Diseases induced by *X. fastidiosa* subsp. *pauca*: ecology, epidemiology and management

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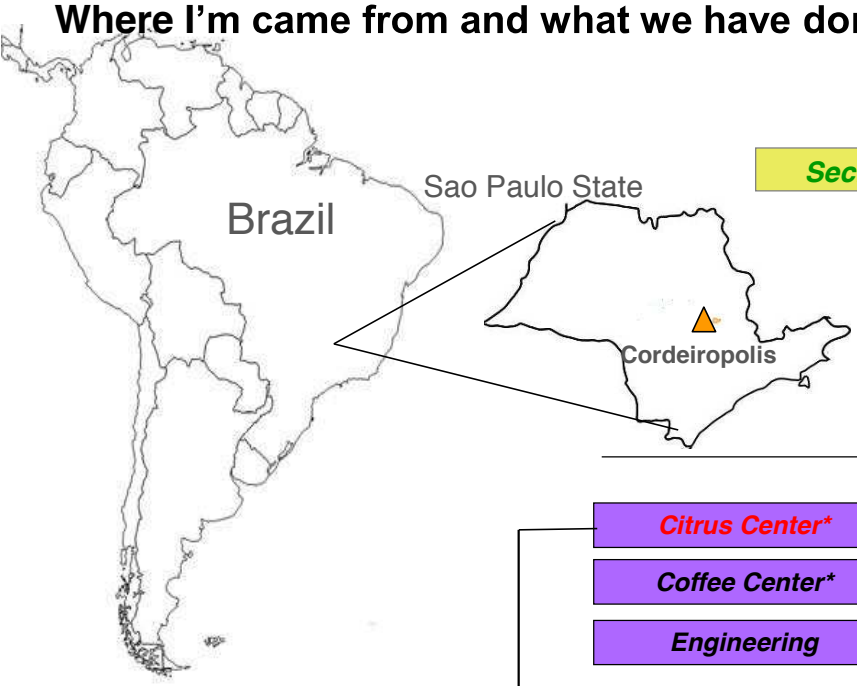
Where I'm came from and what we have done …



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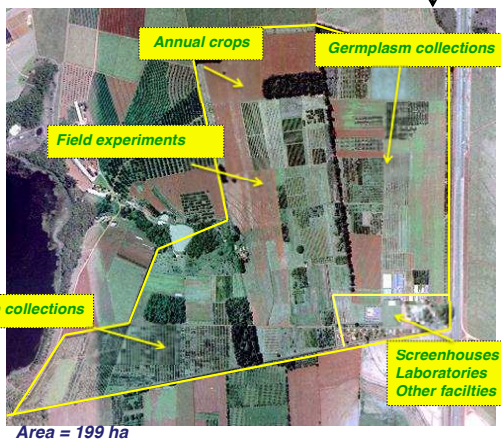


Area = 199 ha

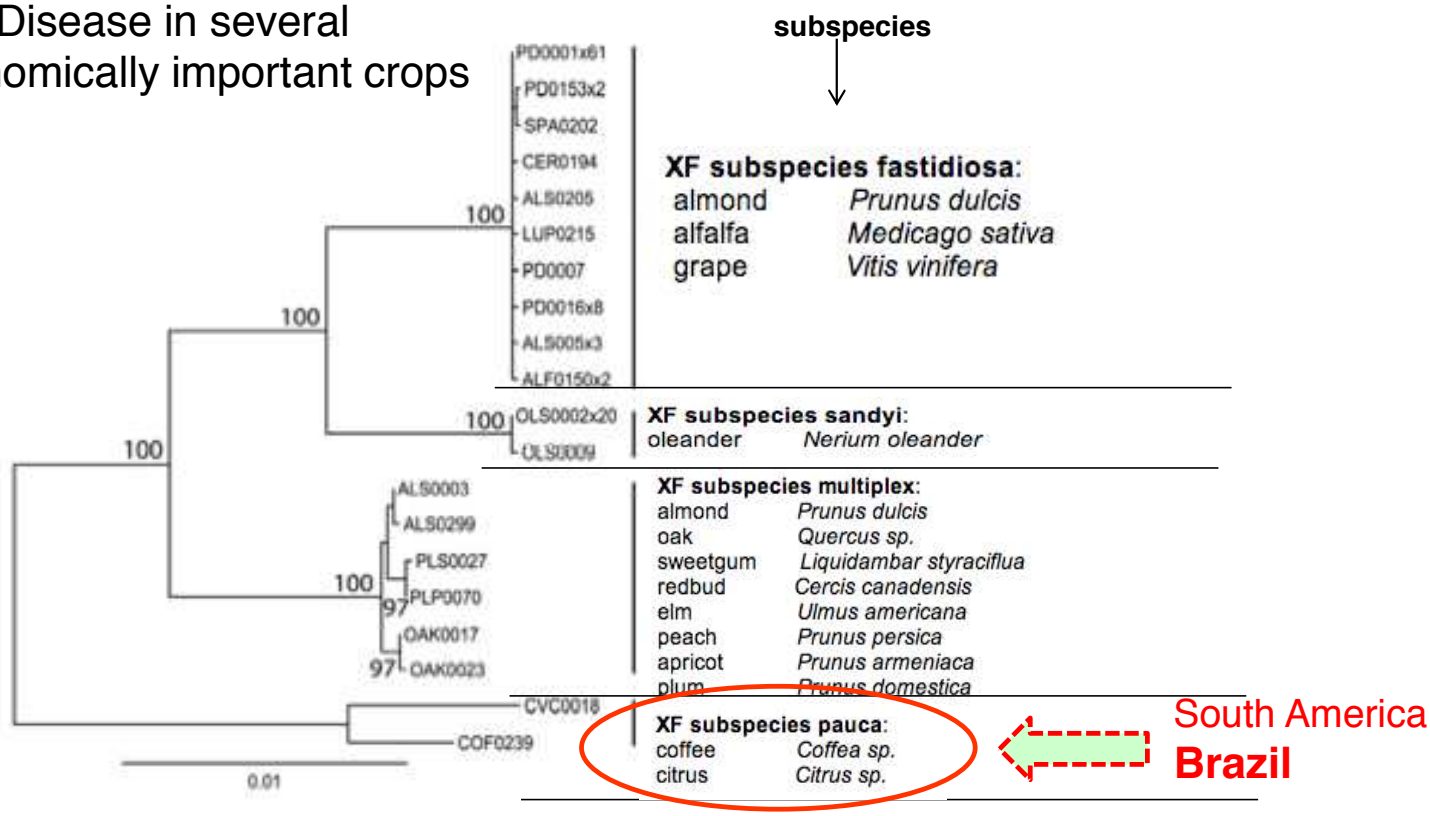
Research Programs at Citrus Center

Breeding
Biotechnology
Plant pathology
Crop physiology

Xylella fastidiosa : multi-host bacteria

✔ Infection a hundred of plants species

✔ Disease in several economically important crops



Maximum likelihood phylogenetic tree of *Xylella fastidiosa*
Yuan et al., 2010 Phytopathology 100:601-611.

X. fastidiosa in Brazil

X. fastidiosa subsp. *multiplex*

causing Plum Leaf Scald

- Firstly reported in neighbor country (AR) in 1935

- in Brazil in 1978 in the Southern region

French & Kitajima. Plant Disease, 1978

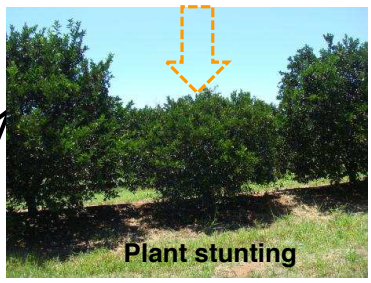
Nowadays is spread for all regions that produced plum (*Prunus domestica*) in Brazil

São Paulo, Paraná, Minas Gerais, Sta Catarina, and Rio Grande Sul

X. fastidiosa subsp. *pauca*

Citrus Variegated Chlorosis - CVC

(Rosetti et al., 1990)



Coffee leaf scorch and/or branch atrophy

(Paradela-Filho et al., 1995 e Lima et al., 1998)

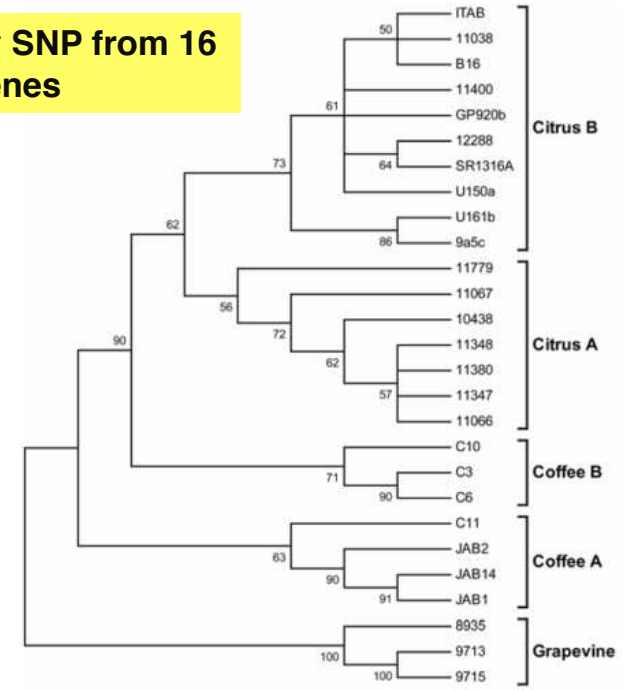
Health branch

X. fastidiosa subsp. *pauca*

- from sweet orange
- from coffee

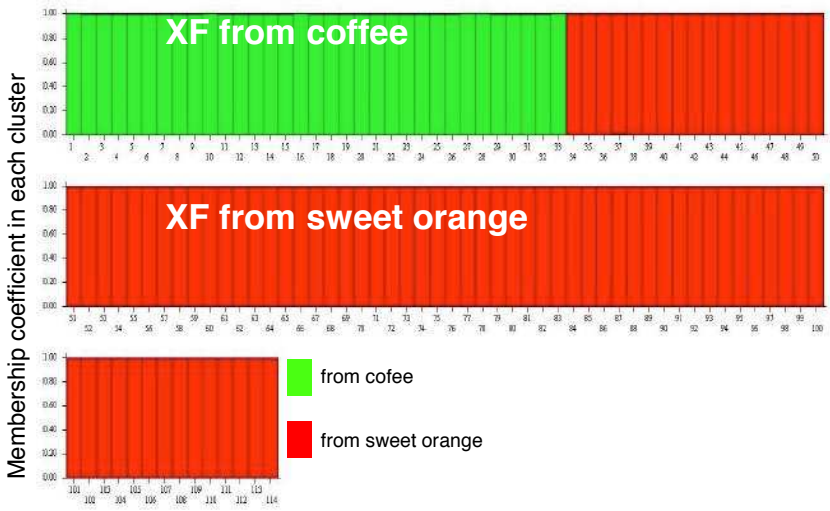
Genetically different !

by SNP from 16 genes



Genetic relationship of *X. fastidiosa* by MEGA using isolates from ad hoc collection.
(Wickert et al., 2003 – Phytopathology)

by Microsatellites markers from 12 loci



Genetic relationship of *X. fastidiosa* by STRUCTURE using isolates from sweet orange and coffee plants closely sampled .
(Francisco, 2014– submitted)

X. fastidiosa subsp. pauca

- from sweet orange
- from coffee

Biologically different !

Patterns of sweet orange and coffee plants infection and colonization buy *X. fastidiosa* subesp. *pauca* isolates from:

XF from	Isolate	Ratio for infection and symptoms in: Citrus host – Infection[c]	Citrus host – CVC symptoms[d]	Coffee host – Infection[c]	Coffee host – CLS symptoms[d,e]
Citrus					
1	10	1/2 (6.1)	1/2	0/20	0/20
1	11	4/13 (5.7 ± 0.5)	0/13	0/20	0/20
1	35	9/11 (6.3 ± 0.1)	1/11	0/20	0/20
1	36	9/19 (4.9 ± 0.3)	1/19	0/20	0/20
1	37	8/15 (5.4 ± 0.3)	3/15	0/20	0/20
1	6570	8/11 (5.4 ± 0.3)	1/11	0/20	0/20
2	18	3/6 (6.1 ± 0.4)	3/6	0/20	0/20
Coffee					
3	29	0/14	0/14	7/20 (4.9 ± 0.2)	0/20
4	1	0/13	0/13	18/20 (5.2 ± 0.1)	0/20
4	4	0/16	0/16	12/20 (5.1 ± 0.1)	0/20
4	3124	0/16	0/16	6/20 (4.8 ± 0.2)	0/20
5	32	0/13	0/13	11/20 (5.4 ± 0.2)	0/20
7	8	0/15	0/15	16/20 (4.9 ± 0.1)	0/20
7	24	0/8	0/8	14/20 (4.7 ± 0.2)	0/20
7	33	0/7	0/7	11/20 (5.4 ± 0.1)	0/20

Adapted from Almeida et al., 2008 - AEM

X. fastidiosa subsp. pauca in Brazil

from sweet orange causing the CVC

***X. fastidiosa subsp.* pauca**

from coffee

Timeline of CVC in Brazil

1987 — **1989** — **1990** — **etiology** — **1993**

Frist reported

Hypothesis:

. Nutritional deficiency
Zn, B, K

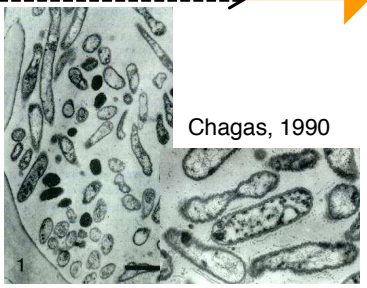
. Virus disease

Grafting transmission of CVC shown an biotic agent associated!

from disease

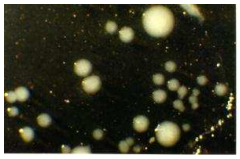
health

Microscopy showed *X. fastidiosa* bacterium-like in the xylem vessels of infected plants!



Chagas, 1990

***X. fastidiosa* isolation from disease leaves!**



Koch's postulate!

Chang et al., 1993

Timeline of CVC in Brazil and actions

1993 ----------> 1996

CVC spread information

✔ **Vector transmission**

Species of Sharpshooters

Lopes et al., 1996.

✔ **Diagnosis**

Previous to disease symptoms expression.

Pooler & Hartung, 1995

✔ **Survey and Epidemiology**

How far the disease was spread from the first reported spot.

The importance of inoculum source from outside and from inside the orchards.

Laranjeira, 1993

Timeline of CVC in Brazil and actions

1993 ----------> 1996 ----------> 2003

CVC spread information

✔ Vector transmission

✔ Diagnosis

✔ Survey and Epidemiology

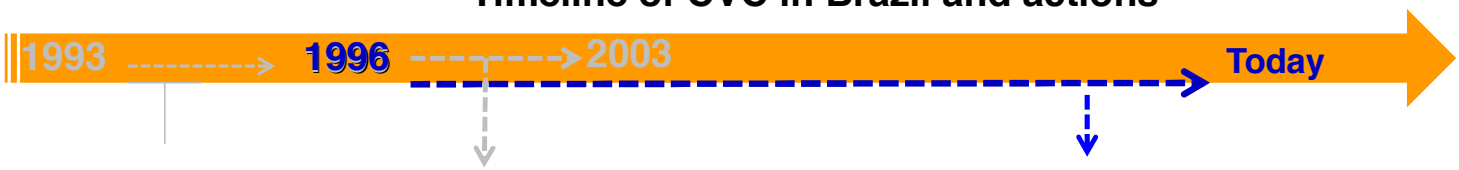
Certify program for citrus propagative material production.

✔ Selection of XF free mother plants and protection in vector proof screen house.

✔ Mother plants, budwood production, and nursery plants all in vector-proof screen house.

✔ Since 2003: Mandatory law "All nursery plant production steps must be under vector-proof screen house !"

Timeline of CVC in Brazil and actions



CVC spread information

✔ Vector transmission

✔ Diagnosis

✔ Survey and Epidemiology

Certified citrus propagative material program

✔ Selection of XF free mother plants and protection in vector proof screen house

✔ Budwood production and nursery plants in vector-proof screen house

✔ Since 2003: Mandatory law "Nursery plant production under screen house !"

Management Strategies

Short-to medium term effect

✔ **Health nursery plants**

✔ **Inoculum reduction**

✔ **Minimizing vector population**

Long-term effect

✔ **Genetic resistance**

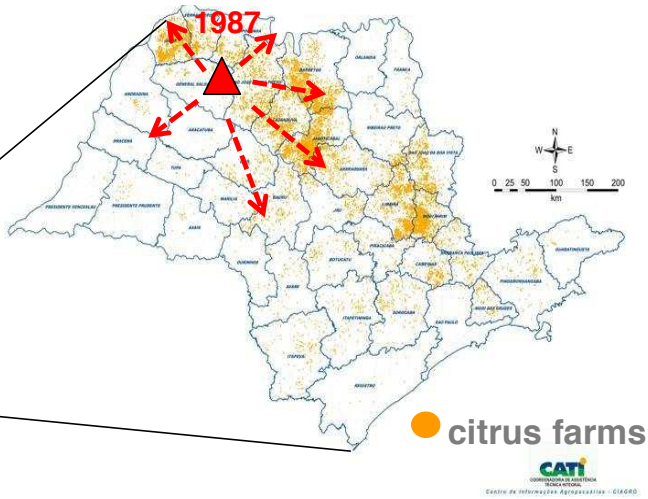
- source of resistance:

- **inbreeding programs**
- **OMG - cisgeny**
- **mass selection**

X. fastidiosa subsp. pauca in Brazil

Origin and Geographic distribution of CVC

São Paulo Map and Geographic distribution of citrus farms



Incidence of CVC (% disease blocks) 10 years after first reported

Year	North	Nortwest	Center	East	South
1996	24.65.	22.83	19.95	ND	22.14

Plant hosts and economic damage

Hosts:

- all commercial sweet orange (C. sinensis) varieties are susceptible

- Most of mandarins (C. reticulata) varieties are resistant, but with some few exception (Carvalhais and Wilking).

- Most of tangors (C. sinensis x C. reticulata) are resistant, but with some few exception (Ortanique, Temple, Umatilla)

- All lemons, acid lime, and pummelos tested until now are resistant.

Alternative hosts: Nicotiana tabacum and Cataranthus roseus

Plant hosts and economic damage

Hosts:

- all commercial sweet orange varieties are susceptible, but with some exceptions.

Contents lists available at ScienceDirect

Crop Protection

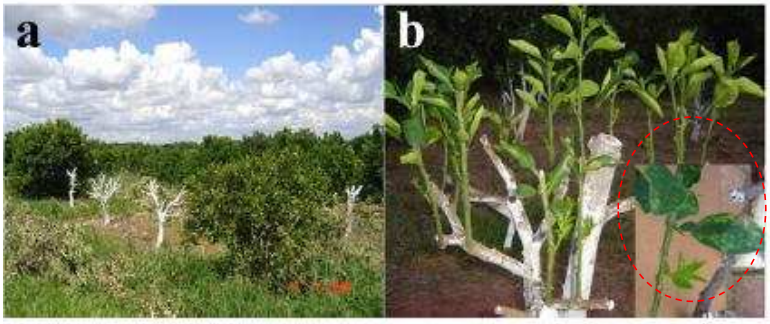
journal homepage: www.elsevier.com/locate/cropro

Navelina ISA 315: A cultivar resistant to citrus variegated chlorosis

André Luiz Fadel [a,*], Eduardo Sanches Stuchi [b], Sérgio Alves de Carvalho [c], Maria Teresa Federici [d], Helvecio Della Coletta-Filho [c]

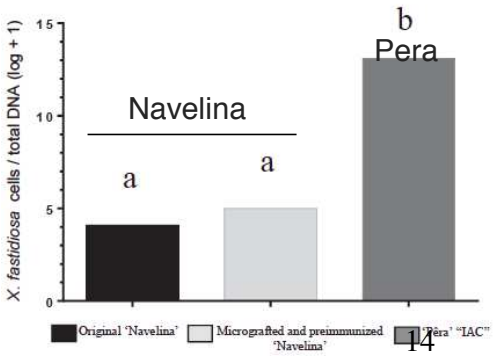
Disease plants in field

Top grafting of Navelina on disease plant



Susceptible Pera variety

X. fastidiosa in tested plants



Plant hosts and economic damage

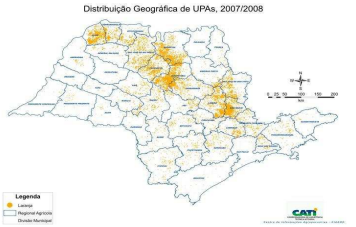
Reduction (%) on fruit production and juice quality on CVC disease plants compared to no-disease

Symptoms level	Fruit production		Juice quality	
	Weight	Number	SS*	Ratio
middle	16.5	13.9	-14%	-22%
strong	75	70.9		

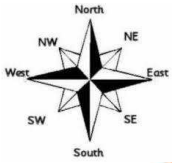
adapted from Laranjeira, 2004

*SS - total Soluble Solid - OBrix

Epidemiology: the spatial incidence and severity of CVC



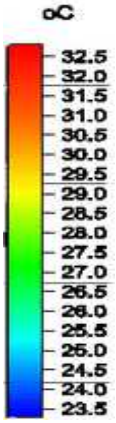
CVC incidence through São Paulo State



The Northern environment

- Water stress
- Warm temperatures
- Sharpshooters population

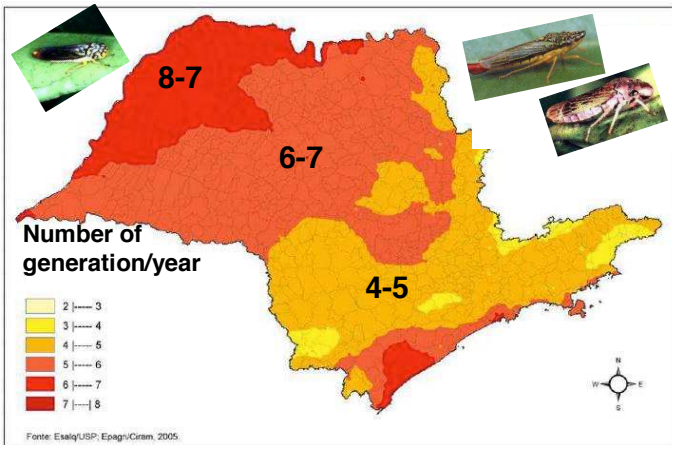
Avg. annual temperature



% CVC infected blocks

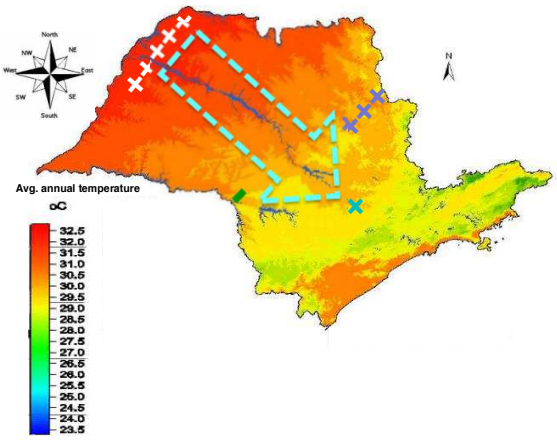
	Center	North	Northwest	West	East	South
2009	52.65	52.52	46.71	1.15	28.23	1.57
2010	38.2	53.03	42.81	4.41	34.86	3.04
2011	42.37	59.73	52.55	1.06	45.15	2.05
2012	42.16	58.35	47.19	0	40.78	3.77

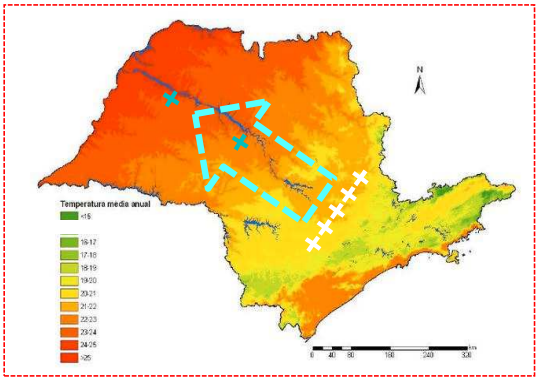
Adapted from Fundecitrus



Epidemiology: the latent infection

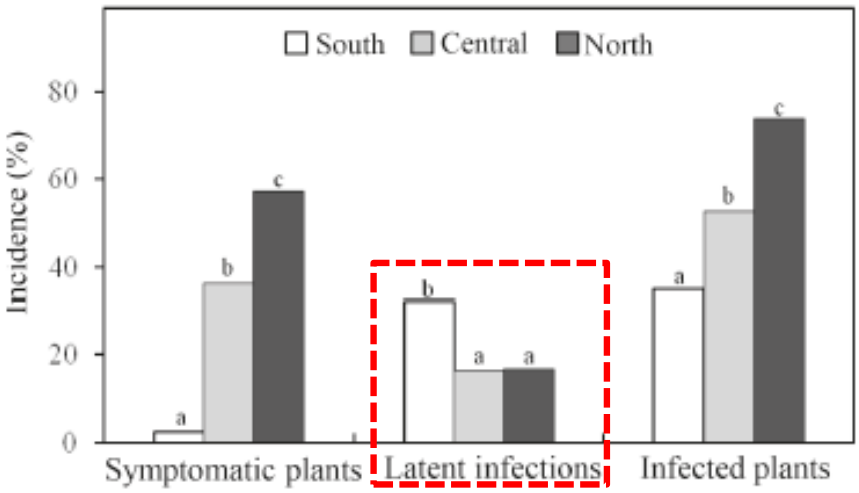
CVC incidence through São Paulo State





X. fastidiosa **- the latent infection is higher in South region**

Journal of Plant Pathology (2013), 95 (3), 493-498

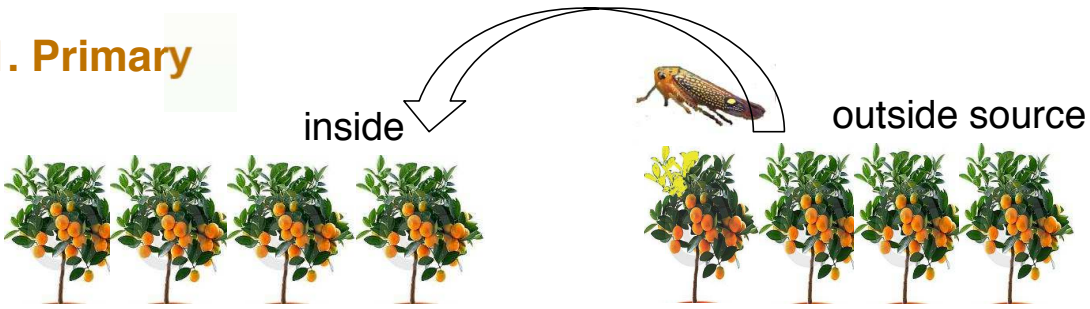


Coletta-Filho et al., 2013

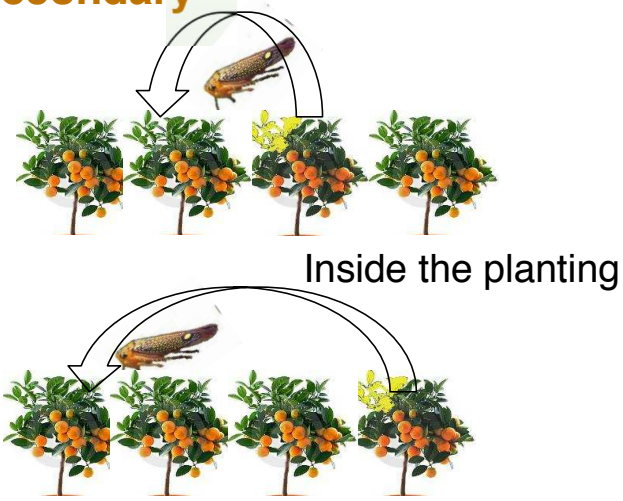
Both incidence and CVC severity are environmentally dependent!

Epidemiology: 1ª and 2ª spreads forms are important for CVC !

1. Primary



2. Secondary



Differently to PD pathosystem, for CVC limited information is available about others sources of inoculum outside sweet orange and its importance to disease epidemiology.

Epidemiology: sources of inoculum

Weeds plants present in orchards

Frequency of infection of weeds plants mechanically inoculated with the CVC strain of *Xylella fastidiosa.*

Scientific name	CVC strain 1st exp.	2nd exp.	3rd exp.
Medicago sativa	…[a]	1/10	5/10
Echinochloa crus-galli	8/10[b]	6/10	7/10
Brachiaria decumbens	2/9	3/10	8/10
Digitaria horizontalis	3/10	1/10	0/10
Brachiaria plantaginea	3/9	9/10	9/10
Solanum americanum	2/9	4/10	3/10
Bidens pilosa	4/10	1/10	0/10
Citrus sinensis cv. Caipira	10/10	2/6	…

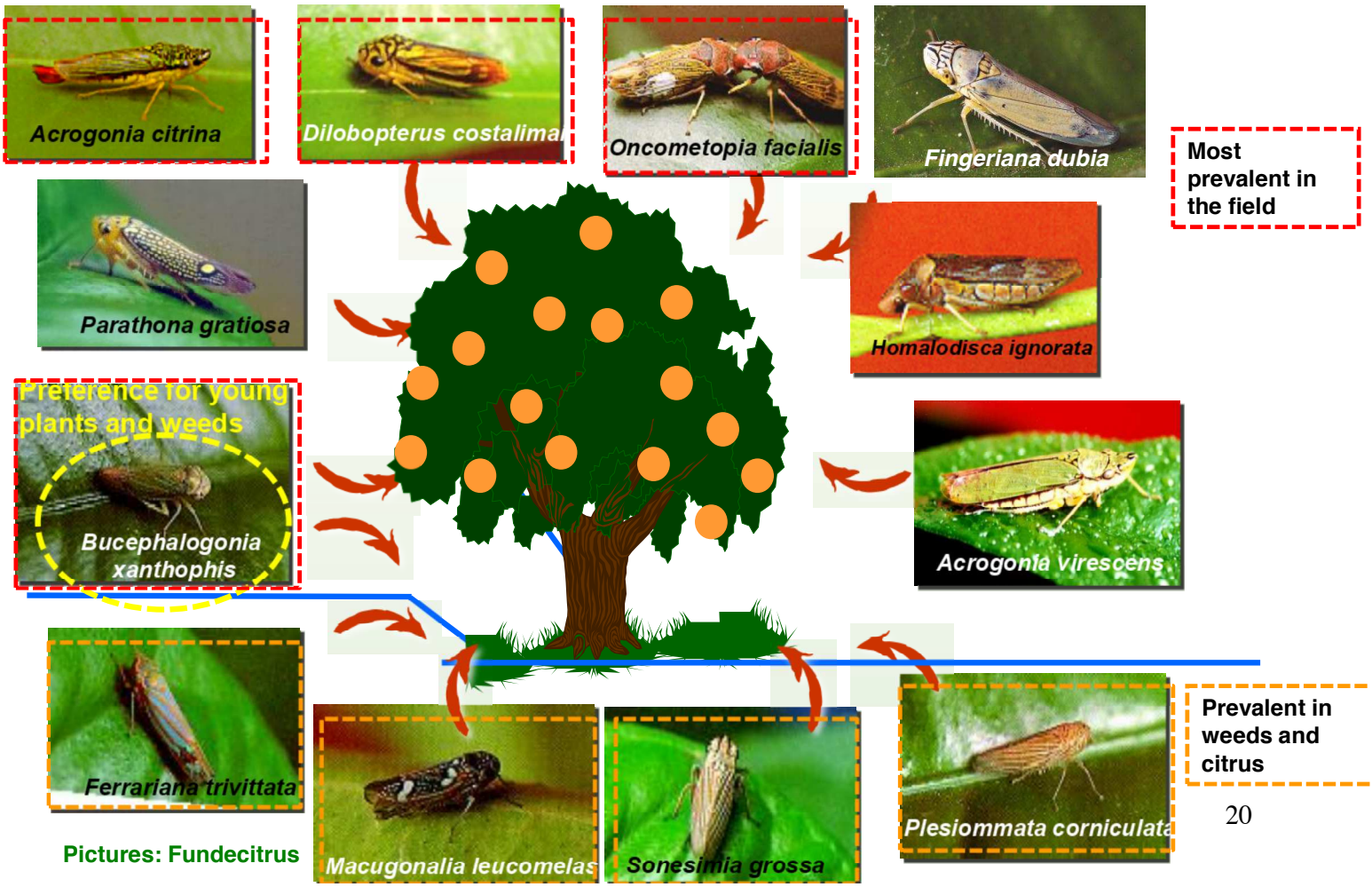
Family: Poceacea

Plants were injected twice with suspensions containing 10^8 to 10^9 CFU of XF/ml and evaluated by PCR 60 DAI

Adapted from: Lopes et al. 2003. Plant Disease 87:544

No acquisition and/or transmission assays were done.

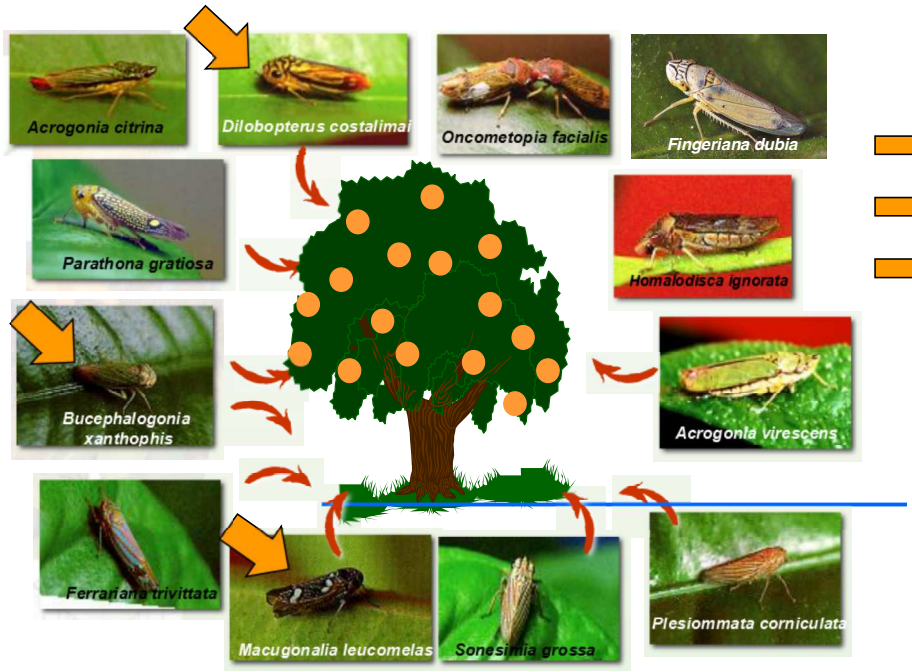
Epidemiology: 13 different species of sharpshooters as vectors



Pictures: Fundecitrus

Epidemiology: vectors

Transmission efficiency is low and different among the species

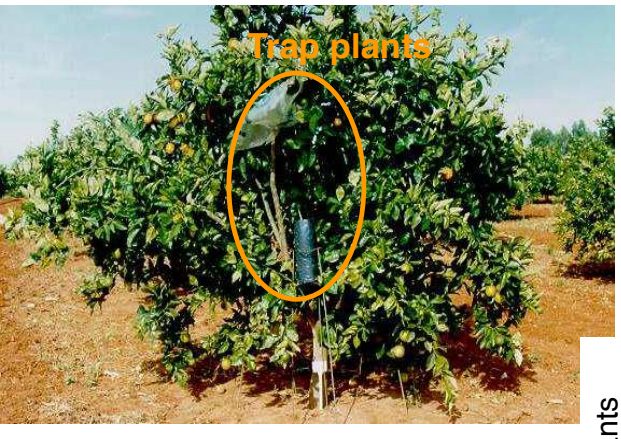


Pictures: Fundecitrus

Sharpshooter sps	Transmission efficiency
Macugolania	17.30%
Bucephalogonia	12.80%
Dilobppterus	5.50%
Plesiommata	2.90%
Parathona	2.80%
Acrogonia	2.30%
Ferrariana	1.90%
Oncometopia	1.30%
Sonesimia	1.20%
Homalodisca	0.50%
A. virensis	0.30%

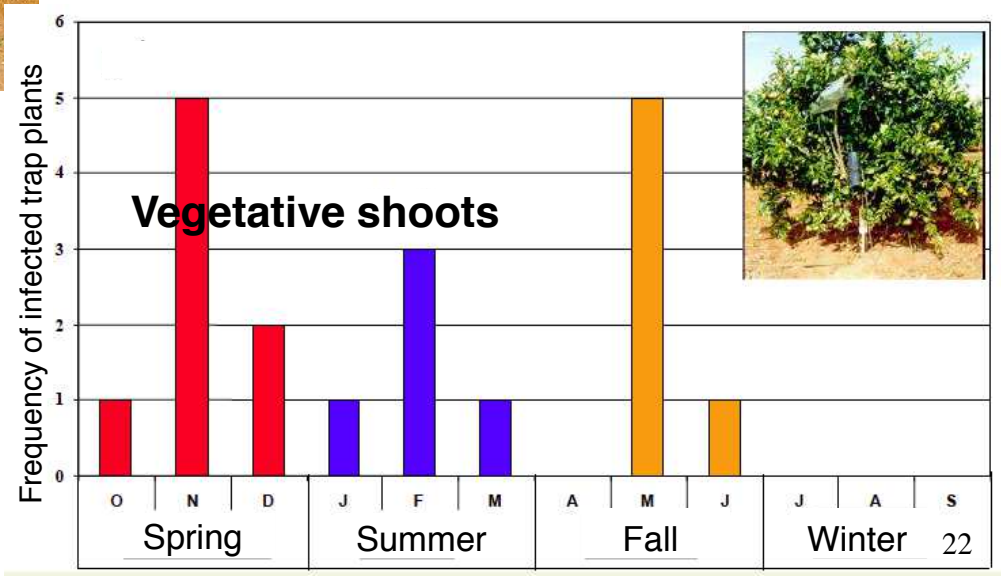
Adapted from: P Yamamoto

Epidemiology: natural infectivity of vectors and transmission



Successful transmission is higher in the wet and warm seasons.

Frequency of trap plants naturally infected by XF. Avg of three orchards.



Adapted from: JRS Lopes

Epidemiology: faunistic distribution of sharpshooters

Different sites of the citrus block host different populations of sharpshooters.

Site	Total collected	No. of species	No. of collections	Shannon-Wiener Diversity (H')
Forest edge	1012	14	58	1.39
Stand periphery	1003	17	58	1.30
Stand interior	846	13	56	1.45

Adapted from: Coelho et al, 2008

Epidemiology: seeds transmission

- **There is NO transmission of XF from seeds to seedlings**

Seven years of negative detection results confirm that *Xylella fastidiosa*, the causal agent of CVC, is not transmitted from seeds to seedlings

Helvécio Della Coletta-Filho · Sérgio Alves Carvalho · Luis Fernando Carvalho Silva · Marcos Antonio Machado

Eur J Plant Pathol (2014) 139:593–596

Evaluation by PCR of *Xylella fastidiosa* subsp. *pauca* transmission through citrus seeds with special emphasis on lemons (*Citrus limon* (L.) Burm. f)

A.B. Cordeiro[a], V.H. Sugahara[a], B. Stein[b], R.P. Leite Junior[a]

Crop Protection (2014) 62:86-92

Open Access Subscription Access

LACK OF EVIDENCE FOR TRANSMISSION OF XYLELLA FASTIDIOSA FROM INFECTED SWEET ORANGE SEED

J.S. Hartung, S. Nian, S. Lopes, A.J. Ayres, R. Brlansky

doi: 10.4454/JPP.V96I3.011

J Plant Pathol (2014) doi: 10.4454/JPP.V96I3.011

CVC Management

The tetrahedron of a vectored disease

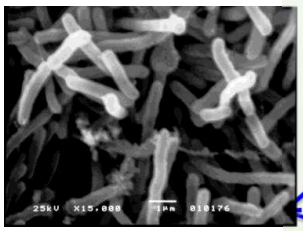
Environment favorable conditions

✔ Warm temperatures

✔ Irregular rainfall distribution

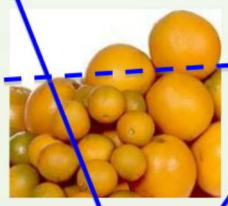
Minimizing vector population

Bacterium virulence



✔ No bactericide molecule so far.

Vector transmission capacity



Host susceptibility

Reduction inoculum source

Planting health young citrus plants

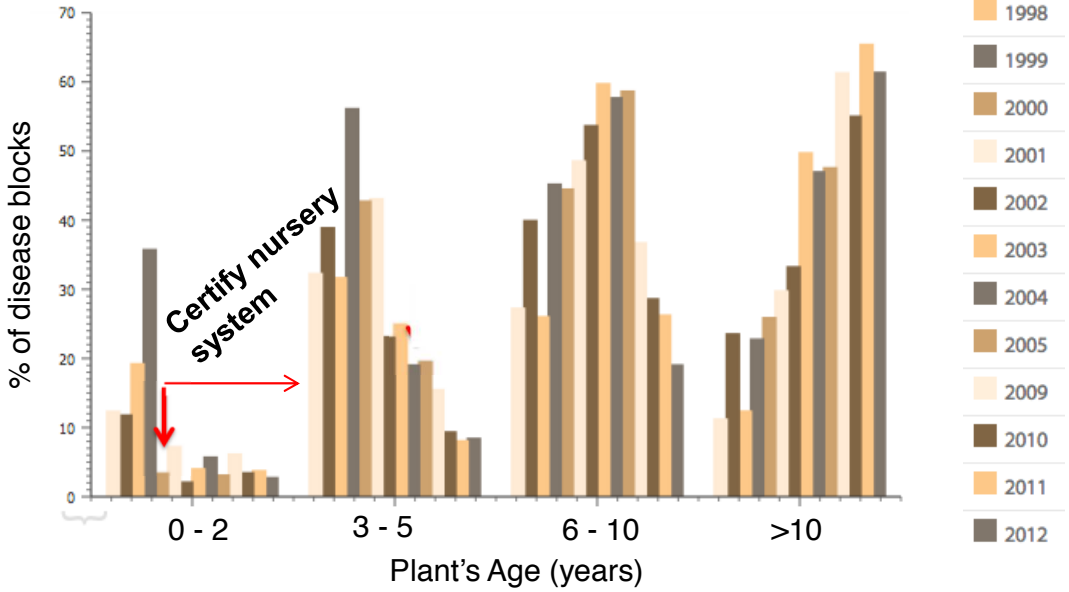
sweet orange

CVC Management – Health nursery plants

Planting health young citrus plants

✔ **Early 2003: Well established system for production of citrus plants under vector-proof screen house.**

Stratification of CVC incidence by plant age (from 1996 to 2012)



CVC Management – Minimizing vector population

Vector population control

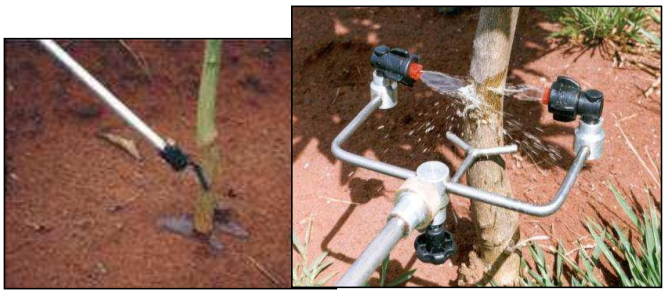
- Inspection of sharpshooter population by yellow stick trap

Chemical control

Systemic and contact molecules

- Special attention to:
  - citrus blocks periphery and bordering forest edge
  - Spring and Summer seasons

Systemic

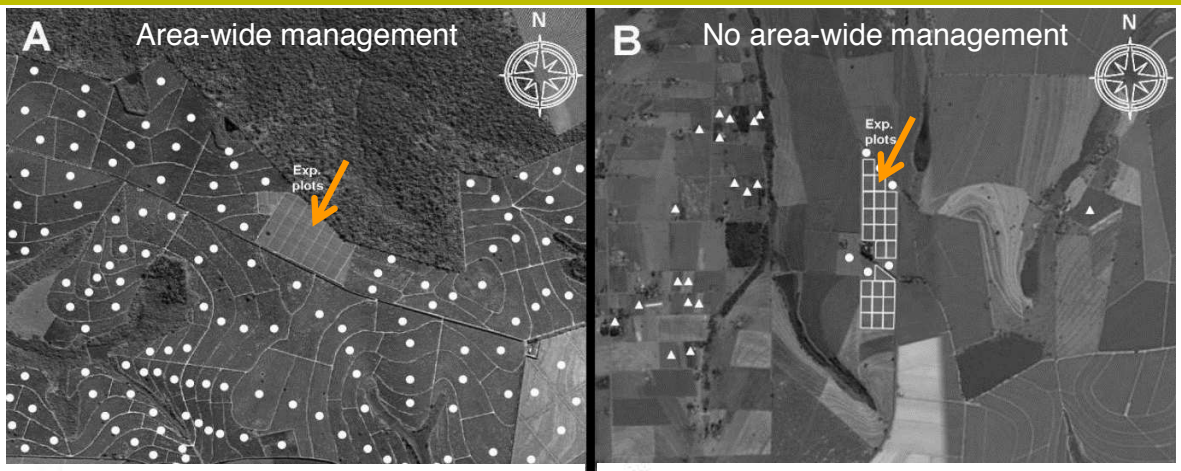


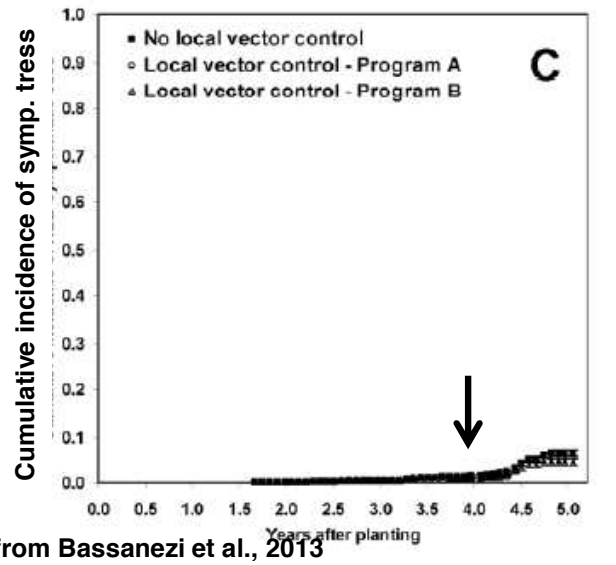
Young plants / soil humidity

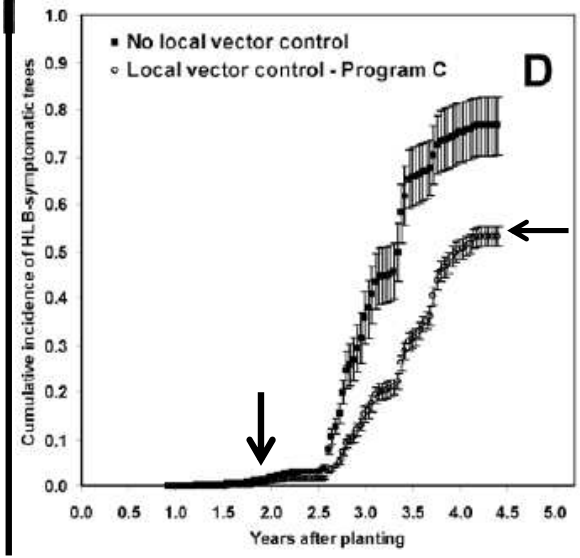
Contact

Older plants / dry seasons

Vector control, one example from HLB (greening) management program in Sao Paulo State







Spray every 14 days

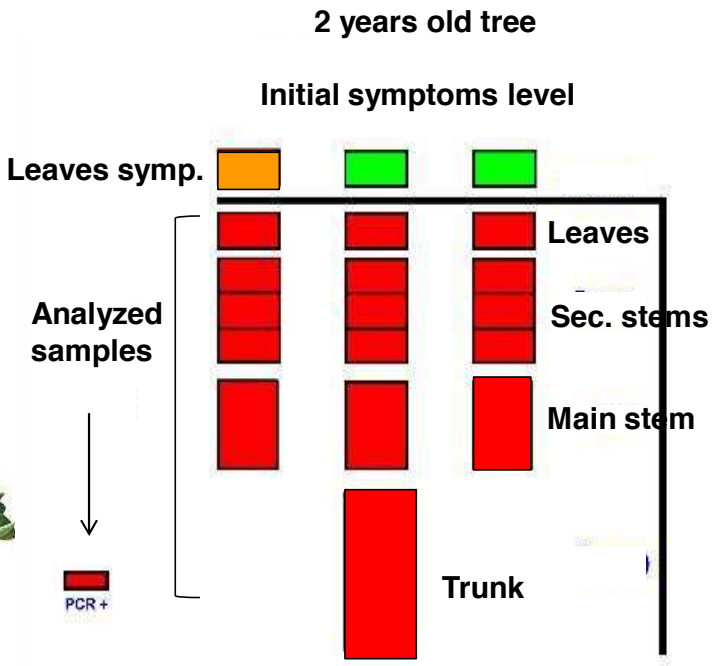
Adapted from Bassanezi et al., 2013

CVC Management – Reduction inoculum sources

Pruning of disease branches **Not work**

Infections in young trees – 2 yr. old

Systemic distribution of XF in early infected plants

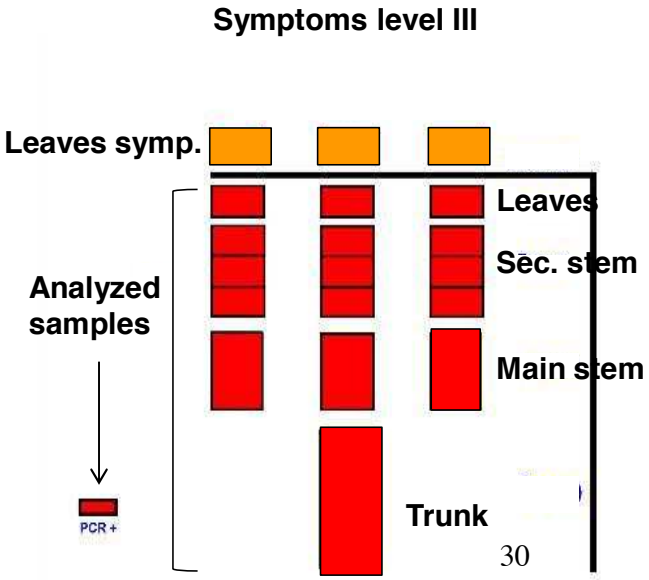


CVC Management - Reduction inoculum sources

Pruning of disease branches **Not work**

High infection level – no biologic death but strong reduction on productivity.

Systemic distribution of XF in severely infected plants



CVC Management - Reduction inoculum sources

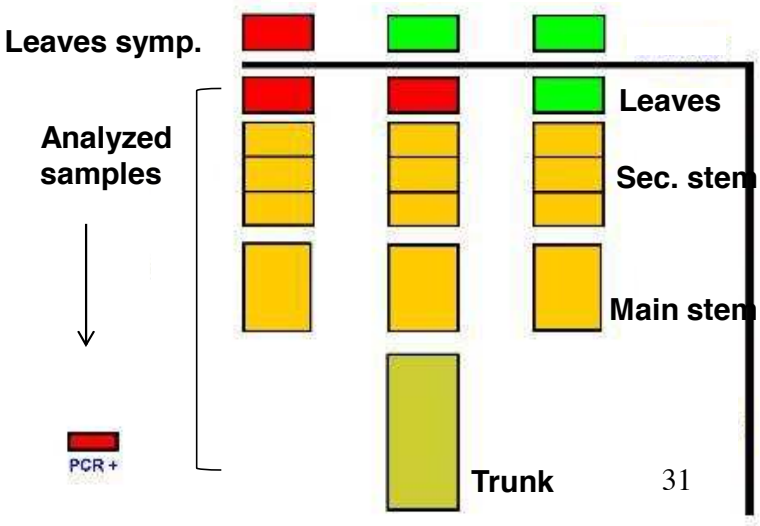
Pruning of disease branches

Work

Late and recent infections **in 4 yr old plants or higher**

Only in trees with initial leaves symptoms.

Systemic distribution of XF in plants with few symptoms



Conclusion

- There is no a cake receipt or a silver bullet to solve bacteria-vector borne diseases.

- There is management strategies !

  - Each pathosytem, geographic region, seasons of year, and spots (blocks) required different intensity of actions within the management package.

- To know the biology and the management the vector population in the one of most important key to break the disease epidemiology.

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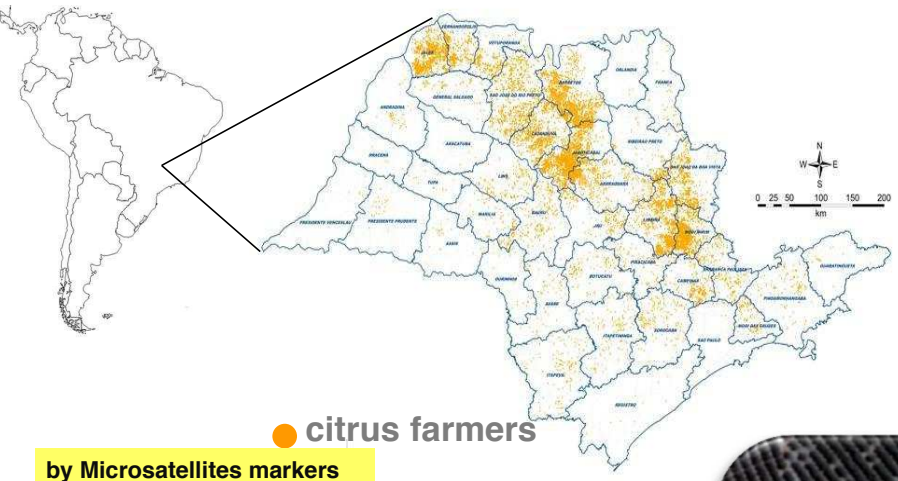
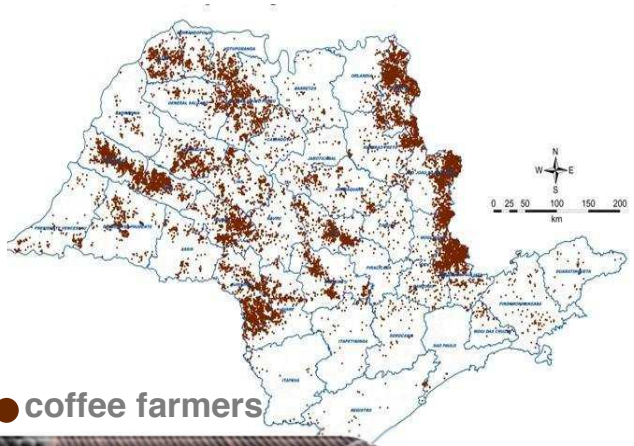
Xylella fastidiosa in Brazil

***X. fastidiosa subsp.* pauca** — from sweet orange; from coffee

Geographic distribution of coffee and citrus farms in SPS, Brazil





by Microsatellites markers from 12 loci