

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

Article

Supplemental Material

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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 | Reference | 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 | Reference | 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 | Reference | 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 | Reference | 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 | |
| Prothioconazol | 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 | Reference | 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 | | | | | | | | | |