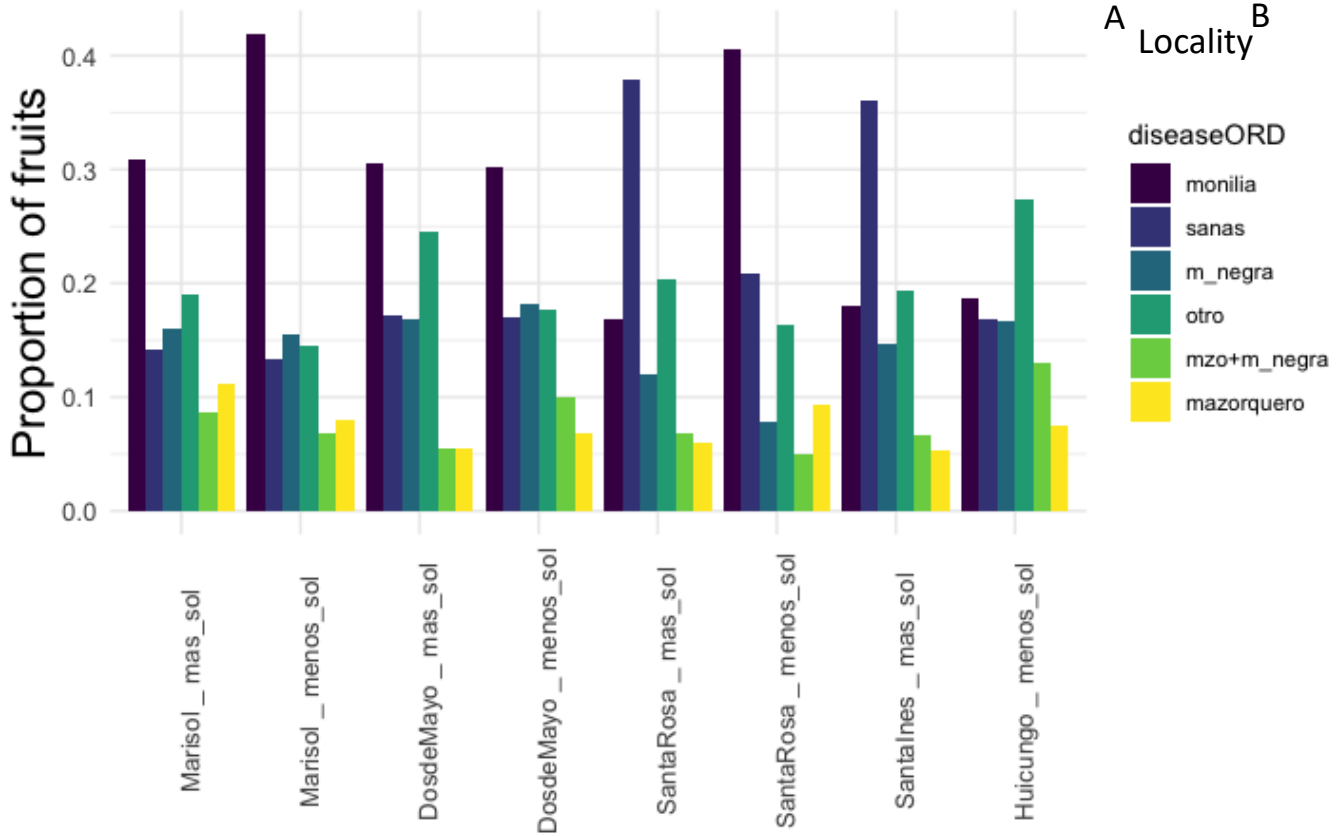


- Monilia affects the highest number of fruits in general

1. Is there a prevalent disease? Is it the same per plot?







- Monilia affects the highest number of fruits in 5/8 localities
- Incidence of diseases differs between localities

2. Can we detect a geographical pattern on disease infection?

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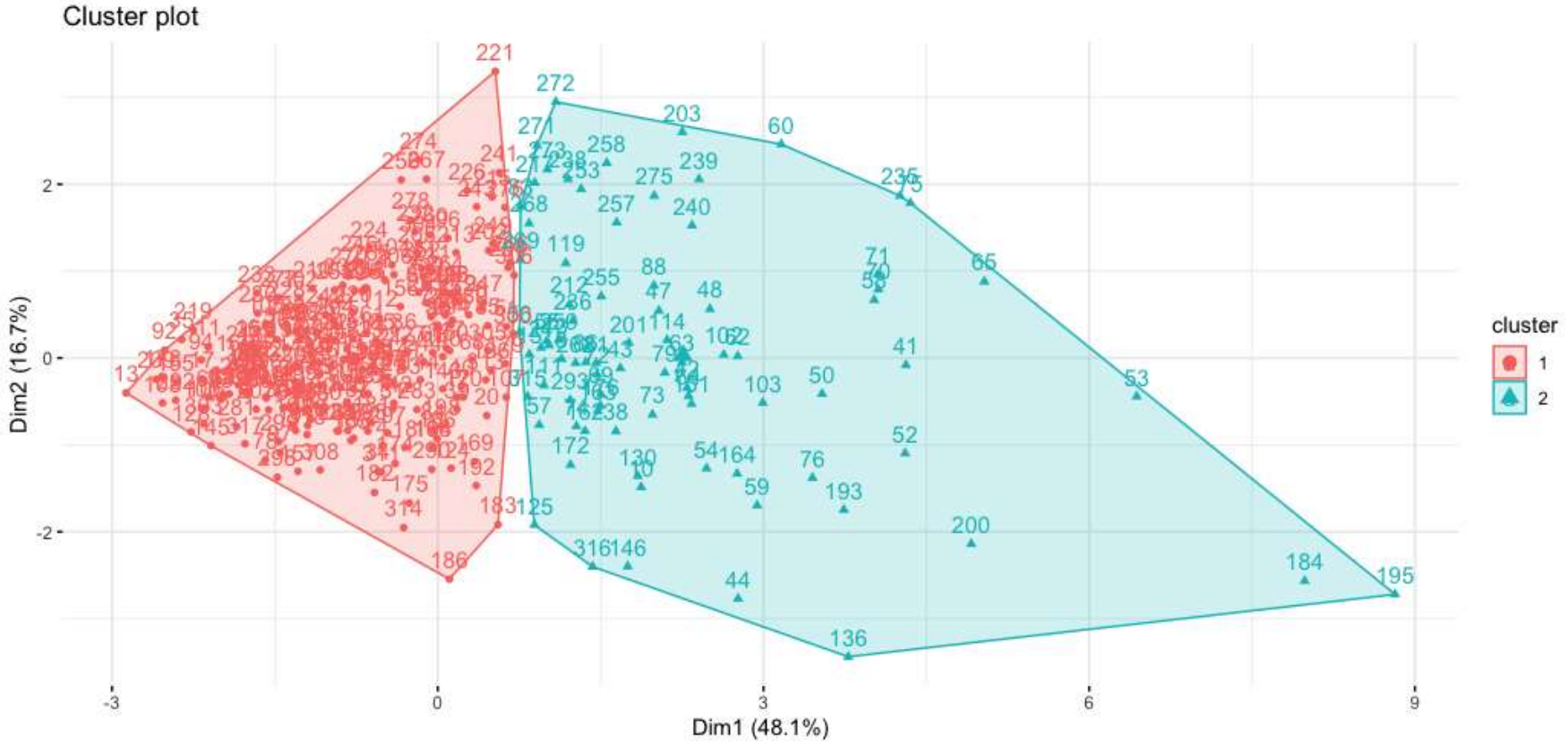


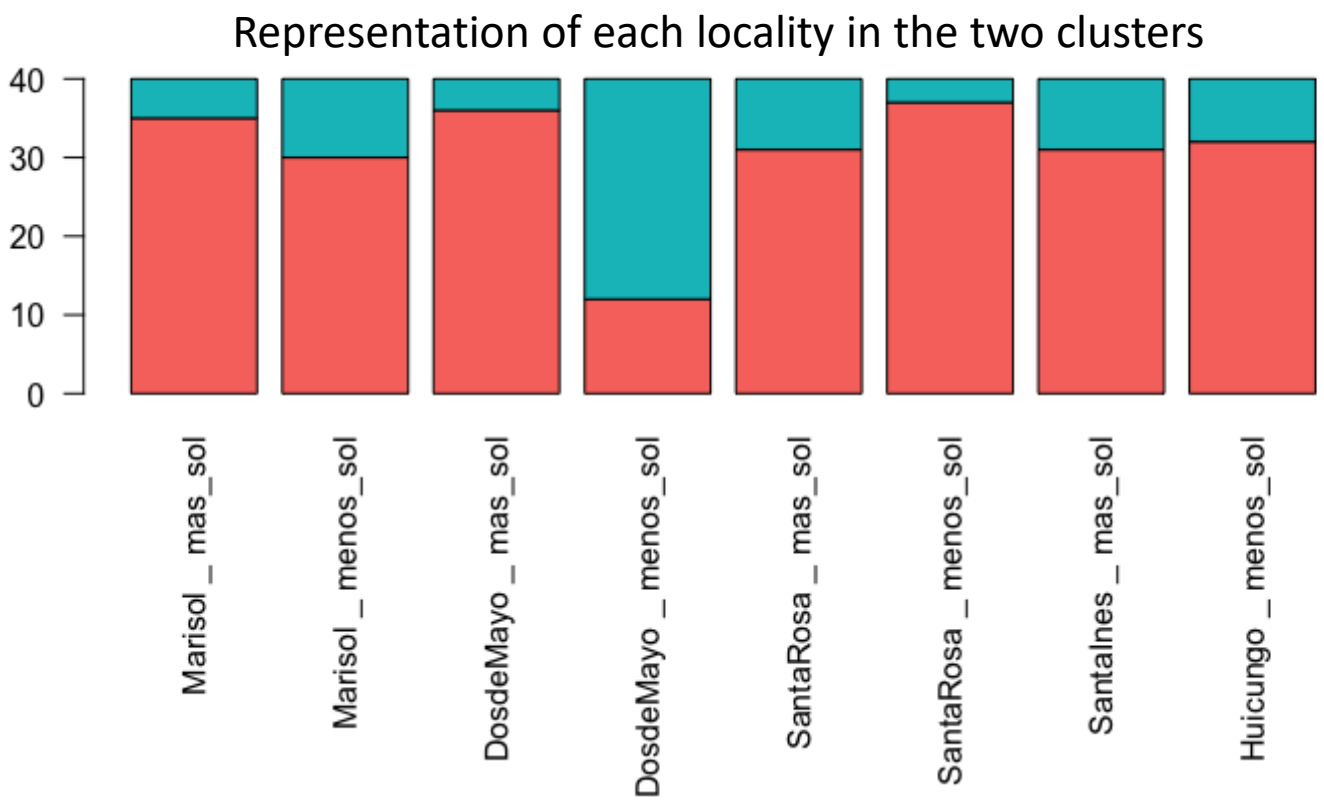
Based on total fruits healthy and affected by the different diseases per tree

2. Can we detect a geographical pattern on disease infection?

Representation of each locality in the two clusters

- Very little geographic structure at large scale
- Perhaps structure at intra-plot scale?

2. Can we detect a geographical pattern on disease infection?



- Very little geographic structure at large scale
- Perhaps structure at intra-plot scale?

3. Is there a temporal pattern on the infection by different diseases?

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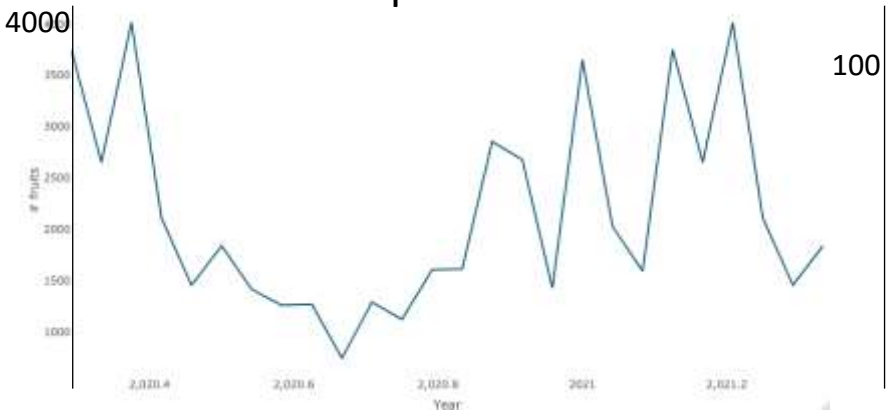
- Number of healthy and sick fruits per tree per date of monitoring.
- General temperature and preciptiation in the study area during the monitoring period

Screenshot: CRU TS Version 4.05 Google Earth Interface
https://crudata.uea.ac.uk/cru/data/hrg/

Total infected fruits through time

Total fruit production



Mazorca negra

100

Mazorquero

45

Monilia

350

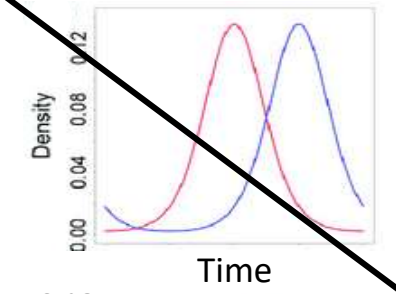
Mazorca negra + Mazorquero

90

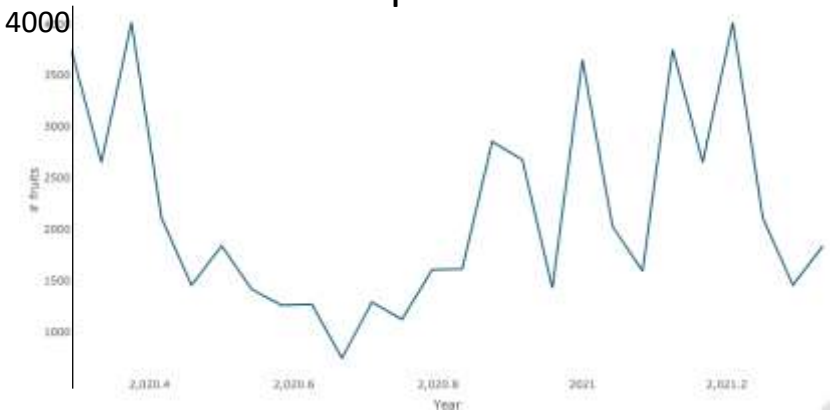
Otro

120

Total infected fruits through time



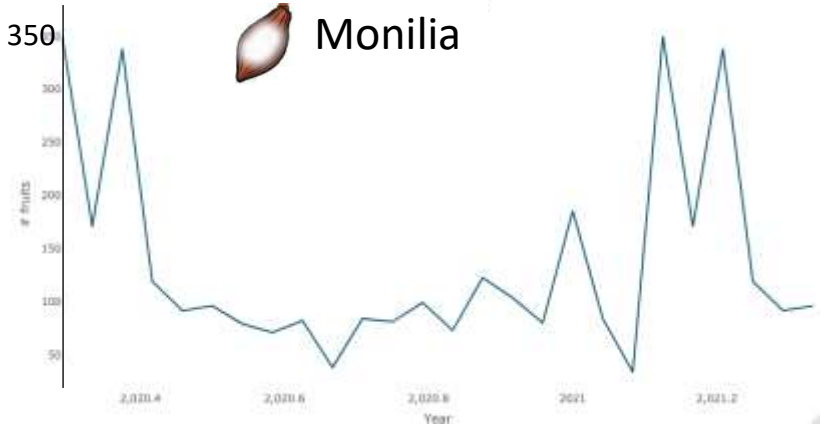
Total fruit production



Mazorca negra

Mazorquero

Monilia

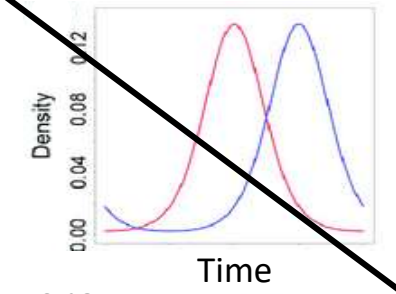


Mazorca negra + Mazorquero

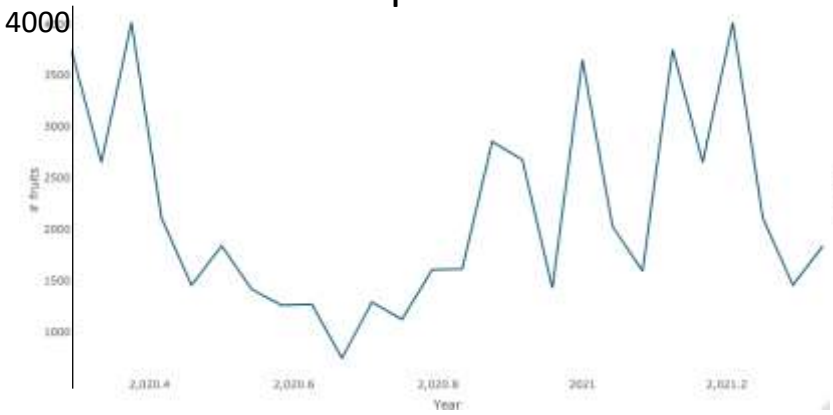
Otro

- All diseases are correlated to total amount of fruits produced➔ availability of ressource.
- Correlation between them too, probably through ressource availability

Total infected fruits through time



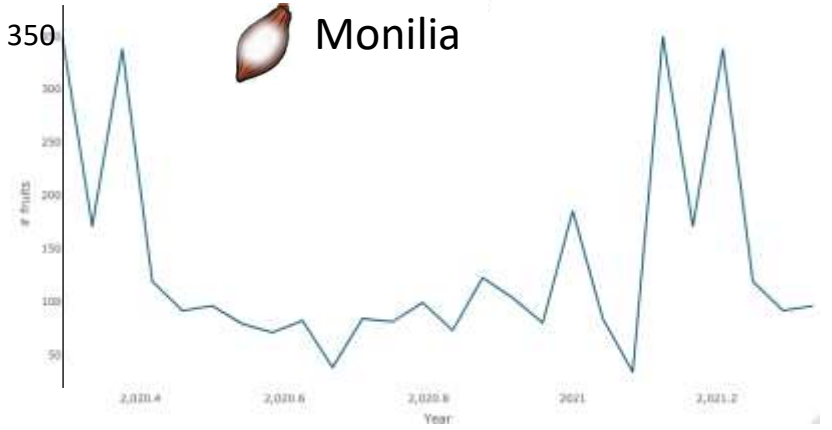
Total fruit production



Mazorca negra

Mazorquero

Monilia



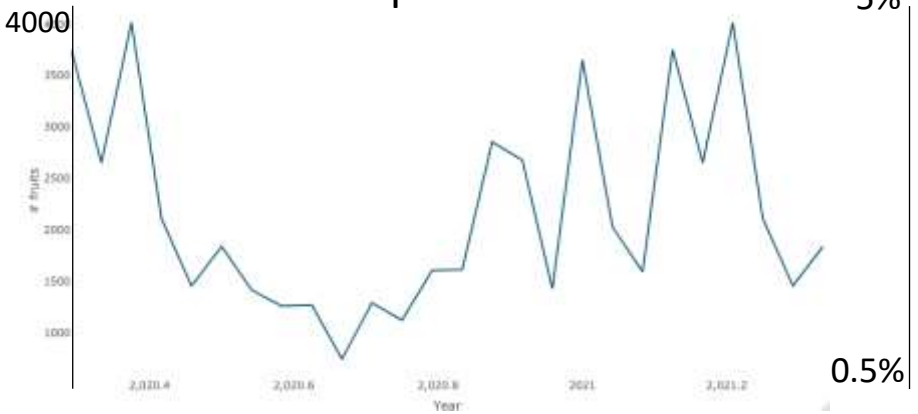
Mazorca negra + Mazorquero

Otro

- All diseases are correlated to total amount of fruits produced➔ availability of ressource.
- Correlation between them too, probably through ressource availability
- Weak correlation between infection and general weather ➔ Microclimate effect?

Percentage of infected fruits through time

Total fruit production



Mazorca negra

5%

0.5%

Mazorquero

2.5%

1%

Monilia

9%

2%

Mazorca negra + Mazorquero

5%

0.5%

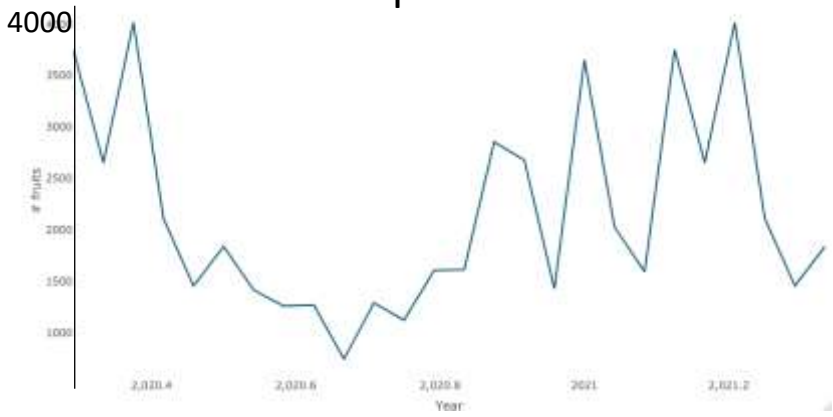
Otro

4.5%

2%

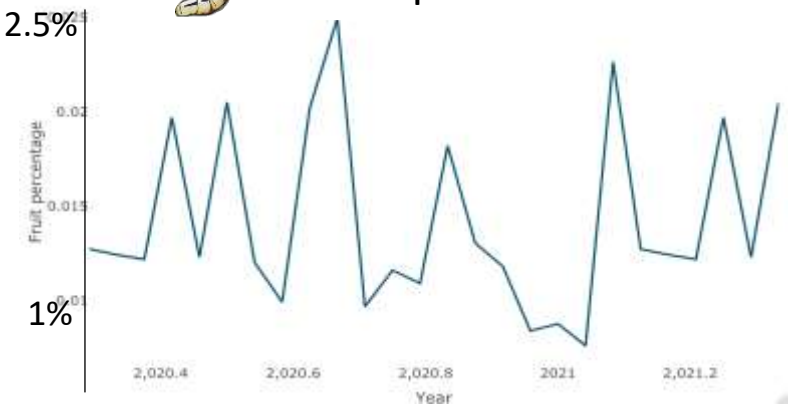
Percentage of infected fruits through time

Total fruit production

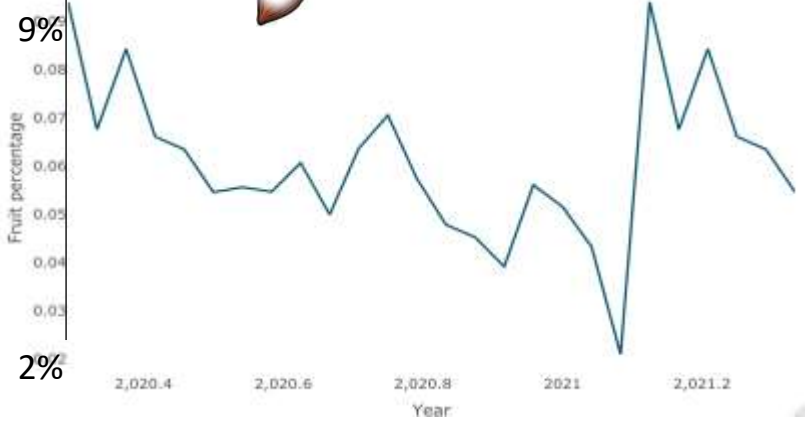


Mazorca negra

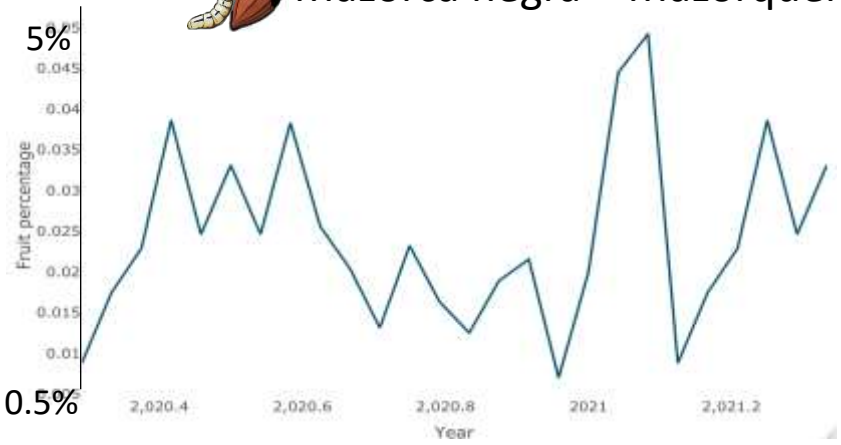
Mazorquero



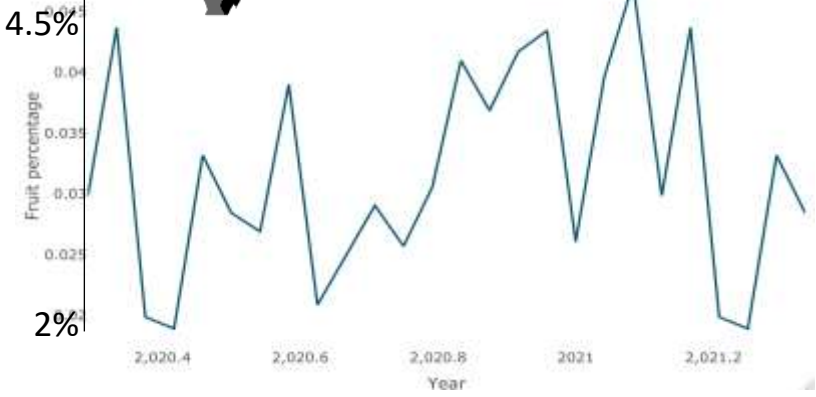
Monilia



Mazorca negra + Mazorquero



Otro



- Temporal differences also on percentage of infection

4. Are there temporal or spatial conditions that can favour disease coinfection at the tree level?

- 1000 times simulation of real infection values per tree per disease per date

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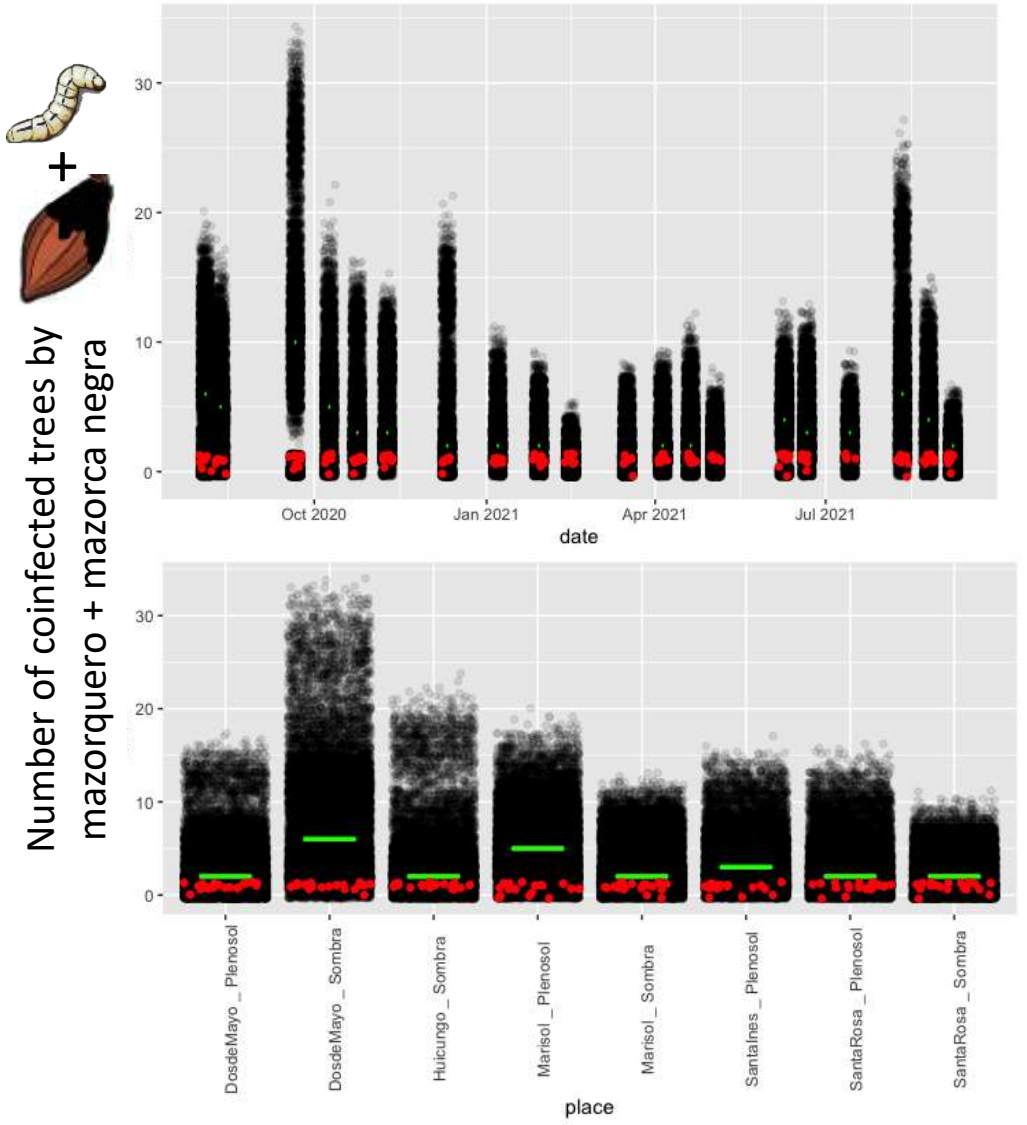
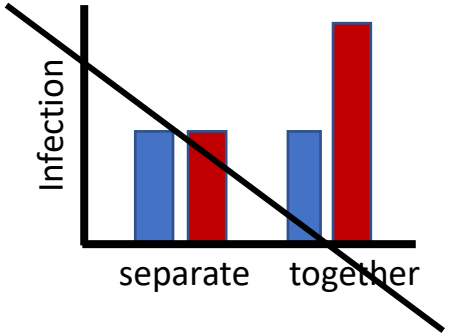
- 1000 times simulation of real infection values per tree per disease per date
- Observed data is under the median of simulated data in several cases





Multipest spatio-temporal dynamics

1. Is there a prevalent disease? Yes!
2. Do diseases infections follow a geographical pattern? No
3. Are there differences in infection through time? If so, are these differences related to resource availability? To climate oscilations? Yes!
4. Are coinfection events promoted by season and/or by spatial differences?

No, but fewer coinfection!

Muchas gracias

¡Los agricultores!
Marcos Ramos, Jhoner Alvarado, Clémentine Alline, Gerben Martijn Ten Hoopen, Leïla Bagny-Beilhe


¡Ustedes por su atención!

Supplementary slides

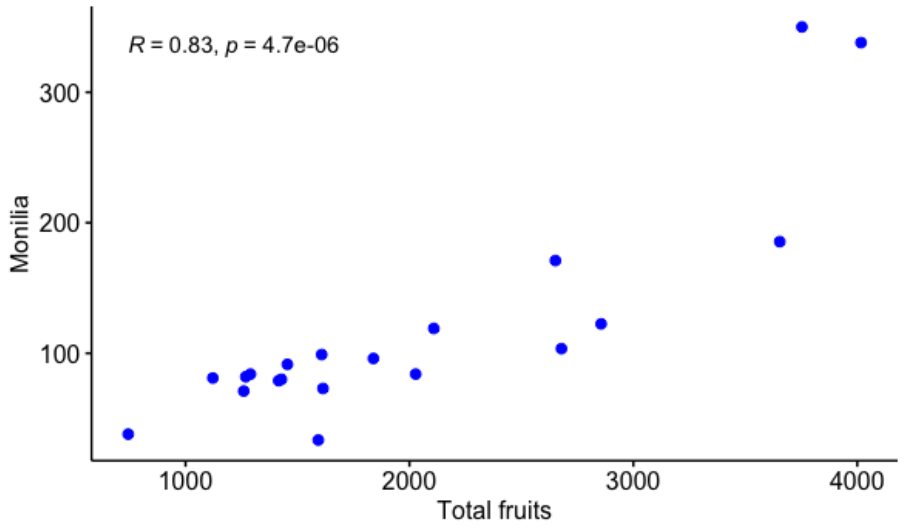
How to propose ecologically friendly solutions?

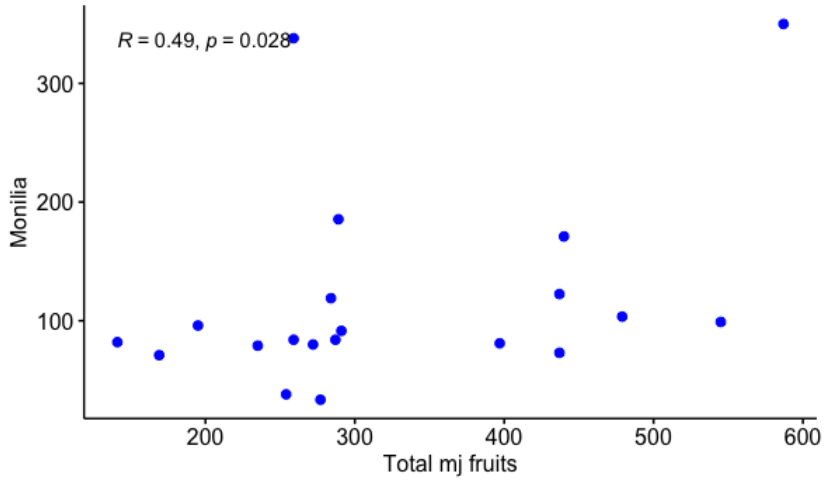
3. Management practices useful against pest and diseases

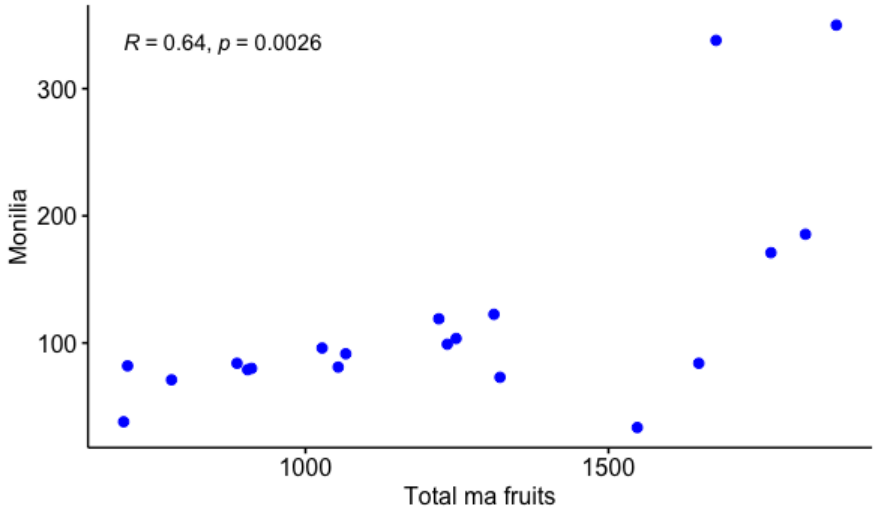
1. Multipest temporal and spatial dynamics

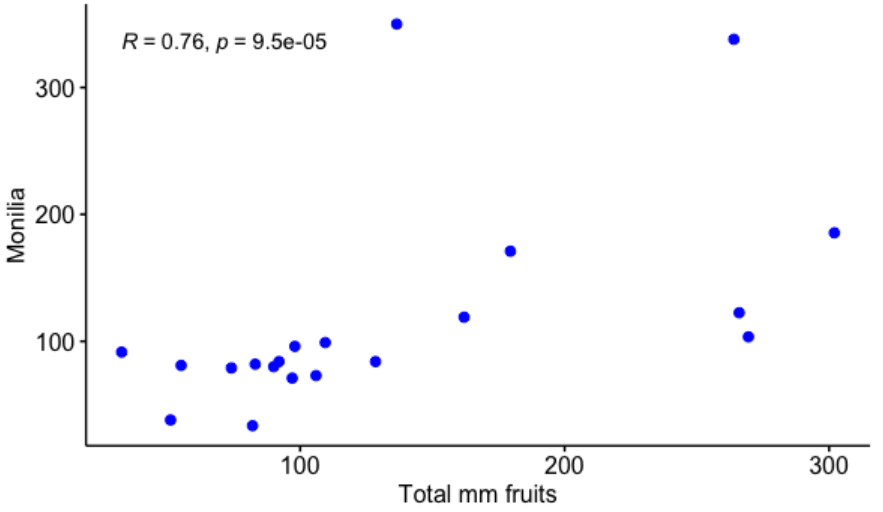
2. Shade effect on infection

Monilia vs fruit availability through time after covid



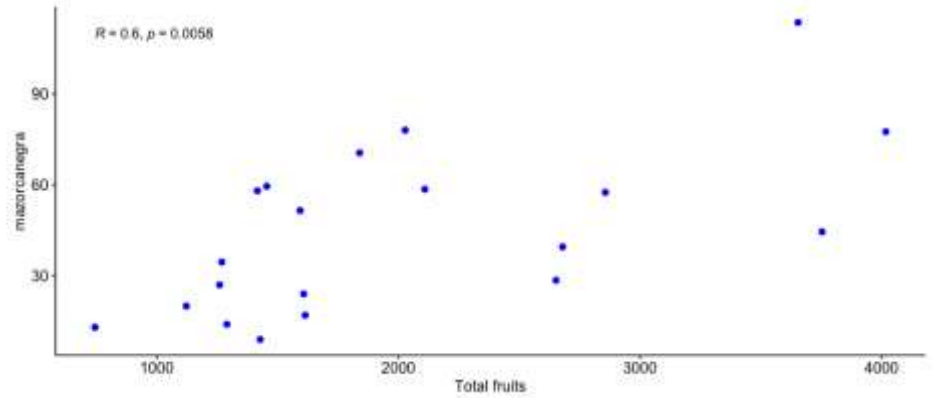


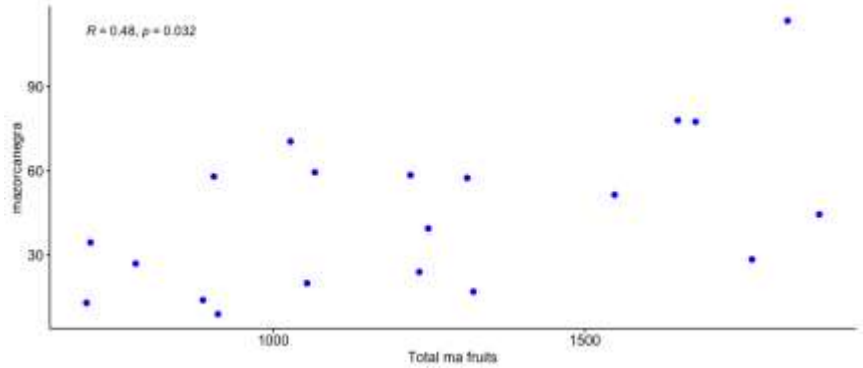


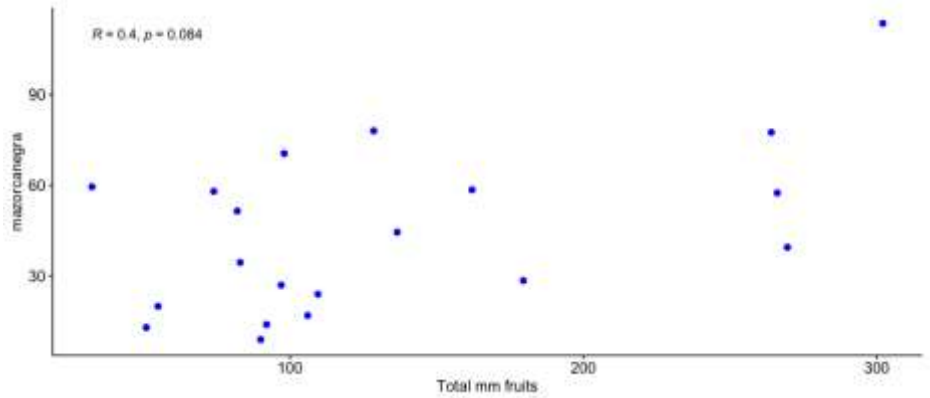


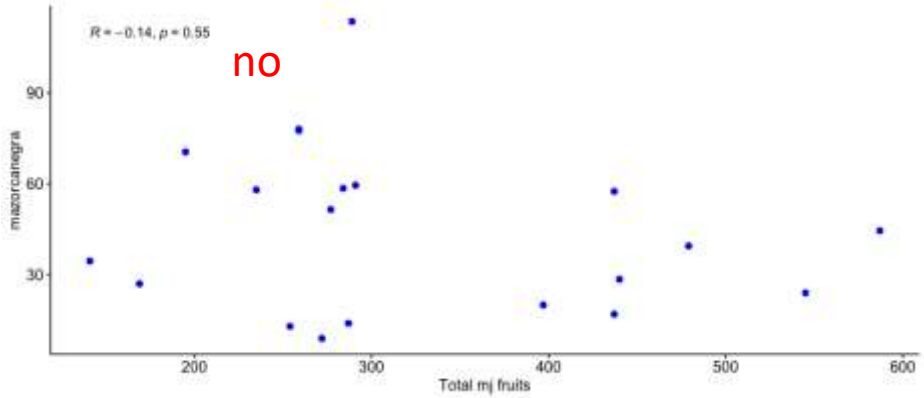
No correlation between monilia and temperature nor precipitation

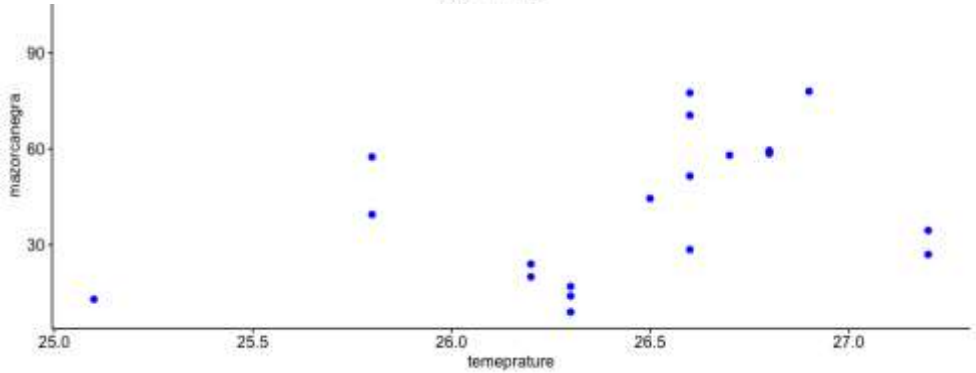
Mazorcanegra vs fruit availability through time after covid





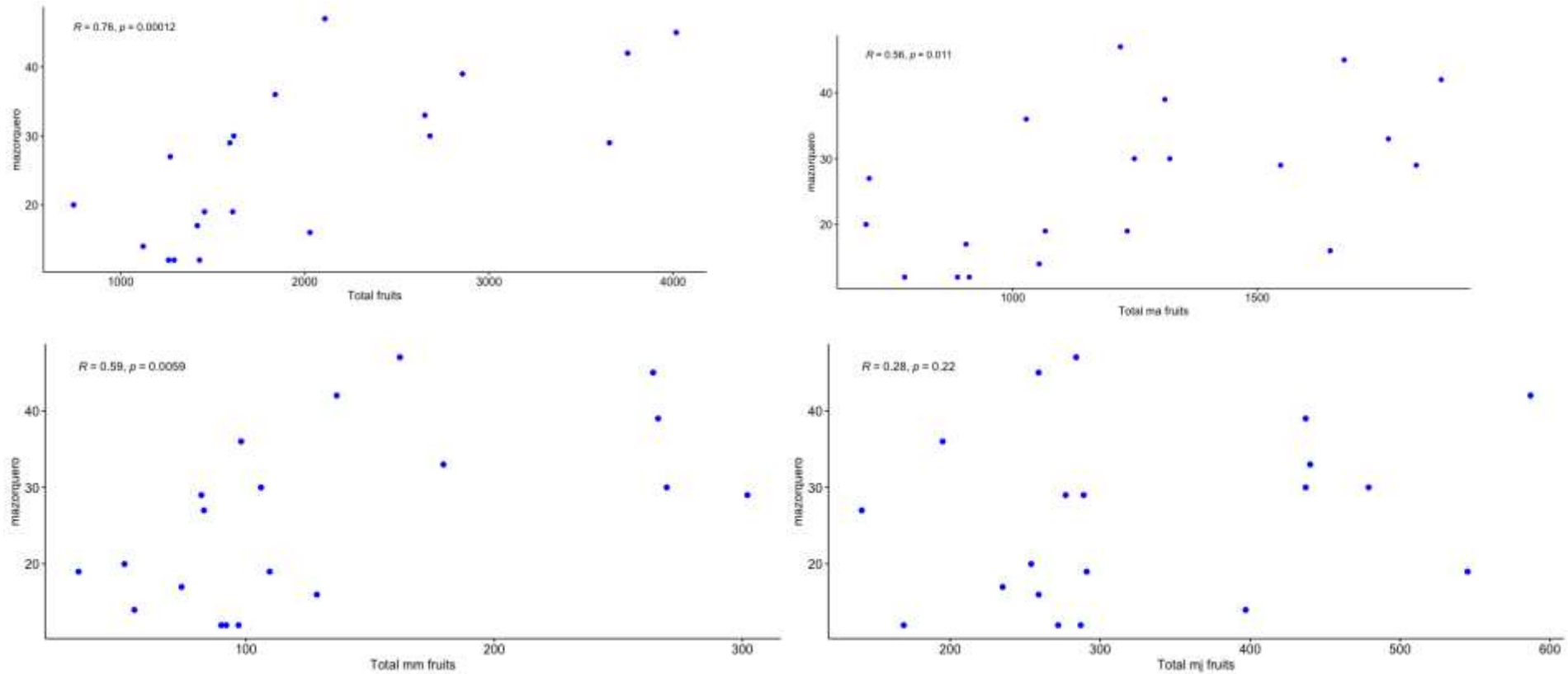






Mazorcanegra affected by temperature but not by precipitation

Mazorquero vs fruit availability through time after covid

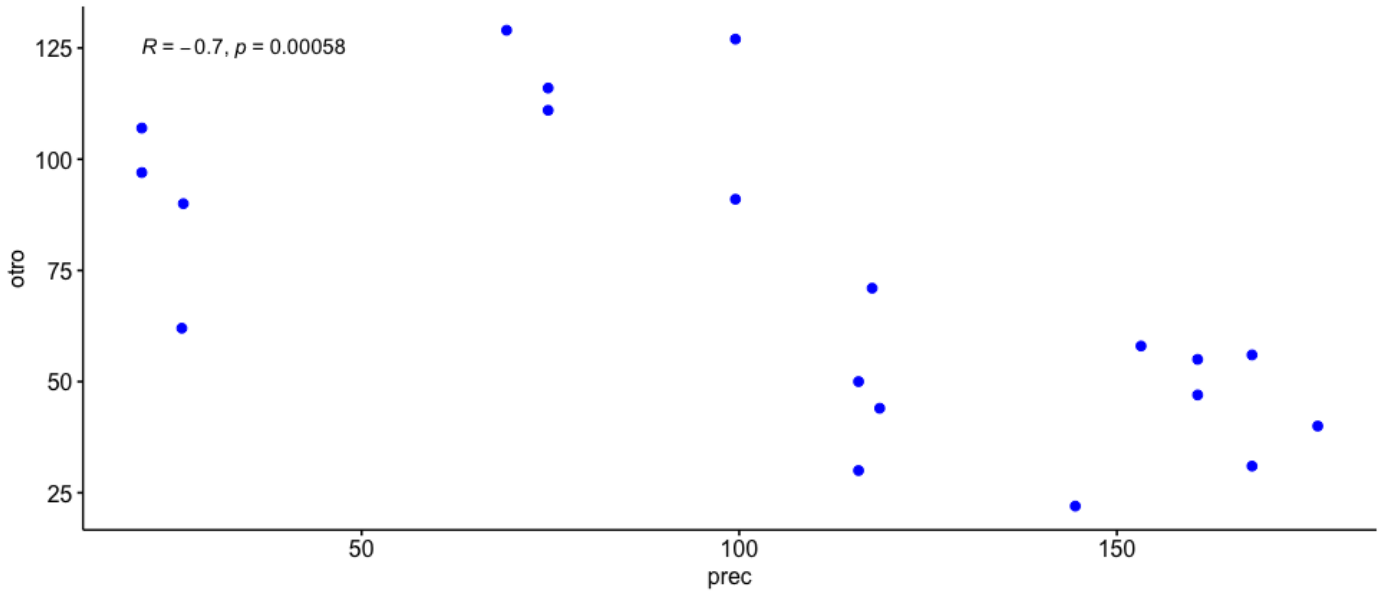


No correlation between mazorquero and temperature nor precipitation

otro vs fruit availability through time after covid

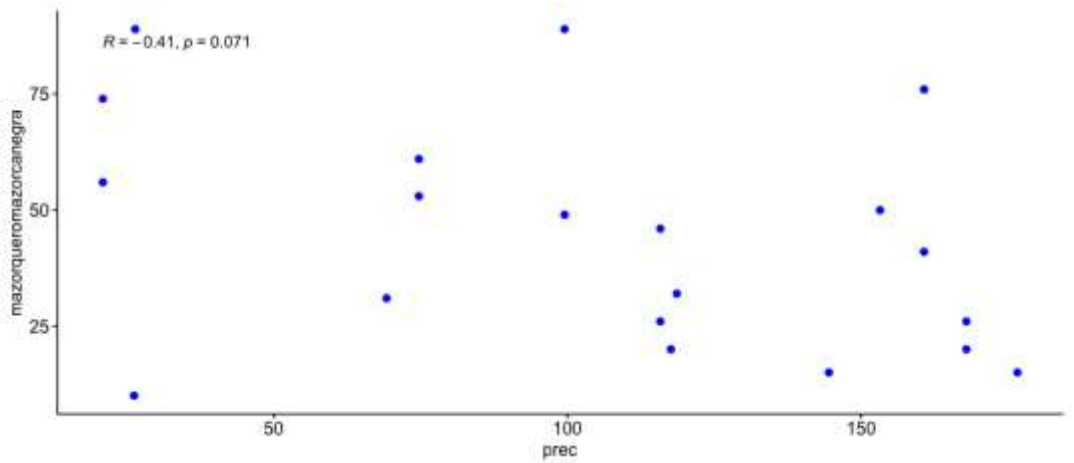
Positive correlation between availability of fruits as a whole and by phenological state

No effect of temperature but negative effect with precipitation



Mazorquero+mazorcanegra vs fruit availability through time after covid

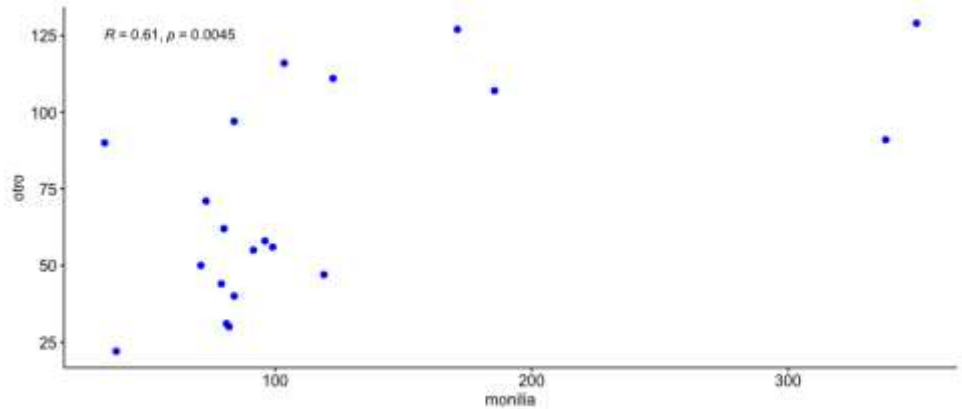
Positive correlation between availability of fruits as a whole and by phenological state
No effect of temperature but marginal effect of precipitation in co-infection

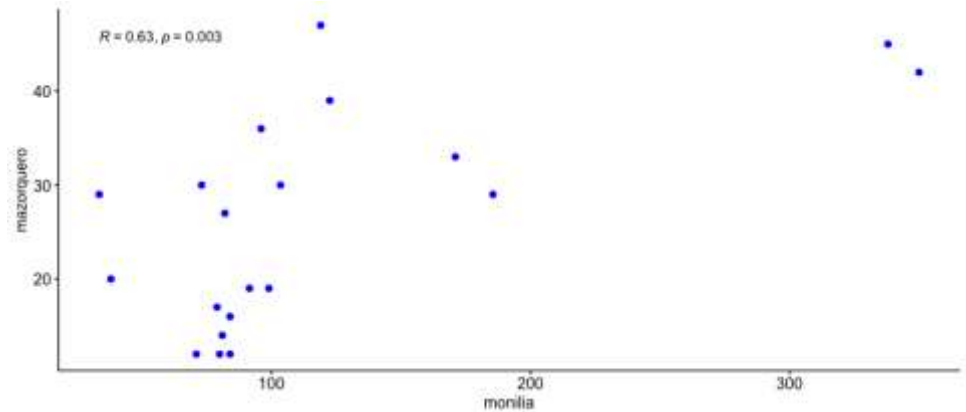


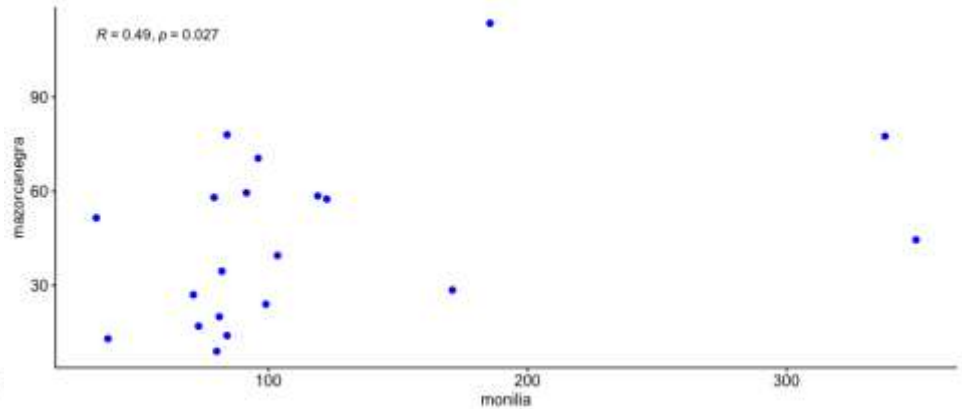
Temporal interaction of diseases throughout time?

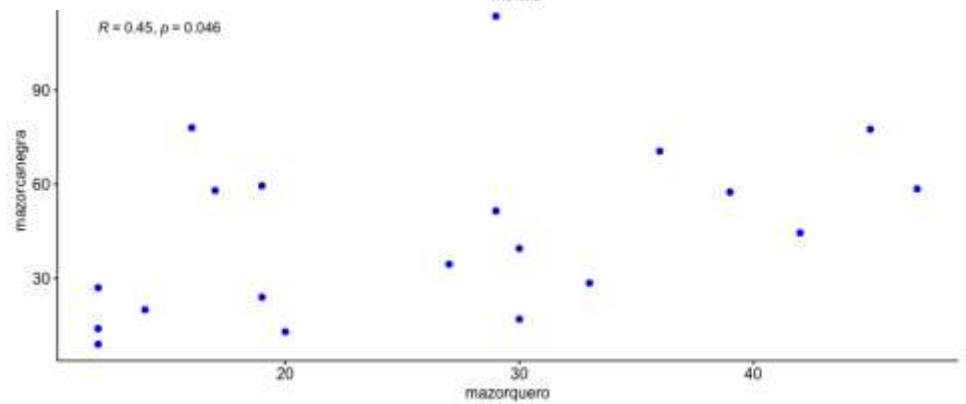
Positive correlation between all diseases pairs throughout time= ressource is far from being limitant and produce competition.

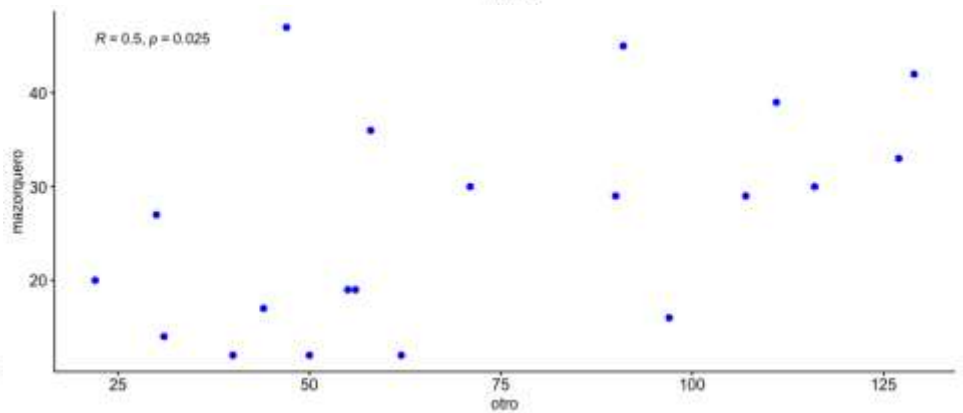
Graphically I cannot see facilitation or synergisitc effect but check how to test them statistically





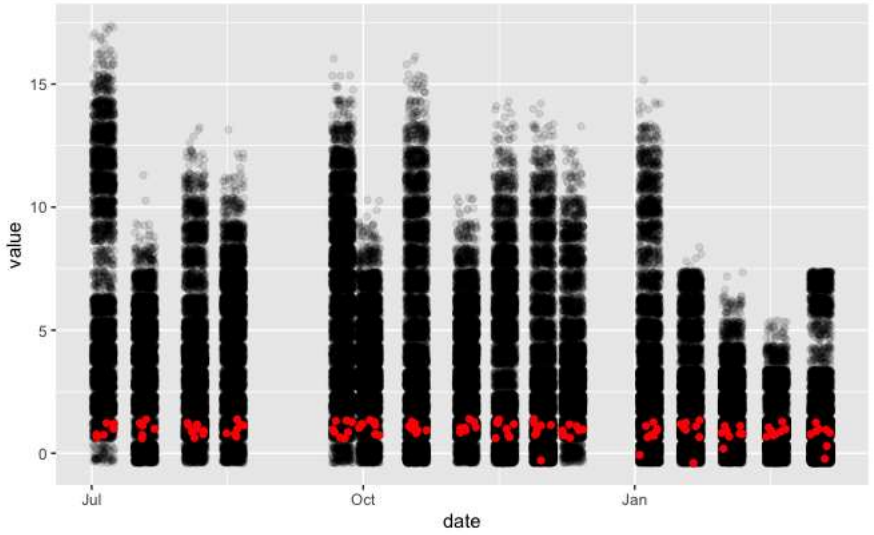






Per date

mnymz



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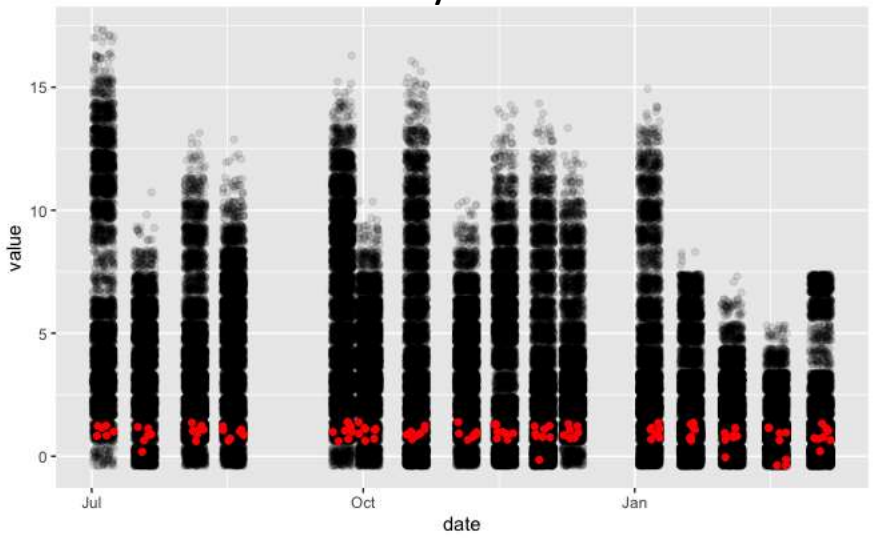

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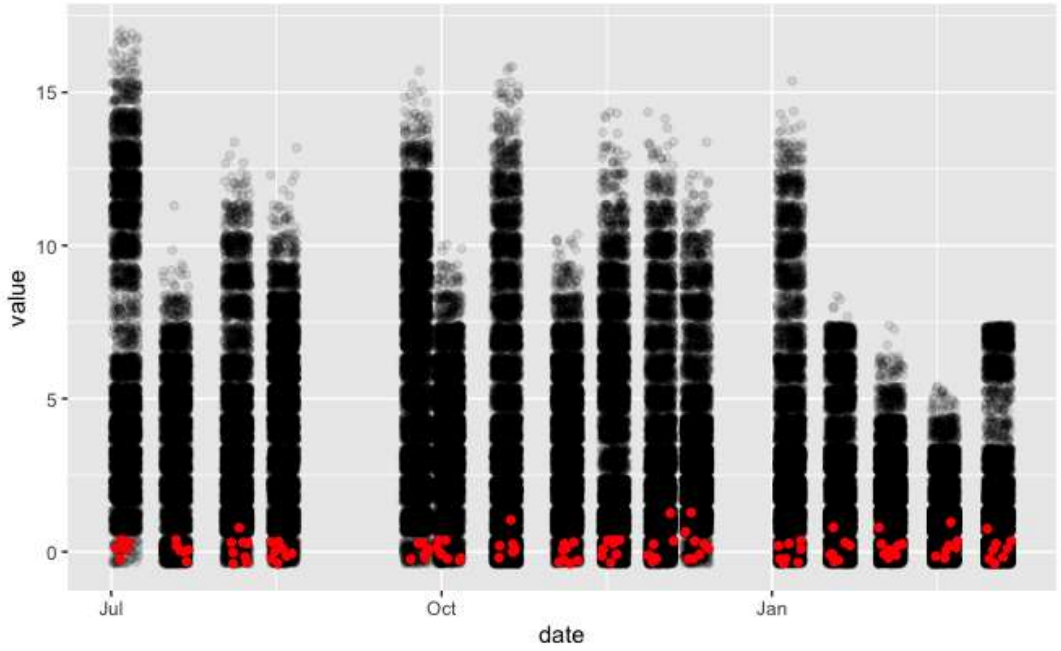

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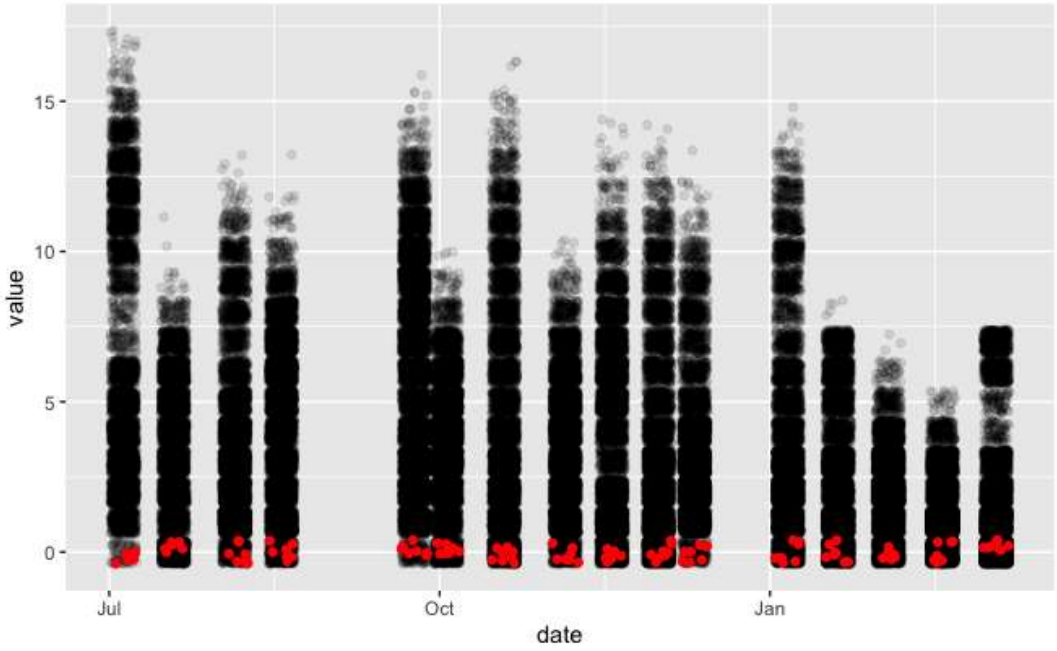

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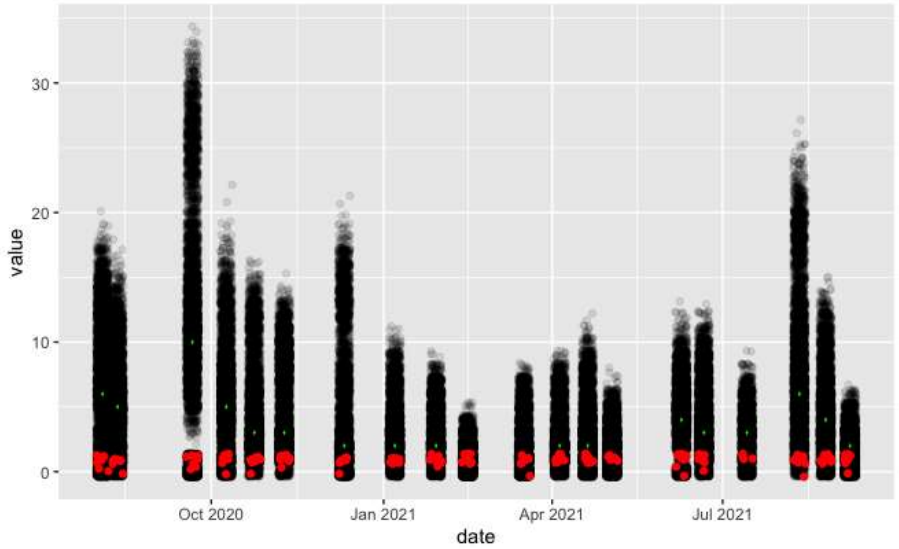

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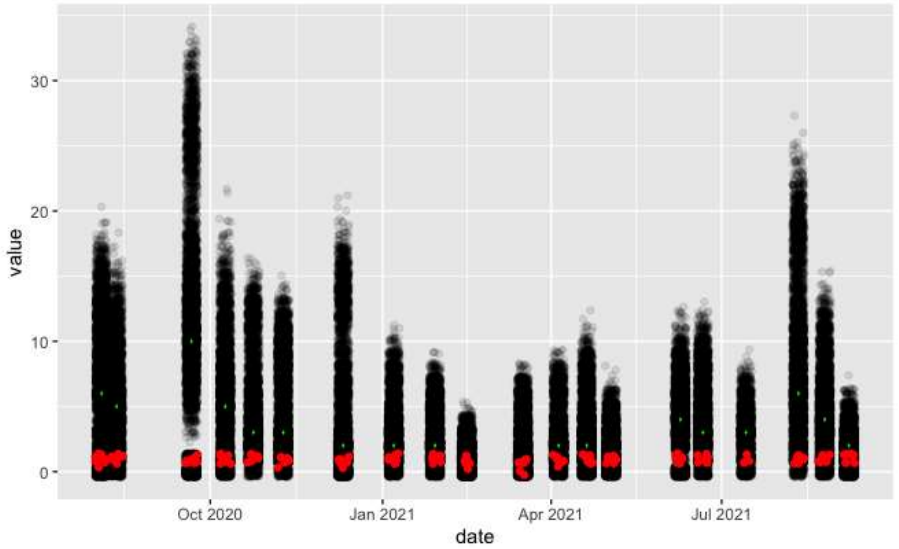

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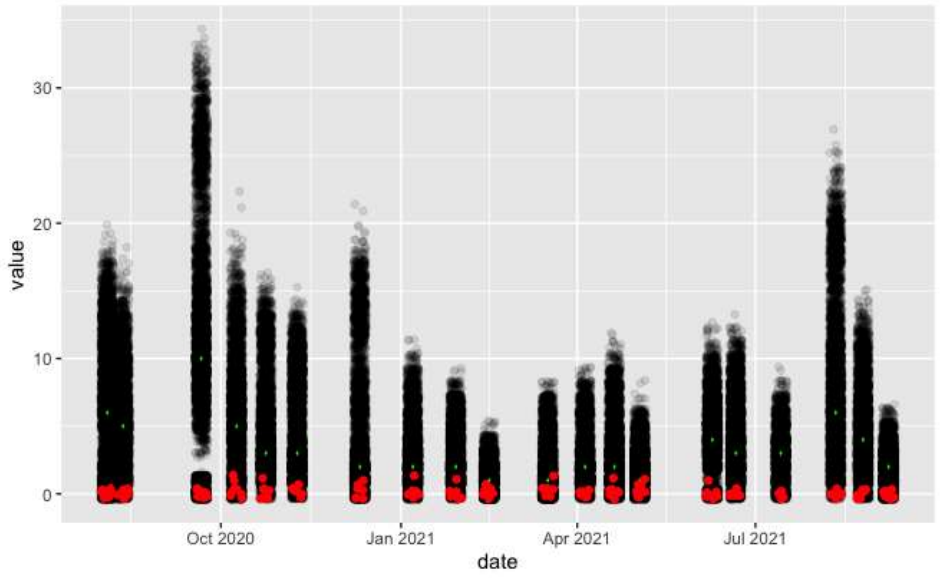

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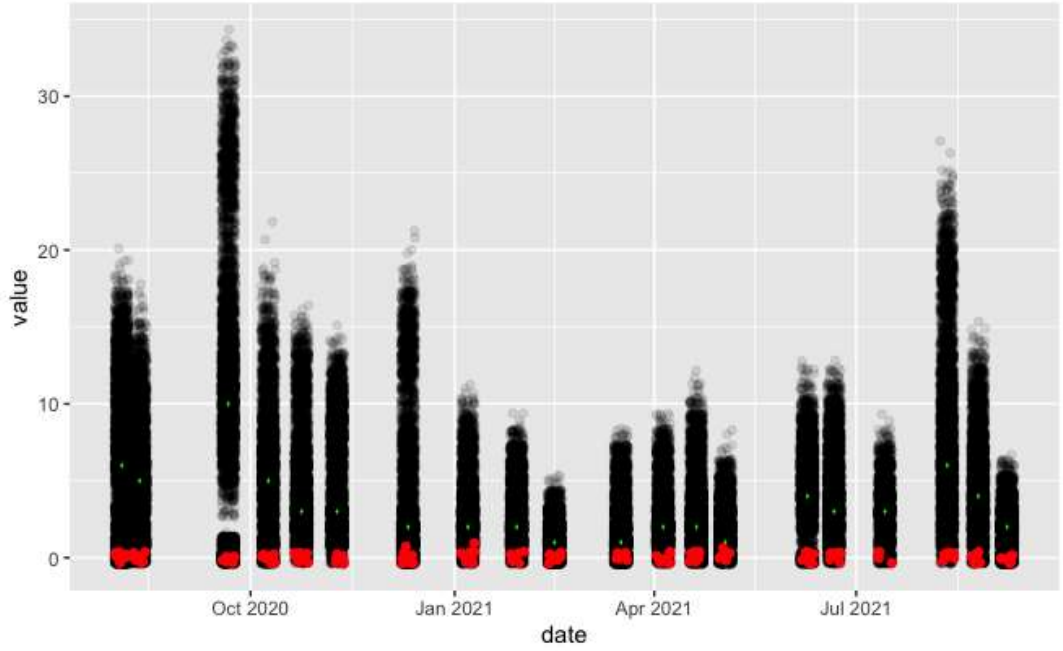

Per locality

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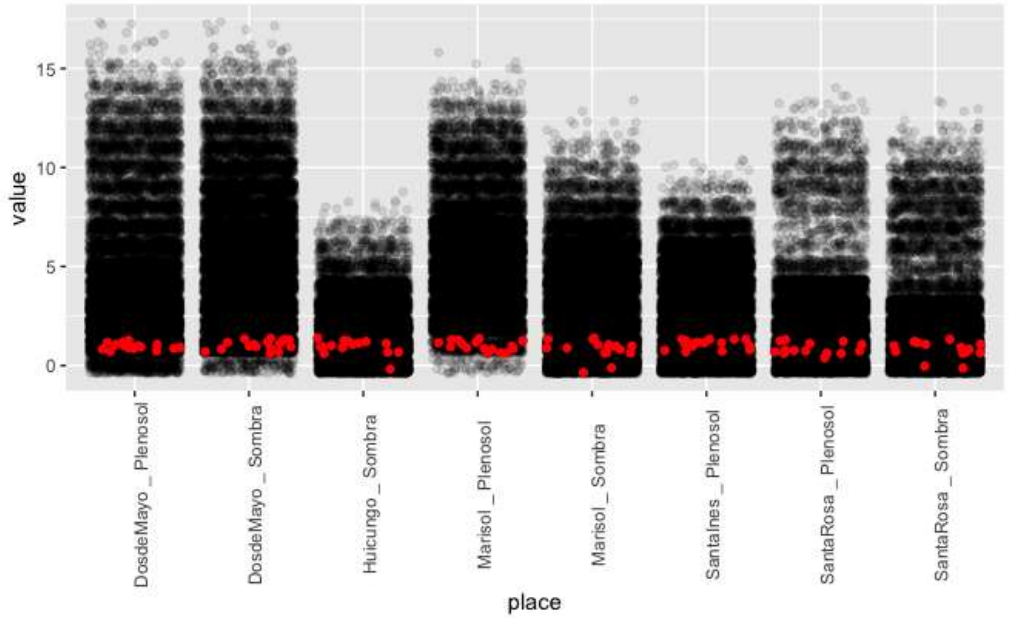

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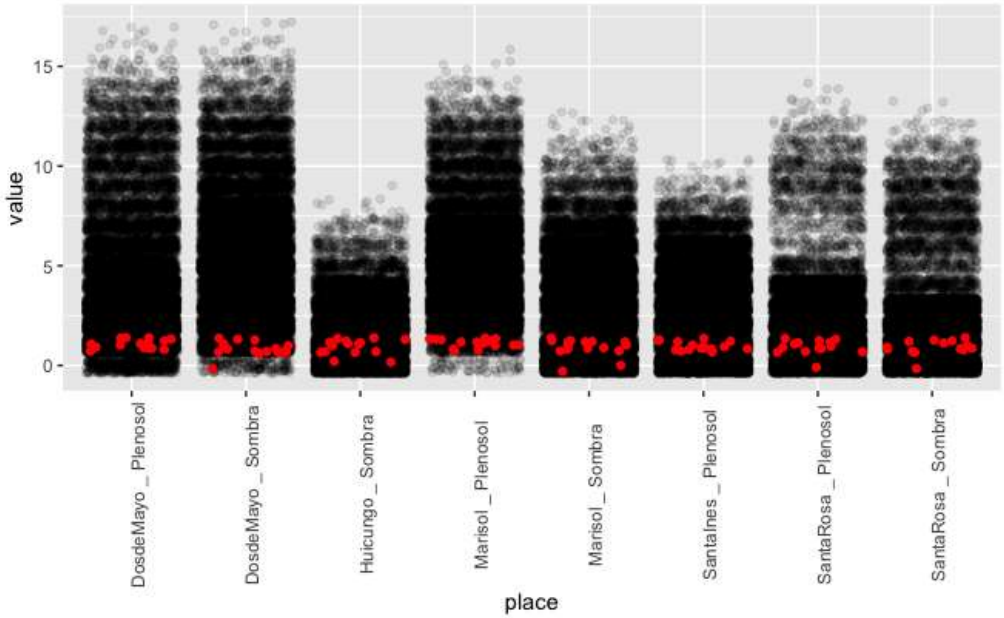

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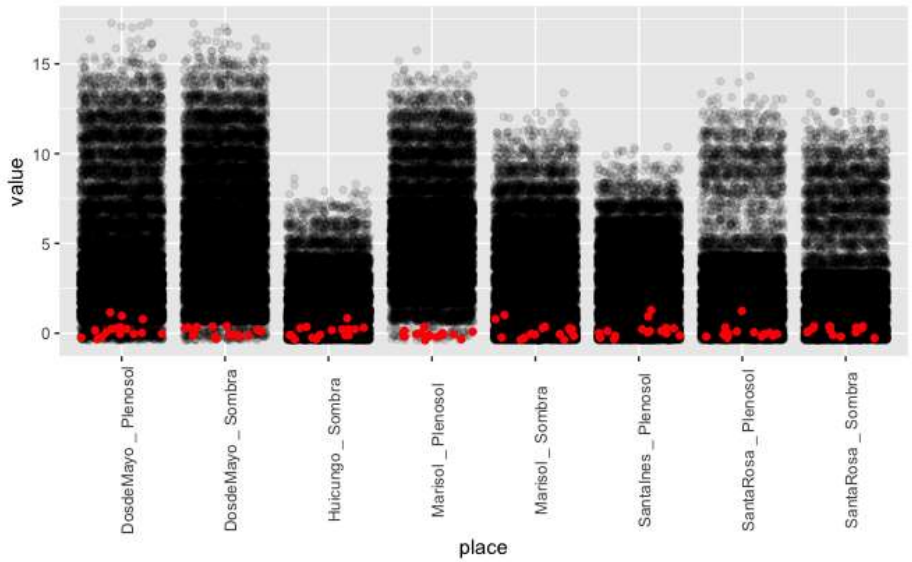

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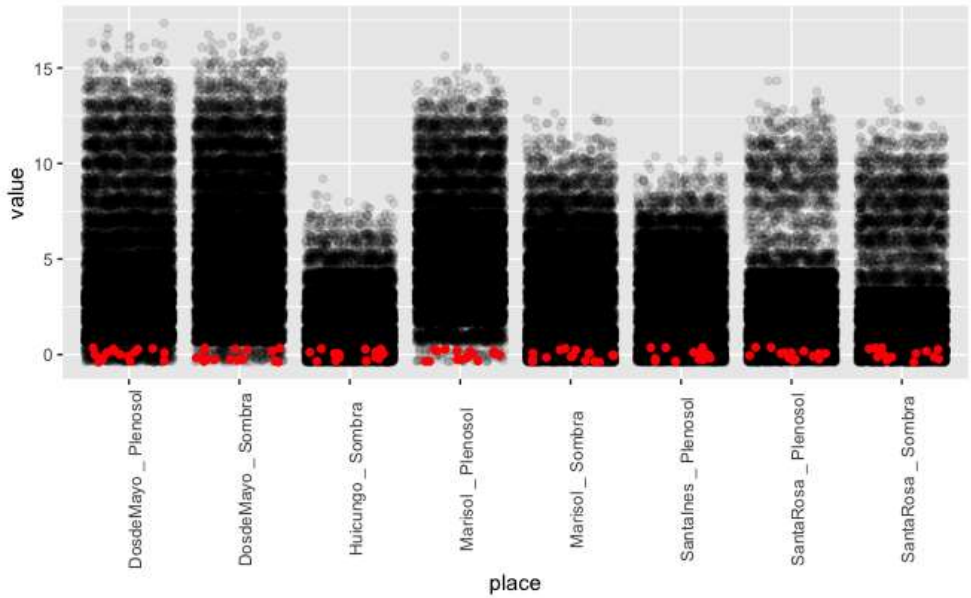

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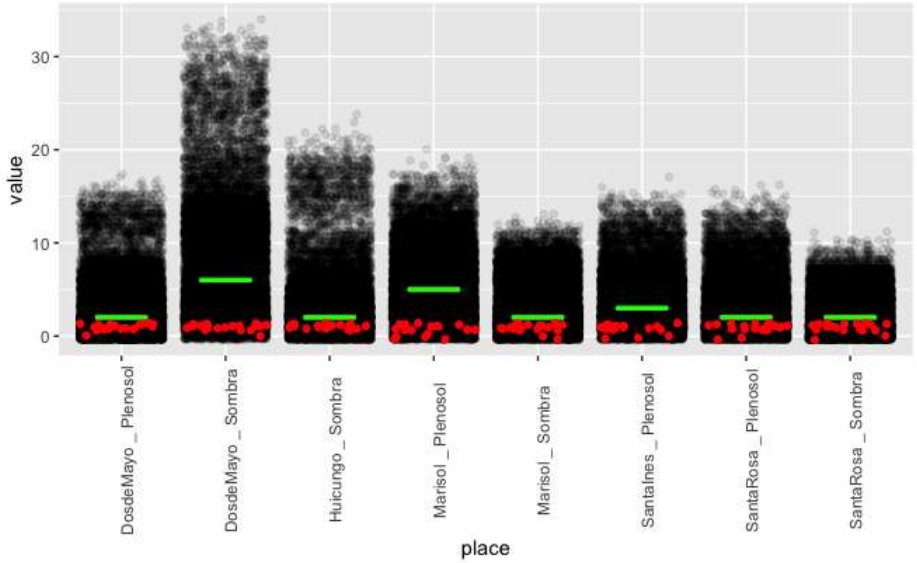

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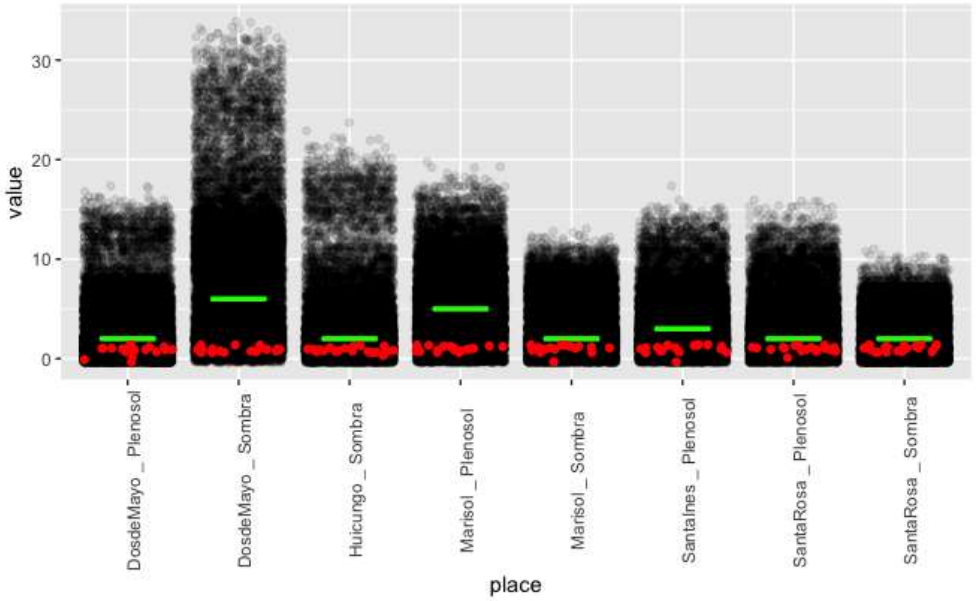

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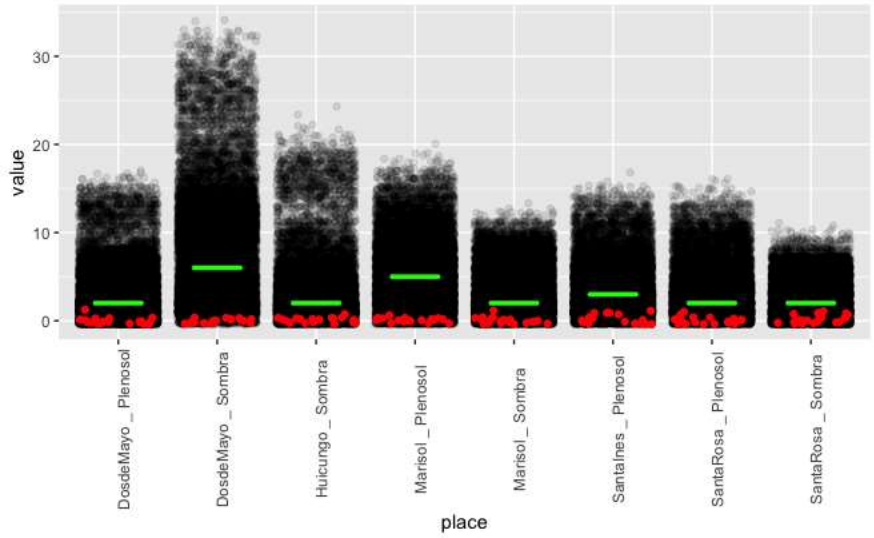

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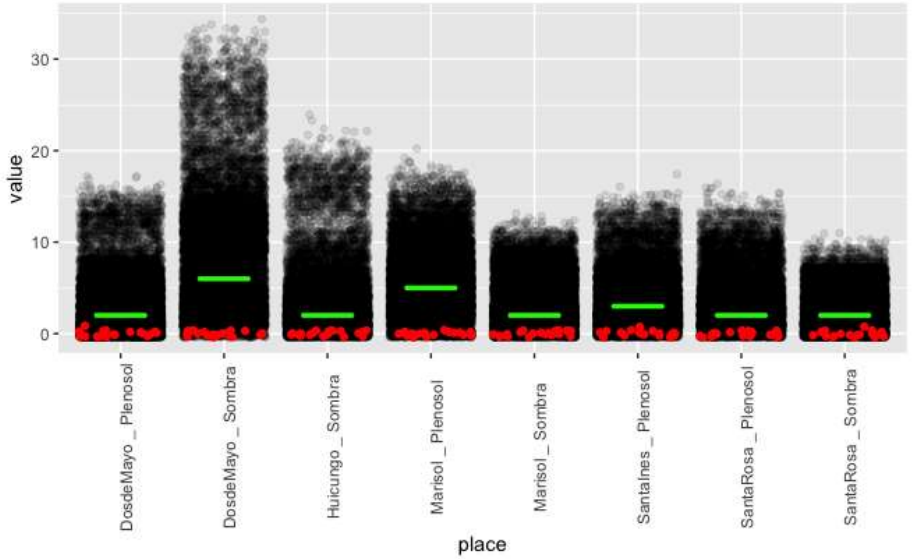
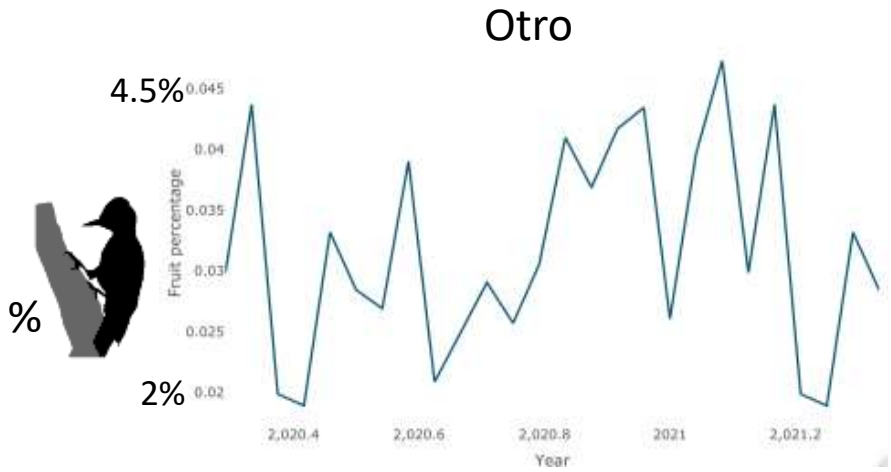


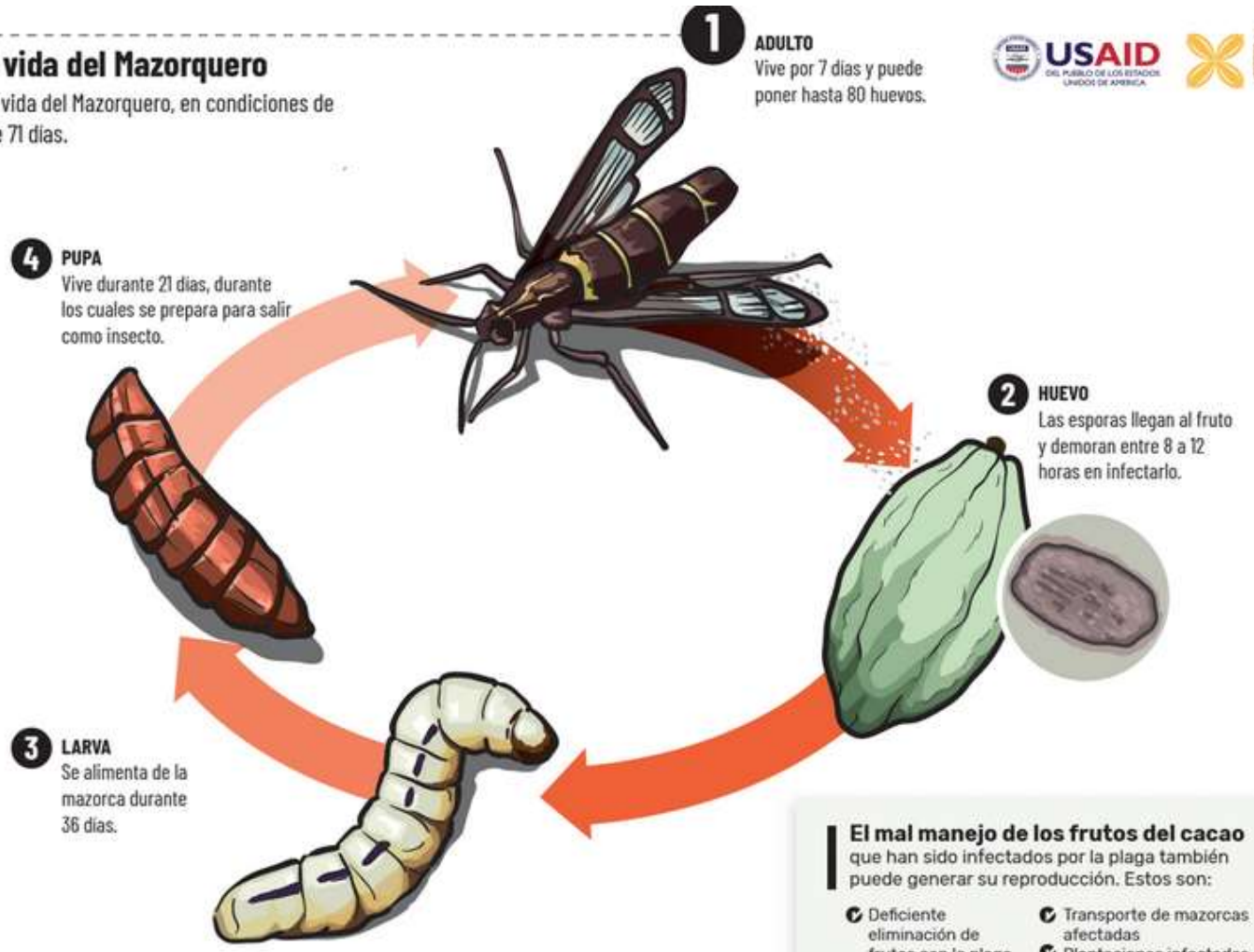
Otro


Otro
120
fruits
2,020.4
2,020.6
2,020.8
2021
2,021.2
Year


Otro
4.5%
%
2%
Fruit percentage
0.045
0.04
0.035
0.03
0.025
0.02
2,020.4
2,020.6
2,020.8
2021
2,021.2
Year

Ciclo de vida del Mazorquero

El tiempo de vida del Mazorquero, en condiciones de campo, es de 71 días.

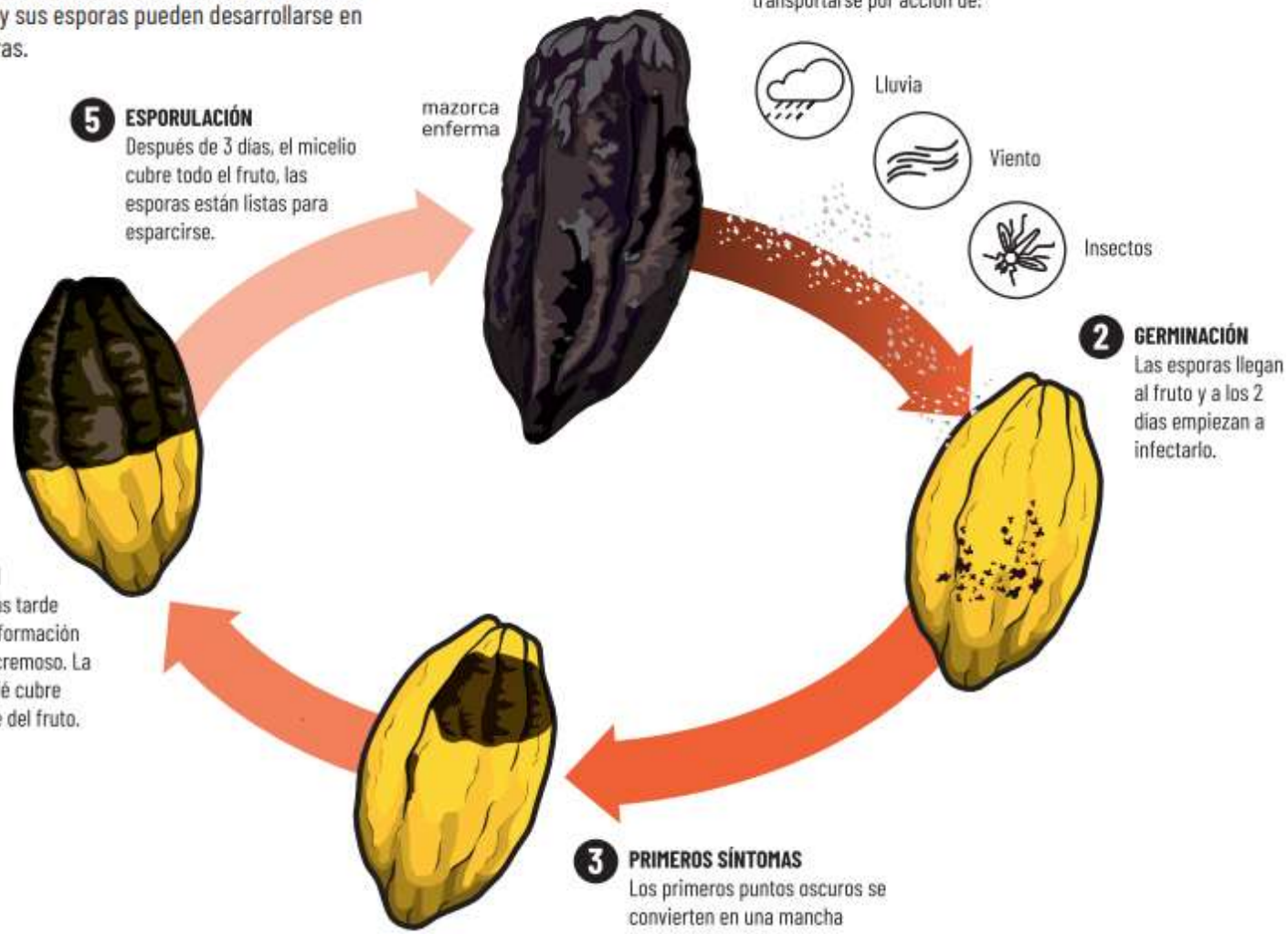


El mal manejo de los frutos del cacao que han sido infectados por la plaga también puede generar su reproducción. Estos son:

- Deficiente eliminación de frutos con la plaga
- Transporte de mazorcas afectadas
- Plantaciones infectadas

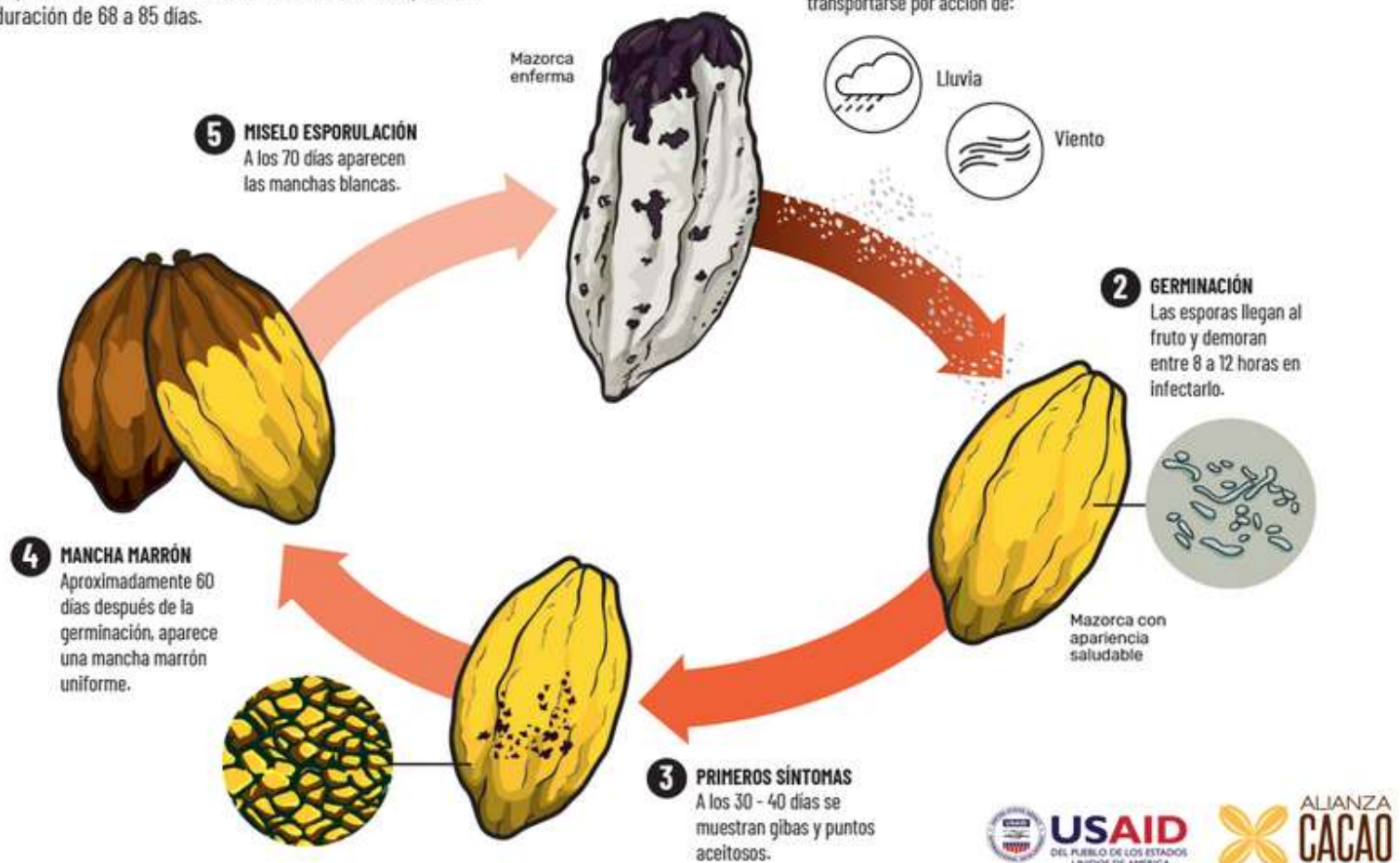
Ciclo de vida de la "mazorca negra"

El tiempo de vida de la "mazorca negra", en condiciones de campo, es de 11 días y sus esporas pueden desarrollarse en frutos en solo 48 horas.



Ciclo de vida de la Monilia

El tiempo de vida de la Monilia, en condiciones de campo, tiene una duración de 68 a 85 días.



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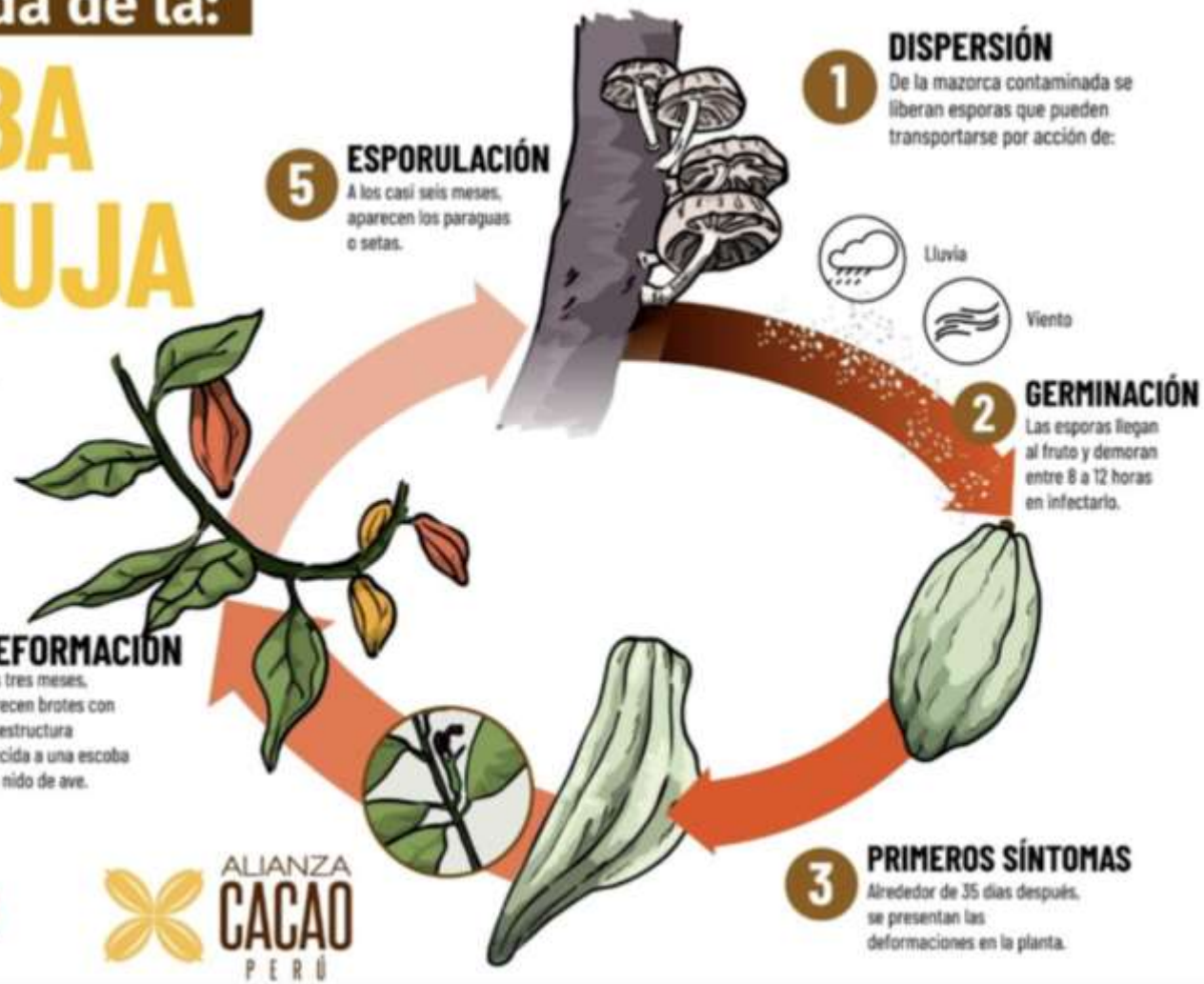
Ciclo de vida de la:

ESCOBA DE BRUJA

Moniliophthora perniciosa

El tiempo de vida de la "Escoba de bruja", en condiciones de campo, tiene una duración de 170 días.



1 DISPERSIÓN
De la mazorca contaminada se liberan esporas que pueden transportarse por acción de:

Lluvia

Viento

2 GERMINACIÓN
Las esporas llegan al fruto y demoran entre 8 a 12 horas en infectarlo.

3 PRIMEROS SÍNTOMAS
Alrededor de 35 días después, se presentan las deformaciones en la planta.

4 DEFORMACIÓN
A los tres meses, aparecen brotes con una estructura parecida a una escoba o un nido de ave.

5 ESPORULACIÓN
A los casi seis meses, aparecen los paraguas o setas.

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