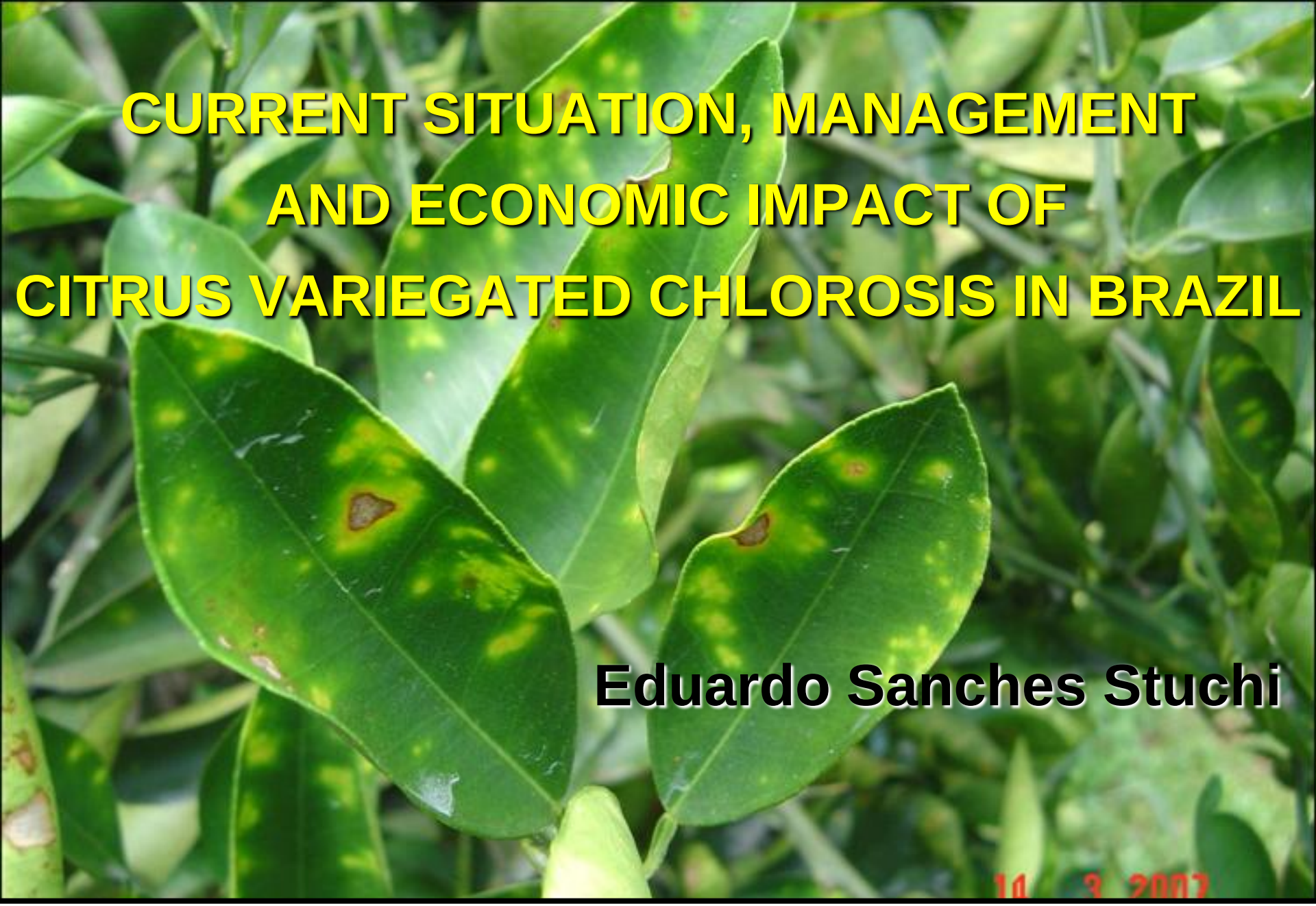
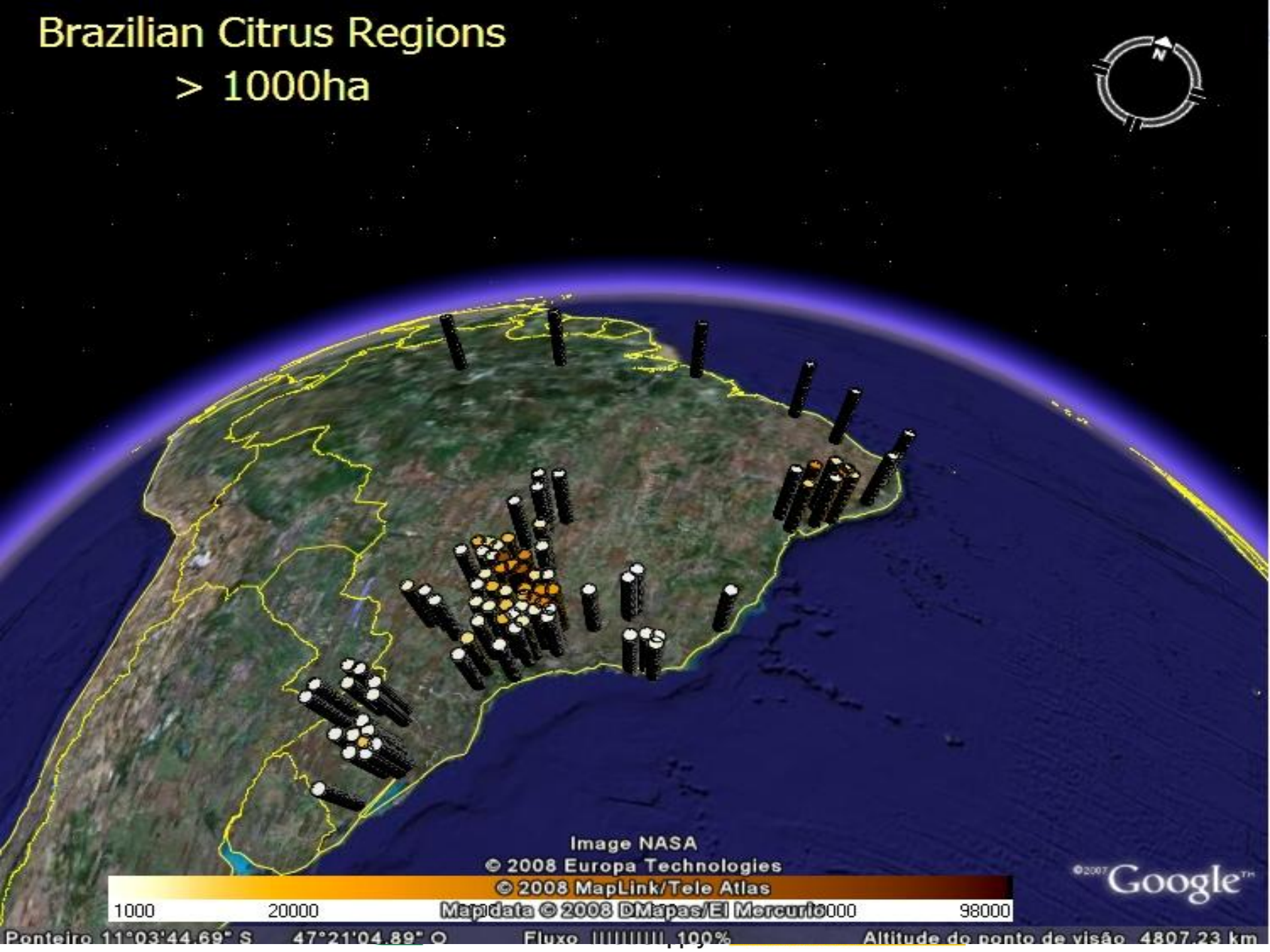


CURRENT SITUATION, MANAGEMENT AND ECONOMIC IMPACT OF CITRUS VARIEGATED CHLOROSIS IN BRAZIL

Eduardo Sanches Stuchi

Embrapa
Ministry of Agriculture, Livestock and Food Supply
BRASIL BRAZILIAN GOVERNMENT

Brazilian Citrus Regions
> 1000ha



Embrapa Cassava & Tropical Fruits

Bahia
Sergipe

Brasília

Bebedouro
Cordeirópolis

Image NASA
Map data © 2008 DMapas/El Mercurio
© 2008 Europa Technologies
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©2007 Google™

1 20000 39000 79000 98000

Ponteiro 13°56'48.83" S 44°14'14.37" O Fluxo 100% Altitude do ponto de visão 2547.59 km

Citriculture in Brazil

- **Brazil:** major orange (40%) and orange juice (60%) producer;
- **São Paulo State:**

  70% of Brazilian orange production;

  98% of Brazilian orange juice;
- **Brazilian citrus agri-industrial bussiness:**

  support 50% of orange juice world demand;

  82% of international market;

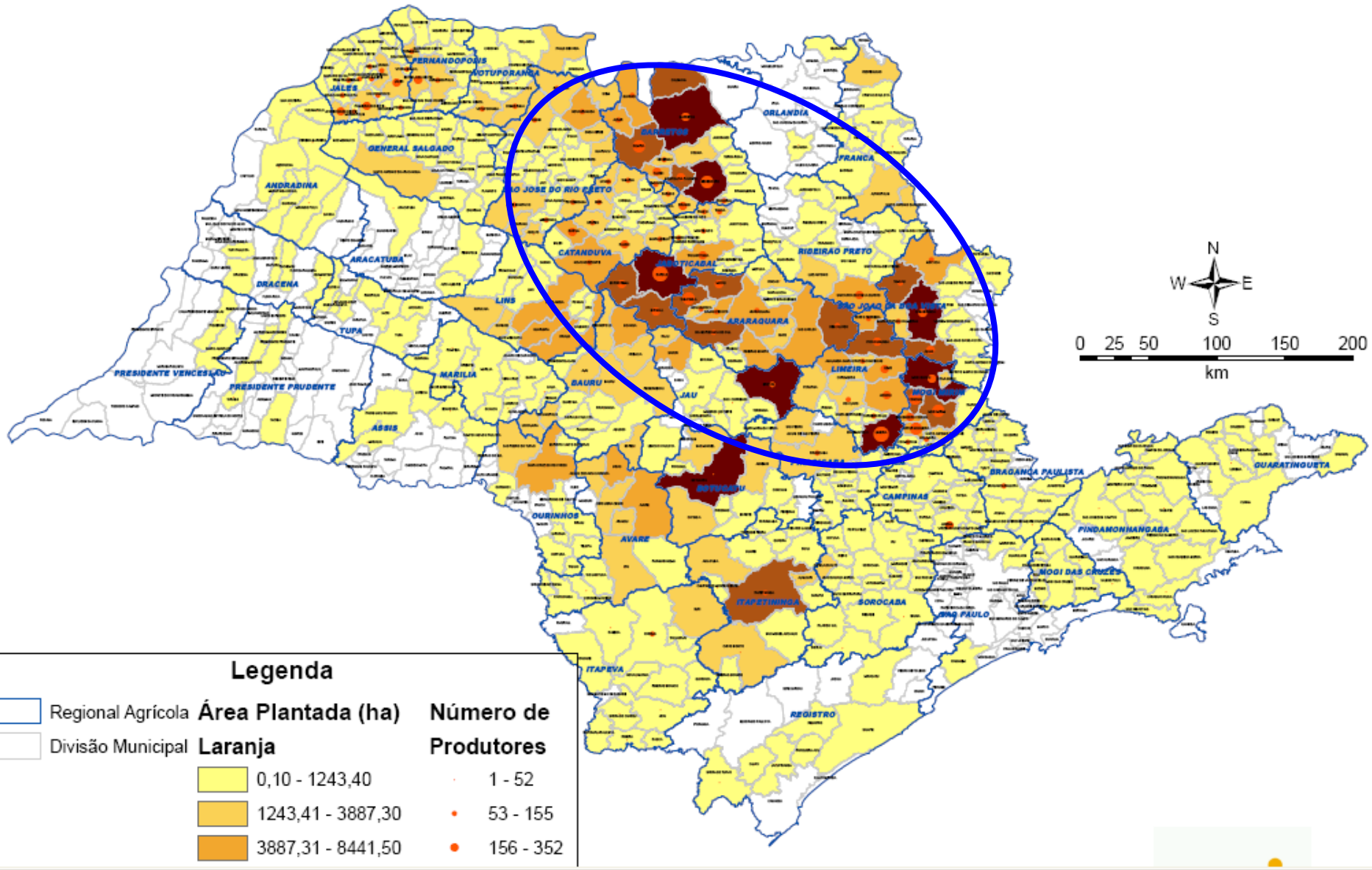
  US$ 1,5 billion in exportation/year;
- **Productive chain:**

  movement US$ 9 billion/year;

  400 thousand jobs;

  main economic activity for 322 municipalities of SPS (50%) and 11 for MGS.

Distribuição Geográfica de área cultivada e número de produtores, 2007/2008



Legenda

Regional Agrícola

Divisão Municipal

Área Plantada (ha) Laranja	Número de Produtores
0,10 - 1243,40	1 - 52
1243,41 - 3887,30	53 - 155
3887,31 - 8441,50	156 - 352

CVC - HISTORY

1987 – First description

1990 – Xylem bacterium observation

1993 – Isolation and symptoms

1995 – *X. fastidiosa* in coffee trees

1996 – Transmission by sharpshooters confirmed

– several species in orchards

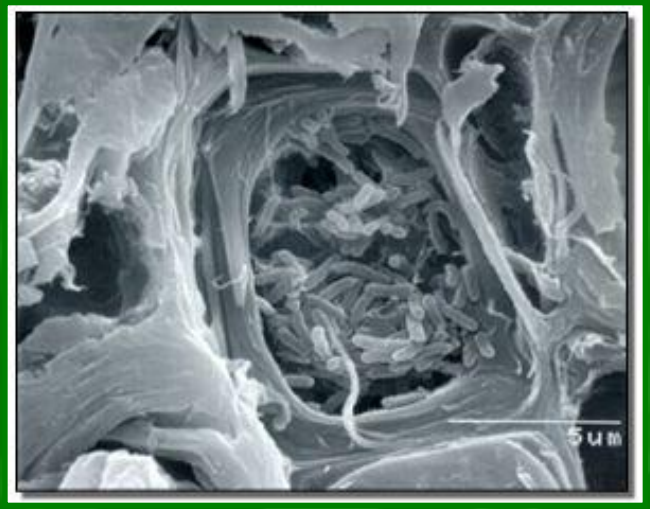
1997 – Infected groves main inoculum source

1998 – New regulation for nurseries

2000 – Genome of Xf (???)

1996-2009 – Mitigation techniques improvement

Xylella fastidiosa



Fotos: José E. O. de Lima

- Gram-negative
- Xylem limited
- Rough cell wall
- Bacilliform (0.25-0.35 x 2-4µm)
- Xylem blokage (obstruction)

Xylella fastidiosa

Isolation - 20 days

32x (PWG)

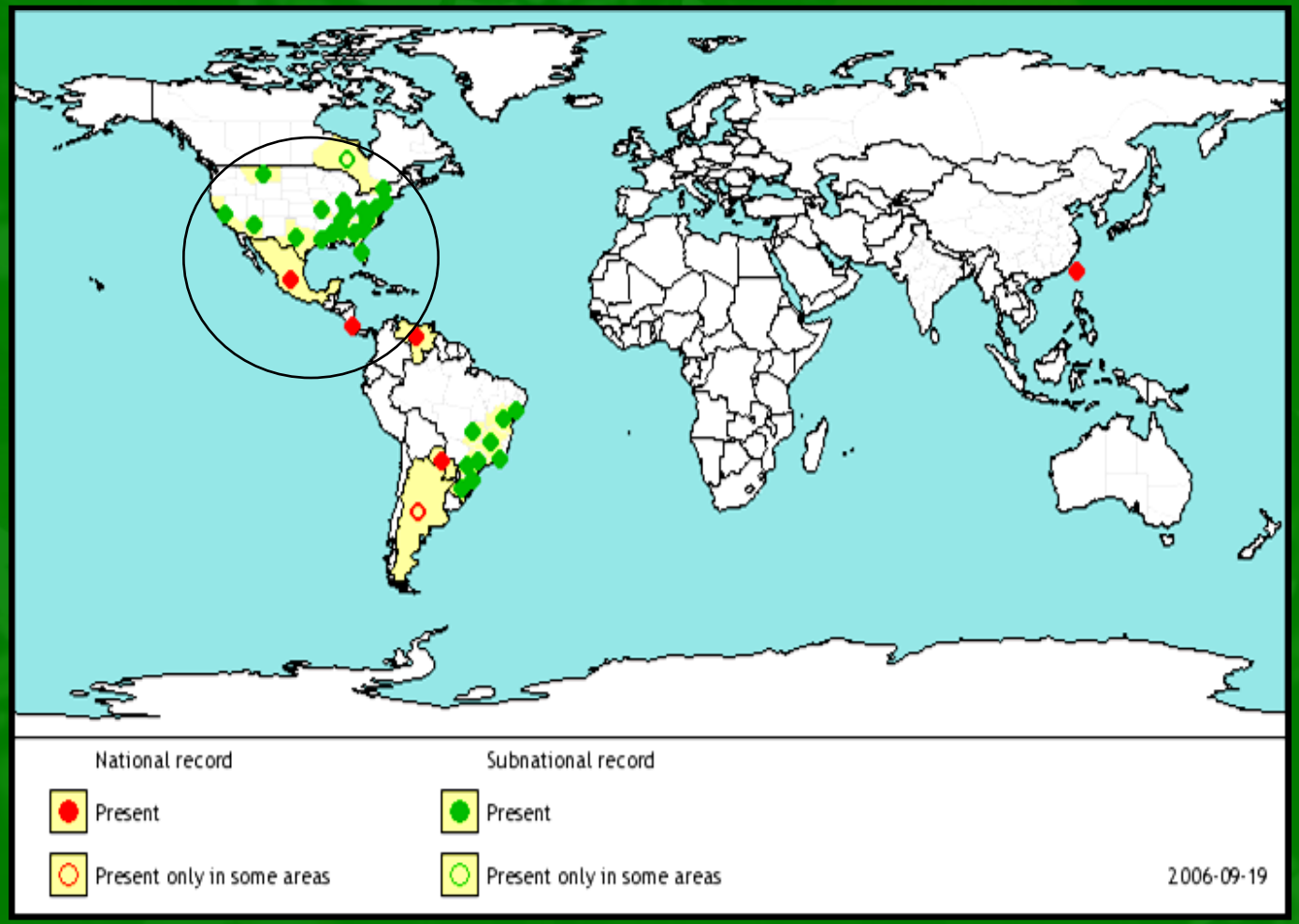
- **Cultivation**
- **Wide range of hosts**
- **A few with symptoms**
- **Endophytic behavior**
- **Brazil: orange, coffee and plum**

<u>Transmission:</u>

- **Grafting**
- **Insect (sharpshooters)**
- **Seeds (???)**

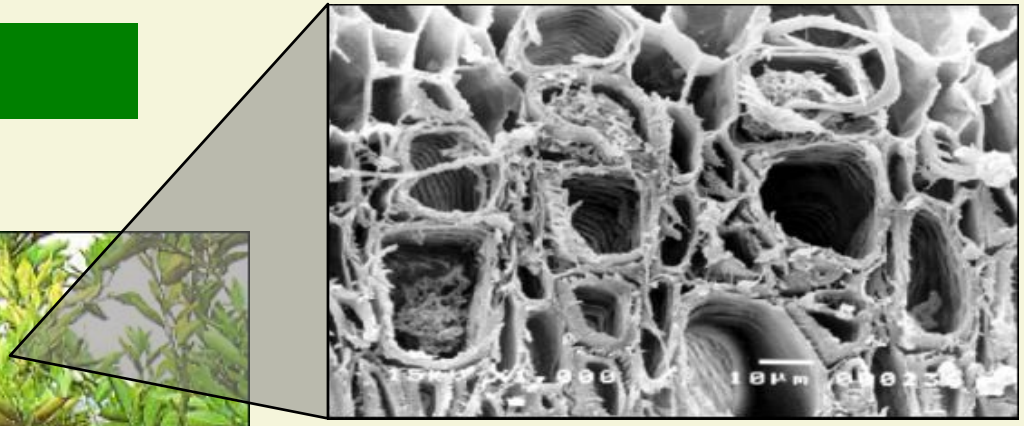
Foto: Prof. João Lopes

Xylella fastidiosa ⏩ Distribution



WHERE?

CVC

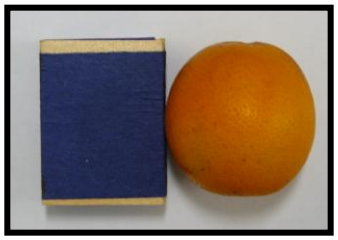


Xylem blokage
Major and minor nutrients

Wilting and yellowing of leaves
Reduction on fruit growth

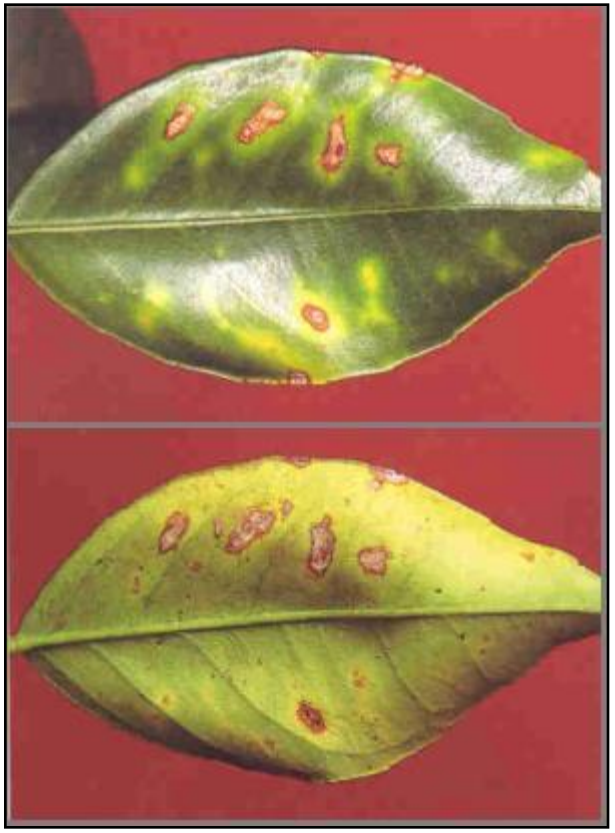
Short economic life

CVC - SYMPTOMS

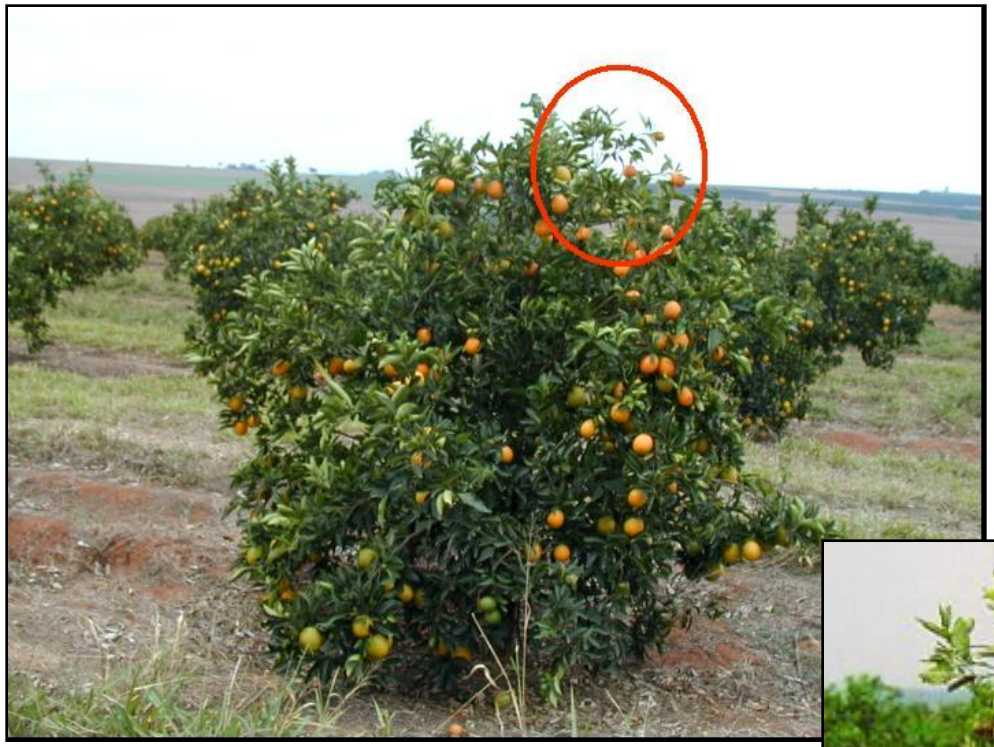


variegated chlorosis

necrotic lesions




MA197




ALL COMMERCIAL SWEET ORANGE IN BRAZIL
Other species: non host or asymptomatic hosts
Since 1990:
- 503 sweet orange clones and cultivars =>ALL CVC +
(except 1 asymptomatic host)
- NO ROOTSTOCKS EFFECT
2 7 2009

CVC SEVERITY SCALES

EECB 4-note scale:

(by visual observation of the symptoms in the trees' canopy)

Note 0: tree canopy with no symptoms

Note 1: tree with a few leaves up to one branch showing foliar symptoms

Note 2: trees with more than one branch up to 50% of the canopy with symptoms

Note 3: tree with more than 3 branches and fruits with symptoms

FUNDECITRUS 3-note scale:

Note 0: tree canopy with no symptoms

Note 1: tree with a few leaves up with more than one branch up to 50% of the canopy withsymptoms

Note 2: tree with more than 3 branches and fruits with symptoms

CVC INTENSITY PROGRESS ON "FOLHA MURCHA SWEET ORANGE GRAFTED ON 12 ROOTSTOCKS. BEBEDOURO, 2006-2008.

Porta-enxerto	Nota média da avaliação visual de CVC * †		
	---------- Ano ----------		
	2006	2007	2008
Tangerineira 'Sun Chu Sha Kat'	**0,40**	**1,40**	**2,70 a**
Trifoliata 'Rubidoux'	**0,33**	**1,00**	**2,20 a**
Citrangeiro 'Carrizo'	**0,78**	**1,33**	**2,10 a**
Limoeiro 'Cravo FCAV'	0,56	1,56	1,90 ab
Trifoliata 'FCAV'	0,56	0,89	1,70 ab
Tangeleiro 'Orlando'	0,44	1,20	1,80 ab
Limoeiro 'Cravo' x citrumeleiro 'Swingle'	0,89	1,44	1,60 ab
Limoeiro 'Cravo Limeira'	0,78	1,22	1,50 ab
Citrumeleiro 'Swingle'	0,38	1,11	1,30 ab
Tangerineira 'Sunki'	0,30	0,70	1,30 ab
Citrandarin 'Changsha' x 'English Small'	0,20	0,50	1,10 ab
Trifoliata 'Flying Dragon'	**0,00**	**0,20**	**0,20 b**
Média Geral	**0,47**	**1,05**	**1,62**
CV (%)	40,25	47,19	44,62
Valor P *	0,2647	0,0839	0,0233

SEVERITY INCREASES FOR ALL ROOTSTOCKS

REDUCTION ON FRUIT SIZE OF "FOLHA MURCHA" SWEET ORANGE GRAFTED ON 12 ROOTSTOCKS. BEBEDOURO, 2008.

Porta-enxerto	Percentagem de frutos por categoria de diâmetro		
	< 50 mm	50 a 60 mm	> 60 mm
	---------- % ----------		
Trifoliata 'Rubidoux'	**18,6**	**59,7 abcd**	**21,7 c**
Trifoliata 'FCAV'	**11,3**	**65,8 abc**	**22,9 bc**
Citrandarin 'Changsha' x 'E.Small'	10,7	60,3 abcd	29,0 abc
Citrangeiro 'Carrizo'	9,7	64,3 abc	26,0 abc
Tangerineira 'Sun Chu Sha Kat'	8,0	46,0 bcd	46,0 abc
Híbrido 'Cravo' x 'Swingle'	7,7	53,0 abcd	39,3 abc
Tangeleiro 'Orlando'	4,0	58,3 abcd	37,7 abc
Trifoliata 'Flying Dragon'	**4,3**	**84,6 a**	**11,1 c**
Citrumeleiro 'Swingle'	3,0	69,0 ab	28,0 abc
Limoeiro 'Cravo FCAV'	2,0	30,0 cd	68,0 ab
Tangerineira 'Sunki'	1,7	30,4 cd	67,9 ab
Limoeiro 'Cravo Limeira'	**2,0**	**28,0 d**	**70,0 a**
CV (%)	**51,03**	**30,43**	**40,57**
Valor p	**0,1363**	**<0,0001**	**<0,0001**

Médias com letras distintas nas colunas indicam diferenças significativas ao nível P indicado (Tukey).

➢ **THE PERCENTAGE OF SMALL FRUITS (D < 50 mm) WAS SIMILAR AMONG ROOTSTOCKS**

SWEET ORANGE TOLERANCE

1/503 non symptomatic host

Navelina ISA 315 cultivar

- recovered by *in vitro* culture of undeveloped ovules - IT
- introduced for CVC resistance studies
- showed to be carrier of cachexia - BR

(indexed biologically in – 1998/99 & 2006)

=> HSVd (cachexia variant?) in viroid inoculation experiment in Italy

Davino et al. (2005) In:Proc.16th Conf. IOCV

- evaluated in two field plots:

Planting 04/2001 – 8 plants (4 inoculated 01/2002)

=> 8 years old (7 years of inoculation)

Planting 02/2000 – 3 plants (1 inoculated 01/2001)

=> 9 years old (8 years of inoculation)

11 asymptomatic trees plus

19 topworked ones

Topworking views

Hypothesis

- somaclonal variation

(the slight variations in plant performance found after tissue culture exposure)

- induced tolerance by cachexia (and other viroids)

Running

- 20 nursery trees planted in 2007 in field at EECB

- challenge STG,nucelar clones and original

(field & greenhouse)

- damages in yield of topworked trees

SWEET ORANGE CULTIVARS TOLERANCE

SIX CULTIVARS (lower number of lesions on leaves):

Olivelands - early

Finike – midseason

Sanguinea - midseason

Vaccaro Blood - midseason

Folha Murcha - late

São Miguel – late

EFFECT ON YIELD

Note 0 trees: tree canopy with no symptoms

X

Note 3 trees : tree with more than 50% of the canopy with symptoms

YIELD (kg tree^{-1})

1) **Acceptable fruits (≥ 50 mm)**

2) **Not acceptable fruits (< 50 mm)**

3) Total Yield (1 + 2)

4) Total Soluble Solids in 1

5) Total Soluble Solids in 2

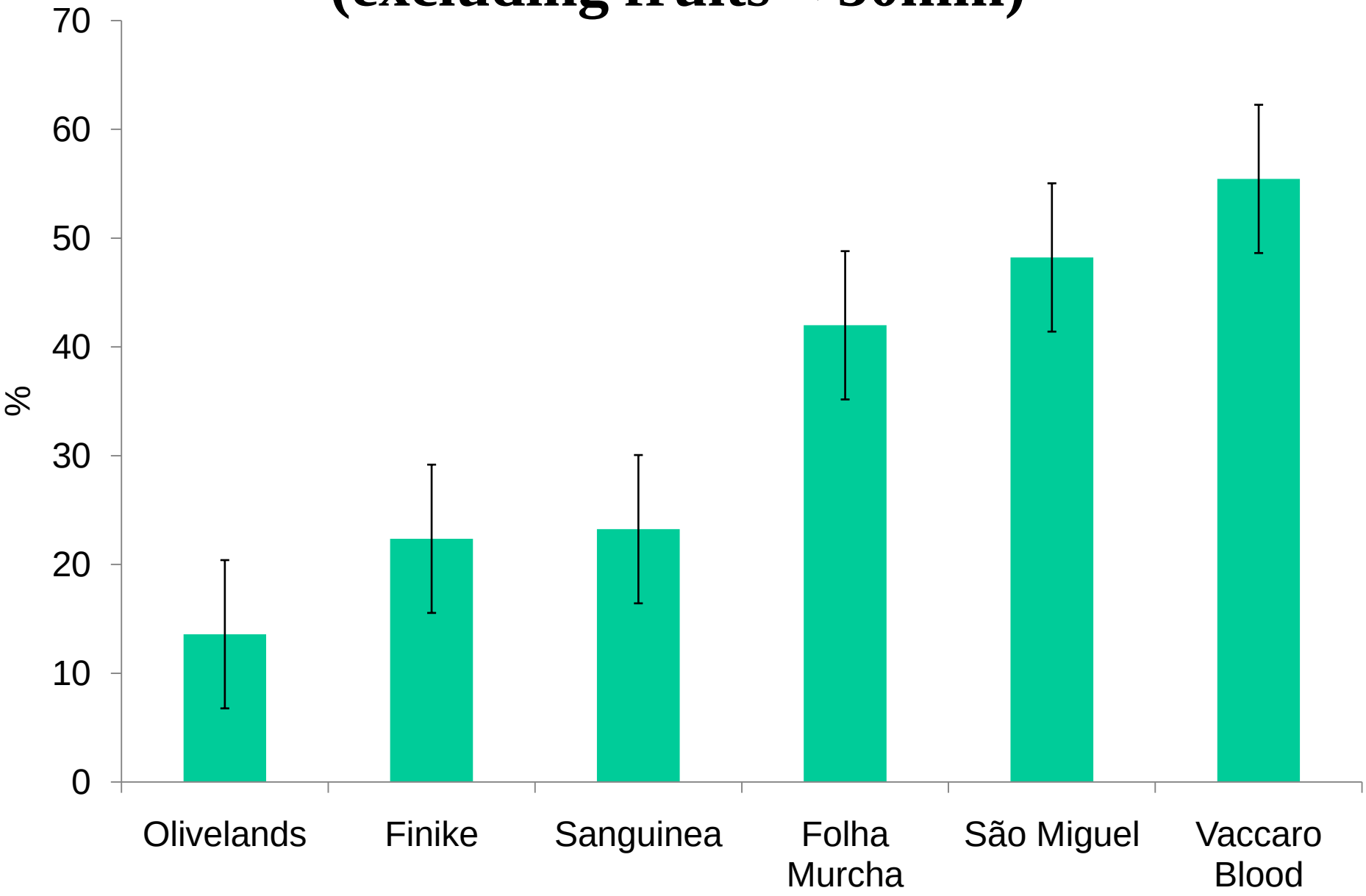
6) Total Soluble Solids (1 + 2)

REDUCTION IN FRUIT AND TSS YIELD (%)

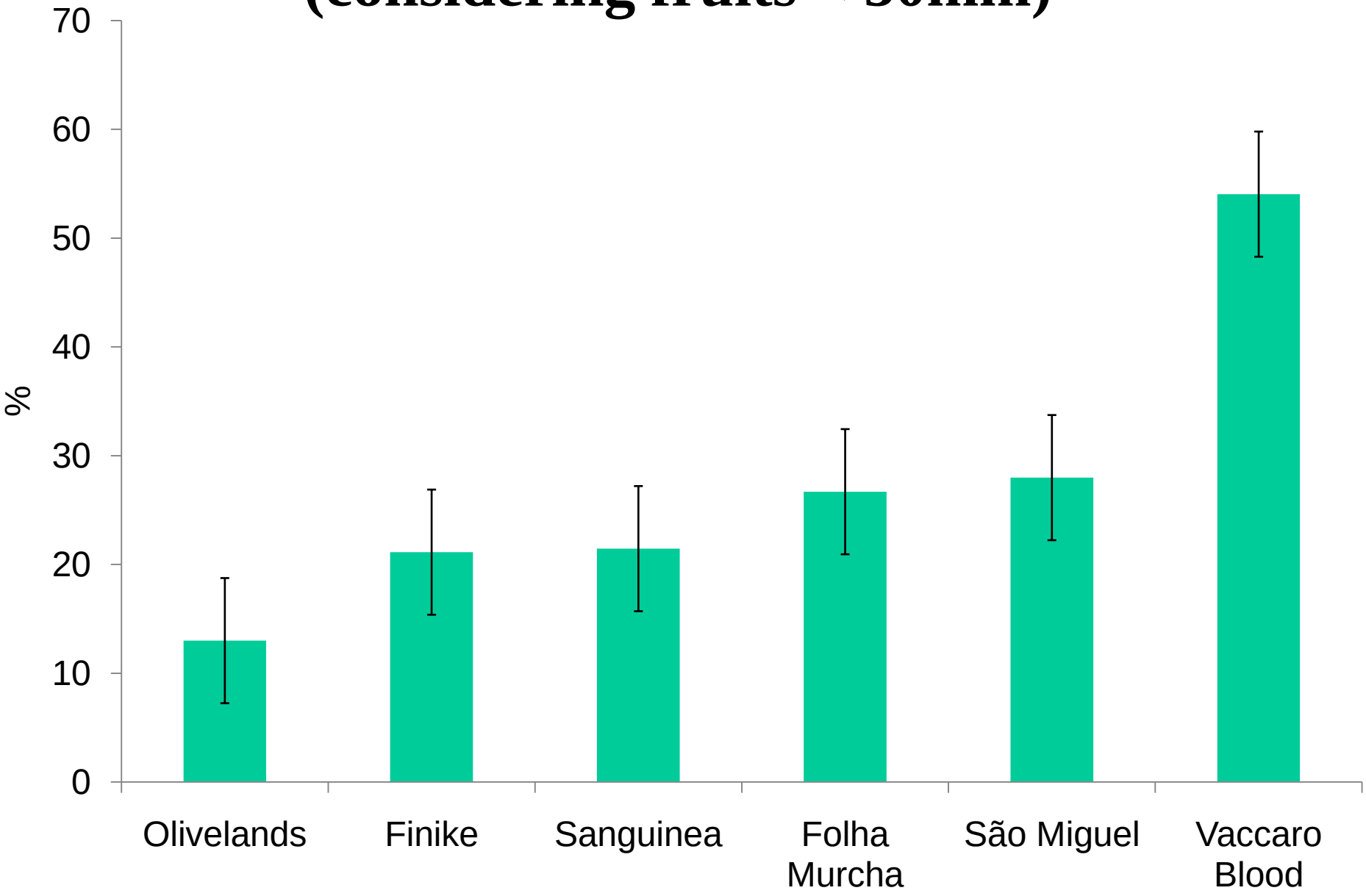
FRUIT WEIGHING
AND COUNTING

FRUIT CLASSIFICATION

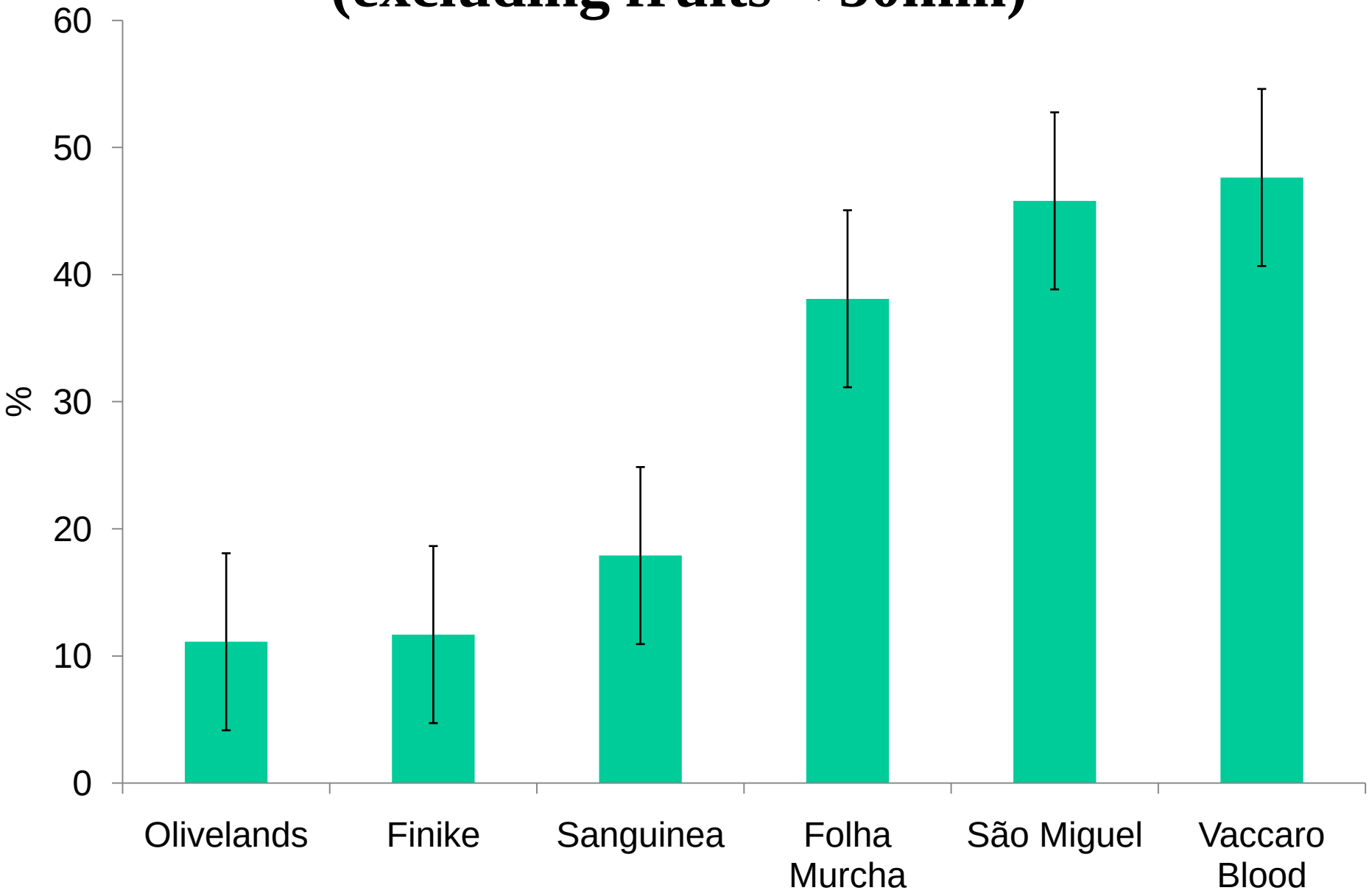
Reduction in fruit yield caused by CVC (excluding fruits < 50mm)



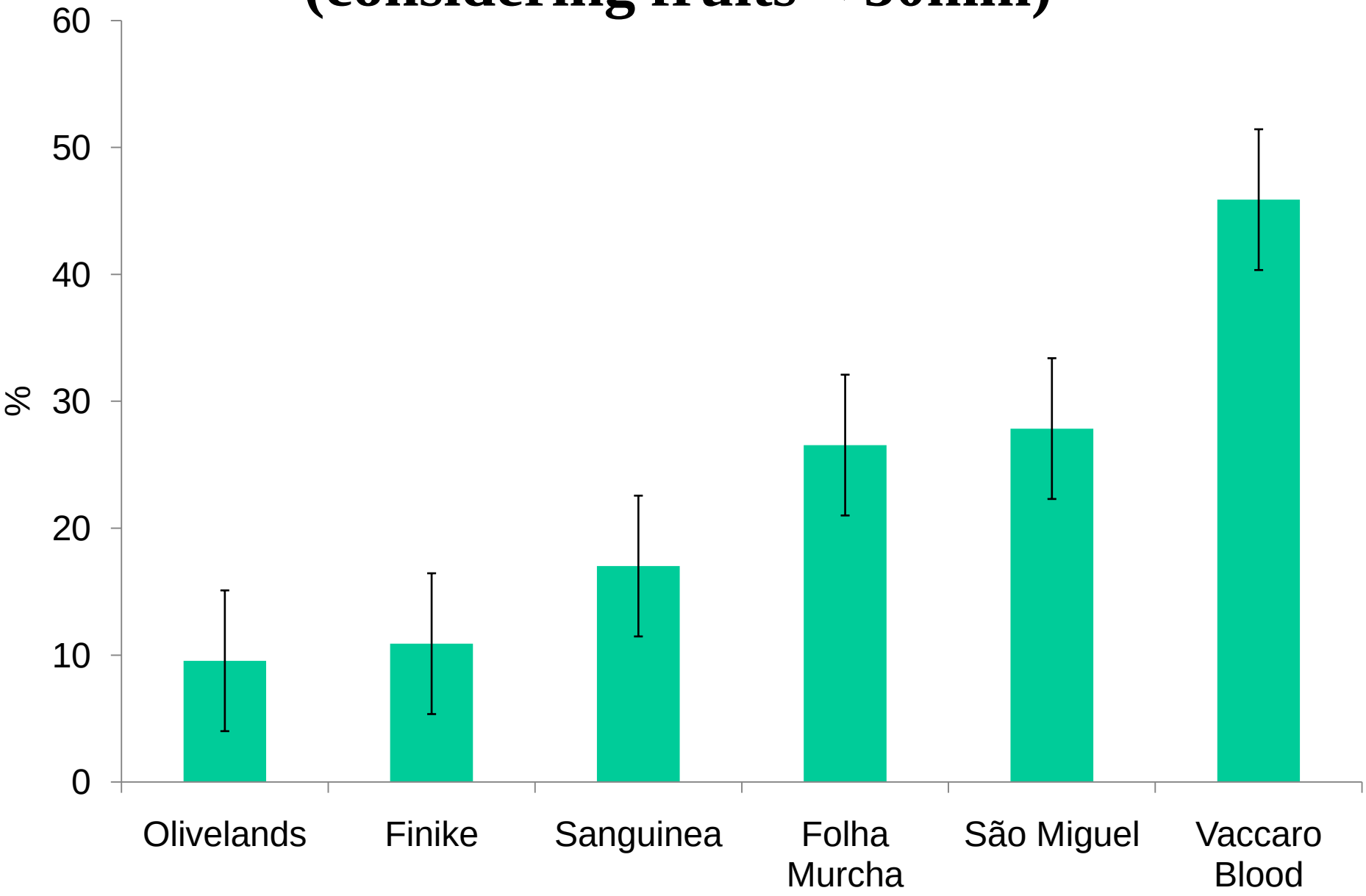
Reduction in fruit yield caused by CVC (considering fruits < 50mm)



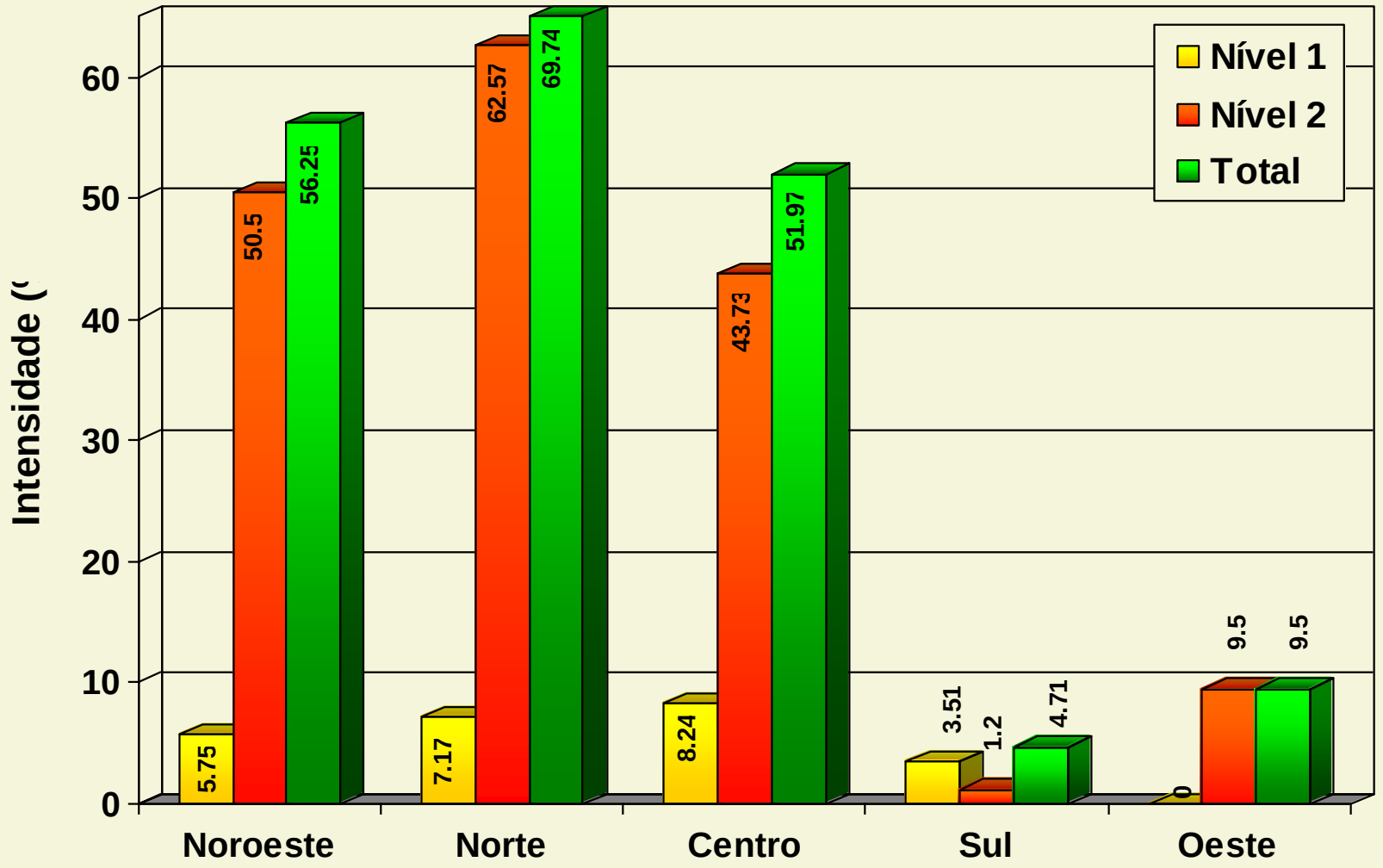
Reduction in TSS yield caused by CVC (excluding fruits < 50mm)



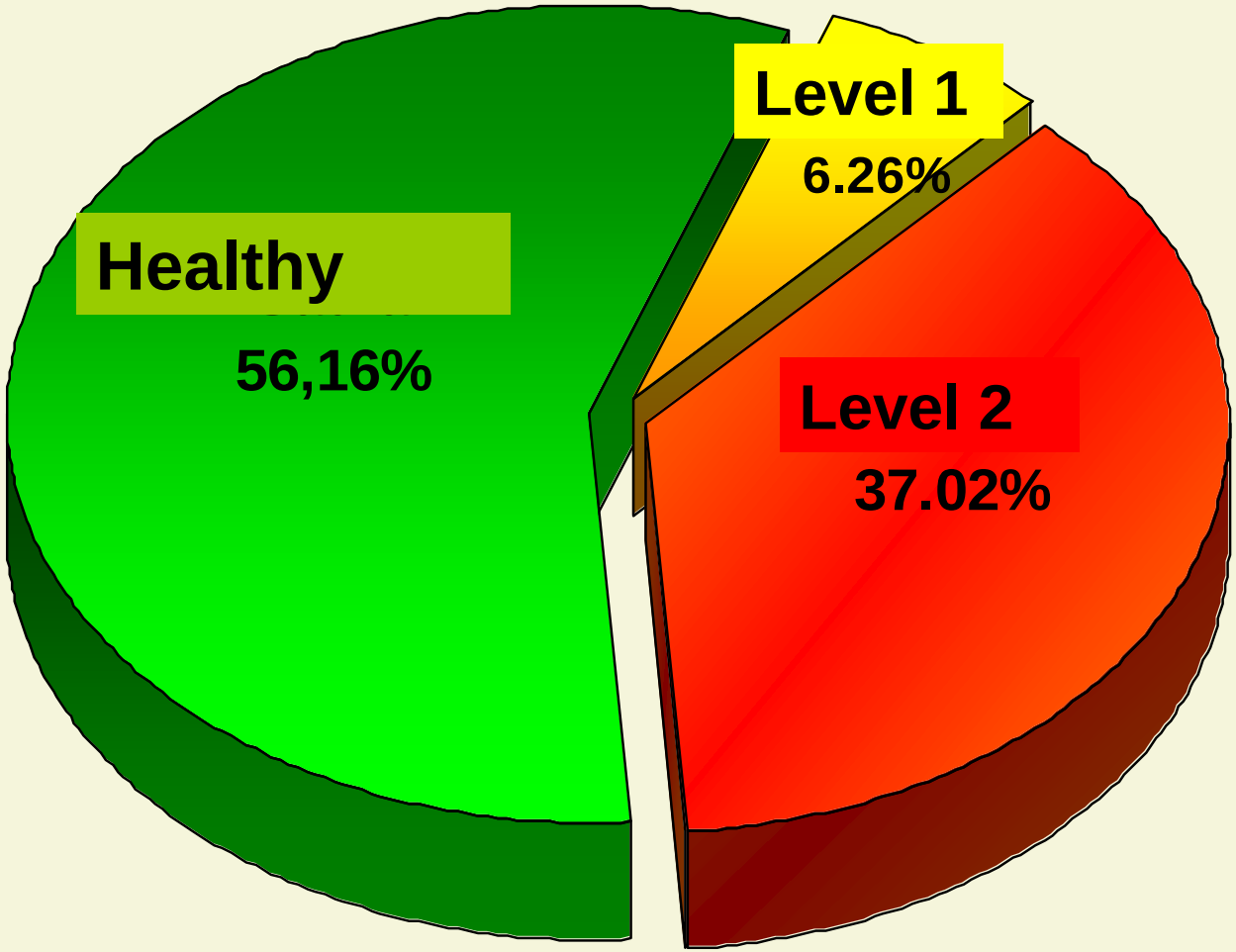
Reduction in TSS yield caused by CVC (considering fruits < 50mm)



INTENSITY OF CVC BY REGION - 2005



INTENSITY OF CVC - 2005



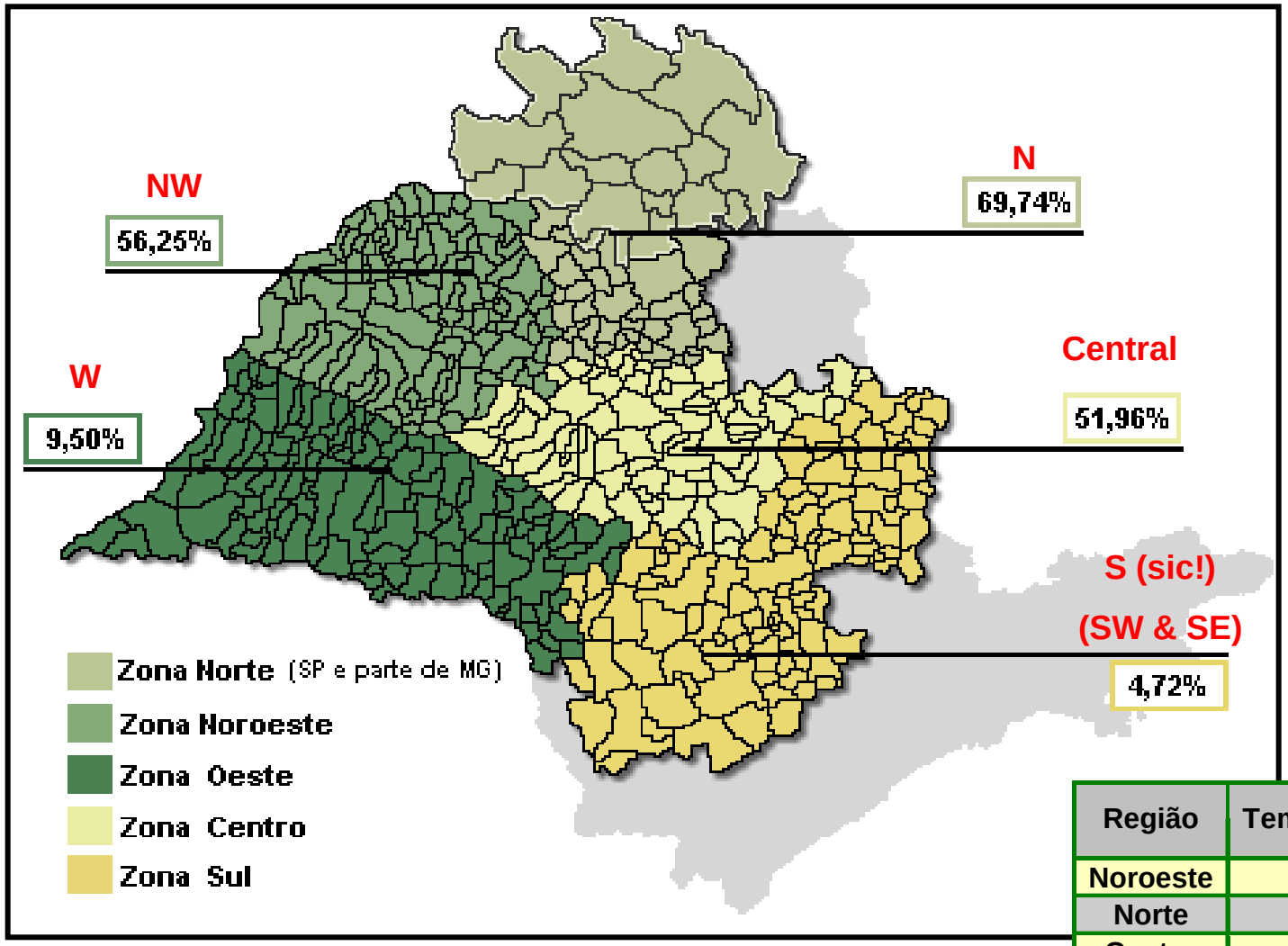
REDUCTION IN YIELD

- SAME NUMBER OF FRUITS PER TREE AT DIFERENT LEVELS

- A INCREASE ON FRUIT NUMBER PER BOX

UNTIL 75% LESS ON FRUIT WEIGHT

CVC: INCIDENCE BY REGIONS



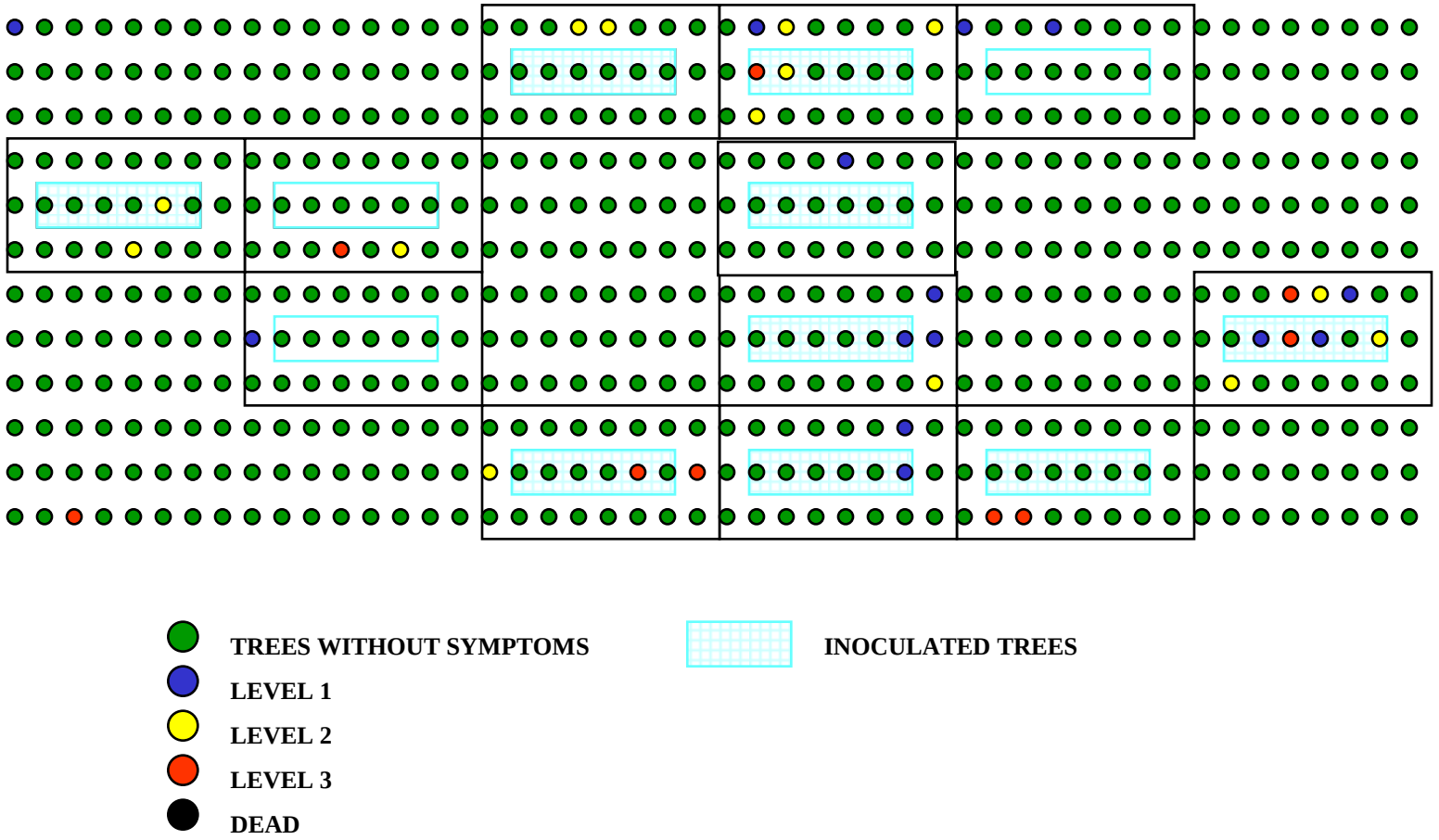
Região	Temperatura	Precip. Def.	
		mm	
Noroeste	23.0	1170	160
Norte	22.6	1282	103
Centro	21.7	1344	60
Sul	21.0	1370	30
Sudoeste	19.7	1380	0

HOT & DRY REGIONS

FUNDECITRUS - IAC

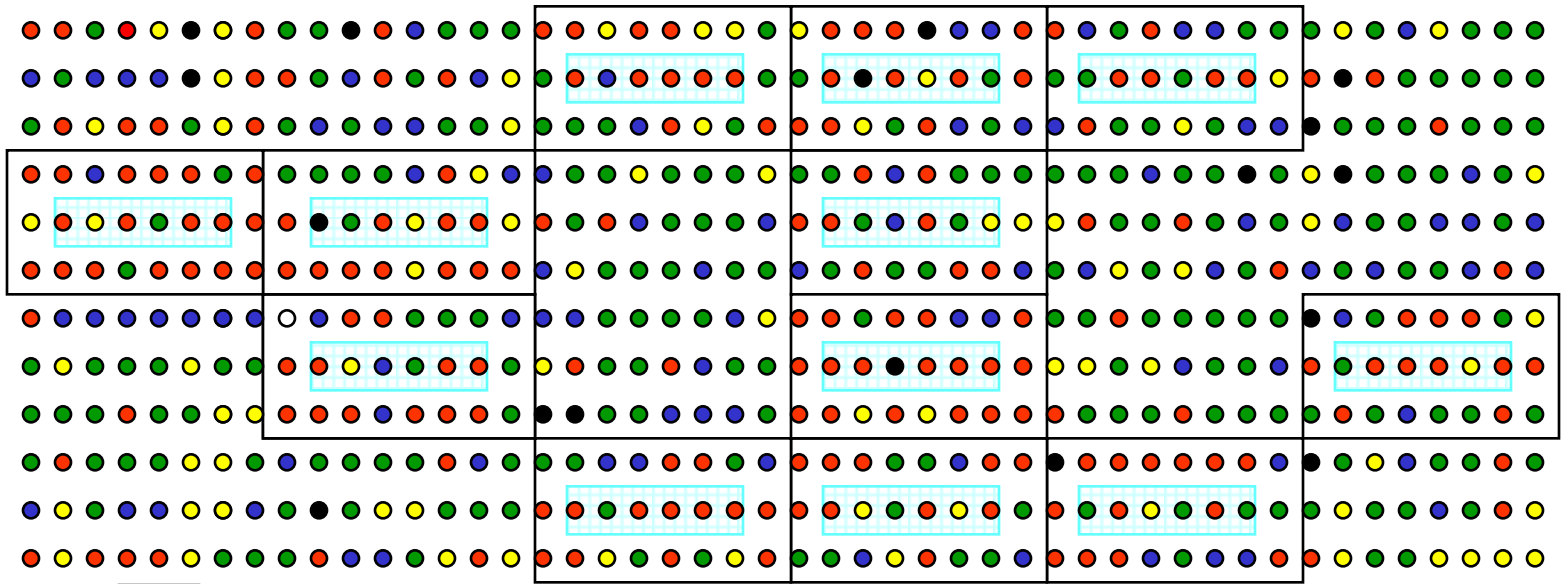
Planting: February, 1999

First evaluation: March, 2001



Planting: February, 1999

Last evaluation: June, 2005



TREES WITHOUT SYMPTOMS

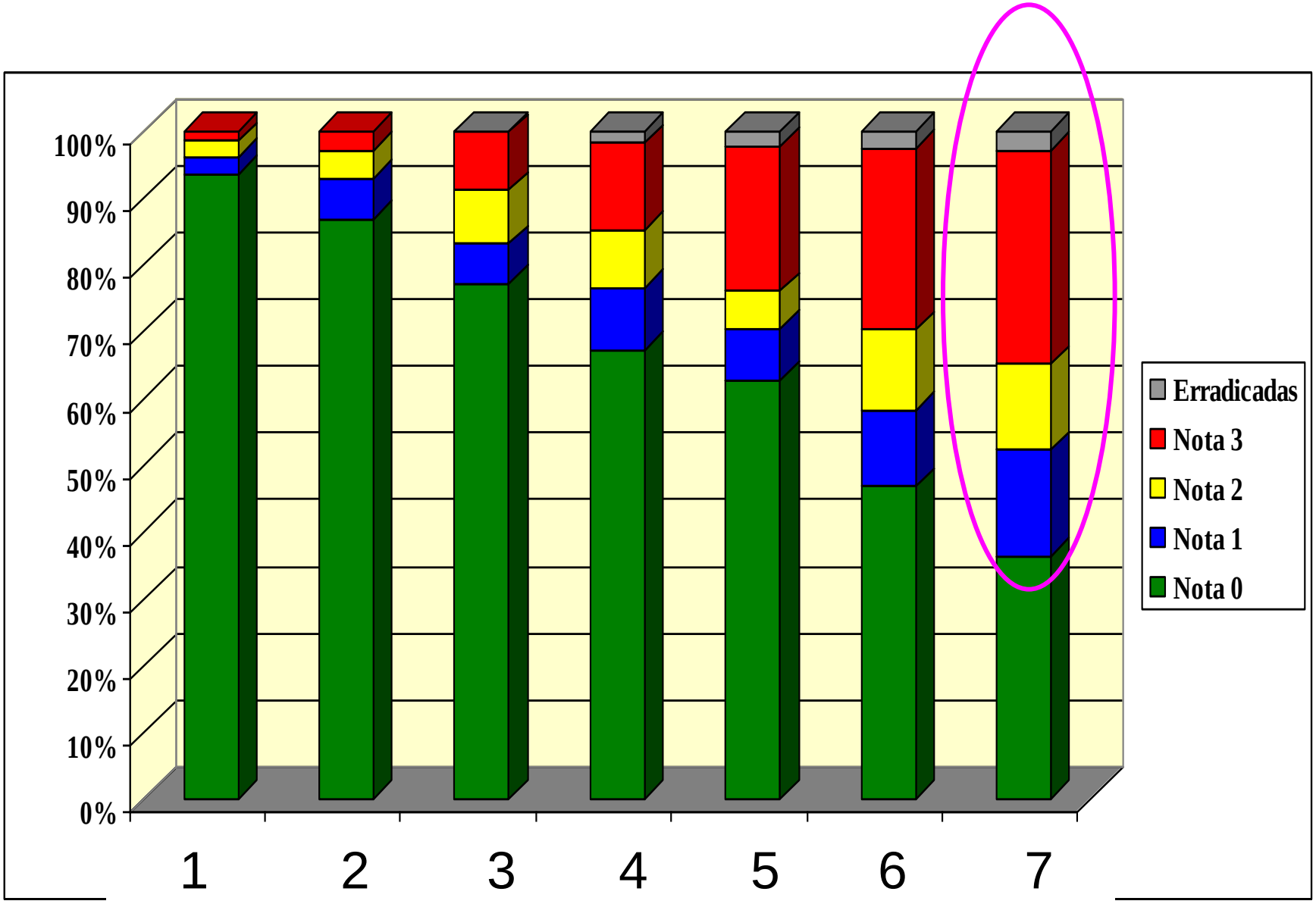
LEVEL 1

LEVEL 2

LEVEL 3

DEAD

INOCULATED TREES


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
2
3
4
5
6
7
Erradicadas
Nota 3
Nota 2
Nota 1
Nota 0

REDUCTION IN YIELD

- SAME NUMBER OF FRUITS PER TREE AT DIFERENT LEVELS

- A INCREASE IN FRUIT NUMBER PER BOX

UNTIL - 75% LESS ON FRUIT WEIGHT

IRRIGATION EFFECT ON CVC INTENSITY

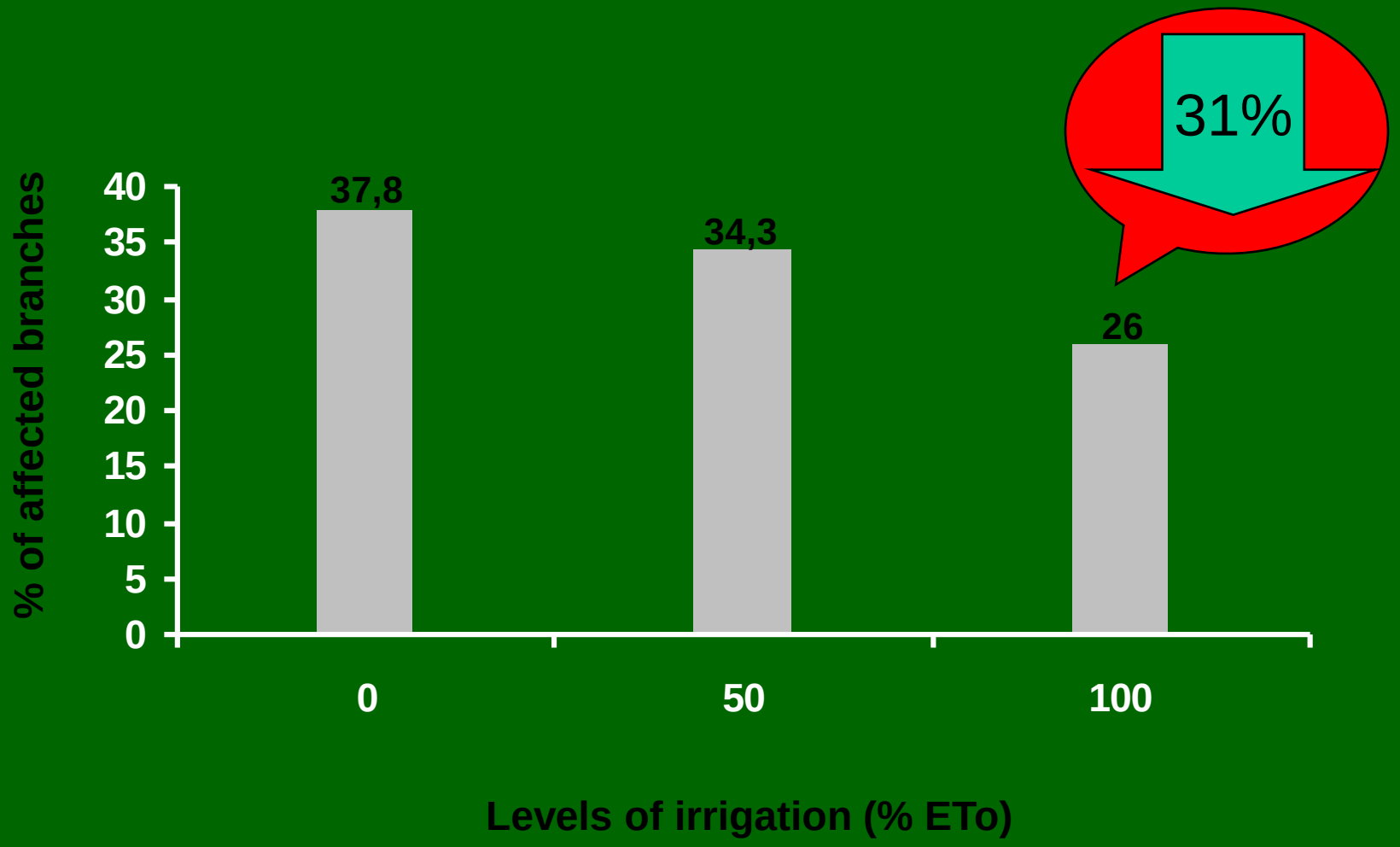
- based on 4-note scale evaluation of Natal sweet orange on Rangpur lime trees planted in February 1999

TREATMENTS	DISEASE INDEX			
	2001	2002	2003	2004
I0CVC0	0.0	0.8	1.0	2.5
I0CVC1	3.0	7.8	9.5	9.8
I100CVC0	0.0	0.5	2.0	6.0
I100CVC1	0.5	5.0	8.8	12.3
I50CVC0	0.0	0.3	1.3	3.5
I50CVC1	1.3	6.0	12.0	12.3

IRRIGATION AS MITIGATIONS STRATEGY

(%) of affected branches

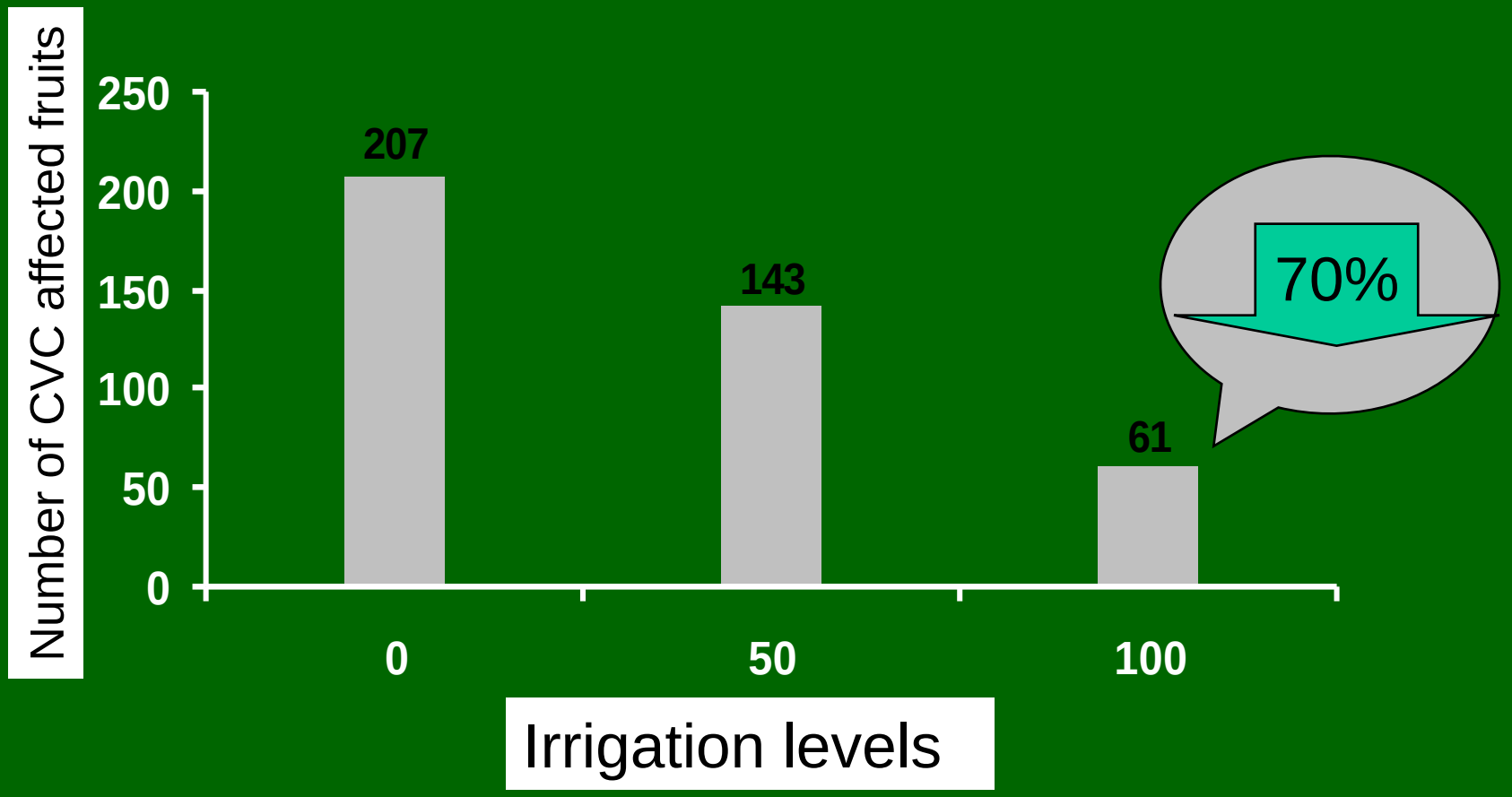
Four evaluations average (2006 a 2008)



IRRIGATION AS MITIGATIONS STRATEGY

Number of affected fruits per tree

Three evaluations average (2006 a 2007)



VECTORS

Cigarrinhas ⏩ Hemiptera - Cicadellinae

Acrogonia citrina

(2,3%)

Oncometopia facialis

(1,3%)

Dilobopterus costalimai

(5,5%)

Bucephalogonia xanthophis

(12,8%)

Macugonalia leucomelas

(17,3%)

Sonesimia grossa

(1,2%)

Plesiommata corniculata

(2,9%)

Ferrariana trivittata

(1,9%)

Parathona gratiosa

(2,8%)

Acrogonia virescens

(0,3%)

Homalodisca ignorata

(0,5%)

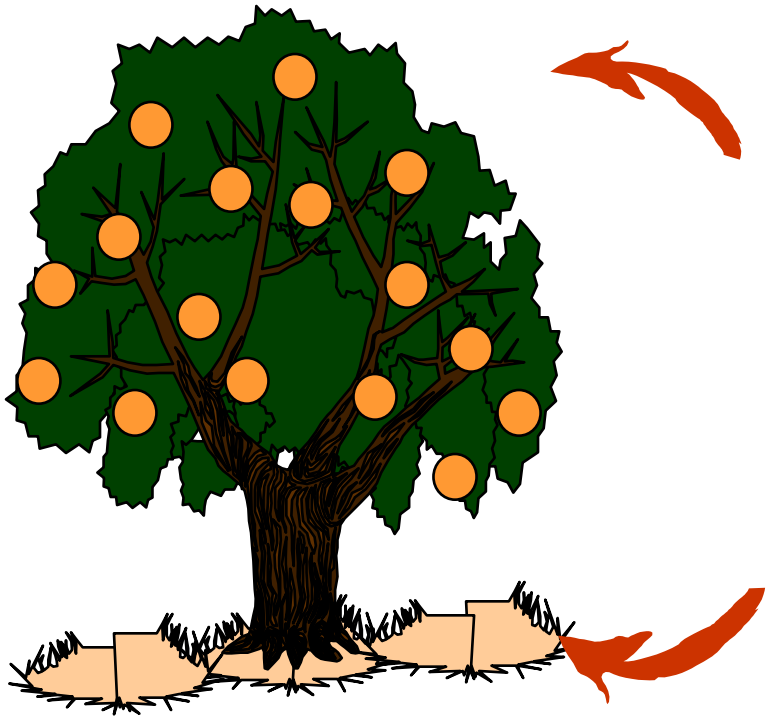
Fingeriana dubia

➢ **Transmission:**

Low rates => not efficient

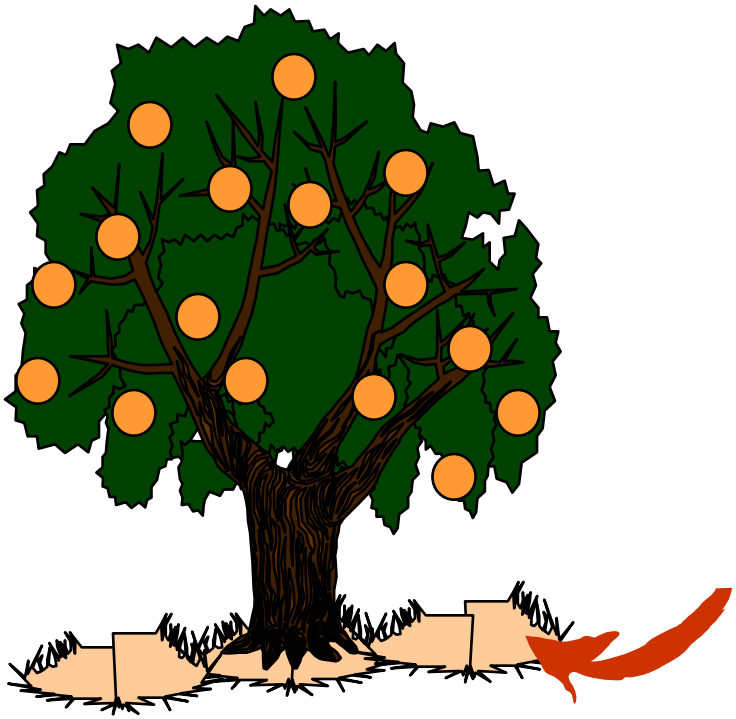
Citrus and grass sharpshooter

(predominant in open air nurseries and young trees)



Bucephalogonia xanthophis

Grass sharpshooters



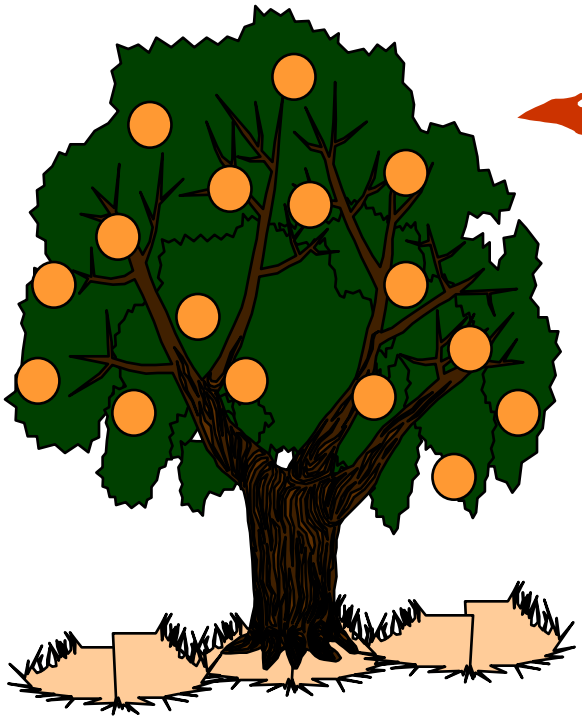
Plesiommata corniculata

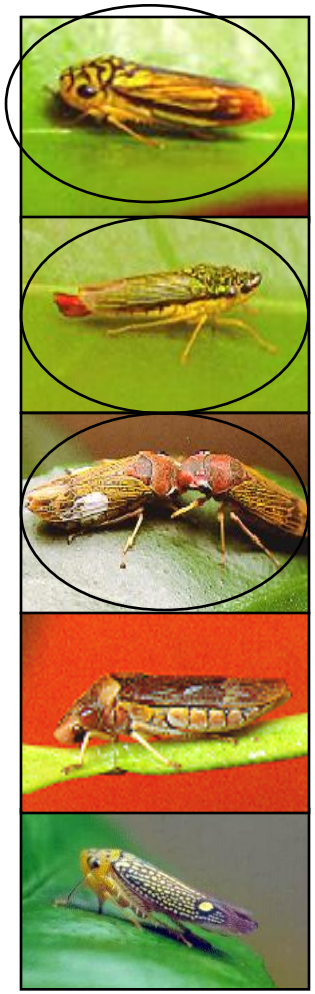
Sonesimia grossa

Macugonalia leucomelas

Ferrariana trivittata

Orange trees sharpshooters





Dilobopterus costalimai

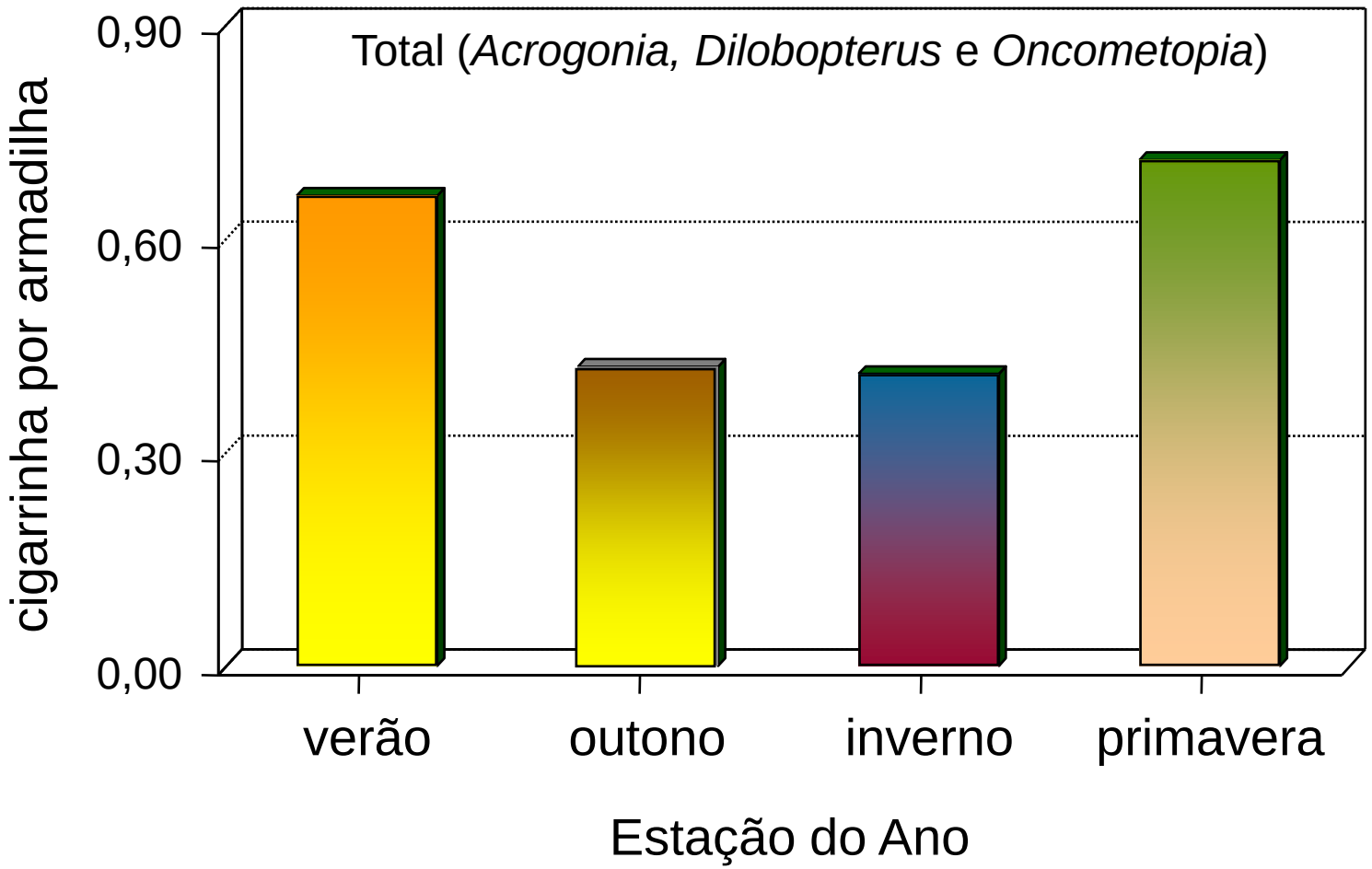
Acrogonia citrina

Oncometopia facialis

Homalodisca ignorata

Parathona gratiosa

HIGH POPULATIONS ON SPRING AND SUMMER



CVC MANAGEMENT

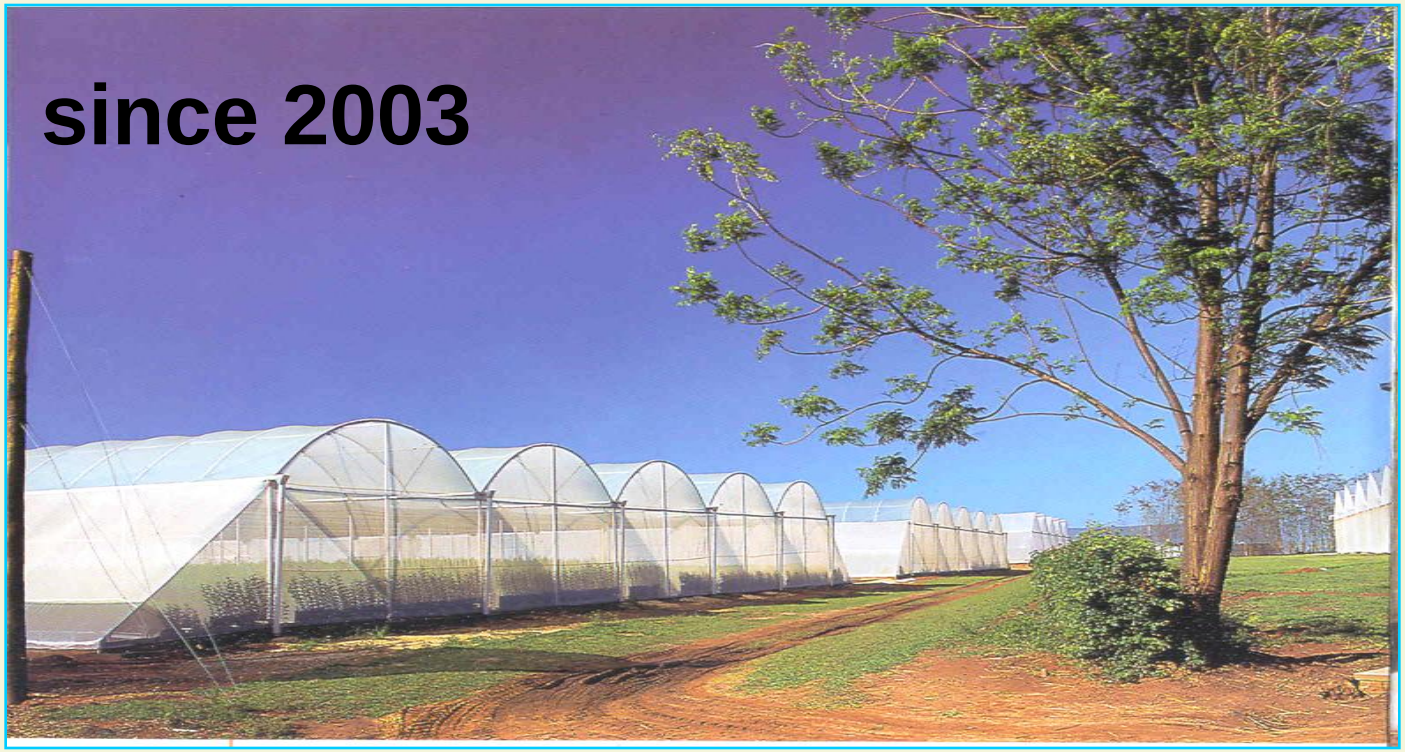
1. Healthy nursery trees

2. Inspection
prunning and erradication of
symptomatic tress

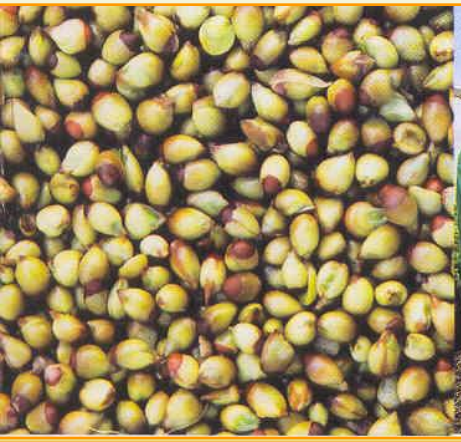
3. Chemical control of
sharpshooters

HEALTHY NURSERY TREES – LAW ENFORCED

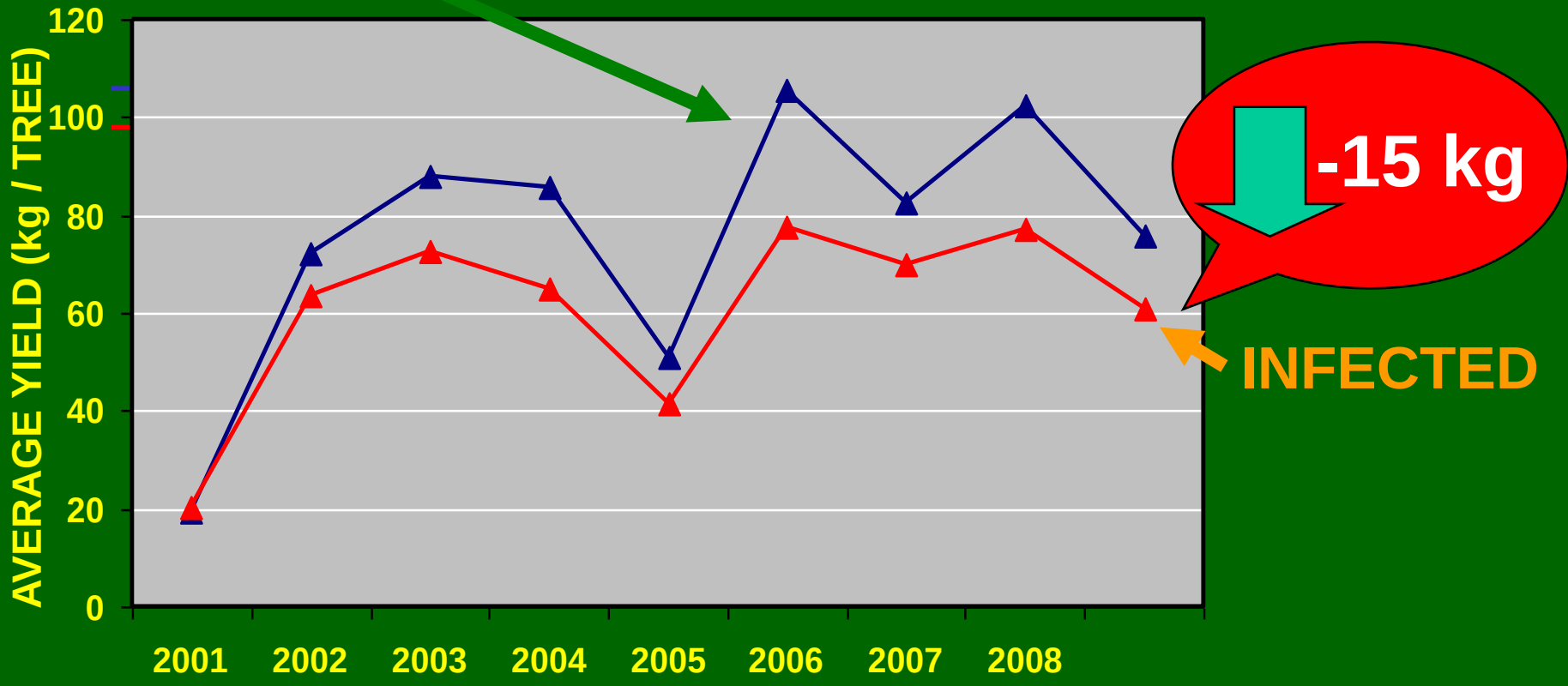
	Aberto	Protegido	Total
1998	948	24	972
Julho/2006	00	511	512



HEALTHY NURSERY TREES



HEALTHY NURSERY TREES IMPORTANCE



550 trees/ha

*** 15kg x 550 trees = 8,3 ton/ha ~ 203 box (40.8 kg) / ha**

PRUNING SYMPTOMATIC BRANCHES

CVC MANAGEMENT

- Pruning => only for > 3 years old blocks
- Inspections => January through July
- Trees with few symptoms (level 1) => pruning
- Trees with more symptoms =>

SHOULD BE REMOVED

VECTOR CHEMICAL CONTROL
Sistemics Inseticides – Before Planting

<u>Commercial Chemicals Names in Brazil:</u>

Actara 250 WG – 1.2 g/tree

Confidor 700 GrDA – 0.5 g/tree

Provado 200 SC – 1.75 mL/tree

5 - 6 thousand nursery trees/worker/day

CVC MANAGEMENT

ORCHARDS <= 6 YEARS OLD

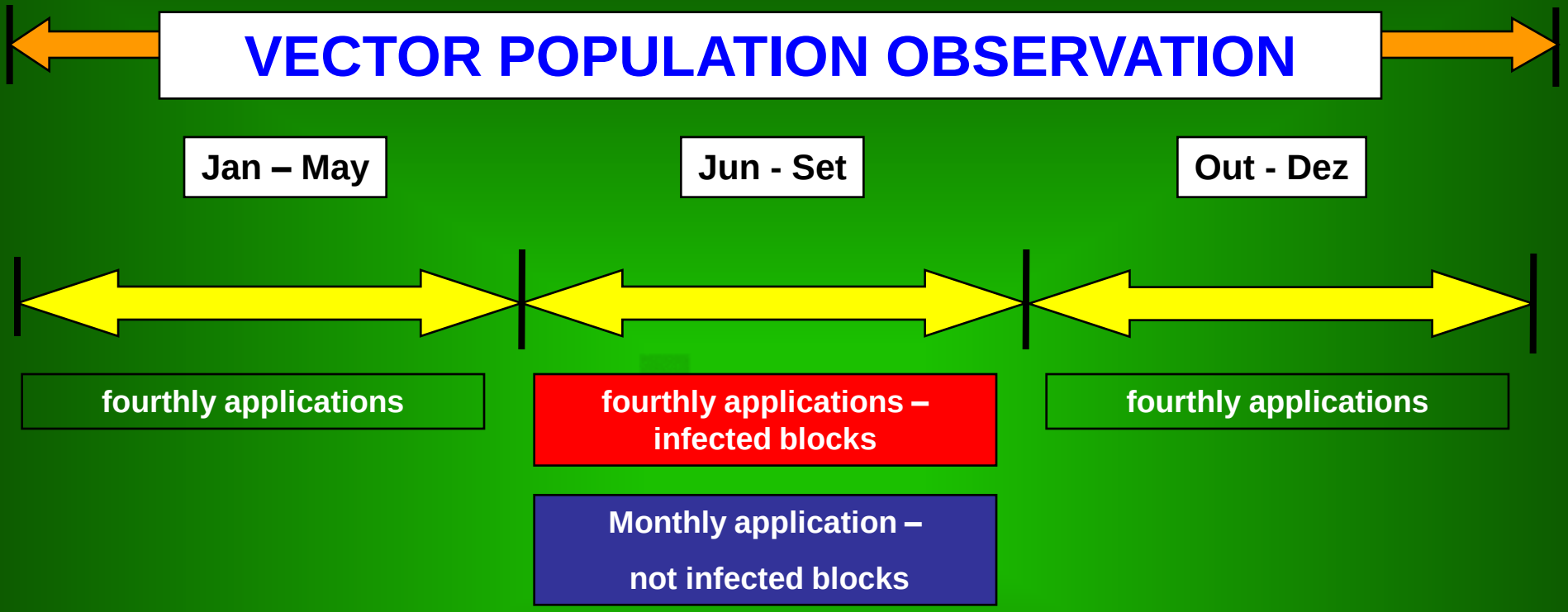
- 18 to 24 application of insecticides per year
- 02 inspections
- vector survey by traps
- Removal of all infected trees until the 3rd year.
- Pruning more than 3 years old plants with only one infected branch (level 1)
- Every tree showing more than one Infected branch should be removed after the 3rd year

CVC MANAGEMENT

ORCHARDS >= 7 ANOS

- Vector control by chemical insecticides when the trees sprout or when sharpshooters where detected in survey
- 01 inspection per year
- Traps
- Removal of infected trees with level 3
- Pruning of trees with only one infected branch without fruit symptoms

Chemical control <= 6 years old



Chemical control >= 7 years old

VECTOR POPULATION OBSERVATION

Jan – Dec

- SHARPSHOOTERS PRESENCE (SURVEY OR TRAP)

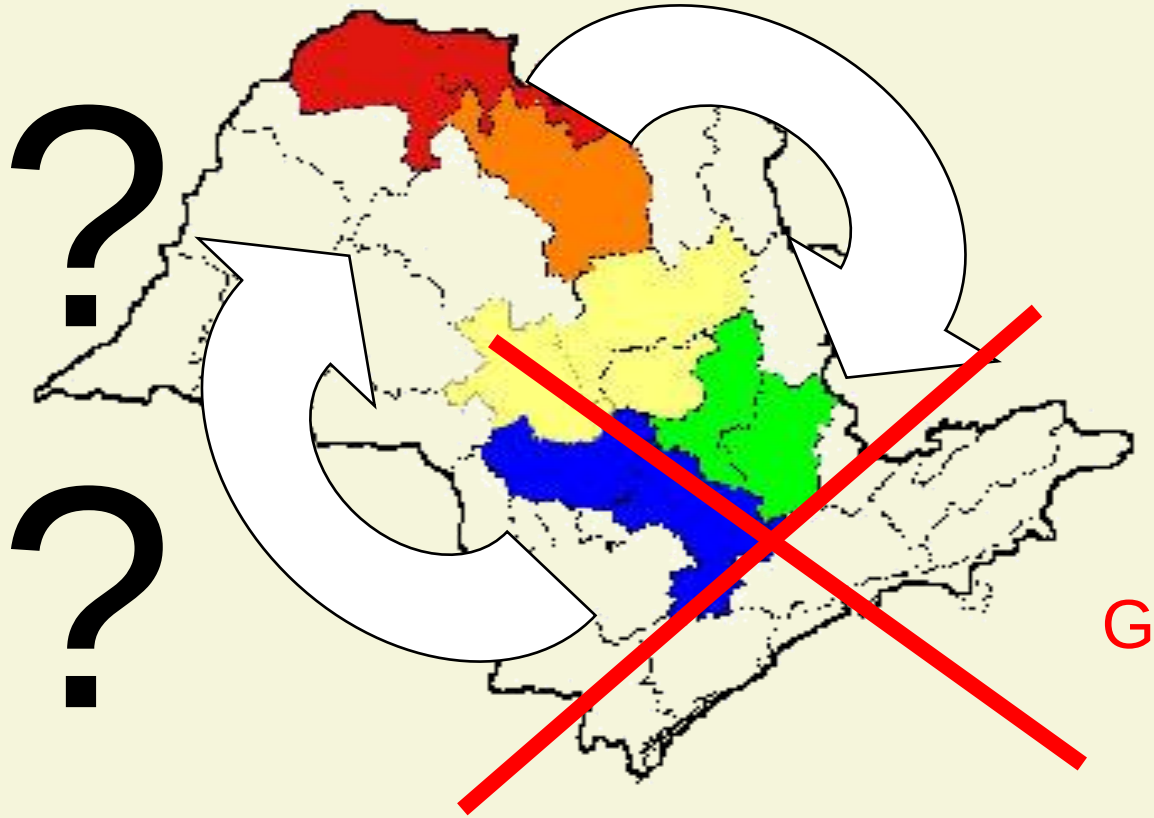
Chemical control

CONCLUDING REMARKS

Due to the reduction in fruit size caused by the disease, in São Paulo the number of fruits required to fill one box increased from 270 in 1996 to 300 in 2006, representing a mean loss of 10% the boxes produced in this period, valued in 121.8 million dollars assuming a mean price of 3.5 dollars per box

(BOVÉ; AYRES, 2007)

NEW GEOGRAPHY



AKNOWLEDGMENTS

- FUNDECITRUS AND FARM ATAC

- CITRUS EXPERIMENTAL STATION TEAM

- Tania Cantuárias-Aviles & Fabricio Packer (PhD Student)

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