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Tuta absoluta in South America: Pest Status, Management & Insecticide Resistance

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Tuta absoluta in South America: Pest Status, Management & Insecticide Resistance

- Outline:
  - Tomato in South America
    - Tomato production
    - Tomato losses
  - The tomato borer (*Tuta absoluta*)
    - Spread & importance
  - Pest management tactics?!
  - Insecticide use
  - Insecticide resistance

Tomato in South America: Production (tons)

Country	2006/2007	2007/2008	2008/2009
China	36,096,890	39,938,708	43,365,543
USA	14,185,200	13,718,200	14,141,900
India	10,055,000	10,303,000	11,148,800
Turkey	9,945,043	10,985,400	10,745,600
Egypt	8,639,020	9,204,100	10,000,000
Italy	6,530,162	5,976,912	6,877,400
Iran	5,534,270	4,826,400	5,887,710
Spain	4,081,480	4,049,750	4,603,600
Brazil	3,431,230	3,867,660	4,310,480
Mexico	3,150,330	2,936,770	2,591,400
South America	6,558,766	6,695,591	7,004,176

(FAO, 2009; IBGE, 2011)

Tomato in South America: Production (tons)

Country	2006/2007	2007/2008	2008/2009
Brazil	3,431,230	3,867,660	4,310,477
Chile	1,270,000	977,000	850,000
Argentina	680,000	701,311	707,551
Colombia	474,317	490,929	457,438
Peru	173,257	210,685	220,435
Venezuela	209,410	199,319	200,000
Bolivia	124,328	122,687	123,600

(FAO, 2009; IBGE, 2011)

Tomato in South America: Brazil

Table

- Production (2010): 3,230,756 tons
- Main area: spread in four main states (Goiás, Minas Gerais, São Paulo, Bahia)

Industry

- Production (2010): 1,079,721 tons
- Main area: central (Goiás)

Tomato in South America: Brazil

Tomato in South America: Losses - main component of production -

Component of production (x)	Estimated production at the start of each x (t,ha^{-1}) (L_x)	Estimated production (t,ha^{-1}) (d_x)	Non-cumulative losses (%) ($100q_x$)	Cumulative losses (%) ($100r_x$)
Plants (vegetative stage)	92.5	1.0	1.1	1.1
Plants (reproductive stage)	91.5	1.1	1.2	2.3
Flowers	90.4	29.5	32.6	34.2
Fruits	60.9	39.5	64.9	76.9
Fruits harvested	21.4	71.1	-	76.9

Picanço, Leite, Guedes & Silva (1998, Crop Prot.)

Tomato in South America: Losses

- Losses:
  - Historical problems with plant diseases until 1980's

  Afterwards…,




Tuta absoluta in South America: Spread

1st report: Huancayo, Peru (1917)

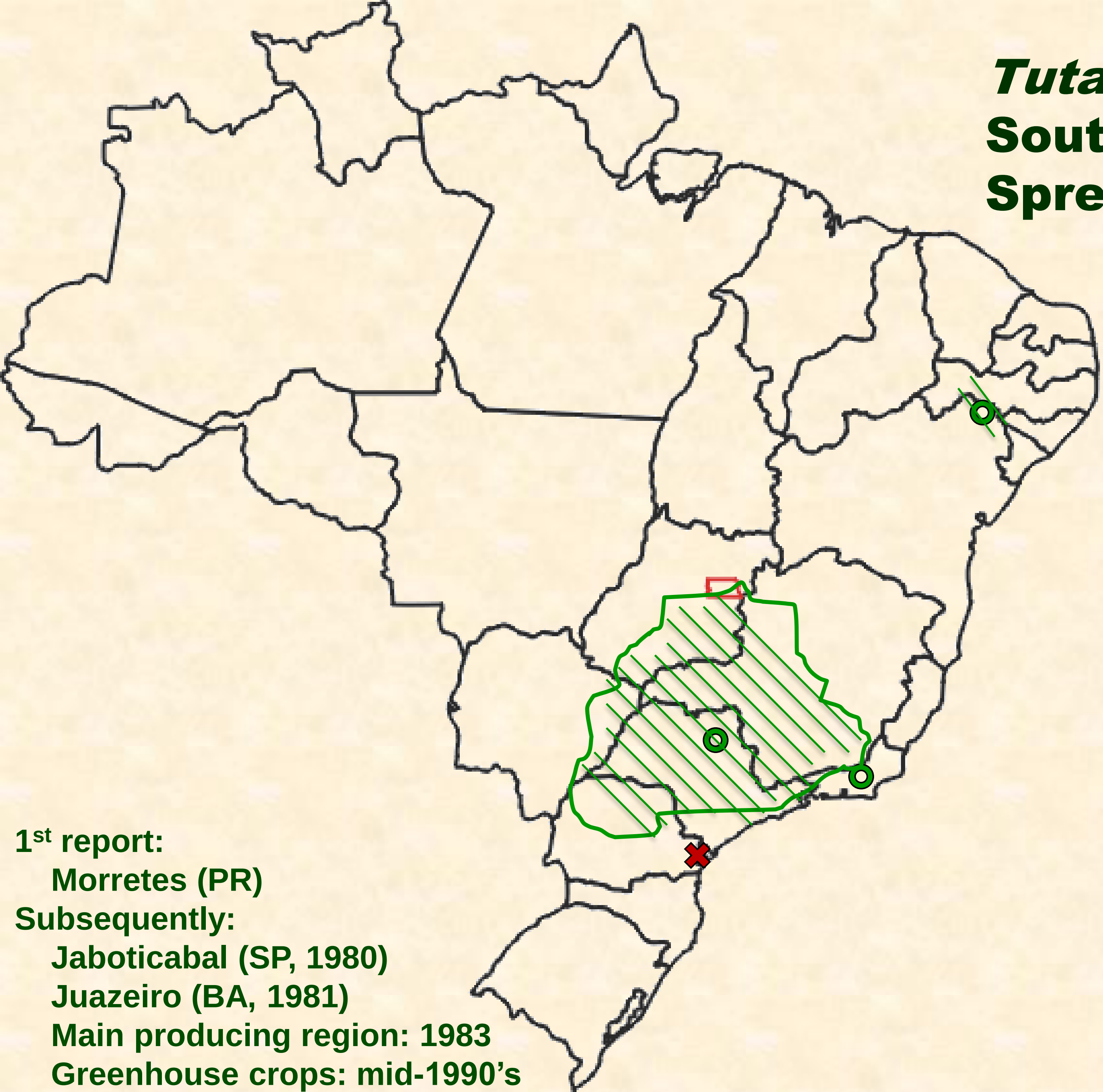
Recognition as potential pest (1960's):

- Peru
- Chile
- Colombia
- Argentina

Subsequent spread (1970's):

- Bolivia
- Paraguay
- Uruguay
- Brazil (1979-1980)

Tuta absoluta in South America: Spread in Brazil



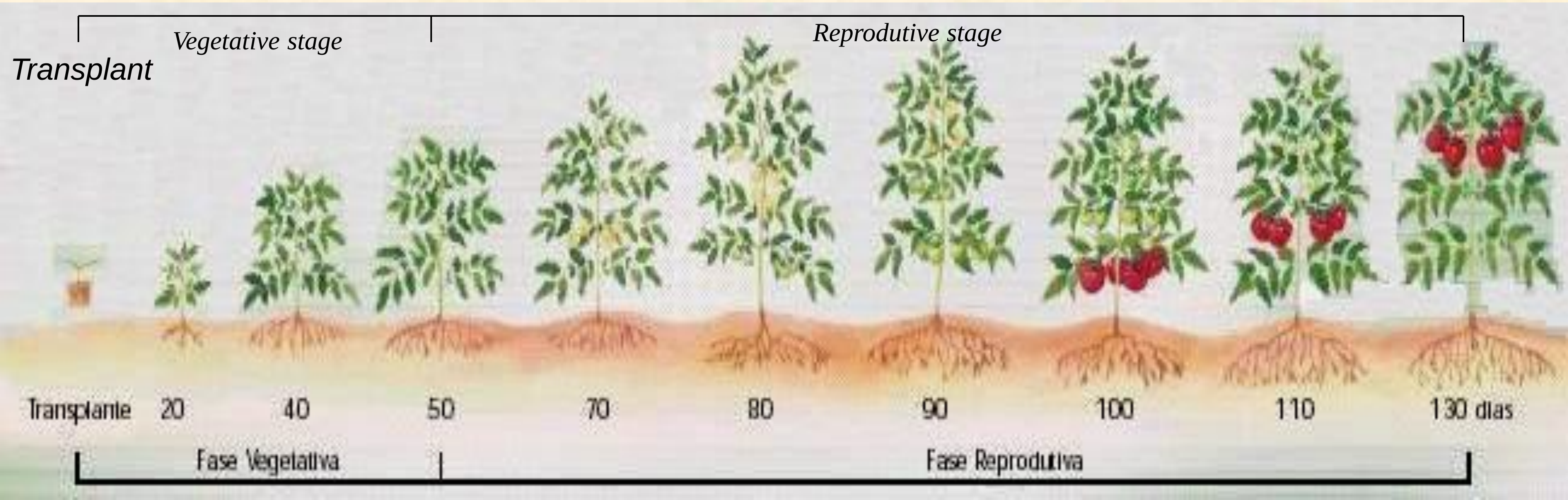
1st report:
Morretes (PR)
Subsequently:
Jaboticabal (SP, 1980)
Juazeiro (BA, 1981)
Main producing region: 1983
Greenhouse crops: mid-1990's

Tuta absoluta in South America: Importance

- Importance:
  - Heavy yield losses: up to 80%
  - Increased insecticide use:
    - From 10-12 to 30 applications/cycle
      - Increased production costs
      - Increased environmental & health risks

Tuta absoluta in South America: Importance

Tomato borer incidence



Pest management tactics?!

- Manipulation of crop environment

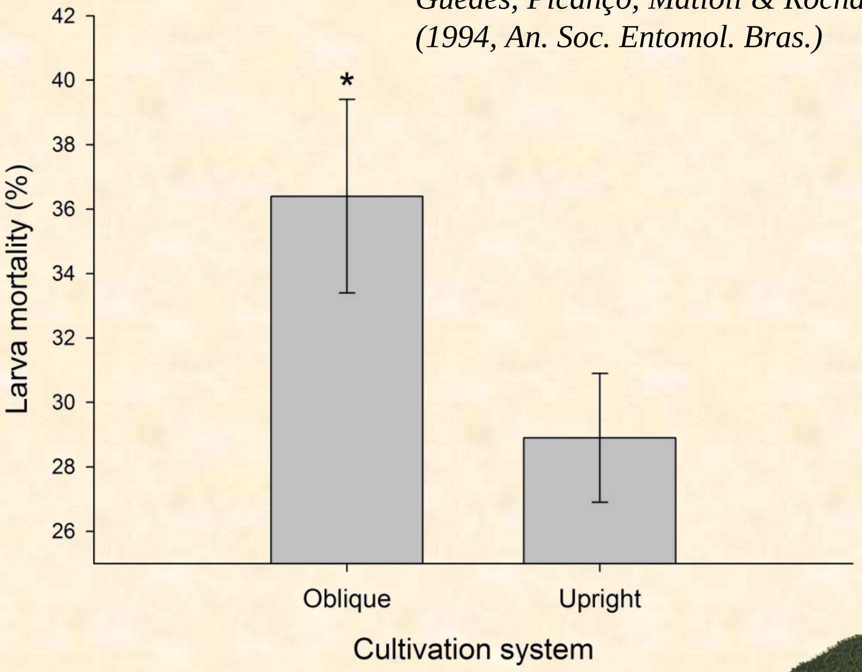
(= cultural control):

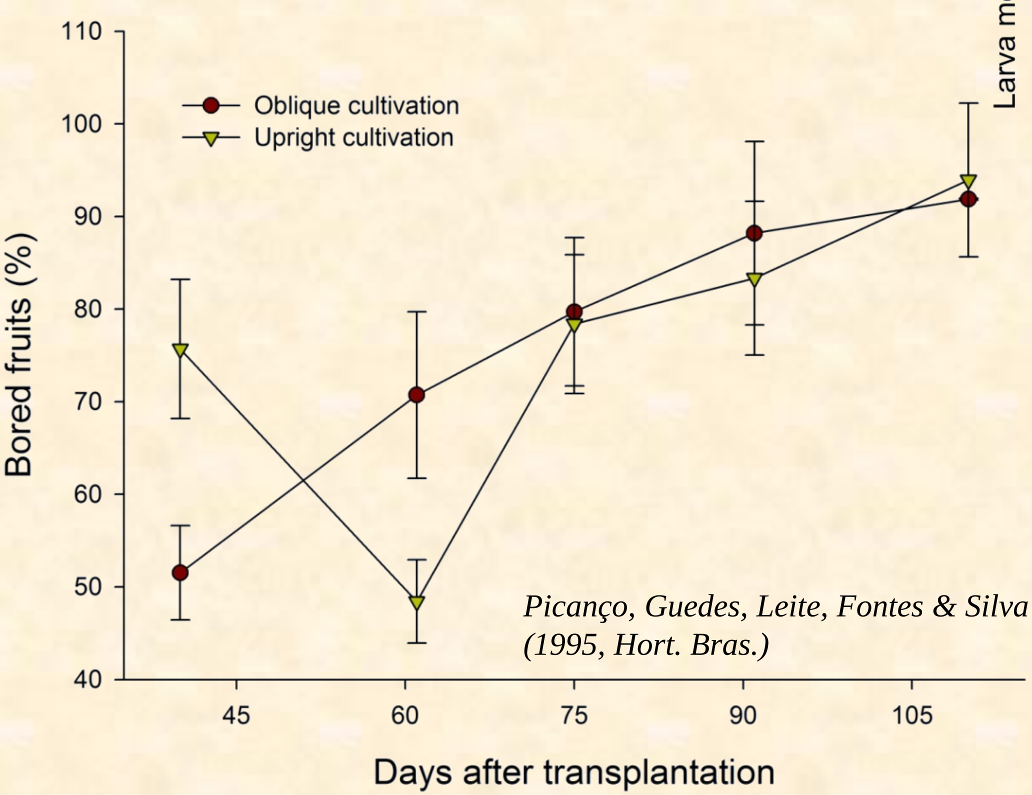
– Change of crop cultivation system (staked or trellised tomato)

- Oblique (0.5 x 1.0 m)
- Upright (0.25 x 1.0 m; pruning at 4th brunch)
- Goal: improvement of insecticide coverage

Pest management tactics?!
- change in cultivation system -

Guedes, Picanço, Matioli & Rocha (1994, An. Soc. Entomol. Bras.)





Picanço, Guedes, Leite, Fontes & Silva (1995, Hort. Bras.)

Pest management tactics?!
- change in cultivation system -

- Additional recommendations:
  - Removal of attacked fruits and fruits fallen on soil
  - Elimination of tomato crop remains
  - If possible, avoid planting tomato during warm and dry season (higher incidence of *Tuta absoluta*)

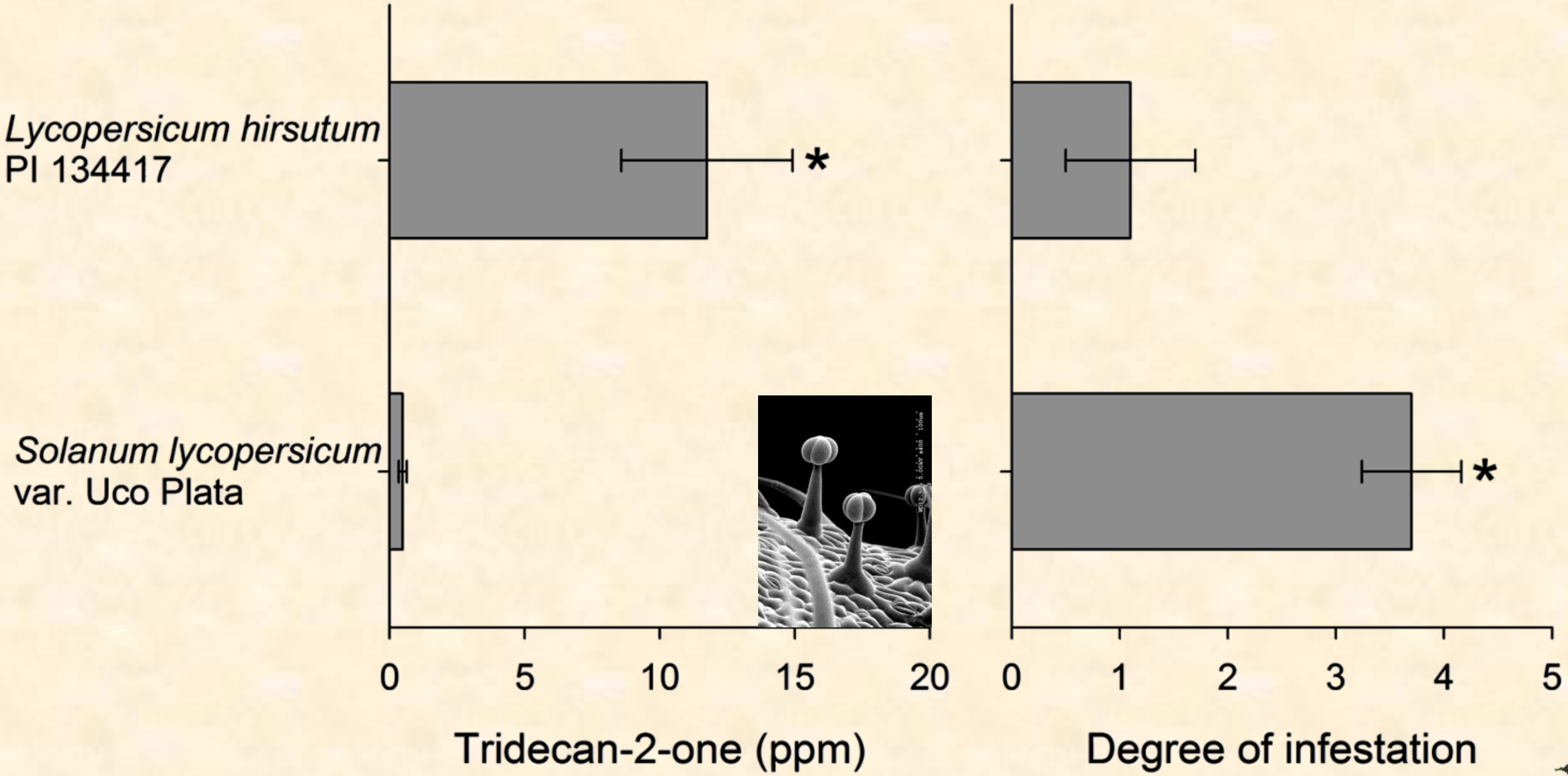
Pest management tactics?!

- tomato resistance to *Tuta absoluta* -

- Sources of resistance available since 1990
- Incorporation into commercial varieties not yet achieved
- Explored:
  - Glandular trichomes (initial focus)
  - Acylsugars (current emphasis)

Pest management tactics?!

- tomato resistance to *Tuta absoluta* -



Gilardión, Pocovi, Hernández, Collavino & Olsen (2001, Pesq. Agropec. Bras.)

Shortcoming: no successful incorporation into commercial varieties

Pest management tactics?!

- tomato resistance to *Tuta absoluta* -

Egg-laying by *Tuta absoluta* in genotypes with varying levels of acylsugars and zingiberene

Genotypes		Number of eggs per 2 cm^2 leaflet area
T1	DÉBORA MAX	22C
T2	TOM-684	24C
T3	TOM-688	11B
T4	TOM-689	8B
T5	ZGB-703	9B
T6	ZGB-704	8B
T7	F_1(ZGB-703 × TOM-688)	10B
T8	F_1(ZGB-703 × TOM-689)	8B
T9	F_1(ZGB-704 × TOM-688)	9B
T10	F_1(ZGB-704 × TOM-689)	10B
T11	F_1(ZGB-703 × TOM-684)	10B
T12	F_1(ZGB-704 × TOM-684)	13B
T13	F_1(TOM-688 × TOM-684)	12B
T14	F_1(TOM-689 × TOM-684)	10B
T15	PI 127826 = *S. habrochaites* (= *L.hirsutum*)	1A
T16	LA 716 = *S.* (= *L.*) *pennellii*	1A

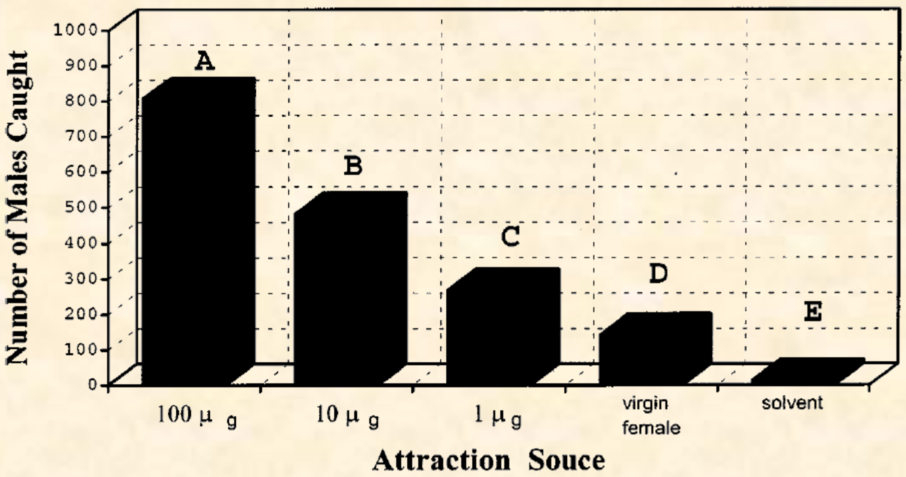
Maluf, Silva, Cardoso, Gomes, Gonçalves Neto, Maciel & Nízio (2010, Euphytica)

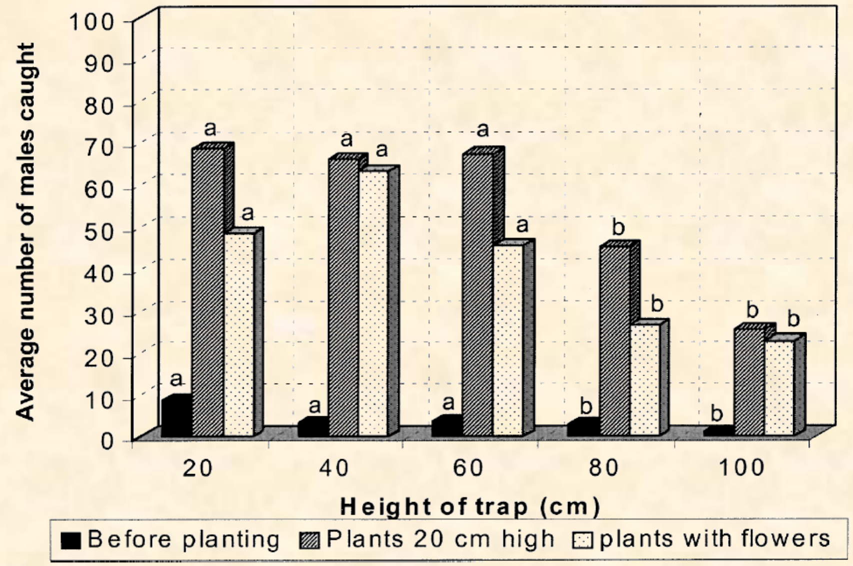
Pest management tactics?!
- Pheromone use -

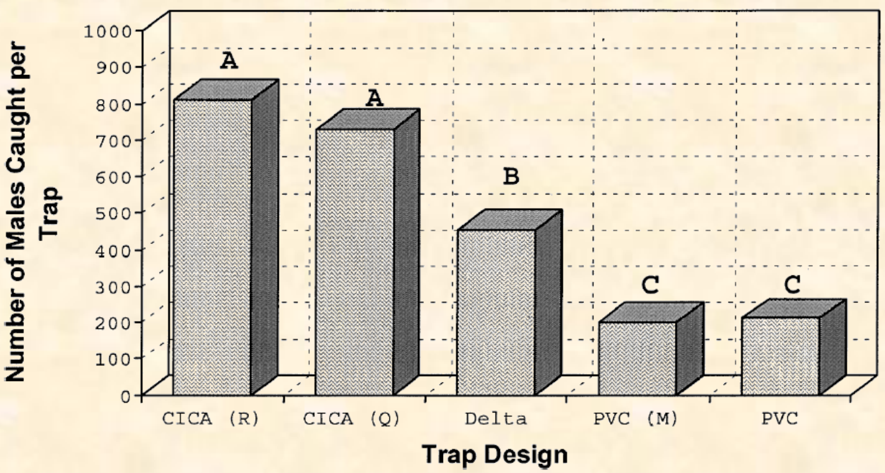
- The sexual pheromone of the tomato borer (*T. absoluta*) was identified, synthesized and confirmed by mid-1990's
  - Main component:
    - (3*E*; 8*Z*; 11*Z*)-3,8,11-tetradecatrienylacetate (TDTA)
- Use attempt:
  - Trapping for decision-making
  - Mating disruption

Pest management tactics?!

- Pheromone use: trap assessments -



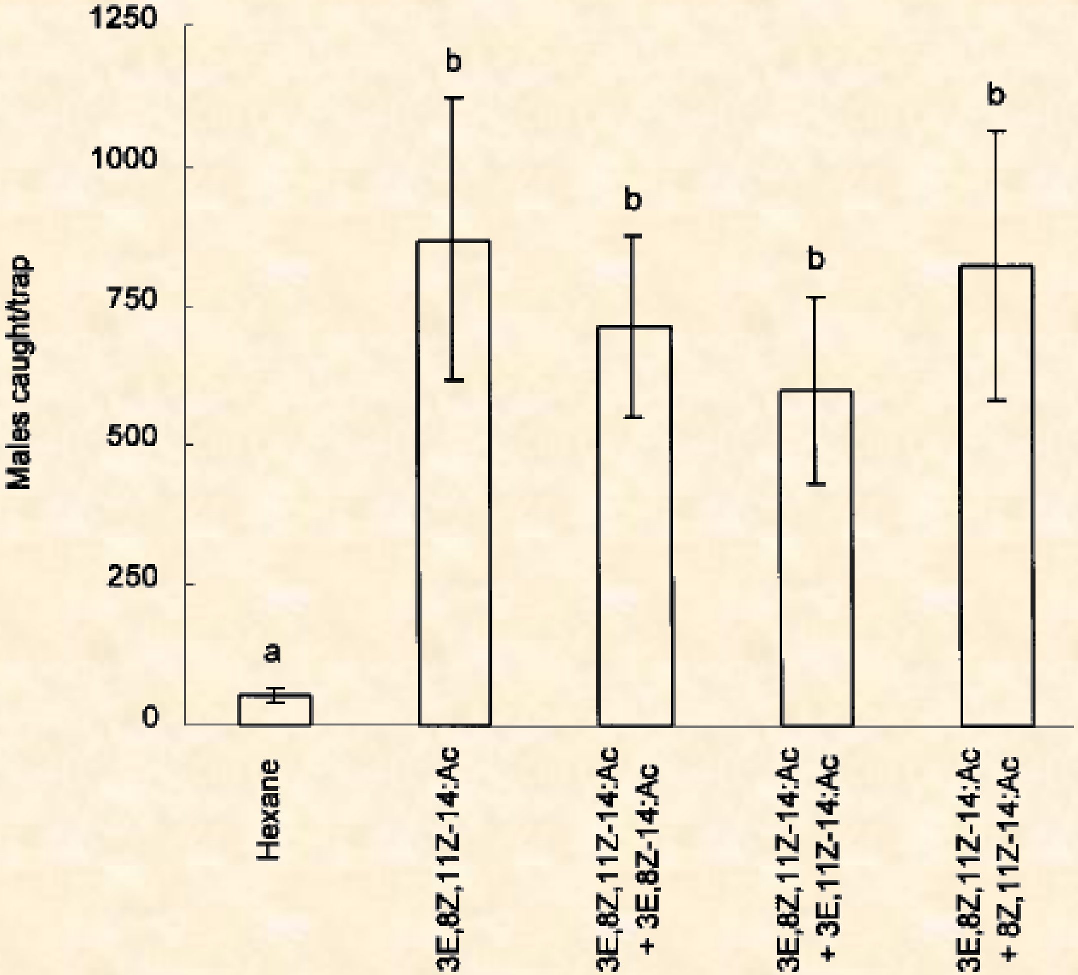




Ferrara, Vilela, Jham, Eiras, Picanço, Attygalle, Svatos, Frighetto & Meinwald (2001, J. Chem. Ecol.)

Pest management tactics?!

- Pheromone use: blend assessment -



Michereff-Filho, Vilela, Attygalle, Meinwald, Svatos & Jham (2000, J. Chem. Ecol.)

Need: Sampling plan and decision-making studies

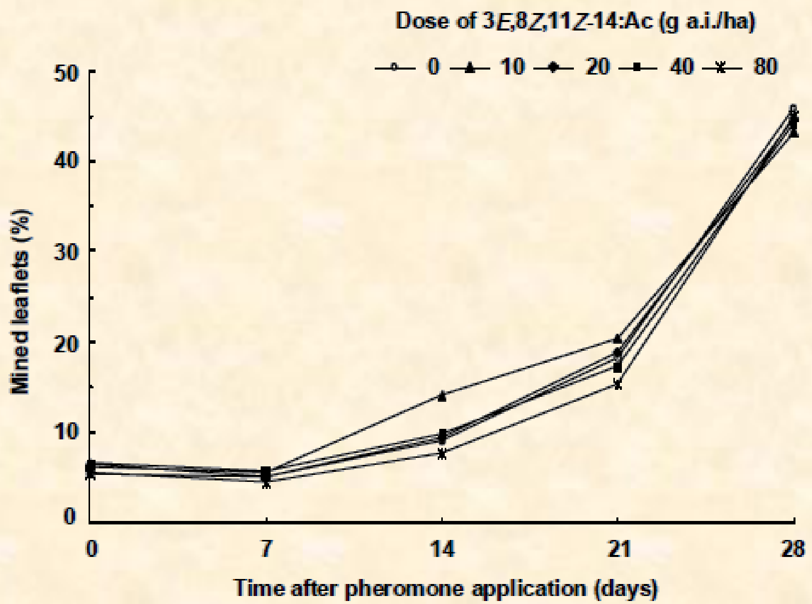
Preliminar recommendation:
2 traps/ha &
EIL of 45 ± 20 insects/trap/day

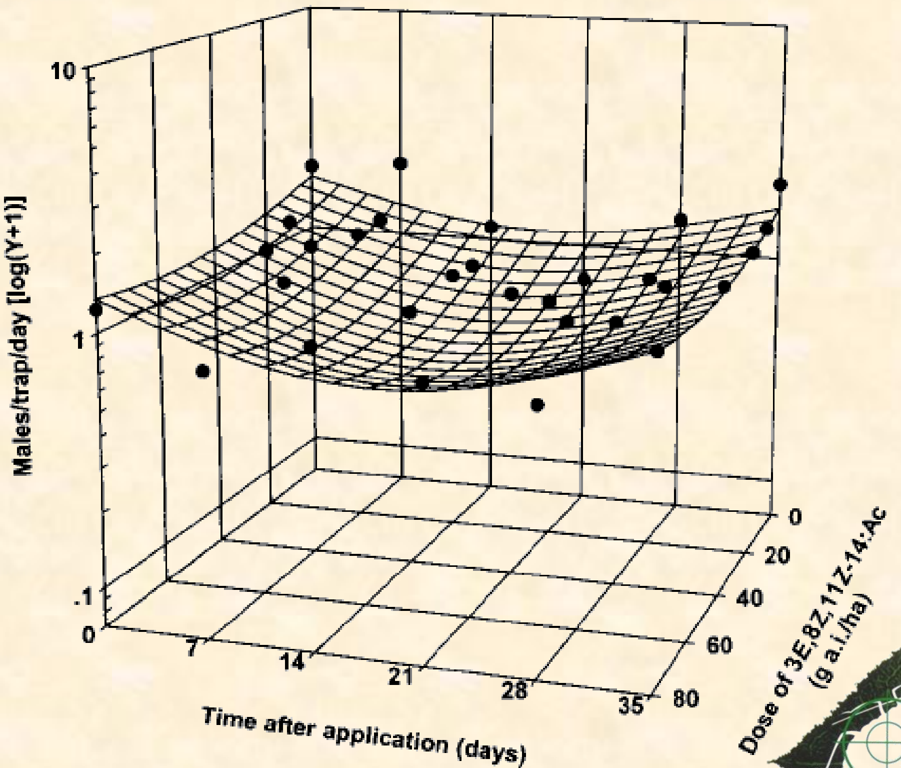
Benvenga, Fernandes & Gravena (2007, Hort. Bras.)

Pest management tactics?!
- Pheromone use: mating disruption -

2,500 dispensers/ha

Michereff-Filho, Vilela, Jham, Attygalle, Svatos & Meinwald (2000, J, Braz, Chem, Soc,)





Results: no-significant reduction in the tomato borer population and injury

Pest management tactics?!
- Biocontrol -

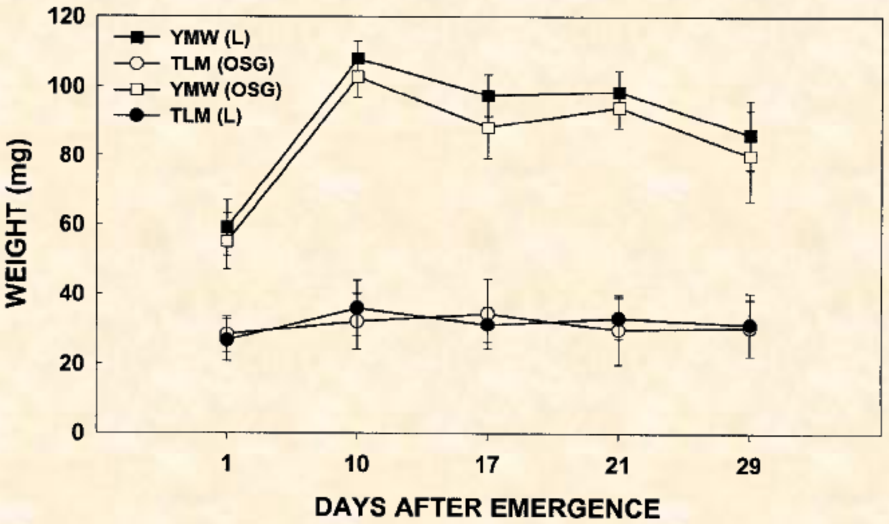
- Biological control against the tomato borer
  - Initial focus:
    - Egg parasitoids (*Trichogramma* spp.)
    - Stinkbug predators (*Podisus nigrispinus* & related species)
    - Limitations of their use

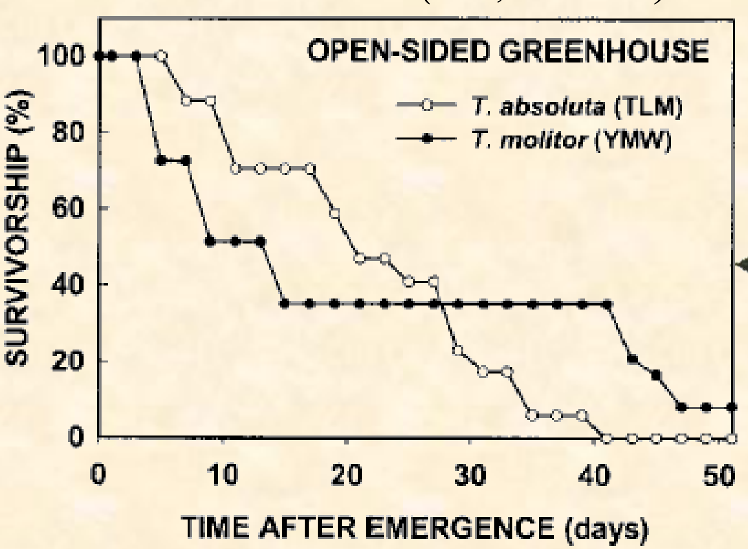
Pest management tactics?!

- Biocontrol: stinkbug *Podisus* -

- Earlier explored
  - Low field incidence
  - High susceptibility to organophosphates
  - High parasitism by egg parasitoids

Vivan, Torres & Veiga (2003, BioControl)

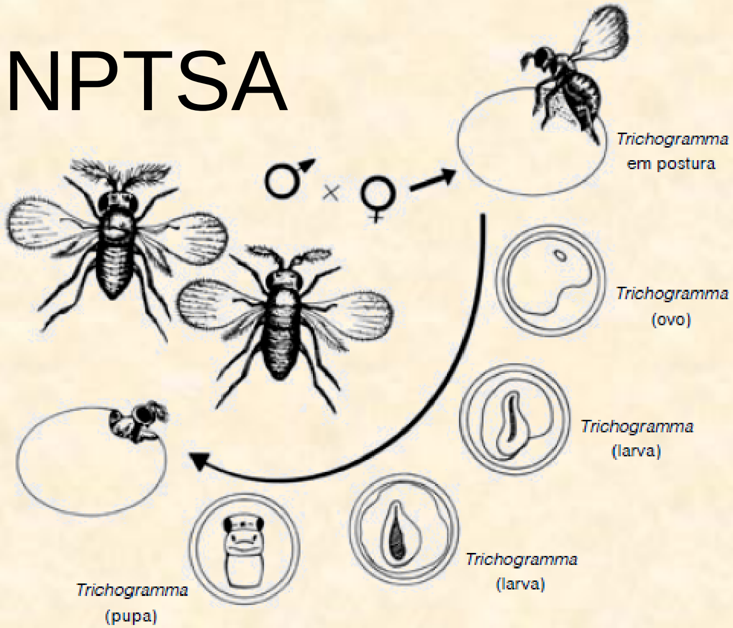


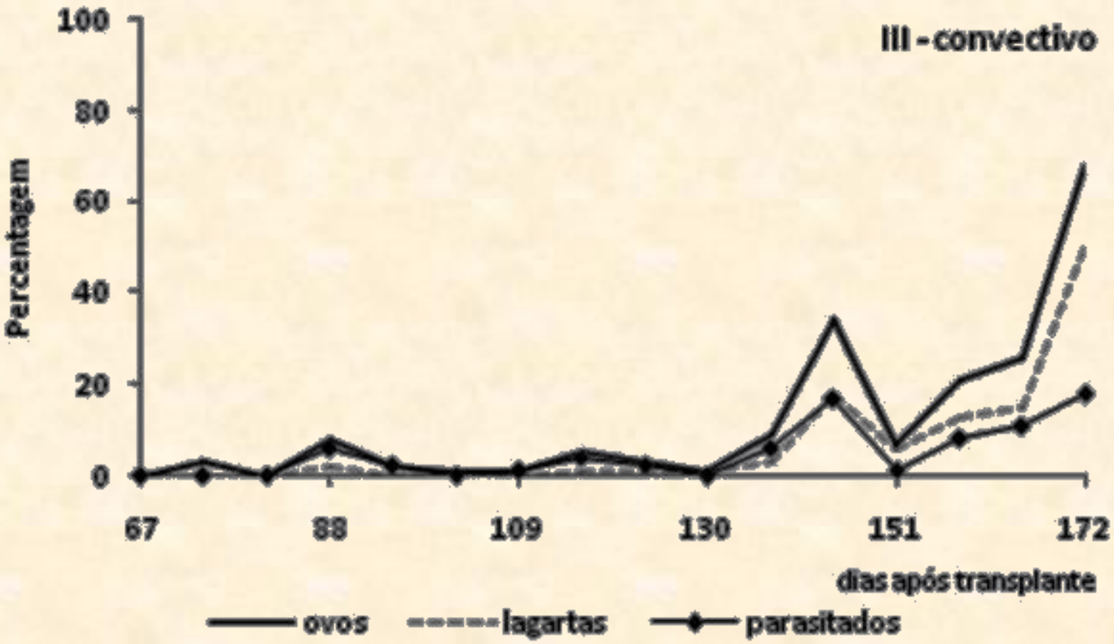


Pest management tactics?!

- Biocontrol: *Trichogramma* egg-parasitoids -

- Promoted by EMBRAPA-CNPTSA (PE) during late 1990's



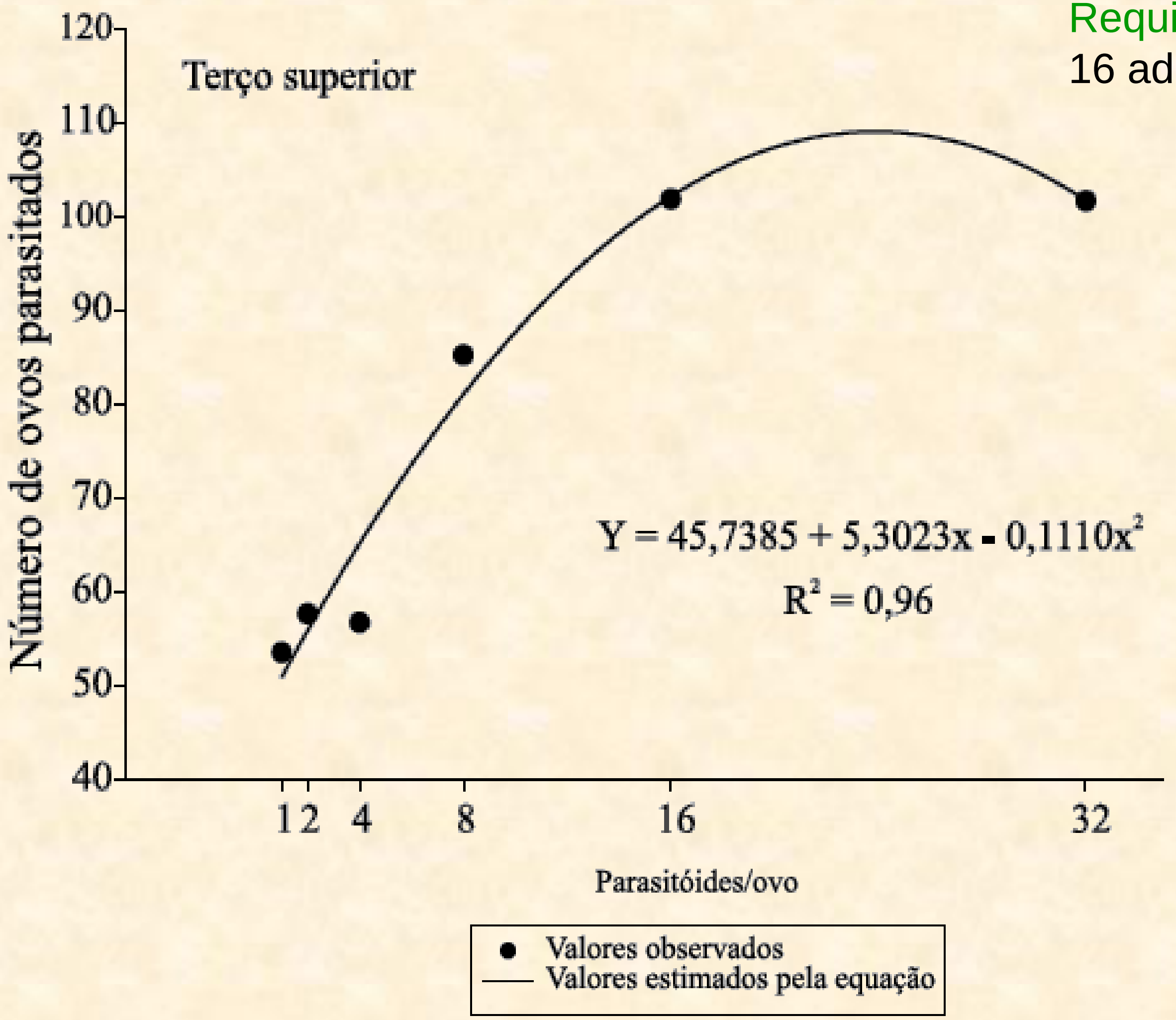


Medeiros, Villas Bôas, Vilela & Carrijo (2009, Hort. Bras.)

Pest management tactics?!

- Biocontrol: *Trichogramma* egg-parasitoids -

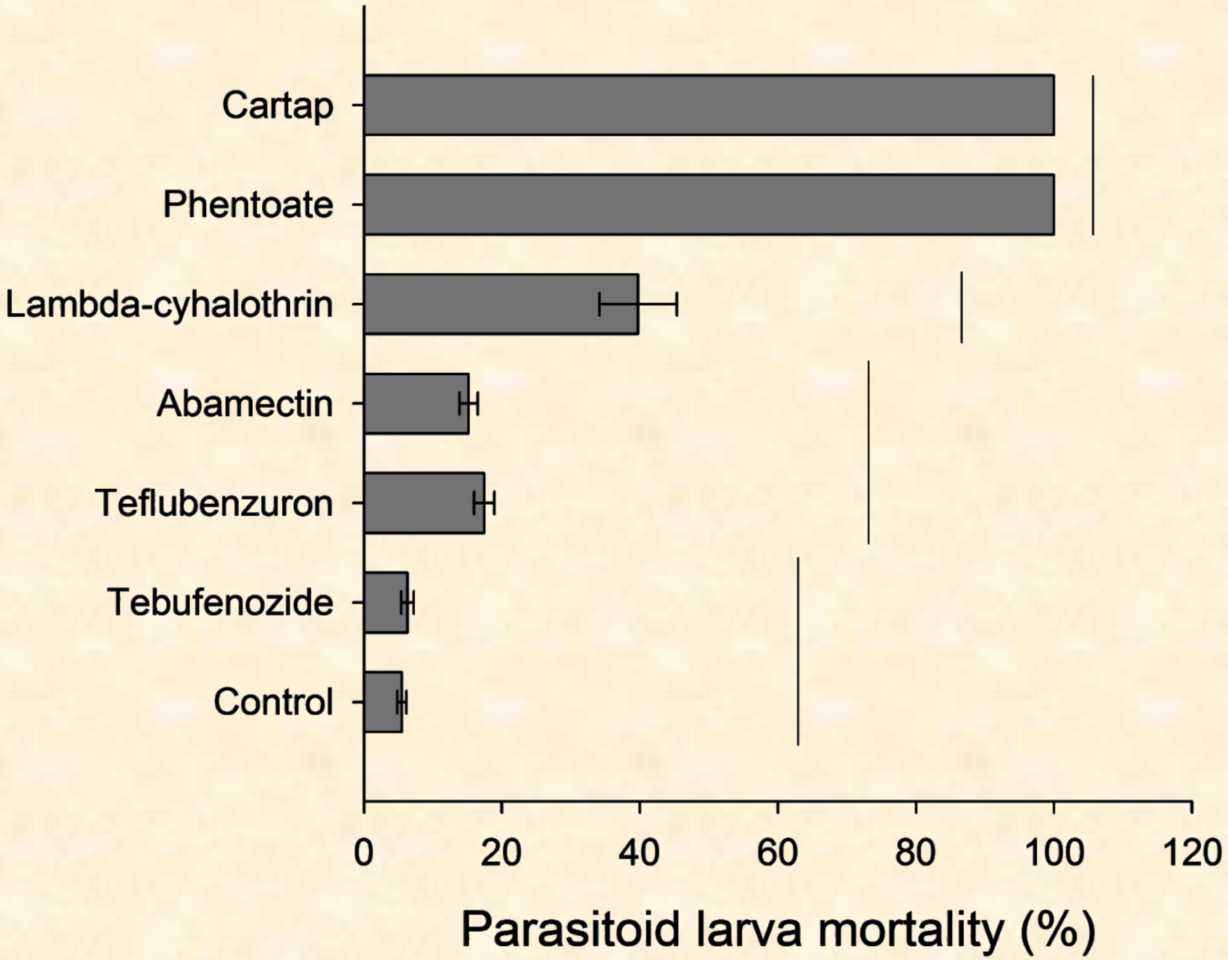
Required parasitoid release density:
16 adults/host egg



Pratissoli, Thuler, Andrade, Zanotti & Silva (2005, Pesq. Agropec. Bras.)

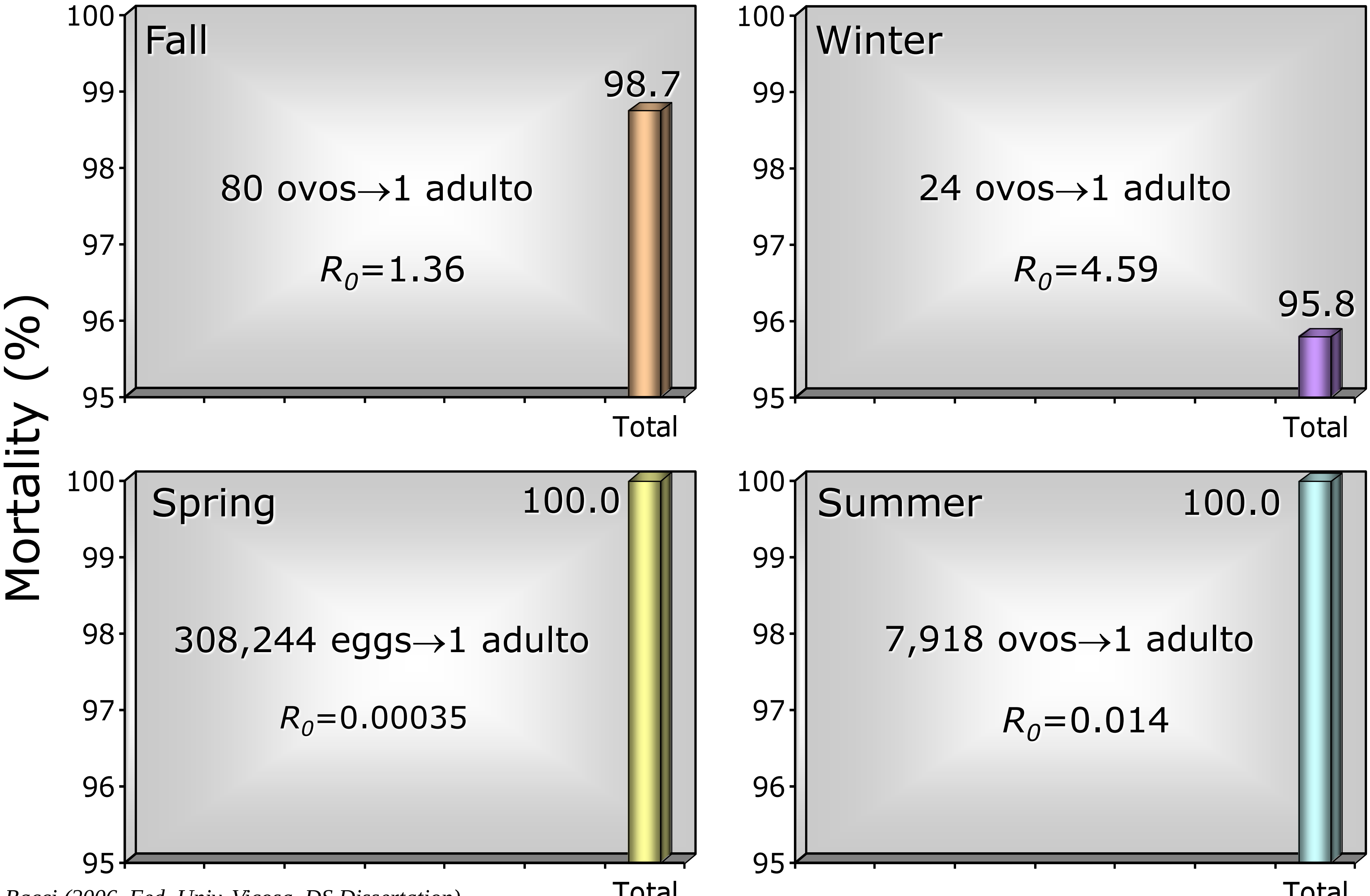
Pest management tactics?!

- Biocontrol: *Trichogramma* egg-parasitoids -



Cônsoli, Parra & Hassan
(1998, J. Appl. Entomol.)

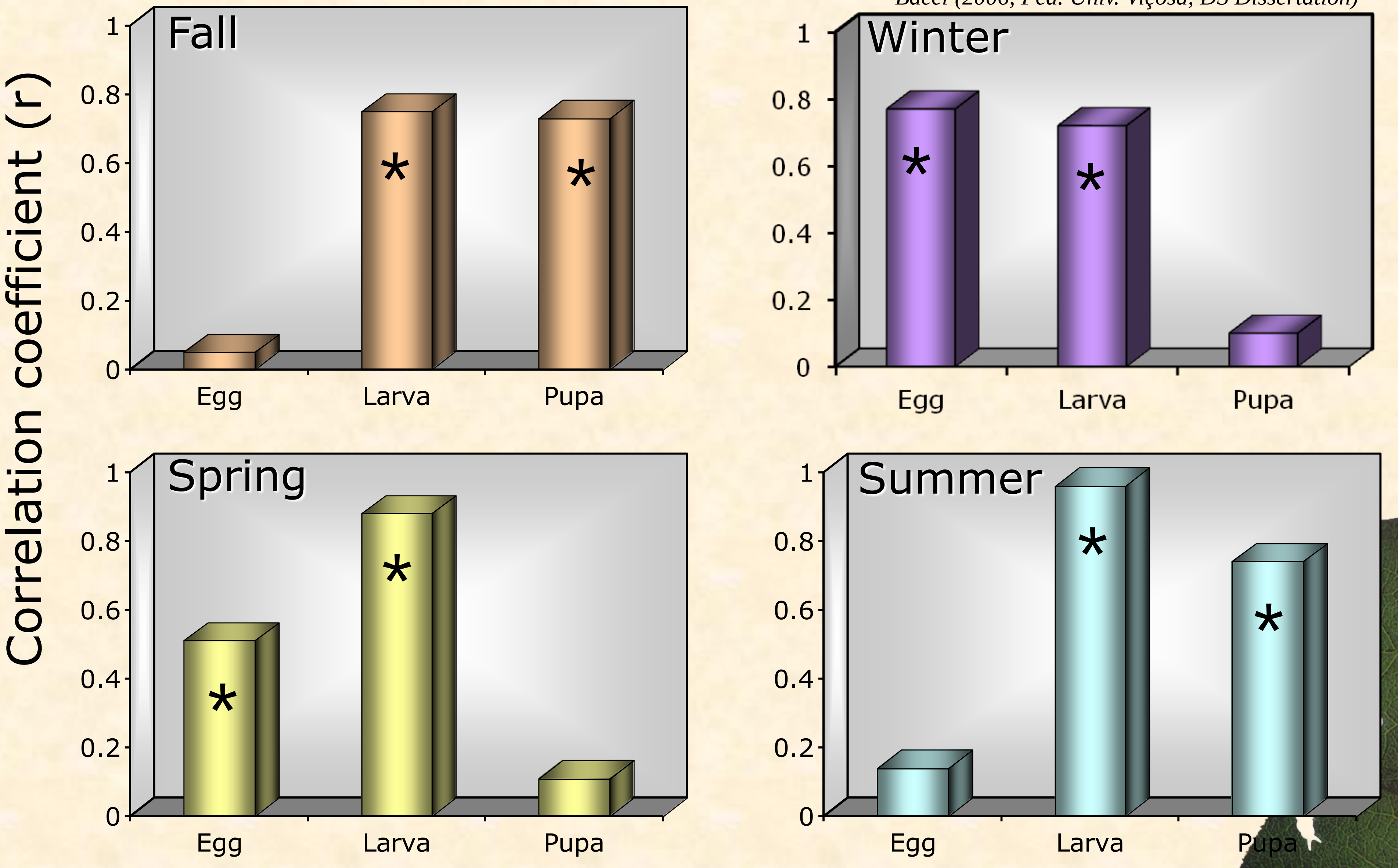
Mortality factors:
Natural biocontrol & conservation of natural enemies



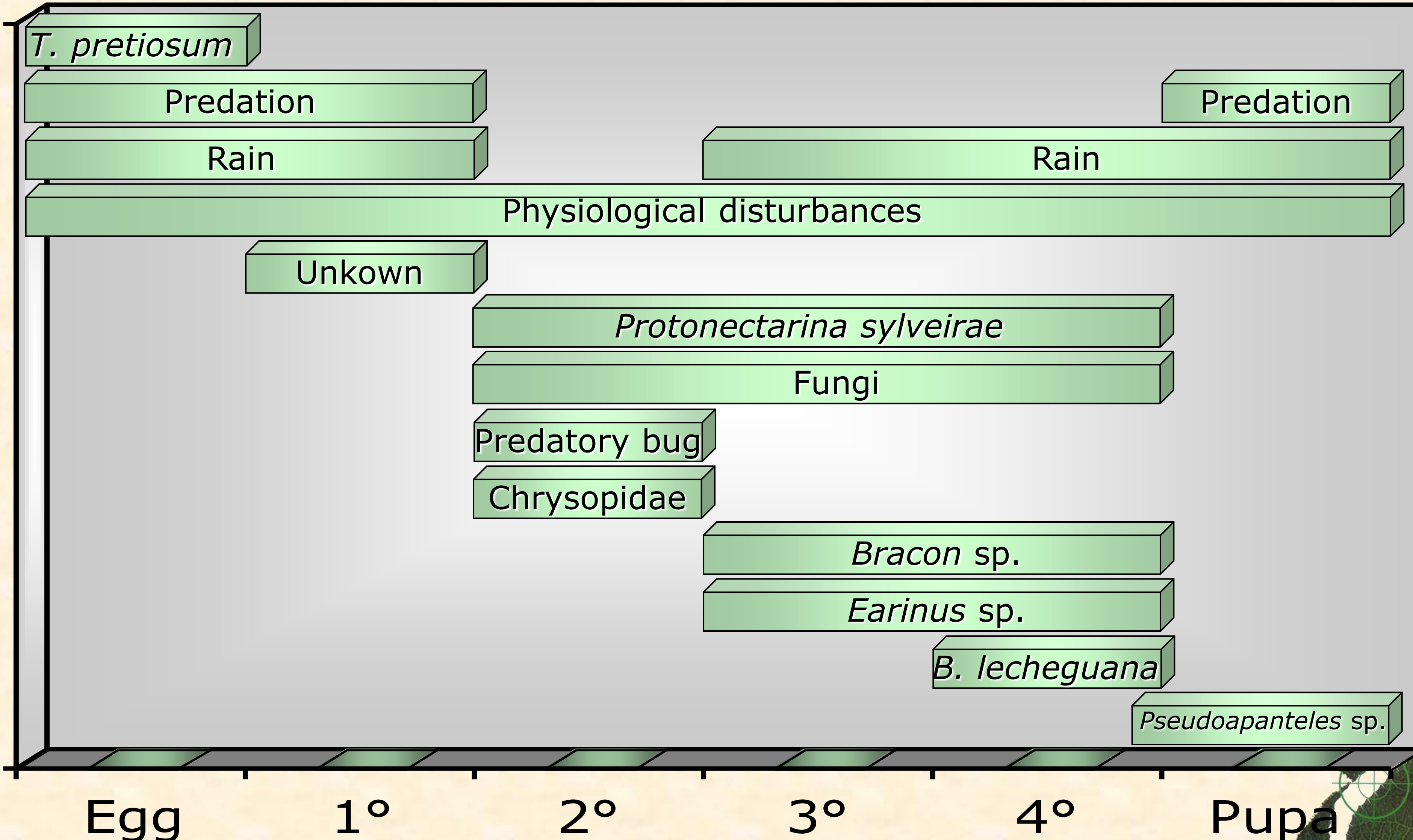
Bacci (2006, Fed. Univ. Viçosa, DS Dissertation)

Critical life stage:
Natural biocontrol & conservation of natural enemies

Bacci (2006, Fed. Univ. Viçosa, DS Dissertation)



Mortality factors:
Natural biocontrol & conservation of natural enemies



Bacci (2006, Fed. Univ. Viçosa, DS Dissertation)

Pest management tactics?!

- Biocontrol -

- Lessons:
  - Natural biological control:
    - Very important!
  - Artificial biological control:
    - So far no good control impact in the field
    - New emphasis:
      - Fungi (*Beauveria basiana* and *Metarhizium anisopliae)*
      - Bacteria *Bacillus thunrigiensis*
      - Other parasitoid species (e.g., *Trichogrammatoidea bactrae & Dineulophus phtorimaeae*

Insecticide use:

- sampling for decision-making -

- Overall sampling currently suggested:
  - Tomato field divided into homogeneous plots
  - 10 sampling points per plot
  - 4 plants inspected per sampling point

(40 per plot)

  - Weekly sampling

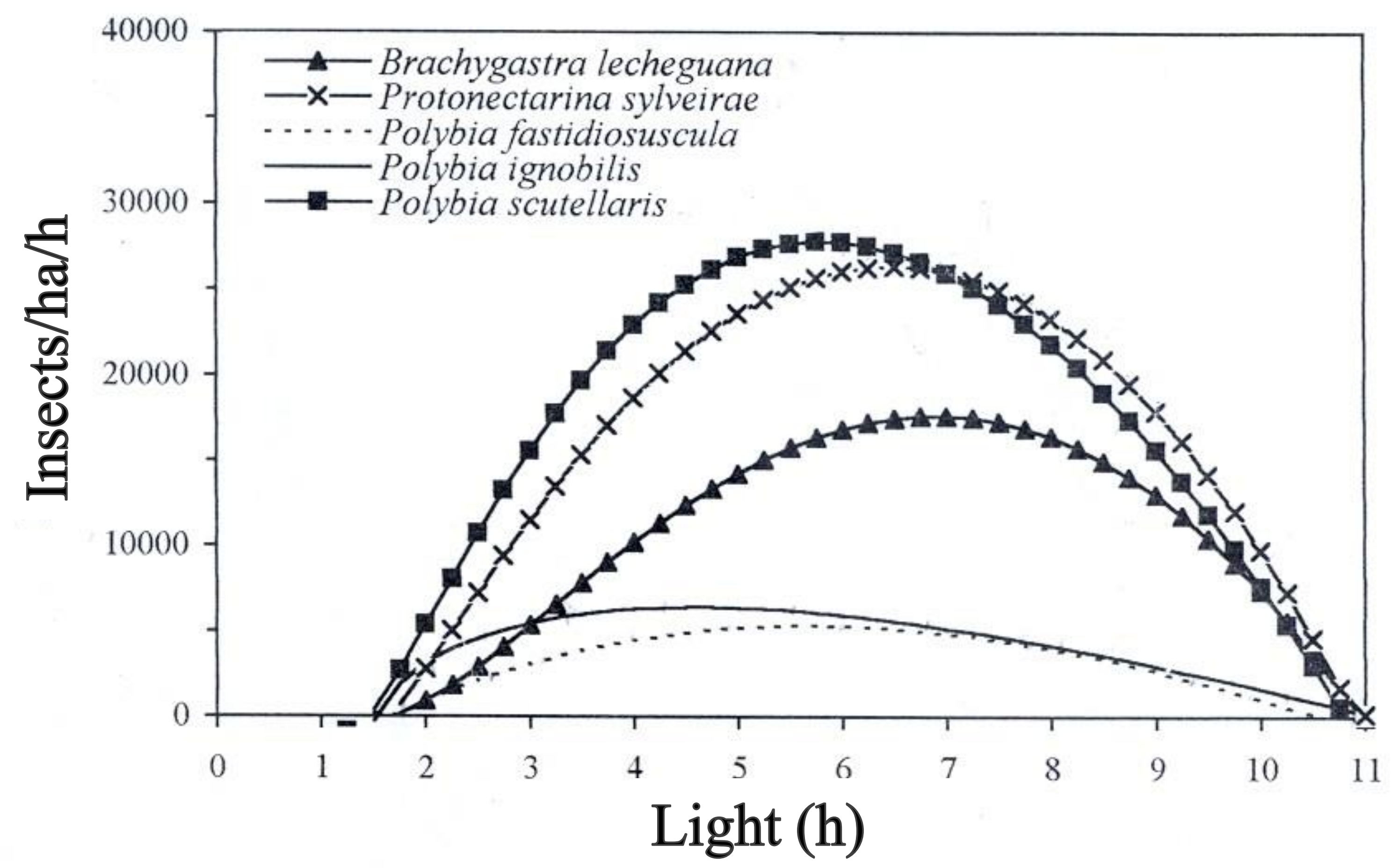
Insecticide use:

- economic injury levels -

Object of inspection	Economic injury levels
✓**Leaves** (mined leaves) 	10% of leaves mines
✓**Fruits** (bored fruits) 	4% of fruits bored

Insecticide use:

- selective application -



Picanço, Bacci, Queiroz, Silva, Miranda, Leite & Suinaga (2011, Sociobiology)

Insecticide use:

- oil as synergist -

Insecticide	Rate of synergism
Abamectin	16
Cartap	2
Phentoate	2
Permethrin	7

Guedes, Picanço, Guedes & Madeira
(1995, Pesq. Agropec. Bras.)

Insecticide use:

- insecticides used against *T. absoluta* -

- Early use (1980's):
  - Organophosphates (methamidophos, phentoate)
  - Cartap
  - Abamectin
  - Pyrethroids (permethrin)
- Mid use (1990's to 2000's)
  - Insect growth regulators (diflubenzuron, tebufenzuron, triflumuron)
  - *Bacillus thunrigiensis*
  - Indoxacarb
- Late use (2000's to present)
  - Chlorfenapyr
  - Spinosad
  - Chlorantraniliprole

Insecticide resistance

- 1st report from Chile (Salazar & Jaime, 1997 *Simiente*):
  - Resistance to organophosphates and pyrethroids in Colina, Quillota and Ovalle (low levels; < 10-fold)
- Subsequent surveys:
  - Brazil (2000, 2001, 2011)
  - Chile (2001)
  - Argentina (2005)
- Little done beyond insecticide resistance surveys except in Brazil

Insecticide resistance: Chile

- Expansion of 1st study to another region (Arica), where moderate to high levels of resistance were observed

- Curiosity: estimated LC_{50}'s much higher than commercial doses suggesting likelihood of field control failures

Insecticide resistance:
Chile (Arica) (survey)

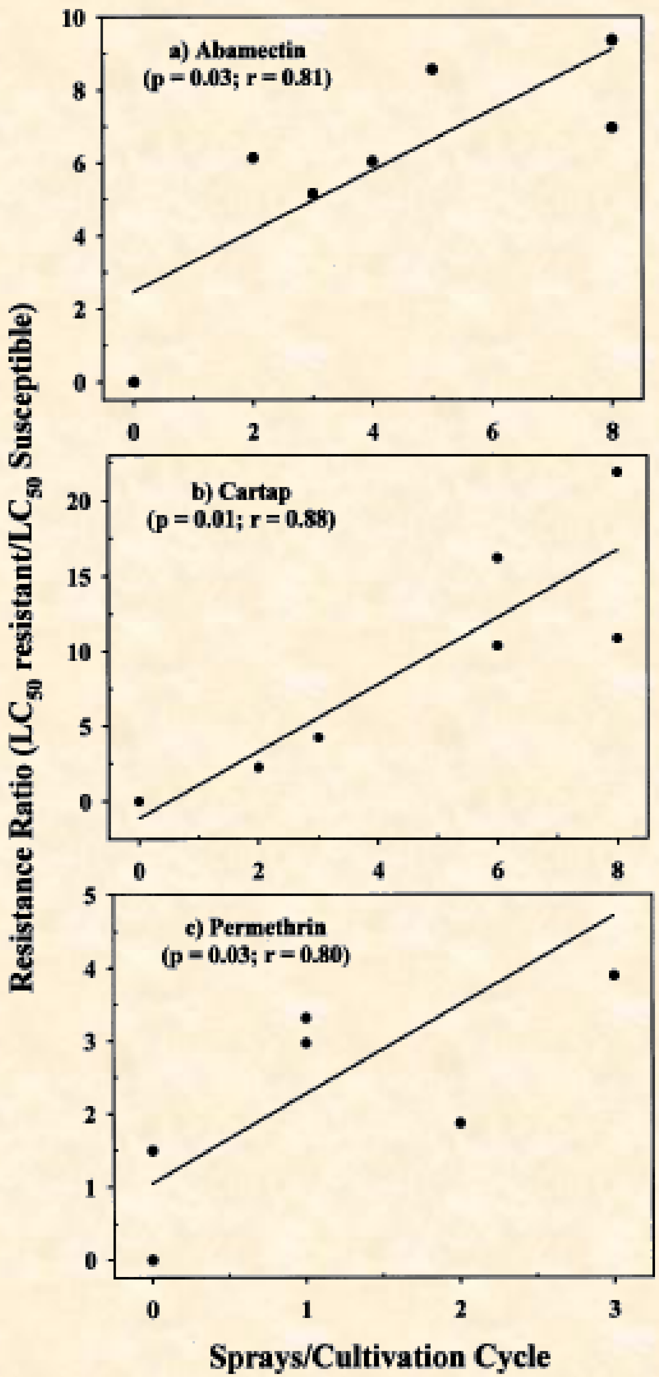
Insecticide	Resistance level relative to commercial label rate	
	1^{st}-2^{nd} instar	3^{rd}-4^{th} instar
Methamidophos	-	24.2
Mevinphos	17.9	10.7
Deltamethrin	1,428.2	1,117.7
Esfenvalerate	115.3	-
Lambda-cyhalothrin	88.2	-

Salazar & Araya
(2001, Agr. Tecn.)

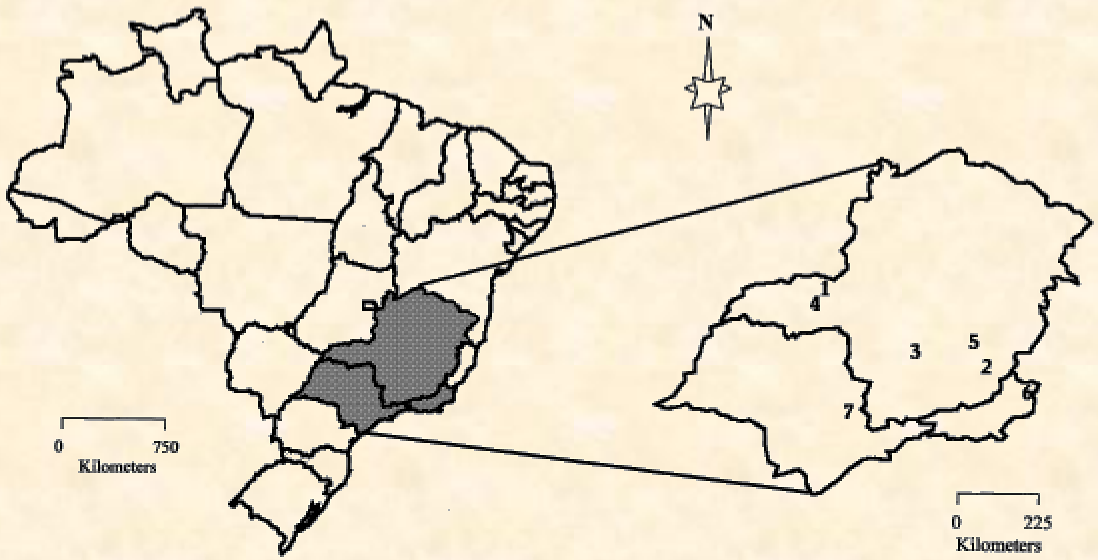
Insecticide resistance:
Argentina (survey)

Insecticide	Population	Resistance Ratio
Deltamethrin	Castelar	-
	Rosario	> 68.4
	Bella Vista	> 68.4
Methamidophos	Castelar	-
	Rosario	0.8
	Bella Vista	0.9
Abamectin	Castelar	-
	Rosario	2.5
	Bella Vista	3.5

Lietti, Botto & Alzogaray
(2005, Neotrop. Entomol.)



Insecticide resistance:
Brazil (survey & selection)



- Low resistance to abamectin and permethrin, and moderate resistance to cartap
- Higher resistance levels achieved with higher insecticide use
- No evidence of cross-resistance

Siqueira, Guedes & Picanço (2000, Agric. For. Entomol.)

Insecticide resistance: Brazil
- potential mechanisms of cartap resistance -

Population	Resistance ratio	Resistance ratio with piperonyl butoxide
Paulínea	-	-
Guiricema	2.2	1.8
Lavras	4.2	1.8
Uberlândia	10.4	2.3
Viçosa	10.9	2.2
São João da Barra	16.2	2.9
Araguari	21.9	3.0

Siqueira, Guedes & Picanço (2000, J. Appl. Entomol.)

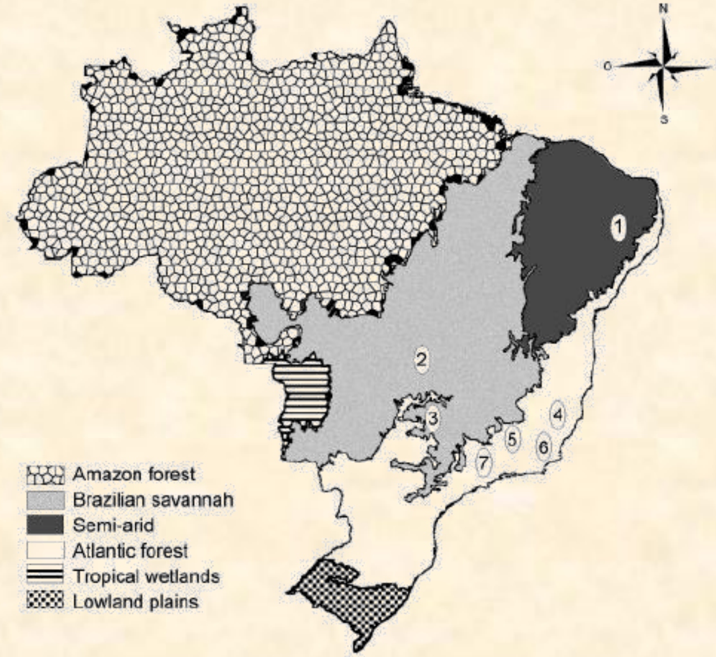
- Cartap resistance suppressed by piperonyl butoxide suggestion a major involvement of detoxification by cytochrome P450-dependent monooxygenases

- Similar results obtained for abamectin, but suppression was not as complete *(Siqueira, Guedes, Fragoso & Magalhães; 2001, Int. J. Pest Manag.)*

Insecticide resistance: Brazil

- recent and comprehensive survey -

Insecticide or Group	Region	Resistance ratio
Pyrethroids	Semi-arid	11.4-12.5
	Savannah	1.0-4.2
	Atlantic forest	1.7-7.0
Deltamethrin + triazophos	Semi-arid	1.1-1.6
	Savannah	1.0-1.5
	Atlantic forest	1.0-16
Abamectin	Semi-arid	1.0-1.1
	Savannah	1.0-1.5
	Atlantic forest	1.3-8.9
Spinosad	Semi-arid	2.0-3.1
	Savannah	1.4-4.8
	Atlantic forest	1.0-3.7
Indoxacarb	Semi-arid	2.1-4.1
	Savannah	3.8-27.3
	Atlantic forest	1.0-27.3
Chitin synthesis inhibitors	Semi-arid	2.9-57.4
	Savannah	1.0-222.7
	Atlantic forest	2.2-153.9
Bacillus thunrigiensis	Semi-arid	1.0-1.3
	Savannah	1.0-2.5
	Atlantic forest	1.2-8.0



Silva, Picanço, Bacci, Crespo, Rosado & Guedes (2011, Pest Manag. Sci.)

Insecticide resistance: Brazil
- control failure likelihood -

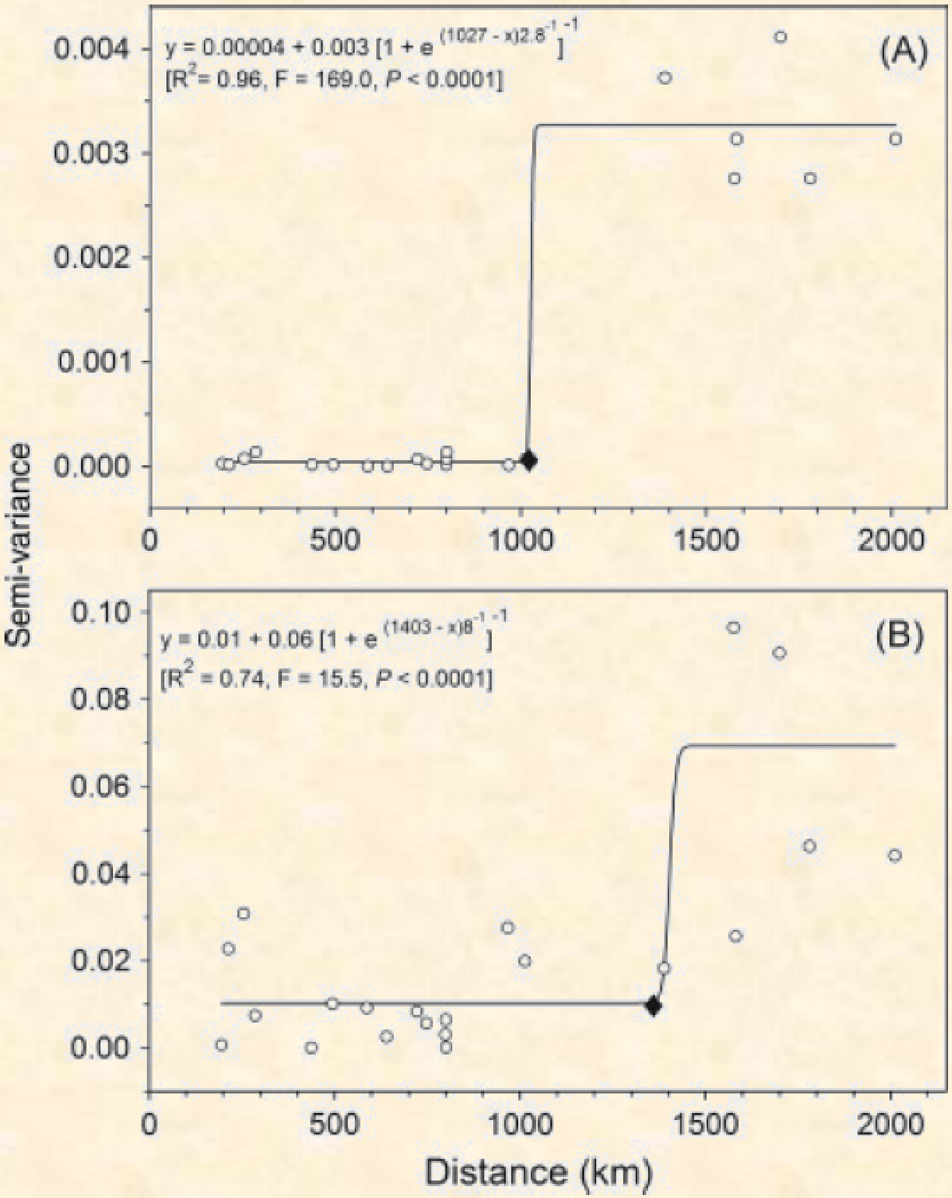
Estimated insecticide mortality (%) of populations of the tomato pinworm *Tuta absoluta* using Brazilian recommended label rates

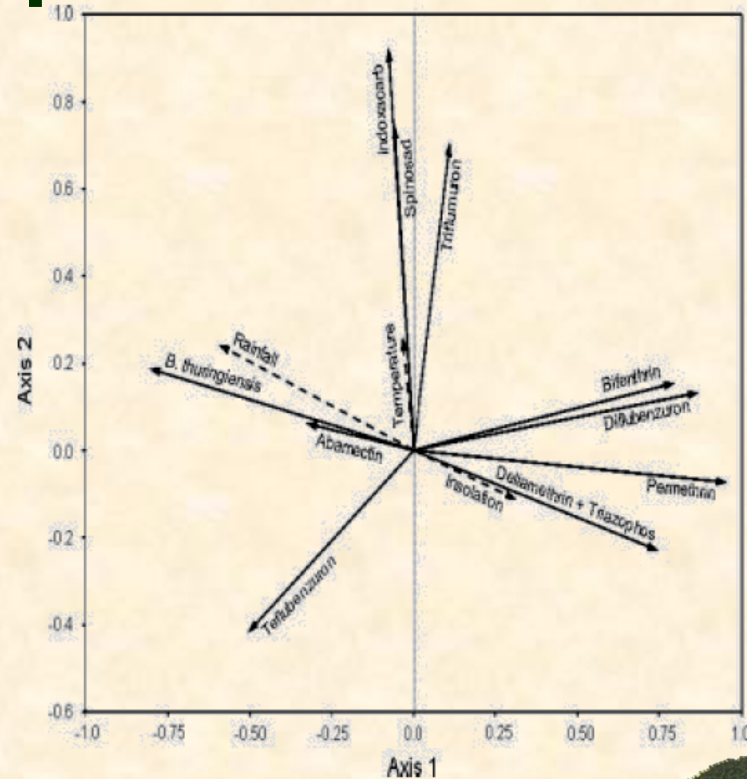
		Brazilian savannah			Atlantic forest			Semi-arid
	Insecticides	Uberlândia	Goianápolis	Paulínia	S. João da Barra	Viçosa	Santa Tereza	C. de São Félix
Neurotoxic	Abamectin	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Bifenthrin	64.0[a]	97.0	70.0[a]	83.0	85.0	93.0	35.0[a]
	Delmethrin + triazophos	91.5	80.0	95.0	86.5	100.0	82.0	95.0
	Indoxacarb	67.0[a]	100.0	91.0	70.0[a]	67.5[a]	100.0	96.0
	Permethrin	30.0[a]	25.0[a]	20.0[a]	4.00[a]	60.0[a]	6.00[a]	15.0[a]
	Spinosad	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Chitin synthesis inhibitor	Diflubenzuron	35.0[a]	77.0[a]	59.5[a]	10.0[a]	64.5[a]	53.0[a]	20.0[a]
	Teflubenzuron	86.0	34.0[a]	92.0	50.0[a]	68.0[a]	20.0[a]	91.0
	Triflumuron	0.00[a]	51.0[a]	25.5[a]	0.00[a]	45.0[a]	4.00[a]	52.0[a]
	B. thuringiensis	44.1[a]	33.7[a]	1.12[a]	46.7[a]	7.00[a]	2.34[a]	46.2[a]

[a] Mortality significantly lower than 80% because the label rate is lower than the lower threshold of the insecticide LC_{80} fiducial interval for the population.

Silva, Picanço, Bacci, Crespo, Rosado & Guedes (2011, Pest Manag. Sci.)

Insecticide resistance: Brazil
- weather influence & spatio-dependence -





Silva, Picanço, Bacci, Crespo, Rosado & Guedes (2011, Pest Manag. Sci.)

Concluding remarks

- Tomato borer management:
  - Still few options available
  - Cultural methods: helpful
  - Tomato resistance: a lot need to be done
  - Biocontrol: not yet consistent
  - Insecticide use:
    - remains as main control method
    - Increased use of effective and selective compounds
    - Rotation of insecticides broadly recommended (IRAC-BR & Brazilian Ministry of Agriculture)
- Tomato borer status:
  - decreasing importance in Brazil

- Shukran -
- Merci -
- Thanks -
Muchas Gracias
Obrigado

IOBC-WPRS
OILB-SROP

NEAR EAST PLANT PROTECTION ORGANIZATION

IBMA
International Biocontrol

IRAC

Entomologia UFV

C A P E S

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

FAPEMIG
Fundação de Amparo à Pesquisa do Estado de Minas Gerais