IRM for sustainable whitefly control with special reference to *Bemisia tabaci*

Insecticide Resistance Action Committee

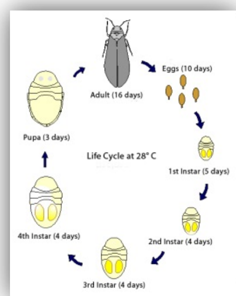
www.irac-online.org

Introduction and background

Whiteflies (Homoptera: Aleyrodidae) globally comprises approx. 1500 species, but only a few of them are known and described as serious sucking pests in numerous agricultural and horticultural settings. Among them the cotton whitefly, *Bemisia tabaci* is by far the most important one, followed by the greenhouse whitefly, *Trialeurodes vaporariorum*. *B. tabaci* is known for its genetic diversity resulting in morphologically indistinguishable species rather than biotypes. The two most important phylogenetic groups of *B. tabaci* from an agricultural perspective are MEAM1 (Middle East-Asia Minor 1; also commonly known as biotype B) and MED (Mediterranean; including the commonly known biotype Q among others). *B. tabaci* causes damage to a diverse range of host plants by symplastic feeding, transmission of numerous plant viruses and indirectly by the excretion of honeydew as a substrate for sooty mold.

In order to keep crop infestations by *B. tabaci* under economic damage thresholds insecticide treatments are quite common, so that insecticide resistance developed against many chemical classes of insecticides. However there are also a number of biological control methods available these days which are particularly successful under greenhouse conditions rather than open field situations.

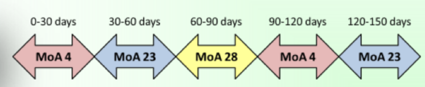
Life cycle *Bemisia tabaci*



Bemisia tabaci adults on cotton

IRM "MoA treatment windows" approach

- The basic rule for adequate rotation of insecticides by mode of action (MoA) is to avoid treating consecutive generations of the target pest with insecticides in the same MoA group, by using a scheme of " MoA treatment windows".
- A treatment window typically encompasses a full life-cycle of *B. tabaci* (max. 30 days).
- Multiple applications of the same MoA group may be possible within a particular window (follow label for maximum number of applications within a window and per crop cycle).
- After a first MoA window of 30 days is completed and if additional insecticide applications are needed, a different and effective MoA should be selected for use in the next 30 days (second MoA window) etc.
- The proposed scheme seeks to minimize the selection of resistance to any given MoA group and requires a minimum of three effective insecticide MoA groups .



MoA window treatment example for *Bemisia* control on tomatoes

Resistance mechanisms in brief

Target-site resistance

Reduced or even no binding of the insecticide to its target-site due to mutations evolved by continuous selection[2], e.g.

- ➢ Knock-down resistance (kdr) → Pyrethroids
- ➢ Modified acetylcholinesterase → OP´s, carbamates

Metabolic resistance

Detoxification (degradation) of insecticides due to the over-expression of metabolic enzymes[3], e.g.

- ➢ Cytochrome P450 CYP6CM1 → Neonicotinoids & pymetrozine
- ➢ Elevated levels of carboxylesterases → Organophosphates

Chemical control of *Bemisia tabaci*

- The IRAC mode of action (MoA) classification scheme[4] lists 13 different MoA´s for whitefly control (covering 17 chemical subgroups)
- Compounds should be used according to the label recommendations
- Select insecticides based on known local effectiveness and selectivity (IPM!)
- Rotating compounds from different mode of action groups is strongly recommended (use window approach) – see box
- Non-chemical control methods should be incorporated (IPM)

IRAC Group	Mode of action	Subgroup	Chemical class
1	Acetylcholinesterase inhibitors	A	Carbamates
		B	Organophosphates
3	Sodium channel modulators	A	Pyrethroids
4	nAChR competitive modulators	A	Neonicotinoids
		C	Sulfoxaflor
		D	Flupyradifurone
7	Juvenile hormone mimics	C	Pyriproxyfen
9	Effectors of chordotonal organs	B	Pymetrozine
		D	Afidopyropen
12	Inhibitors of mitochondrial ATP synthase	A	Diafenthiuron
15	Inhibitors of chitin biosynthesis, type 0	None	Benzoylureas
16	Inhibitors of chitin biosynthesis, type 1	None	Buprofezin
21	Mitochondrial complex I inhibitors	A	METI´s
23	Inhibitors of acetyl-CoA carboxylase	None	Spirotetramat
28	Ryanodine receptor modulators	None	Cyantraniliprole
29	Chord. organ modulators, undefined	None	Flonicamid
UN	Compounds of unknown MoA	None	Azadirachtin

References:

(1) Shatters et al. (2009) *J. Econ. Entomol.* **102**, 750; (2) Alon et al. (2008) *Insect Biochem. Mol. Biol.* **38**, 940; (3) Nauen et al. (2013) *Pest Manag. Sci.* **69**, 457; (4) Sparks & Nauen (2015) *Pestic. Biochem. Physiol.* **121**, 122; (5) Naveen et al. (2017) *Sci. Reports* **7**, 40634

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