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Contrasting susceptibilities to Flavescence dorée in wild *Vitis* species, *Vitis vinifera* cultivars and progenies suggest segregation of genetic traits involved in disease response

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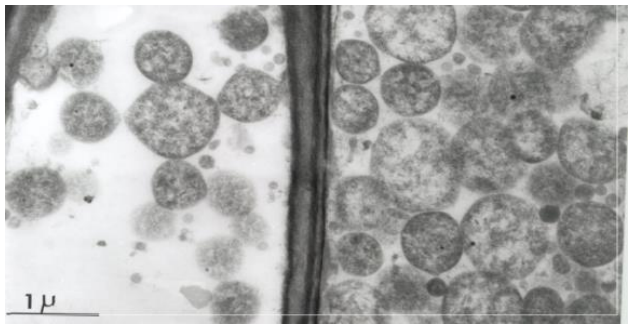
Grapevine Flavescence dorée (FD)



Phytoplasma

Grapevine

Scaphoideus titanus

Grapevine susceptibility to Flavescence dorée (FD) in vineyards

Difference in susceptibility to FD is well described in vineyards

- percentage of infected stocks
- symptom severity
- recovery

Susceptibility/ recovery	*Vitis vinifera*
Less susceptible/ good recovery	Cot, **Merlot**, Syrah
Susceptible/ recovery	Cabernet Franc, Carignan, Cinsault, Colombard, Gamay, Mourverdre, Muscat, Pinot Noir
Highly susceptible	Alicante bouschet, Aramont, Baco 22A, **Carbernet Sauvignon,** Chardonnay, Grenache B, Grenache N, Sauvignon B, Ugni B

Boudon-Padieu 1996

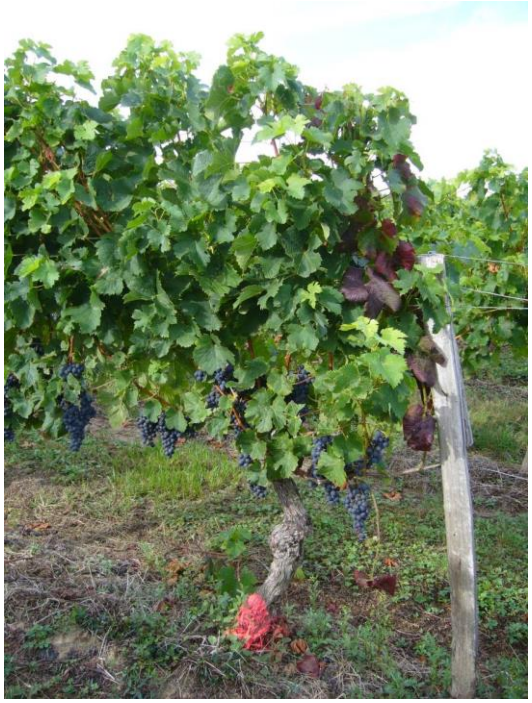
Symptom severity	Rootstocks (*Vitis sp.* hybrids)
No symptom	**5BB**, **41B**, 161.49C, 5C
Low index	101.14MG, 125AA, SO4, 110R, 140Ru
Both indexes	3309C, Fercal, 420 A

Are these differences observed in vineyards related to phytoplasma titers?

Grapevine susceptibility to FD in vineyards

Two *V. vinifera* cultivars emblematic of Bordeaux

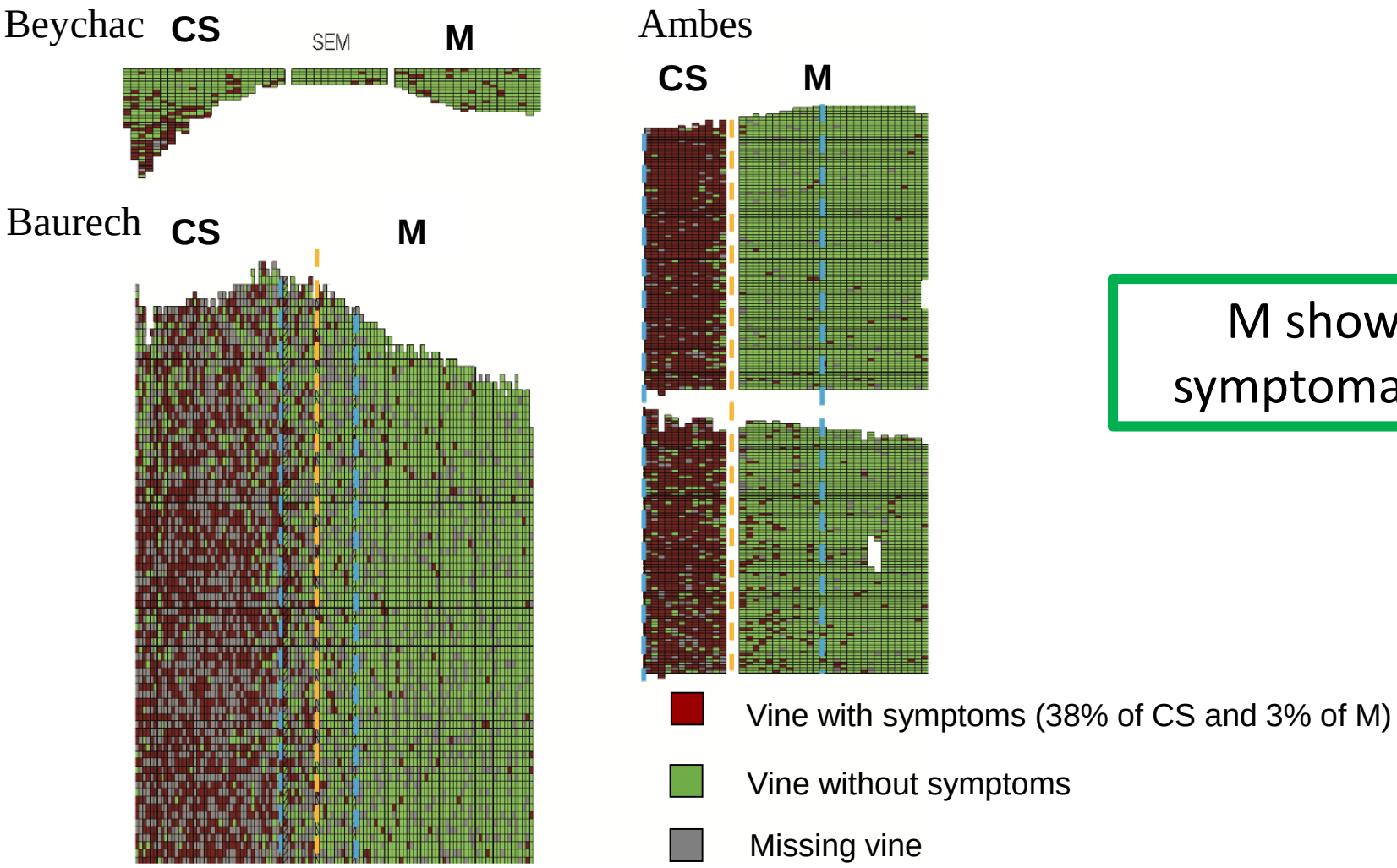
Cabernet Sauvignon
susceptibility +++



Merlot
susceptibility +

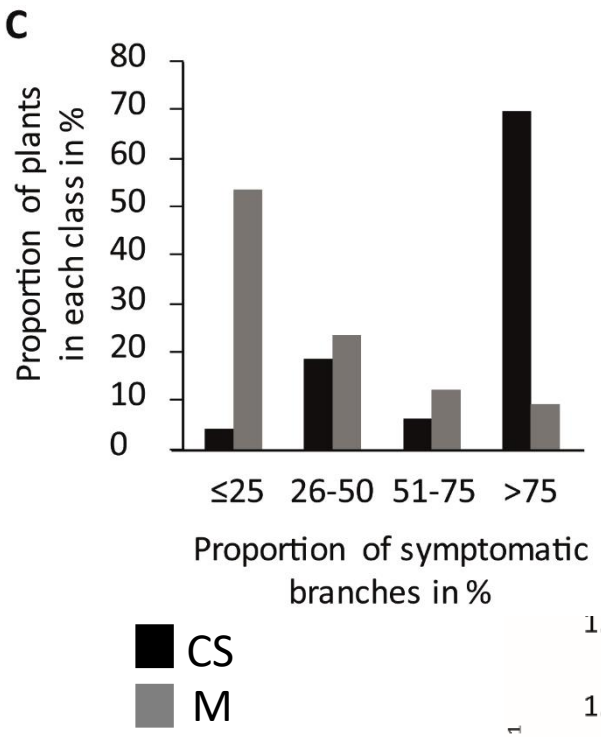
Comparison of the susceptibility to FD of Cabernet Sauvignon (CS) and Merlot (M) in vineyard

3 vineyard plots from Bordeaux area with CS and M growing side by side and with a FD outbreak



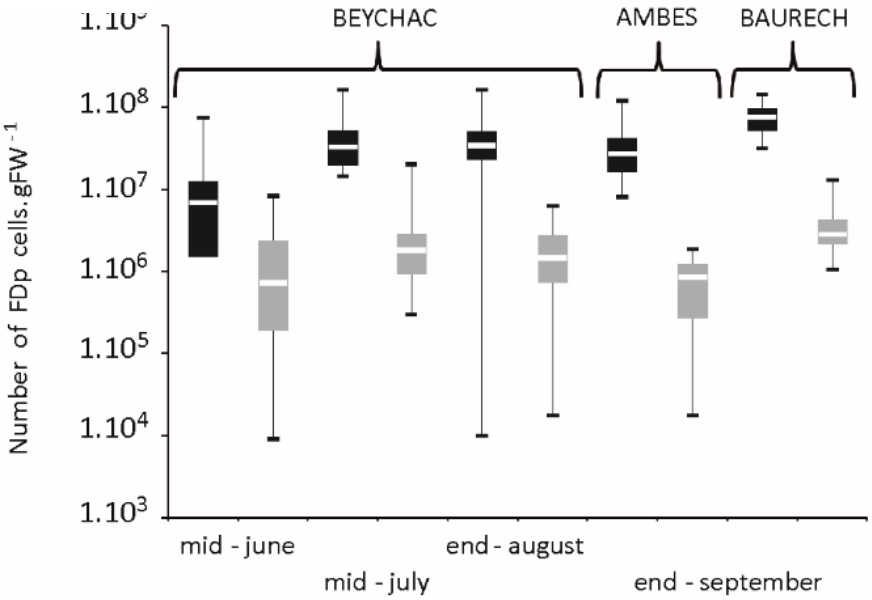
M showed less symptomatic stocks

Comparison of the susceptibility to FD of Cabernet Sauvignon (CS) and Merlot (M) in vineyard



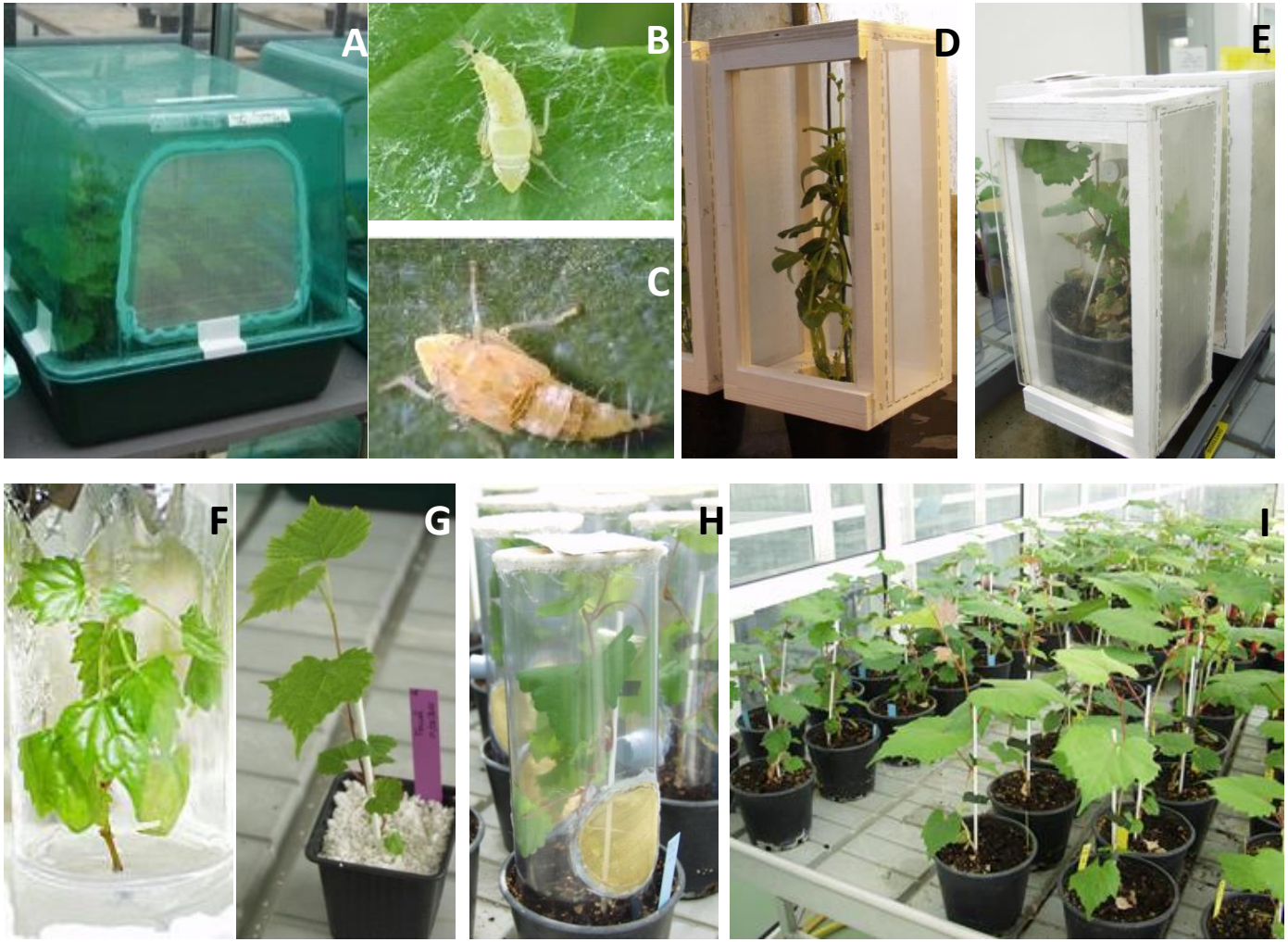
M showed less symptomatic branches

M showed lower FD phytoplasma (FDp) titers



Eveillard et al., 2016

Innovative protocol of controlled FD transmission by *S. titanus* in confined greenhouse allowed the characterization of the response to FD in *Vitis*



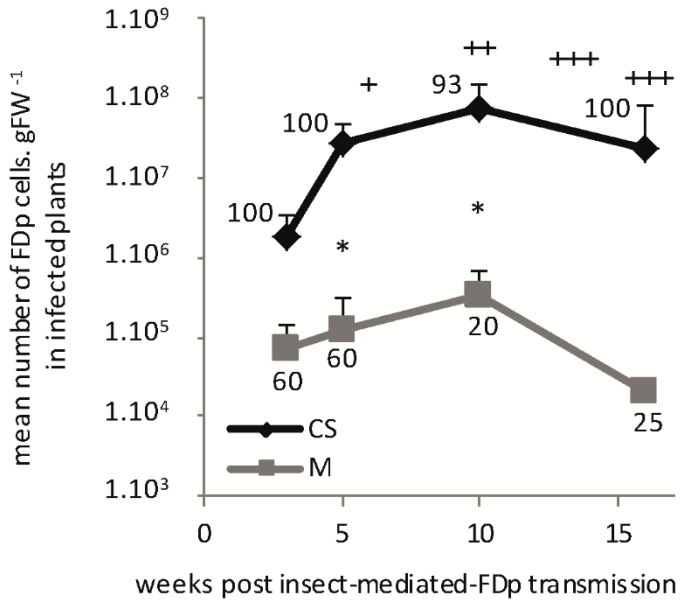
24–32-week protocol

A-C: hatching of *S. titanus* from grapevine canes collected in the vineyard, 6–8 weeks.
D: FDp acquisition by L3–L5 *S. titanus* larvae on FDp-infected broad bean, 1 week.
E: latency period on grapevine, 3–4 weeks.

F-G: acclimatisation of grapevine *in vitro* plantlets, 8 weeks.
H: FDp transmission to grape plants by infectious *S. titanus*, 1 week.
I: incubation of plants, 5–10 weeks, until sampling for FDp quantification and symptoms evaluation.

Comparison of the susceptibility to FD of Cabernet Sauvignon (CS) and Merlot (M) in greenhouse

Time course : determination of FDp titers in M and CS

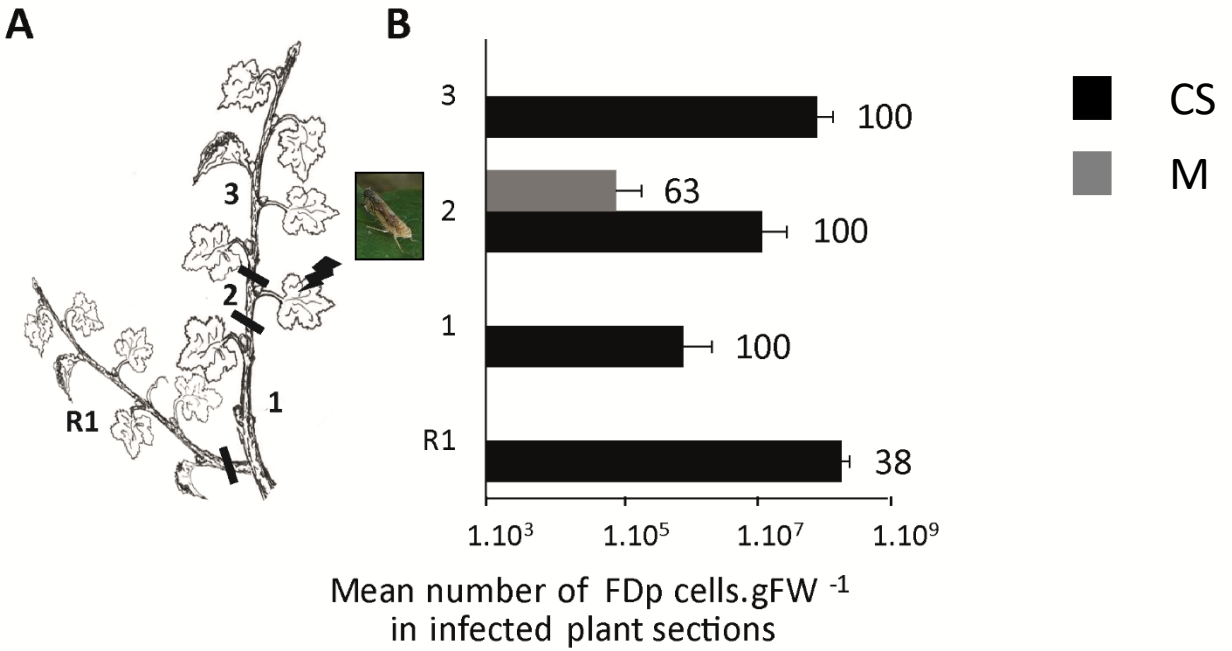


In greenhouse, FDp titers were lower for M (resembling data obtained in vineyards)

Comparison of the susceptibility to FD of Cabernet Sauvignon (CS) and Merlot (M) in greenhouse

Diffusion: inoculation on one leaf

- All CS sections were infected
- in M only the section including the leaf that received the infectious *S. titanus* was positive with low mean FDp titers



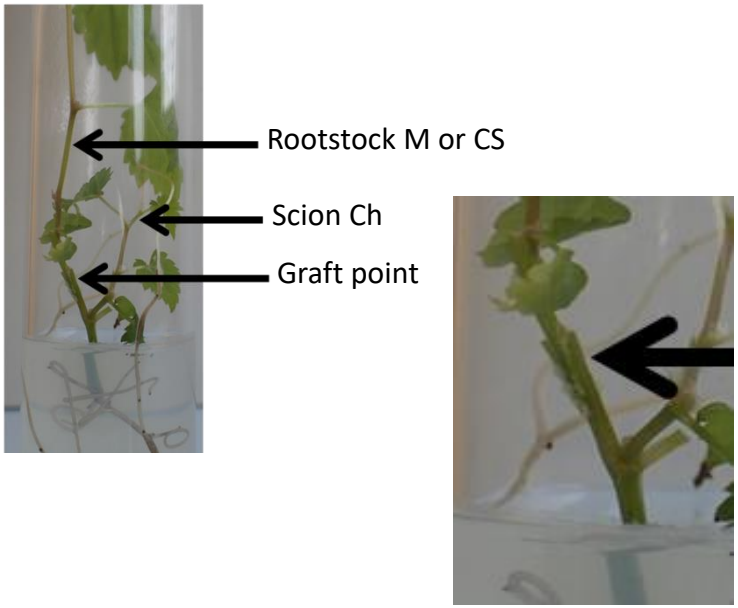
Diffusion of FDp is limited to the site of infection in M

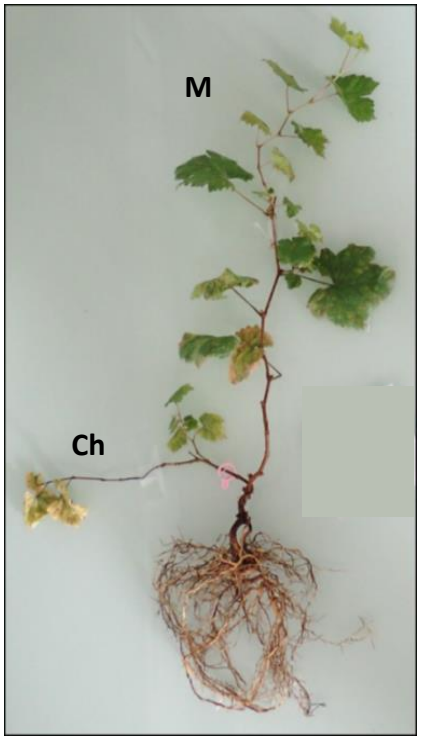
Eveillard et al., 2016

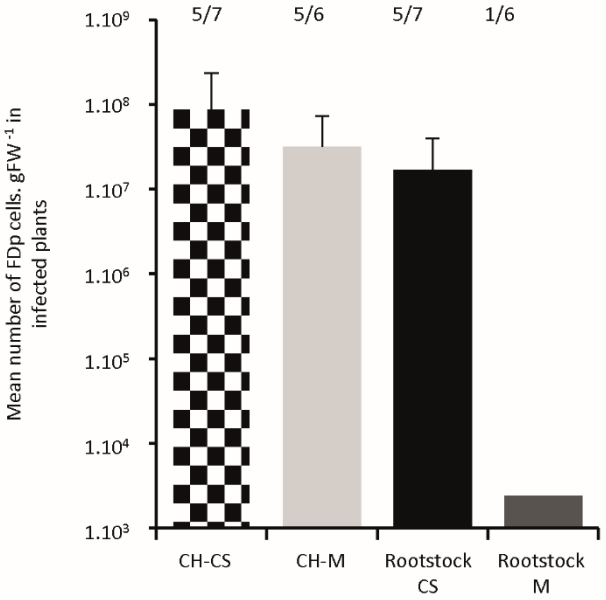
Comparison of the susceptibility to FD of Cabernet Sauvignon (CS) and Merlot (M) in greenhouse

Response results from plant-insect or FDp-plant interactions?

- *In vitro* grafting of a scion of Chardonnay (Ch) on CS and M
- Insect were put exclusively on scion
- All CS rootstocks were infected with high FDp titers, M remained FDp free or occasionnaly with a very low FDp titer







M resistance to FD can be explained by a plant-FDp specific response

Eveillard et al., 2016

Experimental infections of different cultivars with FD

Plant inoculation
with FD-infected *S. titanus*

Incubation of plants
(25° C, 10 weeks)

Size of vines: 20-30 cm

9 cultivars (*Vitis vinifera*)

7 hybrid rootstocks

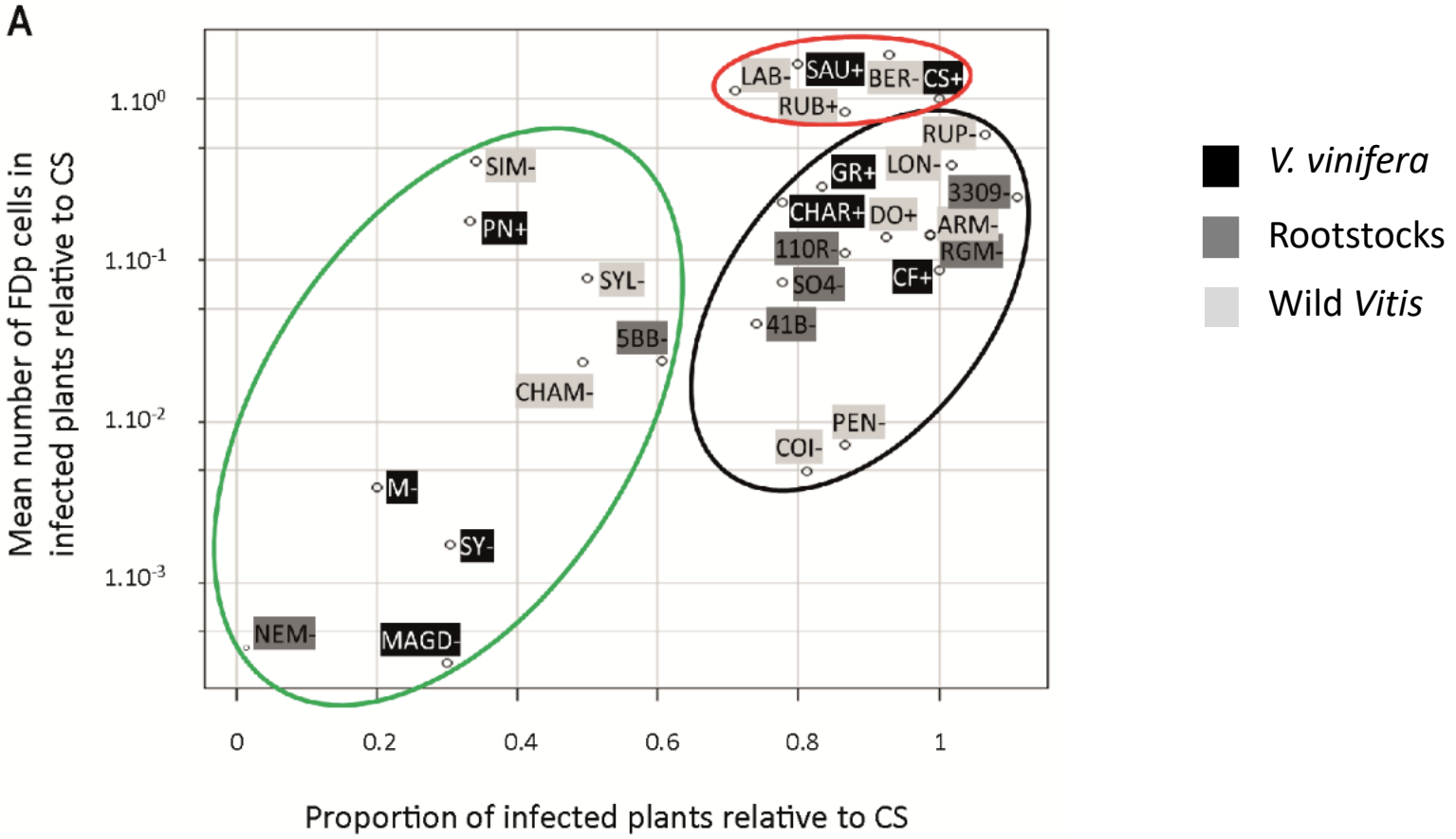
12 *Vitis sp.* from America and Asia (Wild *Vitis*)

- Cabernet Sauvignon as control
- Symptoms evaluation
- Phytoplasma quantification (QPCR)

Responses to FD infection in a collection of *Vitis*

Collection of 28 *Vitis* was phenotyped

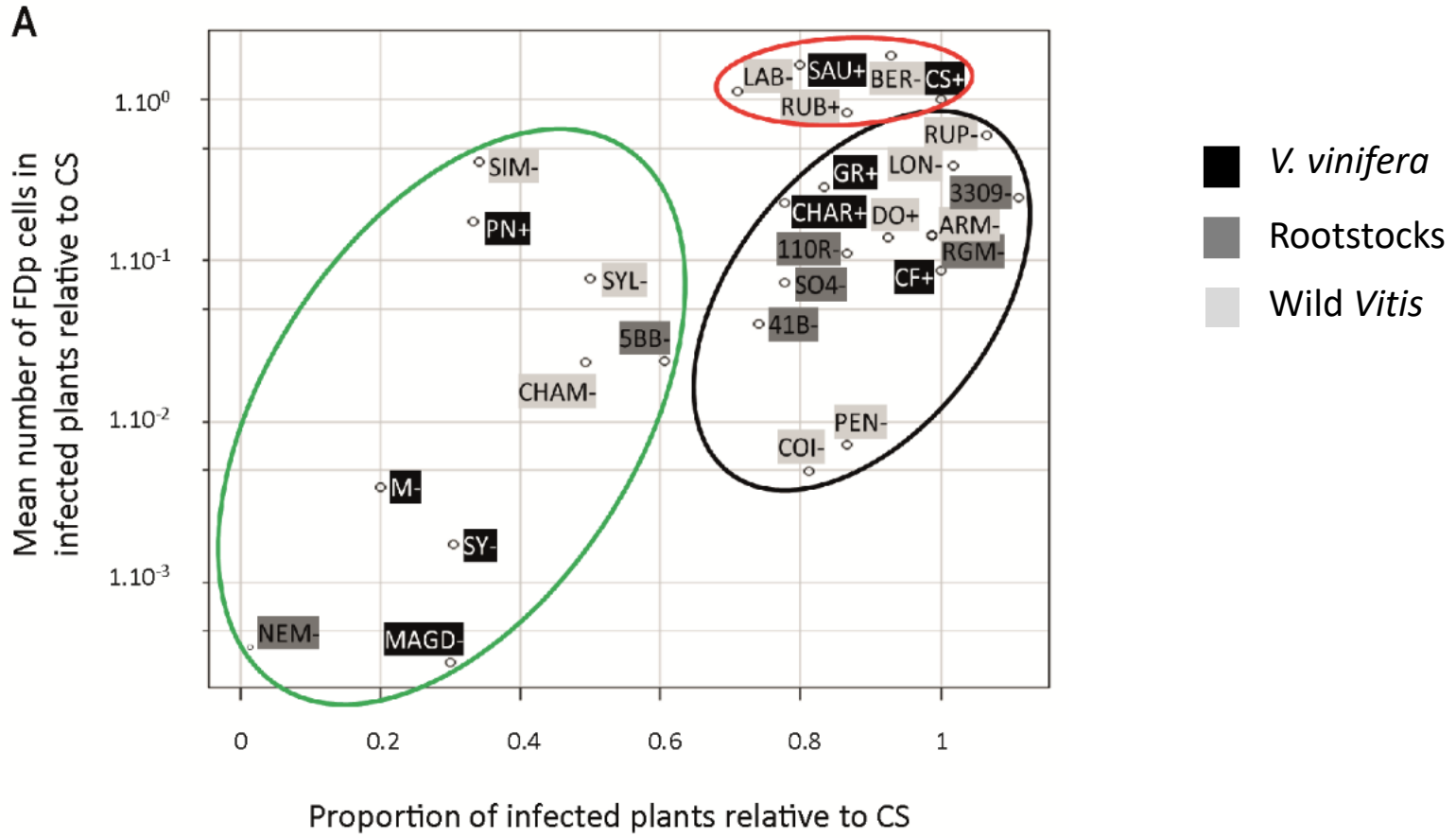
- organized in 3 categories:
  - high FDp titers and high proportion of infected plants (red)
  - intermediate FDp titers and high proportion of infected plants (black)
  - intermediate to low FDp titers and low proportion of infected plants (green)



Eveillard et al., 2016

Responses to FD infection in a collection of *Vitis*

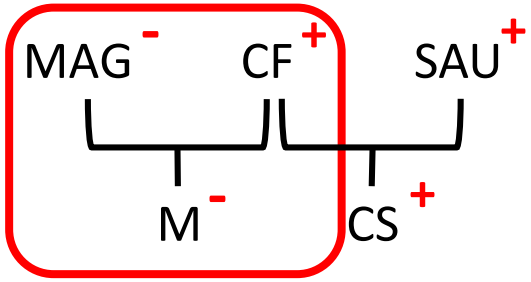
- **Rootstocks** : symptomless with intermediate to high FDp titers: warning, silent reservoir
- ***Vitis vinifera*** in the 3 categories and correspond to the field observations
- No **Wild *Vitis*** showed any resistance to FD



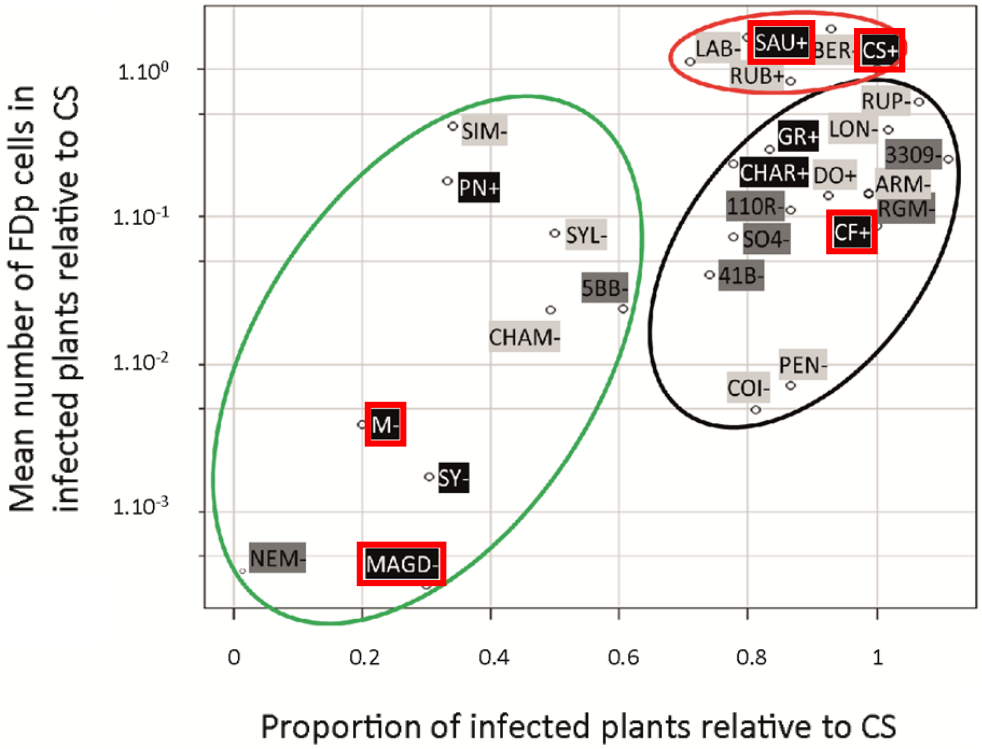
Eveillard et al., 2016

Experimental infections of different cultivars with FD

- Parents of M and CS are Magdeleine Noire des Charentes (Mag), Cabernet Franc (CF) and Sauvignon (Sau) have different susceptibility to FDp



Boursiquot et al., 2009



V. vinifera

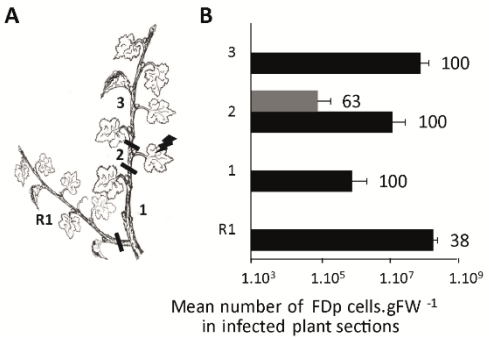
Rootstocks

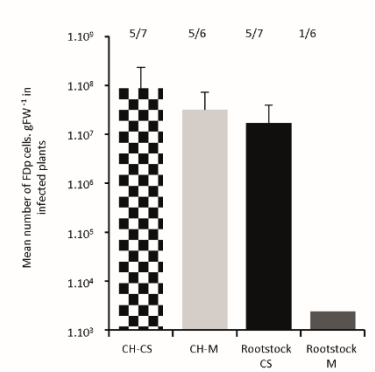
Wild *Vitis*

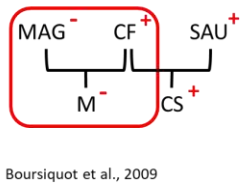
Experimental infections of different cultivars with FD

Distribution of different genetic traits within the *Vitis* genus involved either in

- insect-mediated phytoplasma transmission,
- multiplication,
- circulation,
- symptom development.







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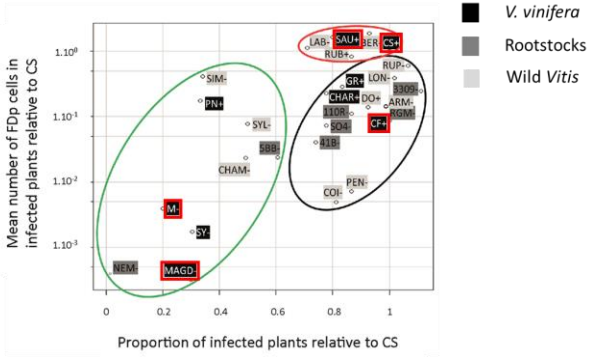
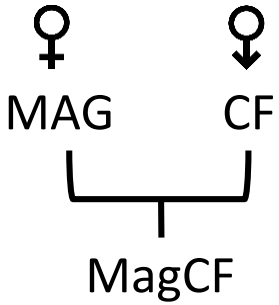
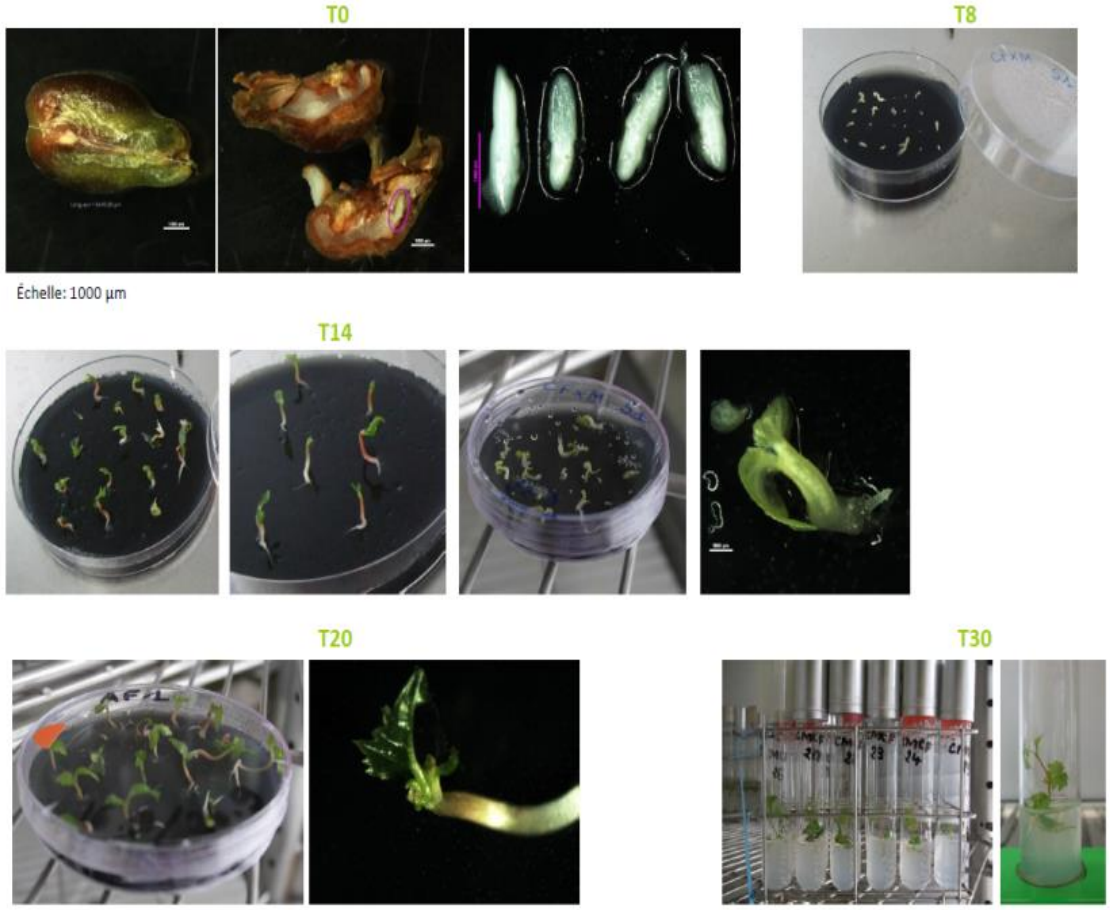


-> cross

Cross between M's parents: Mag and CF

- Crosses were made in Bordeaux, Montpellier and Cognac
- Embryo rescue allowed to obtain seedlings from seeds in only 30 days





30 days from seeds to seedlings with the embryo rescue
(M. Perrin and J. Masson, INRA Colmar)

Phenotyping of M's brothers for FDp susceptibility

- Preliminary data after progeny phenotyping show
    - Progeny is distributed in the 3 groups, highly susceptible, poorly susceptible and intermediate
    - Identification of genotypes with resistance equivalent to Mag or M.

This suggests a segregation in the genetic traits concerning FDp resistance and a quantitative determinism

- **Next:**
- Phenotyping of CFxMag progeny (maternal heredity)
- Phenotyping of MagxMag progeny

- **In the long-term:**
- Increase our phenotyping capacity (by doing less repetition)

Thank to

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Thank you for your attention