A review of the factors that influence pesticide residues in pollen and nectar: future research requirements for optimising the estimation of pollinator exposure

Supporting material Table S1

Summary of studies which allow conclusions to be drawn from the application to residues in pollen and nectar and which have been included in the literature review. The active ingredient, residues in pollen/ nectar, sampling method, application method, dose rate is where the study has been conducted is given. Some studies give only mean residue values. a.i. = active ingredient, GH = Glasshouse, LOQ= Limit of quantification, ND= not detected

Active Ingredient	Crop	Residues in Pollen	Residues in Nectar	Sampling Method	Application Method	Dose Rate	Field/ GH	Refer-ence	Comment
Imidacloprid	Citrus	Not sampled	2.9 - 39.4 ng g^{-1}	Manually & bees	Soil drench	1.02 - 2.04 L ha^{-1}	Field	c	
	Mustard	< Limit of detection (0.001 mg $kg^{-1)}$	Limit of detection (0.001 mg $kg^{-1)}$	Bees	Foliar	21 g a.i. ha^{-1}	Field	d	
	OSR	<Limit of quantification (1 ng g^{-1})	0.6- 2 ng g^{-1}	Bees	Seed/ spray	2.1 g a.i. kg^{-1} seed + 2 g a.i kg^{-1} seed	Field	l	Mean of two years of sampling. Nectar= mean of flower nectar, combs, honey. Pollen = mean of pollen loads and bee bread
	Pumpkin	3.3 - 6.7 ng g^{-1} 30.1 - 40.1 ng g^{-1} 40.5 - 86.6 ng g^{-1} 52.3 - 101.0 ng g^{-1}	0.3 - 0.5 ng g^{-1} 3.8 - 7.3 ng g^{-1} 4.7 - 11.9 ng g^{-1} 9.0 - 13.7 ng g^{-1}	Manual	Various (e.g. soil drench, drip irrigation, foliar)	30 g a.i. ha^{-1} 281 g a.i. ha^{-1} 422 g a.i. ha^{-1} 2 x 211 g a.i. ha^{-1}	Field	f	For clarity only result of one year (2009) shown
	Sunflower	1- 11 ng g^{-1}		Not stated/ by hand	Seed	0.7 - 1.4 mg a.i. $seed^{-1}$	Field	a	
	Sunflower	13 ng g^{-1}		Manual	Seed	1 mg a.i. $seed^{-1}$	Field	k	

Active Ingredient	Crop	Residues in Pollen	Residues in Nectar	Sampling Method	Application Method	Dose Rate	Field/ GH	Refer-ence	Comment
Imidacloprid	Sunflower, swamp milkweed	3.2 mg kg^{-1} (drench); 100 ng g^{-1} (foliar spray)	120 ng g^{-1} (foliar spray) 320 ng g^{-1} (drench)	Manual	Foliar spray Drench	2.75- 71.5 mg a.i. pot^{-1}	GH	e	
	Squash	12-14 ng g^{-1}	10 -11 ng g^{-1}	Manual	Various (e.g. soil drench, drip irrigation, foliar)	140- 358 g a.i. ha^{-1}	Field	o	
	Cotton	5.21- 62.02 ng g^{-1}	ND- 1.76 ng g^{-1}	Manual	Seed	3.5 -5.5 g kg^{-1} seed	Field	g	
	Sunflower	0.0039 mg kg^{-1}	0.0019 mg kg^{-1}	Manual & bees	Seed	0.7 mg a.i. $seed^{-1}$	GH	n	
	Sunflower	< LOQ (0.005 mg kg^{-1})	< LOQ (0.005 mg kg^{-1})	Manual & bees	Seed	0..001 g a.i. $seed^{-1}$	Field		
Thia-methoxam	OSR	1.02 – 11.10 ng g^{-1}	≤ 0.10 – 13.30 ng g^{-1}	Manual & bees	Seed	4.2 g a.i. kg^{-1} seed	Field	b	
	Cotton	ND - 13.17 ng g^{-1}	ND- 1.53 ng g^{-1}	Manual	Seed	3.5 - 5.5 g kg^{-1} seed	Field	g	

Active Ingredient	Crop	Residues in Pollen	Residues in Nectar	Sampling Method	Application Method	Dose Rate	Field/ GH	Refer-ence	Comment
Thia-methoxam	OSR	2.9 ng g^{-1} (max 9.9 ng g^{-1})	4.2 ng/g (max 12.9 ng g^{-1})	Pollen traps	Seed	3.15 g a.i kg^{-1} seed	Field	l	Mean of two years of sampling. Nectar= mean of flower nectar, combs, honey. Pollen = mean of pollen loads and bee bread
	Pumpkin	54.8 - 90.4 ng g^{-1} 60.7 - 127.0 ng g^{-1}	7.8 - 12.2 ng g^{-1} 6.7 - 9.1 ng g^{-1}	Manual	Various (e.g. soil drench, drip irrigation, foliar)	2x 96 g a.i. ha^{-1} (drench) 2x 96 g a.i. ha^{-1} (spray)	Field	f	Only result of one year shown
	Sunflower, swamp milkweed	125 ng g^{-1}	630 ng g^{-1}	Manual	Foliar	1.81- 118 mg a.i. pot^{-1}	GH	e	
		3.2 mg kg^{-1}	320 ng g^{-1}		Soil drench	37.5- 150mg a.i. L^{-1} of spray	GH	e	
	Maize	1.7 ng g^{-1}		Manual	Seed	0.25- 1.25 mg a.i. $seed^{-1}$	Field	h	
	Squash	12 ng g^{-1}	11 ng g^{-1}	Manual	Various	140- 358 g a.i. ha^{-1}	Field	o	
Clothianidin	OSR	≤0.12– 14.50 ng g^{-1}	≤0.17– 13.24 ng g^{-1}	Manual/ bees	Seed	250 g a.i. L^{-1}	Field	b	
	Maize	3. 9 ng g^{-1}	Nectar not produced	Bees	Seed	0.25- 1.25 mg a.i. $seed^{-1}$	Field	h	

Active Ingredient	Crop	Residues in Pollen	Residues in Nectar	Sampling Method	Application Method	Dose Rate	Field/ GH	Refer-ence	Comment
	OSR	1.8- 3.2 ng g^{-1}	1.0- 2.9 ng g^{-1}	Bees	Seed	10 g kg^{-1} seeds	Field/ semi-field	j	
		1.2 ng g^{-1} (max 3.7 ng g^{-1})	2.3 ng g^{-1} (max 10.1 ng g^{-1})	Pollen traps	Seed	5 g a.i kg^{-1} seed	Field	l	Mean of two years of sampling. Nectar= mean of flower nectar, combs, honey. Pollen = mean of pollen loads and bee bread.
		1.3 ± 0.9 mg kg^{-1}	3.0 mg kg^{-1}	Bees	Seed	10 g kg^{-1} seed	Field	m	
Dinotefuran	Sunflower, swamp milkweed	100 ng g^{-1} (spray) 316 ng g^{-1} (drench)	630 ng g^{-1} (spray), 3.2 ng g^{-1} (drench)	Manual	Foliar	30- 120 mg a.i L^{-1} of spray	GH	e	
					Soil drench	11.5- 121 mg a.i. pot^{-1}			
	Pumpkin	44.0- 69.2 ng g^{-1} 36.0- 147.0 ng g^{-1}	7.1- 10.6 ng g^{-1} 5.3- 10.8 ng g^{-1}	Manual	Soil spray	151 g a.i. ha^{-1} 2x 151 g a.i. ha^{-1}	Field	f	only one year shown
Endosulfan	Mustard	2.126 ppm	1.725 ppm	Bees	Foliar	525.00 g a.i. ha^{-1}	Field	d	
Boscalid	OSR	26.2 mg kg^{-1}	1.43 mg kg^{-1}	Bees	Foliar	Proline 250g a.i. kg^{-1}, 0.7 kg ha^{-1}	Field	p	
Pro-thioconazol	OSR	<LOQ (0.01 mg kg^{-1})	0.69 mg kg^{-1}			Cantus (500g a.i. kg^{-1}), 0.5 kg ha^{-1}		p	
Methyl tiophanate	Cherry	4.1 mg kg^{-1}		Pollen traps	Foliar	1.0 kg ha^{-1} Topsin M	Field	i	
Iprodione	Cherry	0.5 mg kg^{-1}		Pollen traps	Foliar	0.375 - 1.5 kg ha^{-1} Rovral 50 WP	Field	i	
	OSR	1.607 mg kg^{-1}	0.858 mg kg^{-1}	Bees	Foliar	75.00 g a.i. ha^{-1}	Field	d	

Active Ingredient	Crop	Residues in Pollen	Residues in Nectar	Sampling Method	Application Method	Dose Rate	Field/ GH	Refer-ence	Comment
Lambda cyhalothrin									
Oxamyl	Pumpkin	3.5 ng g^{-1}	3.5 ng g^{-1}	Manual	Various (e.g. soil drench, drip irrigation, foliar)	140 g a.i. ha^{-1}	Field	f	
Spiromesifen	Mustard	2.052 mg kg^{-1}	1.541 mg kg^{-1}	Bees	Foliar	225.00 g a.i. ha^{-1}	Field	d	
Thiacloprid	OSR	89.1 ng g^{-1} (max 1002.2 ng g^{-1})	6.5 ng g^{-1} (max=208.8 ng g^{-1})	Pollen traps	Spray	50 g a.i. ha^{-1}	Field	l	Mean of two years of sampling. Nectar= mean of flower nectar, combs, honey. Pollen = mean of pollen loads and bee bread.

References:

a) Bonmatin et al 2003/2005, b) Botias et al. 2015, c) Byrne et al. (2014), d) Choudhary and Sharma 2008, e) Cowles and Eitzer 2017, f) Dively and Kamel 2012, g) Jiang et al. 2018, h) Krupke et al. 2012, i) Kubik et al. 1999, j) Kunz et al 2015, k) Laurent and Rathahao 2003, l) Pohorecka et al. (2012), m) Rolke et al. 2016, n) Schmuck et al. 2001, o) Stoner and Eitzer 2012, p) Wallner 2009