Incidence and mechanisms of resistance in *Bemisia tabaci* with special reference to biotype Q

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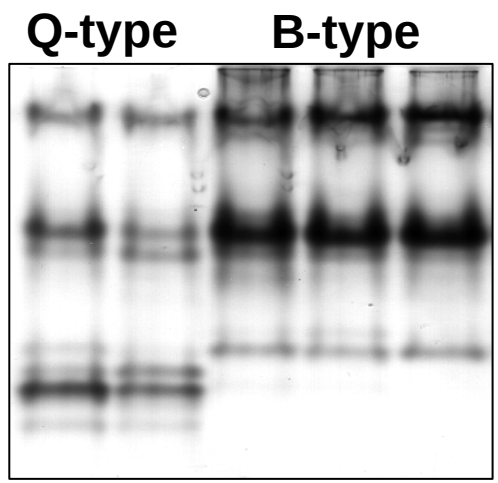
Two important biotypes of *Bemisia tabaci*

Bemisia tabaci
(sweetpotato whitefly)

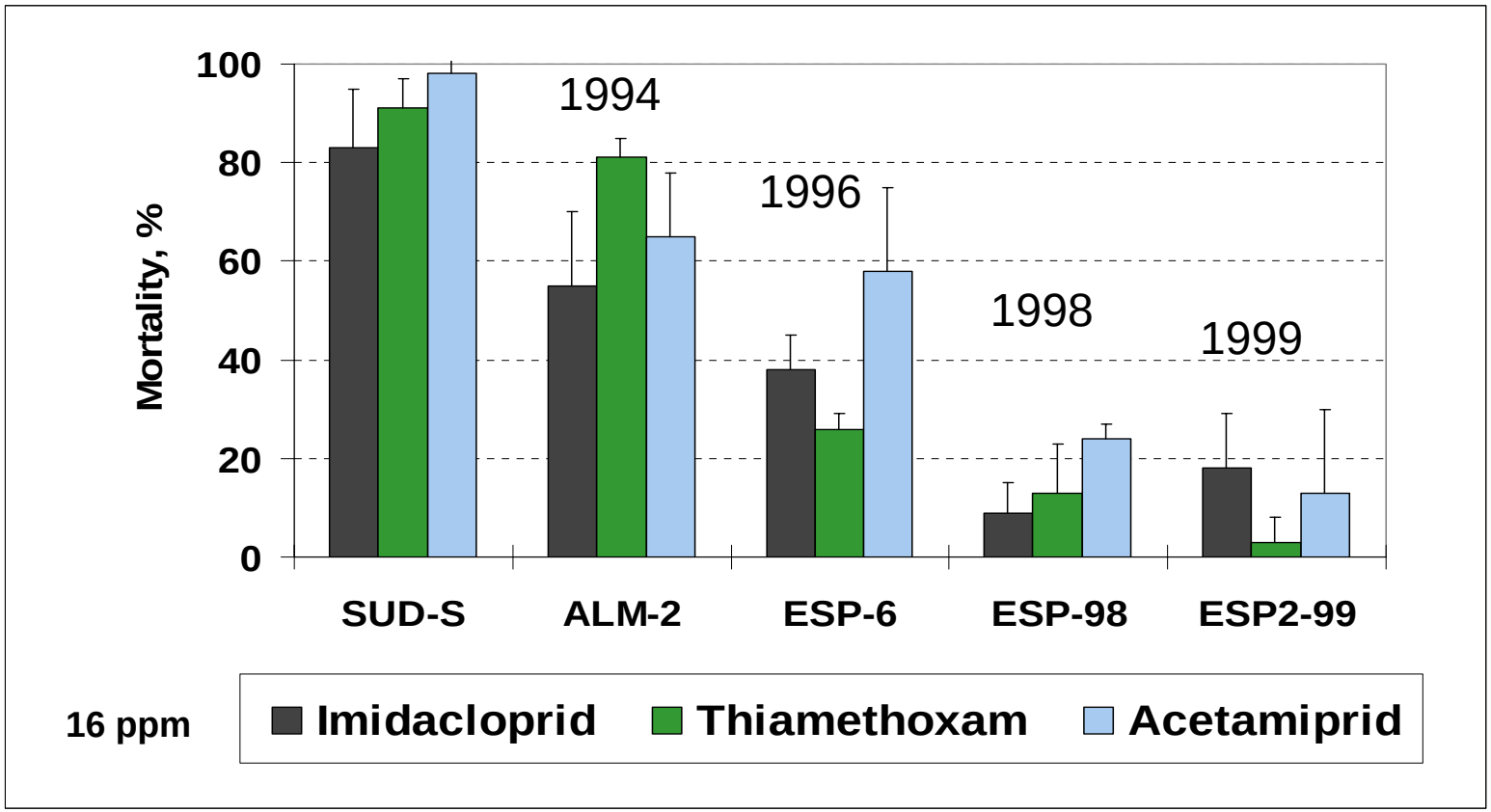
Two important biotypes are B- and Q-types. The most dominant biotype world-wide is B, whereas Q is to a greater or lesser extent restricted to the Mediterranean basin (*e.g.* Almeria Spain).



Esterase banding pattern to differentiate biotypes

Resistance monitoring in Almeria, Spain

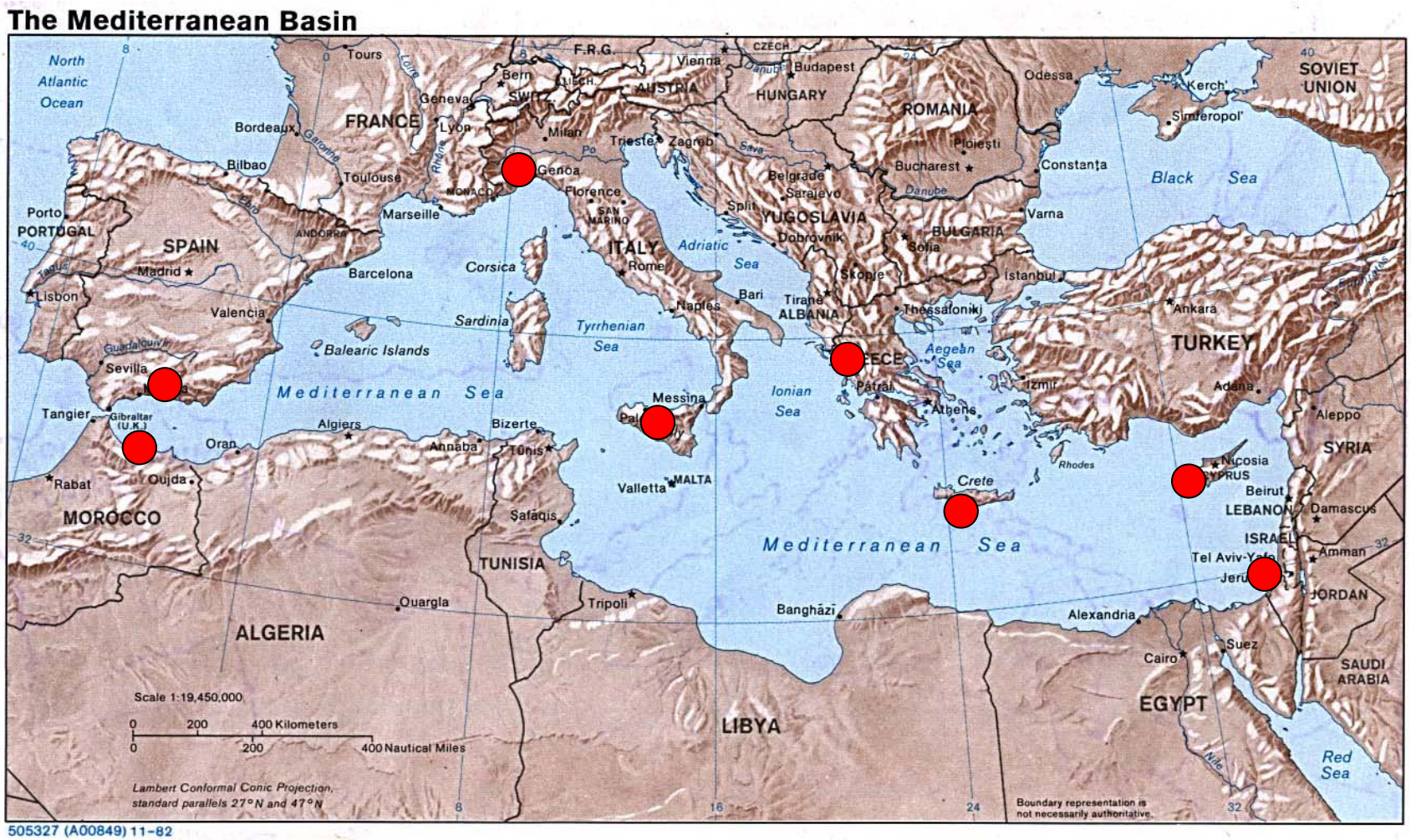
Almeria, Spain



Nauen et al. (2002) Pest. Manag. Sci. 58

Spread of neonicotinoid resistance and Q-biotypes in the Mediterranean basin

Bemisia tabaci



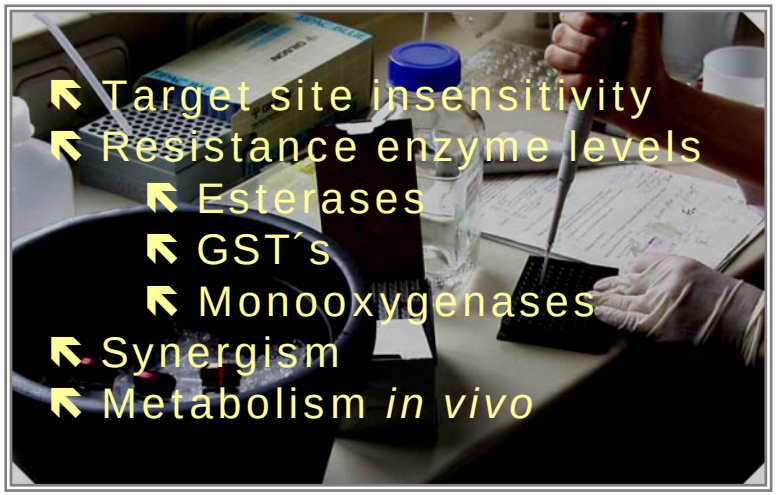
Biochemistry of neonicotinoid resistance

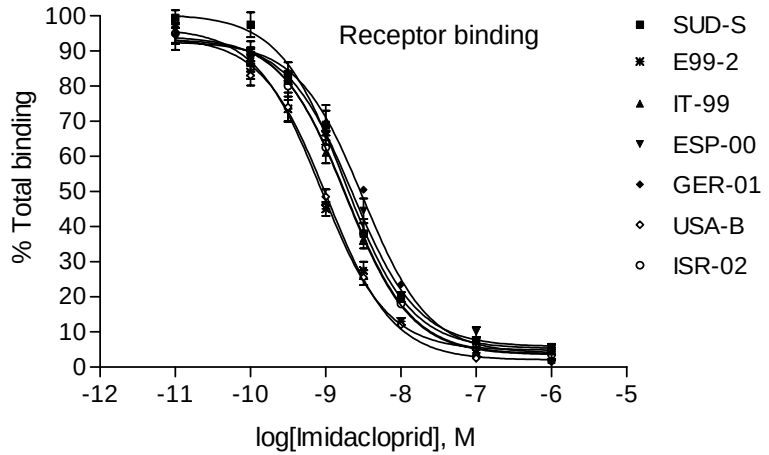
Bemisia tabaci

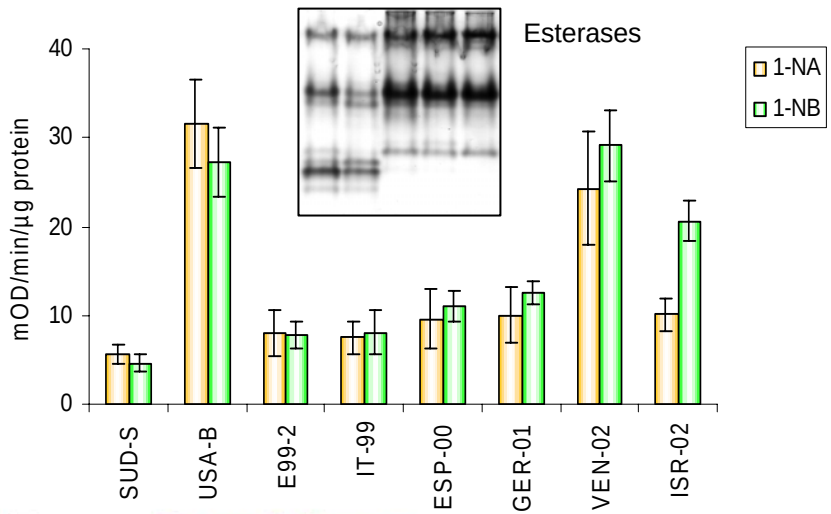
- Target site insensitivity
- Resistance enzyme levels
  - Esterases
  - Glutathione S-transferases
  - Monooxygenases
- Synergism
- Metabolism *in vivo*

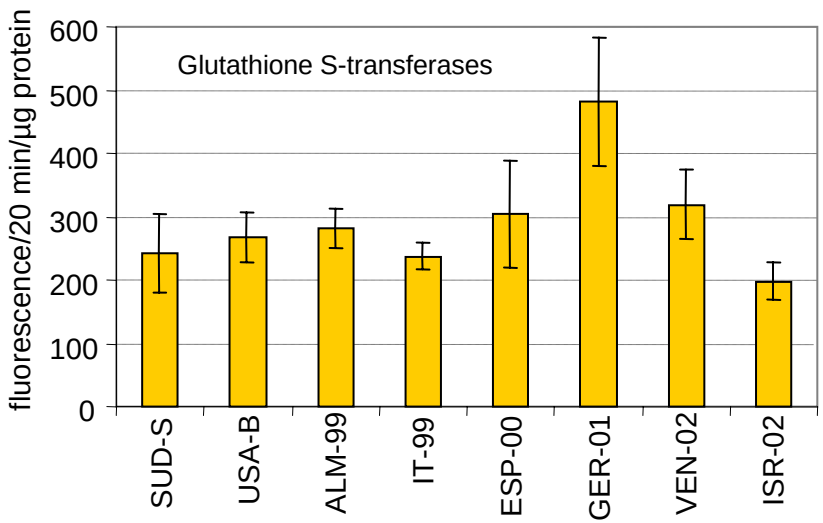
Biochemistry of imidacloprid resistance in whiteflies (negative systems)

Bemisia tabaci





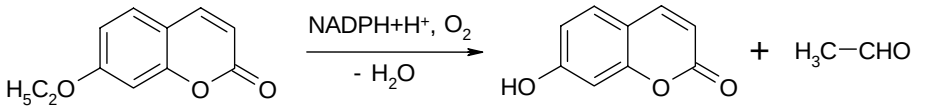


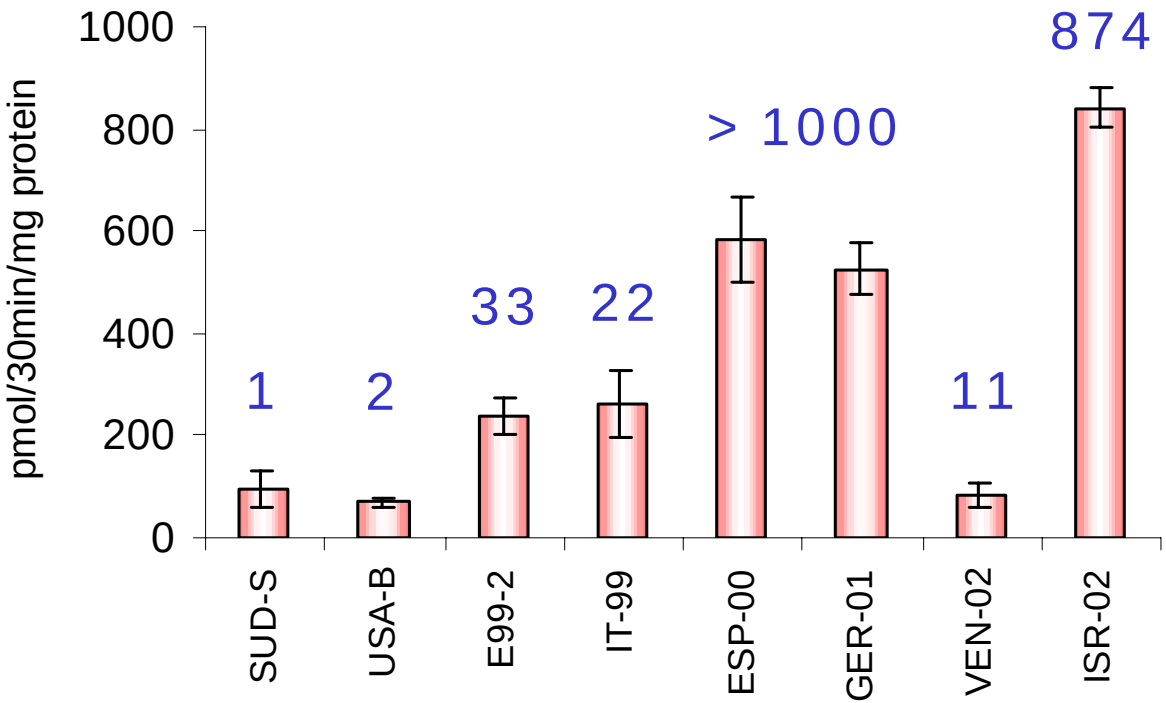


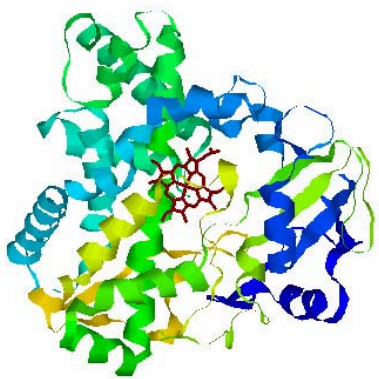
Rauch & Nauen (2003) Arch Insect Biochem Physiol. 54

Monooxygenases confer neonicotinoid resistance in *Bemisia tabaci*

Bemisia tabaci



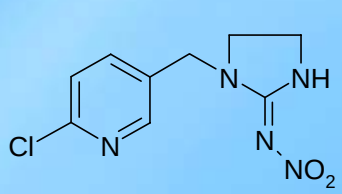


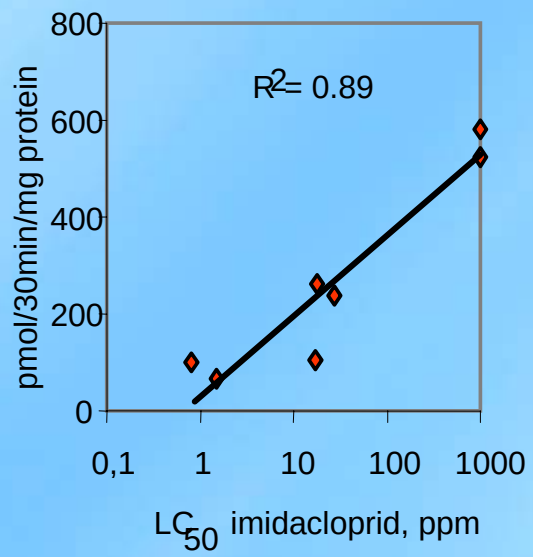


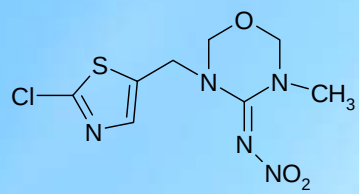
7-Ethoxycoumarin-O-deethylase activity is a biochemical marker linked to neonicotinoid resistance in ***Bemisia tabaci***

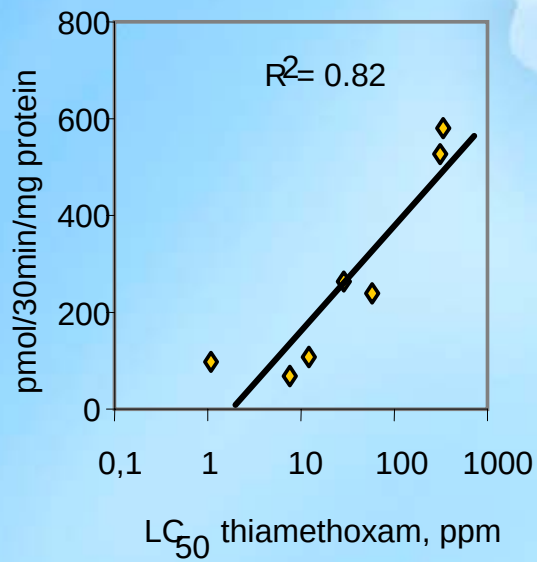
Rauch & Nauen (2003) Arch. Insect Biochem. Physiol. 54

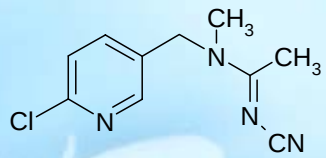
Elevated Cyt P-450 activity confers neonicotinoid cross resistance

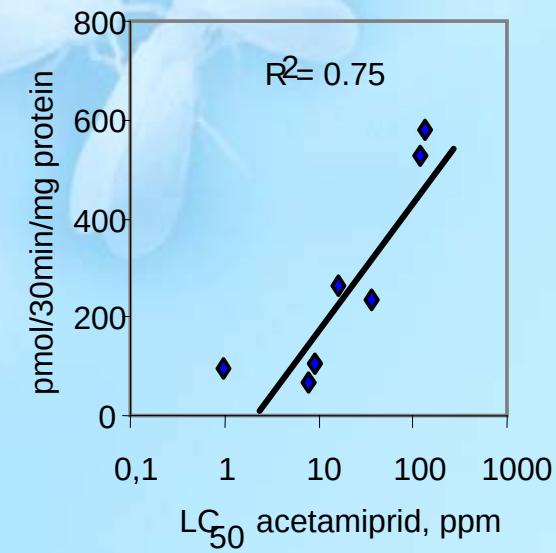






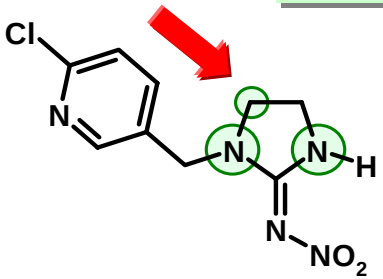




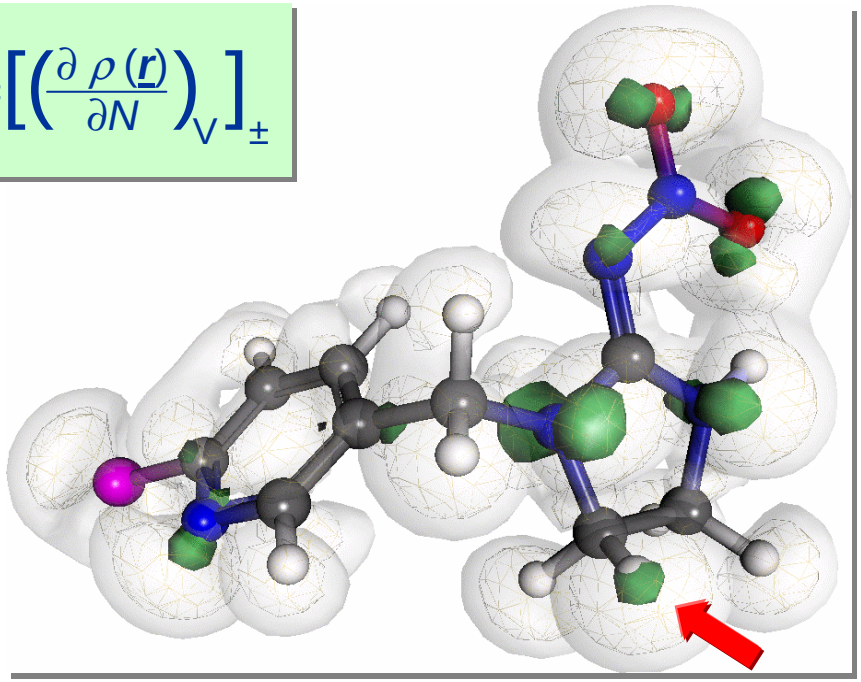


Isosurface of the Fukui Function - Electrophilic Attack

$$f^{\pm}(\underline{r}) = \left[\left(\frac{\partial \rho(\underline{r})}{\partial N}\right)_V\right]_{\pm}$$



IMI



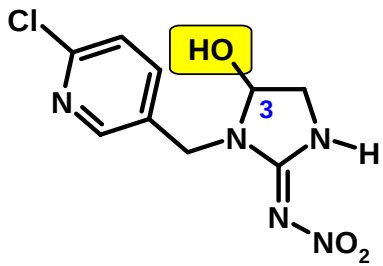
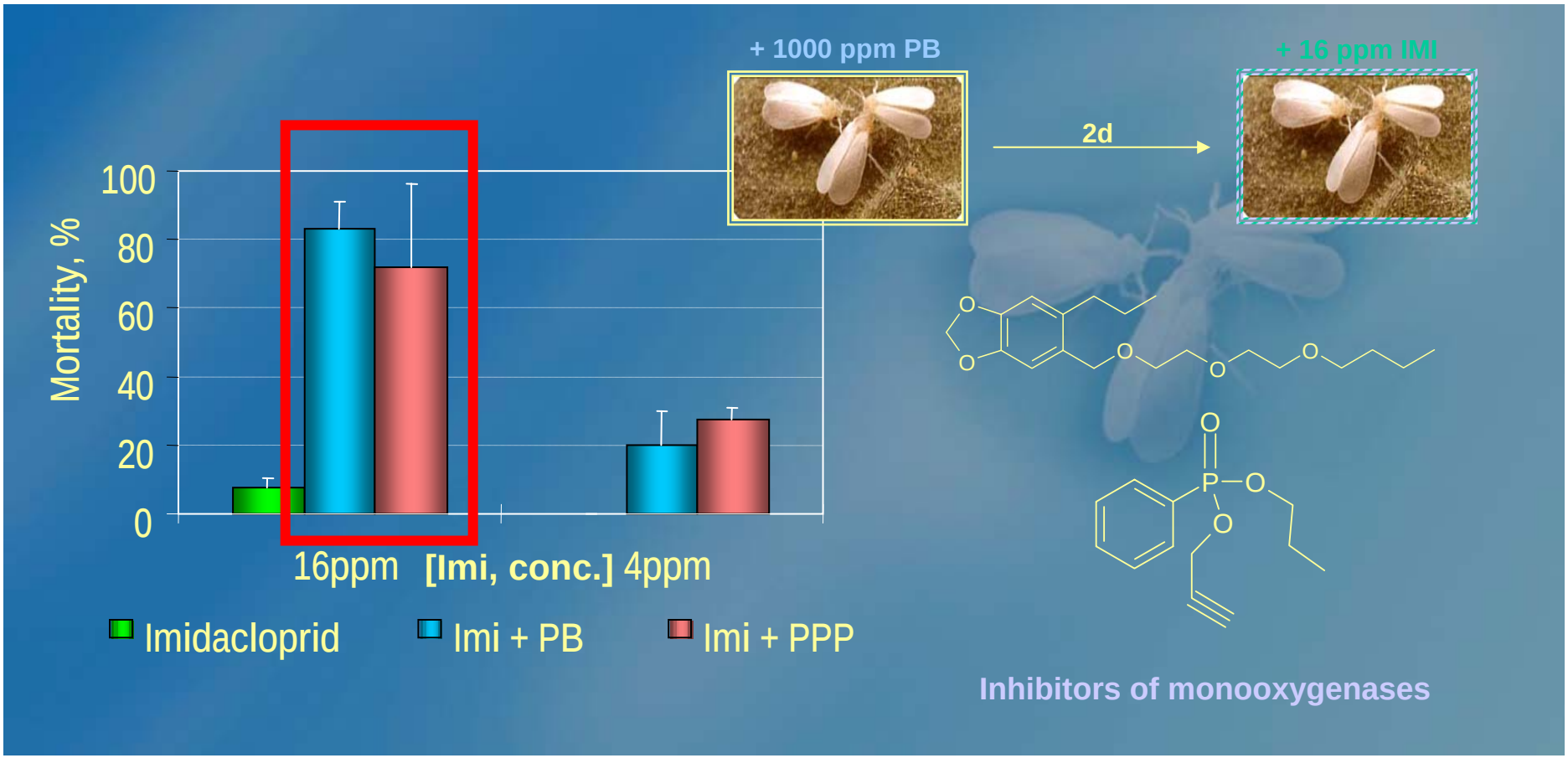


Figure 1. Isosurfaces of the Fukui function for electrophilic attack on IMI. Three levels of isosurfaces are displayed, 0.005 (green, opaque), 0.001 (yellow, transparent) and 0.0005 (white, transparent)

$f^{-}(\underline{r}) = \rho(\underline{r}, N) - \rho(\underline{r}, N-1)$

electrophilic attack Fukui function: electrons are withdrawn from the molecule

Synergism

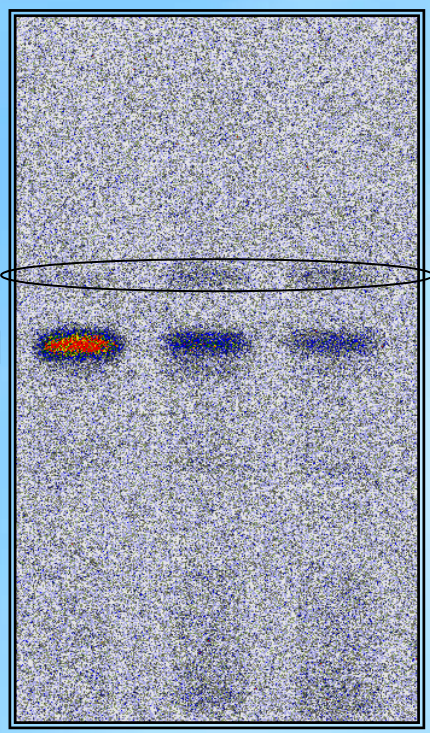

+ 1000 ppm PB
+ 16 ppm IMI
2d
Mortality, %
100
80
60
40
20
0
16ppm
[Imi, conc.]
4ppm
Imidacloprid
Imi + PB
Imi + PPP
Inhibitors of monooxygenases

Only one biochemical mechanism of resistance to neonicotinoid insecticides was found in five years of research: Microsomal monooxygenases

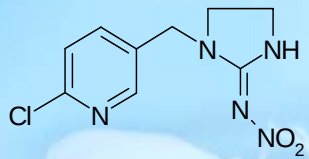
- 20ml glass vials
- 50,000 dpm coated
- Transfer of 500 adults
- 24h exposure
- Homogenisation
- Centrifugation
- Supernatant TLC

SUD-S ESP-00 GER-01

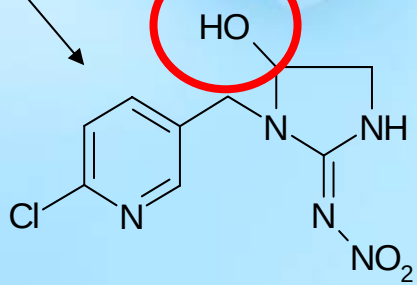
IMI



I_{50}, nAChR

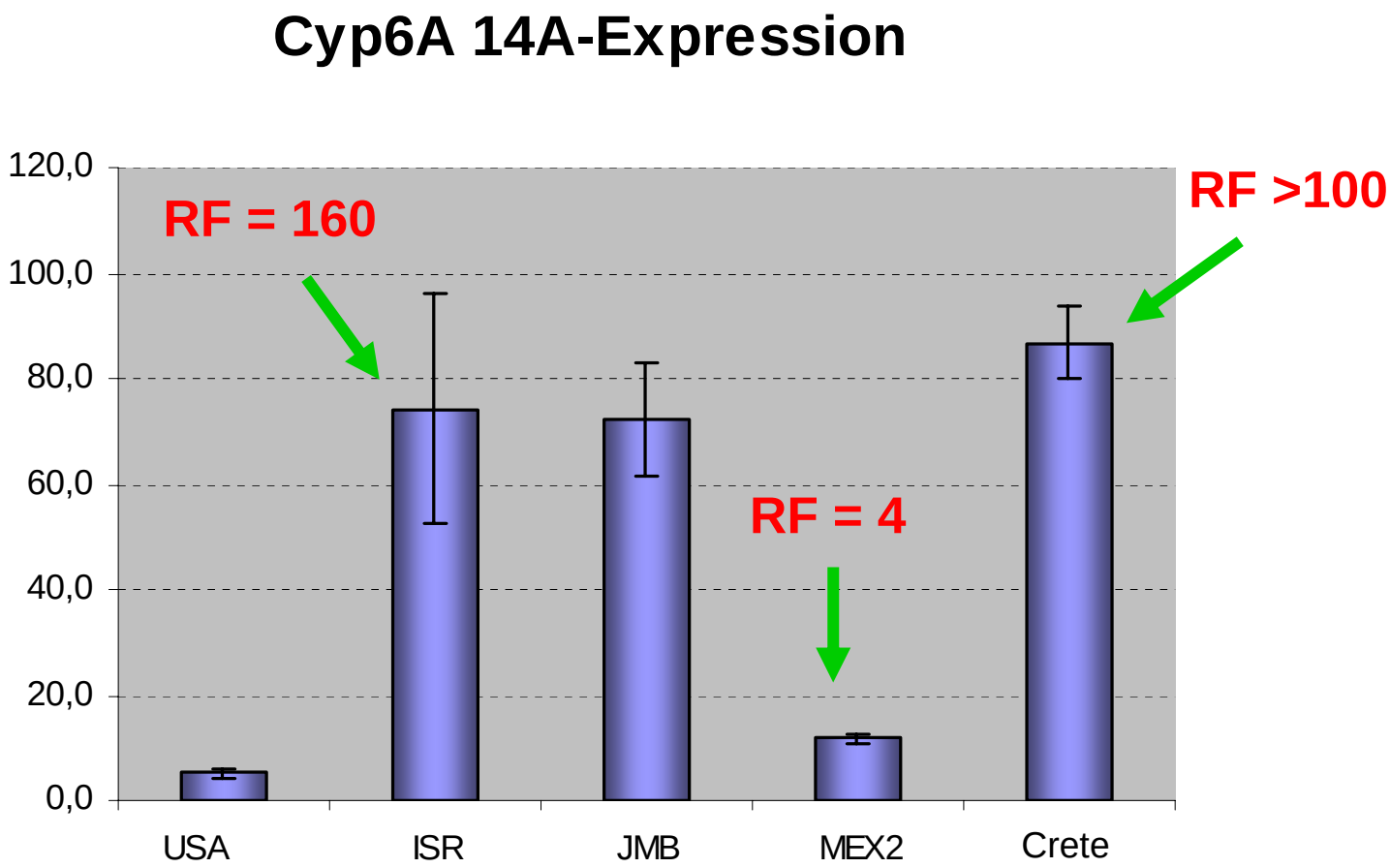


1.8 nM



23 nM

Biochemistry of neonicotinoid resistance – molecular analysis of *B. tabaci* P450 genes identified *cyp6A14A* levels linked to neonicotinoid resistance*



**Data kindly provided by Dr. Juergen Benting (Bayer CropScience, Monheim, Germany)*

INSECTICIDE RESISTANCE AND RESISTANCE MANAGEMENT

Dynamics of Resistance to the Neonicotinoids Acetamiprid and Thiamethoxam in *Bemisia tabaci* (Homoptera: Aleyrodidae)

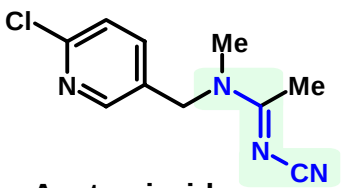
A. RAMI HOROWITZ,[1] SVETLANA KONTSEDALOV,[2] AND ISAAC ISHAAYA[2]

J. Econ. Entomol. 97(6): 2051–2056 (2004)

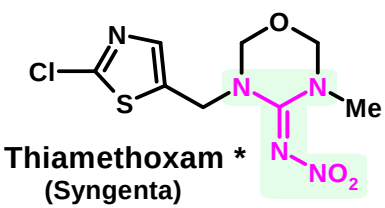
ABSTRACT The dynamics of resistance in the sweetpotato whitefly, *Bemisia tabaci* (Gennadius), to the neonicotinoids acetamiprid and thiamethoxam was studied extensively in cotton fields in Israel during the cotton-growing seasons 1999–2003. Whitefly strains were collected in early and late seasons mainly in three locations in northern, central, and southern Israel. The whiteflies were assayed under laboratory conditions for susceptibility to neonicotinoids, as part of the Israeli cotton insecticide resistance management strategy. Selections to both acetamiprid and thiamethoxam and cross-resistance between them also were conducted in the laboratory. Although no appreciable resistance to acetamiprid was observed up to 2001, a slight increase of approximately five-fold resistance was detected during 2002 and 2003. However, from 2001 to 2003 thiamethoxam resistance increased >100-fold in the Ayalon Valley and Carmel Coast cotton fields. In cross-resistance assays with both neonicotinoids, the strain that had been selected with thiamethoxam for 12 generations demonstrated almost no cross-resistance to acetamiprid, whereas the acetamiprid-selected strain exhibited high cross-resistance of >500-fold to thiamethoxam.

KEY WORDS *Bemisia tabaci*, neonicotinoids, cross-resistance, acetamiprid, thiamethoxam

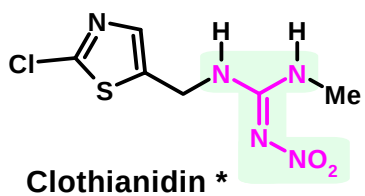
Acetamiprid-selected whiteflies are highly cross-resistant to thiamethoxam, but not *vice versa*!



Acetamiprid
(Nippon Soda)



Thiamethoxam *
(Syngenta)



Clothianidin *
(SumiTake / Bayer AG)

Insecticide cross-resistance in several strains of *Bemisia tabaci*

Strain	Origin	Date	Host plant	Biotype
CRE04-01	Crete	2004	Tomato	Q
BR-JM03	Brazil	2003	Tomato	B
ISR-02	Israel	2002	Ornamentals	B
MEX03-02	Mexico	2003	Tomato	B
TUC-03	USA	2003	Melon	B
ESP-00	Spain	2000	Pepper	Q
ALM-1	Spain	1994	Tomato	Q

12 (!) different whitefly insecticides (i.e. covering all relevant chemical classes commercially available) were tested in a leaf-dip bioassay (3-4d) against all strains,

Strain SUD-S (insecticide susceptible)

		Concentration [ppm]						
Compound		**200**	**40**	**8**	**1,6**	**0,32**	**0,064**	**Sum**
Spiromesifen	Mean	100	100	96	78	45		419
*	SEM	0	0	2,67	10	5,5		
Imidacloprid	Mean	100	100	95	90	65	5	455
	SEM	0	0	5	0	25	5	
Thiamethoxam	Mean	100	93	83	53	20		349
	SEM	0	5	5	5	8		
Dinotefuran	Mean	100	100	100	93	60	0	453
	SEM	0	0	0	9,42	5	0	
Pymetrozine	Mean	100	100	95	95	60	45	495
	SEM	0	0	5	5	10	5	
Pyriproxyfen	Mean	86	52	47	7			192
*	SEM	1,33	7,33	6,5	1,78			
Buprofezin	Mean	100	100	100	71	42	0	413
*	SEM	0	0	0	3,11	3,5	0	
Pyridaben	Mean	95	85	35	25			240
	SEM	5	5	5	10			
Deltamethrin	Mean	70	30	25	20			145
	SEM	20	10	5	0			
Monocrotophos	Mean	100	47	18				165
	SEM	0	14,81	6,01				
Endosulfan	Mean	100	98	50				248
	SEM	0	6	25				

* nymphs

Strain ESP-00 (Q-type)

Compound		Concentration [ppm] 200	40	8	1,6	0,32	0,064	Sum
Spiromesifen	Mean	95	99	72	57	37	0	360
*	SEM	3,33	0,88	2,67	1	8,67	0	
Imidacloprid	Mean	57	27	10	0			94
	SEM	15,56	4,44	0	0			
Thiamethoxam	Mean	87	23	3	0			113
	SEM	6,67	4,44	4,44	0			
Dinotefuran	Mean	100	73	45	27	0		245
	SEM	0	11,11	4,44	4,44	0		
Pymetrozine	Mean	53	47	17	0			117
	SEM	22,22	11,11	5	0			
Pyriproxyfen	Mean	73	44	19	7			143
*	SEM	1,5	4,5	5	6,5			
Buprofezin	Mean	73	54	47	17			191
*	SEM	3,5	2	4,5	9,5			
Pyridaben	Mean	100	63	0				163
	SEM	0	11,1	0				
Deltamethrin	Mean	43	0					43
	SEM	24,44	0					
Monocrotophos	Mean	53	17	7				77
	SEM	4,44	8,89	4,44				
Endosulfan	Mean	100	57	40	17			214
	SEM	0	4,44	6,67	4,44			
Flonicamid	Mean	73	20	0	0			93
	SEM	4,44	4,44	0	0			

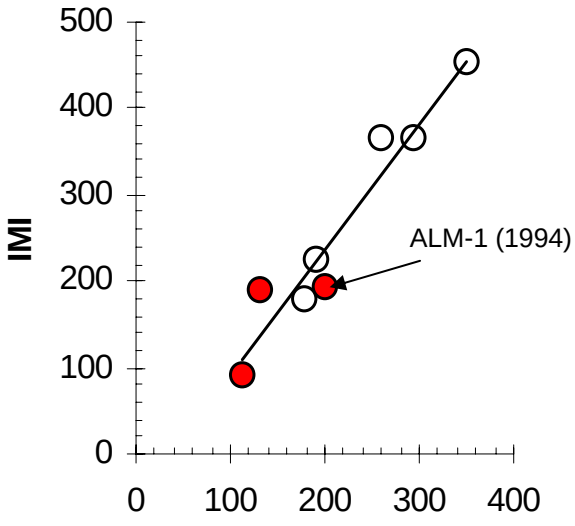
* nymphs

Neonicotinoid cross-resistance in *Bemisia tabaci*

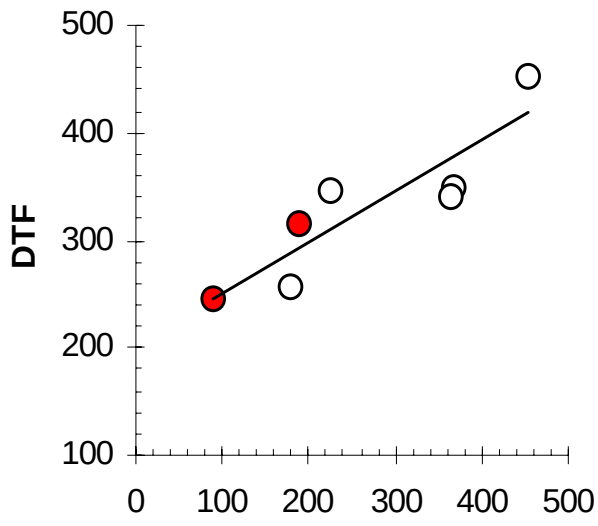
IMI = Imidacloprid

TMX = Thiamethoxam

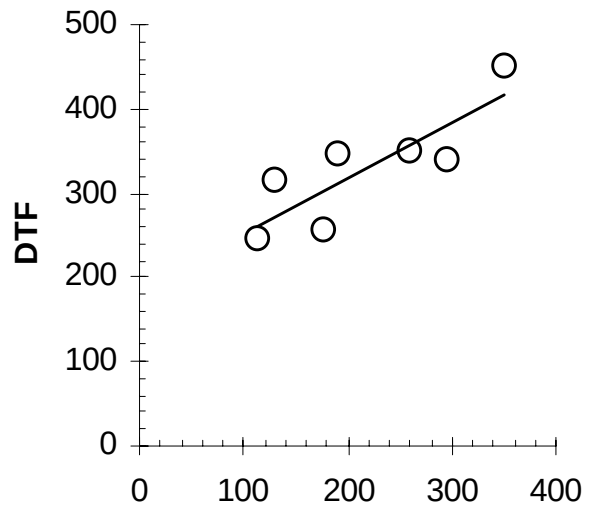
DTF = Dinotefuran



y = 1,4592x - 54,2
R^2 = 0,9289



y = 0,472x + 203,26
R^2 = 0,79

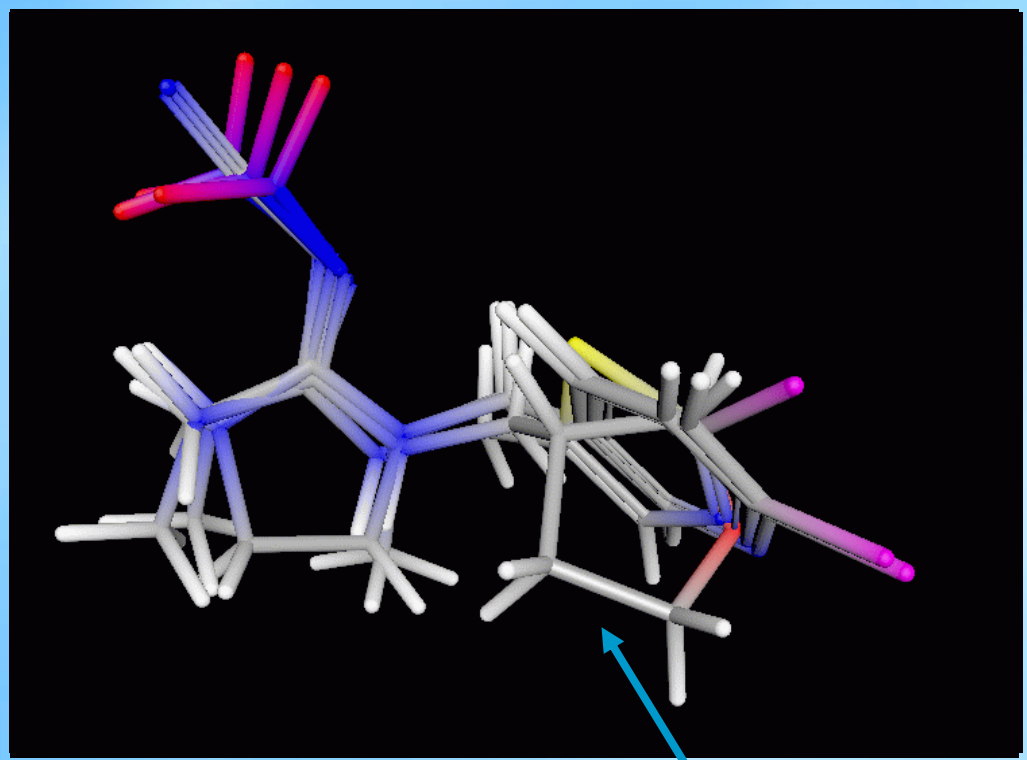


y = 0,6622x + 186,2
R^2 = 0,7048

Q-type
B-type

Correlated are efficacy indices for the compounds displayed. An efficacy index results from mortality figures scored at different concentrations and subsequently summarized.

Alignment of DFT/BP/SVP/COSMO optimized geometries of neonicotinoids



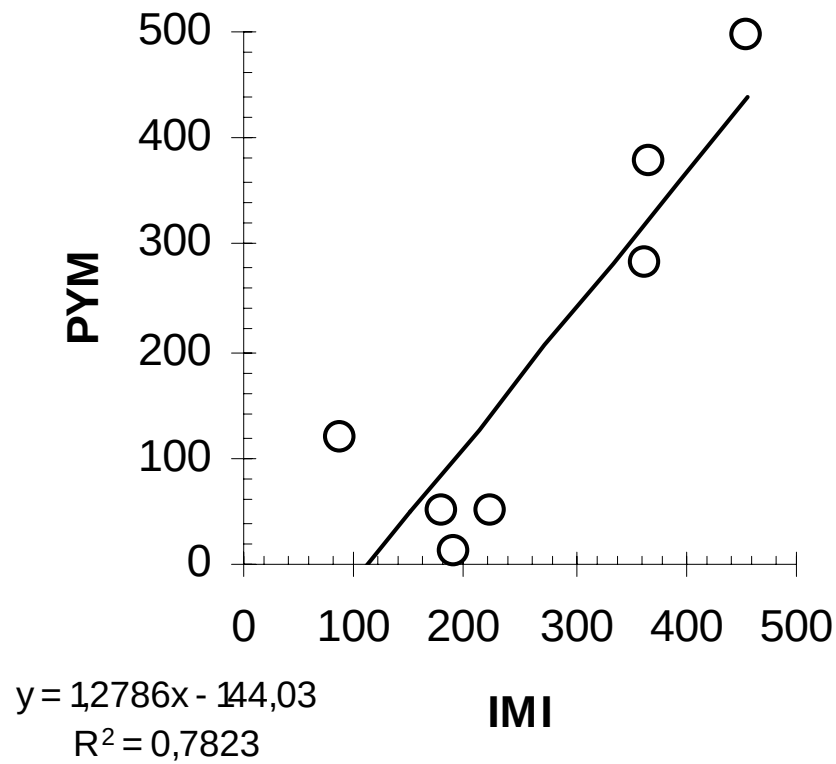
Dinotefuran

The alignment was done by minimization of the mutual spatial distance of three pharmacophoric points, namely

(i) the positively charged C-atom connected to the N-NO_2 and N-CN moiety
(ii) the nitro/cyano groups themselves
(iii) the nitrogens of the aromatic rings

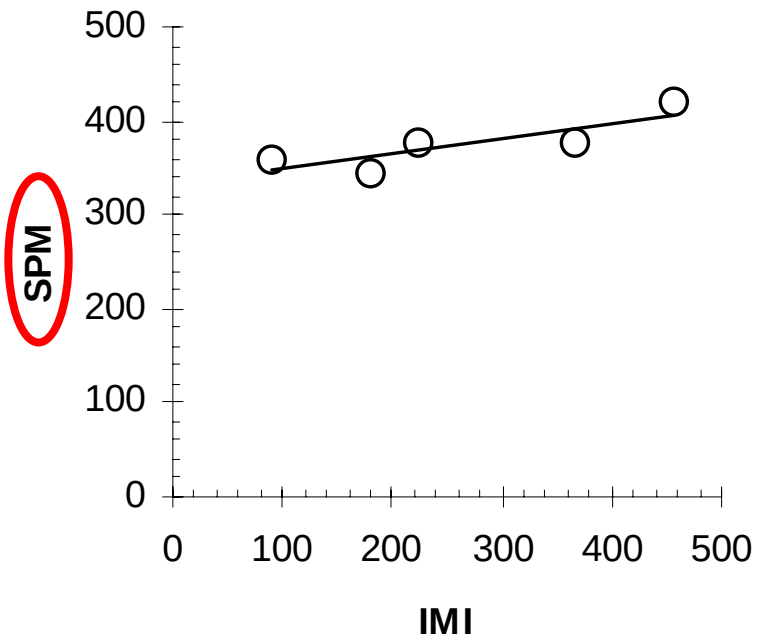
Pymetrozine is clearly cross- resistant to neonicotinoids in *Bemisia tabaci* as results from leaf-dip bioassays revealed

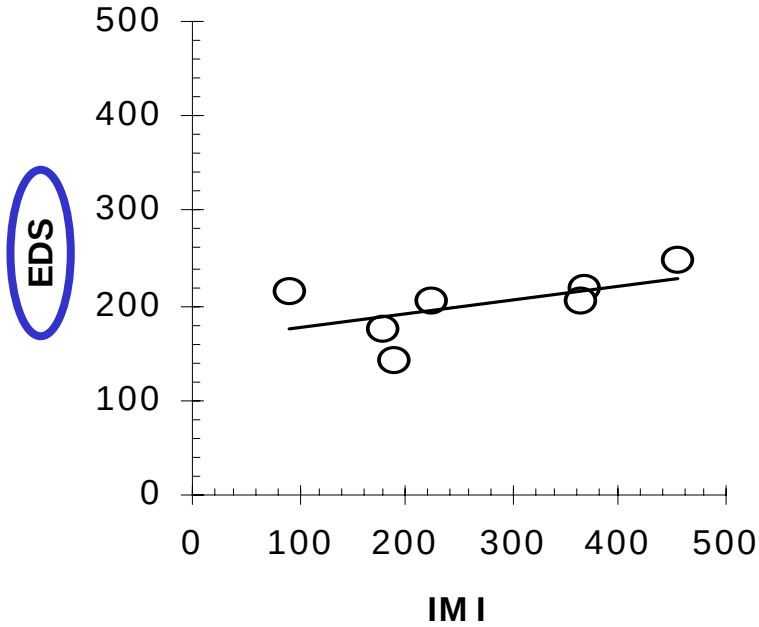
IMI = Imidacloprid
PYM = Pymetrozine



Correlated are efficacy indices for the compounds displayed. An efficacy index results from mortality figures scored at different concentrations and subsequently summarized.

Efficacy of spiromesifen and endosulfan against *Bemisia tabaci* is not correlated w/ neonicotinoid resistance as leaf-dip bioassays revealed

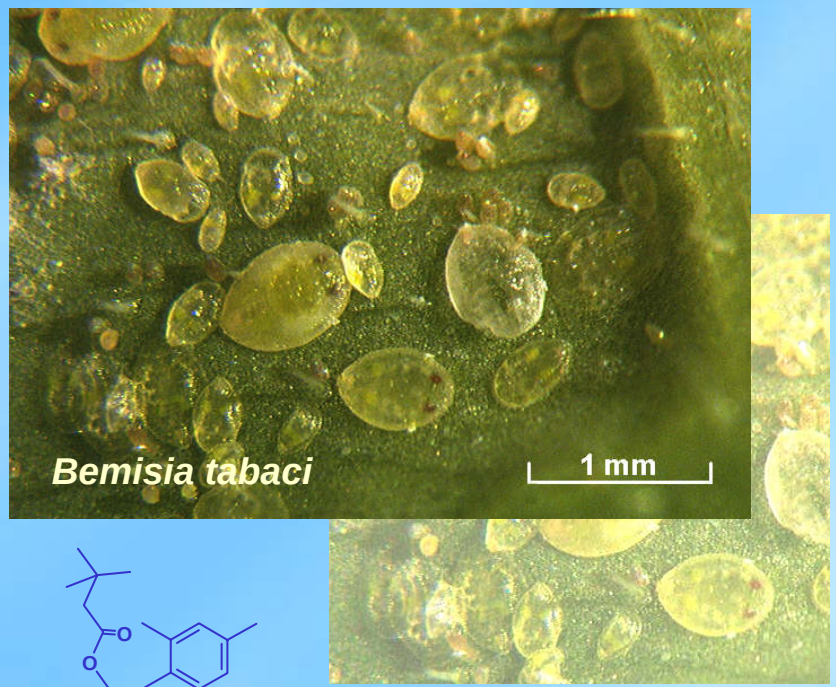




Correlated are efficacy indices for the compounds displayed. An efficacy index results from mortality figures scored at different concentrations and subsequently summarized.

IMI = Imidacloprid
SPM = Spiromesifen
EDS = Endosulfan

Spiromesifen* is highly active against neonicotinoid resistant whiteflies and a new chemical tool in IRM



- ➔ Active against whitefly nymphs (all stages)
- ➔ Active against adults at high concentrations
- ➔ Reduction of adult fecundity (fewer eggs)
- ➔ Transovarial effects on egg hatch
- ➔ New IRAC MoA Group 23

* o·b·e·r·o·n® SMART PERFORMANCE!

NEW! JUDO

Bayer CropScience

Summary

- There is cross-resistance between all neonicotinoid insecticides in field-collected strains of *B. tabaci,* i.e. selecting with one will impact performance of all others
- Pymetrozine seems to be cross-resistant to neonicotinoids
- Neonicotinoids are most likely detoxified by oxidative metabolism as elevated P450 levels, synergist studies and *in vivo* metabolism experiments revealed
- Neonicotinoid resistance in B- and Q-biotypes is conferred by different cytochrome P450´s
- No target site insensitivity yet found
- Spiromesifen is a new chemical option and tool for whitefly resistance management