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CITRUS PEST MANAGEMENT IN THE NORTHERN MEDITERRANEAN BASIN (SPAIN, ITALY AND GREECE)

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Abstract. Main management options for arthropod pests of citrus and species recently introduced in the northern Mediterranean regions are reviewed. Available control strategies are discussed, including visual inspection practices, insect trapping methods and natural enemies release in augmentative or classical biological control. IPM practices and side effects of pesticides are also reviewed.

1. INTRODUCTION

The most widely cultivated citrus species in the Mediterranean region include orange [*Citrus sinensis* (L.) Osbeck], lemon [*Citrus limon* (L.) Burman f.], mandarin (*Citrus reticulata* Blanco), tangerine (*Citrus deliciosa* Tenore), grapefruit (*Citrus paradisi* Macfadyen), sour orange (syn. Chinese bitter orange, bigarade orange, Seville orange) (*Citrus aurantium* L.), lime [*Citrus aurantifolia* (Christm.) Swingle] and citron (*Citrus medica* L.) (Katsoyannos, 1996). Minor citrus species are pumelo (syn. shaddock) [*Citrus maxima* (Burm.) Merrill, syn. *C. grandis* (L.) Osbeck, *C.*

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decumana L.], bergamot (*Citrus bergamia* Risso) and chinotto or myrtle-leaved orange (*Citrus myrtifolia* Raf.).

The total area of citrus production in the Mediterranean region sums up to 1,036,878 ha (Franco, García-Marí, Ramos, & Besrí, 2006; ISTAT, 2007; El-Otmani, Srairi, & Benhaddou, 2007; Laajimi & Ben Mimoun, 2007; MAPA, 2007; Salama Eid, Latif, & Hassan, 2007) with more than 2/3 of the entire area concentrated in Spain, Italy, Egypt and Turkey (Table 1). Integrated Pest Management is performed on a percentage of this area that varies in each country from less than 1% in France (Corsica) to 100% in Israel. In Italy, Morocco and Portugal 10–20% of the total citrus production area is under IPM, while in Turkey this management strategy is applied on 30% of this area. Integrated production (IP) is only reported in Spain, Italy, Portugal and France ranging between 0.4% (Portugal) and 10% (Italy) of the total citrus area (Franco et al., 2006).

Table 1. Total area of citrus production and percentage of integrated pest management (IPM) and integrated production (IP) in Mediterranean countries (modified from Franco et al., 2006. N.a. stands for not available).

Country	*Citrus production area (ha)*	*IPM (%)*	*IP (%)*
Spain	311,004	Most of the area	5
Italy	164,938	10–20	10
Egypt	151,075	n.a.	n.a.
Turkey	150,000	30	–
Morocco	80,000	10–20	–
Greece	57,526	Most of the area	–
Algeria	45,400	n.a.	–
Portugal	27,755	14	0.4
Tunisia	18,600	n.a.	n.a.
Israel	17,300	100	–
Georgia	11,000	n.a.	–
France (Corsica)	1,800	<1	<5
Montenegro	480	–	–

In Italy, France, Portugal and Spain citrus growers receive financial support for practicing IPM and IP as part of EU Agri-environmental measures. Requisites for a grower to receive this aid, depending on the country, include: being an associate of an IPM/IP farmer organization (Italy, Portugal); attending a course on IPM/IP (Spain, Portugal); following official IPM/IP guidelines (Italy, Spain, Portugal); keeping accurate records of pesticide applications and, in the case of IP, other cultural practices (Italy, Portugal, Spain).

IPM/IP guidelines are defined at regional level in Greece, Portugal and Turkey, and at both regional and national level in Israel, Italy and Spain. IPM/IP certification companies are reported in Italy, Spain and Portugal (Franco et al., 2006).

Guidelines for Integrated Production of Citrus have been produced by the IOBC/WPRS Commission "IP-Guidelines and Endorsement" (IOBC/WPRS, 2004), and they mainly concern standards for the IP organizations in order to develop national or local guidelines. According to these standards and in relation to integrated plant protection, all available preventive (indirect) plant protection measures must be applied before direct control techniques are used. Priority should be given to natural, cultural, biological, genetic (GMOs are generally excluded and permission may be given on a case-by-case study) and biotechnical methods of pest control and the use of agrochemicals should be minimized.

The decision for the application of direct control methods must be based on economic thresholds, wherever possible, risk assessments and forecasts, including those provided by official forecasting services. A restricted list of the key pests, diseases and weeds that require regular attention must be established by the IP organizations and their populations should be regularly monitored and recorded. In addition at least three key natural enemies in each crop must be identified in national/regional guidelines. Furthermore, the use of plant protection products toxic to these beneficial arthropods should be reduced to a minimum and always in periods of low activity of the natural enemies, or of low risk for them. Populations of key natural enemies must be preserved and incremented.

With regard to pesticides, all those locally or nationally available must be classified by the IP organizations in two lists: the "green list" including the permitted products and the "yellow list" including those pesticides permitted with restrictions. The pesticides categorization is based on several criteria (i.e. toxicity to man, toxicity to key natural enemies, toxicity to other natural organisms, pollution of ground and surface water, ability to stimulate pests, selectivity, persistence, incomplete information, necessity of use), and it is already established for certain pesticides and pesticide groups as follows:

- Not permitted: pyrethroid insecticides and acaricides, non-naturally occurring plant growth regulators (their use can only be allowed when absolutely necessary), organochlorine insecticides and acaricides, water polluting products and very persistent herbicides;
- Permitted with restrictions: dithiocarbamate fungicides (normally maximum of three applications per season and not in succession, so that predatory phytoseiid mites are not affected), fosetil-Al and phosphonate potassium (maximum of two applications per year), metalaxyl (maximum of 2 g/m^2), residual (soil) herbicides (except toxic, polluting or very persistent products) in the first 3 years after planting (maximum of one dose-equivalent per annum).

Officially recognized dose adjustment protocols must be used where available, in order to adapt dose rates to the size and density of the target trees being sprayed. The maximum volume of application per hectare must be defined according to the

tree volume. A strategy of mandatory measures for minimizing the risk of resistance development of pests to pesticides (e.g. maximum number of applications per year, alternation of pesticides with different mode of action) must be set by the IP organizations. The growers/applicators must be trained in the use and the application of pesticides.

2. MAIN ARTHROPOD PESTS AND CONTROL STRATEGIES

In the citrus producing countries of the Mediterranean basin more than 140 pests and diseases are reported, including 108 insects, 10 mites, 1 nematode, 14 fungi, 2 bacteria and 8 virus and virus like diseases (Franco et al., 2006).

Among arthropods, the major pests, i.e. reported as key-pests in at least 50% of the countries, include the medfly *Ceratitis capitata* (Wiedemann) (100% of the countries), the California red scale *Aonidiella aurantii* (Maskell) (71%), the citrus leafminer *Phyllocnistis citrella* Stainton (71%) and the citrus mealybug *Planococcus citri* (Risso) (71%) (Table 2).

Quarantine pests recently introduced in the western Mediterranean area include the brown citrus aphid *Toxoptera citricida* (Kirkaldy) (Northern Spain, from Galicia to the Basque Country, Madeira island and North of Portugal), the African citrus psylla *Trioza erytreae* (Del Guercio) (Madeira and Canary islands) and the citrus snow scale *Unaspis citri* (Comstock) (Azores, Malta and France). These species are included in the EPPO lists A1–A2 and are therefore regulated as quarantine pests in the whole EPPO region (EPPO, 2007). Special attention must be paid to *T. citricida* and *T. erytreae* as they are efficient vectors of the citrus tristeza virus (CTV) and the Huanglongbing agent (Candidatus *Liberobacter*), respectively.

2.1. Sampling and Monitoring

In IPM, pest control decisions are directly dependent upon knowing the status and population trends of the most important insect pests and their natural enemies (Beardsley, AliNiazee, & Watson, 1979; Cavalloro & Prota, 1983; Katsoyannos, 1996). Sampling and monitoring are the means for acquiring this important knowledge. Simplified sampling guidelines for monitoring the main citrus insect pests in the northern Mediterranean have been advised by experts defining methods of visual inspection as well as trapping using food, chromotropic and sexual attractants for monitoring purposes (Katsoyannos, 1996) (Tables 3 and 4).

2.2. Biological Control

Biological Control has been proved very effective in management of insect pests in citrus orchards. Among 65 cases of successful biological control and 83 cases of satisfactory control of insect pests in various crops, which have been recorded all over the world, 61.5% of the first mentioned and 21.7% of the latter concern citrus (De Bach, 1964).

Several programmes of augmentative and classical biological control by means of parasitoids and predators of the main citrus pests have been conducted in most of the northern Mediterranean citrus growing countries (Table 5). The results vary, however, several successful cases have been recorded (Viggiani, 1975; Amaro, 1992; Noyes & Hayat, 1994; Katsoyannos, 1996; Tsagarakis, Kalaitzaki, Lykouressis, Michelakis, & Alexandrakis, 1999; Kalaitzaki, 2004; Siscaro, Caleca, Reina, Rizzo, & Zappalà, 2003; Siscaro, Di Franco, & Zappalà, 2008; Gomes da Silva, Borges da Silva, & Franco, 2006; Jacas, Urbaneja, & Viñuela, 2006; Malausa, Rabasse, & Kreiter, 2008; Zappalà, Siscaro, & Longo, 2008).

Table 2. Arthropod pests of citrus and rating of their pest status in the northern Mediterranean regions (modified from Franco et al., 2006).*

Group	*Order*	*Family*	*Species*	*France (F)*	*Greece (G)*	*Italy (I)*	*Montenegro (M)*	*Portugal (P)*	*Spain (S)*	*Turkey (T)*
Insects										
	Orthoptera									
		Acrididae	*Anacridium aegyptium* (L).		0	1	0	1	1	0
		Tettigonidae	*Phaneroptera nana* Fiebre		0	0	0	2	1	0
	Thysanoptera									
		Thripidae	*Frankliniella bispinosa* (Morgan)		0	0		1[a]	0	0
			Frankliniella occidentalis (Pergande)	1	1	1		2	1	2
			Heliothrips haemorrhoidalis (Bouché)		1	2[b]		2	1	0
			Pezothrips kellyanus (Bagnall)		2	2		1[b]	1	2
			Thrips australis (Bagnall)		0	0		1	0	0
			Thrips flavus Schrank		1	1		2	1	0
			Thrips major Uzel		1	0		2	1	2
			Thrips tabaci Lindeman		1	1	1	2	0	2
	Hemiptera									
		Pentatomidae	*Nezara viridula* (L.)		1	1	0	1	0	2
		Miridae	*Closterotomus trivialis* (Costa)		2	2	0	0	1,2	0
		Flatidae	*Metcalfa pruinosa* (Say)	**3**	**1**	**1**	**1**	**0**		**0**
		Cicadellidae	*Empoasca decedens* (Paoli)		0	1	1	0	2[c]	1
		Triozidae	*Trioza Erytreae* (Del Guercio)	**0**	**0**	**0**		**3**[a]	**2**[d]	**0**

Table 2 continued

Group	*Order*	*Family*	*Species*	*France (F)*	*Greece (G)*	*Italy (I)*	*Montenegro (M)*	*Portugal (P)*	*Spain (S)*	*Turkey (T)*
		Aleyrodidae	*Aleurothrixus Floccosus* (Maskell)	**3**	**2**	**2**	**1**	**3**	**2**	**2**
			Bemisia afer (Priesner & Hosny)		0	1	0	0	1	0
			Bemisia tabaci (Gennadius)							2
			Dialeurodes citri (Ashmead)	**3**	**2**[e]	**1**	**3**	**0**	**1**	**1**
			Dialeurodes citrifolii (Morgan)		0	0	0	1[a]	0	0
			Parabemisia myricae (Kuwana)	0	1	1	0	1	1	2
			Paraleyrodes bondari Peracchi		0	0	0	1[a]	0	0
			Paraleyrodes citricolus Costa Lima		0	0	0	1[a]	0	0
			Paraleyrodes minei Iaccarino		0	0	0	1	1	2
		Aphididae	*Aphis craccivora* Kock	2	1	1	2	1	1	2
			Aphis fabae Scopoli	2	1	1		1	1	0
			Aphis gossypii Glover	**3**	**2**	**2**	**0**	**3**	**2**	**1**
			Aphis spiraecola Patch		**2**	**2**	**0**	**3**	**2**	**1**
			Aulacorthum solani (Kaltenbach)	2	1	1	0	1	0	0
			Macrosiphum euphorbiae (Thomas)	2	1	1	0	1	0	0
			Myzus ornatus Laing		0	0	0	1[a]	0	0
			Myzus persicae (Sulzer)	2	1	1		1	1	1
			Neomyzus circunflexum (Buckton)		0	0	0	0	0	0
			Rhopalosiphum maidis (Fitch)		0	1	0			0
			Toxoptera aurantii (Boyer de) (Fonscolombe)	**3**	**2**	**2**	**2**	**3**	**1**	**2**
			Toxoptera citricida (Kirkaldy)	**0**	**0**	**0**	**0**	**3**[fa]	**2**[g]	**0**
		Margarodidae	*Icerya purchasi* Maskell	**3**	**1**	**1**	**1**	**2**	**1**	**1**
		Ortheziidae	*Orthezia insignis* Douglas		0	0	0	1[a]	0	0

Table 2 continued

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		Pseudococcidae	*Nipaecoccus nipae* (Maskell)		0	0	0	1[a]	0	0
			Phaenacoccus madeirensis Green		0	1	0	0		0
			Planococcus citri (Risso)	**3**	**3**	**2, 3**	**1**	**3**	**1, 2**	**3**
			Pseudococcus calceolariae (Maskell)		0	1	0	2	1	0
			Pseudococcus longispinus (Targioni-Tozzetti)		1	1	0	1	1	0
			Pseudococcus viburni (Signoret)		0	1	0	2	0	1
		Coccidae	*Ceroplastes floridensis* Comstock		**1**	**0**	**0**	**1**[ah]	**1**	**3**
			Ceroplastes japonicus Green		1	1	0	0		0
			Ceroplastes rusci (L.)		1	2	0	1	1	1
			Ceroplastes sinensis Del Guercio	**3**	**1**	**1**	**1**	**2**	**1**	**0**
			Coccus hesperidum L.	**3**	**1**	**1**	**1**	**2**	**1**	**2**
			Coccus pseudo-magnoliarum (Kuwana)		1	1	2	0		2
			Coccus viridis (Green)		0	0	0	1[a]	0	0
			Eucalymnatus tessellates (Signoret)		0	0	0	1[a]	0	0
			Parasaissetia nigra (Nietner)		0	0	0	1[a]	0	0
			Parthenolecanium persicae (F.)		0	1	0	1	0	0
			Protopulvinaria pyriformis (Cockerell)	0	1	1	0	1,2[a]	1	0
			Pulvinaria floccifera (Westwood)		0	1	0	0		0
			Saissetia coffeae (Walker)		0	1	0	1,2	1	
			Saissetia oleae (Olivier)	**3**	**1**	**2**	**2**	**2**	**1**	**2**
		Diaspididae	*Aonidiella aurantii* (Maskell)	**3**	**2**	**3**	**1**	**3**[i]	**3**	**3**
			Aspidiotus nerii Bouché		**1**	**3**[b]	**0**	**1**	**2**[b]	**0**
			Chrysomphalus aonidum (L.)		1	2	0	0	0	0
			Chrysomphalus dictyospermi (Morgan)	**3**	**1**	**1**	**1**	**2**	**1**	**2**

Table 2 continued

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			Chrysomphalus pinnulifer Maskell		0	0	0	1,2[a]	0	0
			Hemiberlesia rapax (Comstock)		0	1	0	1	1	0
			Lepidosaphes gloverii (Packard)	**3**	**0**	**2**	**0**	**1**	**1**	**0**
			Lepidosaphes beckii (Newman)	**3**	**2**	**1**	**1**	**3**	**2, 3**	**2**
			Lopholeucaspis japonica (Cockerell)		0	0	0	0		0
			Mycetaspis personata (Comstock)		0	0	0	1[a]	0	0
			Parlatoria pergandei Comstock	**3**	**1**	**2**	**0**	**2**	**2, 3**	**1**
			Parlatoria ziziphi (Lucas)	0	2	2	0	0	1	0
			Diaspidiotus perniciosus (Comstock)		0	0	0	0	0	0
			Unaspis citri (Comstock)	**0**	**0**	**0**	**0**	**3**[h]	**0**	**0**
			Unaspis yanonensis (Kuwana)	2	0	2	0	0		0
Lepidoptera										
	Gracillariidae		*Phyllocnistis citrella* Stainton	**3**	**2**	**2**[jk]	**3**[jk]	**3**[j]	**1, 2**	**3**[j]
	Hyponomeutidae		*Prays citri* (Millière)	**3**	**2**	**2**[b]	**0**	**3**[b]	**3**[b]	**1**[b]
	Tortricidae		*Archips rosanus* (L.)		1	1	1	0		0
			Cacoecimorpha pronubana (Hübner)		1	1	1	2	1	2
	Geometridae		*Cleora fortunata* (Blachier)		0	0	0	1[a]	0	0
			Gymnoscelis pumilata Hübner		0	1	0	0		0
			Gymnoscelis rufifasciata (Haw.)		0	0	0	1	0	0
	Noctuidae		*Helicoverpa armigera* (Hübner)		0	0	0	1[b]	1	2
			Peridroma saucia (Hübner)		0	0	0	1	0	0
	Pyralidae		*Cryptoblabes gnidiella* (Millière)		1	1	0	2	1	2
			Ectomyelois ceratoniae (Zeller)		1	1	0	2	1	2

Table 2 continued

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		Nymphalidae	*Charaxes jasius* L.		0	1	0	0		0
	Diptera									
		Tephritidae	*Ceratitis capitata* (Wiedemann)	**3**	**3**	**3**	**2, 3**[e]	**3**	**3**	**3**[lm]
	Coleoptera									
		Curculionidae	*Asynonychus godmani* (Cratch)		0	0	0	1	0	0
			Lyxus algirus L.		0	0	0	2	1	0
			Otiorrhynchus aurifer Boheman		0	**2**[ik]	0	0		0
			Otiorrhynchus cribricollis Gyllenhall		0	**2**[ik]	0	0	1	0
			Pantomorus cervinus (Boheman)		0	0	0	2[a]	0	0
		Scarabaeidae	*Cetonia carthami aurataeformis* Curtis		0	0	0	1	0	0
			Oxythyrea funesta (Poda)		1	1	1	1	1	0
			Tropinota hirta (Poda)			1	1	1	1	0
			Tropinota squalida (Scop.)		1	1	0	1	1	0
	Hymenoptera									
		Formicidae	*Camponotus nylanderi* Emery		0	2[n]	0	0		0
			Crematogaster scutellaris (Olivier)		0	2[n]	0	0		0
			Lasius niger (L.)		0	2[n]	0	2[a]	1	0
			Linepithema (=*Iridomyrmex*) *humile* (Mayr)		0	2[n]	0	2	1	0
			Tapinoma nigerrimum (Nylander)		0	2	0	0		0
			Tapinoma simrothi Krausse		0	0	0	2[a]	1	0
Mites										
	Acariformes									
		Eriophyidae	*Aculops pelekassi* (Keifer)		2	2	2	0	0	0
			Eriophyes sheldoni (Ewing)		2	2[b]	1	2[b]	2[b]	1
			Phyllocoptruta oleivora (Ashmead)		**1**	**0**	**0**	**0**	**0**	**3**

Table 2 continued

Group	*Order*	*Family*	*Species*	*France (F)*	*Greece (G)*	*Italy (I)*	*Montenegro (M)*	*Portugal (P)*	*Spain (S)*	*Turkey (T)*
		Tarsonemidae	*Polyphagotarsonemus latus* (Banks)		1	2[b]	0	2[bk]	1	2
		Tenuipalpidae	*Brevipalpus californicus* (Banks)		1	1	0	1	1	0
			Brevipalpus phoenicis (Geijskes)		1	0	0	2	1	0
		Tetranychidae	*Eutetranychus banksi* (McGregor)		**0**	**0**	**0**	**3**[i]	**2**[o]	**0**
			Eutetranychus orientalis (Klein)		0	0	0	0	2[c]	0
			Panonychus citri McGregor	**3**	**2**	**2**	**3**	**2**	**2**	**1**
			Tetranychus urticae (Koch)	**1**	**2**	**1,2**	**1**	**1**	**1–3**	**2**

* Ratings: 3 = key pest, requires the application of control measures most of the years because of economic damage; 2 = occasional pest, may reach economic injury level; 1= potential pest, always below economic injury level; 0 = not reported on citrus. [a] = Madeira Island. [b] = on lemon. [c] = in Southern Spain. [d] = only in Canary Islands. [e] = limited areas. [f] = North of Portugal. [g] = not reported in the main citrus growing areas of Spain yet. [h] = Azores. [i] = Algarve. [j] = on young trees. [k] = in nurseries. [l] = on mandarin. [m] = on sweet orange. [n] = natural enemies disruption. [o] = in western Andalusia. Ratings of species considered key-pests in at least one country are shown in bold.

Table 3. Visual inspection practices.

Plant parts		*Purpose – target pest*
During the growing season/ warm periods of the year		Twigs are shaken by hand and the number of adults of whiteflies taking flight is noted (every week)
Twigs		Observations are made on the presence of honeydew, sooty mould and ants, which are associated with the presence of aphids, whiteflies and soft scales as well as on cottony egg masses which are associated with mealybugs. Parasitism should be also recorded
		Detection of the citrus leafminer
	Apical twigs of…	Monitoring the presence of aphids (every week) and *Closterotomus trivialis* (spring)
	Green twigs	Monitoring the development of armoured scales (every 2 weeks), soft scales (every 2–3 weeks) and 1st and 2nd instar nymphs of *Icerya purchasi*
	Previous flushing twigs	Detection of *Eriophyes sheldoni*-affected organs in spring and mid-summer
	Flowers	Detection of the citrus moth
	Fruits	Monitoring the development of diaspidid scales (every 2 weeks) and locating foci of infestation Fruits and fruit stem inspections for mealybugs, white cottony egg mass, sooty mould developed on secreted honeydew and ants, which are associated with mealybugs (every 2 weeks) Detection of the citrus moth Detection of *Tetranychus urticae* during the summer-early autumn Detection of *Ceratitis capitata* as colour change begins In the packinghouse, presence of diaspidid scales should be checked
	Young leaves	Detection of whitefly and soft scales foci of infestation in the orchard Observations are made on the presence of sooty mould and ants, which are associated with whiteflies, soft scales and mealybugs (every 2–3 weeks) Detection of the citrus mite, *Panonychus citri*, at the end of summer
Cold periods of the year		Detection of *T. urticae* from May to October
Twigs		Detection of 3rd instar nymphs and pre-ovipositing females of *I. purchasi*

[a] Visual inspections also allow monitoring coccinellid predators on trees.

Table 4. Insect pests trapping methods.

Type of trap	*Purpose – target pest*
Yellow water-pan traps	Monitoring aphids: Moericke pan-traps, both square (60 × 60 × 10 cm) and round (30 cm in diameter), painted canary yellow inside and containing water with a spoonful of added detergent up to a depth of 3–4 cm are commonly used; should be placed in the citrus orchards in mid-spring, 2–5 traps/ha, 70 cm above the ground, to be checked 1–2 times/week during the growing season
Suction traps of 12 m high	Monitoring aphids
Yellow sticky traps	Catching newly emerged whitefly adults: traps should be placed in the lower outside canopy of the south or southeast quadrant of the tree Catching males of *Aonidiella aurantii* and other armoured scales Monitoring parasitoids and detection of leafhoppers (*Empoasca* spp.)
Sex pheromone-baited traps	Attracting adult males of *A. aurantii* [pheromone (3Z, 6R)-3-methyl-6-isopropenyl-3.9-decadien-l-yl acetate]; 2–5 traps/ha at 1.8–2.5 height above the ground, to be checked twice a week from early spring to mid-late autumn Attracting adult males of *Planococcus citri*: various designs of traps available, the yellow or white sticky trap with pheromone [(1R-CIS)-3-isopropenyl-2.2-dimethylcyclobutyl-methyl acetate] dispenser being most effective; 2–5 traps/ha; catches to be correlated with shifts in the population densities of female mealybugs Monitoring of the citrus moth, *Prays citri*
White traps coated with glue mixed with trimedlure as well as other sex and food attractants	Catching adults of *Ceratitis capitata*; 10 traps/ha
Transparent sticky band traps	Measuring the density of crawlers of *A. aurantii* in order to determine the timing of chemical treatment; the traps are tightly fixed around heavily infested twigs from mid spring onwards For other diaspidids and soft scales
Beating branches of trees with a rubber-covered stick over a 1 m^2 cloth screen	Monitoring coccinellid predators

Table 5. Parasitoids/predators associated with augmentative or classical biological control (ABC and CBC respectively) of citrus insect pests in northern Mediterranean countries (modified from Katsoyannos, 1996).

Insect pests	*Parasitoids/Predators*	*Country of release / Frequency of occurrence / Success of control**					
		France	*Greece*	*Italy*	*Portugal*	*Spain*	*Turkey*
Flatid planthoppers (Flatidae)							
Metcalfa pruinosa	*Neodryinus typhlocybae* (Ashmead) (Dryinidae)	CBC, 1996: E, Fr		CBC, 1987 (on other crops in Veneto): E, Fr; CBC, 2004 (on citrus in Sicily): E		CBC, 2007: (on other crops)	
Whiteflies (Aleyrodidae)							
Aleurothrixus floccosus	*Cales noacki* Howard (Aphelinidae)	CBC, 1971: E, vFr	CBC, 1991: E, vFr	CBC, 1980s: E, vFr	CBC, 1978: E, vFr	CBC, 1970: E, Fr, SC	
	Amitus spiniferus (Brèthes) (Platygastridae)	CBC, 1973: E; CBC, 1980-82: TE, F (Corsica)		CBC, 1981: E (Liguria) CBC, 1983: E, P (Sicily)		CBC, 1971: E, MrC	
	Delphastus pusillus (LeConte) (Coccinellidae)	CBC, 1994: F					
Dialeurodes citri	*Encarsia* (= *Prospaltella*) *lahorensis* (Howard) (Aphelinidae)	CBC, 1976: E, Fr CBC, 1984: NR(Corsica)	CBC, 1976: E (Corfu)	CBC, 1973: E, vFr CBC, 1978: E, vFr (Sicily); CBC, 1980: NR (Sardinia)		CBC, 1992: NR	CBC, 1976: NT
	Serangium montazerii Fürsch (= *Serangium parcesetosum* Sicard) (Coccinellidae)	CBC, 1986: E, Re (Corsica) CBC,1987-88: E, Re					

Table 5 continued

Insect pests	*Parasitoids/Predators*	*Country of release / Frequency of occurrence / Success of control**					
		France	*Greece*	*Italy*	*Portugal*	*Spain*	*Turkey*
Parabemisia myricae	*Eretmocerus debachi* Rose & Rosen (Aphelinidae)		CBC, 1989-91: NR (Crete)	CBC,1991: E; CBC, 1991: NR (Sicily)		CBC, 1995: E, Fr, SC	CBC, 1986: E, Fr
Aphids							
	Lysiphlebus testaceipes (Cresson) (Braconidae)	CBC, 1973-74: E, Fr		Accidental introduction, 1977: Fr		CBC, 1976: E, Fr, PC	
	Harmonia axyridis Pallas (Coccinellidae)		CBC, 1994: F (continent, Chios & Crete)				
Fluted scales (Margarodidae)							
Icerya purchasi	*Rodolia* (=*Novius*) *cardinalis* (Mulsant) (Coccinellidae)	CBC, 1912: E, Fr	CBC, 1913: Fr (Chios)	CBC, 1901: E, Fr	CBC, 1988: E, Fr	CBC, 1922: E, Fr; CBC, 1997: F	CBC, 1912: E, Fr
Mealybugs (Pseudococcidae)							
Planococcus citri	*Leptomastix dactylopii* Howard (Encyrtidae)	CBC, 1953: F CBC, 1972: E, MdC		CBC, 1956: E, Fr (Sicily); CBC, 1960s: F (Procida island); CBC, 1975: NR; CBC, 1989-90: NR; ABC, 1979-81: PC (Sardinia)	CBC, 1991: F	CBC, 1951: NR; CBC, 1977: E, Fr, PC; CBC, 1981: NR; ABC, 1978: PC	CBC, 1969: E, MdC

Table 5 continued

Insect pests	*Parasitoids/Predators*	*Country of release / Frequency of occurrence / Success of control**					
		France	*Greece*	*Italy*	*Portugal*	*Spain*	*Turkey*
	Cryptolaemus montrouzieri Mulsant (Coccinellidae)	CBC, 1918: E, Fr	CBC, 1933, 1964-5, 1969: F (continent); CBC, 1977: NR; ABC, 1977: SC (Crete); ABC, 1991-92: SC (continent)	CBC, 1908, 1988: E; CBC, 1965: E (Sicily); ABC, 1965: SC (Sicily); ABC, 1979-81: SC (Sardinia)	CBC, 1918-29: E	CBC, 1926, 1974: NR; ABC, 1927: E, Fr, PC	CBC, 1965: NR
Planococcus citri	*Nephus reunioni* Fürsch (Coccinellidae)		CBC, 1977: NR (Crete); ABC, 1970s: PC (Crete);	CBC, 1970s: NR (Sicily)	CBC, 1984: E		
	Nephus (*Sidis*) *anomus* (Mulsant & Rey) (Coccinellidae)		ABC, 1991-92: PC (continent); CBC, 1992: NR (continent)				
	Nephus quadrimaculatus (Herbst) (Coccinellidae)		ABC, 1991-92: PC (continent)				
	Coccidoxenoides perminutus Girault (= *Pauridia peregrina* Timberlake) (Encyrtidae)			CBC, 1959: F (Procida island)			
Soft scales (Coccidae)							
Coccus hesperidum	*Coccophagus ceroplastae* (Howard) (= *Aneristus ceroplastae* Howard) (Aphelinidae)	CBC, 1973-75: E					
Coccus pseudomagnoliarum	*Rhyzobius forestieri* (Mulsant) (Coccinellidae)		CBC, 1981: E, Fr (Chios); ABC, 1983-92:				

Table 5 continued

Insect pests	*Parasitoids/Predators*	*Country of release / Frequency of occurrence / Success of control**					
		France	*Greece*	*Italy*	*Portugal*	*Spain*	*Turkey*
Saissetia oleae	*Microterys nietneri* (Motschulsky) (Encyrtidae)	CBC, 1969: E, MdC; CBC, 1971:	CBC, 1962: E, MdC	CBC, 1970: E, MdC (Sardinia); CBC, 1971: E, MdC	CBC, 1977-78: E, Fr	CBC, 1921: F	
	Metaphycus helvolus (Compere) (Encyrtidae)	E, MdC (Corsica)				CBC, 1976: E, MdC	
	Metaphycus lounsburyi (Howard) (= *Metaphycus bartletti* Annecke & Mynhardt) (Encyrtidae)	CBC, 1970s E, MdC; CBC, 1980: E, MdC (Corsica)	CBC, 1970s: TE (Crete)	CBC, 1979: E, MdC		CBC, 1979: E, MdC; CBC, 1988: E, PC	
	Metaphycus swirskii Annecke & Mynhardt (Encyrtidae)	CBC, 1979: E	CBC, 1970s: TE (Crete);	CBC, 1977: E			
	Diversinervus elegans Silvestri (Encyrtidae)	CBC, 1972-75: E, PC; CBC, 1979: NR (Corsica)	CBC, 1973-79; TE (Crete)	CBC, 1977: NR			
	Rhyzobius forestieri (Mulsant) (Coccinellidae)	CBC, 1986: E, Fr	CBC, 1981: E, Fr (Chios); ABC, 1983: SC (Chios)				
Armoured scales (Diaspididae)							
Aonidiella aurantii	*Aphytis melinus* DeBach (Aphelinidae)		CBC, 1962: E, MdC E, MrC (Crete)	CBC, 1964: E, MdC (Sicily)		CBC, 1976: E, Fr, PC	
	Aphytis lingnanensis Compere (Aphelinidae)		CBC, 1963: F	CBC, 1966: NR (Sicily)		CBC, 1976: E, PC	CBC, 1968: NR

Table 5 continued

Insect pests	*Parasitoids/Predators*	*Country of release / Frequency of occurrence / Success of control**					
		France	*Greece*	*Italy*	*Portugal*	*Spain*	*Turkey*
Aonidiella aurantii	*Aphytis coheni* DeBach (Aphelinidae)		CBC, 1962: F			CBC, 1936:F; CBC, 2000:F	
	Encarsia (= *Prospaltella*) *perniciosi* (Tower) (Aphelinidae)		CBC, 1969: NR				
	Comperiella bifasciata Howard (Encyrtidae)	CBC, 1960: E, Fr	CBC, 1921, 1969, 1972: NR; CBC, 1970s: E, MrC (Crete)	CBC, 1939:NR CBC, 1989:E, Fr (Sicily)			CBC, 1987:NR
	Rhyzobius (= *Lindorus*) *lophanthae* (Blaisdell) (Coccinellidae)	Accidental introduction, 1908: Fr		CBC, 1908: E, Fr, P		CBC, 1908: E, Fr, PC	
	Chilocorus nigritus (Fabricius) (Coccinellidae)						CBC, 1980: NR
Aspidiotus nerii	*Aphytis chilensis* Howard (Aphelinidae)		CBC, 1979: E, Fr (Crete)	ABC, 1972: NR (Sicily)		CBC, 1976: NR	
	Aphytis melinus DeBach		CBC, 1979: E, Fr (Crete)			CBC, 1976: NR	
Chrysomphalus dictyospermi	*Aphytis melinus* DeBach	CBC, 1966: E	CBC, 1962: E, Fr	CBC, 1964: E, Fr (Sicily)		CBC, 1967: E, Fr	
	Encarsia (= *Aspidiotiphagus*) *lounsburyi* (Berlese & Paoli) (Aphelinidae)			CBC, 1916: E			
Lepidosaphes beckii	*Aphytis lepidosaphes* Compere (Aphelinidae)	CBC, 1973: E, Fr	CBC, 1962: E, Fr		CBC, 1976-77: E, Fr		
Lepidosaphes glowerii	*Encarsia herndoni* (Girault) [=*Encarsia elongata* (Dozier)] (Aphelinidae)	CBC, 1987-88: E, Fr (Corsica)		CBC, 1988: E, Fr (Sicily)		CBC, 1979: E, Fr, SC	
Unaspis yanonensis	*Aphytis yanonensis* DeBach & Rosen (Aphelinidae)	CBC, 1984: E; ABC, 2000: MdC					
	Coccobius fulvus (Compere & Annecke) (Aphelinidae)	CBC, 1984: E, Fr					

Table 5 continued

Insect pests	*Parasitoids/Predators*	*Country of release / Frequency of occurrence / Success of control**					
		France	*Greece*	*Italy*	*Portugal*	*Spain*	*Turkey*
Moths							
Phyllocnistis citrella (Gracillariidae)	*Ageniaspis citricola* Logvinovskaya (Encyrtidae)		CBC, 1996: F (Crete)	CBC 1995-96: F	CBC, 1998: F (Madeira)	CBC 1995-96: E, SC (Canary Islands)	
	Semielacher petiolatus (Girault) (Eulophidae)		CBC, 1996-99: E (Crete, Peloponnese)	Accidental introduction, 1998: vFr, SC	Accidental introduction, 2003: vFr	CBC, 1995: E, PC	
	Cirrospilus ingenuus Gahan [=*Cirrospilus quadristriatus* (Subba Rao & Ramamani)] (Eulophidae)		CBC, 1996: F (Crete)			CBC, 1995: F	
	Quadrastichus sp. (now *Quadrastichus citrella* Reina & LaSalle) (Eulophidae)			CBC, 1996: F		CBC, 1995: F	
	Quadrastichus sp. (Eulophidae)		CBC 1996-1999: E (Crete) F (Peloponnese)				
	Galeopsomyia fausta LaSalle (Eulophidae)					CBC. 1997: F	
	Citrostichus phyllocnistoides (Narayanan) (Eulophidae)		CBC 1996-99: E, vFr	CBC 1998-99: E, vFr, SC	Accidental introduction, 2003: Fr	CBC, 1998-99: E, Fr,SC	
Fruit flies (Tephritidae)							
Ceratitis capitata	*Aceratoneuromyia indica* (Silvestri) (= *Syntomosphyrum indicum* Silvestri) (Eulophidae)			CBC, 1909: F			
	Dirhinus giffardi Silvestri (Chalcididae)			CBC, 1913: NR			
	Diachasma fullawayi Silvestri (Braconidae)					CBC, 1931: F	
	Diachasmimorpha tryoni (Cameron) (Braconidae)					CBC, 1931: F	
	Psyttalia incisi (Silvestri) (= *Opius incisi* Silvestri) (Braconidae)					CBC, 1931: F	
	Tetrastichus giffardianus Silvestri (Eulophidae)					CBC, 1960: F (Canary Islands)	
	Diachasmimorpha longicaudata (Ashmead) (Braconidae)					CBC, 1979: F	

* Fr = Frequent; vFr = very frequent; E = Established; TE = Temporarily established; F = Failed; NR = Not reported; Re = Recorded; Po = Positive; SC = Substantial control; MdC = Moderate control; MrC = Minor control; PC = Partial control.

2.3. Chemical Control

Although many classical or augmentative biological control trials of arthropod pests have been successful in citrus, chemical control is still used. The recently finalized EU Review Programme on the inclusion of old active substances of plant protection products (registered in the EU up to 1993) in the positive list (Annex I) of the Directive 91/414/EEC (CEC, 1991), based on agreed and harmonised criteria for evaluating the safety of pesticides, resulted in a modification of the availability of insecticides, acaricides and insect attractants authorized for citrus pest management in the various member states of the E.U. (Tables 6 and 7) (Hellenic Ministry of Rural Development and Food, 2008; MAPA, 2008; MiPAAF, 2008). Some of these pesticides were also tested to evaluate their side effects on beneficial arthropods (Table 8).

Table 6. Insecticides, acaricides and insect attractants (active substances) registered for use on citrus in Spain, Italy and Greece (June 2008).

Country	*Insecticides/acaricides/insect attractants (active substances)*
Spain	Abamectin (O, L, M, G), acetamiprid (O, L, M, G), alpha-cypermethrin (O, L, M, G), azadirachtin (O, L, M, G), *Bacillus thuringiensis* var. *kurstaki* (O, L, M, G), benfuracarb (O, L, M, G), bifentrin (O, L, M, G), buprofezin (O, L, M, G), carbosulfan (O, L, M, G), chlorpyrifos (O, L, M, G), chlorpyrifos-methyl (O, L, M), cihexatin (O, L, M, G), clofentezine (O,L,M,G), cypermethrin (O, L, M, G), deltamethrin (O, L, M, G), diazinon (O, L, M, G), dichlorvos (O, L, M, G), dicofol (O, L, M, G), diflubenzuron (O, M, G), dimethoate (O, L, M, G), etofenprox (O, M, G), etoxazol (O, M), fenazaquin (O, M, G), fenbutatin oxide (O, M, G), fenitrothion (O, L, M, G), fenoxycarb (O, M, G), fenpyroximate (O, L, M, G), flufenoxuron (O, M, G), hexythiazox (O, L, M, G), imidacloprid (O, L, M, G), kaolin (O, M), lambda-cyhalothrin (O, L, M, G), lufenuron (O, L, M, G), malathion (O, L, M, G), methomyl (O, L, M, G), methoxyfenozide (O, M), mineral oil (O, L, M, G), oxydemeton-methyl (O, L, M, G), phosmet (O, L, M, G), piridaben (O, L, M, G), pirimicarb (O, L, M, G), pirimiphos-methyl (O, L, M, G), potassium salts of vegetable fatty acids (O, L, M), propargite (O, L, M, G), pymetrozine (O, L, M, G), pyriproxifen (O, L, M, G), spinosad (O, L, M, G), tau-fluvalinate (O, L, M, G), tebufenozide (O, L, M, G), tebufenpyrad (O, L, M, G), trichlorfon (O, L, M, G)
Italy	Abamectin (O, L, M), acrinathrin (O, L, G), alfamethrin (O, L, M), azadirachtin (O, L, M, G), *Bacillus thurigiensis* var. *aizawai* (O, L, M), *Bacillus thurigiensis* var. *kurstaki* (O, L, M), *Beauveria bassiana* (O, L, M), bifentrin (O, L, M), buprofezin (O, L, M), calcium polysulfur

Table 6 continued

	(O, L, M), chlorpyrifos (O, L, M), chlorpyrifos-methyl (O, L, M, C), clofentezine (O, L, M, Cl, G, B), cypermethrin (O, L), deltamethrin (O, L, M), diazinon (O) **(1)**, dicofol (O, L, M), dimethoate (O, L, M) **(2)**, ethoprophos (O, L, M), etofenprox (O, L, M, Cl, B, SO, G, P, T, C), etoxazol (O, L, M, Cl, B, SO, G, P, T, C), fenazaquin (O, L, M, Cl), fenbutatin oxide (O, L, M), fenpyroximate (O, L, Cl), flufenoxuron (O, M, Cl), fluvalinate (O, M), hexythiazox (O, L, M), imidacloprid (O, L, M, Cl), lambda-cyhalothrin (O), lufenuron (O, L, M, Cl), malathion (O, L, M, Cl, B, SO, G, P, T, C) (**1**), methomyl (O, L, M), methoxyfenozide (O, M, Cl), mineral oil (O, L, M, Cl), phosalone (O, L, M) **(3)**, phosmet (O, L, M), pirimicarb (O, L, M), pirimiphos-methyl (O, L), propargite (O, L, M, G, Cl), pymetrozine (O, L, M, Cl), pyrethrines (O, L, M), pyridaben (O, L, M, Cl, T), pyriproxifen (O, L, M), rotenone (O, L, M), spinosad (as bait) (O, L, M, Cl, SO, C, G, B, T), spirodiclofen (O, L, M, Cl, G, B, C, SO), tebufenozide (O, L, M), tebufenpyrad (O, L, M, Cl, G, C, T, B), thiamethoxam (O, L, M, Cl), trichlorfon (O, L, M) **(4)**, zeta-cypermethrin (O, L)
Greece	Acetamiprid (O, L, M, and nurseries, G, C), azadirachtin (O, L, M, G), *Bacillus thurigiensis* var. *aizawai* (O, L, M, G, C), *Bacillus thuringiensis* var. *kurstaki* (O, L, M, G, C), *Beauveria bassiana* (M), buprofezin (O, L, M, G, SO, C), chlorpyrifos (O, L, M, G, P), chlorpyrifos-methyl (O, L, M), cypermethrin (O, M,G), deltamethrin (O, L, M, G, C, P), diflubenzuron (O, L, M, G, P), fatty acid potassium salt (O, L, M, G, C), fenoxycarb (O, L, M), flucythrinate (O, L, M, G), flufenoxuron (O, L), imidacloprid (O, L, M, G), methomyl (O, L, M, P), methoxyfenozide (O, M, G), mineral oil (O, L, M, G, SO, P), phosmet (O, L, M, G), pirimicarb (O, L, M, G, P), pymetrozine (O), pirimiphos-methyl (M), pyrethrins (O, L, M, G), pyriproxyfen (O, L, M), tau-fluvalinate (O, L, M, G), tebufenozide (L, M), thiamethoxam (O, L, M)
	Insect attractants: farnesol (O, L, M, G), nerolidol (O, L, M, G)

O: Orange, L: Lemon, M: Mandarin, G: Grapefruit, SO: Sour orange, C: Citron, P: Pomelo, Cl: Clementine, T: Tangerine, B: Bergamot. 1 = Active substance not included in the Annex I of the directive 91/414/EC, the commercial plant production products are revoked from 6 December 2007 and the stocks were commercialized and used until 6 December 2008. 2 = Use allowed only on nonproductive orchards. For some commercial plant production products the extension of the authorization for use on citrus to control aphids has been approved with a pre-harvest interval of 100 days. 3 = Active substance not included in the Annex I of the directive 91/414/EC. The authorization of the commercial plant production products containing phosalone is revoked from 23 June 2007. The stocks were commercialized and used until 22 June 2008. 4 = Active substance not included in the Annex I of the directive 91/414/EC. The authorization of the commercial plant production products containing this a.i. is revoked from 21 November 2007. The stocks were commercialized and used until 21 November 2008.

Table 7. Insecticides, acaricides and insect attractants (active substances) registered for use against the main arthropod pests of citrus in Spain, Italy and Greece (June 2008).

Pest	*Insecticides/acaricides (active substance)*[a]
Thrips (Thysanoptera)	Acrinathrin (I), chlorpyrifos (G), fatty acid potassium salt (G), malathion (I), pirimiphos-methyl (I), rotenone (I)
Whiteflies (Aleyrodidae) *Aleurothrixus floccosus* *Dialeurodes citri*	Acetamiprid (S), azadirachtin (S, G), buprofezin (S, G), carbosulfan (S), chlorpyrifos (S), cypermethrin (I), deltamethrin (I), dimethoate (S), etofenprox (S), fatty acid potassium salt (G), fenazaquin (S, I), fenpyroximate (S), imidacloprid (S, I, G), lufenuron (S, I), malathion (S, I), methomyl (S), mineral oil (G), phosmet (S), piridaben (S), pyrimiphos-methyl (S), rotenone (I), zeta-cypermethrin (I)
Aphids (Aphididae) *Aphis gossypii* *Aphis spiraecola* *Toxoptera aurantii* *Toxoptera citricida*	Acetamiprid (S, G), alpha-cypermethrin (S), azadirachtin (S, G), benfuracarb (S), bifentrin (S), carbosulfan (S), chlorpyrifos (S, G), chlorpyrifos-methyl (G), cypermethrin (S, I, G), deltamethrin (S, I), dimethoate (S), etofenprox (S), fatty acid potassium salt (G), fenitrothion (S), flucythrinate (G), fluvalinate (I), imidacloprid (S, I), lambda-cyhalothrin (I), malathion (I), methomyl (S), mineral oil (S, G), oxamyl (G), oxydemeton-methyl (S), phosmet (S), pimetrozine (S, I), pirimicarb (S, I,G), pyrimiphos-methyl (S, I), potassium salts of vegetable fatty acids (S), pymetrozine (G), pyrethrines (G), rotenone (I), tau-fluvalinate (S), thiamethoxam (I, G), zeta-cypermethrin (I)
Armoured scales (Diaspididae) *Aonidiella aurantii* *Aspidiotus nerii* *Chrysomphalus dityospermi* *Lepidosaphes beckii* *Parlatoria pergandei* *Parlatoria ziziphi* *Unaspis citri*	Azadirachtin (S), buprofezin (S, G), chlorpyrifos (S, G), chlorpyrifos-methyl (G), cypermethrin (I, G), flucythrinate (G), dimethoate (S), fenitrothion (S), fenoxycarb (S), fenpyroximate (S), malathion (S, I), methomyl (S, I), mineral oil (S, I, G), phosmet (S, I, G), pyrimiphos-methyl (S), pyriproxifen (S, I, G), rotenone (I)
Soft scales (Coccidae) *Ceroplastes sinensis* *Coccus hesperidum* *Saissetia oleae*	Azadirachtin (S), buprofezin (S), chlorpyrifos (S, G), chlorpyrifos-methyl (G), cypermethrin (S, I, G), deltamethrin (I), dimethoate (S), fenitrothion (S), fenoxycarb (S, G), fenpyroximate (S), flucythrinate (G), imidacloprid malathion (S), malathion (I), methomyl (S, I), mineral oil (S, I, G), phosmet (S, I), pyriproxifen (S, I, G), pyrimiphos-methyl (S), rotenone (I), tau-fluvalinate (S)

Table 7 continued

Mealybugs (Pseudococcidae) *Planococcus citri*	Azadirachtin (S), buprofezin (S, G), chlorpyrifos (S, G), cypermethrin (I, G), dimethoate (S), fenitrothion (S), flucythrinate (G), malathion (S, I), methomyl (S, I), mineral oil (S, I, G), phosmet (S, I, G), pyrimiphos-methyl (S, I), rotenone (I)
Moths *Phyllocnistis citrella* (Gracillariidae) *Prays citri* (Hyponomeutidae)	Abamectin (S, I: *P. citrella*), acetamiprid (G: *P. citrella* nurseries), alpha-cypermethrin (S), azadirachtin (S, G: *P. citrella*), *Bacillus thuringiensis* var. *aizawai* (G: *P. citri*), *Bacillus thuringiensis* var. *kurstaki* (S, G: *P. citri*), benfuracarb (S), buprofezin (*P. citrella*), carbosulfan (S), chlorpyrifos (S, G), cypermethrin (S, I: *P. citri,* G), deltamethrin (S), diazinon (S), dichlorvos (S), diflubenzuron (S) dimethoate (S), etofenprox (S), fenitrothion (S), fenoxycarb (S), fenpyroximate (S), flucythrinate (G: *P. citri*), flufenoxuron (S, I, G: *P. citrella*), imidacloprid (S, I, G: *P. citrella*), lufenuron (S, I), malathion (S, I), methomyl (S, I), methoxyfenozide (I, G: *P. citrella*), mineral oil (G), phosmet (S, I), pyrimiphos-methyl (S, I), rotenone (I: *P. citri*) tau-fluvalinate (S), tebufenozide (S, I, G: *P. citrella*), thiamethoxam (I, G: *P. citrella*)
Fruit flies (Tephritidae) *Ceratitis capitata*	Azadirachtin (S), *Beauveria bassiana* (G), cypermethrin (I, G), deltamethrin (I), dichlorvos (S), etofenprox (I), flucythrinate (G), imidacloprid (S), lambda-cyhalothrin (S, I), lufenuron (S), malathion (S, I), phosmet (S, I, G), pyrimiphos-methyl (I), rotenone (I), spinosad bait (I), trichlorfon (S, I), zeta-cypermethrin (I)
Mites *Eutetranychus banksi* *Panonychus citri* *Phyllocoptruta oleivora* *Tetranychus urticae*	Abamectin (S, I: *T. urticae*), acrinathrin (I), bifentrin (S), buprofezin (S), clofentezine (S, I), dicofol (S, I, G), etoxazol (S, I, G), fenazaquin (S, I, G), fenbutatin oxide (S, I, G), fenitrothion (S), fenpyroximate (S, I), flufenoxuron (S, I), hexythiazox (S, I), malathion (S), mineral oil (S, I, G), oxamyl (G), oxydemeton-methyl (S), propargite (S, I, G), pyridaben (S, I), pyrimiphos-methyl (S, I), spirodiclofen (I), tebufenpyrad (S, I, G)

[a] G = Greece; I = Italy; S = Spain.

Table 8. Side effects of pesticides (active substances), registered for the control of citrus pests, on beneficial arthropods[a].

Active substance	*Rodolia cardinalis*	*Cryptolaemus montrouzieri*	*Euseius stipulatus*	*Lysiphlebus testaceipes*	*Leptomastix dactylopii*	*Cales noacki*
Abamectin	1	3–4	2–3			3–4
Azadirachtin	3–4	1	1	1	3–4	
Bacillus thuringiensis var. *kusrtaki*	1	1	1	1	1	1
Benfuracarb			1			2–3
Bifentrin	3–4		3–4		1	
Buprofezin	1–2	3	1–2	1	1–2	1
Carbosulfan	1–2		1–2	1		2–3
Chlorpyrifos	1–2	2	2	3	3	2–3
Chlorpyrifos-methyl	1	1	3	3	2–4	1–2
Clofentezine	1	2	1–2			1
Cypermethrin	4	4	4	1		3–4
Deltamethrin	4	3–4	4	1	4	3
Diazinon	3		2	3		1–2
Dicofol	1	1–4	3–4	1	3–4	2
Diflubenzuron			1			1–2
Dimethoate	1	4	2–3	1–2	4	2
Fenazaquin	4	2	4			3
Fenbutatin oxide		1	2	1	1	1
Fenitrothion	1–2		3	1–2	4	3
Fenoxycarb		4	1–2			2
Flucythrinate		2				3
Flufenoxuron			2–3			1–2
Fosalone	2			1		3
Hexythiazox	1		1	1		
Imidacloprid	4		2–3	1	4	3
Lambda-cyhalothrin						3
Lufenuron	4	1	1			1
Malathion	2–3	4	2	3	4	3–4
Methomyl	4	4	4	2		3–4
Mineral oil	1	1–2	1–2	2	1	1–4
Oxydemeton-methyl	1	3	2	1	3	1–2
Phosmet	4	4	2–3	1	3	4
Piridaben			4		1	
Pirimicarb	1–2	2	1–2	1	1	1
Pyrimiphos-methyl	1–2	1–2	1–4		4	3–4
Propargite			4	1		2–3
Pyriproxifen	4	4	1		1–2	2–3
Spinosad	1	1		4	3–4	

Table 8 continued

Tau-fluvalinate	4	3	3–4	1	3	2
Tebufenozide			1			
Tebufenpyrad		2				
Trichlorfon	2–3	1	1	3	1–2	2
Zeta-cypermethrin	4	4	4	1		3–4

[a]Classification according to the IOBC WG "Pesticides and Beneficial Organisms" standards: 1 = harmless; 2 = slightly harmful; 3 = moderately harmful; 4 = harmful (sources: Jacas & García Marí, 2001; Pascual-Ruíz & Urbaneja, 2006; Urbaneja et al., 2008; Suma, Zappalà, Mazzeo, & Siscaro, 2009).

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