3er Taller Internacional sobre Plagas Cuarentenarias de los cítricos

3rd International workshop on citrus quarantine pests

Control of *Diaphorina citri* through regional management in São Paulo, Brazil

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Overview

1. São Paulo HLB situation

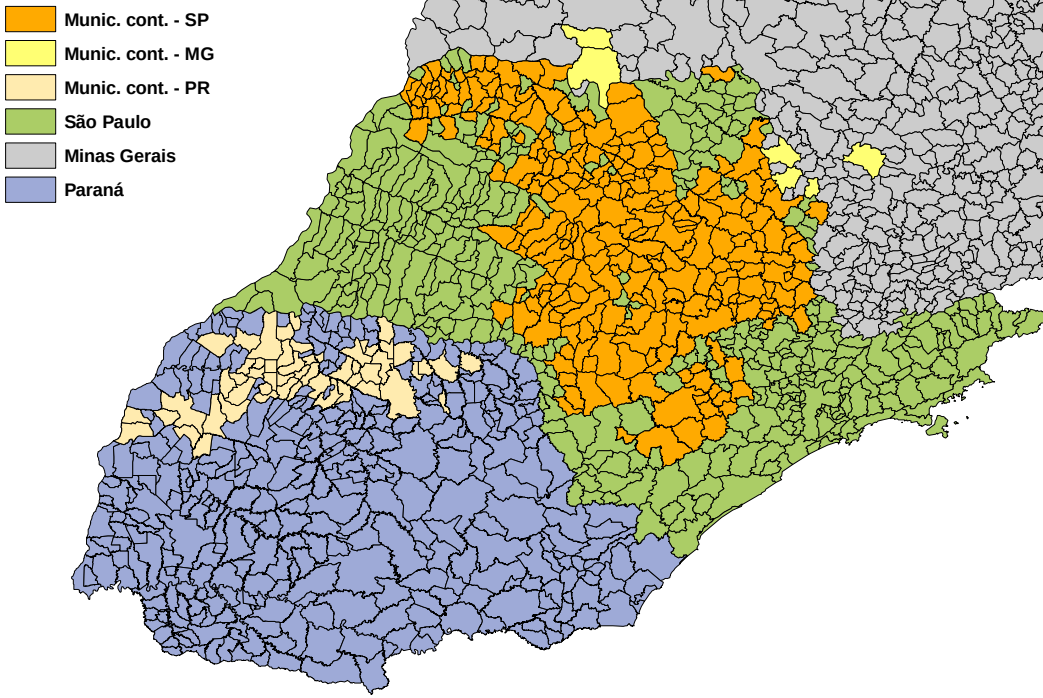
2. Regional management researches

3. Natural mortality and biological control

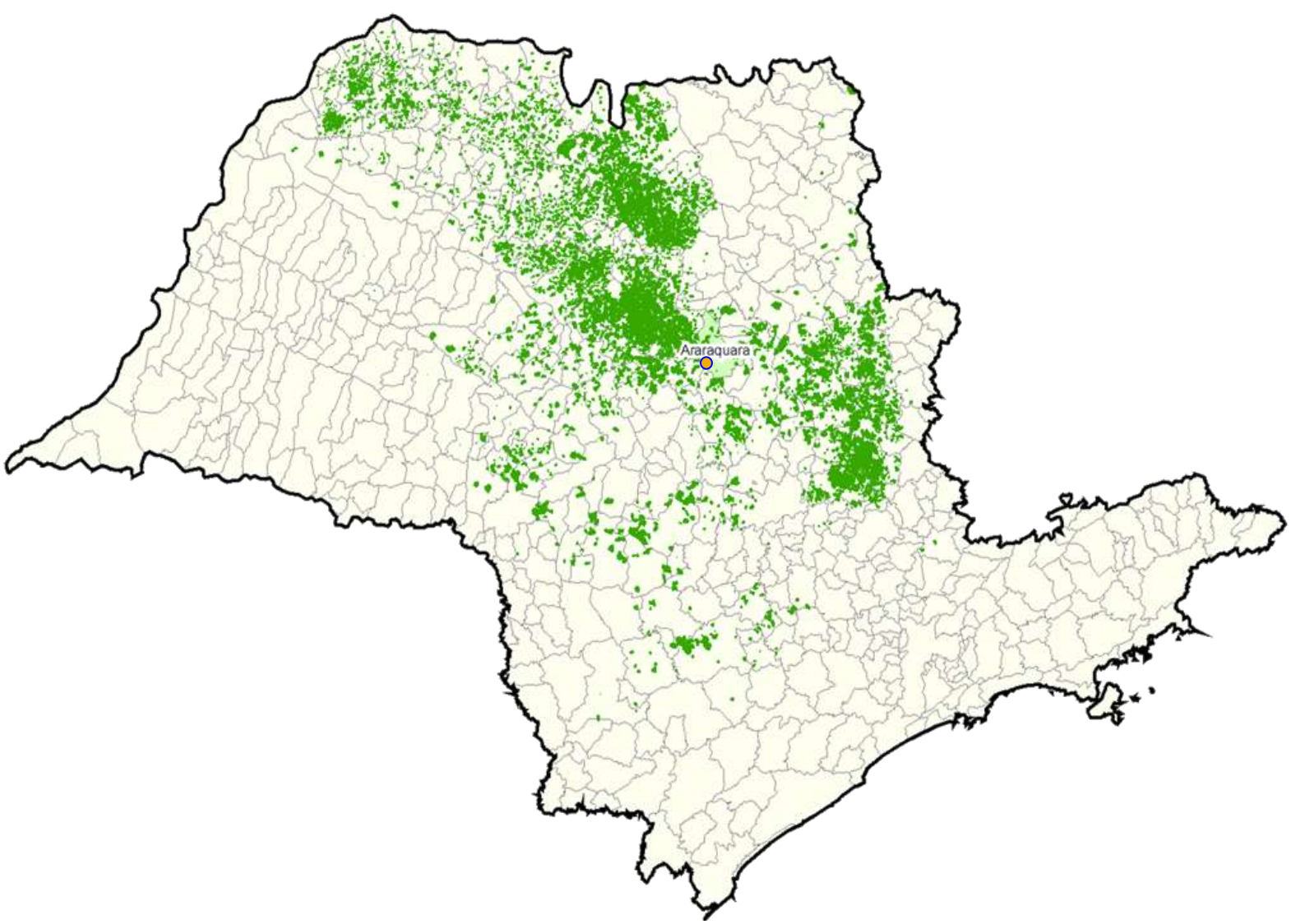
4. Insecticide programs and *D. citri* susceptibility

5. Challenges and perspectives

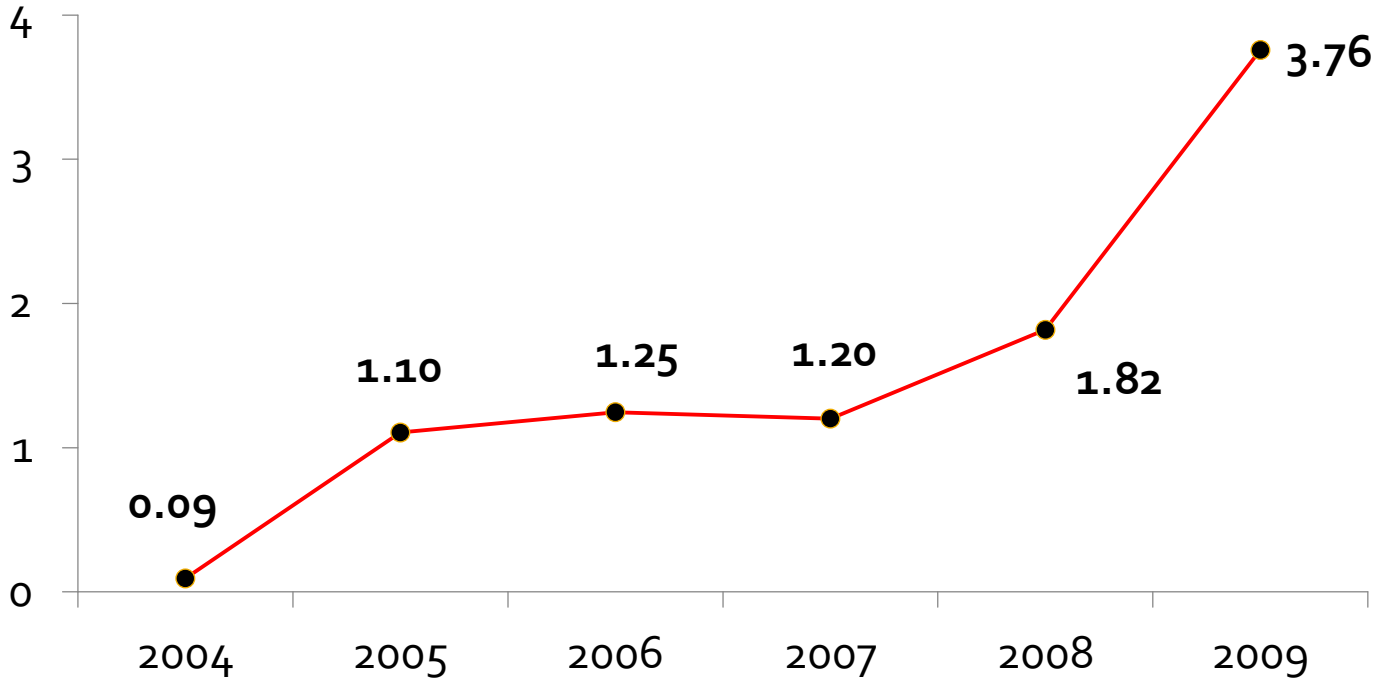
Greening - Municípios contaminados nos Estados de São Paulo, Minas Gerais e Paraná



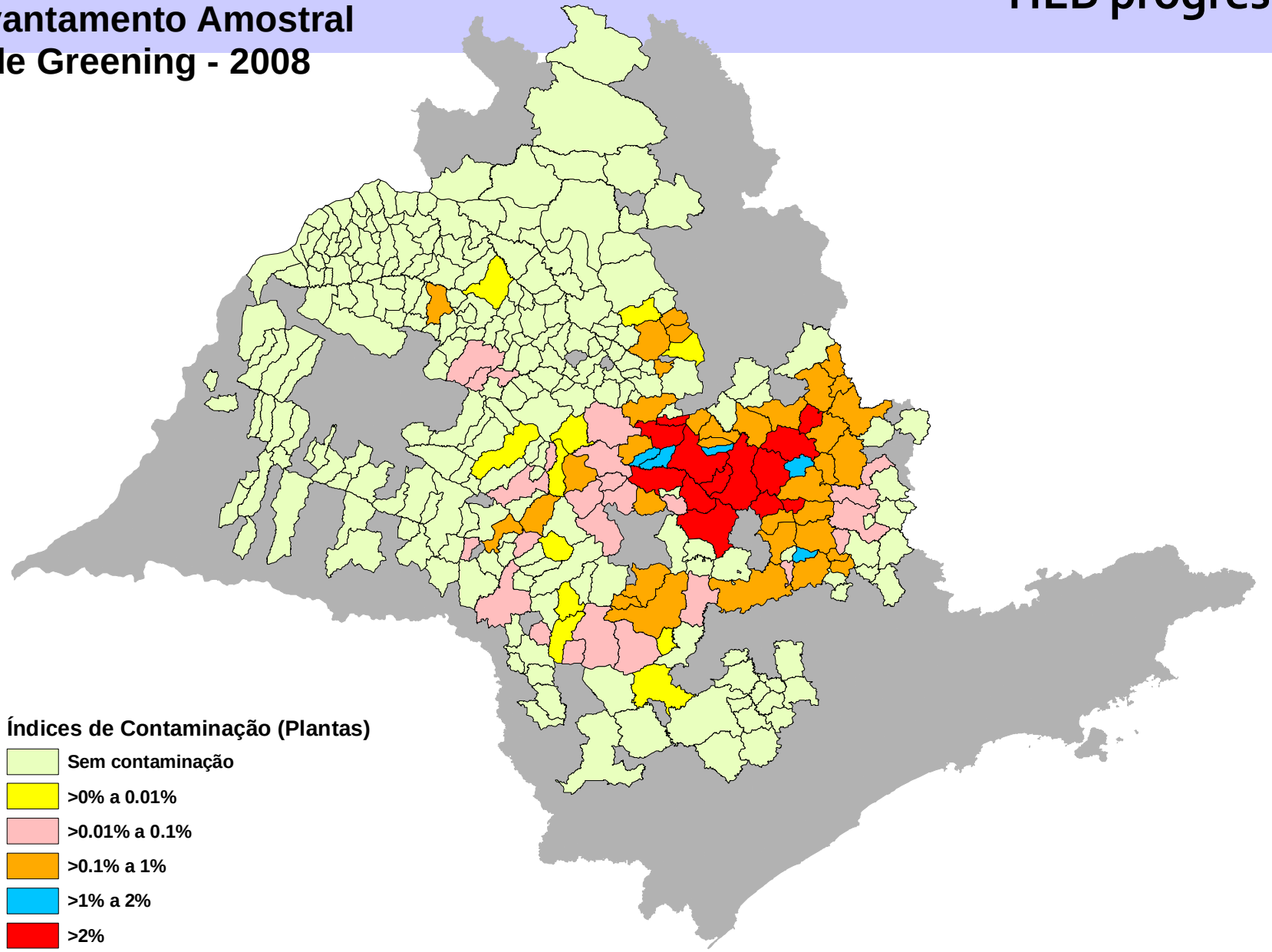
HLB in São Paulo



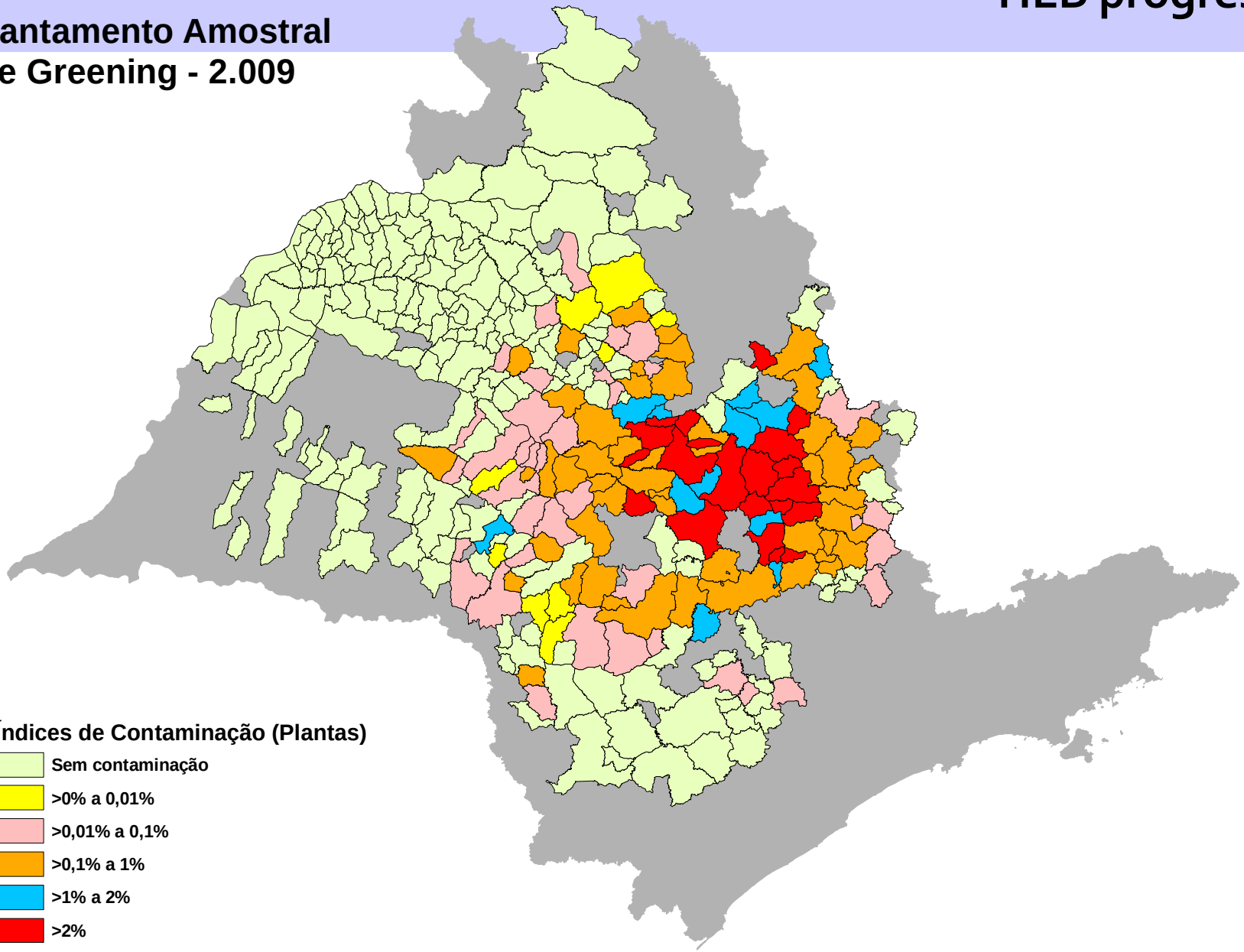
HLB incidence in a well conducted grove in SPaulo central area



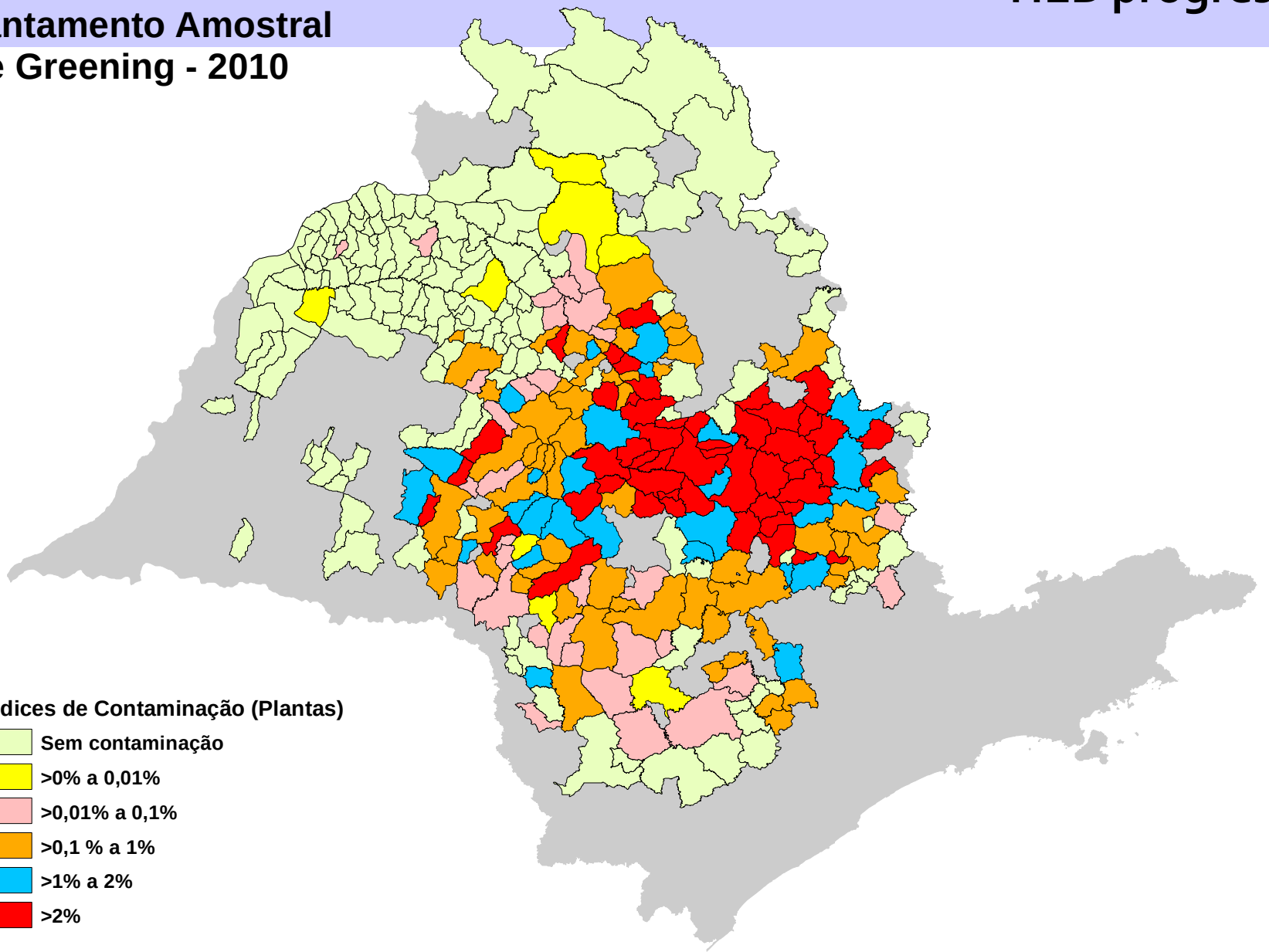
Levantamento Amostral de Greening - 2008



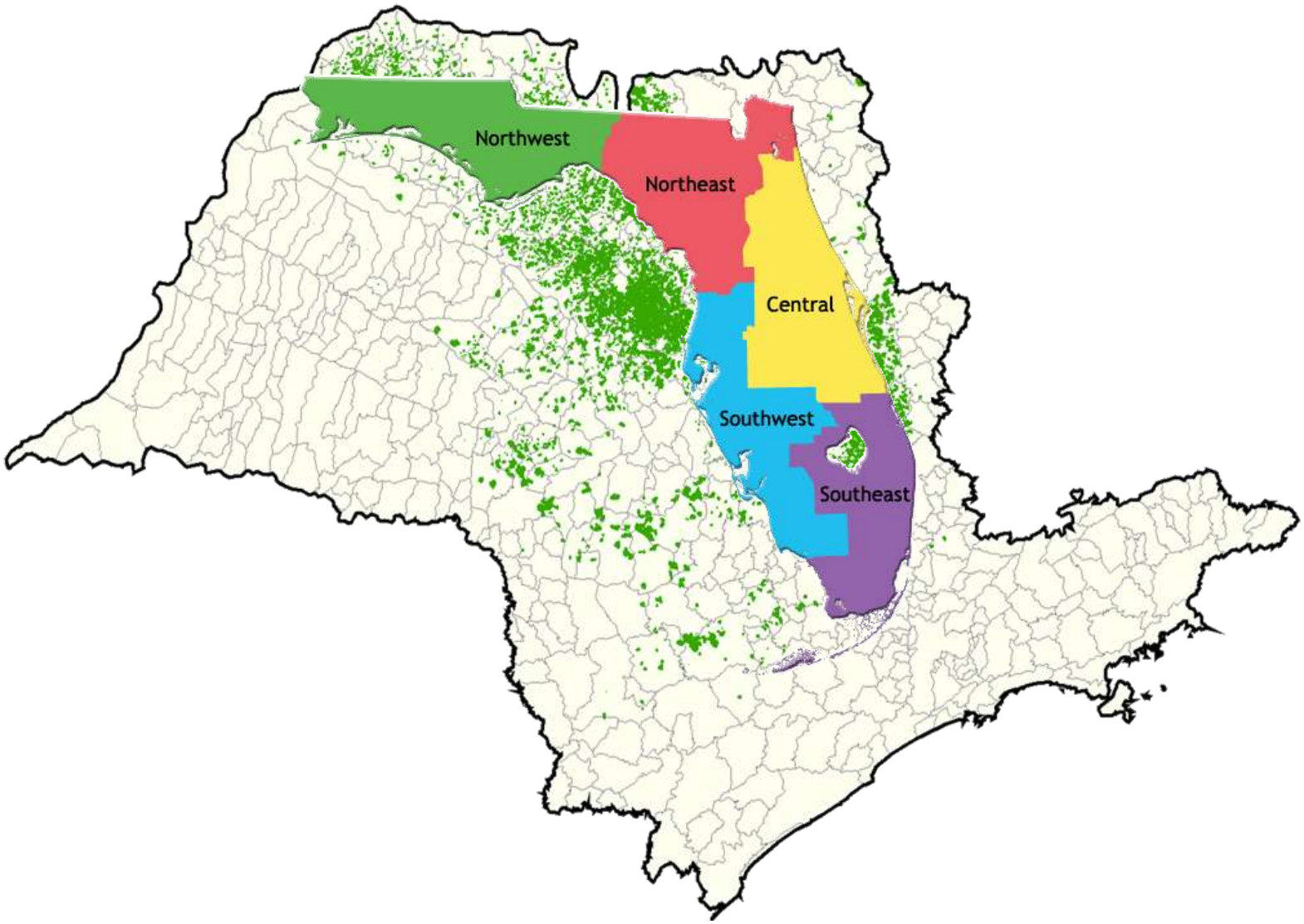
Levantamento Amostral de Greening - 2.009



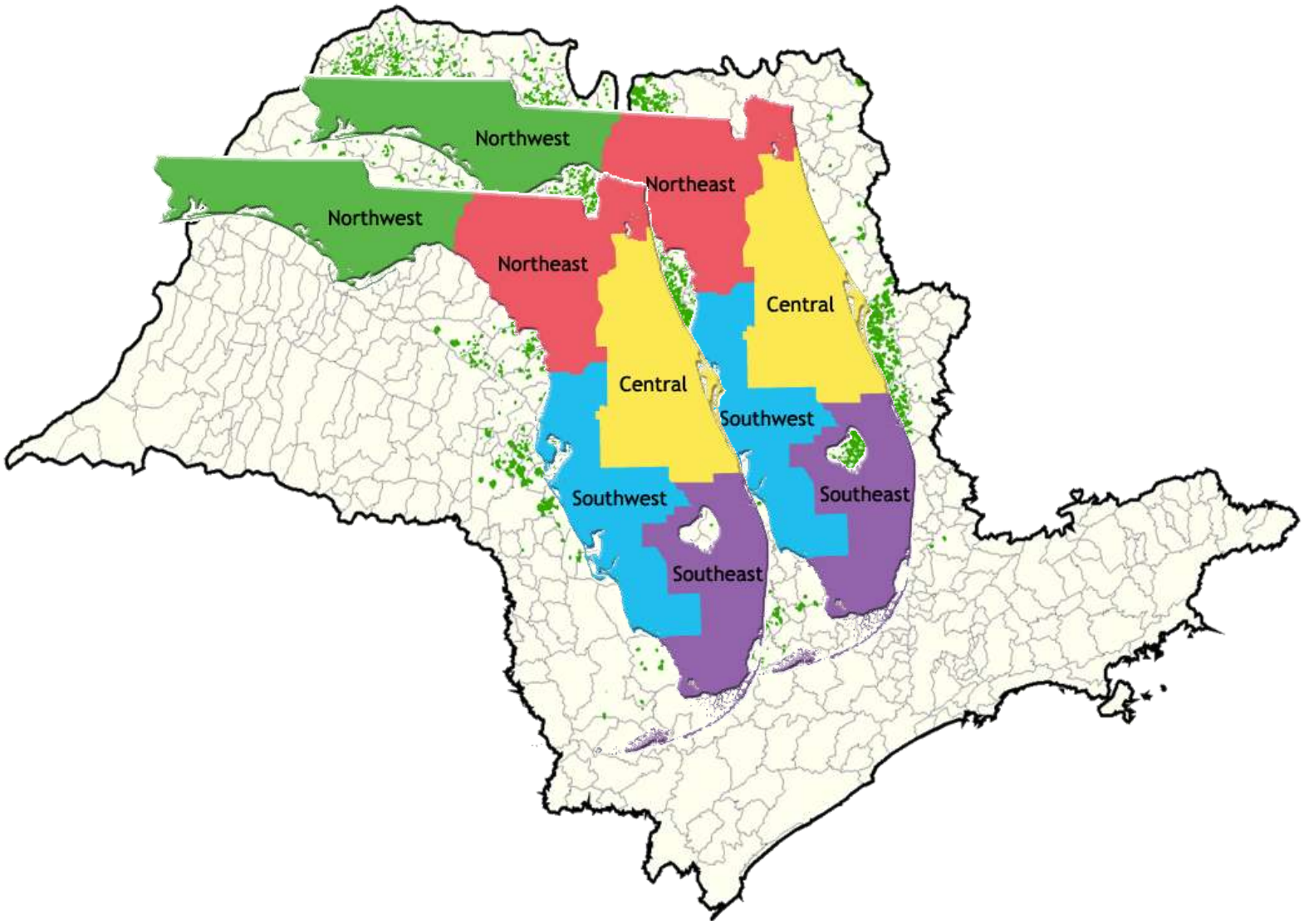
Levantamento Amostral de Greening - 2010



HLB today



HLB in few years



Low prices and high losses

How many citrus growers ???

(i) inoculum removal and insect vector control are initiated at low HLB-incidence

(ii) trees are older than 5 years

(iii) the farm is large (several hundred hectares)

(iv) HLB-management is practiced on all citrus farms within 4 km

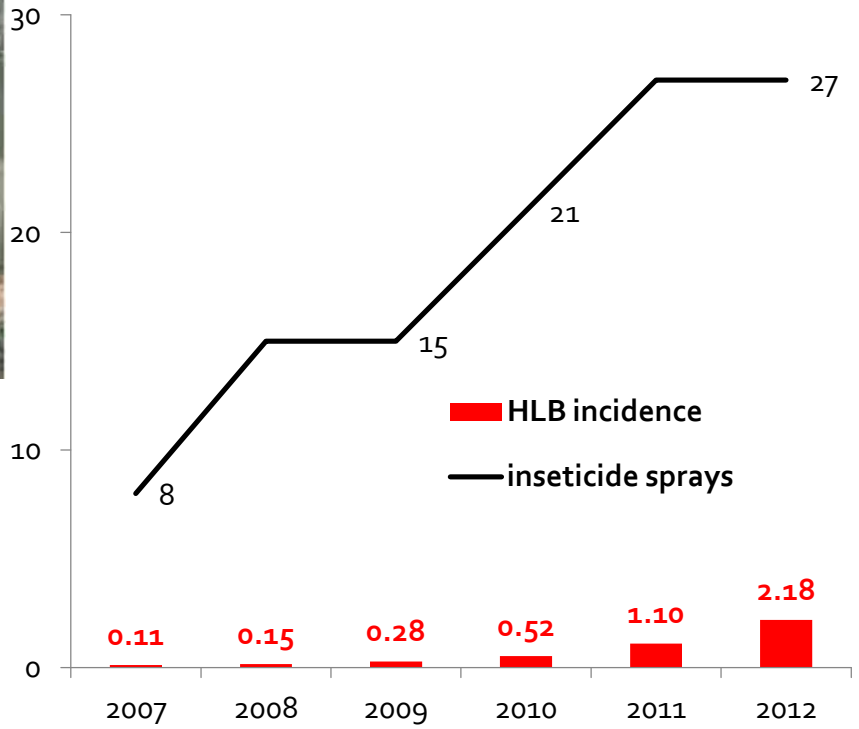
(v) the farm is in a region with an overall low HLB incidence

(Belasque Jr. et al. 2010)

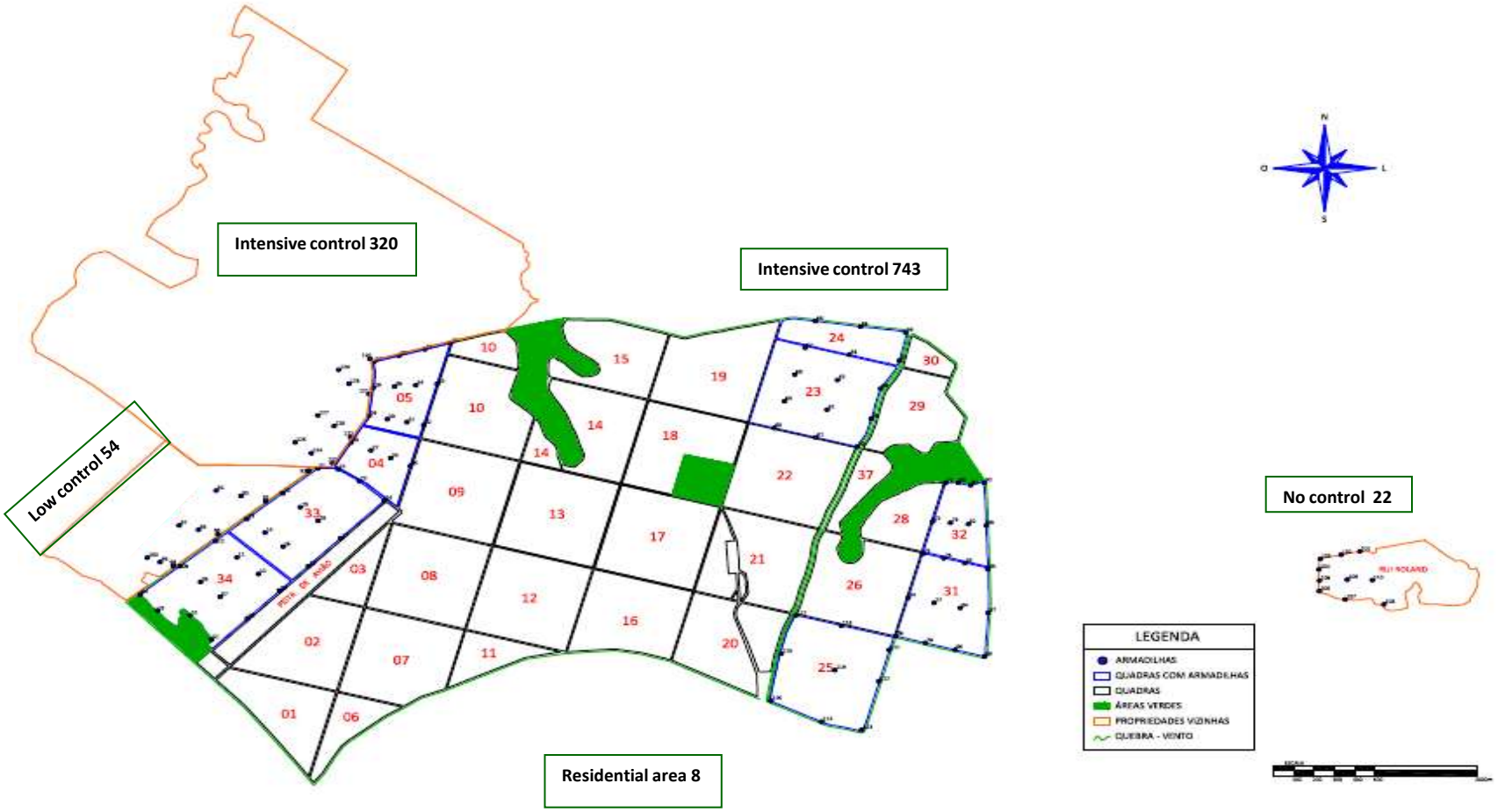
ANHEMBI STUDY - location

ANHEMBI STUDY - maps

ANHEMBI STUDY - history



ANHEMBI STUDY - maps



Who is the guilty ? always the edge

ANHEMBI STUDY – yellow sticky trap

ANHEMBI STUDY - areas

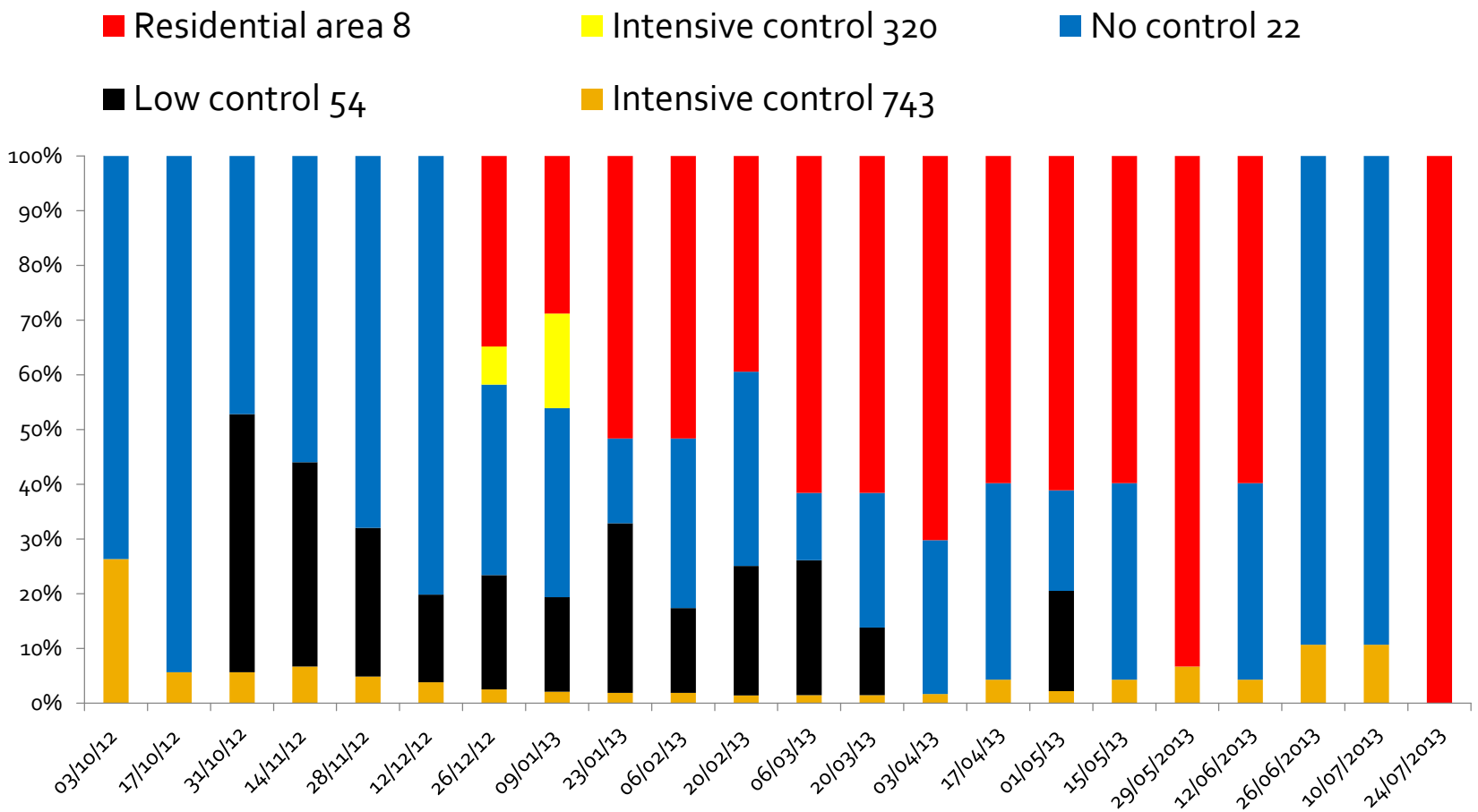
Area	hectares	Host plants	Vector	HLB
No control 22	22	Oranges	-	-
Low control 54	54	Oranges	+	-
Intensive control 320	320	Oranges, tangerines	+++	+++
Intensive control 743	743	Oranges	+++	+++
Residential area 8	8	Oranges, lemons	-	-

- no control; + low control; +++ intensive control

ANHEMBI STUDY - % of traps with ACP

Sampling	Intensive control 743	Low control 54	No control 22	Intensive control 320	Residential 8
03/10/12	3,6	0,0	10,0		
17/10/12	1,2	0,0	20,0		
31/10/12	2,4	20,0	20,0		
14/11/12	3,6	20,0	30,0		
28/11/12	3,6	20,0	50,0		
12/12/12	2,4	10,0	50,0	0,0	
26/12/12	3,6	30,0	50,0	10,0	50,0
09/01/13	1,2	10,0	20,0	10,0	16,7
23/01/13	1,2	20,0	10,0	0,0	33,3
06/02/13	1,2	10,0	20,0	0,0	33,3
20/02/13	1,2	20,0	30,0	0,0	33,3
06/03/13	1,2	20,0	10,0	0,0	50,0
20/03/13	1,2	10,0	20,0	0,0	50,0
03/04/13	1,2	0,0	20,0	0,0	50,0
17/04/13	2,4	0,0	20,0	0,0	33,3
01/05/13	1,2	10,0	10,0	0,0	33,3
15/05/13	1,2	0,0	10,0	0,0	16,7
29/05/2013	1,2	0,0	0,0	0,0	16,7
12/06/2013	1,2	0,0	10,0	0,0	16,7
26/06/2013	1,2	0,0	10,0	0,0	0,0
10/07/2013	1,2	0,0	10,0	0,0	0,0
24/07/2013	0,0	0,0	0,0	0,0	16,7
mean	**1,7**	**9,1**	**19,5**	**1,2**	**28,1**

ANHEMBI STUDY –areas and catches



ANHEMBI STUDY – ACP PCR+

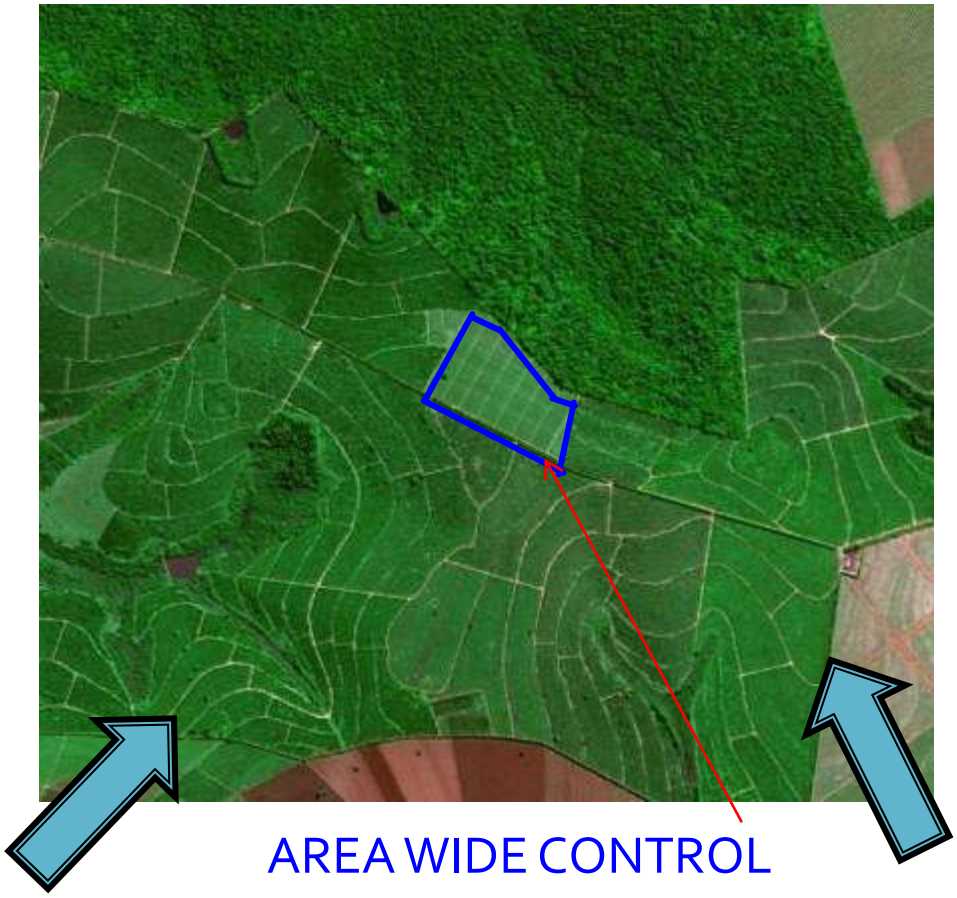
Sampling	Intensive control 743	Low control 54	No control 22	Intensive control 320	Residential 8
03/10/12	0/3	0/0	1/1		
17/10/12	0/1	0/0	0/2		
31/10/12	0/2	0/2	0/2		
14/11/12	0/3	0/2	0/3		
28/11/12	3/3	1/2	1/5		
12/12/12	1/2	1/1	3/5	0	
26/12/12	1/3	0/3	0/5	0/1	0/3
09/01/13	0/1	0/1	0/2	0/1	0/1
23/01/13	0/1	0/2	0/1	0	0/2
06/02/13	0/1	0/1	1/2	0	2/2
20/02/13	1/1	1/2	1/3	0	0/2
06/03/13	0/1	0/2	0/1	0	2/3
20/03/13	0/1	1/1	0/2	0	0/3
03/04/13	0/1	0	1/2	0	0/3
17/04/13	1/2	0	0/2	0	0/2
total	7/26	4/19	8/38	0/2	4/21
%	**26,9**	**21,1**	**21,1**	**0,0**	**29,4**

ACP infectivity

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Regional control				1,4					
Local control (Bassanezi et al. 2013)				10,2					
Intensive control (16 areas)			0,9	2,7					
Anhembi study								22,2	21,2

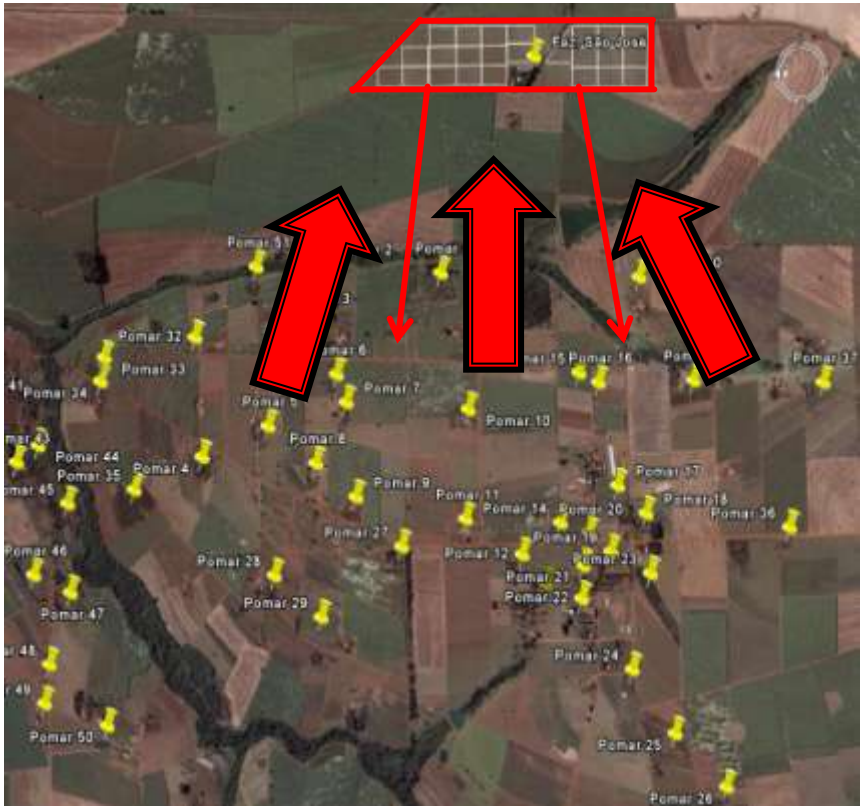
Cumulative HLB incidence

6,0%



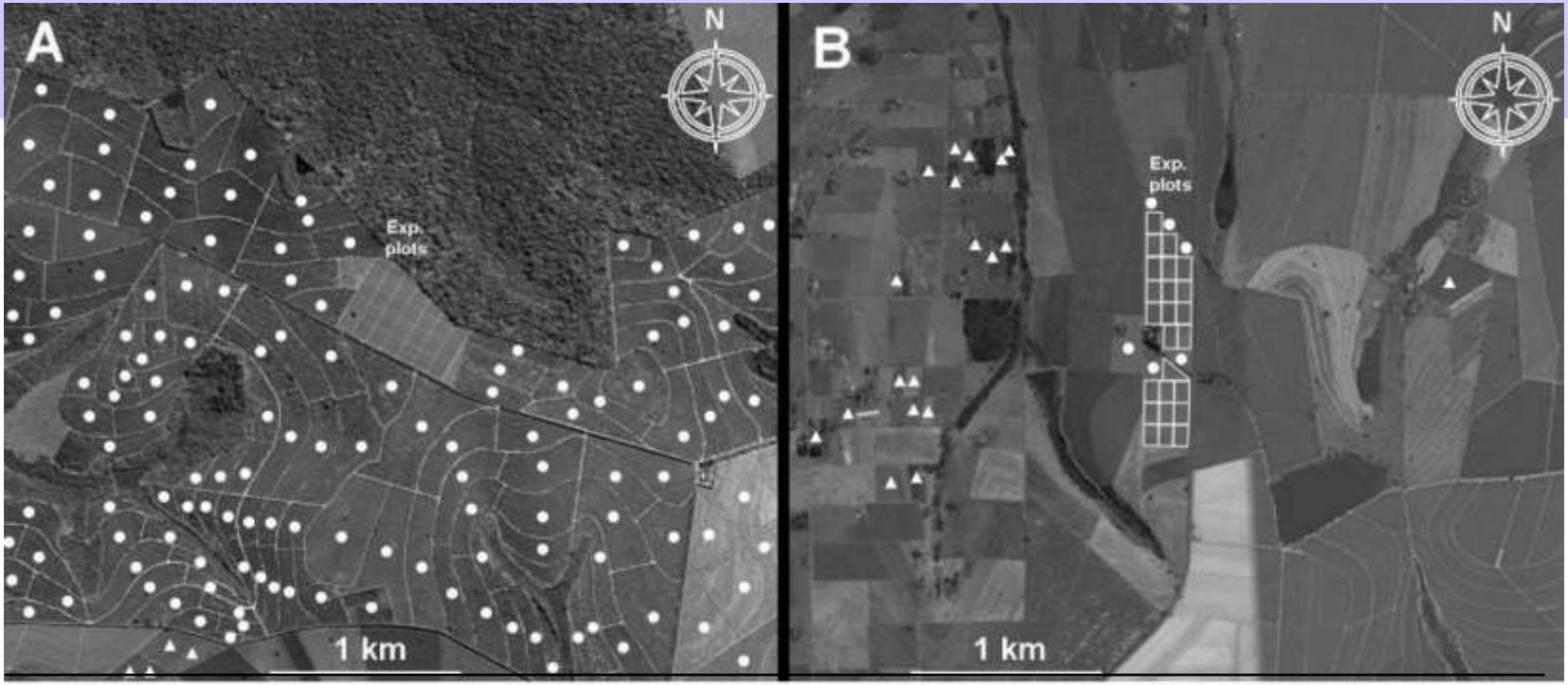
AREA WIDE CONTROL

65,0%



LOCAL CONTROL

(Bassanezi et al. 2013)



Area wide control

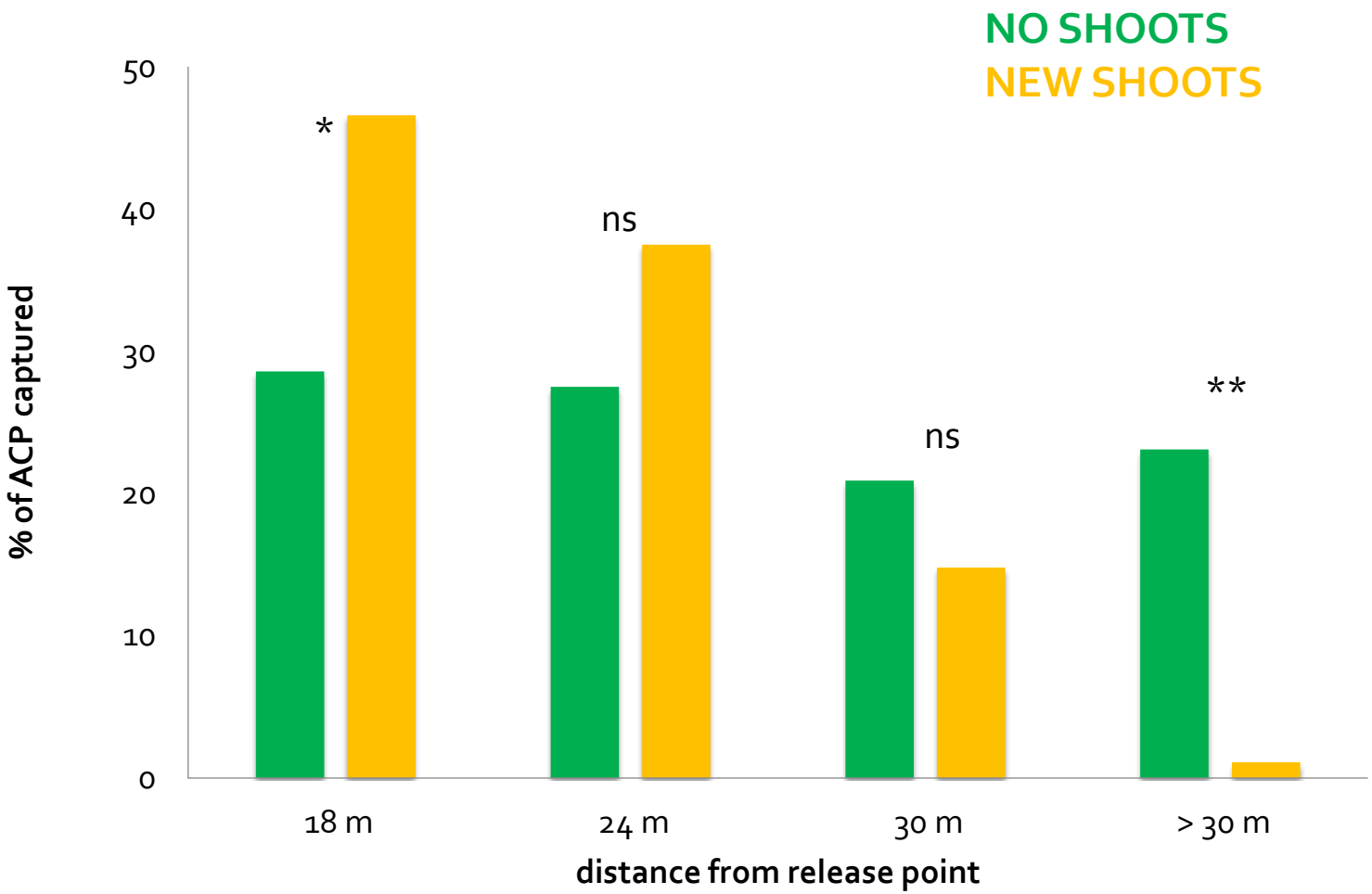
HLB trees erradication	ACP/trap	HLB incidence
Every 28 d	0,0966 a	6,06 a
Every 56 d	0,0878 a	4,94 a
Every 112 d	0,1044 a	6,13 a
ACP		
No control	0,1213 a	6,22 a
Program A	0,0792 b	6,33 a
Program B	0,0893 ab	4,59 a

Local control

HLB trees erradication	ACP/trap	HLB incidence
Every 14 d	0,3048 a	70,32 a
Every 28 d	0,1594 a	63,32 a
Every 84 d	0,2634 a	61,27 a
Every 182 d	0,2173 a	65,10 a
ACP		
No control	0,4595 a	76,86 a
Program C	0,0826 b	53,14 b

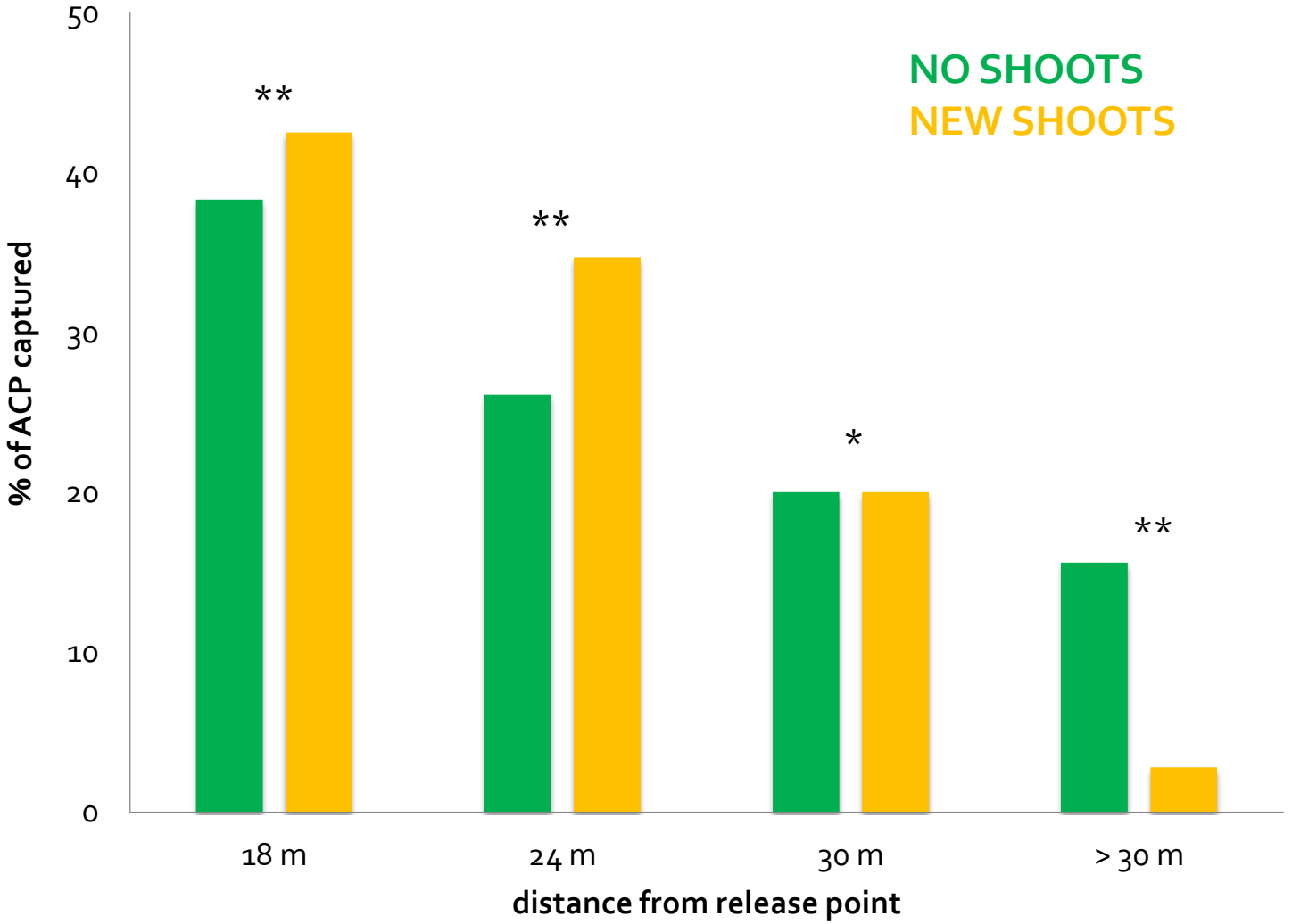
(Bassanezi et al. 2013)

6 HOURS AFTER RELEASE OF ADULTS



(Tomaseto 2012)

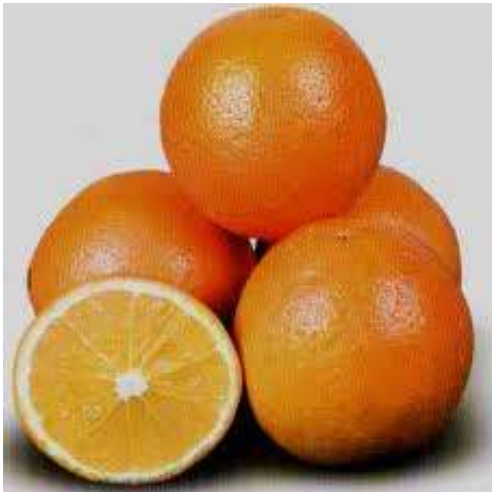
5 DAYS AFTER RELEASE OF ADULTS



(Tomaseto 2012)

DIFFERENCES IN SUSCETIBILITY TO HLB IN SP

HAMILIN ORANGE



TANGERINE PONKAN

MORE INCIDENCE/SEVERITY

LESS INCIDENCE/SEVERITY

LIMON PERSA

PERA ORANGE

Sweet oranges varietes and HLB incidence (2005-2011)

Area	Hamilin	Pera	Valencia	Hamilin/Pera
Grove A 15yo	3.42	1.35	3.45	**2.5**
Grove B 8yo	3.05	1.42	2.74	**2.1**
Grove C 7yo	13.52	6.42	5.30	**2.1**
Grove D 8yo	2.92	1.92	2.46	**1.5**
Grove E 4yo	1.16	0.66	0.91	**1.8**
Grove F 4yo	0.74	0.36	0.38	**2.0**
mean	**4.14**	**2.02**	**2.54**	**2.0**

High natural mortality: eggs and small nymphs (abiotic factors)

stage	*individuals*	*dead*	*mortality*	*survival*	*factor*
Araras region					
eggs	406	118	**0.291**	0.709	unviable
small nymphs	288	197	**0.684**	0.316	weather and host
large nymphs	91	84	**0.923**	0.077	weather and host
adults	7			0.429	sex ratio
females	3				
Piracicaba region, 1st generation					
eggs	739	452	**0.612**	0.388	unviable
small nymphs	287	114	**0.397**	0.603	weather and host
large nymphs	173	42	0.243	0.757	weather and host
adults	131			0.504	sex ratio
females	66				
Piracicaba region, 2nd generation					
eggs	516	360	**0.698**	0.302	unviable
small nymphs	156	110	**0.705**	0.295	weather and host
large nymphs	46	15	0.326	0.674	weather and host
adults	31			0.613	sex ratio
females	19				
Piracicaba region, 3rd generation					
eggs	617	397	**0.643**	0.357	unviable
small nymphs	220	45	**0.205**	0.795	weather and host
large nymphs	175	43	0.246	0.754	weather and host
adults	132			0.561	sex ratio
females	74				

(Paiva & Parra 2012)

Natural parasitism of *D. citri* nynphs by *T. radiata* (São Paulo)

		n	mean	min	max
Year	2005	34	**20.0**	0.0	91.6
	2006	8	**12.8**	0.0	67.7
	2007	21	**5.4**	0.0	32.4
	2008	6	**35.5**	0.0	91.7
"Season"	"spring" (Oct-Dec)	18	**10.7**	0.0	67.7
	"summer" (Jan-Mar)	22	**25.7**	0.0	91.7
	"autumn" (Apr-Jun)	21	**14.6**	0.0	91.6
	"winter" (Jul-Sep)	8	**5.6**	0.0	32.7
Region	North	14	**13.3**	0.0	66.7
	Center	20	**20.9**	0.0	91.7
	West	16	**11.4**	0.0	43.7
	South	19	**16.9**	0.0	67.7

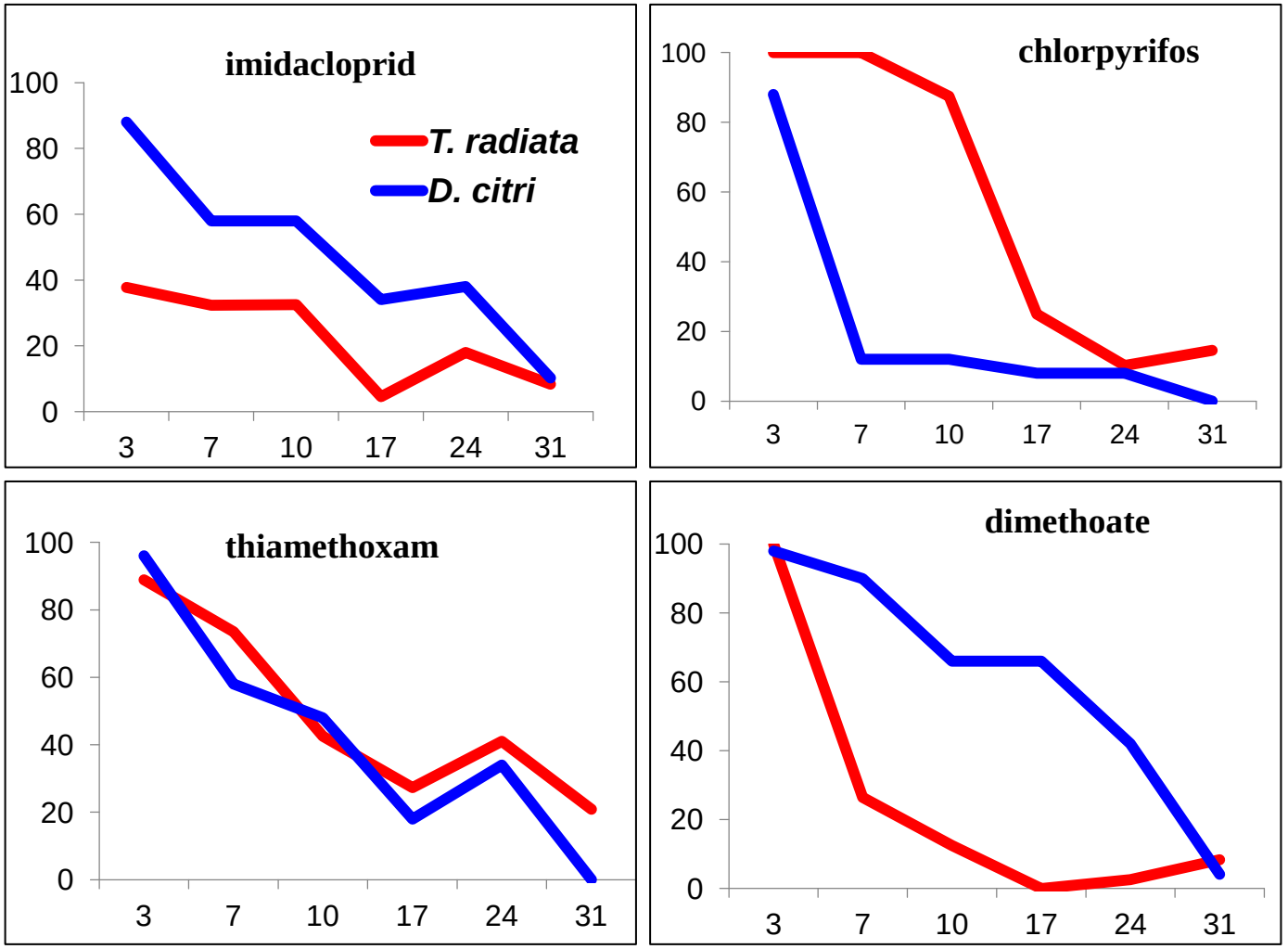
(Paiva & Parra 2012)

Natural parasitism of *D. citri* nynphs by *T. radiata*

		n	mean	min	max
Grove age (years)	1-3	15	**6.6**	0.0	67.7
	4-6	20	**24.6**	0.0	91.6
	7-9	17	**12.6**	0.0	66.7
	10 +	13	**18.6**	0.0	91.7
Orange variety	Hamlin	11	**35.6**	1.0	91.7
	Pera	15	**20.1**	0.0	67.7
	Valencia	31	**9.1**	0.0	43.7
	Natal	5	**7.3**	0.0	30.4

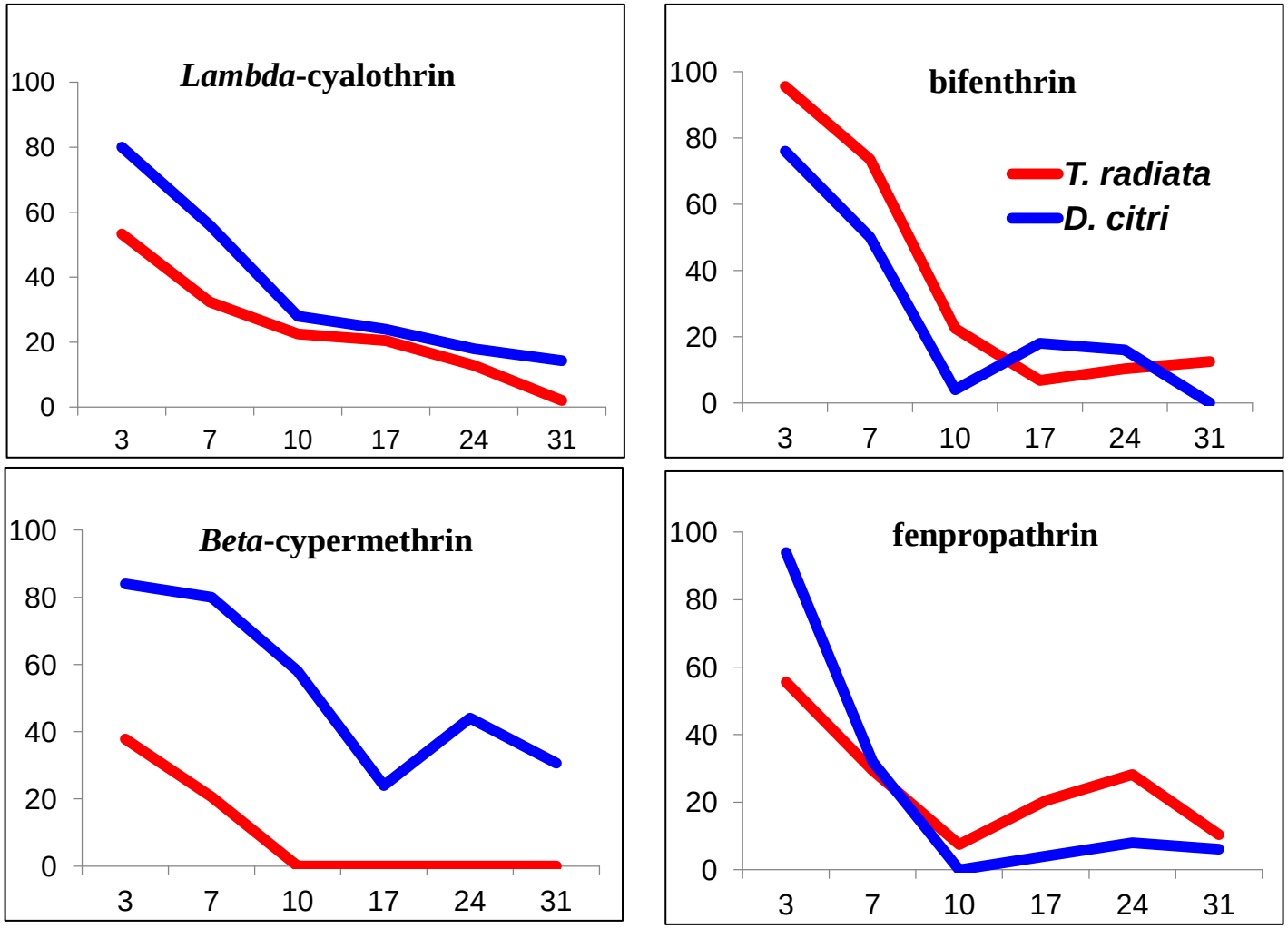
(Paiva & Parra 2012)

Insecticide toxicity: *T. radiata* x *D. citri*



(Beloti 2013)

Insecticide toxicity: *T. radiata* x *D. citri*



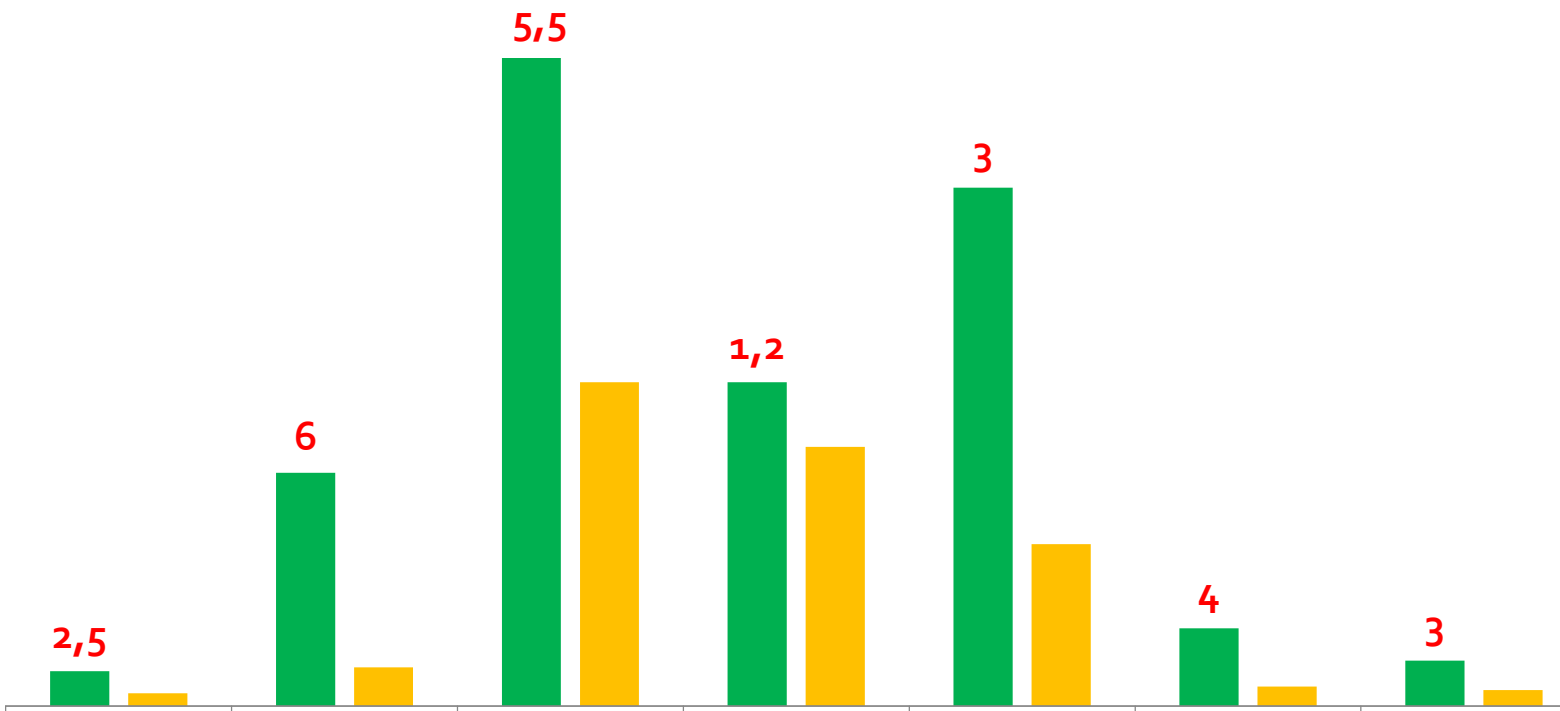
(Beloti 2013)

Doses and frequency of sprays

	FLORIDA	SÃO PAULO
Organophosphates	chlorpyrifos dimethoate phosmet	chlorpyrifos dimethoate phosmet
Pyrethroids	fenpropathrin *zeta*-cypermethrin	fenpropathrin *beta*-cypermethrin bifenthrin
Neonicotinoids	imidacloprid thiamethoxam	imidacloprid thiamethoxam
Spinosyn	spinetoram	
Other	spirotetramat	
Mixtures	thiamethoxam + chlorantraniliprole thiamethoxam + abamectin	
Source:	*2012 Florida Citrus Pest Management Guide: AsianCitrus Psyllid and Citrus Leafminer*	*Produção Integrada dos Citros PIC BRASIL (reviewed: 31/may/2013)*

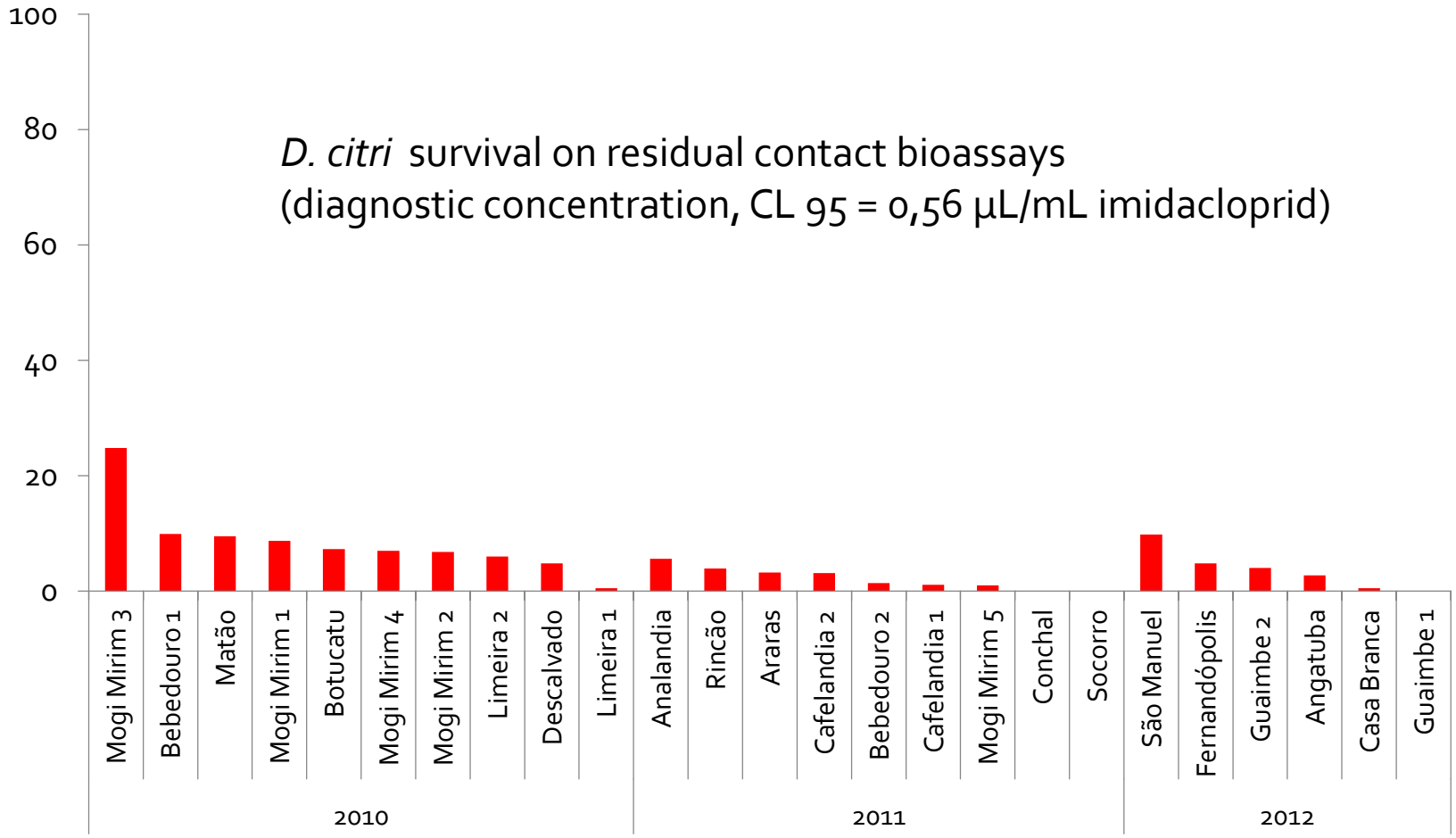
Doses and frequency of sprays

Flórida = 8 to 12 sprays/yr.
São Paulo = 12 to 36 sprays/yr.



	cypermethrin	fenpropathrin	chlorpyrifos	dimethoate	phosmet	imidacloprid	thiamethoxan
Flórida	54	360	2800	500	800	120	70
São Paulo	20	60	500	400	250	30	25

D. citri RESISTANCE MONITORING



(Poltronieri 2013)

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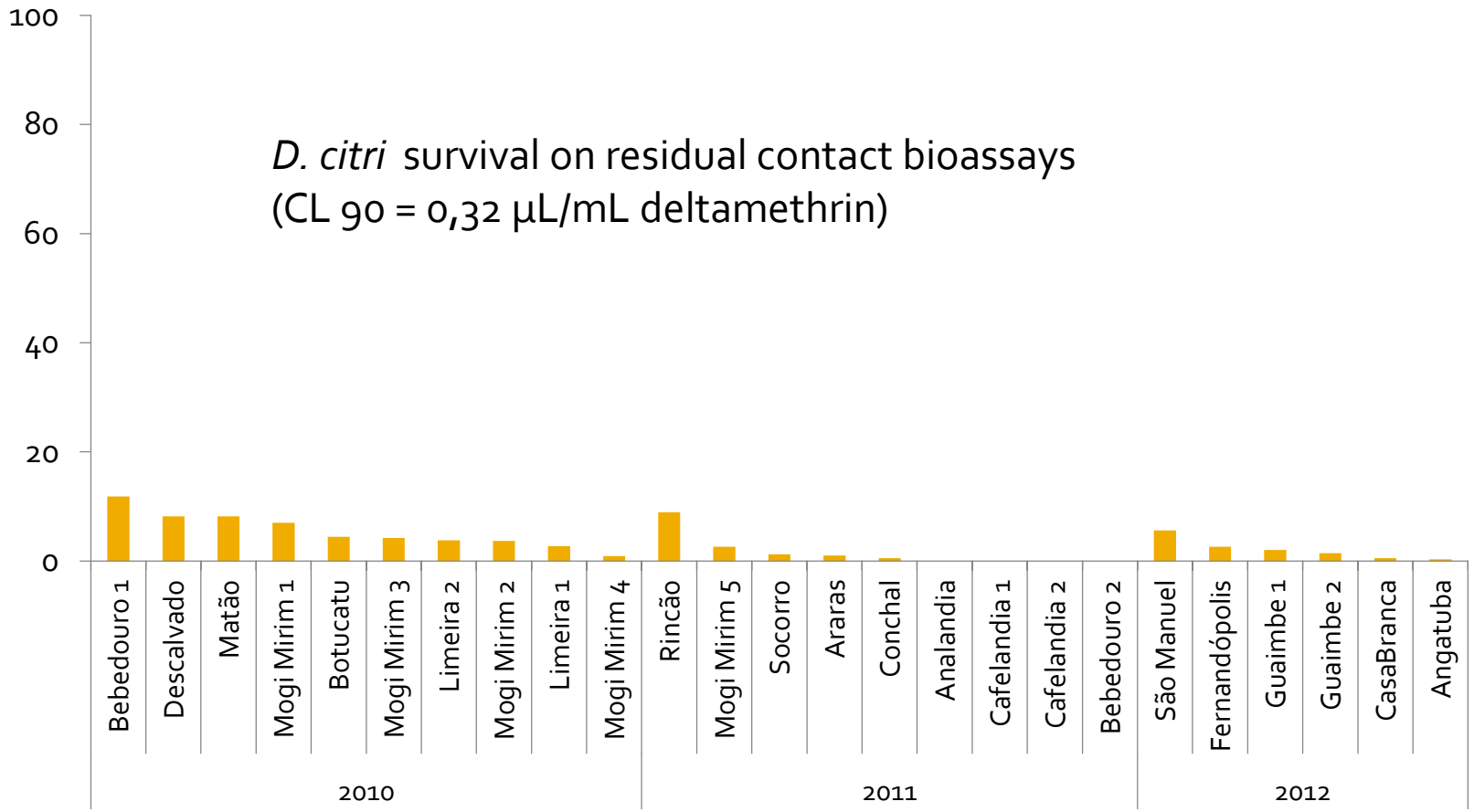
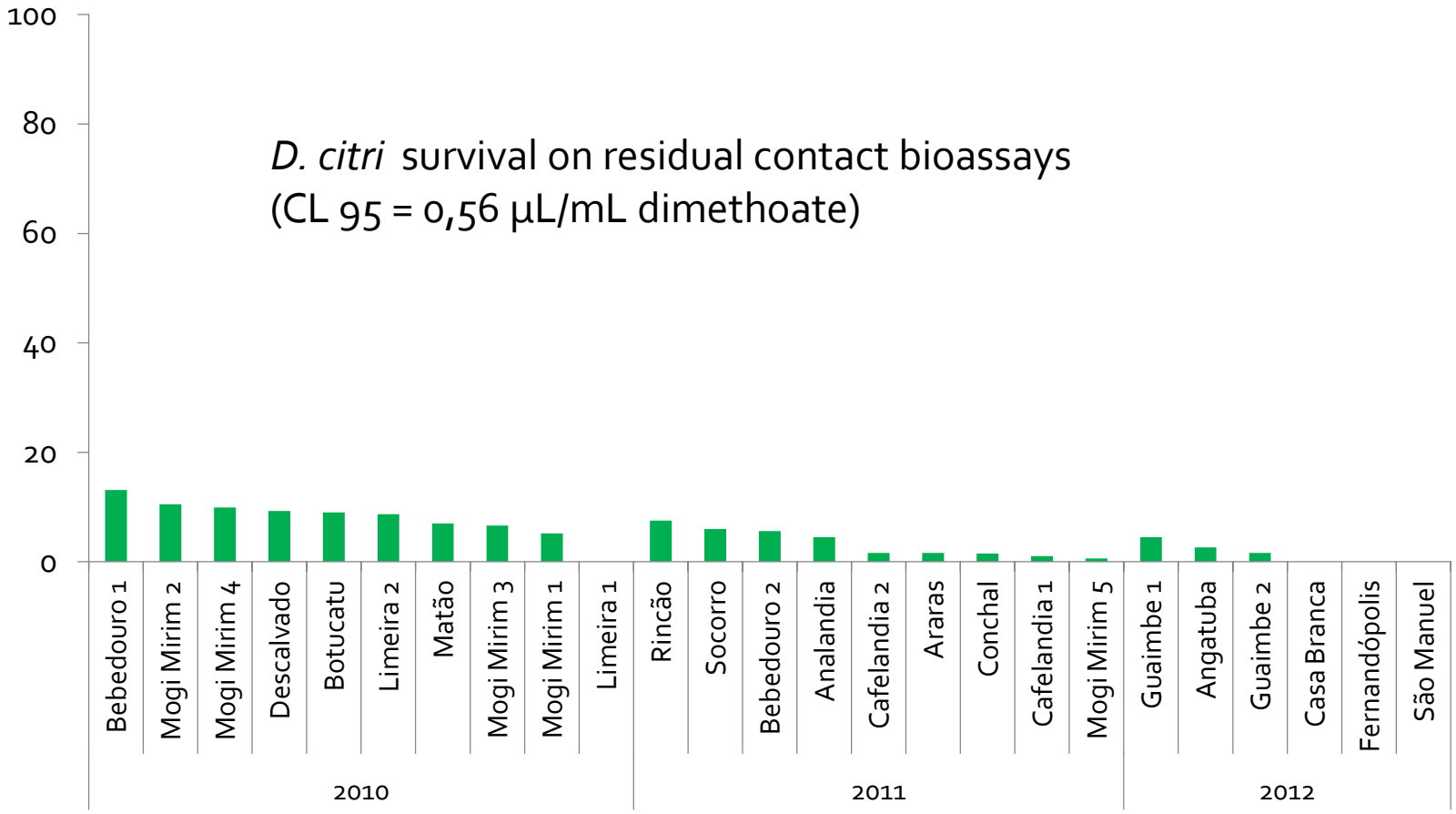


(Poltronieri 2013)

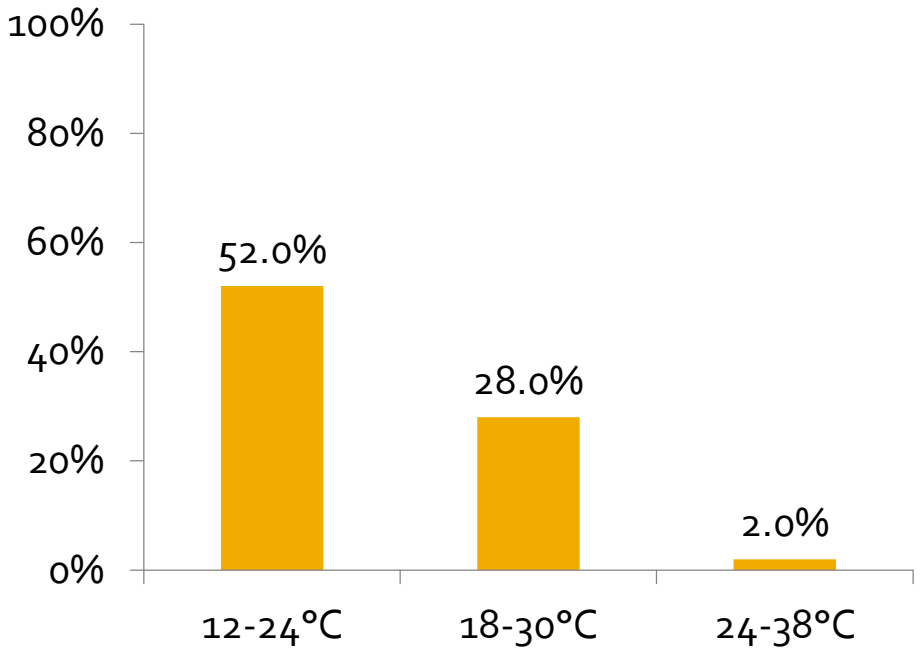
D. citri RESISTANCE MONITORING



(Poltronieri 2013)

‘*Candidatus* Liberibacter asiaticus’ acquisition rates by *Diaphorina citri* are decreased by higher temperature

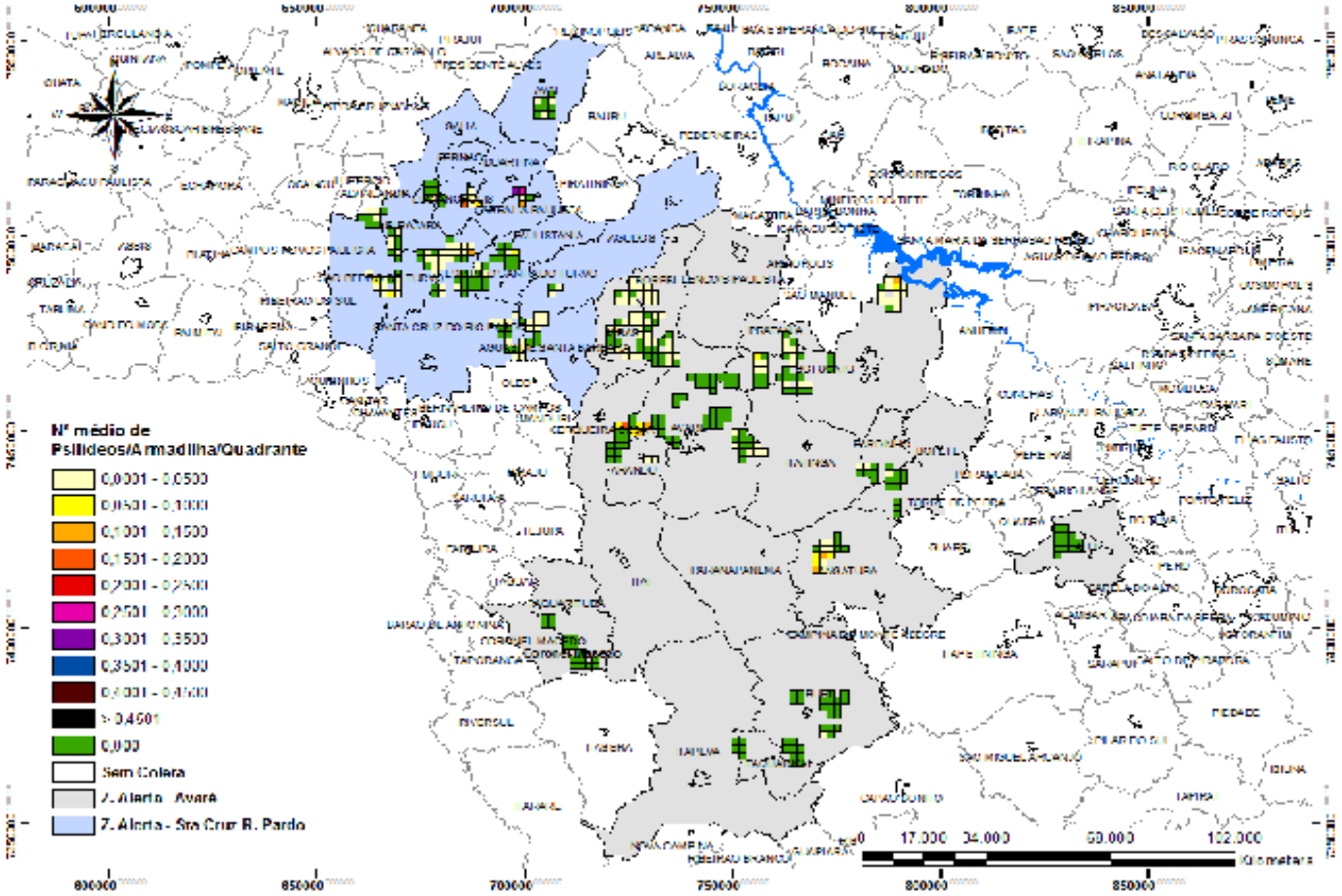
Frequency of acquisition in *D. citri* (long exposure)					Frequency of acquisition in *D. citri* (short exposure)						
days	14,6-28°C		24-38°C		days	12-24°C		18-30°C		24-38°C	
60	31/58	53,4%	14/56	25,0%	3 to 30	26/50	52,0%	14/50	28,0%	1/50	2,0%
90	52/59	88,1%	20/56	35,7%							
120	32/41	78,1%	12/45	26,7%							



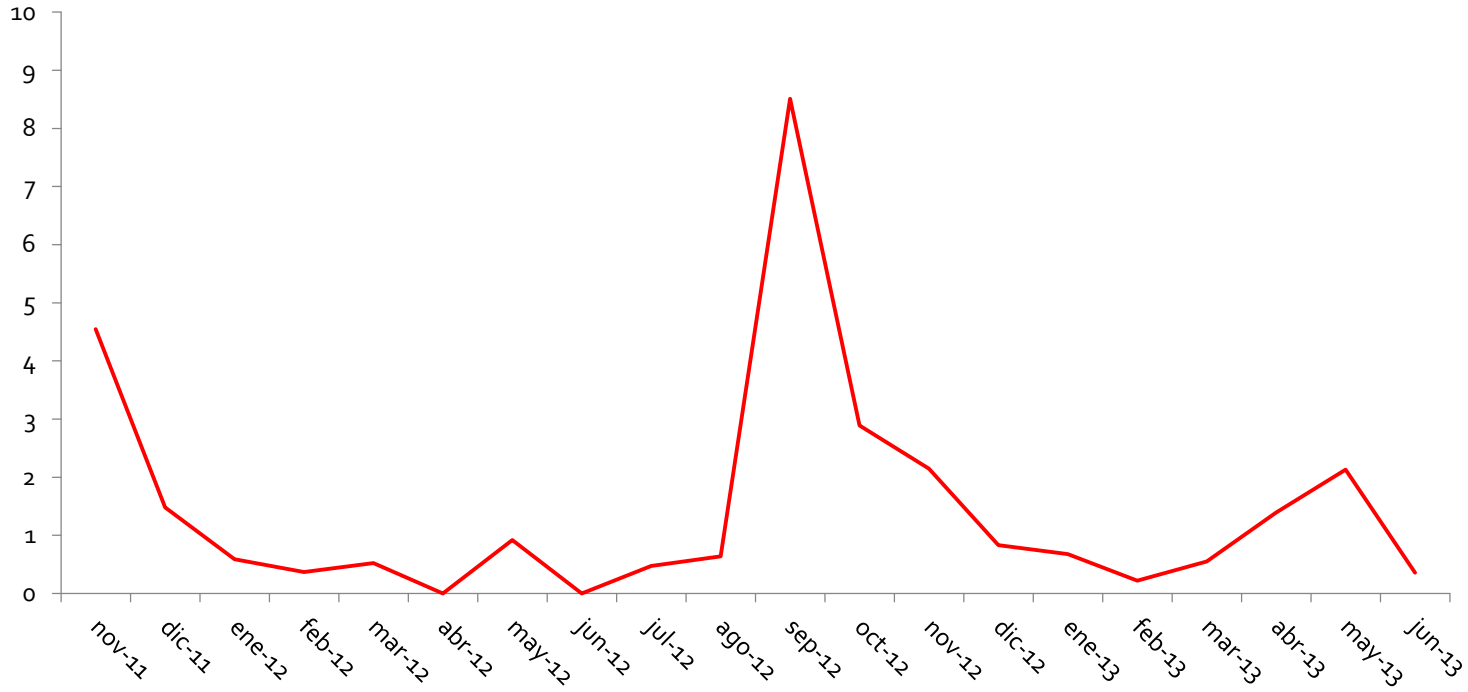
(Lopes et al. 2013)

FUNDECITRUS REGIONAL PROGRAMS

Region	Avare	Santa Cruz do Rio Pardo
startet at	2010	2009
hectares	30 mil	20 mil
groves	29	21
cooperative actions (sprays)	10	12



FUNDECITRUS REGIONAL PROGRAMS



% yellow stick traps with ACP in Avare region

CHALLENGES FOR REGIONAL CONTROL

1. URBAN AND RECREATION AREAS

2. LACK OF COOPERATION AND ANIMOSITIES BETWEEN

MAJOR GROWERS (PROCESSORS) AND OTHER GROWERS

3. IMIDACLOPRID BANNED BY AIR SPRAY

4. *Murraya* ABUNDANCE

5. HIGH INOCULUM REGIONAL