Sulfoxaflor and bees

Sulfoxaflor has recently come onto the market in China (Shao et al. 2013) and the USA (Dow Agro Sciences 2013; USEPA 2013), was reviewed by the EFSA in 2014 (EFSA 2014) and approved in the European Union in 2015.

Sulfoxaflor, an active substance of the family of sulfoximines, is a fourth-generation neonicotinoid based on its target receptors and binding sites, that exhibits a high insecticidal activity against a broad range of sap-feeding insects (Babcock et al. 2011, Cutler et al. 2013).

Mode of action

It acts on nAChRs, with a pharmacological profile similar to that of imidacloprid (Cutler et al. 2013). For this reason, sulfoxaflor may be considered as a neonicotinoid. However, the nature of the interactions with nAChRs differs between sulfoxaflor and the other neonicotinoids (Sparks et al. 2013). The action of sulfoxaflor and other sulfoximines, similar to that of imidacloprid, involves receptor desensitization, receptor selectivity, a differential action at low and high doses and, probably, receptor desensitization after a prolonged exposure (Oliveira et al. 2011, Watson et al. 2011, Cutler et al. 2013). This needs to be taken into account when considering possibilities for insecticide rotation in order to manage resistance toward neonicotinoids based on modification of the target site (Cutler et al. 2013).

Considering the pharmacoloy (binding sites at nACh receptors) of sulfoxaflor, insects belonging to the hemiptera order show the highest sentitivity. However, toxicity to non-hemiptera insects can be also expected at higher application rates (Cutlre et al. 2013).

Metabolism

Compared to imidacloprid, acetamiprid, dinotefuran, thiamethoxam, and clothianidin for which the extents of metabolism are respectively 85.1, 95.5, 55.1, 46.8, and 45.6 % after 24 h, sulfoxaflor presents an almost undetectable metabolism (Sparks et al. 2012).

Toxicity to bees

Table in Annex 1 summarices the LD50 values included in the European dossier. The EFSA identified a high risk to bees and several data gaps were also pointed out, namely the effects on non-Apis bees or the risk of field uses when applying risk mitigation measures. Among others, potential adverse effects on bee brood could not be excluded together with toxicity following foliar application (EFSA 2014).

The USEPA determines that the acute oral toxicity (LD_{50}) to be 0.052 µg of sulfoxaflor per bee and that the acute contact toxicity (LD_{50}) to be 0.13 µg of active substance per bee. In parallel, the EFSA determines an oral LD_{50} of 0.146 µg of sulfoxaflor per bee and a contact LD_{50} of 0.379 µg of sulfoxaflor per bee. When sulfoxaflor is included into commercial formulations the oral LD50 of

two products is 0.065 or 0.075 μg of sulfoxaflor per bee, respectively. This may indicate possible synergistic effects with some of the coformulants. Sulfoxaflor has proved to potentiate the herbicial effects of pyridine carboxylic acid compounds (Satchivi and Schmitzer 2011), however it is not clear to what extend the insecticidal effect of sulfoxaflor is also enhance by this combination.

The EFSA concluded a high toxicity to bees even considering the numerous limitations in the studies included into the dossier and a number of sub-lethal effects do not taken into account in the framework of risk assessment (Bee Life 2013 Annex II).

Residues using Good Agricultural Practicies (GAPs)

Residues in fruits and other matrices folliwing an application of sulfoxaflor under GAP are used for the estimation of MRLs. The FAO has summarised the residues in different crops collected from studies carried out worldwide. Higest residue (HR) values in citrus fruits was 0.44 mg kg^{-1}, in pomme fruits 0.26 mg kg^{-1}, in stone fruits 1.2 mg kg^{-1}, in grapes 1.6 mg kg^{-1}, and strawberries 0.21 mg kg^{-1}. On fruiting vegetables and cucurbits the HR value is 0.27 mg kg^{-1}. Leafy vegetiables HR value is 2.9 mg kg^{-1} sulfoxaflor. (FAO 2011)

Analytical sensibility

Currently there is the possiblity to detect sulfoxaflor at a level of detection (LOD) of ranging from 0.2 to 0.6 μg kg^{-1}, and LOQs from 0.7 to 2.0 μg kg^{-1} (Xu et al. 2012). These are more than 100 times lower than the MRLs proposed by the European Commission in (MRL 0.05 mg kg^{-1}).

Annexe 1. Results of acute toxicity tests (laboratory)

Test species	Test substance	Test system / Duration	Endpoint	Reference
Honey bee	Sulfoxaflor (technical)	Lab. acute oral, 48h	LD_{50} oral = 0.146 µg a.s./bee	Bergfield, A. 2007a IIA 8.7.1 /01
Honey bee	Sulfoxaflor (technical)	Lab. acute contact, 72h	LD_{50} contact = 0.379 µg a.s./bee	Bergfield, A. 2007b IIA 8.7.2/01
Honey bee	GF-2626	Lab. acute oral, 48h	LD_{50} oral = 0.539 µg GF-2626/bee LD_{50} oral = 0.065 µg Sulfoxaflor/bee	Vinall, S. 2010a IIIA1 10.4.2.1 /01
Honey bee	GF-2626	Lab. acute contact, 48h	LD_{50} contact = 2.356 µg GF-2626/bee LD_{50} contact = 0.283 µg Sulfoxaflor/bee	Vinall, S. 2010b IIIA1 10.4.2.2 /01
Honey bee	GF-2372	Lab. acute oral, 48h	LD_{50} oral = 0.153 µg GF-2372/bee LD_{50} oral = 0.075 µg Sulfoxaflor/bee	Vinall, S. 2010 IIIA2 10.4.2.1 /01
Honey bee	GF-2372	Lab. acute contact, 48h	LD_{50} contact = 0.224 µg Sulfoxaflor/bee	Vinall, S. 2009 IIIA2 10.4.2.2 /01
Bumble bee	GF-2032	Lab. acute oral and contact, 72h	LD_{50} oral = 0.027 µg XDE/208/bee LD_{50} contact = 7.554 µg Sulfoxaflor/bee	Vinall, S. 2009 IIIA1 10.4.2.1 /02
Honey bee	X11719474	Lab. acute oral, 48h	LD_{50} oral >100 µg./bee*	Vinall, S. 2009 IIA 8.7.1 /02
Honey bee	X11519540	Lab. acute oral, 48h	LD_{50} oral >91.2 µg./bee*	Vinall, S. 2010a IIA 8.7.1 /03
Honey bee	X11579457	Lab. acute oral, 48h	LD_{50} oral = 45.7 µg./bee	Vinall, S. 2010b IIA 8.7.1 /04
Honey bee	X11721061	Lab. acute oral, 48h	LD_{50} oral >103.5 µg./bee*	Vinall, S. 2010c IIA 8.7.1 /05
Honey bee	GF-2032	Laboratory foliar residue toxicity test	No significant adverse effects to bees when exposed to foliar residues of GF-2032 treated 3, 6 or 24 hours previously at 200 g Sulfoxaflor/ha.	Lee, B. 2008 IIIA1 10.4.3/01
Honey bee	GF-2372	Laboratory foliar residue toxicity test	No significant adverse effects to bees when exposed to foliar residues of GF-2372 treated 3, 6 or 24 hours previously at 100 and 200 g Sulfoxaflor/ha.	Bergfield, A. 2009 IIIA2 10.4.3/01

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