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WASHINGTON, D.C. 20460

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OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

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MEMORANDUM

SUBJECT: **Sulfoxaflor:** Ecological Risk Assessment for Section 3 Registration for Various Proposed New Uses

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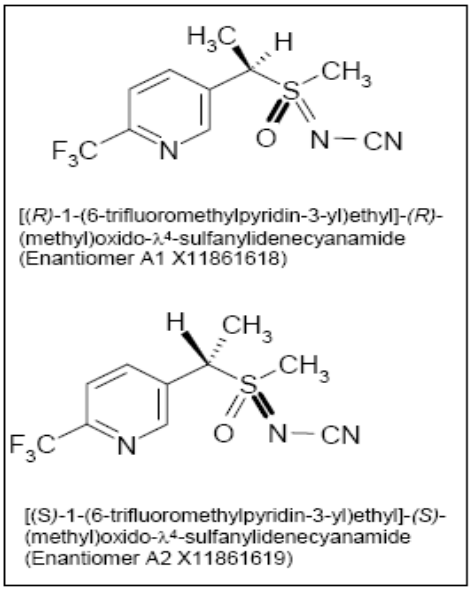
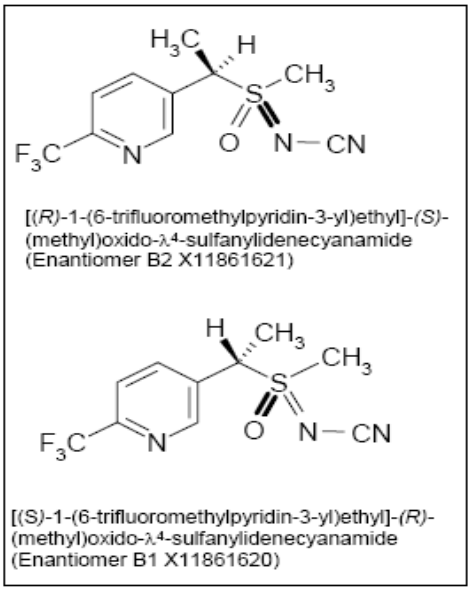
The Environmental Fate and Effects Division (EFED) has completed the environmental fate and ecological risk assessment in support of the proposed Section 3 new uses of the insecticide sulfoxaflor.

Ecological Risk Assessment for the Registration of Sulfoxaflor



Diastereomer 1
X11546257



Diastereomer 2
X11546258

Sulfoxaflor: A 50:50 Mixture of Diastereomer 1 and 2; CAS No. 946578-00-3
PC Code: 005210

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1 Executive Summary

1.1 Overview

Sulfoxaflor (N-[methyloxido[1-[6-(trifluoromethyl)-3-pyridinyl]ethyl]-lambda 4-sulfanylidene]) is currently the only member of the novel sulfoximine insecticide subclass (IRAC subclass 4C) of nicotinic acetylcholine receptor (nAChR) agonists.[1] As an agonist of the nAChR, sulfoxaflor exhibits excitatory responses in target organisms including tremors, followed by paralysis and mortality. Importantly, sulfoxaflor appears to interact with the nAChR differently than the neonicotinoid insecticides (IRAC subclass 4A) which is thought to contribute to its efficacy on neonicotinoid-resistant target pests (Watson et al., 2017). Sulfoxaflor consists of two diastereomers in a ratio of approximately 50:50 with each diastereomer consisting of two enantiomers.

Sulfoxaflor is formulated as a suspension concentrate and water dispersible granule and is proposed for application as a liquid foliar spray on a variety of crops. Currently this chemical is registered on brassica, leafy, bulb, fruiting, and root and tuber vegetables, commercial turfgrass, cereal grains, small fruits and berries, canola, ornamentals, pome and stone fruits, tree nuts, and succulent and dry beans. This assessment includes expansion of some of these uses as well as new uses on citrus fruits, cotton, cucurbit vegetables, soybeans, strawberry, pineapple, caco, avocado, rice, corn and sorghum, and non-grass animal feeds. Sulfoxaflor is systemically distributed in plants. The chemical exhibits toxicity through both the direct contact and oral ingestion of contaminated plant tissues and provides both rapid knockdown (symptoms are typically observed within 1-2 hours of application) and residual control (generally provides from 7 to 21 days of residual control).

Transformation products of sulfoxaflor in the environment include: X11719474 (X-474; major degradate[2] in aquatic and terrestrial systems), X11579540 (X-540; major degradate in aquatic but minor in terrestrial systems), and X11579457 (X-457; minor degradate in aquatic and terrestrial systems). Following consideration of exposure and toxicity for the residues of interest the stressor of concern is defined as parent sulfoxaflor only for terrestrial and aquatic organisms.

For terrestrial and aquatic ecological receptors, available evidence indicates that the X-474 degradate does not share the same Mode Of Action (MOA) as the parent and is much less toxic based on measures of effect relevant to ecological risk assessment. Available data suggests the potential for X-540 to be of comparable toxicity as parent sulfoxaflor, but it is not formed in

[1] http://www.irac-online.org/eClassification/

[2] Major degradates are those that constitute >10% of total residues; minor degradates are < 10% of total residues

significant amounts (*i.e.,* >10% formation). Detailed data and information concerning this decision are presented in the problem formulation section of this document.

1.2 Risk Conclusions Summary

Below is a summary of the environmental risk conclusions for aquatic and terrestrial organisms, based on risk quotient (RQ) values and whether they exceed levels of concern (LOCs) for non-listed species.

The potential for acute or chronic risk to fish and aquatic invertebrates is determined to be low, as acute and chronic RQ values do not exceed the respective acute and chronic LOCs of 0.5 and 1, except for use on rice. The potential for risk to aquatic and terrestrial plants is also determined to low, as RQ values do not exceed the LOC (1) for aquatic and terrestrial plants.

The potential for acute or chronic risk to birds is determined to be low. Comparisons of modeled estimated environmental concentration (EEC) to non-definitive toxicity endpoints shows a large margin in concentrations. Acute and chronic diet-based RQ values do not exceed applicable LOCs.

A potential for chronic risk to mammals is identified. Specifically, chronic dose-based RQ values up to 3.8 were determined using a refined foliar DT_{50} (dissipation time half-life) and exceed the LOC of 1 for at least one mammalian dietary category and size class across the majority of uses.

A summary of the acute and chronic RQ values pertaining to aquatic and terrestrial plants and animals (except bees) is shown in **Table 1-1.**.

Table 1-1. Summary of Risk Quotients for Taxonomic Groups from Proposed Uses of Sulfoxaflor.

Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Freshwater fish	Acute	<0.01	No	--
	Chronic	<0.01 – 0.16	No	--
Estuarine/ marine fish	Acute	<0.01	No	--
	Chronic	<0.01 – 0.09	No	--
Freshwater invertebrates	Acute	<0.01	No	--
	Chronic	<0.01	No	--
Estuarine/ marine invertebrates	Acute	<0.01– 0.26	No	--
	Chronic	0.02 – 1.17	Yes	RQs exceeding LOCs for water-column species for use on rice. Based on a 5% delay in time to first brood.
	Sub-chronic	0.01 – 0.74	No	--

Taxa	Exposure Duration	Risk Quotient (RQ) Range[1]	RQ Exceeding the LOC for Non-listed Species	Additional Information/ Lines of Evidence
Benthic invertebrates	Chronic	0.08 – 3.83	Yes	RQs exceeding LOCs for benthic species for use on rice. Based on a 20% reduction in survival.
Mammals	Acute	<0.01 – 0.03	No	--
	Chronic	0.02 – 3.29	Yes	RQs exceeding LOCs for mammals for all uses *except* cacao and canola. Based on increased pup mortality.
Birds	Acute	Not calculated	--	RQs not calculated due to non-definitive toxicity in acute studies.
	Chronic	<0.01 – 0.23	No	--
Aquatic plants	N/A	<0.01	No	
Terrestrial plants	N/A	<0.14	No	No species affected >25% in either study (seedling emergence and vegetative vigor). One incident related to decreased soybean yield was reported.

Level of Concern (LOC) Definitions:
Terrestrial Animals: Acute=0.5; Chronic=1.0; Terrestrial invertebrates=0.4
Aquatic Animals: Acute=0.5; Chronic=1.0
Plants: 1.0
[1] RQs reflect exposure estimates for parent and degradate X-540 and maximum application rates allowed on labels.

Regarding risks to bees, the following proposed uses of sulfoxaflor are considered to result in low risk to honey bees because they are either not attractive or are harvested prior to bloom:

- Brassica, Leafy, and Bulb vegetables, Barley, Oats, Rye, Teff, Triticale, Wheat, Rice, Commercial Turfgrass, and Conifer/Christmas tree

For the proposed uses on honey-bee attractive crops, a potential for acute and chronic risk to honey bees (and non-*Apis* bees for which the honey bee serves as a surrogate) is identified based on default Tier 1 assessment results. Refined Tier I acute and chronic oral RQ values exceed the acute and chronic LOCs for at least one honey bee caste and life stage with all proposed uses with an exposure potential identified for honey bees. Acute contact risks are indicated at the Tier 1 level (RQ = 0.6 to 1.1) for uses with application rates of 0.047 lb a.i./A and higher. At Tier I, risk is evaluated at the individual level.

At Tier II (which investigates the risk at the colony level), results from semi-field tunnel studies indicate risk from the combined contact and oral exposure of honey bees are short-lived (observed effects 3 days or less based on increased individual worker mortality) when applied

during foraging at application rates ranging from 0.02 to 0.07 lb a.i./A. At the highest application rate (0.09 lb a.i./A), elevated mortality rates of forager bees are indicated up to 8 days after application. The combined contact and oral exposure is expected only for those crops that allow applications during bloom. Importantly, these studies indicate that these short-term effects did not result in longer-term effects on colony strength and brood development, which addresses multiple uncertainties associated with previous assessments.

Also, at the Tier II level, a low potential for colony-level risk associated with oral exposure to sulfoxaflor is indicated for the following crops:

- Pome fruit, Cotton, Canola and Corn, Sorghum, Millet, and Teosinte

Despite proposed restrictions on applications no sooner that 3 days prior to bloom or until after petal fall, the following proposed uses of sulfoxaflor suggest a potential for colony-level risk resulting from oral exposure:

- Stone fruit, Small fruit, Tree nuts and pistachio, Tree farms or plantations, Home orchards, vineyards, or tree fruits

Furthermore, a potential for colony-level risk is indicated for the following uses which allow one or more applications during bloom:

- Citrus, Strawberry, Non-grass animal feeds, Cucurbit and Fruiting vegetables, Root and Tuber, Avocado (cacao & pineapple), Legumes, and Ornamentals

A summary of the Tier I and Tier II results for risks to honey bees is shown in **Table 1-2..**

Table 1-2. Summary of on-field risk findings for honey bees (Apis mellifera) for the proposed foliar use patterns of sulfoxaflor.

Crop Group	Honey Bee Attractive[1]	Residue Data Available	Individual Bee (Tier I) Risk		Honey Bee Colony (Tier II) Risk	Risk Conclusions[2]
			Default	Refined		
Root/Tuber Vegetables	No	NA	NA	NA	NA	**LOW RISK** [3]
	Yes[4]	No [9]	Yes	NA	Yes	**RISK**
Bulb Vegetables	No	NA	No	NA	NA	**LOW RISK** [3]
Leafy Greens Vegetables	No	NA	No	NA	NA	**LOW RISK** [3]
Brassica Vegetables	No	NA	No	NA	NA	**LOW RISK** [3]
Legumes	Yes	No [9]	Yes	NA	Yes	**RISK**
Fruiting Vegetables	No	NA	NA	NA	NA	**LOW RISK** [3]
	Yes[5]	No [9]	Yes	NA	Yes	**RISK**
Cucurbit Vegetables	Yes	**Pumpkin**	Yes	Yes	Yes	**RISK**

Crop Group	Honey Bee Attractive[1]	Residue Data Available	Individual Bee (Tier I) Risk		Honey Bee Colony (Tier II) Risk	Risk Conclusions[2]
			Default	Refined		
Citrus Fruits	No [6]	**Mandarin**	NA	NA	NA	**LOW RISK** [3]
	Yes	**Grapefruit, lemon, navel orange**	Yes	Yes	Yes	**RISK**
Pome Fruits	Yes	**Apple**	Yes	Yes	No	**LOW RISK**
Stone Fruits	Yes	**Peach**	Yes	Yes	Yes	**RISK**
Berries / small fruits	Yes	**Strawberry**	Yes	Yes	Yes	**RISK**
Tree nuts	Yes	No[10]	Yes	NA	Yes	**RISK**
Cereal Grains	No	No	NA	NA	NA	**LOW RISK**
	Yes	**Buckwheat**	Yes	Yes	No	**LOW RISK**
Non-grass animal feed	Yes	**Alfalfa**	Yes	Yes	Yes	**RISK**
Oilseed[7]	Yes	**Cotton**	Yes	Yes	No	**LOW RISK**
		Canola	Yes	Yes	No	**LOW RISK**
Pineapple, cacao, avocado	Yes	No [10]	Yes	NA	Yes	**RISK**
Other: Commercial Turfgrass [8]	No	No	NA	NA	NA	**LOW RISK**
Other: Ornamentals	No	No	NA	NA	NA	**LOW RISK** [3]
	Yes	No [9]	Yes	NA	Yes	**RISK**
Other: Tree farms	No	No	NA	NA	NA	**LOW RISK** [3]
	Yes	No [10]	Yes	NA	Yes	**RISK**

NA = not assessed.

[1] Based on USDA 2017.

[2] If crop is not attractive to bees or is harvested prior to bloom (USDA 2017), Tier I RQs are not calculated and risk conclusion is "LOW RISK."

[3] Agronomic practices indicate root/tubers, bulb, leafy brassica and most fruiting vegetables are harvested prior to bloom, unless grown for seed (USDA 2017). Other members of a crop group are not attractive to bees. These factors limit exposure of bees on the treated field. Exposure may occur on the treated field if crop is grown for seed (*i.e.*, when the crop is allowed to flower). Although sulfoxaflor may be applied to crops grown for seed, the spatial footprint for these uses is expected to be limited due to low pounds applied/yr and specific geographic areas where crops are grown for seed.

[4] Exposure is presumed for honey bee-attractive root and tubers (sweet potato, Jerusalem artichoke, edible burdock, dasheen, horseradish) since available information does not indicate they are harvested prior to bloom (USDA 2017).

[5] Applies to chilies, peppers, roselle and okra which are honey bee attractive (USDA 2017).

[6] During bloom, mandarin orange trees are tented with nets to prevent pollination from bees.

[7] Cotton is attractive for nectar only while other crops in this group are attractive for both. Cotton is also applied at a different rate than other crops in this group.

[8] Uses on commercial turf are not expected to result in exposure of bees due to management practices which limits the occurrence of weeds.

[9] Used surrogate data from all available herbaceous plants

[10] Used surrogate data from all available orchard (woody) plants

It is noted that there is a potential for repeated applications of sulfoxaflor to honey-bee attractive crops during or near bloom to result in combined oral exposures that exceed the 10-d exposure duration of the colony feeding study upon which the Tier II oral risk assessment is based. Such crops where repeated applications may be made during bloom include cucurbits, strawberry, alfalfa (when not harvested before bloom), pineapple, avocado, cacao, attractive fruiting vegetables, attractive root and tubers, and legumes. In addition, honey bee colonies used to pollinate multiple crops in succession could potentially become exposed to sulfoxaflor for combined time periods lasting longer than 10 days. Therefore, it is possible that colony-level effects could occur at lower dietary concentrations for exposures substantially longer than the 10-d exposure used to establish the current NOAEC of 0.47 mg a.i./kg. The 42-d colony feeding study suggests that long term exposures of honey bee colonies result in a similar NOAEC of 0.43 mg a.i./kg in sucrose solution (MRID 50849601). However, there is uncertainty in this study due to variable exposures encountered with the feeding solutions. If honey bee colonies were to become exposed to sulfoxaflor for periods lasting substantially longer than 10 days and such longer exposures led to greater sensitivity of colonies, there is a potential for the oral Tier II risk assessments results to underestimate colony-level risk to honey bees.

1.3 Environmental Fate and Exposure Summary

Sulfoxaflor has a low potential for volatilization from dry and wet surfaces (vapor pressure= 1.9 x 10-8 torr and Henry's Law constant= 1.2 x 10-11 atm m^3 $mole^{-1}$, respectively at 25 °C). The chemical is characterized by a water solubility ranging from 550 at pH 9 to 1,380 ppm at pH 5. The partitioning coefficient of sulfoxaflor from octanol to water (log Kow = 0.802) suggests low potential for bioaccumulation in aquatic organisms such as fish.

Sulfoxaflor residues that may reach the soil system are subjected to rapid aerobic bio-degradation (t½ <1 day) while residues deposited onto foliage may enter the plant tissue and persist in the plant through different plant growth stages. Sulfoxaflor is empirically shown to be stable to hydrolysis and photolysis on soil surfaces and in aquatic environments. In field studies, sulfoxaflor has shown similar readiness to bio-degrade aerobically in nine out of ten terrestrial field dissipation studies on bare-ground/cropped plots (half-lives were <2 days in nine cropped/bare soils in CA, FL, ND, ON and TX and was 8 days in one bare ground soil in TX).

The chemical is characterized by very high to high mobility (Kfoc ranged from 11-72 mL g-1). Rapid soil degradation is expected to limit the magnitude of chemical residues that may potentially leach and contaminate ground water. Contamination of groundwater by sulfoxaflor will only be expected when excessive rain occurs within a short period (few days) of multiple applications in vulnerable sandy soils. Contamination of surface water by sulfoxaflor is expected to be mainly related to drift and very little due to run-off. This is because drifted sulfoxaflor that

reaches aquatic systems is expected to persist while residues that reach the soil system are expected to degrade quickly with only a slight potential for run-off.

In contrast to sulfoxaflor parent, the major degradate X-474 and two other degradates (X-540 and X-457) are expected to be highly persistent in aerobic soil/aquatic systems. Adsorption data for these degradates indicate that they can be characterized by very high to high mobility for X-474 (Kfoc ranged from 7-68 mL g-1) and very high mobility for X-457 and X-540 (Kfoc ranged from 2-44 mL g-1 for X-457 and Kfoc ranged from 1-25 mL g-1 for X-540). Both surface and ground water contamination is expected from these three degradates following leaching drift/run-off events. The major degradate X-474 is expected to dominate the exposure resulting from use of sulfoxaflor.

With respect to the fate of sulfoxaflor in bee-relevant matrices, available residue data indicates that sulfoxaflor persists for relatively short periods of time in pollen and nectar. Among the 28 dissipation half-life values (DT_{50}) calculated, the mean DT_{50} was approximately 1 day and the 90^{th} percentile was about 2 days for both pollen and nectar. These data indicate that sulfoxaflor is not expected to increase in its accumulation in pollen and nectar following repeated applications in accordance with the label retreatment intervals.

1.4 Ecological Effects Summary

Based on available data, sulfoxaflor is classified as slightly toxic to practically non-toxic to fish and freshwater water column dwelling aquatic invertebrates on an acute exposure basis. Adverse effects of sulfoxaflor on aquatic plants, as indicated by the effect concentrations resulting in 50% reduction in growth (EC_{50}) approach 100 mg a.i./L, indicating it has low toxicity to aquatic plants. Sulfoxaflor is highly toxic to saltwater invertebrates (mysid shrimp; *Americamysis bahia*) on an acute exposure basis. The NOAEC for chronic toxicity of sulfoxaflor to freshwater benthic invertebrates (midge, *Chironomus riparius*) is 0.037 mg a.i./L in porewater. The high toxicity of sulfoxaflor to mysid shrimp and aquatic insects relative to the water flea is similar to other insecticides which act on the insect nAChR.

For birds and mammals, sulfoxaflor is classified as moderately toxic to practically non-toxic on an acute exposure basis. The threshold for chronic toxicity (NOAEL) to birds is 200 ppm and that for mammals is 100 ppm in the diet. Sulfoxaflor did not exhibit deleterious effects to terrestrial plants at or above its proposed maximum application rates.

For bees, sulfoxaflor TGAI is classified as very highly toxic with acute oral and contact LD_{50} values of 0.15 and 0.13 µg a.i./bee, respectively, for adult honey bees (*Apis mellifera*). For larvae, an 8-d oral LD_{50} of >0.415 µg a.i./bee was determined (*i.e.,* greater than the highest test concentration). On a chronic exposure basis, 10-d NOAEL of 0.0054 µg a.i./bee/day was

determined for adult honey bees while a 22-d NOAEL of 0.212 µg a.i./bee/day was determined for larval honey bees. The primary metabolite of sulfoxaflor (X-474) is practically non-toxic to the honey bee. This lack of toxicity for the metabolite is consistent with the cyano-substituted neonicotinoids where similar cleavage of the cyanide group appears to eliminate their insecticidal activity. The acute oral toxicity of sulfoxaflor to adult bumble bees (*Bombus terrestris*) is similar to the honey bee; whereas its acute contact toxicity is about 20X less toxic for the bumble bee. Sulfoxaflor formulated products did not demonstrate substantial residual toxicity to honey bees exposed via treated and aged alfalfa (*i.e.,* mortality was <15% at maximum application rates), corresponding to RT_{25} values of less than 3 hours. All recommended data according to USEPA 2014; 2016 and required data according to 40 CFR Part 158.630 for individual bees (Tier I laboratory studies) have been submitted and are sufficient for RQ calculation in risk assessment for sulfoxaflor.

At the colony (Tier II) level, three newly submitted tunnel studies indicate that effects on forager bees are short lived (*i.e.,* 8 days or less depending on application rate and endpoint) when sprayed on crops while bees are actively foraging. At all tested rates, the short-term effects on individuals did not result in long-term effects on colonies, as indicated by colony strength and brood development being similar among control and treated colonies. At the 0.02-0.04 lbs a.i./A treatment group, no colony-level effects were identified following overwintering, while at higher rates (0.07-0.09 lbs a.i./A), results on overwintering were inconclusive due to high colony loss in control colonies. However, no long-term colony-level effects were observed prior to overwintering and submitted studies from other insecticides that act on the nicotinic acetylcholine receptor indicate that effects on colonies post overwintering are not more sensitive than those expressed prior to overwintering. Furthermore, the relatively short duration (3 days or less) of forager mortality and quantifiable residues of sulfoxaflor in pollen and nectar are not suggestive of long-term exposure.

Two colony feeding studies (Tier II) that evaluated effects of oral exposure to sulfoxaflor were also submitted, one of which is considered acceptable for quantitative use in risk assessment. This study, which evaluated the effects of feeding colonies spiked sucrose solution for 10 days, showed that concentrations of 1.85 and 3.78 mg a.i./kg resulted in sustained reductions in colony strength, brood development, hive weight and increased worker and larval bee mortality. Exposure to 3.78 mg a.i./kg also resulted in reduced overwintering success. Based on this study, the colony-level NOAEC and LOAEC used for assessing oral risk is 0.47 and 1.85 mg a.i./kg in sucrose solution. While a similar colony-level NOAEC of 0.43 mg a.i./L was indicated from a 42-d continuous exposure of honey bee colonies to sulfoxaflor (MRID 50849601). However, this study is classified as supplemental (qualitative) due to uncertainties associated with actual exposures that hives received during the study.

2 Introduction

This Section 3 New Use assessment examines the potential ecological risks associated with proposed label uses of sulfoxaflor on non-listed non-target organisms. Federally listed threatened/endangered species ("listed") are not evaluated in this document. For additional information on listed species see **Appendix C**. This assessment uses the best available scientific information on the use, environmental fate and transport, and ecological effects of sulfoxaflor. The general risk assessment methodology is described in the *Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs* ("Overview Document") (USEPA, 2004). Additionally, the process is consistent with other guidance produced by the Environmental Fate and Effects Division (EFED) as appropriate. When necessary, risks identified through standard risk assessment methods are further refined using available models and data. This risk assessment incorporates the available exposure and effects data and most current modeling and methodologies.

Sulfoxaflor was registered as a new chemical by EPA in 2013. Following a legal challenge to the registration, all uses were vacated in late 2015. In 2016, EPA registered sulfoxaflor for uses where exposure of bees could be precluded (i.e., for unattractive crops or with applications after bloom). Several Section 18 emergency exemption registrations have been granted between vacatur of uses and the time of this assessment. Additional ecological toxicity studies were submitted to support the registration of previously vacated uses and additional new uses of sulfoxaflor. This assessment reviews previous studies and newly submitted studies to provide a full assessment for all requested use patterns.

3 Problem Formulation

3.1 Mode of Action for Target Pests

Sulfoxaflor is a new class of insecticide as it is currently the only member of the sulfoximine subclass of the Group 4 insecticides according to the Insecticide Resistance Action Committee (IRAC). Other subclasses include the neonicotinoid insecticides, Group 4A, containing the cyano-substituted (*e.g.*, acetamiprid) and the nitroguanidine-substituted neonicotinoids (*e.g.*, imidacloprid, thiamethoxam, clothianidin and dinotefuran). Group 4 chemicals are agonists of the nicotinic acetylcholine receptor (nAChR) whereby it exhibits excitatory responses including tremors, followed by paralysis and mortality in target insects (Zhu *et al.* 2011). Sulfoxaflor has also not demonstrated cross-resistance in strains of whitefly and brown planthopper that were bred to be highly resistant to the nitroguanidine subclass neonicotinoid such as imidacloprid (Zhu *et al.* 2011); this lack of cross resistance is believed to be partially due to sulfoxaflor's lack of susceptibility to the metabolic mechanisms that are considered responsible for insect resistance to neonicotinoids (*e.g.*, upregulation of monooxygenase [CYP6G1] enzymes). Zhu *et*

al. also indicate the specific nature sulfoxaflor binding to the nAChR likely differs from that of other subclasses, Group 4A as well as Group 4D (butenolides: flupyradifurone). As a result, the IRAC classifies sulfoxaflor in its own subclass (subclass C; sulfoximines) under Group 4 (nicotinic acetylcholine receptor agonists).

3.2 Label and Use Characterization

Sulfoxaflor is proposed for application as a liquid foliar spray applied by ground and aircraft equipment on a variety of crops. In 2012 a Section 3 new chemical ecological risk assessment (DP382619)[3] was conducted for the use sulfoxaflor on various crops. In 2016, EFED published an addendum[4] to the 2012 risk assessment following the 9th Circuit Court's decision regarding concern for the potential risks to bees. The referenced addendum focused on assessment of risk to bees and was based on the revised labels for Transform® WG and Closer® SC (active ingredient: sulfoxaflor). The revised labels contained many changes relative to the labels associated with the initial 2012 Section 3 registration. The notable changes included:

(1) removal of certain bee attractive crops (*e.g.,* citrus, cotton, cucurbits, soybean and strawberry;
(2) prohibiting applications before or during bloom (*e.g.,* canola, stone fruits, pome fruits, *etc*.);
(3) prohibiting use on crops grown for seed production (*e.g.,* brassica, bulb Veg., leafy Veg., *etc*.); and
(4) lowering the maximum single application rate to 0.09 lb a.i/A (ground or aerial spray) and maximum annual rate to 0.266 lb a.i/A for all uses.

The label summary, hereunder, takes into consideration all current uses and label changes.

3.2.1 Label Summary

Sulfoxaflor is proposed to be used on a wide variety of use patterns to control or suppress piercing/sucking insect pests including aphids, plant bugs, stink bugs, whiteflies and certain scales, thrips and psyllids. Sulfoxaflor is formulated as a suspension concentrate "SC" (Proposed label: **Closer® SC, Reg. No.** 62719-623 containing 2 lb a.i/gal) and as water dispersible granule "WG" (Proposed label: **Transform® WG, Reg. No.** 62719-625 containing 50% a.i by weight).

Formulations are proposed to be applied as a liquid spray by ground, air blast, and aerial equipment onto the crop foliage. The potential spatial extent of usage areas is large when

[3]Environmental Fate and Ecological Risk Assessment for Sulfoxaflor Registration (DP Barcode 382619 dated December 19, 2012) URL: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2010-0889-0022

[4] 2016 Addendum to the Environmental Fate and Ecological Risk Assessment for Sulfoxaflor Registration (DP Barcodes 430221 and 430222 dated May 16, 2016)

considering the use patterns that are proposed. **Table 3-1.** contains a summary of all crops proposed to be treated with sulfoxaflor.

Notable label information and restrictions are:

(1) **Medium to coarse spray** is proposed to be applied 4 ft. above target foliage for ground application and <10ft for aerial application;

(2) Although more than two applications are permitted for most of the crops, **no more than two consecutive applications** per crop (or per cutting for alfalfa) may be applied;

(3) The proposed single application rate is slightly different between **Closer®** and **Transform®** (*e.g.*, 0.043 compared to 0.047 lb. a.i/A; 0.0859 compared to 0.0898; 0.070 compared to 0.071 lb. a.i/A); however, single rate and number of applications per year in both labels are set by the same maximum yearly rate;

(4) For application to rice: Flood water may be released only after 7 days post application; and Do not use treated rice fields for the aquaculture of edible fish and crustaceans; and

(5) Application restrictions are included in the labels for certain crops to mitigate possible exposure to bees. These restrictions are summarized in **Table 3-1**.

Table 3-1. Crop use patterns proposed for sulfoxaflor; ground or aerial for all uses except for turf and non-commercial ornamentals (ground application).*

Use Site/ Location (Variety and/or Crop Group)	App Type	Max Single Rate lbs ai/A	Max # App/yr*	Max Annual Rate lbs ai/A/yr*	MRI (d)	Comments (e.g. geographic/application timing restrictions, pollinator specific language)
Alfalfa: Alfalfa and other non-grass animal feeds (Crop Group 18)	Ground/ Aerial	0.0898	3	0.266	7	Advisory: 48 hours notification of beekeepers within 1 mile
Avocado	Ground/ Aerial	0.0898	3	0.266	7	
Barley: Barley, Oats, Rye, Teff, Triticale and Wheat	Ground/ Aerial	0.043	2	0.086	14	
Beans: Beans (Succulent, Edible Podded, and Dry)	Ground/ Aerial	0.071	4	0.266	14	
Brassica Veg.: Brassica (Cole) Leafy Vegetables (Crop Group 5)	Ground/ Aerial	0.0898	3	0.266	7	Do not use on crops grown for seed (Closer® label only)
Bulb Veg.: Bulb Vegetables (Crop Group 3-07)	Ground/ Aerial	0.0898	3	0.266	7	
Cacao	Ground/ Aerial	0.036	4	0.140	28	
Canola: Canola (Rapeseed) (Subgroup 20A)	Ground/ Aerial	0.023	2	0.046	14	Do not apply period: 3 d prior to bloom until petal fall
Citrus (Crop Group 10)	Ground/ Aerial	0.0898	3	0.266	14	Allow only one application 3 d prior to bloom until after petal fall/year Advisory: 48 hours notification of beekeepers within 1 mile; Limit application timing when managed bees and native pollinators are least active (before 7 am; after 7 pm; temperature <55 ^{o}F);
Corn (Field, Sweet, Seed, and Popcorn), Millet, Sorghum and Teosinte	Ground/ Aerial	0.047	2	0.094	14	

Use Site/ Location (Variety and/or Crop Group)	App Type	Max Single Rate lbs ai/A	Max # App/yr*	Max Annual Rate lbs ai/A/yr*	MRI (d)	Comments (e.g. geographic/application timing restrictions, pollinator specific language)
Cotton	Ground/ Aerial	0.071	4	0.266	5	Advisory: 48 hours notification of beekeepers within 1 mile
Cucurbits: Cucurbit Vegetables (Crop Group 9)	Ground/ Aerial	0.071	4	0.266	7	Advisory: 48 hours notification of beekeepers within 1 mile; Limit application timing when managed bees and native pollinators are least active (before 7 am; after 7 pm; temperature <55 ^{o}F);
Fruiting Veg.: Fruiting Vegetables (Crop Group 8) and Okra	Ground/ Aerial	0.071	4	0.266	7	
Home Orchards: Vineyards or Fruit Trees (For professional use only): Citrus, Pome & Stone Fruits & Grapes	Ground	0.0898	3	0.266	7	Do not apply period: 3 d prior to bloom until petal fall (not citrus or grapes) Advisory: 48 hours notification of beekeepers within 1 mile; Limit application timing when managed bees and native pollinators are least active (before 7 am; after 7 pm; temperature <55 ^{o}F);
Leafy Veg.: Leafy Vegetables (Except *Brassica*) (Crop Group 4) and Watercress	Ground/ Aerial	0.0898	3	0.266	7	
Ornamentals in Nurseries: Ornamentals (Herbaceous and Woody) Growing in Greenhouses, Residential and Commercial Landscapes and Nurseries (Including Conifer Seedling Nurseries and Conifer Seed Orchards)	Ground	0.0898	3	0.266	14	May apply a maximum of four applications at reduced rates (yearly maximum= 0.266) that may include only one application at a rate of 0.071 lb. a.i/A during bloom.
Pineapple	Ground/ Aerial	0.0898	2	0.18	14	
Pome Fruits (Crop Group 11)	Ground/ Aerial	0.0898	3	0.266	7	Do not apply period: 3 d prior to bloom until petal fall

Use Site/ Location (Variety and/or Crop Group)	App Type	Max Single Rate lbs ai/A	Max # App/yr*	Max Annual Rate lbs ai/A/yr*	MRI (d)	Comments (e.g. geographic/application timing restrictions, pollinator specific language)
Rice	Ground/ Aerial	0.0665	4	0.266	14	
Root and Tuber Veg. (2; 1A and 1B)	Ground/ Aerial	0.0898	3	0.266	7	
Root and Tuber Veg.: Leaves of Root and Tuber Vegetables (Crop Group 2)	Ground/ Aerial	0.0898	3	0.266	7	
Potatoes (Crop Groups 1C and 1D)	Ground/ Aerial	0.071	4	0.266	14	
Small Fruits: Small Fruit Vine Climbing (Except Fuzzy Kiwifruit) (Subgroup 13-07F)1 and Low Growing Berry (Except Strawberry) (Subgroup 13-07G)	Ground/ Aerial	0.0898	3	0.266	7	Do not apply period: 3 d prior to bloom until petal fall
Soybean	Ground/ Aerial	0.071	4	0.266	14	
Stone Fruits (Crop Group 12)	Ground/ Aerial	0.0898	3	0.266	7	Do not apply period: 3 d prior to bloom until petal fall
Strawberry	Ground/ Aerial	0.071	3	0.266	7	Advisory: 48 hours notification of beekeepers within 1 mile; Limit application timing when managed bees and native pollinators are least active (before 7 am; after 7 pm; temperature <55 ^{o}F).
Tree Farms or Plantations	Ground/ Aerial	0.0898	3	0.266	14	Do not apply period: 3 d prior to bloom until petal fall Advisory: 48 hours notification of beekeepers within 1 mile; Limit application timing when managed bees and native pollinators are least active (before 7 am; after 7 pm; temperature <55 ^{o}F);

Use Site/ Location (Variety and/or Crop Group)	App Type	Max Single Rate lbs ai/A	Max # App/yr*	Max Annual Rate lbs ai/A/yr*	MRI (d)	Comments (e.g. geographic/application timing restrictions, pollinator specific language)
Tree Nuts (Crop Group 14)1 and Pistachio	Ground/ Aerial	0.0898	3	0.266	7	Do not apply period: 3 d prior to bloom until petal fall
Turfgrass (Commercial Sod Farms Only)	Ground	0.0898	3	0.266	7	

App=application; MRI = Minimum retreatment interval; ai=active ingredient; d=day.

**** Maximum* annual application rate**: It is noted that the single rate used varies depending on the crop, pest type and degree of infestation. Label minimum single rates range from 0.016 to 0.071 lbs a.i/A and maximums ranging from 0.036 to 0.09. Furthermore, the number of applications range from two to 4 applications per year with intervals between applications ranging from 5 to 28 days\ Information is provided on an annual basis, unless otherwise specified.

4 Residues of Concern

In this risk assessment, for aquatic organisms, the stressor of concern to aquatic organisms is considered to be sulfoxaflor parent only. The majority of sulfoxaflor degradates are considered minor and not included in consideration for degradates of concern. Although X-474 is considered a major degradate, it is also not included in the stressor for aquatic organisms because it is practically non-toxic to aquatic organisms on an acute exposure basis and the expectation that it does not share the same MOA as parent due to loss of cyano-substitution. Available toxicity data for degradates is summarized in Section 6.1 and 6.2.

For terrestrial animals (birds, mammals, and terrestrial invertebrates), the stressor of concern is defined as parent sulfoxaflor only. This definition considers the lower potency of the two primary degradation products in plants (X-474 and X-061) and lack of significant exposure expected for X-540. The X-540 degradate is not formed at significant quantities to result in exposure of terrestrial organisms. For terrestrial plants, the stressor is defined as sulfoxaflor only given that no comparative toxicity data for plants are available for the parent or degradates and that parent chemical was not toxic to terrestrial plants at or above the proposed maximum application rates.

5 Environmental Fate Summary

Sulfoxaflor is a systemic insecticide which displays translaminar movement when applied to foliage. As no new data is available to describe the fate properties of sulfoxaflor, a summary of the physical chemistry and environmental fate properties is provided below. For a full description of the environmental fate of this chemical, refer to the previous new chemical assessment (USEPA 2012a).

Physical and chemical properties

The physical and chemical properties of sulfoxaflor are summarized in **Table 5-1.** These data indicate that the chemical is characterized by a water solubility ranging from 550 to 1,380 ppm in alkaline to acidic conditions, respectively. Sulfoxaflor has a low potential for volatilization from dry and wet surfaces (vapor pressure= 1.9×10^{-8} torr and Henry's Law constant= 1.2×10^{-11} atm m^3 $mole^{-1}$, respectively at 25 °C). The partitioning coefficient of sulfoxaflor from octanol to water (K_{ow}) suggests low potential for bioaccumulation in aquatic organisms such as fish. However, the logarithm of its partitioning coefficient from octanol to air (Log K_{oa}=10) suggests potential bioaccumulation in terrestrial organisms, but the expected relative availability in air is low because the amount expected to partition into air is low (low volatility) and its half-life in the air is expected to be short (range of 8-16 hours). Furthermore, sulfoxaflor is not expected to partition into the sediment due to low K_{oc}.

Table 5-1. Summary of Physical-Chemical, Sorption, and Bioconcentration Properties of Sulfoxaflor and Residues of Concern.

Property	Description or Value	Reference*
CAS Name	Sulfoxaflor: cyanamide, N-[methyloxido[1-[6-(trifluoromethyl)-3-pyridinyl]ethyl]-lambda 4-sulfanylidene]-	Registrant Data
Molecular Formula	$C_{10}H_{10}F_3N_3OS$	
CAS number	946578-00-3	
PC code	005210	
Molecular Weight	277.27 g/mol	
Solubility (mg/L @ 20˚C)	**Parent** **X-474** pH 5 → 1,380 mg/L 7,270 mg/L pH 7 → 570 mg/L 7,200 mg/L pH 9 → 550 mg/L 8,480 mg/L In purified water: 670 mg/L 8,090 mg/L	478320-10 478320-23 for X-474
Vapor pressure	Parent 20°C → ≤ 1.1 x 10^{-8} torr; ≤ 1.4 x 10^{-6} Pa; ≤ 1.4 x 10^{-11}atm 25°C → ≤ 1.9 x 10^{-8} torr; ≤ 2.5 x 10^{-6} Pa; ≤ 2.5 x 10^{-11}atm X-474 25°C → ≤ 2.0 x 10^{-9} torr; ≤ 2.7 x 10^{-7} Pa; ≤ 2.7 x 10^{-12}atm	478320-06 478320-22 for X-474
Henry's Law Constant (@ 20 & 25˚C)	6.7 x 10^{-12} atm m^3 $mole^{-1}$; 5.1 x 10^{-9} torr m^3 $mole^{-1}$ 1.2 x 10^{-11} atm m^3 $mole^{-1}$; 9.1 x 10^{-9} torr m^3 $mole^{-1}$	478320-07 from VP at 20°C Calculated from VP at 25°C
Half-life in Air ($t_{½}$ in hours)	range: 7.8 - 15.5	EPI-Suit v3.2 (AOPWIN) & Level III Fugacity Model
Log K_{oa}	10.11	EPI-Suit v3.2 (KOAWIN)
K_{ow} @ 20˚C & pH 7	Parent: 6 (Log K_{ow} = 0.802) X-474, X-540 and X-457: <2 (Log K_{ow} = 0.3)	478320-11 478320-20/24/27
K_{oc}	7 – 74 mL/g	47832018

CV=Coefficient of Variation

[1]All estimated values were calculated according to "*Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in Problem Formulations for Registration Review, Registration Review Risk Assessments, Listed Species Litigation Assessments, New Chemical Risk Assessments, and Other Relevant Risk Assessments*" (USEPA, 2010).

Fate properties

Table 5-2. contains a summary of abiotic and biotic laboratory degradation for sulfoxaflor and its major degradates X-474.

Table 5-2. Fate properties of sulfoxaflor parent and its major degradate X-474.

Property	Description or Value & Other Relevant Information	Reference (MRID
Hydrolysis half-life @ 25 °C	**Parent: Stable** in sterile aqueous buffered solution at pH values of 5, 7 and 9 **X-474 degradate: Stable** in sterile aqueous buffered solution at pH7	478321-49 (parent Study) No study for X-474; results inferred from the dark controls of the aqueous photolysis study (MRID 478322-83)

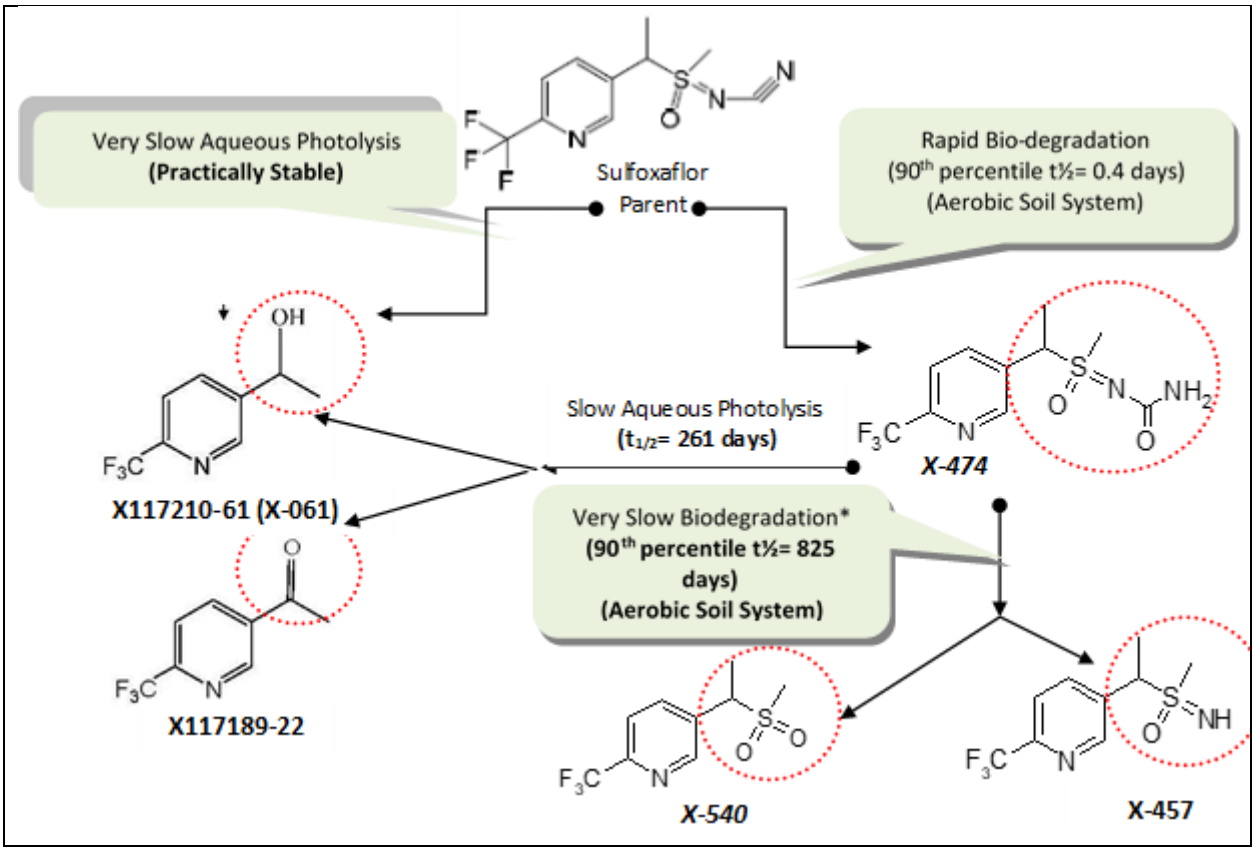
Property	Description or Value & Other Relevant Information	Reference (MRID
Environmentally relevant Aqueous photolysis half-lives @ 25 °C; 40°N latitude in summer sunlight	**Parent: >1,000 days** in sterile aqueous buffered solution at pH 7.0 **Major degradates: None** **Minor degradates:** X-061 with a maximum of 2.5% @ end of study (EOS) **X-474 degradate:** **261 days** in sterile aqueous buffered solution at pH 7 **Major degradates: None** **Minor degradate:** X-061 (maximum 4.4% at EOS) and X-922 with a maximum of 8.6% @ EOS	478322-83
Soil photolysis half-life	**Stable**	478320-21
Aerobic Soil half-life, days @ 25 ºC	**Lenawee light clay**, Michigan, USA: CL (**Parent= 0.3; X-474= >1,000**); **Pullman light clay**, Texas, USA: CL (**Parent= 0.4; X-474= >1,000**); **Fayette clay loam**, Iowa, USA: L (**Parent= 0.6; X-474= >1,000**); **Slagle clay loam**, Virginia, USA: SL (**Parent= 0.5; X-474= >1,000**); **Cranwell Series** (Site I), Lincolnshire, UK: LS (**Parent= <1; X-474= 203**); **Aberford Series** (Site J1), Rutland, UK : L (**Parent= <1; X-474= 85**); **Malham Series** (Site E), Derbyshire, UK: SL (**Parent= <1; X-474= 381**); and **LUFA 5M,** Kreis Rheim-Pfalz, Germany: SL (**Parent= <1; X-474= 251)**	478655-78 And 478320-13
Aerobic Aquatic (days in the total system)	**System 1** Pond water: sediment, UK: (Parent= **88**; X-474= **NC**); and **System 2** Pond water: sediment, UK: (Parent= **37**; X-474= **NC**)	478320-14
Anaerobic Aquatic (days in the total system)	**System 1** Pond water: sediment, VA: (Parent= 3**82**; X-474= **5,270**); and **System 2** Pond water: sediment, IA: (Parent= 103; X-474= 1,090)	473723-11
Terrestrial Field Dissipation (DT50 in days for Bare Ground-Cropped plots)	CA (2.0-1.9); FL (0.7-1.6); ND (0.3-0.1; Ontario, Canada (0.6-0.9); and TX (8.1-1.5) Consistent with lab studies the Major degradate was X-474 with DT50 ranging from 27-248 days in the top 6" of the soil and 6 to 200 days in the entire profile	47832282
Adsorption/Desorption (Koc L/Kg)	Parent (Range: 11-72, Average: 35, n=17)) X-474 (Range: 7-68, Average: 30, n=17)	47832018

Abbreviations: NC= Cannot be calculated due to gain or only few points are available; **Soil Textural Classes: CL**= Clay Loam; **L**= Loam Soil; **SL**= Sandy Loam Soil; and **LS**= Loamy sand; Data for aerobic systems from parent study while that for anaerobic systems from two separate studies: one for parent and the other for the major degradate X-474

Abiotic degradation data in **Table 5-2.** indicates that hydrolysis, and both aqueous and soil photolysis are not expected to be important in sulfoxaflor dissipation in the natural environment. In the hydrolysis study, parent was shown to be stable in acidic/neutral/alkaline sterilized aqueous buffered solutions (pH values of 5, 7 and 9; MRID 47832-149). In addition, parent chemical as well as its major degradate, were shown to degrade relatively slowly by aqueous photolysis in sterile and natural pond water (t½= 261 to >1,000 days; MRID 478322-83/84). Furthermore, sulfoxaflor was stable to photolysis on soil surfaces (MRID 478320-21).

Biotic degradation data in **Table 5-2.** indicates sulfoxaflor is expected to biodegrade rapidly in aerobic soil (half-lives <1 day). Under aerobic aquatic conditions, biodegradation proceeded at a more moderate rate with half-lives ranging from 37 to 88 days. The major degradate formed in aerobic soil/aquatic systems is X-474. Under anaerobic soil conditions, the parent compound was metabolized with half-lives of 113 to 120 days while under anaerobic aquatic conditions the chemical was more persistent with half-lives of 103 to 382 days. In contrast to its short-lived parent, the major degradate X-474 is expected to be more persistent than its parent in aerobic/anaerobic aquatic systems and some aerobic soils. In other soils, less persistence is expected due to mineralization to CO2 or the formation of X-540 (max. of 12%) and others minor degradates.

Figure 5-1 represents a summary of the degradation profile for sulfoxaflor noting that details concerning parent degradation products observed in the soil and aquatic systems are presented in the 2012 assessment. After consideration of the degradation profile in the referenced assessment, it was concluded that the major degradate of sulfoxaflor is X-474 in addition to the degradate X-540 which was observed only in the soil system at a maximum concentration of 12% (Was not observed in aquatic systems). Expected residues reaching aquatic system by run-off include X-474 and X-540 as major and minor degradates, respectively. Parent reaching aquatic systems by drift is expected to result in a residue dominated by the degradate X-474 only.



* Half-lives were >1,000 days in US soils with no degradates observed. In contrast, half-lives ranged from 85-381 days in EU soils producing degradate X-540 & X-457. Separate aerobic soil experiments showed that both of these degradates are persistent (90th percentile half-lives were 526 days (range 96 to 670 days) for X-457 and 2,808 days (range 71 to 3,630 days) for X-540

Figure 5-1. Expected environmental degradation pathways and transformation profiles for Sulfoxaflor.

6 Ecotoxicity Summary

Ecological effects data are used to estimate the toxicity of sulfoxaflor to surrogate species. Previously submitted ecotoxicity data on the effects of sulfoxaflor and its associated products on aquatic and terrestrial plants and animals have been reviewed in a new chemical risk assessment (USEPA 2012a; USEPA 2016a). In addition, newly submitted toxicity data for bees (Tier I and Tier II) have been submitted since 2016. These data are summarized in Section 6.1 and Section 6.2**.**

Table 6-1. and **Table 6-2.** summarize the most sensitive measured toxicity endpoints available across taxa. These endpoints are not likely to capture the most sensitive toxicity endpoint for a particular taxon but capture the most sensitive endpoint across tested species for each taxa. All studies in this table are classified as acceptable or supplemental. Non-definitive endpoints are designated with a greater than or less than value.

6.1 Aquatic Toxicity

The most sensitive aquatic toxicity study endpoints for each group is summarized below in **Table 6-1.**. The available data indicate that sulfoxaflor technical grade active ingredient (TGAI) is practically nontoxic to freshwater fish, estuarine/marine fish, and freshwater invertebrates on an acute exposure basis. Sulfoxaflor is highly toxic to estuarine/marine invertebrates on an acute exposure basis.

The No Observable Adverse Effects Concentrations (NOAECs) are approximately 10-times more sensitive than the acute LC_{50}s for invertebrates and 100-times more sensitive for fish.

Sub-chronic and chronic sediment studies are available and toxicity endpoints are used to assess risk from pore water exposure. Midge are 100-times more sensitive than daphnia based on chronic effects. This is expected based on mode of action.

Data on aquatic algae are available with the freshwater diatom yielding the most sensitive endpoints. Vascular aquatic plants demonstrated toxic effects less than 50% up to the highest concentration tested.

Table 6-1. Aquatic Toxicity Endpoints Selected for Risk Quotient Calculations for Sulfoxaflor.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in mg a.i./L (unless otherwise specified)[1]	MRID or ECOTOX No./ Classification	Comments
Freshwater Fish (surrogates for vertebrates)					
Acute	TGAI 95.6% ai	Bluegill sunfish (*Lepomis macrochirus*)	96-h LC_{50} = >363	47832112 (Supplemental)	Practically nontoxic

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value in mg a.i./L (unless otherwise specified)[1]	MRID or ECOTOX No./ Classification	Comments
Acute	Degradate X474	Rainbow trout (*Oncorhynchus mykiss)*	96-h LC_{50} = >478	47832105 (Acceptable)	Practically nontoxic
Chronic	TGAI 95.6% ai	Fathead minnow (*Pimephales promelas*)	30-day (ELS) NOAEC = 0.65 LOAEC = 1.25	47832126 (Supplemental)	Reduced fry dry weight (18%)
Estuarine/marine Fish (Surrogates for vertebrates)					
Acute	TGAI 95.6% ai	Sheepshead minnow (*Cyprinodon variegatus*)	96-h LC_{50} = 266	47832110 (Acceptable)	Practically nontoxic
Chronic	TGAI 95.6% ai	Sheepshead minnow (*Cyprinodon variegatus*)	30-Day NOAEC = 1.2 LOAEC = 2.4	47832129 (Acceptable)	Reduced length (2.7%)
Freshwater Invertebrates					
Acute	TGAI 95.6% ai	Water flea (*Daphnia magna*)	48-h LC_{50} = >400	47832114 (Acceptable)	Practically nontoxic
Acute	Degradate X474	Water flea (*Daphnia magna*)	48-h LC_{50} = >205	47832106 (Acceptable)	Practically nontoxic
Chronic	TGAI 95.6% ai	Water flea (*Daphnia magna*)	21 day NOAEC = 50.5 LOAEC = 101	47832127 (Acceptable)	Reduced reproduction (40%)
Estuarine/ marine invertebrates					
Acute	TGAI 95.6% ai	Mysid shrimp (*Americamysis bahia*)	96-h LC_{50} = 0.64	47832117 (Acceptable)	Highly toxic
Chronic	TGAI 95.6% ai	Mysid shrimp (*Americamysis bahia*)	28-day NOAEC = 0.11 LOAEC = 0.24	47832128 (Acceptable)	Decreased days to first brood (4.5%)
Freshwater invertebrate (sediment)[2]					
Sub-chronic	TGAI 95.6% ai	Midge (*Chironomus dilutus*)	10 day Pore water: NOAEC = 0.099 LOAEC = 0.174	47832109 (Acceptable)	Dry weight (31%) and survival (55%)
Chronic	TGAI 95.6% ai	Midge (*Chironomus riparius*)	28 day Pore water: NOAEC = 0.019 LOAEC = 0.037	Gerke A (2009) (Supplemental)	Emergence (23%)
Aquatic plants and algae					
Vascular	TGAI 95.6% ai	Duckweed (Lemna gibba)	7-d EC_{50} = >99 NOAEC = 99	47832125 (Acceptable)	Dry weight and frond count
Non-vascular	TGAI 95.6% ai	Freshwater diatom (Navicula pelliculosa)	96-h EC_{50} = 81.2 NOAEC = 3.54	47832123 (Acceptable)	Biomass and yield

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient

[1] NOAEC and LOAEC are reported in the same units.

[2] With a log K_{oc} of 0.8 sulfoxaflor is not expected to partition into the sediment, therefore toxicity endpoints used from this study to assess risk are from pore water exposure only.

>Greater than values designate non-definitive endpoints where no effects were observed at the highest level tested, or effects did not reach 50% at the highest concentration tested (USEPA, 2011).

6.2 Terrestrial Toxicity

The most sensitive aquatic toxicity study endpoints for each group is summarized below in Table 6-2.. These data indicate that sulfoxaflor TGAI ranges from slightly-toxic to moderately toxic to birds including passerines and mammals (slightly-toxic) on an acute oral exposure basis. A non-definitive toxicity endpoint is included for acute oral toxicity to birds and is based on regurgitation of the test material. This study is fully described in the previous new chemical assessment (DP382619). Additionally, sulfoxaflor is considered practically non-toxic on a sub-acute dietary exposure basis. Sulfoxaflor is highly toxic to honey bees at all life stages on an acute contact and oral exposure basis. Discussion of the honey bee effects data, specifically higher tier studies, is described in more detail in **Section 11.4**.

In 20-week reproductive toxicity study on the mallard, the NOAEC and LOAEC were 200 and >200 mg a.i./kg-diet, respectively, with no observed effects. Laboratory rats fed diets containing sulfoxaflor had a NOAEC and LOAEC of 6.07 and 24.6 mg a.i./kg-diet based on increased post-implantation loss, stillbirth, and decreased gestational survival.

The available data for terrestrial plants exposed to the formulated product Closer (GF-2032) indicate that sulfoxaflor exposure to seeds in treated soils resulted in no observable effects up to double the proposed single application rate. Exposure to foliage resulted in reduced plant dry weight at application rates equivalent to 0.18 lbs a.i./A.

Table 6-2. Terrestrial Toxicity Endpoints Selected for Risk Estimation for Sulfoxaflor.

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value[1]	MRID or ECOTOX No./ Classification	Comments
Birds (surrogates for terrestrial amphibians and reptiles)					
Acute Oral	TGAI 95.6% a.i.	Bobwhite Quail *(Colinus virginianus)*	LD_{50} = 676 mg a.i./kg-bw	47832101 (Acceptable)	Slightly toxic
Acute Oral	TGAI 95.6% a.i.	Zebra finch (*Poephila guttata)*	LD_{50} = >80 mg a.i./kg-bw	47832072 (Supplemental)	Moderately toxic Based on regurgitation of test material
Acute Oral	Degradate X474	Bobwhite Quail *(Colinus virginianus)*	LD_{50} > 2250 mg a.i./kg-bw	47832073 (Acceptable)	Practically nontoxic
Sub-acute dietary	TGAI 95.6% a.i.	Mallard duck (*Anas platyrhynchus)*	5-days LC_{50} = >5,620 mg a.i./kg-diet	47832104 (Acceptable)	Practically nontoxic
Chronic	TGAI 95.6% a.i.	Mallard duck (*Anas platyrhynchus)*	20-weeks NOAEC = 200 LOAEC = >200 mg/kg-diet	47832120 (Acceptable)	No effects
Mammals					
Acute Oral	TGAI 95.6% a.i.	Mouse *(Mus musculus)*	LD_{50} = 750 mg a.i./kg-bw	47832040 (Acceptable)	Slightly toxic

Study Type	Test Substance (% a.i.)	Test Species	Toxicity Value[1]	MRID or ECOTOX No./ Classification	Comments
Chronic (2-generation reproduction)	TGAI 95.6% a.i.	Rat (*Rattus norvegicus)*	NOAEL = 6.07 LOAEL = 24.6 mg a.i./kg-bw/day	47832142 (Acceptable)	3-4x increase in pup mortality
Terrestrial invertebrates					
Acute contact (adult)	TEP 22% a.i.	Honey bee (Apis mellifera L.)	LD_{50} = 0.130 µg a.i./bee	47832419 (Acceptable)	Highly toxic
Acute oral (adult)	TGAI 95.6% a.i.	Honey bee (Apis mellifera L.)	LD_{50} = 0.146 µg a.i./bee	47832103 (Acceptable)	Highly toxic
Chronic oral (adult)	TGAI 95.6% a.i.	Honey bee (Apis mellifera L.)	10 day NOAEC = 0.0054 LOAEC = 0.01 µg a.i./bee	50166901 (Acceptable)	Reduced food consumption (23%)
Short term repeated dose (larval)	TGAI 95.6% a.i.	Honey bee (Apis mellifera L.)	LD_{50} = >0.415 µg a.i./larvae	50026402 (N/A)*	Highly toxic
Chronic oral (larval)	TGAI 95.6% a.i.	Honey bee (*Apis mellifera L.*)	22 day NOAEC = 0.212 LOAEC = 0.412 µg a.i./larvae	50026402 (Acceptable)	Reduced adult emergence and day 22 mortality (29%),
Colony Feeding study (10-days)	TEP 12% a.i.	Honey bee (*Apis mellifera L.*)	NOAEC = 0.47 LOAEC = 1.85 µg a.i/L	50444502 (Supplemental)	Reductions in number of adults and brood
Colony Feeding study (6-week)	TGAI 95.6% a.i.	Honey bee (*Apis mellifera L.*)	NOAEC = 0.43 LOAEC = 1.0 µg a.i/L	50849601 (Supplemental)	Reductions in number of adults and brood
Terrestrial and wetland plants					
Vegetative Vigor	TEP22% a.i.	Various species	Dicots (NA): IC_{25} = >0.18 lb a.i./acre; NOAEC = 0.18 lb/acre) Monocots (Onion): IC_{25} = >0.18 lb a.i./acre; NOAEC = 0.09 lb/acre)	47832425 (Supplemental)	Reductions in growth (11% in onion only)
Seedling Emergence	TEP22% a.i.	Various species	Dicots (NA): IC_{25} = >0.36 lb a.i./acre; NOAEC = 0.36 lb/acre Monocots (NA): IC_{25} = >0.36 lb a.i./acre; NOAEC = 0.36 lb/acre	47832427 (Acceptable)	No effects at any treatment.

TGAI=Technical Grade Active Ingredient; TEP= Typical end-use product; a.i.=active ingredient

[1] NOAEC and LOAEC are reported in the same units.

>Greater than values designate non-definitive endpoints where no effects were observed at the highest level tested, or effects did not reach 50% at the highest concentration tested (USEPA, 2011).
* classification not applicable, short-term repeat dose LC50 being used in lieu of acute single dose study.

6.3 Incident Data

The Incident Data System (IDS) provides information on the available ecological pesticide incidents, including those that have been aggregately reported to the EPA that reported since the 2012 assessment to support the initial registration to when the database was last searched on March 20, 2019. Although reported incidents may support a potential risk concern, the lack of reported incidents does not necessarily negate a potential risk concern because ecological incidents are often not observed and may go unreported.

According to IDS, one ecological incident was reported to EPA on 1/2/2014 with a certainty classification of possible. This event purportedly involved three insecticides: acephate, dichrotophos, and sulfoxaflor. A beekeeper in Dunklin County, MO stated from June through August, crops (including watermelon) were treated with pesticides, including Bidrin® [dichrotophos], acetate, and sulfoxaflor as well as tank mixes of a variety of chemical products. The beekeeper reported that over 1,000 hives were affected by the pesticide use, which is listed as "incapacitation" in the Incident Database System (IDS) database. There is no information on how many other pesticides may have been used, the legality of the use, the timing of pesticide application, presence or absence of other potential stressors (*e.g.,* pests like *Varroa* mites*;* disease such as *Nosemosis*) or data confirming that pesticide exposure actually occurred (*e.g.,* measured residues of pesticides in bees or the hive). Use of the pesticides was not confirmed independently. Given the limited information associated with this incident report and the apparent application of multiple pesticides, linking these reported effects to any one pesticide is not possible.

One other incident was reported to EPA in July 2015. One hundred seventy-six acres of soybeans were treated near Zumbrata, Minnesota with Transform WG Insecticide (active ingredient, Sulfoxaflor). The grower reported that of the 176 acres treated, all acres were affected with reductions in yield. There is no information on how many other pesticides may have been used or the presence or absence of other potential stressors. Given the limited information associated with this incident report definitively linking these reported effects to sulfoxaflor is not possible. No other incidents potentially associated with sulfoxaflor use over the past several years (either from Section 18 emergency uses on cotton, sorghum, alfalfa or from previously registered Section 3 uses) have been reported to the Agency.

7 Analysis Plan

7.1 Overall Process

This assessment uses a weight of evidence approach that relies heavily, but not exclusively, on a risk quotient (RQ) method. RQs are calculated by dividing an estimate environmental concentration (EEC) by a toxicity endpoint (*i.*e., EEC/toxicity endpoint). This is a way to determine if an estimated concentration is expected to be above or below the concentration associated with the effects endpoint. The RQs are compared to regulatory levels of concern (LOCs). For acute and chronic risks to vertebrates and invertebrates, the LOCs are 0.5 and 1.0, respectively, and for plants, the LOC is 1.0. The acute and chronic risk LOCs for bees are 0.4 and 1.0, respectively. In addition to RQs, other available data (*e.g.*, incident data) can be used to help understand the potential risks associated with the use of the pesticide.

Sulfoxaflor is practically non-toxic to fish and aquatic and terrestrial plants had no observed toxicity during testing. Further, sulfoxaflor is also slightly toxic to terrestrial birds, mammals, and plants. A screening approach is used to evaluate possible risk based on exposure for these taxa. Further characterization around chronic risk to mammals is described based on a definitive toxicity endpoint. The main mode of action for sulfoxaflor is on invertebrate organisms both aquatic and terrestrial. A full assessment of every use pattern and modeling scenario will follow for these taxa. Furthermore, sediment toxicity studies would generally not be required for sulfoxaflor because of its low log K_{oc} (0.8) and lack of propensity to partition into the sediment. However sub-chronic and chronic sediment studies were available and, therefore toxicity endpoints are used to assess risk from pore water exposure only.

7.2 Modeling

Various models are used to calculate aquatic and terrestrial EECs (see **Table 7-1.).** The specific models used in this assessment are discussed further below.

Table 7-1. List of the Models Used to Assess Risk.

Environment	Taxa of Concern	Exposure Media	Exposure Pathway	Model(s) or Pathway
Aquatic	Vertebrates/ Invertebrates (including sediment dwelling)	Surface water and pore water	Runoff and spray drift to water and sediment	PRZM-VVWM with PWC version 1.52[1] PFAM version 2.0[2]
	Aquatic Plants (vascular and nonvascular)			
Terrestrial	Vertebrate	Dietary items	Ingestion of residues in/on dietary items as a result of direct foliar application	T-REX version 1.5.2[3]
	Bees and other terrestrial invertebrates	Contact Dietary items	Spray contact and ingestion of residues in/on	BeeREX version 1.0

Environment	Taxa of Concern	Exposure Media	Exposure Pathway	Model(s) or Pathway
			dietary items as a result of direct application	
All Environments	All	Movement through air to aquatic and terrestrial media	Spray drift	AgDRIFT version 2.1.1 (Spray drift)

[1] The Pesticide in Water Calculator (PWC) is a Graphic User Interface (GUI) that estimates pesticide concentration in water using the Pesticide Root Zone Model (PRZM) and the Variable Volume Water Model (VVWM). PRZM-VVWM.
[2] Pesticides in Flooded Applications Model (PFAM) is used to simulate EECs when pesticides are applied to flooded or intermittently flooded areas.
[3] The Terrestrial Residue Exposure (T-REX) Model is used to estimate pesticide concentration on avian and mammalian food items.

8 Aquatic Organisms Risk Assessment

8.1 Aquatic Exposure Assessment

8.1.1 Modeling

The latest exposure modeling for sulfoxaflor was that executed for the 2012 section 3 ecological risk assessment (DP Barcode 382619)[5]. Since then, many changes in labeled use patterns and application parameters were proposed. Therefore, new modeling is needed to cover changes in the labels and use current models. In this respect, it is noted that aquatic exposure for this assessment covers both the 2012 and the proposed new uses (i.e., current and proposed and/or modified uses) simulated using current models. In 2012 assessment models used were Tier II PRZM, (v3.12.2, May 2005) and EXAMS (v2.98.4.6, April 2005) coupled with the input shell pe5.pl (August 2007) [6] or EXAMS-PRZM Exposure Simulation Shell (EXPRESS, v.1.03.02, July 2007) [7].

Except for rice cranberry and watercress (grown in intermittently flooded fields), surface water aquatic modeling was simulated using currently approved PWC (version 1.52)[8]. The PWC model uses scenarios to specify soil, climatic, and agronomic inputs in PRZM, and are intended to result in high-end water concentrations associated with a particular crop and pesticide within a geographic region. Each PWC scenario is specific to a vulnerable area where the crop is

[5]Environmental Fate and Ecological Risk Assessment for Sulfoxaflor Registration (DP Barcode 382619 dated December 19, 2012) URL: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2010-0889-0022
[6] **PRZM/EXAMS pe5-pl Archived Model** URL: https://archive.epa.gov/oppefed1/web/html/water_models_archive.html#przmexamsshell
[7] **EXPRESS Archived Model** URL: https://www.epa.gov/ceam/express-exams-przm-exposure-simulation-shell
[8] **PWC URL:** https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#PWC

commonly grown. Soil and agronomic data specific to the location are built into the scenario, and a specific climatic weather station providing 30 years of daily weather values is associated with the location. Rice, cranberry and watercress were simulated using the Tier II Pesticide in Flooded Applications Model (PFAM version 2).

Preliminary Modeling

Sulfoxaflor is proposed to be used on many crops and a streamline approach was established to identify use patterns that may cause risk concern and identify application dates giving the highest exposure EECs. Since publication of the 2012 ecological risk assessment, no new fate and transport studies were submitted, and no change is necessary in the chemical input parameters used for modeling. Therefore, it was possible execute preliminary modeling using the same approach detailed in the 2012 ecological risk assessment. Simulations for the preliminary modeling used the same chemical input parameters but different inputs for rates and scenarios (**Table 8-1**)

Table 8-1. PWC Input Parameters Specific to Use Patterns for Sulfoxaflor.

Abbreviated: Labeled Name Use Pattern[1]	Max. Application Rate [2]	Representative scenario(s)
Alfalfa	0.0898 x 3= 0.266 @ 7 d	CAalfalfa_WirrigOP; CArangelandhayRLF_V2; ILalfalfaNMC; MNalfalfaOP; NCalfalfaOP; PAalfalfaOP; TXalfalfaOP
Avocado	0.0898 x 3= 0.266 @ 7 d	CAAvocadoRLF_V2; FLavocadoSTD
Barley	0.043 x 2= 0.086 @ 14 d	CAWheatRLF_V2 (Spring Wheat); NDwheatSTD (Spring wheat); ORwheatOP (Winter Wheat); TXwheatOP (Winter Wheat)
Beans	0.071 x 3= 0.213 Plus 0.053 x 1= 0.266 @ 14 d	ILbeansNMC; MIbeansSTD; ORsnbeansSTD; WAbeansNMC
Berries and small fruit Including Cranberries	0.0898 x 3= 0.266 @ 7 d	CAWineGrapesRFL; ORberriesOP
		MA_Cranberry_Winter Flood; OR_Cranberry_Winter Flood; WI_Cranberry_Winter Flood
Brassica Veg.	0.0898 x 3= 0.266 @ 7 d	CAColeCropRLF_V2; FLcabbageSTD; PAvegetableNMC; STXvegetableNMC
Bulb Veg.	0.0898 x 3= 0.266 @ 7 d	CAGarlicRLF_V2; CAGarlicRLF_V3; CAonion_WirrigSTD; GAOnion_WirrigSTD; WAonionsNMC
Cacao	0.036 x 3=0.108 Plus 0.032 x 1= 0.140 @ 28 d	PRcoffeeSTD with 21504 HI weather station
Canola	0.023 x 2= 0.046 @ 14 d	NDcanolaSTD
Citrus	0.0898 x 3= 0.266 @ 14 d	CAcitrus_WirrigSTD; FLcitrusSTD; STXgrapefruitNMC
Corn	0.047 x 2= 0.094 @ 14 d	CAcornOP; FLsweetcornOP; KSCornStd; KSsorghumSTD; NCcornESTD; NCcornWOP; NDcornOP; NECornStd; ORswcornOP; STXcornNMC; TXcornOP; TXsorghumOP
Cotton	0.071 x 3= 0.213 Plus 0.053 x 1= 0.266 @ 5 d	CAcotton_WirrigSTD; MScottonSTD; NCcottonSTD; STXcottonNMC; TXcottonOP

Abbreviated: Labeled Name Use Pattern[1]	Max. Application Rate [2]	Representative scenario(s)
Cucurbits	0.071 x 3= 0.213 Plus 0.053 x 1= 0.266 @ 7 d	CAMelonsRLF_V2; FLcucumberSTD; MImelonStd; MOmelonStd; NJmelonStd; STXmelonNMC
Fruiting Veg.	0.071 x 3= 0.213 Plus 0.053 x 1= 0.266 @ 7 d	CAtomato_WirrigSTD; FLpeppersSTD; FLtomatoSTD; PAtomatoSTD; STXvegetableNMC
Home Orchards	0.0898 x 3= 0.266 @ 7 d or 14 d	CAgrapes_WirrigSTD; CAWineGrapesRLF_V2; NYGrapesSTD (all for vineyards)
Leafy Veg. and Watercress	0.0898 x 3= 0.266 @ 7 d	CAlettuceSTD
		No location-specific scenario[4]
Ornamentals in Nurseries	0.0898 x 3= 0.266 @ 14 d	CAnurserySTD_V2; FLnurserySTD_V2; MInurserySTD_V2; NJnurserySTD_V2; ORnurserySTD_V2; TNnurserySTD_V2
Pineapple	0.09 x 2=0.18 @ 14 d	PRcoffeeSTD (four runs with four of HI weather stations: 21504, 22516, 22521, and 22536)
Pome Fruits	0.0898 x 3= 0.266 @ 7 d	NCappleSTD; ORappleSTD; PAappleSTD_V2; WAorchardsNMC
Potatoes	0.071 x 3= 0.213 Plus 0.053 x 1= 0.266 @ 14 d	IDNpotato_WirrigSTD; MEpotatoSTD; NCSweetPotatoSTD
Rice	0.0665 x 4= 0.266 @ 14 d	**ECO STD with turnover scenarios**: ECO AR no Winter; ECO CA Winter; ECO LA no Winter; ECO MO no Winter; ECO MS no Winter; ECO TX no Winter
Root and Tuber Veg.	0.0898 x 3= 0.266 @ 7 d	CAPotatoRLF_V2; CAsugarbeet_WirrigOP; FLcarrotSTD; FLpotatoNMC; MNsugarbeetSTD; NCSweetPotatoSTD; WApotatoNMC
Soybean	0.071 x 3= 0.213 Plus 0.053 x 1= 0.266 @ 14 d	MSsoybeanSTD
Stone Fruits	0.0898 x 3= 0.266 @ 7 d	CAfruit_WirrigSTD; GAPeachesSTD; MICherriesSTD; WAorchardsNMC
Strawberry	0.071 x 3= 0.213 Plus 0.053 x 1= 0.266 @ 7 d	CAStrawberry-noplasticRLF_V2; FLstrawberry_WirrigSTD
Tree Farms or Plantations	0.0898 x 3= 0.266 @ 14 d	CAForestryRLF
Tree Nuts	0.0898 x 3= 0.266 @ 7 d	CAalmond_WirrigSTD; GAPecansSTD; ORfilbertsSTD
Turfgrass	0.0898 x 3= 0.266 @ 7d	CATurfRLF; FLturfSTD; PAturfSTD
X-mass Trees	0.0898 x 3= 0.266 @ 14 d	ORXmasTreeSTD

[1] ***Abbreviated: Labeled Name Use Pattern:*** Refer to **Section 3**: Label and use characterization for more details

[2] ***Max. Application Rate:*** the maximum application rates. For example, the rate for **alfalfa**= 0.0898 x 3= 0.266 @ 7 d= Maximum single rate x Maximum number of applications= Maximum yearly rate @ Minimum application interval in 7 days; All in lb. a.i/A. It is important to note that ***single rates and number of applications were adjusted based on the maximum label yearly rates*** specified in **Section 3** (Label and use characterization)

[3] Bushberries including dry harvested cranberries and those grown with intermittently flooded fields

[4] The PFAM model was parameterized to mimic a flowing water condition in the watercress bed with a weir height of 2 inches (0.051 meters). A maximum water depth of 1.5 inches (0.0381 m) and a minimum depth of 0.5 inches (0.0127 m) were simulated based on the crop profile for watercress in Hawaii[9]

In addition, the following label information and restrictions were also incorporated into deciding input related to other inputs:

(1) **Types of applications:** Ground or aerial for all uses except for turf, home orchards and non-commercial ornamentals (ground application);
(2) **Efficiency and drift:** Efficiency values were 0.99 and 0.95 for ground and aerial applications, respectively. Examination of the newly submitted labels warranted changing the drift values as follows: 0.089 for aerial (medium to coarse spray), 0.011 for ground (low boom/ medium to coarse spray) and 0.022 for air blast. For conservatism, aerial application is assumed in the ROI model runs for all uses. However, applicable drift fractions were used for the application procedure in executing the parent runs chosen for refinement;
(3) **Application windows and timing of first application***:* Time batch analysis was used for all simulations using an application window spanning from 14-21 days after scenarios emergence dates to 21-days before the scenarios harvest dates with 7-day steps. For each use pattern, the scenario with the highest EEC was chosen to represent that use noting that the chosen EECs were the maximums obtained within the specified application window of the scenario. Simulations for the parent were only executed for scenarios giving the maximum EECs and associated date of first application.; and
(4) Rice, cranberry and watercress were simulated for parent only with Tier II Pesticide in Flooded Applications Model (PFAM version 2) using scenarios listed in **Table 8-1**. The model calculates the estimate environmental concentrations (EECs) in rice paddy, the cranberry bog, or water existing the watercress field resulting from pesticide application. It is noted that:
    a. Application rates and timing for rice: 1st application of 0.074 kg/ha 60 days after planting (stink bugs appearance window), 2nd application of 0.074 kg/ha 14 days after the 1st application, 14 days with no application, 3rd application of 0.075 kg/ha 14 days after the period of no application, and 4th application of 0.075 kg/ha 14 days after the 3rd application (All application occurs to water after flooding);
    b. Application rates and timing for cranberry: Modeled three applications of 0.1001 kg/hac with 7-day intervals. Sulfoxaflor parent degrades very quickly to its major degradate X-474 in the soil system (t ½ = 0.4 days) while its half-life in aquatic systems range from 141 days (aerobic conditions) to 672 days (anaerobic conditions. Therefore, it is important to know if the pesticide is to be applied to

[9] Crop profile for watercress in Hawaii URL: https://ipmdata.ipmcenters.org/documents/cropprofiles/HIwatercress.pdf

the dry soil or to the water in the bog. Very low EECs is expected if the pesticide is applied to dry soil because drift/runoff =zero in PFAM cranberry scenarios and the pesticide reaching the soil will degrade very quickly before it had the opportunity to partition into water after flooding the bog. In contrast much, higher EECs are expected if the pesticide is applied directly to the bog in presence of water. Labels do not have specific instructions on when the pesticide is to be applied and the only available information that it could be applied up to one day before harvest (Flood used for harvest occuring late September to October[10]; PHI= 1 day). Literature appear to suggest that application of insecticides to cranberries lies beyond the flooding events[11] as indicated from: (1) most of the important insect infestations appears from May to harvesting "No flood period" and (2) One of the purposes for flooding is to combat pests via this agronomic practice. To cover all possible applications, modeling is executed for the following application assumptions: application to dry field (ORberriesOP with first application date of May 7); Two applications to dry field + one application to bog water (1 day before harvest= label PHI); One application to dry field + two applications to bog water; and All three applications to bog water.

c. Application rate and timing for watercress is the same as leafy vegetables. Application is simulated using PFAM as it requires irrigation/flowing water during the growing period (All application occurs to water as no specific instruction was present in the label for drying the field before application).

EFED recommend including specific instructions, in the label, for sulfoxaflor application to cranberry and watercress. In absence of such instructions, modeling gives high exposure EECs for some of the assumptions (refer to modeling results, below, for various application assumptions).

Final Modeling

Based on the results obtained from the preliminary modeling, risk may result from use patterns listed in **Table 8-2**, along with scenarios and application windows/dates where the highest exposure is expected to occur.

[10]Cranberry harvest dates; URL http://www.wiscran.org/cranberries/

[11] Cranberry insects of the Northwest, URL: http://www.umass.edu/cranberry/downloads/Cranberry%20Insects%20of%20the%20NorthEast.Averill.Sylvia.Franklin.2000.pdf

Table 8-2. Use patterns with expected risk and scenario, application window, date of first application expected to give the highest exposure.

Use	Scenario	Modeled Application Window[1]	Expected Date for the Highest Exposure EECs[1]
Alfalfa	TXalfalfaOP	2-Mar to 22-Sep (7-d step)	6-Apr
Beans	MIbeansSTD	22-Jun to 17-Aug (7-d step)	27-Jul
Brassica Veg.	CAColeCropRLF_V2	6-Nov to 2-Apr (7-d step)	5-Feb
Citrus	FLcitrusSTD	4-Jun to 15-Oct (7-d step)	24-Sep
Cotton	NCcottonSTD	22-Jun to 7-Sep (7-d step)	24-Aug
Cranberries[2]	ORberriesOP	22-Apr to 5-Aug (7-d step)	May-7
	Two applications (dry field) + One application to bog (1 day before harvest)		
	One application (dry field) + Two application to bog		
	All three applications to bog water		
Cucurbits	STXmelonNMC	22-Feb to 19-Apr (7-d step)	22-Feb
Fruiting Veg.	STXvegetableNMC	22-Oct to 25-Feb (7-d step)	11-Feb
Leafy Veg.	CAlettuceSTD	9-Mar to 27-Apr (7-d step)	27-Apr
Ornamentals in Nurseries	MInurserySTD	9-Apr to 3-Sep (7-d step)	30-Jul
Pineapple	PRcoffeeSTD	22-Jan to 30-Jul (7-d step)	5-Feb
Pome Fruits	NCappleSTD	22-Apr to 5-Aug (7-d step)	20-May
Potatoes	MEpotatoSTD	22-Jun to 14-Sep (7-d step)	17-Aug
Rice	ECO CA Winter	Refer to text, above	2-Jul
Root and Tuber Veg.	MNsugarbeetSTD	6-Jun to 26-Sep (7-d step)	12-Sep
Soybean	MSsoybeanSTD	May-7 to Sep-17 (7-d step)	17-Sep
Strawberry	CAStrawberry-noplasticRLF	29-Jan to 4-Jun (7-d step)	12-Feb
Watercress[2]	FL [2]	No window	01-Feb

[1] Modeled application window: Time window related to the emergence date of the scenario (Simulation step in days). For example: Potatoes= 22-Jun to 14-Sep (7-d step)= Simulation was executed for application of the pesticide over a time window spanning from 22-Jun to 14-Sep with 7-day steps planted and pesticide is applied to in presence of water

[2] Since FL is a major watercress production area, the meteorological data from Tampa, FL (w 12842.dvf) was used

Use patterns, scenarios first date of application identified in **Table 8-2** above were modeled for the stressor (parent sulfoxaflor). In this final modeling, input parameters used are those for parent sulfoxaflor (**Table 8-3**) with the application parameters summarized in **Table 8-1** and with consideration to label restrictions and information presented above. The results are summarized in **Table 8-4** and example runs in **Appendix A**.

Table 8-1.. Aquatic Modeling Input Parameters for Chemical Tab for Sulfoxaflor Parent.

Parameter (units)	Value	Source (MRID)	Comments
K_{OC} (L/Kg)	35	478320-14	Average (n= 17) [1]
Water Column Metabolism Half-life (days) at 25°C	141	478320-14	Represents the 90 percent upper confidence bound from aerobic aquatic metabolism studies (n=2; t ½ = 88 and 37) [1]

Parameter (units)	Value	Source (MRID)	Comments
Benthic Metabolism Half-life (days) at 25°C	672	478322-77	Represents the 90 percent upper confidence bound from anaerobic aquatic metabolism studies (n=2; t ½ = 382 and 103) [1]
Aqueous Photolysis Half-life (days) @ pH 7; 25°C; and40 °N	Stable	478322-83	The chemical is stable to photolysis in water
Hydrolysis Half-life (days)	Stable	478321-49	The chemical is stable at pH 5, 7, and 98 [1]
Soil Half-life (days) at 25°C	0.4	478322-78 478320-13	Represents the 90 percent upper confidence bound from aerobic soil metabolism studies (n=8; t ½ = 0.3, 0.4, 0.6; 0.5; 0.1; 0.1; 0.1 and 0.3) [1]
Molecular Weight (g/mol)	277.27	Calculated	--
Solubility in Water (mg/L)	570	478320-10	--
Vapor Pressure @25°C	1.9×10^{-8}	--	Calculated from VP, solubility and Molecular Weight
Heat of Henry J/mol @25°C			

[1] Other input parameters for the applications tab are shown in **Table 8-1.**

[2] For details refer to the: Environmental Fate and Ecological Risk Assessment for Sulfoxaflor Registration (DP Barcode 392619, Dated December 19, 2012

Table 8-3. Maximum exposure EECs for sulfoxaflor parent.

Use	PWC Scenario	1-in-10-year EEC					Drift Contribution to EECs[1]
		Water Column µg/L			Pore-Water µg/L		
		1-day	21-day	60-day	1-day	21-day	
Alfalfa	TXalfalfaOP	7.7	7.36	6.69	4.85	4.84	36%
Beans	MIbeansSTD	3.8	3.72	3.62	3.27	3.29	75%
Brassica Veg.	CAColeCropRLF_V2	4.2	4.11	3.94	3.42	3.41	70%
Citrus	FLcitrusSTD	5.1	5.19	4.75	3.75	3.74	49%
Cotton	NCcottonSTD	5.1	4.90	4.67	4.22	4.22	52%
Berries[2]	ORberriesOP (dry)	2.47	2.41	2.28	2.02	2.02	99%
	All Applications dry	Negligible (drift/runoff is zero in PFAM)					0%
	2 dry + 1 wet (1-day before harvest2	0.48	0.04	0.015	Not Determined		0%
	1 dry + 2 wet	32.8	6.13	2.15			
	2dry + 1 wet	64.8	22.7	7.95			
	All 3 wet (to bog)	96.1	68.7	25.1			
Cucurbits	STXmelonNMC	3.3	3.10	2.79	2.1	2.1	65%
Fruiting Veg.	STXvegetableNMC	2.74	2.65	2.47	1.83	1.8	81%
Leafy Veg.	CAlettuceSTD	2.6	2.50	2.38	2.06	2.06	97%
Ornamentals in Nurseries	MInurserySTD	3.0	2.86	2.72	2.61	2.63	86%
Pineapple	PRcoffeeSTD	2.2	2.03	1.82	1.39	1.38	66%
Pome Fruits	NCappleSTD	6.1	5.87	5.57	4.32	4.36	57%
Potatoes	MEpotatoSTD	4.2	4.20	4.27	4.21	4.22	87%
Rice	ECO CA Winter	164	129	106	76	72.8	0%
Root and Tuber Veg.	MNsugarbeetSTD	3.8	3.78	3.82	3.66	3.66	87%

Use	PWC Scenario	1-in-10-year EEC					Drift Contribution to EECs[1]
		Water Column µg/L			Pore-Water µg/L		
		1-day	21-day	60-day	1-day	21-day	
Soybean	MSsoybeanSTD	4.3	4.25	4.10	3.7	3.68	67%
Strawberry	CAStrawberry-noplasticRLF	4.1	4.04	3.91	3.36	3.36	64%
Watercress (Water released from beds)	Refer to Table 8-2, above	26.8	3.83	1.34	1.21	1.03	0%

[1] Sulfoxaflor is non-persistent in the soil system but much more persistent in aquatic systems. Source of aquatic contamination is mainly associated with sulfoxaflor parent reaching aquatic systems by drift (drift contribution ranges from 36 to 99%). <1% of the contribution is from run-off with eroded sediment (the chemical Koc is very low). The rest of the exposure comes from run-off dissolved in water possibly as a result of rain shortly after application

[2] For PFAM scenario giving the highest EECs: WI_Cranberry_Winter Flood

Modeling Uncertainties

There is uncertainty regarding exposure EECs for flooded-fields of cranberry and watercress uses. Exposure EECs are largely dependent on whether the chemical is applied to dry soil or to water in the cranberry bog or the watercress field. Additionally, water use practices at individual production facilities are expected to vary and can impact exposure estimates in different waterbodies associated with the production (*i.e.*, cranberry bog, watercress bed, and receiving water bodies). For example, recycling at an individual facility could potentially lead to higher exposure concentrations than those modeled. Finally, it is important to note that watercress is a minor crop as available, proprietary data indicate that 733 acres of watercress were harvested nationwide in 2012 (USDA, 2014)[12].

8.2 Aquatic Organism Risk Characterization

As toxicity data indicates that sulfoxaflor is relatively non-toxic to most aquatic organisms, a preliminary screen was conducted calculating RQs only from the highest predicted EECs for all taxa on an acute and chronic basis.

8.2.1 Aquatic Vertebrates

Sulfoxaflor exhibits relatively low toxicity to fish. All study endpoints were at least 6-10 times above all modeled EECs. A conservative risk screen was conducted by comparing maximum EECs from those use patterns with the highest EECs to the acute and chronic toxicity endpoints. All calculated RQs were well below the acute and chronic LOC.

[12] USDA, 2014. United States Department of Agriculture (USDA). 2014. 2012 Census of Agriculture. National Agricultural Statistics Service. United States Summary and State Data, Volume 1. AC-12-A-51. Issued May 2014. URL: http://www.agcensus.usda.gov/Publications/2012/

The proposed uses of sulfoxaflor are expected to pose low risk to aquatic vertebrates (fish and aquatic-phase amphibians).

Table 8-4. Acute and Chronic Vertebrate Risk Quotients for Non-listed Species.

Use Sites	1-in-10 Yr EEC µg/L		Risk Quotient			
			Freshwater		Estuarine/Marine	
	Daily Ave	60-day Ave	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]
			LC_{50} = 363000 µg a.i./L	NOAEC = 660 µg a.i./L	LC_{50} = 266000 µg a.i./L	NOAEC = 1200 µg a.i./L
Alfalfa and Other non-grass animal feeds	7.7	6.69	0.00	0.01	0.00	0.01
Cotton	5.1	4.67	0.00	0.01	0.00	0.00
Pome fruits	6.1	5.57	0.00	0.01	0.00	0.00
Rice	164	106	<0.01	0.16	<0.01	0.09
Cranberry	96.1	25.1	0.00	0.04	0.00	0.02
Watercress	26.8	1.34	0.00	0.00	0.00	0.00
Soybean	4.3	4.1	0.00	0.01	0.00	0.00

Bolded values exceed the LOC for acute risk to non-listed species of 0.5 or the chronic risk LOC of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.

[1] The EECs used to calculate these RQs are based on the 1-in-10-year peak 1-day average value from **Table 8-3.**

[2] The EECs used to calculate these RQs are based on the 1-in-10-year 60-day average value from **Table 8-3**.

8.2.2 Aquatic Invertebrates

Based on the chemical properties, sulfoxaflor is not expected to partition to sediment (log Kow = 0.802, Koc = 7 – 74 mL/g); however, aquatic sediment studies are available. Therefore, invertebrates in the water column and sediment were evaluated in this assessment. Invertebrates in the sediment were evaluated through exposure to pore water only. This comparison would also be relevant to the potential risk from sulfoxaflor to other aquatic invertebrates beyond the traditional test species, *Daphnia*.

Similar to fish, sulfoxaflor appears to exhibit low toxicity to aquatic invertebrates. Based on the available data estuarine and marine water column species are more sensitive than freshwater species. Both sub-chronic and chronic sediment studies are available for freshwater species with the chronic study yielding more sensitive endpoints. RQs above the chronic LOC (1.0) were calculated for estuarine/marine water column invertebrates and benthic freshwater invertebrates from use on rice. For water column invertebrates the mysid LOAEC was 240 µg a.i./L and the maximum rice EEC was 164 µg a.i./L. For benthic species tested, midge, the LOAEC was 37 µg a.i./L and the maximum rice EEC was 76 µg a.i./L. At the benthic LOAEC there was a 23% reduction in midge emergence from the larval stage. In these studies effects on growth and reproduction were observed. All other water column and pore water RQs were well below the respective LOCs as shown in **Table 8-5.** and **Table 8-6..** Other insecticides in the same class as sulfoxaflor do not show toxicity to daphnia but do for other aquatic invertebrates. It is important to consider other aquatic invertebrate data available for example the chronic midge

study. When comparing the midge chronic endpoint to the water column EECs exceedances would again be evident for crops grown in water, like rice, watercress, and cranberry.

Overall, proposed uses of sulfoxaflor are likely to pose low risk to water column and benthic invertebrates, except for some chronic risk from use on rice and other crops grown in saturated soils or standing water.

Table 8-5. Acute and Chronic Aquatic Water Column Invertebrate Risk Quotients.

Use Sites	1-in-10 Yr EEC µg/L		Risk Quotient			
			Freshwater		Estuarine/Marine	
	Daily Ave	21-day Ave	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]
			LC_{50} = 400000 µg a.i./L	NOAEC = 50500 µg a.i./L	LC_{50} = 640 µg a.i./L	NOAEC = 110 µg a.i./L
Alfalfa and Other non-grass animal feeds	7.7	7.36	0.00	0.00	0.01	0.07
Cotton	5.1	4.9	0.00	0.00	0.01	0.04
Pome fruits	6.1	5.87	0.00	0.00	0.01	0.05
Rice	164	129	0.00	0.00	0.26	1.17
Cranberry	96.1	68.7	0.00	0.00	0.15	0.62
Watercress	26.8	3.83	0.00	0.00	0.04	0.03
Soybean	4.3	4.25	0.00	0.00	0.01	0.04

Bolded values exceed the LOC for acute risk to non-listed species of 0.5 or the chronic risk LOC of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.

[1] The EECs used to calculate this RQ are based on the 1-in-10-year peak 1-day average value from **Table 8-3.**

[2] The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average value from **Table 8-3**.

Table 8-6. Aquatic Benthic Invertebrate Risk Quotients.

Use Site	1-in-10 Yr EEC Pore Water		Risk Quotients Freshwater	
			Sub-Chronic[1]	Chronic[1]
	1-day	21-day	NOAEC = 99 µg a.i./L	NOAEC = 19 µg a.i./L
Alfalfa and Other non-grass animal feeds	4.85	4.84	0.05	0.25
Cotton	4.22	4.22	0.04	0.22
Pome fruits	4.32	4.36	0.04	0.23
Rice	76	72.8	0.74	**3.8**
Watercress	1.21	1.03	0.01	0.05
Soybean	3.7	3.68	0.04	0.19

Bolded values exceed the LOC for acute risk to non-listed species of 0.5 or the chronic risk LOC of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.

[1] The EECs used to calculate this RQ are based on the 1-in-10-year 21-day average value from Error! Reference source not found.The pore water EEC is listed first in µg/L.

8.2.3 Aquatic Plants:

Sulfoxaflor has low toxicity to aquatic plants. All modeled EECs are well below the most sensitive toxicity endpoints for both vascular and non-vascular aquatic plants with all calculated

RQs less than 0.01. Therefore, proposed uses of sulfoxaflor are expected to pose low risk to vascular and non-vascular aquatic plants.

Table 8-7. Aquatic Plant Risk Quotients for Non-listed Species.

Use Sites	1-in-10 Year Daily Average EEC µg/L	Risk Quotients	
		Vascular	Non-vascular
		IC_{50} = 99000 µg a.i./L	IC_{50} = 81200 µg a.i./L
Alfalfa and Other non-grass animal feeds	7.7	<0.01	<0.01
Cotton	5.1	<0.01	<0.01
Pome fruits	6.1	<0.01	<0.01
Rice	164	<0.01	<0.01
Cranberry	96.1	<0.01	<0.01
Watercress	26.8	<0.01	<0.01
Soybean	4.3	<0.01	<0.01

The LOC for non-listed plants is 1. The endpoints listed in the table are the endpoint used to calculate the RQ.

9 Terrestrial Vertebrates Risk Assessment

9.1 Terrestrial Vertebrate Exposure Assessment

Terrestrial wildlife exposure estimates are typically calculated for birds and mammals by emphasizing the dietary exposure pathway. Sulfoxaflor is applied through aerial and ground spray application methods. Therefore, potential dietary exposure for terrestrial wildlife in this assessment is based on consumption of sulfoxaflor residues on food items following spray (foliar) applications.

Potential risks to mammals and birds are derived using T-REX (version 1.5.2) with biological inputs including: 1) acute and chronic toxicity data for the mouse/rat and mallard, 2) weights of three mammalian and avian size classes, and 3) various dietary categories being consumed. Chemical-specific inputs include: 1) application rate, 2) application interval, 3) frequency of applications, and a chemical-specific foliar dissipation half-life of 12.3 days. See **Appendix B** for details on the derivation of the chemical-specific foliar dissipation half-life. For some crops, information from residue-decline trials indicates relatively short half-lives (e.g., a few days), particularly on foliage. For these crops, there is uncertainty regarding whether the relatively short duration of exposure expected in the field would elicit similar reproductive effects as chronic studies where animals are fed treated diets continuously.

For sulfoxaflor, the proposed use patterns encompass five use rates with varying application intervals. Included in the table below are the crops associated with each combination. These combinations give multiple different modeling scenarios for T-REX:

- **3 x 0.090 lb ai/A @ 7 d interval** (alfalfa, avocado, berries, pome and stone fruits, veg.-brassica, veg.-bulb, veg.-leafy, veg.-root/tuber+leaves, watercress, tree nuts, turf grass)

- **3 x 0.090 lb ai/A @ 14 d interval** (citrus, home orchards (pome and stone fruits), ornamentals, rice, tree farm/plantation)
- **2 x 0.090 lb ai/A @ 14 d interval** (pineapple)
- **3 x 0.071 + 1 x 0.053 lb ai/A @ 5 d interval** (cotton)
- **3 x 0.071 + 1 x 0.053 lb ai/A @ 7 d interval** (veg.-cucurbit, veg.-fruiting)
- **3 x 0.071 + 1 x 0.053 lb ai/A @ 14 d interval** (potato, soybean, other beans)
- **2 x 0.047 lb ai/A @ 14 d interval** (grains, corn)
- **4 x 0.036 lb ai/A @ 28 d interval** (cacao)
- **2 x 0.023 lb ai/A @ 14 d interval** (canola)

9.1.1 Dietary Items on the Treated Field

Potential dietary exposure for terrestrial wildlife in this assessment is based on consumption of sulfoxaflor residues on food items following foliar spray applications. EECs for birds[13] and mammals from consumption of dietary items on the treated field were calculated using T-REX v.1.5.2. For the foliar uses, EECs are based on application rates, number of applications, and intervals presented in **Table 3-1.**. Upper-bound Kenaga nomogram values are used to derive EECs for sulfoxaflor exposures to terrestrial mammals and birds on the field of application based on a 1-year time period. Consideration is given to different types of feeding strategies for mammals, including herbivores, insectivores and granivores. Dose-based exposures are estimated for three weight classes of birds (20 g, 100 g, and 1,000 g) and three weight classes of mammals (15 g, 35 g, and 1,000 g). A Summary of EECs are found in **Table 9-1.**.

[13] Birds are also used as a proxy for reptiles and terrestrial-phase amphibians.

Table 9-1. Summary of Dietary (mg a.i./kg-diet) and Dose-based EECs (mg a.i./kg-bw) as Food Residues for Birds, Reptiles, Terrestrial-Phase Amphibians and Mammals from Labeled Uses of Sulfoxaflor (T-REX v. 1.5.2, Upper Bound Kenaga).

Food Type	Dietary-Based EEC (mg/kg-diet)	Dose-Based EEC (mg/kg-body weight)					
		Birds			Mammals		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
3 x 0.09 lb a.i./acre, 7 day interval							
Short grass	46	52	30	13	44	30	7.0
Tall grass	21	24	14	6.1	20	14	3.2
Broadleaf plants/small insects	26	29	17	7.5	25	17	4.0
Fruits/pods/(seeds, dietary only)	2.9	3.3	1.9	0.84	2.7	1.9	0.44
Arthropods	18	21	12	5.2	17	12	2.8
Seeds (granivore)	NA	0.73	0.41	0.19	0.61	0.42	0.10
3 x 0.09 lb a.i./acre, 14 day interval							
Short grass	36	41	23	10	34	24	5.5
Tall grass	16	19	11	4.8	16	11	2.5
Broadleaf plants/small insects	20	23	13	5.9	19	13	3.1
Fruits/pods/(seeds, dietary only)	2.2	2.6	1.5	0.65	2.1	1.5	0.34
Arthropods	14	16	9.1	4.1	13	9.3	2.1
Seeds (granivore)	NA	0.57	0.32	0.14	0.48	0.33	0.08
3 x 0.071 + 1 x 0.053 lb a.i./acre, 5 day interval							
Short grass	37	42	24	11	35	24	5.7
Tall grass	17	19	11	5.0	16	11	2.6
Broadleaf plants/small insects	21	24	14	6.1	20	14	3.2
Fruits/pods/(seeds, dietary only)	2.3	2.6	1.5	0.68	2.2	1.5	0.35
Arthropods	15	17	9.5	4.2	14	9.6	2.2
Seeds (granivore)	NA	0.59	0.34	0.15	0.49	0.34	0.08
3 x 0.071 + 1 x 0.053 lb a.i./acre, 7 day interval							
Short grass	37	42	24	11	35	24	5.7
Tall grass	17	19	11	5.0	16	11	2.6
Broadleaf plants/small insects	21	24	14	6.1	20	14	3.2
Fruits/pods/(seeds, dietary only)	2.3	2.6	1.5	0.68	2.2	1.5	0.35
Arthropods	15	17	9.5	4.2	14	9.6	2.2
Seeds (granivore)	NA	0.59	0.34	0.15	0.49	0.34	0.08
2 x 0.047 lb a.i./acre, 14 day interval							
Short grass	16	19	11	4.8	16	11	2.5

Food Type	Dietary-Based EEC (mg/kg-diet)	Dose-Based EEC (mg/kg-body weight)					
		Birds			Mammals		
		Small (20 g)	Medium (100 g)	Large (1000 g)	Small (15 g)	Medium (35 g)	Large (1000 g)
Tall grass	7.5	8.6	4.9	2.2	7.2	5.0	1.1
Broadleaf plants/small insects	9.2	11	6.0	2.7	8.8	6.1	1.4
Fruits/pods/(seeds, dietary only)	1.0	1.2	0.67	0.30	0.98	0.68	0.16
Arthropods	6.4	7.3	4.2	1.9	6.1	4.2	0.98
Seeds (granivore)	NA	0.26	0.15	0.07	0.22	0.15	0.03
4 x 0.036 lb a.i./acre, 28 day interval							
Short grass	11	12	7.0	3.1	10	7.1	1.6
Tall grass	4.9	5.6	3.2	1.4	4.7	3.3	0.76
Broadleaf plants/small insects	6.1	6.9	3.9	1.8	5.8	4.0	0.93
Fruits/pods/(seeds, dietary only)	0.67	0.77	0.44	0.20	0.64	0.44	0.10
Arthropods	4.2	4.8	2.7	1.2	4.0	2.8	0.65
Seeds (granivore)	NA	0.17	0.10	0.04	0.14	0.10	0.02

9.2 Terrestrial Vertebrate Risk Characterization

Sulfoxaflor exhibits low toxicity to birds on an acute and sub-acute exposure basis. Dose-based endpoints for birds were greater than the highest test level. Because these studies did not yield definitive acute toxicity endpoints, acute RQs could not be calculated. Instead, a conservative analysis was conducted by comparing peak EECs to the highest test levels in the acute toxicity test as seen in **Table 9-2.**. Based on this comparison and as per non-definitive endpoint guidance (USEPA 2011), acute and chronic risks for birds are not anticipated with this analysis. All non-definitive endpoints are above the maximum EEC determined from T-REX modeling, see **Appendix B** for example T-REX output.

Table 9-2. Comparison of avian endpoints and relevant EECs.

Relevant exposure	Endpoint value	Maximum EEC
Acute oral	>80 mg a.i./kg-bw	52 mg a.i./kg-bw
Sub-acute dietary	>5620 mg a.i./kg-diet	46 mg a.i./kg-diet
Chronic dietary	>200 mg a.i./kg-diet	46 mg a.i./kg-diet

RQ values for mammals are generated based on the upper bound EECs discussed above and toxicity values contained in **Table 6-2.**. On an acute dose-based exposure for mammals, RQ values range from >0.01 to 0.04, and do not exceed the LOC for non-listed animals. No dietary-based acute endpoints were available for mammals.

Table 9-3. Acute RQ values for Mammals from Labeled Uses of Sulfoxaflor (T-REX v. 1.5.2, Upper Bound Kenaga).

Food Type	Acute Dose-Based RQ LD_{50} = 750 mg a.i./kg-bw		
	Small (15 g)	Medium (35 g)	Large (1000 g)
3 x 0.09 lb a.i./acre, 7 day interval			
Herbivores/Insectivores			
Short grass	0.04	0.03	0.02
Tall grass	0.02	0.01	0.01
Broadleaf plants	0.02	0.02	0.01
Fruits/pods/seeds	<0.01	<0.01	<0.01
Arthropods	0.01	0.01	0.01
Granivores			
Seeds	<0.01	<0.01	<0.01

Bolded values exceed the LOC for acute risk to non-listed species of 0.5 or the chronic risk LOC of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.

For chronic exposures for mammals, dietary RQs based on a model estimated NOAEC of 100 mg a.i./kg-diet range from >0.01 to 0.46 based on upper bound values. For chronic dose-based RQs based on reproductive and offspring effects (LOAEL = 24.6 mg a.i./kg-bw), RQs range from >0.01 to 3.29 based on upper bound values. The maximum EEC from T-REX is 44 mg/kg-bw

which is double the dose observed to cause 4 times increase in pup mortality. This effect was observed in the first and second generation born in the rat chronic study. Additionally, at the highest use rate (0.09 lb a.i./A) the LOC would be exceeded for 36 days with the lower use rate (0.047 lb a.i./A) exceeding the LOC for 3 days. Based on this analysis, RQs generated for all use rates greater than 0.036 lb a.i./A at multiple size classes and dietary items exceed the chronic risk LOC of 1. The full listing of RQ calculations for each use rate and interval are provided in **Table 9-4.**.

Table 9-4. Chronic RQ values for Mammals from Labeled Uses of Sulfoxaflor (T-REX v. 1.5.2, Upper Bound Kenaga).

Food Type	Chronic Dose-Based RQ NOAEL = 6.07 mg a.i./kg-bw			Chronic Dietary RQ NOAEC = 100 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1000 g)	
3 x 0.09 lb a.i./acre, 7 day interval				
Herbivores/Insectivores				
Short grass	**3.3**	**2.8**	**1.5**	0.46
Tall grass	**1.5**	**1.3**	0.69	0.21
Broadleaf plants	**1.9**	**1.6**	0.85	0.26
Fruits/pods/seeds	0.21	0.18	0.09	0.03
Arthropods	**1.3**	**1.1**	0.59	0.18
Granivores				
Seeds	0.05	0.04	0.02	N/A
3 x 0.09 lb a.i./acre, 14 day interval				
Herbivores/Insectivores				
Short grass	**2.6**	**2.2**	**1.2**	0.36
Tall grass	**1.2**	**1.0**	0.54	0.16
Broadleaf plants	**1.4**	**1.2**	0.66	0.20
Fruits/pods/seeds	0.16	0.14	0.07	0.02
Arthropods	**1.0**	0.86	0.46	0.14
Granivores				
Seeds	0.04	0.03	0.02	N/A
3 x 0.071 + 1 x 0.053 lb a.i./acre, 5 day interval				
Herbivores/Insectivores				
Short grass	**3.0**	**2.6**	**1.4**	0.43
Tall grass	**1.4**	**1.2**	0.64	0.20
Broadleaf plants	**1.7**	**1.5**	0.78	0.24
Fruits/pods/seeds	0.19	0.16	0.09	0.03
Arthropods	**1.2**	**1.0**	0.55	0.17
Granivores				
Seeds	0.04	0.04	0.02	N/A
3 x 0.071 + 1 x 0.053 lb a.i./acre, 7 day interval				
Herbivores/Insectivores				
Short grass	**2.7**	**2.3**	**1.2**	0.37
Tall grass	**1.2**	**1.0**	0.56	0.17
Broadleaf plants	**1.5**	**1.3**	0.68	0.21

Food Type	Chronic Dose-Based RQ NOAEL = 6.07 mg a.i./kg-bw			Chronic Dietary RQ NOAEC = 100 mg a.i./kg-diet
	Small (15 g)	Medium (35 g)	Large (1000 g)	
Fruits/pods/seeds	0.17	0.14	0.08	0.02
Arthropods	**1.0**	0.89	0.48	0.15
Granivores				
Seeds	0.04	0.03	0.02	N/A
2 x 0.047 lb a.i./acre, 14 day interval				
Herbivores/Insectivores				
Short grass	**1.2**	**1.0**	0.54	0.16
Tall grass	0.54	0.46	0.25	0.08
Broadleaf plants	0.66	0.56	0.30	0.09
Fruits/pods/seeds	0.07	0.06	0.03	<0.01
Arthropods	0.46	0.39	0.21	0.06
Granivores				
Seeds	0.02	<0.01	<0.01	N/A
4 x 0.036 lb a.i./acre, 28 day interval				
Herbivores/Insectivores				
Short grass	0.77	0.66	0.35	0.11
Tall grass	0.35	0.30	0.16	0.05
Broadleaf plants	0.43	0.37	0.20	0.06
Fruits/pods/seeds	0.05	0.04	0.02	<0.01
Arthropods	0.30	0.26	0.14	0.04
Granivores				
Seeds	<0.01	<0.01	<0.01	N/A

Bolded values exceed the LOC for the chronic risk LOC of 1.0. The endpoints listed in the table are the endpoint used to calculate the RQ.

10 Terrestrial Plant Risk Assessment

As indicated in the previous assessments (USEPA 2012a, 2016), adverse effects were noted only in the vegetative vigor terrestrial plant study conducted at an application rate of 0.18 lb a.i./acre. Effects were noted up to 15% inhibition in growth. This rate is higher than the maximum single application rate allowed for flowable uses of sulfoxaflor. However, the NOAEC for this study is 0.09 lb a.i./A which is equal to the maximum application rate. Therefore, all of the RQs for terrestrial plants are below the LOC for risk to terrestrial plants (i.e., the RQs are all <1). There is a reported incidence for sulfoxaflor application to soybean which resulted in reduced yield. In this case risk to terrestrial plants is considered low but cannot be ruled out.

11 Terrestrial Invertebrate Risk Assessment

In accordance with EPA's Guidance for Assessing Pesticide Risk to Bees (USEPA/PMRA/CDPR 2014), the terrestrial invertebrate risk assessment focuses on bees; primarily the honey bee, *Apis mellifera*. As sulfoxaflor is an insecticide the majority of risk is to invertebrates.

Therefore, the following bee assessment is highly refined to fully characterize the risk to these vulnerable taxa. The generalized scheme the EPA uses for assessing pesticide risks to bees is shown in **Figure 11-1.** The first step in this process begins with assessing the potential for bees to become exposed to the pesticide based on its actual or proposed use pattern. For those uses where a reasonable potential for exposure exists, the second step involves conducting a Tier I risk assessment based on effects and exposure data specific to individual bees. The Tier I assessment is initially conducted using default ("high end") estimates of exposure. If Tier I risks are identified with these default exposure assumptions, then refinements may be made using field data on pesticide residues in pollen and nectar.

For those uses where Tier I risks are still indicated, the third step involves conducting a higher tier risk assessment based on exposure and effects at the colony level. The Tier II assessment relies on colony-level effects information derived from "semi-field" studies (*e.g*. tunnel or colony feeding), where exposure is partially controlled, and replication of treatments is achievable. The Tier II effects assessment includes both tunnel and colony feeding studies. Tunnel studies evaluate effects resulting from both contact and oral exposure from foliar spray to colonies held in tunnels (usually for 7-10 days). Colony feeding studies evaluate effects from oral exposure only, whereby colonies are fed spiked diet (usually via sucrose solution) and evaluated for colony-level effects. Colony-level effects from tunnel studies are related to application rate and timing whereas those from colony feeding studies are related to the pesticide concentration in their diet. The Tier II assessment is intended to apply broadly to multiple uses of a pesticide.

If deemed necessary based on risk assessment and risk management considerations, the fourth step in the risk assessment process involves the evaluation of colony-level effects based on Tier III (full field) studies. These Tier III studies are designed to address actual exposure conditions of honey bee colonies associated with the pesticides use to a specific crop, application method and rate. These studies are generally reserved for addressing specific uncertainties or concerns identified from lower tier assessments for a particular crop and use. Historically, the utility of Tier III field studies for assessing pesticide risks to honey bees has been limited. The primary reasons include the influence of multiple factors that confound interpretation of these studies (*e.g.,* uncertainty in quantifying pesticide exposure, variation in forage habitat, differences in weather conditions among sites, exposure to other pesticides, prevalence of disease). In addition, the practical constraints on the design of Tier III studies often limits replication and statistical power.

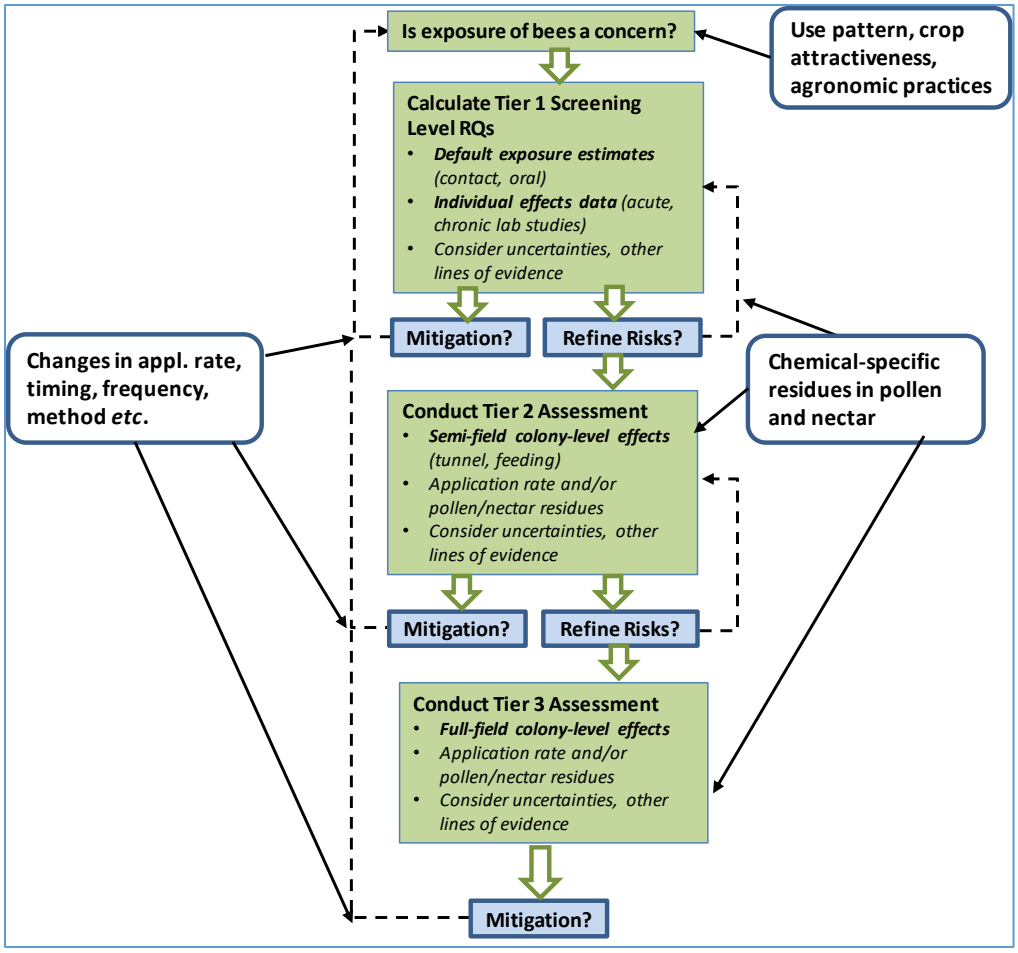


Figure 11-1. Framework for Assessing Pesticide Risks to Bees (USEPA 2014).

11.1 Exposure Potential of Bees

This exposure potential of bees to a given pesticide use is based on the combination of the pesticide's use pattern, agronomic practices, and the attractiveness of the crop to bees. The crops to which sulfoxaflor is proposed for application is listed in **Table 11-1.** along with the crop attractiveness information, relevant agronomic practices, and label restrictions, all of which are considered in assessing the potential for bees to become exposed on the treated field. In addition to honey bees, the attractiveness of crops to other non-*Apis* bees are also considered. With foliar spray applications, off-field assessments are conducted regardless of whether the crop is attractive or not, since there is always a potential for bee-attractive plants to reside adjacent to the treated field. Bees may be exposed on the field to several crops proposed for use with sulfoxaflor.

Table 11-1. Summary of Information on the Attractiveness of Registered Use Patterns for Sulfoxaflor to Bees.

Crop Name	Honey Bee Attractive?	Bumble Bee Attractive?	Solitary Bee Attractive?	Notes and Label Restrictions
Alfalfa*	Y (Pollen and Nectar)	Yes	Yes	Crop can be harvested prior to bloom when not used for seed production.
Canola* [1]	Y (Pollen and Nectar)	Y	Y	Don't apply period: 3 d prior to bloom until petal fall
Cotton*	Y (Nectar)	Y	Y	Pollen not considered honey-bee attractive
Cereal grains [2]	N	N	N	Most members wind pollinated
Corn	Y (Pollen)	Y	Y	Wind pollinated, but can be visited during pollen shedding
Root and tubers[3]	Y (nectar & pollen)	Y	Y	Bees important for seed production; typically harvested prior to bloom.
Potatoes	Y	Y	Y	Sweet potato only attractive member
Bulb vegetables	Y (nectar & pollen)	Y	Y	Typically harvested prior to bloom.
Leafy Vegetables	Y (nectar & pollen)	Y	Y	Bees important for seed production, crop harvested prior to bloom when not used for seed production.
Brassica Vegetables	Y (nectar & pollen)	Y	Y	Harvested before bloom; Label language stating do not use on crops grown for seed.
Fruiting Vegetables	N [4]	Y	Y	Pollen only for most members; May be grown in greenhouses, with bumble bees for pollination
Cucurbit Vegetables*	Y (Pollen and Nectar)	Y	Y	Most members bloom indeterminately
Sorghum	Y (Pollen)	---	Y	
Soybean	Y (Pollen and Nectar)	Y	Y	
Other Beans	Y (Pollen and Nectar)	Y	Y	
Citrus Fruits*	Y (Pollen and Nectar)	Y	Y	Allow only one application 3 d prior to bloom until after petal fall/year
Pome fruits*	Y (Pollen and Nectar)	Y	Y	Do not apply period: 3 d prior to bloom until petal fall
Stone Fruits*	Y (Pollen and Nectar)	Y	Y	Don't apply period: 3 d prior to bloom until petal fall
Tree nut	Y (Pollen and Nectar)	Y	Y	Don't apply period: 3 d prior to bloom until petal fall
Small fruits, grape, strawberry*	Y (Pollen and Nectar)	Y	Y	Don't apply period: 3 d prior to bloom until petal fall (other fruits); Grape is pollen only attractive

Crop Name	Honey Bee Attractive?	Bumble Bee Attractive?	Solitary Bee Attractive?	Notes and Label Restrictions
Avocado	Y (Pollen and Nectar)	--	Y	
Rice	N	N	N	
Christmas tree	N	N	N	
Ornamentals	Y (Pollen and Nectar)	Y	Y	May include only one application at a rate of 0.071 lb. a.i/A during bloom.
Tree farms and plantations	Y (Pollen and Nectar)	Y	Y	Do not apply period: 3 d prior to bloom until petal fall
Commercial turfgrass	N	N	N	Commercial turfgrass is managed to not include flowering plants.

Groups where members have residue data available are indicated with *
When information was not available from USDA 2017 document, cell was indicated with a "--"
[1] Canola represents the oilseed subgroup 20A which includes the canola varietals.
[2] Excludes proposed uses on corn, sorghum, millet, and teosinte (addressed elsewhere in this table)
[3] Excluding potatoes, some members are not harvested prior to bloom including, Jerusalem artichoke, burdock, turmeric, and dasheen.
[4] Okra and roselle nectar and pollen indicated to be attractive to honey bees (USDA, 2017), while chillies and peppers are attractive for pollen only.

11.1.1 Tier I Default EEC (Contact and Oral)

In Tier I, pesticide exposures are estimated based on honey bee castes with known high-end consumption rates. For larvae, food consumption rates are based on 5-day old larvae, which consume the most food compared to other days of this life stage. For adults, the screening method relies upon nectar foraging bees, which consume the greatest amount of nectar of all castes while nurse bees consume the greatest amount of pollen. It is assumed that this value will be comparable to the consumption rates of adult drones (males) and will be protective for adult queens as well.

Nectar is the major food source for foraging honey bees as well as nurse bees (young, in-hive females). Therefore, pesticide residues in nectar likely account for most of the exposures to bees and may represent most of the potential risk concerns for adult bees. However, if residues in pollen are of concern, exposures to nurse bees, which consume more pollen than any other adult honey bees, should be considered. This is the case especially when pesticide concentrations in pollen are much greater than in nectar, or for crops that mainly provide pollen to bees and would be assessed on a case-by-case basis. The Bee-REX model is a screening level tool that is intended for use in a Tier I risk assessment to assess exposures of bees to pesticides and to calculate risk quotients. This model is individual-based and is not intended to assess exposures and effects at the colony-level (*i.e.,* for honey bees).

The Tier I exposure method is intended to account for the major routes of pesticide exposure that are relevant to bees (*i.e.*, through diet and contact). In the model, bees foraging in a field treated with a pesticide through foliar spray could potentially be exposed to the pesticide through direct spray as well through consuming contaminated food.

Table 11-2. and **Table 11-3.** below (extracted from *Guidance for Assessing Pesticide Risks to Bees*, USEPA et al. 2014) summarizes the exposure estimates for contact and dietary exposures for adult and larvae resulting from foliar application of pesticides.

Table 11-2. Summary of contact and dietary exposure estimates for foliar applications, soil treatment, seed treatments, and tree trunk injections of pesticides for Tier I risk assessments.

Measurement Endpoint	Exposure Route	Exposure Estimate*
Foliar Applications		
Individual Survival (adults)	Contact	$AR_{English}$*(2.7 μg a.i./bee) AR_{Metric}*(2.4 μg a.i./bee)
Individual Survival (adults)	Diet	$AR_{English}$ *(110 μg a.i /g)*(0.292 g/day) AR_{Metric} *(98 μg a.i /g)*(0.292 g/day)
Brood size and success	Diet	$AR_{English}$ *(110 μg a.i /g)*(0.124 g/day) AR_{Metric} *(98 μg a.i /g)*(0.124 g/day)

$AR_{English}$ = application rate in lbs a.i./A; AR_{Metric} = application rate in kg a.i./ha

*Based on food consumption rates for larvae (0.124 g/day) and adult (0.292 g/day) worker bees and concentration in pollen and nectar.

Table 11-3. Summary of estimated food consumption rates of bees.

Life Stage	Caste (task in hive)[a]	Average age (in days)[a]	Daily consumption rate (mg/day)			
			Jelly	Nectar[b]	Pollen	Total
Larval	Worker	1	1.9	0	0	1.9
		2	9.4	0	0	9.4
		3	19	0	0	19
		4	0	60 [c]	1.8[d]	62
		5	0	120 [c]	3.6[d]	124
	Drone	6+	0	130	3.6	134
	Queen	1	1.9	0	0	1.9
		2	9.4	0	0	9.4
		3	23	0	0	23
		4+	141	0	0	141
Adult	Worker (cell cleaning and capping)	0-10	0	60[f]	1.3 - 12[g,h]	61 - 72
	Worker (brood and queen tending, nurse bees)	6-17	0	113 - 167[f]	1.3 - 12[g,h]	114 - 179
	Worker (comb building, cleaning and food handling)	11-18	0	60[f]	1.7[g]	62
	Worker (foraging for pollen)	>18	0	35 - 52[f]	0.041[g]	35 - 52

Life Stage	Caste (task in hive)[a]	Average age (in days)[a]	Daily consumption rate (mg/day)			
			Jelly	Nectar[b]	Pollen	Total
	Worker (foraging for nectar)	>18	0	292 (median)[c]	0.041[g]	292
	Worker (maintenance of hive in winter)	0-90	0	29[f]	2[g]	31
	Drone	>10	0	133 - 337 [c]	0.0002[c]	133 - 337
	Queen (laying 1500 eggs/day)	Entire life stage	525	0	0	525

[a] Winston (1987)
[b] Consumption of honey is converted to nectar-equivalents using sugar contents of honey and nectar.
[c] Calculated as described in this paper.
[d] Simpson (1955) and Babendreier *et al*. (2004)
[e] Pollen consumption rates for drone larvae are unknown. Pollen consumption rates for worker larvae are used as a surrogate.
[f] Based on sugar consumption rates of Rortais *et al.* (2005). Assumes that average sugar content of nectar is 30%.
[g] Crailsheim *et al.* (1992, 1993)
[h] Pain and Maugenet 1966

11.1.2 Tier I Refined EEC (Oral)

Tier I Refined Acute EEC. Given the limitations of using residue trial data to account for temporal and spatial variability, the Agency defines the field residue acute EEC as the overall maximum residue value measured for each matrix (pollen, nectar). If replicate data are reported (*i.e.,* multiple samples on a given sampling day), then the acute EEC would be the maximum of the replicates. These field residue acute EECs are then used to calculate the acute RQ for adult and larval bees (caste and life stage/task specific).

Tier I Refined Chronic EEC. Given the short exposure windows of chronic adult and larval toxicity tests and relatively coarse temporal resolution associated with the field residue data, the Agency defines the field residue chronic EECs as the highest daily average residue value determined from a given sampling event.

Notably, with corn, sorghum, millet, teosinte and potatoes (other than sweet potatoes), significant oral exposure is only expected via ingestion of pollen since these crops do not produce nectar. Therefore, risk estimation only considered pollen as an exposure route for these crops whereby the nurse bees are the most exposed group of adult bees relative to other castes. Inversely, cotton pollen is not attractive to honey bees and therefore, only ingestion of nectar is considered as an exposure route for cotton.

With the proposed uses on canola, pome fruits, stone fruits, tree nuts, small fruits and berries (except strawberry), applications of sulfoxaflor three days before bloom through petal fall are prohibited. However, given the systemic uptake of sulfoxaflor in plants, residues could

potentially persist in pollen and nectar with pre-bloom applications before the 3-day pre-bloom window.

Thirteen new residue studies were submitted in support of these sulfoxaflor new use registrations in addition to the previously reviewed four. These studies were evaluated and residue data (when applicable) in various plant matrices were used to refine exposure estimates for honeybees. **Table 11-4** summarizes the key elements of the available registrant submitted foliar application residue studies. Full study summaries are detailed for previously reviewed residue studies as well as newly submitted studies in **Appendix F**.

Table 11-4. Summary of available registrant submitted foliar application residue studies.

Crop Group (Crop)	No. Sites/ Location/ Duration	Formulation, Appl. Rate, Interval, Application Timing	Matrix	Residue-based Acute EEC (mg/kg)	Residue-based Chronic EEC (mg/kg)	DAA (days)	Study Notes	Classification (Reference)
Phacelia	5 tents, Germany (2011)	GF-2626 0.021 lb ai/A 0.043 During bloom	Nectar/ Pollen	0.05/0.29 0.09/0.81	0.04/0.29 0.06/0.81	5/0 5/0	• Bee collected • No QA/QC information provided for analytical results • Replicate nectar samples, one composite pollen sample	Supplemental (MRID 48476601)
Phacelia	6 tents, Germany (2017)	GF-2626 0.021 lb ai/A 0.043 lb ai/A During bloom	Nectar/ Pollen	0.359/0.351 0.338/0.928	0.359/0.351 0.338/0.928	0 0	• Inconsistencies [1] • Bee collected	Acceptable (MRID 50444501)
Buckwheat	6 tents, NC (2017)	Closer SC (GF-2032) 0.023 lb ai/A 0.071 lb ai/A 0.090 lb ai/A During bloom	Nectar	0.00879 0.0219 0.0119	0.00447 0.0163 0.0116	3 3 7	• Only nectar was collected • Colony size was not equalized • Sulfoxaflor detected in control matrices • Plant collected by hand	Supplemental (MRID 50494501)
Buckwheat	6 tents, KS (2018)	Closer SC (GF-2032) 0.023 lb ai/A 0.071 lb ai/A 0.090 lb ai/A During bloom	Nectar/ Pollen	0.441/0.196 1.21/0.716 2.37/2.48	0.441/0.196 1.21/0.716 2.37/2.48	1 1 2	• Inconsistencies [1] • Storage and transit stability were not determined. • Bee collected	Supplemental (MRID 50604601)

Crop Group (Crop)	No. Sites/ Location/ Duration	Formulation, Appl. Rate, Interval, Application Timing	Matrix	Residue-based Acute EEC (mg/kg)	Residue-based Chronic EEC (mg/kg)	DAA (days)	Study Notes	Classification (Reference)
Cotton	1 site, CA (2012)	Transform WG (GF-2372) 1 x 0.045 lb ai/A 2 x 0.045 @ 5 day int 2 x 0.089 @ 5 day int During bloom	Nectar/ Pollen	0.13/0.22 0.05/0.83 0.07/2.78	0.06/0.15 0.05/0.51 0.04/1.65	1/3 5 0	• Bee collected • Tunnel study with residue measurements	Supplemental (MRID 48755606)
Canola	2 sites, OR and ND (2017)	Transform WG (GF-2372) 2 x 0.023 lb a.i./A @ 14 day int Pre-bloom and during bloom	Nectar Pollen	0.0747 1.33	0.0525 0.535	1 2	• Highest nectar in ND; highest pollen in OR • OR pollen 5-10x higher than ND • Poor (<70% or >120%) QC spike recovery of some samples • Inconsistencies [2] • Plant collected by hand	Supplemental (MRID 50355204)*
Canola	4 sites, Germany (2017)	Transform WG (GF-2372) 24 g a.i./h (0.02 lb a.i./A) During bloom	Nectar Pollen	0.268 4.05	0.268 4.05	0 0	• Winter canola • At various stages of flowering • Plant collected by hand • Inconsistencies [1 2 3]	Acceptable (MRID 50444406)
Sunflower	1 site, KS (2017)	Transform WG (GF-2372) 2 x 0.09 lb ai/A @ 7 day int Pre-bloom and during bloom	Nectar Pollen	0.473 5.34	0.473 5.34	1 DASA 4 DAFA	• Sampled after first application and again after second application • Plant collected by hand • Inconsistencies [1]	Acceptable (MRID 50355201)
Pumpkin	1 site, MD (2012)	Sulfoxaflor (24% ai) 2 x 0.022 and	Nectar/ Pollen	0.03/0.03 0.38/0.08	0.01/0.03 0.20/0.03	N/A	• Plant collected by hand • Residues higher after second treatment	Acceptable (MRID 48755601)

Crop Group (Crop)	No. Sites/ Location/ Duration	Formulation, Appl. Rate, Interval, Application Timing	Matrix	Residue-based Acute EEC (mg/kg)	Residue-based Chronic EEC (mg/kg)	DAA (days)	Study Notes	Classification (Reference)
		2 x 0.089 lb ai/A @ 14 day int During bloom						
Pumpkin	2 sites, NC and CA (2017)	Closer SC (GF-2032) 2 x 0.07 lb ai/A @ 7 day int Pre-bloom and mid-bloom	Nectar Pollen	0.208 4.36	0.121 2.55	1/0 0	• Max measured in NC • Inconsistencies [2] • Poor (<70% or >120%) QC spike recovery of some samples • Plant collected by hand • Cali residues more than 10x less than NC	Supplemental (MRID 50355202)
Pumpkin	4 sites, France and Germany (2017)	GF-2626 48 g a.i./h (0.04 lb a.i./A) During bloom	Nectar Pollen	1.36 0.162	1.36 0.162	1 1	• At various stages of flowering • Plant collected by hand • Inconsistencies [1 2 3]	Acceptable (MRID 50444403)
Citrus	2 Sites, California (2016)	Closer SC (GF-2032) 0.09 lb ai/A Pre-bloom, mid-bloom, fall	Nectar	0.854 0.51	0.854 0.214	11 (GF) 5 (MO)	• Mandarin orange, navel orange, lemon, grapefruit • Pollen samples not collected • No plot history or soil data provided • Stability and analytical method info not reported	Supplemental (MRID 50256403)
Peach	5 plots, MI (2017)	Closer SC (GF-2032) 0.09 lb ai/A Pre-bloom through mid-bloom	Nectar Pollen	0.398 269	0.398 269	0 1	• From plot 3 which was applied at BBCH 61 • Inconsistencies [1 2] • Poor QA/QC spike recovery	Supplemental (MRID 50355203)

Crop Group (Crop)	No. Sites/ Location/ Duration	Formulation, Appl. Rate, Interval, Application Timing	Matrix	Residue-based Acute EEC (mg/kg)	Residue-based Chronic EEC (mg/kg)	DAA (days)	Study Notes	Classification (Reference)
Apple	4 sites, France and Germany (2017)	GF-2626 48 g a.i./h (0.04 lb a.i./A) During bloom	Nectar Pollen	0.181 5.19	0.181 5.19	1 1	• At various stages of flowering • Inconsistencies [1 2 3]	Acceptable (MRID 50444405)
Strawberry	2 sites, FL and CA (2017)	Closer SC (GF-2032) 2 x 0.070 lb a.i./A @ 7 day int Pre-bloom and during bloom	Nectar Pollen	16.8 81.9	15.2 65.3	0 0	• Inconsistencies [2] • Measured residues were greater in CA compared to FL • Issues with QC sample recovery	Supplemental (MRID 50444402)
Strawberry	4 sites, France and Germany (2017)	GF-2626 24 g a.i./h (0.02 lb a.i./A) During bloom	Nectar Pollen	0.894 12.7	0.894 12.7	5 1	• Used bumblebees • Inconsistencies [1 2 3] • Overall residues were higher in France than Germany	Acceptable (MRID 50444404)
Alfalfa	2 sites, NC and CA (2017)	Transform WG (GF-2372) 2 x 0.090 lb a.i./A Pre-bloom and during bloom	Nectar Pollen	31.8 73.6	19.8 58.4	0 0	• Inconsistencies [2] • Poor QC spike recovery • Measured residues were greater in CA than NC • NC had a 7 day interval while CA had 10 day	Supplemental (MRID 50444401)

1 All samples were composited by day therefore there is no difference between acute and chronic EECs

2 No separate control plots; "control samples" were taken prior to application

3 No soil information included in the study report

* Referred to as 50256404 in previous assessments

11.2 Tier I Effects Assessment

For sulfoxaflor, the Tier I laboratory toxicity database is complete for adult contact exposure and for larval and adult oral exposure[14] (acute and chronic; **Table 11-5**). Details on some of the registrant-submitted Tier I toxicity test results with sulfoxaflor are found in the previous Section 3 new chemical risk assessment (D382619). Additional Tier I toxicity studies were submitted after the previous new chemical assessment and are described in **Appendix D**. Toxicity values selected for Tier I risk assessment are shown below in **Table 11-5** in bold. All recommended data according to USEPA 2014; 2016 and required data according to 40 CFR Part 158.630 for individual bees (Tier I laboratory studies) have been submitted and are sufficient for RQ calculation in risk assessment for sulfoxaflor.

The Tier I data for sulfoxaflor indicate that parent chemical is the stressor of concern since all major degradates of sulfoxaflor are practically non-toxic to bees on an acute exposure basis (**Table 11-5**). This lack of toxicity of the degradates is also seen for other aquatic and terrestrial taxa. The acute toxicity of both TEPs are relatively similar to that of the TGAI (*i.e.,* within 2X on an acute contact basis and 3X on an acute oral basis; **Table 11-5**). It is evident that adult bees are more sensitive than larval bees to acute and chronic sulfoxaflor exposures. Among bee taxa, the bumble bee, *B. terrestris,* is about 60X less sensitive to sulfoxaflor (TEP GF-2032-SC) on a mass a.i./bee basis than the honey bees on an acute contact basis, which may be related to the larger size of bumble bees relative to honey bees. On an acute oral basis, sulfoxaflor TEP (GF-2032-SC) is similarly toxic to honey bees and bumble bees, with acute oral LD_{50} values within 2X.

Table 11-5. Tier I honey bee (*Apis mellifera*) and bumble bee (*Bombus terrestris*) toxicity test results for sulfoxaflor **.**

Test Guideline	Type of Toxicity (Purity)[(1)]	Toxicological Endpoint	MRID (Classification)
Honey bee, adult (*Apis mellifera*)			
850.3020	Acute (contact) TGAI	LD_{50} (72-h): 0.379 µg a.i./bee	47832102 (Acceptable)
	Acute (contact) TEP: GF-2032-SC (Closer®)	**LD_{50} (48-h): 0.130 µg a.i./bee**	47832419 (Acceptable)
	Acute (contact) TEP: GF-2372-WG (Transform®)	**LD_{50} (48-h): 0.224 µg a.i./bee**	47832511 (Acceptable)
OECD 213	**Acute (oral) TGAI**	**LD_{50} (48-h): 0.146 µg a.i./bee**	47832103 (Acceptable)
	Acute (oral) TEP: GF-2032-SC (Closer®)	LD_{50} (48-h): 0.0515 µg a.i./bee	47832417 (Acceptable)

[14] The acute and chronic larval assay reflects both oral and contact (dermal) exposure.

Test Guideline	Type of Toxicity (Purity)[1]	Toxicological Endpoint	MRID (Classification)
	Acute (oral) X474	LD_{50} (96-h): >100 µg a.i./bee	47832107 (Acceptable)
	Acute (oral) X061	LD_{50} (48-h): >104 µg a.i./bee	48445809
850.3030	Toxicity of Residues on Foliage (TEP: GF-2372-WG (Transform®)	24-h aged residue mortality: 14% (0.089 lb ai/A or 100 g ai/ha) 15% (0.178 lb ai/A or 200 g ai/ha)	47832512 (Acceptable)
	Toxicity of Residues on Foliage (TEP: GF-2032-SC Closer®)	3-h aged residue mortality: 4% (200 g ai/ha)	47832420 (Acceptable)
OECD 245	**Chronic (oral) TGAI**	**NOAEL (10-d): 0.0054 µg a.i./bee/d LOAEL (10-d): 0.010 µg a.i./bee/d (food consumption)**	50166901 (Acceptable)
	Chronic (oral) TGAI	NOAEL (10-d): 0.0116 µg a.i./bee/d (mortality)	50024601 (Supplemental, Qualitative)
Honey bee, larvae (*Apis mellifera)*			
OECD 237	Acute, single dose (TGAI)	LD_{50} (7-d): >0.2 µg a.i./larvae	48755602 (Supplemental)
N/A	**Short-term, repeated dose (TGAI)**	**LD_{50} (8-d): >0.415 µg a.i./larvae**	50024602 (N/A) [2]
OECD 239**	Chronic, repeated dose (TGAI)	NOAEL (7-d): 0.02 µg a.i./larvae; LOAEL (7-d) = 0.2 µg a.i./bee	48755603 (Supplemental)
	Chronic[3], repeated dose (TGAI)	**NOAEL (22-d): 0.212 µg a.i./larvae; LOAEL (22-d) = 0.415 µg a.i./larvae**	50024602 (Acceptable)
Bumble bee, adult (*Bombus terrestris)*			
OECD 246	Acute (contact) (TEP: GF-2032-SC)	LD_{50} (72-h): 7.55 µg a.i./bee	47832418 (Supplemental)
OECD 247	Acute (oral) (TEP: GF-2032-SC)	LD_{50} (72-h): 0.027 µg a.i./bee	47832418 (Supplemental)

[1]TGAI >95% ai; Closer = 21.8% ai; Transform = 50% ai. .

[2] classification not applicable, short-term repeat dose LC_{50} being used in lieu of acute single dose study

[3] Chronic larval endpoints are based on MRID 50024602 because it is fully acceptable, while the previously submitted study (MRID 48755603) reported high control mortality beyond 7 days and is considered supplemental.

Bolded endpoints are those used in risk assessment and RQ calculation

11.3 Tier I Risk Characterization

Contact and dietary exposure are estimated separately using different approaches specific for different application methods. The Bee-REX model (Version 1.0) calculates default (*i.e*., high end, yet reasonably conservative) EECs for contact and dietary routes of exposure for foliar, soil, and seed treatment applications.

In cases where the Tier I RQs exceed the level of concern (LOC, discussed below), estimates of exposure may be refined using measured pesticide concentrations in pollen and nectar of treated crops, and further calculated for other castes of bees using their food consumption rates as summarized in the White Paper to support the Scientific Advisory Panel (SAP) on the pollinator risk assessment process (USEPA, 2012b). An example output from Bee-REX model calculation for the following Tier I default contact and oral exposure RQs can be found in **Appendix E**.

11.3.1 Tier I Risk Estimation (Contact Exposure)

On-Field Risk

By design, the Tier I assessment begins with (high end) estimates of exposure via contact and oral routes. For contact exposure, only the adult (forager and drones) life stage is considered since this is the relevant life stage for honey bees. Furthermore, toxicity protocols have only been developed for acute exposures. Effects are defined by laboratory exposures to groups of individual bees. Based on the proposed labels and crop attractiveness to bees, a potential for on-field exposure via contact with foliar spray droplets is identified for the following proposed uses:

- Non-grass animal feed, oilseed crops, corn, sorghum, millet, and teosinte, attractive root and tubers, attractive fruiting vegetables, cucurbit vegetables, soybean and other beans, citrus, pome, and stone fruits, tree nuts, small fruits and berries, avocado, and ornamentals

Based on the proposed labels restricting application during bloom, on-field exposure via contact with foliar spray droplets was not assessed for the following uses:

- Canola, pome and stone fruits, tree nuts, and small fruits and berries (except strawberry)

Table 11-6 and **Table 11-7** summarize the Tier I acute contact RQ values for adult honey bees that are assumed to be foraging on treated crop during pesticide application based on the

Closer® and Transform® TEP, respectively . Since bees would be expected to be exposed to a typical end-use product (TEPs) being sprayed on the field rather than the TGAI, the acute contact LD_{50} values for the TEPs were used to calculate acute contact RQs. In addition, there is about a 2X difference in the acute toxicity of TRANSFORM® vs. CLOSER®, therefore, RQ values were calculated for each TEP separately. Acute contact RQ values exceed the acute risk LOC of 0.4 for all proposed uses that are attractive to honey bees. The magnitude of effect associated with these RQ values correspond to lethality to a group of exposed worker bees between 20% (RQ of 0.57) to 80% (RQ of 1.9). These estimates of lethality are derived using the median Probit slope of 3.2 determined from an analysis of acute contact and oral toxicity data for honey bees (USEPA 2012b). It was used here since a test-specific slope was not determined from the submitted data. As honey bees are used as a surrogate for other *Apis* and non-*Apis* bees at Tier I, these risk conclusions would apply to other bee species as well.

Table 11-6. Default Tier I Adult, Acute Contact Risk for Honey Bees Foraging on Sulfoxaflor, TEP Closer®[3].

Use Pattern	Max. Single Application Rate	Dose (*µg* a.i./bee per 1 lb a.i./A)[1]	Sulfoxaflor Contact Dose (*µg* a.i./bee)	Acute RQ[2]
Root and tuber[4], citrus, fruits, strawberry, alfalfa, avocado, and ornamentals	0.09 lb a.i./A	2.7	0.033	**1.9**
Potato, Cotton, Soybean, other beans, fruiting[4] and cucurbit vegetables	0.071 lb a.i./A	2.7	0.026	**1.5**
Corn, Sorghum, Millet, and Teosinte	0.047 lb a.i./A	2.7	0.017	**0.98**

[1] Source: USEPA 2014. Guidance for Assessing Pesticide Risks to Bees

[2] Based on a 48-h acute contact LD_{50} of 0.13 µg a.i./bee for Sulfoxaflor (MRID 47832419).

[3] **Bolded** RQ value exceeds (or potentially exceeds) the acute risk LOC of 0.4

[4] Honey bee attractive members of these crop groups only

Table 11-7. Default Tier I Adult, Acute Contact Risk for Honey Bees Foraging on Sulfoxaflor, TEP Transform®[3].

Use Pattern	Max. Single Application Rate	Dose (*µg* a.i./bee per 1 lb a.i./A)[1]	Sulfoxaflor Contact Dose (*µg* a.i./bee)	Acute RQ[2]
Root and tuber[4], citrus, fruits, strawberry, alfalfa, avocado, and ornamentals	0.09 lb a.i./A	2.7	0.033	**1.1**
Potato, Cotton, Soybean, other beans, fruiting[4] and cucurbit vegetables	0.071 lb a.i./A	2.7	0.026	**0.86**

Corn, Sorghum, Millet, and Teosinte	0.047 lb a.i./A	2.7	0.017	**0.57**

[1] Source: USEPA 2014. Guidance for Assessing Pesticide Risks to Bees

[2] Based on a 48-h acute contact LD_{50} of 0.224 µg a.i./bee for Sulfoxaflor (MRID 47832511).

[3] **Bolded** RQ value exceeds (or potentially exceeds) the acute risk LOC of 0.4

[4] Honey bee attractive members of these crop groups only

Off-Field Risk

In addition to bees foraging on the treated field, bees may also be foraging on blooming plants adjacent to the treated fields. In these situations, bees may become exposed through interception of pesticide spray droplets that drift off site during application. In order to estimate the potential contact exposure of bees to sulfoxaflor when foraging on plants adjacent to treated fields, AgDRIFT (version 2.1.1) was run based on available label information. For ground and aerial (non-ULV) applications, the label specifies that only medium or coarser spray nozzles shall be used. Furthermore, the label specifies a boom height of <4 ft for ground applications and <10 feet for aerial applications. For wind speed, the labels prohibit application above a wind speed of 10 mph.

Results of AgDRIFT modeling for off-site deposition of spray droplets at the maximum proposed application rate of 0.09 lb a.i./A as shown in **Table 11-8.**. Since the drift of ground and aerial sprays declines exponentially with distance from the treated field, the highest off-field exposures occur at the near edge of treated fields. Based on AgDRIFT modeling with the maximum application rate of 0.09 lb a.i./A and the Tier 1 acute contact risk assessment presented earlier, the acute risk LOC is exceeded for bees potentially foraging in sites ranging up to 2 to 12 feet from the treated field, depending on the application method. For this analysis, "medium to coarse" spray nozzles with a median droplet diameter of 341 µm was assumed.

Table 11-8. Equivalent Sulfoxaflor Application Rates Predicted by AgDRIFT at Various Distances from the Application Site for the Maximum Application Rate of 0.09 lb a.i./A. and Distance from Treated Field Beyond Where the Acute Risk Level of Concern for Bees (Contact Exposure) is Exceeded.

Method	**Droplets**	**Dv0.5 (um)**	**Distance from the field and point estimate of application rate (lb a.i./A)**					**Distance from filed edge where the acute risk LOC is exceeded[3] (ft)**
			10 ft	**20ft**	**40ft**	**80ft**	**150ft**	
Ground[1]	M/C	341	0.0041	0.0022	0.0013	0.0007	0.0004	2
Aerial [2]	M to C	341	0.0205	0.0142	0.0096	0.0053	0.0024	12

Table Notes:

M = medium spray nozzle, C = coarse spray nozzle, (M to C assumes a median droplet diameter of 341 µm)

[1] Boom height = 4.2 ft,

[2] boom height = 10 ft, wind speed = 10 mph, spray volume 3 gal/A

[3] Distance to LOC of 0.4 which equates to an application rate of 0.019 lb a.i./A for CLOSER™ based on a 48-h acute contact LD50 of 0.130 µg a.i./bee for (MRID 47832419) and a contact dose of 2.7 µg a.i./bee per 1 lb a.i./A.

Based on the acute contact toxicity of CLOSER™, the acute risk LOC is exceeded at an application rate of 0.019 lb a.i./A and higher. Using all the application rates of CLOSER™ which exceed this rate, the distance from the field edge where the acute risk LOC of 0.4 would be exceeded was determined using AgDRIFT (**Table 11-9.**). The other formulated product (TRANSFORM™) is roughly 50% less toxic on an acute contact exposure basis than CLOSER™; therefore, the distances at which the acute contact risk LOC is exceeded will be shorter than those shown in Table 11-9. for CLOSER™. As honey bees are used as a surrogate for other *Apis* and non-*Apis* bees at the Tier I level, these risk conclusions would apply to other bee species as well.

Table 11-9. Distance from the Treated Field Where the Acute Risk LOC (Contact Exposure) For CLOSER is Exceeded for Various Application Rates of Sulfoxaflor as Determined by AgDRIFT.

Method	Droplets	Dv0.5 (um)	Distance from Field Edge Where the Acute Contact Risk LOC is Exceeded[3] (ft)			
			0.036 lb ai/a	0.043 lb ai/A	0.07lb ai/A	0.09 lb ai/A
Ground[1]	M/C	341	<1	<1	2	2
Aerial [2]	M to C	341	<1	<1	5	12

Table Notes:
M = medium spray nozzle, C = coarse spray nozzle, (M to C assumes a median droplet diameter of 341 µm)
[1] Boom height = 4.2 ft,
[2] boom height = 10 ft, wind speed = 10 mph, spray volume 3 gal/A
[3] Distance (round to nearest ft) to LOC of 0.4 which equates to an application rate of 0.019 lb a.i./A for CLOSER™ based on a 48-h acute contact LD50 of 0.130 µg a.i./bee for (MRID 47832419) and a contact dose of 2.7 µg a.i./bee per 1 lb a.i./A.

Contact With Residues On Foliage (RT_{25})

Bees may come into contact with pesticide residues that have deposited onto foliage when they are foraging on attractive plants adjacent to the treated field. For sulfoxaflor, data are available from two studies that examined the toxicity of residues on treated foliage. These studies were conducted according to the Office of Chemical Safety and Pollution Prevention (OCSPP) test guideline 850.3020, as summarized in the previous Section 3 risk assessment (DP 382619). The toxicity of residues on foliage studies assess the toxicity of aged residues on treated alfalfa. Based on aged residues of the CLOSER™ formulation (GF-2032-SC) on alfalfa after application at 200 g/ha (0.18 lb a.i./A), less than 5% mortality occurred following 3 to 24 hours of exposure (MRID 47832420). With the TRANSFORM™ formulation (GF-2372-WG) at the same application rate, up to 15% mortality occurred following exposure to alfalfa aged from 3-24 hours (MRID 47832512). Collectively, these studies suggest that aged residues of these two sulfoxaflor formulations result in low mortality to honey bees via contact with treated foliage, *i.e.*, the compounds exhibit low "residual toxicity" with RT_{25} values < 3 hours. It is further noted

that the application rate used in these studies (0.18 lb a.i./A) is double the maximum single application rate of sulfoxaflor proposed for this registration (0.09 lb a.i./A).

11.3.2 Tier I Risk Estimation (Oral Exposure)

On-Field Risk

For oral exposure, the Tier I assessment considers just the caste of bees with the greatest oral exposure (foraging adults). If risks are identified using default (high end) estimates of exposure, then other factors are considered for refining the Tier I risk estimates. These factors include other castes of bees and available information on residues in pollen and nectar which is deemed applicable to the crops of interest. On an oral exposure basis, all proposed application rates exceed the acute and chronic risk LOC both adults and larval honey bees using default estimates of exposure at Tier I **(Table 11-10)**. As honey bees are used as a surrogate for solitary bees these risk conclusions would apply to other bee species as well.

Table 11-10. Tier I (Default) Oral Risk Quotients for Adult and Larval Honey Bees[3].

Use Pattern	Max. Single Appl. Rate	Bee Stage	Unit Dose (µg a.i./bee per 1 lb a.i./A)[1]	Oral Dose (µg a.i./bee)	Acute Oral RQ[2]	Chronic Oral RQ[4]
Root and tuber[5], citrus, pome, and stone fruits, tree nuts, berries, alfalfa, avocado, and ornamentals	0.09 lb a.i./A	Adult	32	2.891	**20**	**540**
		Larval	13.6	1.224	**3.0**	**5.8**
Potato, Cotton, Soybean, other beans, fruiting[5] and cucurbit vegetables	0.07 lb a.i./A	Adult	32	2.281	**16**	**420**
		Larval	13.6	0.965	**2.3**	**4.6**
Corn, Sorghum, Millet, and Teosinte	0.047 lb a.i./A	Adult	32	1.510	**10**	**280**
		Larval	13.6	0.691	**1.5**	**3.0**
Canola	0.023 lb a.i./A	Adult	32	0.739	**5.0**	**140**
		Larval	13.6	0.313	**0.75**	**1.5**

[1] Source: USEPA 2014. Guidance for Assessing Pesticide Risks to Bees.
[2] Based on a 48-h acute oral LD_{50} of 0.146 µg a.i./bee for adults (MRID 47832103) and 8-d LD_{50} of >0.415 µg a.i./bee for larvae (MRID 50024602).
[3] **Bolded** RQ value exceeds (or potentially exceeds) the acute risk LOC of 0.4 or chronic LOC of 1.0
[4] Based on a 10-d chronic NOAEL of 0.0054 µg a.i./bee/d for adults (MRID 50166901) and a 22-d chronic NOAEL of 0.212 µg a.i./bee/d for larvae (MRID 50024602)
[5] Honey bee attractive members of these crop groups only

Off-Field Risk

Bees may also become exposed to sulfoxaflor which has been deposited on (or translocated into) pollen and nectar of blooming plants adjacent to treated fields. To provide an estimate of the potential oral exposure of bees to sulfoxaflor when foraging on plants adjacent to treated fields, AgDRIFT (version 2.1.1) was run as described previously in **Table 11-9.** for the acute contact exposures. Based on this AgDRIFT modeling and default (high end) estimates of exposure for adult nectar foragers (the highest exposed type of honey bee), the acute risk LOC is exceeded from 16 to 361 feet beyond the edge of the treated field, depending on the application rate and application method (**Table 11-11**).

Table 11-11. Distance from the Treated Field Edge Where the Acute Risk LOC Is Exceeded for Adult bees (Default, Oral Exposure) as Determined Using AgDRIFT.

Method	Droplets	Dv0.5 (um)	Distance (ft)			
			0.023 lb ai/A	0.043 lb ai/A	0.07 lb ai/A	0.09 lb ai/A
Ground[1]	M/C	341	16	36	66	89
Aerial [2]	M to C	341	135	210	295	361

Table Notes:
M = medium spray nozzle, C = coarse spray nozzle
[1] Boom height = 4.2 ft,
[2] boom height = 10 ft, wind speed = 10 mph, spray volume 3 gal/A
[3] distance (round to nearest ft) to LOC of 0.4 which equates to 0.0007 lb ai/A for default (high end) oral exposure.

11.3.3 Tier I Risk Estimation (Refined Oral Exposure)

The Tier I risk assessment reflects default assumptions of exposure estimates of honey bees to the pesticide. By design, the initial Tier I risk assessment reflects simplified, high-end estimates of exposure to quickly identify uses which pose minimal risk to bees. However, LOC exceedances that are based on the default (high-end) estimates of exposure do not necessarily mean that risk will occur. In such cases, refinement of default estimates of exposure may be conducted using more realistic estimates of exposure that reflect the residues resulting from actual use patterns (*e.g.*., empirical residues in pollen/nectar) for sulfoxaflor where data are available. Currently, EPA does not have standard methods for refining default acute contact exposure estimates. For oral exposure, refinement of Tier I risk estimates is possible based on consideration of different bee castes and tasks (each differing in their nectar and pollen consumption rates) and measured values of pesticide residues in pollen and nectar.

On-Field Risk

As distinguished from the default Tier I assessment, in cases where residue information in pollen and nectar are available, these data can be used to refine the estimates of oral exposure

as well as further characterize the level of risk for other castes of bees using their food consumption rates. These refined exposure estimates in pollen and nectar are then compared to the Tier I (*i.e.*, individual level) toxicity endpoints in a manner similar to that for the model-generated or default Tier I exposure estimates. Rather than reporting the highest exposure estimates for contact and/or dietary exposure routes (as with the default Tier assessment), the Bee-REX model also calculates dietary exposure values and associated RQs for larvae of different ages, adult workers with different tasks (and associated energy requirements) and the queen using the various aforementioned consumption rates. RQ calculations for each use pattern that has residue information available is reported in **Table 11-12.**. Additional characterization of RQ values derived from the residue study selected EECs was conducted using the entire pollen and nectar data set obtained for each study where the totality of the data will be compared to the Tier I endpoints to yield a set of resultant RQs over time. This analysis is described in full in **Appendix G**.

Table 11-12. Maximum Acute and Chronic RQ Values for Adult and Larval Honey Bees Determined Using Measured Residues of Sulfoxaflor in Pollen and Nectar.

Use Pattern	Bee life stage	Nectar/Pollen Consumption Rate (mg/d)[1]	Acute Pollen/Nectar Residue EEC (mg/kg)	Acute Oral RQ [2, 3]	Chronic Pollen/Nectar Residue EEC (mg/kg)	Chronic Oral RQ [3, 4]
Non-grass animal feeds (Alfalfa[5])	Adult Nectar Forager	292 / 0.041	73.6/31.8	**64**	58.3/19.8	**1070**
	Adult Nurse Bee	140 / 9.6		**35**		**620**
	Larval Worker (5-d old)	120 / 3.6		**9.8**		**12.2**
Pome Fruit (Apple[6])	Adult Nectar Forager	292 / 0.041	5.19/0.181	0.36	5.19/0.181	**9.8**
	Adult Nurse Bee	140 / 9.6		**0.51**		**14**
	Larval Worker (5-d old)	120 / 3.6		0.10		0.19
Cereal Grains (Buckwheat[6])	Adult Nectar Forager	292 / 0.041	2.48/2.37	**4.7**	2.48/2.37	**130**
	Adult Nurse Bee	140 / 9.6		**2.4**		**66**
	Larval Worker (5-d old)	120 / 3.6		**0.71**		**1.4**
Canola[7] Subgroup	Adult Nectar Forager	292 / 0.041	4.05/0.268	**0.54**	0.535/0.0525	**2.8**
	Adult Nurse Bee	140 / 9.6		**0.52**		**2.3**
	Larval Worker (5-d old)	120 / 3.6		0.11		0.039
Cotton[5]	Adult Nectar Forager	292 / 0.041	2.78/0.13	0.26	1.65/0.06	**3.3**
	Adult Nurse Bee	140 / 9.6		0.31		**4.5**
	Larval Worker (5-d old)	120 / 3.6		0.06		0.06
Citrus[7] (grapefruit,	Adult Nectar Forager	292 / 0.041	0.854	**1.7**	0.854	**46**
	Adult Nurse Bee	140 / 9.6		**0.82**		**22**

Use Pattern	Bee life stage	Nectar/Pollen Consumption Rate (mg/d)[1]	Acute Pollen/Nectar Residue EEC (mg/kg)	Acute Oral RQ [2, 3]	Chronic Pollen/Nectar Residue EEC (mg/kg)	Chronic Oral RQ [3, 4]
lemon, mandarin, orange)	Larval Worker (5-d old)	120 / 3.6		0.25		0.48
Stone Fruit (Peach[6])	Adult Nectar Forager	292 / 0.041	269/0.398	**0.87**	269/0.398	**24**
	Adult Nurse Bee	140 / 9.6		**18**		**490**
	Larval Worker (5-d old)	120 / 3.6		**2.4**		**4.8**
Cucurbit Vegetables (Pumpkin[7])	Adult Nectar Forager	292 / 0.041	4.36/0.779	**1.6**	2.55/0.121	**6.6**
	Adult Nurse Bee	140 / 9.6		**1.0**		**7.7**
	Larval Worker (5-d old)	120 / 3.6		0.26		0.11
Phacelia[6]	Adult Nectar Forager	292 / 0.041	0.338/0.928	**1.9**	0.338/0.928	**50**
	Adult Nurse Bee	140 / 9.6		**0.91**		**25**
	Larval Worker (5-d old)	120 / 3.6		0.27		0.53
Small fruits and berries, Strawberry[7]	Adult Nectar Forager	292 / 0.041	81.9/16.8	**34**	65.3/15.2	**820**
	Adult Nurse Bee	140 / 9.6		**22**		**510**
	Larval Worker (5-d old)	120 / 3.6		**5.6**		**9.7**
Sunflower[6]	Adult Nectar Forager	292 / 0.041	5.34/0.473	**0.95**	5.34/0.473	**26**
	Adult Nurse Bee	140 / 9.6		**0.80**		**6.9**
	Larval Worker (5-d old)	120 / 3.6		0.18		0.36

[1] Source: USEPA 2014. Guidance for Assessing Pesticide Risks to Bees.

[2] Based on a 48-h acute oral LD_{50} of 0.146 µg a.i./bee for adults (MRID 47832103) and 8-d LD_{50} of >0.415 µg a.i./bee for larvae (MRID 50024602).

[3] **Bolded** RQ value exceeds (or potentially exceeds) the acute risk LOC of 0.4 or chronic LOC of 1.0;

[4] Based on a 10-d chronic NOAEL of 0.0054 µg a.i./bee/d for adults (MRID 50166901) and a 22-d chronic NOAEL of 0.212 µg a.i./bee/d for larvae (MRID 50024602)

[5] Study has multiple replicate samples per day therefore a chronic averaged EEC was calculable.

[6] Study took one composited sample per day therefore a chronic averaged EEC was not calculable and both acute and chronic EECs are the same.

[7] There were multiple studies available with both replicate and composited sampling methods. Therefore, the highest single residue between all studies was use for Acute EEC selection and only those with average residues were used to select the chronic EEC.

Table 11-13. below summarizes the Tier I analysis of risk to pollinators and if each crop group will be assed at the Tier II level. As honey bees are used as a surrogate for other *Apis* and non-*Apis* bees a the Tier I level, these risk conclusions would apply to other bee species as well.

Table 11-13. Summary of Risk at Each Stage of Tier I Bee Assessment.

Crop Group	Bee Attractive?	Tier I	Refined Tier I	Notes
Non-grass animal feed	Yes	Risk	Risk	Move to Tier II assessment
Oilseed: Canola & Cotton	Yes	Risk	Risk	Move to Tier II assessment considering label bloom restriction
Corn, sorghum, millet, teosinte	Yes (Pollen only)	Risk	Y	Move to Tier II assessment using surrogate crops
Root and tubers	Some	Risk	NA	Move to Tier II assessment using surrogate crops
Potatoes	Some	Risk	NA	Move to Tier II assessment using surrogate crops
Bulb vegetables	Yes (harvested before bloom)	No	NA	No on field risk
Leafy Vegetables	Yes (harvested before bloom)	No	NA	No on field risk
Brassica Vegetables	Yes (harvested before bloom)	No	NA	No on field risk
Fruiting Vegetables	Some	Risk	NA	Move to Tier II assessment using surrogate crops
Cucurbit Vegetables	Yes	Risk	Risk	Move to Tier II assessment
Legumes: Beans & soybean	Yes	Risk	NA	Move to Tier II assessment using surrogate crops
Citrus Fruits	Yes	Risk	Risk	Move to Tier II assessment
Pome fruits	Yes	Risk	Risk	Move to Tier II assessment considering label bloom restriction
Stone Fruits	Yes	Risk	Risk	Move to Tier II assessment considering label bloom restriction
Tree nut	Yes	Risk	NA	Move to Tier II assessment using surrogate crops and considering label bloom restriction
Small fruits, grape, strawberry	Yes	Risk	Risk	Move to Tier II assessment considering label bloom restriction
Avocado	Yes	Risk	NA	Move to Tier II assessment using surrogate crops
Rice	No	No	NA	No on field risk
Christmas tree	No	No	NA	No on field risk
Ornamentals	Some	Risk	NA	Move to Tier II assessment using surrogate crops
Tree farm	Some	Risk	NA	Move to Tier II assessment using surrogate crops

11.4 Tier II Effects Assessment

The Tier II risk assessment focuses on characterizing pesticide risks to honey bees at the colony level. It is conducted for uses where Tier I risks are indicated as described previously. The Tier II assessment is important because effects that occur at the individual bee level may not occur at the colony level due to differences in exposure and compensatory mechanisms of the hive. In addition, evaluating effects at the colony level integrates multiple mechanisms by which a toxicant can affect the proper functioning of a colony (*e.g.,* behavior abnormalities, navigation, and learning) which may not be indicated by individual-level effects data. Tier II effects data for sulfoxaflor include both semi-field tunnel studies and colony feeding studies, which are described further in this section.

11.4.1 Contact + Oral exposure (Tunnel Studies)

As described in the previous Section 3 risk assessment, a total of 6 Tier 2 semi-field (tunnel) studies were submitted as part of the original new chemical registration. In these studies, effects observed on mortality, flight activity and behavioral abnormalities were short-lived (3 days or less) at application rates up to 0.09 lb ai/A. No sustained effects were observed on parameters such as forager mortality, flight activity, behavior abnormalities and hive strength at the proposed application rates; however, a number of limitations in these studies were previously noted which introduced uncertainty as to understanding the potential for long-term effects on colonies. Specifically, short-term effects on brood were not evident compared to controls; however, due to deficiencies in the study execution and/or design, the potential effects on brood over longer-time periods could not be conclusively determined. Additional Tier II studies were submitted to the Agency in 2018 and are summarized below.

Six tunnel studies were submitted previously however there were several limitations that resulted in restricted utility of these Tier II studies as described in **Appendix H**. Three new registrant-submitted tunnel studies were reviewed to support this assessment. These studies evaluated the effect of combined contact and oral exposures on honey bee colonies maintained in tunnel enclosures for 7-10 days followed by post-exposure monitoring outside of the tunnel through overwintering. Importantly, these new tunnel studies evaluated long-term effects on colonies at the proposed application rates of sulfoxaflor, thereby addressing limitations identified in the previous 6 tunnel studies. One tunnel study each was conducted in North Carolina, USA (MRID 5049451), Kansas, USA (MRID 50604601), and in Pforzheim, Germany (MRID 50444501).

In the North Carolina tunnel study sulfoxaflor formulated product Closer SC was applied at nominal rates of 0.023, 0.071, and 0.090 lb ai/acre to flowering buckwheat (*Fagopyrum esculentum*). The honey bee colonies were exposed for 10 days using 6 replicate tunnel tents

per treatment level. Following the 10-day test exposure, the hives were monitored daily for an additional 30 days, and through overwintering.

In the Kansas tunnel study sulfoxaflor formulated product (Closer SC) was applied at nominal rates of 0.023, 0.071, and 0.090 lb ai/acre to flowering buckwheat (*Fagopyrum esculentum*). The honey bee colonies were exposed for 9 days using 8 replicate tunnel tents per treatment level. Following the 9-day test exposure, the hives were monitored daily for an additional 9 months at another site including overwinter. **Table 11-14.** summarizes the study design and results of each study with discussion to follow.

In the Germany study, sulfoxaflor formulated product (Closer SC) was applied at rates of 0.021 and 0.043 lb ai/A to flowering plants (*Phacelia tanacetifolia*) during bee flight. The honey bee colonies were exposed for 7 days using 6 replicate tunnel tents per treatment level in addition to controls. Following the 7-day exposure and relocation, the hives were monitored through overwintering.

Table 11-14. Summary of Tier II colony-level tunnel studies conducted with sulfoxaflor.

Study Attribute	Results Summary		
	1. Renz (2017) MRID 50444501	**2. Louque (2017)** MRID 50494501	**3. Howerton (2018)** MRID 50604601
Classification	Supplemental	Supplemental	Supplemental
Test Substance	GF-2626 (11.8%)	Closer GF-2032 (22.7%)	Closer GF-2032 (21.8%)
Timing/Location	2016-17, Pforzheim, Germany	2016-17, North Carolina, USA	2017-18, Stilwell, Kansas
Application Timing & Rate	**During flight:** **0.021, and 0.043 lb ai/A** (24 & 48 g ai/ha)	**During flight:** **0.023, 0.071, and 0.090 lb ai/A** (24, 80, 100 g ai/ha)	**During Flight:** **0.023, 0.071, and 0.090 lb ai/A** (24, 80, 100 g ai/ha)
No. Reps. / Treatment	6	6	6
% of US Max. Single Appl. Rate	16-32%	16-100%	16-100%
Crop	*Phacelia*	*Fagopyrum esculentum* (Buckwheat)	*Fagopyrum esculentum* (Buckwheat)
Exposure Pathways Assessed	Direct contact, oral	Direct contact, oral	Direct contact, oral
Exposure Duration, Month of Study Initiation	**In-Tunnel Exposure:** (pre-application) **4d** (post-application) **7d** **Post Tunnel Obs.:** **Overwinter** July test initiation	**In-Tunnel Exposure:** (pre-application) **2d** (post-application) **10d** **Post Tunnel Obs.:** **Overwinter** June test initiation	**In-Tunnel Exposure:** (pre-application) **3d** (post-application) **9d** **Post Tunnel Obs.:** **Overwinter** June test initiation
Forager Mortality	**Day 0**: up to 5X increase (treatment dependent; ***S***) **Day 1-40**: ≈ control levels **(*NS*)**	**Day 0**: up to 18X increase (treatment dependent; ***S***) **Day 1-3**: 3X-8X increase (treatment dependent; ***S)*** **Day 4-10**: ≈ control levels @ 0.023 & 0.071 rate **(*NS*)**; ~2X controls @ 0.09 rate through day 8 (***NS*)**	**Day 0**: up to 20X increase (treatment dependent; ***S***) **Day 1-2**: 1.5X-7X increase (treatment dependent; ***S*** at 0.071 and 0.090 rates***)*** **Day 4-9**: ≈ control levels with spikes in mortality ***S*** for 0.071 rate
Flight Intensity	**Day 0-2**: Significant decrease in intensity at both treatments **Days 3-7**: treatment ≈ controls	Highly variable within and between groups, but mean activity 30%-70% of controls through 9 DAA	Mean activity significantly decreased 30%-40% of controls through 9 DAA at all treatment levels.

Study Attribute	Results Summary		
	1. Renz (2017) MRID 50444501	**2. Louque (2017)** MRID 50494501	**3. Howerton (2018)** MRID 50604601
Forager Behavior	Some behavioral abnormalities ≤ 7DAA, locomotion problems or inactivity	No abnormal behavior of bees was observed in any treatment during exposure.	No abnormal behavior of bees was observed in any treatment during exposure.
Brood Development	**Treat vs. Control:** First and second cohort showed no difference between control and treatments.	**Treat vs. Control:** First cohort unable to be assessed due to lack of brood. Second cohort showed no sustained differences, but results confounded by high variability in control hives.	**Treat vs. Control:** First cohort had differences in termination rate, brood index, and compensation rate (***S*** at 0.090 rate). Second cohort showed no difference between control and treatments.
Colony Strength	**Treat vs. Control:** No sustained effects, intermittent differences in number of eggs or larvae.	**Treat vs. Control:** No sustained effects, intermittent differences in pollen stores.	**Treat vs. Control:** No sustained effects, intermittent differences in number of brood and honey stores.
Overwintering success	All colonies survived overwintering	Very poor control survival (50%) limits utility of overwintering data	Very poor control survival (30%) limits utility of overwintering data
Residues	Residues in bee-collected pollen and nectar below LOQ by 3DAA. In hive nectar and bee bread sustained above the LOQ at the end of sampling 7DAA.	Residues in hive nectar and bee bread ~ LOQ by 10-24 DAA	Residues in bee-collected pollen and nectar sustained above the LOQ by end of sampling at 7DAA. No in hive residues collected.
Study Limitations*	1. Less than proposed maximum application rate tested. 2. Not enough brood to accurately assess development in the first cohort.	1. Not all colonies had enough brood in the first cycle and was not analyzed. 2. Poor control overwintering survival prevented analysis. 3. Initial colony size was not recorded, and some hives did not meet the population criteria listed in the protocol.	1. Only one replicate was tested in the residue portion of the study. 2. Storage and transit stability of the residue samples collected were not determined. 3. Poor control overwintering survival prevented analysis.
Reference Toxicant	**Dimethoate (400g/ha); Fenoxycarb (300g/ha);**	**Novaluron (0.0778 lb/A); Dimethoate (0.1 & 1 L/ha);**	**Dimethoate (0.055 lb/A); Rimon (0.079 lb/A)**
S=significantly different from controls (p<0.05), NS= not significantly different from controls (p>0.05)			

An endpoint by endpoint discussion of for each study is included in the full review of these Tier II tunnel studies in **Appendix I**.

In the Germany study, applications of 0.021 and 0.043 lb a.i./A resulted in a statically significant ($p < 0.05$) increase in mean daily mortality up to 5X greater than controls on the day treatments were applied (**Figure 11-2**). Beyond 1 day after application, mean forager mortality was similar among both treatments and the controls and not statistically different. Foraging activity in the 0.021 and 0.043 lb a.i./A treatments decreased significantly on the day of application during bee flight and significant reductions in flight activity were observed at the beginning of the exposure period through 2 days after application. Treatments of 0.021 and 0.043 lb a.i./A influenced the behavior of honey bees, mainly on the day of application during bee flight. In-hive residues showed that sulfoxaflor does enter the hive in a dose-dependent manner and declined over time to less than the limit of detection within 7 days of application. There was no effect of either treatment on colony size, total number of brood cells, storage of nectar and pollen, brood index, compensation index, termination rate of eggs/young larvae/old larvae, or pupae weight. Further, sulfoxaflor exposure did not appear to impact the overwintering success of the honey bee colonies (colonies in control, 0.021 and 0.043 lb a.i./A treatments all had overwintering success rates 100%).

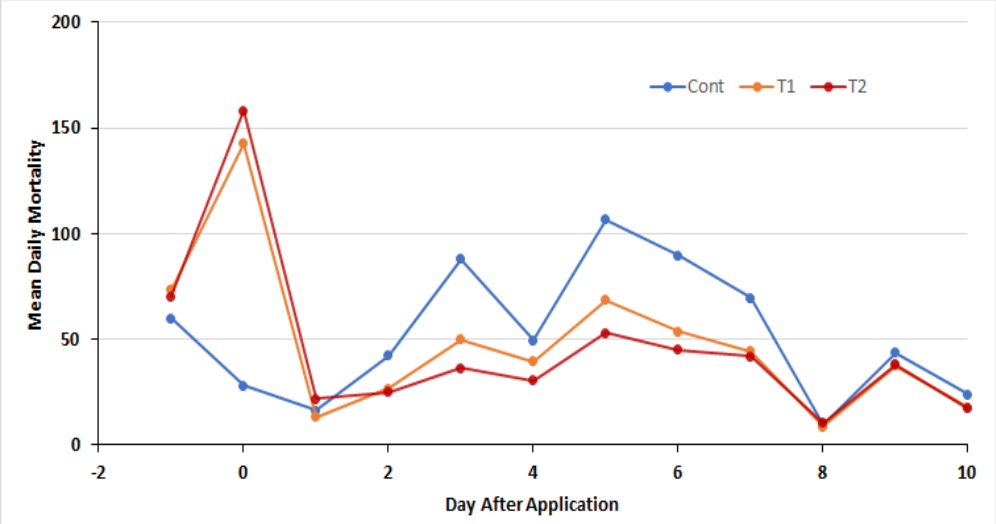


Figure 11-2. Daily mean mortality of forager honey bees vs. day after application for Germany tunnel study. T1 & T2 = 0.021 and 0.043 lb ai/A, respectively (MRID 50444501).

In the North Carolina study, a 10-day honey bee exposure to an application of Closer to buckwheat had short-term effects on a honey bee colony's foraging intensity and adult bee mortality. Mean forager mortality significantly ($p < 0.05$) increased from 3X to 18X that of controls on the day of exposure, depending on treatment (**Figure 11-3**). At the 0.09 lb a.i./A rate, mean forager mortality remained elevated *(i.e.*, 2X controls or higher) through 8 days after

application, but was not statistically significant (p>0.05). At the 0.071 lb a.i./A treatment, mean adult mortality was elevated only through 3 days after application. With the lowest treatment (0.023 lb a.i./A) elevated mortality was observed only through 1 day after application. Flight intensity was highly variable within and between groups which resulted in low statistical power. From 1-9 days after application, the overall average flight intensity was reduced to between 30%-70% of controls but did not show a clear trend with application rate. Honey bee brood development and colony strength were similar between the control and treatment groups for both cohorts 1 and 2. In-hive residues showed that sulfoxaflor does enter the hive in a dose dependent manner and concentrations declined over time to control levels within 10 days. Honey bee colonies in control, 0.023, 0.071 and 0.090 lb a.i./A treatments had overwintering survival rates of 50, 83, 17 and 17% respectively. Unfortunately, poor overwintering performance in the controls limited the utility of this endpoint. As the control performance was poor, the low overwintering survival in the treatments could not be attributed to sulfoxaflor exposure.

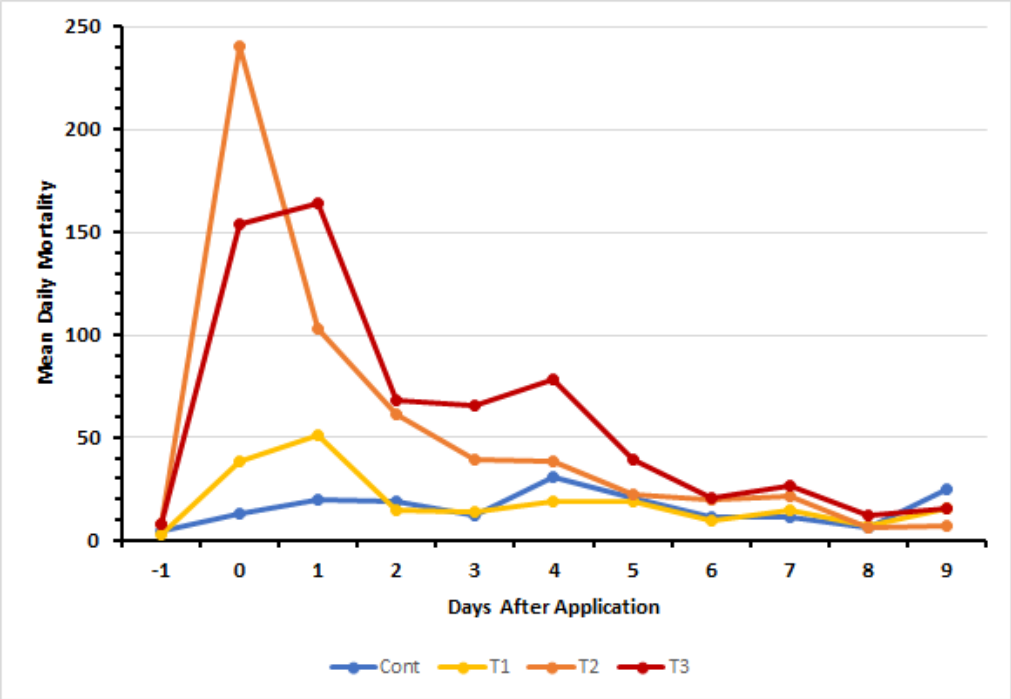


Figure 11-3. Daily mean mortality of forager honey bees vs. day after application for North Carolina tunnel study. T1, T2, T3 = 0.023, 0.071 and 0.09 lb ai/A, respectively (MRID 50494501).

In the Kansas study, a 9-day honey bee exposure to an application of Closer to buckwheat had effects on a honey bee colony's foraging intensity and adult bee mortality. Mean adult mortality significantly ($p < 0.05$) increased from 7X to 20X that of controls on the day of exposure, depending on treatment (**Figure 11-5**). At all treatment rates, mean forager mortality remained significantly elevated from controls until 2 days after application. Spikes in mortality

were seen on day 4 and 9 after application with the 0.071lb a.i./A treatment significantly different. Flight intensity was variable within and between groups. However, from 1-9 days after application, flight intensity was significantly reduced to between 30%-40% of controls but did not show a clear trend with application rate. Honey bee brood development had significant reductions at multiple metrics for cohort 1 but was similar between the control and treatment groups for cohort 2. Honey bee collected nectar and pollen residues showed that sulfoxaflor is collected in a dose dependent manner and concentrations declined over time with elevated levels until the last sampling day (7 DAA). Colonies in control, 0.023, 0.071 and 0.090 lb a.i./A treatments had overwintering survival rates of 37, 33, 17 and 50% respectively. Unfortunately, poor overwintering performance limited the utility of this endpoint. As the control performance was poor, the low overwintering survival could not be attributed to sulfoxaflor exposure.

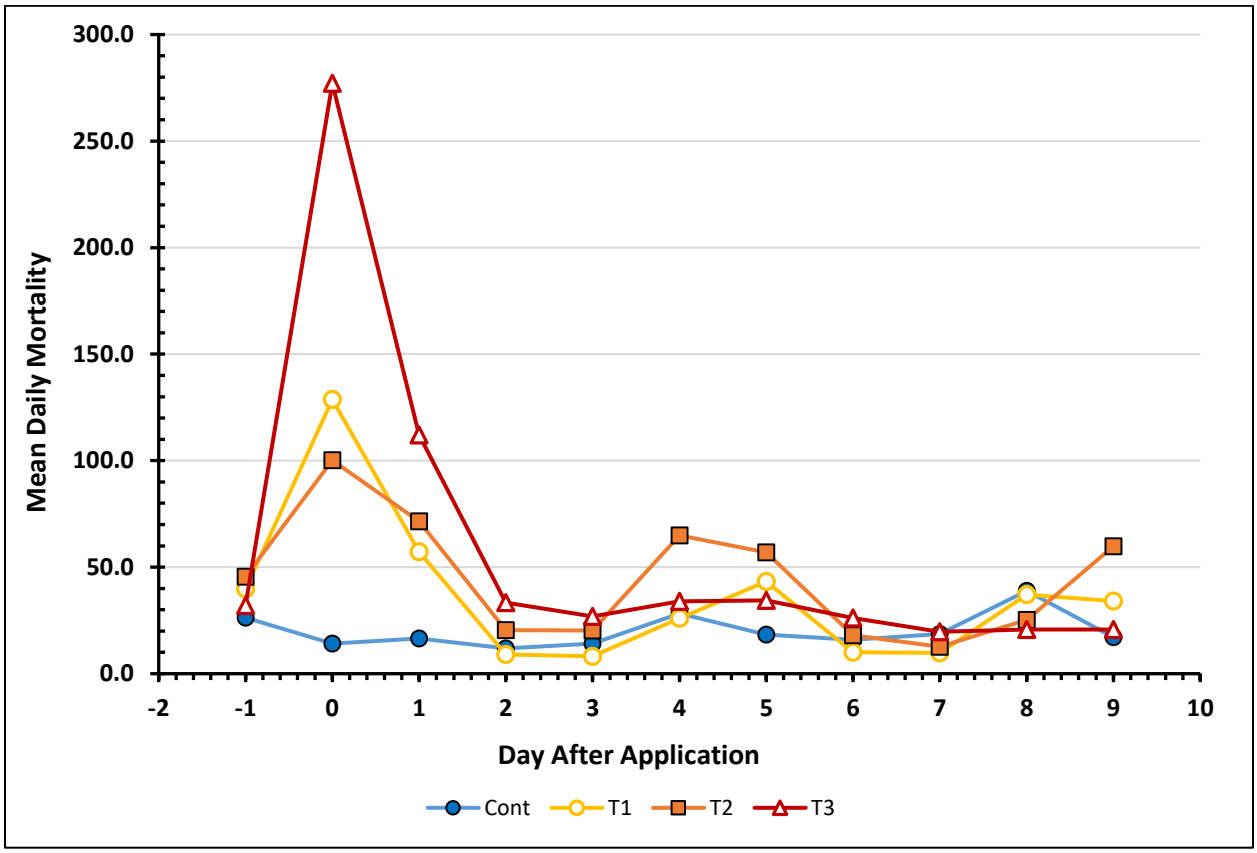


Figure 11-4. Daily mean mortality of forager honey bees vs. day after application for the Kansas tunnel study. T1, T2, T3 = 0.023, 0.071 and 0.09 lb ai/A, respectively (MRID 50604601).

In summary, the combined contact and oral exposures of 7-10 days in both tunnel studies showed acute effects to honey bees including mortality, abnormal behavior and decreased flight intensity. These acute effects were apparent at all application rates with comparable

magnitude of effects but dissipated to levels similar to controls within four days of exposure. Importantly, no treatment-related effects on colony-level endpoints (*e.g.*, hive strength, brood development, food stores, $p < 0.05$) were observed following long-term monitoring in either tunnel study. Treatment-related effects on overwintering success was not indicated up to 0.043 lb a.i./A based on the Germany study and was inconclusive in the US tunnel study due to high colony loss in controls. Therefore, the new tunnel study results confirmed those of the previous tunnel studies that combined contact and oral exposure to sulfoxaflor via applications of 0.023 to 0.09 lb ai/A resulted in short-term (less than 2 weeks) effects on honey bee mortality, flight activity and behavior. Collectively, the new studies further indicate that these short-term effects did not result in long-term impacts on colonies, including colony strength, brood production (0.023-0.09 lb ai/A), and overwintering success (up to 0.043 lb ai/A).

11.4.2 Oral exposure (Colony Feeding Studies)

In a registrant-submitted colony feeding study conducted in the U.S., sulfoxaflor was fed to colonies via 50% sucrose solution at nominal concentrations of 0 (tap water negative control), 0.02, 0.1, 0.2, 0.5, and 1.2 mg ai/kg nectar in a field setting near Belvidere, NC (MRID 50849601). One colony at each treatment concentration was replicated among 12 sites while 2 colonies /site were used for controls (24 control colonies total). The honey bee colonies were dosed for a 42-day exposure period with treated sucrose solutions, renewed twice weekly for that period. Feeding solutions were analytically measured three times during the study (weeks 0, 3, and 5). However, results from these analytical measurements and a subsequent sucrose mixing experiment (MRID 50849501) indicate that the actual concentrations fed to colonies during weeks 3 and 5, were highly variable due to incomplete mixing prior to sampling, particularly at the two highest treatments. Assessments were made to evaluate the overall colony performance at several time points prior to exposure, during exposure, in the fall, and after overwintering.

In a second registrant-submitted colony feeding study conducted in Europe, sulfoxaflor was provided via 50% sucrose solution at nominal concentrations of 0 (tap water negative control), 0.02, 0.10, 0.50, 2.0, and 4.0 mg ai/kg in a field setting to free-foraging honey bees near Pforzheim, Germany (MRID 50444502). Feeding solutions were analytically confirmed once during feeding on day 3 with measured concentrations of 0, 0.0179, 0.0938, 0.471, 1.85, and 3.78 mg ai/kg. The honey bee colonies were exposed for 10 days with treated sucrose solutions, which were renewed daily during the exposure period. Assessments were made of multiple individual and colony level endpoints, including bee mortality, foraging behavior, brood development, colony strength, colony weight, food stores, *Varroa* infestation, and overwintering success

Assessments of colony condition (adult bee, capped brood cells, and pollen estimates), colony weight, colony failure, food consumption, and the presence of *Varroa* mites and *Nosema* spores were performed before, during, and post-exposure. Additionally, storage stability of residue samples, feeding solution verification, and residues analysis in nectar, honey, and pollen was performed.

A summary of the salient features and results of each study is provided in **Table 11-15..** A more detailed review of these studies is provided in **Appendix J** and **Appendix K.**

Table 11-15. Summary of Tier II colony-level feeding studies conducted with sulfoxaflor.

Study Attribute	Results Summary	
	1. Louque (2017) MRID-50849601	**2. Szczesniak (2017)** MRID 50444502
Classification	Supplemental (qualitative)	Supplemental (quantitative)
Test Substance	TGAI (95.6% a.i.)	GF-2626 (12% a.i.)
Timing/Location	2016-17 North Carolina, USA	2016-17, Baden-Wurttenberg, Germany
Exposure period & Concentration	**6 week (42 day) continuous feeding** 0, 0.017, 0.085, 0.17, 0.43, and 1.0 mg ai/kg (Nominal) **Week 0:** <DL, 0.013, 0.073, 0.14, 0.36, 0.90 mg ai/kg (Meas.= 77%-90% nominal) **Week 3:** <DL, 0.019, 0.054, 0.06, 0.018, 0.28 mg ai/kg (Meas. = 4%-110% nominal) **Week 5:** <DL, 0.017, 0.084, 0.15, 0.11, 0.19 mg ai/kg (Meas. = 20%-100% nominal)	**10 days continuous feeding** 0, 0.02, 0.10, 0.50, 2.0, and 4.0 mg ai/kg (Nominal) < DL, 0.018, 0.094, 0.47, 1.85, 3.78 mg ai/kg (Measured) (90%-95% of nominal)
No. Reps. / Treatment	12 (24 control)	5 (+1 for residue)
Feeding Timing	2000 mL sucrose/feeding event, renewed twice weekly	200 mL sucrose/day/colony, renewed daily
Colonies	96 colonies (sister queens) from packages, established 8 weeks before test initiation, 10 combs, all brood stages present, queen right with 6.200-7,800 adults at CCA3	42 colonies (sister queens) with 7670 to 9945 adults, 5-10 brood combs, 3-10 honey combs; established 33 days before test initiation
Sucrose Consumption/ Storage[1]	*13%* ↓ and 37% ↓ in overall consumption during exposure at 0.43 and 1.0 mg ai/kg treatments (S)	55% ↓ in daily mean consumption @ 4 mg ai/kg relative to controls.
Residues in Hive Matrices	Dose-dependent increase in nectar/honey and bee bread during dosing (weeks 3 and 5) and after dosing (week 11). Concentrations in nectar were ~5-10X those in bee bread. By week 11, residues in honey were 30%-50% of those during dosing.	Dose-dependent increase in most hive matrices at 11 days after feeding (DAF)**, steep decline by 19 DAF** (except pupae), concentrations **~ LOQ by 45 DAF**. Peak concentrations in nectar > worker jelly> larvae ~ pupae >> pollen
Residue Spike Recovery	Some spike recovery samples fell below 70% or above 120% of spiked amounts.	90%-101% among various hive matrices & feeding solution
Adult Bee Mortality	Not Assessed	**During Feeding**: **3X ↑ @ 4 mg ai/kg *(S)*** **1 Wk. Post Feeding: 4X ↑ @ 4 mg ai/kg** (122 dead bees/d; *NS*)

Study Attribute	Results Summary	
	1. Louque (2017) MRID-50849601	**2. Szczesniak (2017)** MRID 50444502
		<u>2 Wk. Post Feeding:</u> 12X ↑ @ 4 mg ai/kg (238 dead bees/d; ***S***); **6X ↑@ 2 mg ai/kg** (128 dead bees/d; *NS*) **<u>3-5 Wk. Post Feeding</u>:** Mortality rates were similar among treatments
Larval and Pupal Bee Mortality	Not Assessed	**<u>During Feeding: 7</u>X ↑ @ 4 mg ai/kg *(S)*** **<u>1 Wk. Post Feeding</u>: 40X ↑@ 4 mg ai/kg** (12.7 dead bees/d; ***S***); **22X ↑ @ 2 mg ai/kg** (6.8 dead bees/d; ***S***) **<u>2 Wk. Post Feeding</u>: 275X↑ @ 4 mg ai/kg** (56 dead bees/d; ***S***); **580X ↑ @ 2 mg ai/kg** (157 dead bees/d; ***S***); **13X ↑ @ 0.5 mg ai/kg** (2.6 dead bees/d; *NS*) **3-5 Wk. Post Feeding:** similar low loss rates at all treatments
Forager Behavior	No abnormalities reported	Relatively high number of behavioral abnormalities @ 2 and 4 mg ai/kg (cramping, locomotion problems, and inactive bees). Abnormalities @ 0.02-0.5 mg ai/kg similar to controls
Colony Strength	**1.0 mg ai/kg:** Significant reductions (25%) @ CCA7 only (0.05< p <0.1) **0.017-0.43 mg ai/kg:** similar or higher than controls at all CCAs	**<u>2 & 4 mg ai/kg:</u>** sustained treatment related reductions in # adults @ 9 CCA 5-11 (34-76%; ***S***) **<u>0.02 mg ai/kg:</u>** significant reductions at CCA 6, 9-11 ***(S)***; poor hive strength in one hive prior to exposure; not considered treatment related
Brood Development	**1.0 mg ai/kg:** Significant reductions in pupae @ CCA4 (16%) and CCA6 (29%; 0.05< p <0.1) **0.017-0.43 mg ai/kg:** pupae numbers similar or higher than controls at all CCAs, except for apparent non-treatment related reduction in hives fed 0.017 mg ai/kg at CCA6 (49%) and CCA7 (66%; p<0.05) Eggs and larvae were not assessed	**<u>2 & 4 mg ai/kg:</u>** sustained treatment related reductions in total brood (4 to 8 CCAs; 44%-69%; ***S***); Significant reductions in # eggs, larvae, pupae at multiple CCAs ***(S)*** **<u>4 mg ai/kg</u>** (1st brood cycle): Significant increase in mean brood termination (30%-50%; ***S***); decrease in mean brood index ***(S)***; and decrease in mean brood compensation rate (S) monitored from eggs. Small (<20%) to no increase when monitored from older life stages.
Food Stores	**<u>Pollen (bee bread):</u> 1.0 mg ai/kg:** Significant reductions in (39% & 52%) @ CCA6 & CCA7 (P<0.05) **0.43 mg ai/kg:** 24% reduction at CCA7 (0.05< p <0.1)	**<u>Pollen:</u>** large reduction at multiple CCAs @ 4 mg ai/kg (70%-100%; ***S***) **<u>Honey:</u>** 30%-70% reduction @ 2 and 4 mg ai/kg during CCA 6 - CCA 15 (***S*** @ CCA8).

Study Attribute	Results Summary	
	1. Louque (2017) MRID-50849601	**2. Szczesniak (2017)** MRID 50444502
	0.017-0.17 mg ai/kg: similar or higher than controls **Honey:** not assessed	
Hive Weight	**1.0 mg ai/kg:** Sustained reductions in hive weight (40-50%), statistically significant @ CCA7 **0.017-0.43 mg ai/kg:** weights generally +/- 20% of controls	**2-4 mg ai/kg:** sustained reductions in hive weight (20-25%; ***S***)
Varroa & Nosema	No treatment related effects indicated for mites or *Nosema*; mite loads typically < 3 mites/100 bees	No treatment related effects on *Varroa* infestation indicated; non-standard method of monitoring
Overwintering Success and Condition	**Controls:** 34% overwintering success **0.017-1.0 mg ai/kg:** 25%-75% overwintering success	**4 mg ai/kg:** 60% overwintering success (2/5 colonies collapsed); Reduced honey stores ***(S)***
Overall NOAEC & LOAEC	**0.43 mg ai/kg** **1.0 mg ai/kg**	**NOAEC = 0.47 mg ai/kg** **LOAEC = 1.85 mg ai/kg**
Study Limitations	1. Uncertainty in the delivered exposures to hives at least on weeks 3 and 5 2. Did not monitor all stages of brood (*e.g.,* eggs, larvae) or honey stores 3. High colony loss after overwintering in controls (67%) invalidates overwintering portion of the study. 4. Analytical recovery of residues in hive matrices at various spiked concentrations exceeded generally accepted range of 70%-120%)	1. Relatively low number of replicates (5), resulting in low statistical power 2. All colonies located at a single site (no site-to-site variability) 3. Inconsistent supplemental feeding on 16 DAF 4. Non-random placement of hives 5. Feeding solutions analyzed only once
Reference Toxicant Effects	**None**	**Dimethoate (0.86 mg ai/kg);** - similar brood pattern as controls - no sig diff in # dead bees; -slight transient effects **Fenoxycarb (171 mg ai/kg);** - effect on brood pattern - sustained ↑in # dead bees; -effects on total brood and certain stages

S=significantly different from controls ($p<0.05$), NS= not significantly different from controls ($p>0.05$)

[1] refers to removal of sucrose from the feeder for immediate consumption and processing/storage in the hive.

German Colony Feeding Study: In the 10-d colony feeding study, exposure to 1.85 and 3.78 mg ai/kg treatments resulted in sustained (and statistically significant, $p < 0.05$) impacts on multiple colony-level endpoints including:

- Colony strength (34%-76% reduction)
- Brood strength (44%-69% reduction)
- hive weight (20%-25% reduction)

- Honey stores (30%-70% reduction)

Furthermore, large increases in adult, pupal and larval bee mortality by 2 weeks post feeding for colonies fed 1.85 and 3.78 mg a.i./kg sulfoxaflor. Mortality of adult bees at these concentrations is consistent with effects observed in the acute oral Tier I study with sulfoxaflor (MRID 47832103), with approximately 50% mortality occurring after 48 hours for bees fed 5 mg a.i./kg. In another Tier I study, significant reductions in food consumption were seen for adult bees fed 0.44 mg a.i./kg (the highest test concentration) but no significant effects were observed on survival (MRID 50166901). The mortality experienced by larvae at 1.85 and 3.78 mg ai/kg is also reasonably consistent with reductions in adult emergence and increased mortality when larvae were fed 2.6 ppm sulfoxaflor (MRID 50026402).

Additionally, significant reductions in pollen stores were seen in colonies fed 3.78 mg ai/kg sulfoxaflor relative to controls (70%-100%) and overwintering success was 60% compared to 100% in controls and lower treatments.

Colonies exposed to 0.018-0.47 mg ai/kg showed transient and/or non-significant effects on colony level endpoints relative to controls. Colony strength in hives of the 0.018 mg ai/kg treatment were significantly reduced relative to controls, but this reduction is not considered treatment related due to the lack of a dose response and the influenced of one poor performing hive as indicated by reduced colony strength prior to the initiation of exposure.

The most sensitive endpoints from the colony-level feeding studies are:

NOAEC = 0.47 mg ai/kg sucrose
LOAEC = 1.85 mg ai/kg sucrose

U.S. Colony Feeding Study: In the 42-d colony feeding study conducted in the U.S., sustained colony-level impacts were observed only for hives fed 1.0 mg ai/kg. Significant reductions relative to controls seen in bee bread (pollen) stores, # of pupae, and colony weight. The NOAEC and LOAEC are considered to be 0.43 and 1.0 mg ai/kg respectively. The NOAEC and LOAEC are relatively similar to those identified from the German colony feeding study, despite its exposure duration being 4X longer (42 days vs 10 days). The following impacts on colony-level endpoints are indicated at the highest test concentration (1.0 mg ai/kg-nominal):

- Colony strength (up to 25% reduction)
- # Pupae (up to 29% reduction)
- Hive weight (40-50% reduction)
- Pollen stores (up to 52% reduction)

Only 33% of the honey bee colonies survived overwintering which invalidated the overwintering portion of this study. Furthermore, there is substantial uncertainty in the exposure of colonies at the highest test concentrations (0.43 and 1.0 mg ai/kg). While measured concentrations of sulfoxaflor in sucrose solutions approximated nominal values on week 0, mean measured concentrations were just 4% to 28% of nominal values in these treatments on weeks 3 and 5 (**Appendix K**). A follow up study (MRID 50849501) was conducted to replicate the preparation, mixing and transport of feeding solutions from this CFS. The mixing study demonstrated incomplete mixing of sulfoxaflor in sucrose feeding solutions up to 3 hours after preparation in the highest two test concentrations. It is thought that the heterogeneous distribution of sulfoxaflor was feeding solutions was caused by differing densities of the 50% sucrose and stock solutions. Regardless, these results suggest that honey bee colonies fed the highest test concentrations (which correspond to the NOAEC and LOAEC), experienced highly variable exposures over time. Additional limitations in this study include lack of monitoring of all brood stages and honey stores. Therefore, results from this study are not considered suitable for quantitative use in risk assessment.

11.5 Tier II Risk Characterization (Contact + Oral Exposure)

The characterization of colony-level risk resulting from the combined contact and oral exposure of honey bees to a variety of sulfoxaflor application rates relies primarily on the three newly submitted Tier II tunnel studies described previously (MRID 50494501, 50444501, and 50604601). These studies tested application rates that were most relevant to the proposed uses and included long-term monitoring of hive strength, brood development and overwintering success so that any latent effects on colony-level endpoints would be identified. Furthermore, the exposure of bees within the tunnel is considered a reasonable worst case scenario since applications were made while bees were actively foraging on the treated crop over the duration of the exposure (7-10 days) and bees were forced to forage only on treated crop.

The effects identified in these studies are summarized according to application rate, as shown in **Table 11-16..** In addition, the proposed uses of sulfoxaflor which allow applications during bloom to honey bee-attractive crops are also indicated. Among the available endpoints, the duration of increased forager mortality relative to controls (defined as $\geq$ 2X) appears to scale according to application rate. For example, at application rates from 0.02-0.04 lb a.i./A, forager bee mortality was elevated for 2 days or less, while at rates of 0.07 and 0.09 lb a.i./A, it was elevated for 3 and 8 days after application, respectively. At all tested rates, the short-term effects did not result in long-term effects on colonies, as indicated by colony strength and brood development. At the 0.02-0.04 lb a.i./A, no effects were identified on overwintering, while at higher rates (0.07-0.09), results on overwintering were inconclusive due to high colony loss in control colonies. However, given the relatively short duration of forager mortality and

quantifiable residues of sulfoxaflor in pollen and nectar, the mechanisms for any potential effects on colonies post-overwintering are not evident. Furthermore, colony feeding studies conducted with other nicotinic acetylcholine receptor agonists (*e.g.,* the neonicotinoids, MRID 50312501, 50432101, and 49510001) indicate that effects on overwintering are equivalent or less sensitive than those observed prior to overwintering.

Table 11-16. Risk characterization for combined contact + oral exposure of honey bees to sulfoxaflor applications made during bloom.

Application Rate (lb a.i./A)	Applicable Crops*	Short-term Effects	Long-Term Effects
0.02- 0.04	Corn, Sorghum, Millet, Teosinte, Cacao**	Increased forager mortality for ≤ 2 days Reduced flight intensity for ≤ 9 days	No long-term effects on colony-strength, brood development or overwintering success indicated
0.07	Cotton, Cucurbits, Sweet Potato, Strawberry Attractive Fruiting Veg. Beans (including soybean); Ornamentals	Increased forager mortality for 3 days Reduced flight intensity for 9 days	No long-term effects on colony-strength, brood development, overwintering effects inconclusive
0.09	Alfalfa, Citrus, Pineapple**, Attractive Root/Tubers, Tree Farms	Increased forager mortality for 8 days Reduced flight intensity for 9 days	No long-term effects on colony-strength, brood development, overwintering effects inconclusive
* applicable crops are considered attractive to honey bees for which applications are permitted during bloom ** information on the attractiveness of cocao or pineapple to bees is not available			

11.6 Tier II Risk Characterization (Oral Exposure)

11.6.1 Selection of the Tier II Endpoints

For those uses indicating risk based on the Tier I assessment, a higher tier risk assessment is conducted. The higher tier risk assessment is based on colony-level effects on honey bees combined with estimates of exposure derived from higher tier field residue studies. At the Tier II level, a NOAEC and LOAEC of 0.47 and 1.85 mg ai/kg of sulfoxaflor in sucrose solution was determined from the registrant-submitted colony feeding study (MRID 49501001). The NOAEC and LOAEC of 0.47 and 1.85 mg ai/kg, respectively, are based on reductions in colony-level apical endpoints including numbers of adults and number of pupae that persisted across multiple assessments of the colonies throughout the course of the study.

At this time, the colony feeding study preformed in Europe (MRID 49501001) is considered the most robust Tier II study available from which to characterize the colony-level effects of sulfoxaflor to honey bees. Specifically, this study demonstrates a robust dose-response

relationship between sucrose residues and colony-level apical endpoints, includes an evaluation of over-wintering colony survival, provides raw data that enabled an independent statistical evaluation of the responses, and was conducted according to Good Laboratory Practice specifications. However, this study does have some limitations. Mainly, a 10-day exposure period does not represent the possibility of longer-term exposures that may be associated with multiple applications to longer bloom duration crops (*i.e.* cotton and cucurbit vegetables). The Tier II oral risk assessment for honey bees will be based on a NOAEC of 0.47 mg ai/kg and a LOAEC of 1.85 mg ai/kg determined from the German colony feeding study.

The colony feeding study preformed in the US (MRID 50444502) tested at a similar range of concentrations as the European study (MRID 50849601) and results indicate colony level effects at similar LOAEC and NOAEC concentrations. While this suggests that the colony-level effects from 10-d and 42-d exposures to sulfoxaflor in sucrose solutions are similar, several major uncertainties associated with the US colony feeding study render it as unsuitable for quantitative use in risk assessment. Specifically, there is evidence of highly inconsistent concentrations in sucrose feeding solutions fed to colonies during this study. In addition, some endpoints were not included in the study design, including egg and larval abundance and nectar stores. Therefore, the US colony feeding study is unable to provide conclusive data regarding the effects of 42-d oral exposures on honey bee colonies.

11.6.2 Integration of Pollen and Nectar Exposure

A new method has been developed to integrate exposure from both pollen and nectar for the assessment of risk at the Tier II level for crops where both are considered attractive to honey bees. An integrated method for addressing combined pollen and nectar exposure at the colony level is desirable for two reasons. First, relatively large differences in the concentrations of pesticides (including sulfoxaflor) in pollen and nectar may occur, in some cases up to two orders of magnitude. Second, honey bee colonies collect, process, store and consume nectar differently compared to pollen.

To integrate the differential exposure expected to pollen vs. nectar at the colony level, a method has been developed that considers the amount of each matrix consumed on a daily basis by various bee life stages and castes of bees within the colony. It also considers information on the differential amount of pollen and nectar typically used by honey bee colonies from available data. Summarized below, the “total food” method combines pollen and nectar exposure by differentially weighting residues in each matrix. Specifically, the pollen and nectar residue values from each sampling event are converted to a total nectar equivalent concentration ($C_{total\text{-}t}$; ng a.i./g; Equation 1). $C_{total\text{-}t}$ is the sum of the concentration in nectar (at a given time), *i.e.*, $C_{nectar\text{-}t}$ (ng a.i./g), and the concentration in pollen at the same time divided by a

factor of 20, *i.e.*, $C_{pollen\text{-}t}$ (ng a.i./g)/20. Details on the derivation of the weighting factor for pollen are provided in **Appendix L**.

Equation 1. $$C_{total-t} = C_{nectar-t} + \frac{C_{pollen-t}}{20}$$

11.6.3 Extrapolation of Residues Among Application Rates and Crops

The submitted residue studies for sulfoxaflor reflect a wide variety of application rates, which in turn, affect the magnitude of residues in pollen and nectar. In order to make appropriate comparisons of residue data with the proposed uses of sulfoxaflor, residue values were scaled to the appropriate application rate used in the assessment (*e.g.,* the maximum allowable single application rate). This scaling was conducted by multiplying the residue value by the ratio of the actual to the target application rate. The assumption of proportionality between residue concentration and application rate is consistent with the approach used in human health risk assessment in addition to assessing risks to other non-target taxa.

Since it is not realistically feasible, nor practical, to conduct field residue studies for every crop for which a pesticide is being proposed, residue data are extrapolated to other crops within the same crop group when crop-specific data are lacking. This approach is consistent with that taken by EPA on human health assessments and other recent honey bee risk assessments. When residue data were not available for any crop within the crop group, data from more robust data sets are used for risk determination based largely on agronomic similarities. Specifically, for attractive members of root and tuber vegetables, fruiting vegetables, and legumes, the available residue data for herbaceous plants from other crop groups (small fruits, oilseed, cucurbits, and alfalfa) are considered for risk characterization, after adjusting to the appropriate application rate. These crops were chosen since they are similar in form (*e.g.,* non-woody). For selected orchard crops that lacked residue data, specifically, pineapple, avocado, tree nuts and bee-attractive tree farms, the available residue data from applications to citrus, pome, and stone fruit crops were used for risk characterization. Applications to ornamentals can fall into both of these groups and were assessed in both.

11.6.4 Persistence of Sulfoxaflor in Pollen and Nectar

As part of the Tier II risk characterization, the persistence of sulfoxaflor in pollen and nectar was evaluated to inform the duration that bees may be orally exposed. Specifically, a kinetic analysis of the pollen and nectar residue data was conducted for the purposes of calculating DT_{50} (time to 50% dissipation of residues) and DT_{90} (time to 90% dissipation of residues) values. Estimates of DT_{50} and DT_{90} values were determined within a crop and matrix (*e.g.,* nectar from flowers, nectar from bees, etc.). Where possible, DT_{50} and DT_{90} values were derived separately

for each study trial. With many studies, however, replication of residue samples at a given sampling event was not performed within a study trial. In these cases, residue data were combined among trials for DT_{50} calculation. Prior to consideration in risk characterization, DT_{50} estimates were screened for statistical robustness (*e.g.,* statistical significance and confidence limites around parameter estimates, r^2), as described in **Appendix M**.

Summary statistics for the DT_{50} and DT_{90} values for sulfoxaflor are shown in **Table 11-17.**. A total of 28 reliable DT_{50} and DT_{90} values were calculated among pollen and nectar matrices with 9 different crops. In general, DT_{50} values are similar among nectar and pollen matrices, with average DT_{50} values approximating 1 day and 90th percentiles approximating 2 days. Separate analysis of flower vs. bee-collected samples did not indicate obvious differences in DT_{50} values **(Appendix M)**. The DT_{90} values are typically 3X longer than their corresponding DT_{50} values, but 90% of the DT_{90} values are still approximately 7 days or less. In conclusion, this analysis of the dissipation rates of sulfoxaflor indicates that it displays relatively short persistence in pollen and nectar. Furthermore, based on these DT_{50} values and observations from residue studies that evaluated single vs. multiple applications of sulfoxaflor (*e.g.,* MRID 50355201, 48755606), increased accumulation of sulfoxaflor in pollen and nectar is not expected after successive applications when considering the application intervals on the proposed labels.

Table 11-17. Summary of DT_{50} and DT_{90} values for sulfoxaflor in pollen and nectar

Matrix	Parameter	Mean	Median	90th	Max	# Crops	# Values
Nectar [1]	DT_{50} (days)	1.3	1.1	2.3	3.7	8	16
	DT_{90} (days)	4.2	3.7	7.7	12.2		
Pollen [1]	DT_{50} (days)	0.9	0.6	2.2	2.5	7	12
	DT_{90} (days)	1.3	2.1	7.3	8.2		

[1] includes flower and bee-collected matrices. Source: Appendix M

In addition to plant-derived pollen and nectar, limited data are available for evaluating the persistence of sulfoxaflor in hive matrices (*e.g.,* uncapped nectar, stored pollen, honey, larvae, brood jelly). Since the processing and storage of hive matrices could affect the persistence of sulfoxaflor within the hive, evaluation of these data is instructive for understanding the potential duration of "in-hive" exposure of honey bees. Residue data in hive matrices are available from two colony feeding studies (MRID 49501001; 50444502) and two newly submitted tunnel studies (MRID 5049451; 50444501). Although the hive residue data from these studies are not suitable for DT_{50} calculation due to the limited number and spacing of sampling events, they do provide for a qualitative assessment of sulfoxaflor persistence in colonies.

Based on the European colony feeding study (MRID 49501001), sulfoxaflor residues in hive nectar, pollen, and larvae decline by 50% or greater over a period of 8 days from the cessation of sucrose feeding. Residues in pupae remained stable of this 8-day period. However, by 35

days following dosing, residues in all matrices were 1-15% of those measured immediately after dosing, thus indicating that residues are relatively short lived in honey bee colonies. For the US colony feeding study (MRID 50444502), high variability in the dosing solution renders a qualitative analysis of residue declines uncertain. For the two tunnel studies, hive residues where at or near the level of quantitation (LOQ) in most hive matrices (bee bread, capped nectar) following application to the test crop (MRID 5049451; 50444501). In one case, sulfoxaflor residues in larval bees peaked 1 day after application but declined to at or below the LOQ by day 3 at the lowest application rate (0.023 lb a.i./A), by day 7 at the middle application rate (0.071 lb a.i./A) and by day 10 at the highest application rate (0.09 lb a.i./A). Collectively, these data indicate the persistence of sulfoxaflor in hive matrices of honey bee colonies is relatively short.

11.6.5 Risk Determinations

Finally, risk assessment determinations at the Tier II were made by evaluating multiple lines of evidence. One line of evidence included the magnitude, duration and frequency that residues in pollen and nectar (expressed as total food equivalence) exceeded the CFS colony-level NOAEC and LOAEC. Another line of evidence involved evaluating the extent to which bees would have to forage on the treated field in order for the colony-level NOAEC and LOAEC to be exceeded. Agronomic practices, bloom duration and the spatial 'footprint' of the crop were other factors which were used to characterize risk. Information on the persistence of residues in pollen and nectar was also considered for evaluating the potential for prolonged exposure and accumulation of residues from multiple applications. Finally, since sulfoxaflor has been registered in the U.S. for 2 years and approved for multiple Section 18 Emergency Use Exemptions, ecological incident information was reviewed as an additional line of evidence.

In cases where residues are below the colony-level effects endpoints (i.e., NOAECs and LOAECs), and no other evidence is available to suggest that there are risk concerns, a "low risk" conclusion is made for honey bee colonies. If residue values exceed the colony-level endpoints, then a colony level "risk" conclusion is made.

11.6.6 Cucurbit vegetables (Crop Group 9)

The cucurbit vegetable crop group includes, among other members, melons, squash, and pumpkin. Sulfoxaflor is proposed for use on crop group 9 as a whole. For foliar applications, the single maximum application rate is 0.071 lb a.i./A and allow for four applications per year up to a yearly maximum rate of 0.266 lb a.i./A. According to USDA (2017), melons, squash, and gourds require bee pollination and use managed sources of pollination. The cucurbit vegetables

group includes advisory language[15] on the proposed labels. Residue data from studies on pumpkin were used as a surrogate for the whole cucurbit vegetable crop group. Based on the submitted residue data for pumpkins, a potential for colony-level effects is indicated with the proposed use on cucurbit vegetables. This section describes the lines of evidence associated with the assessment of risks of sulfoxaflor to honey bee colonies from foliar applications to cucurbit vegetable crops. A summary of the lines of evidence is presented in **Table 11-18..**

Table 11-18. Lines of evidence table for cucurbit vegetables.

Residue Exceedance Attribute(1)	**NOAEC**	**LOAEC**
Frequency: Number daily mean residue values > NOAEC & LOAEC	3/32	1/32
Duration: Number of days > NOAEC & LOAEC	3	3
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	4.7X (21%)	1.2X (84%)
Additional Lines of Evidence	**Information**	
Crop Attractiveness (2) & Spatial Scale	Attractive (nectar and pollen); long bloom duration (Indeterminate bloom)	
Managed Pollinators	Required	
DT_{50} / Residue decline	Mean Pollen: 1.0 d; Nectar: 0.9 d	
Ecological Incidents	One incident classified as possible	
Other Considerations	Residue data are well disturbed spatially (3 sites in U.S., 4 sites in EU). However, variability is high among sites (>100X) and the NOAEC is exceeded at only 2/7 sites. This suggests that site-specific differences are an important factor in colony-level risk. Risk determination is not sensitive to reported residues in pumpkin pollen.	
Tier II Risk Conclusion	**Risk**	

(1) Residue data: Pumpkin (MRID 50355202); pumpkin (MRID 50444403); pumpkin (48755601)
(2) Based on USDA 2017

Residue Profile in Pollen and Nectar

Available residue data for foliar applications of sulfoxaflor to cucurbits is shown in **Figure 11-5**. Residue values are normalized to the maximum single application rate proposed for sulfoxaflor for the crop group (0.071 lb a.i./A). Given the relatively short half-life of sulfoxaflor in pollen and nectar (90% of DT_{50} values $\leq$ 2 days), normalizing residues to the last application rate is considered appropriate. A study conducted in Maryland (MRID 48755601) on pumpkins examines a high (0.09 lb a.i./A) and low rate (0.02 lb a.i./A) of application on the residues in

[15] Notifying known beekeepers within 1 mile of the treatment area 48 hours before the product is applied will allow them to take additional steps to protect their bees. Also, limiting application to times when managed bees and native pollinators are least active, e.g., before 7 am or after 7 pm local time or when the temperature is below 55oF at the site of application, will minimize risk to bees.

pollen and nectar. This study had two applications at each rate 7 days apart and collected residue samples between each application. This study design provided information about the possibility of accumulation of residues in nectar and pollen after multiple applications. The magnitude of residues in pumpkin after the first and second application was similar, adding to the confidence that sulfoxaflor does not accumulate in plant tissue with multiple applications.

A study conducted in North Carolina (NC) and California (CA) (MRID 50355202) also tests two applications but at the single maximum application rate of 0.071 lb a.i./A. This study collected all samples after the second application. Residues in nectar and pollen at the NC site declined rapidly after application. In contrast, residues in CA were close to the limit of detection or not detected at any timepoint after application.

Finally, a third residue study (MRID 50444403) was conducted in two sites in Germany and two in France. These studies quantified residues from one application to pumpkin plants in a tunnel, with bees used to collect plant nectar and pollen. All sites applied sulfoxaflor at a lower rate of 0.04 lb a.i./A. One site in Germany and one in France reported residues in nectar that then declined over time, as in the NC site, while the other two sites reported residues that were below levels of quantitation, similar to the CA site. In the European study, sulfoxaflor was detected in pollen from all sites which subsequently declined over time.

For the oral route of exposure, residues in nectar and pollen, expressed as total food, are compared against the Tier II CFS endpoint. (**Figure 11-5**). Mean measured total food residues from foliar applications of sulfoxaflor to pumpkins range from <0.01 to 2.2 mg a.i./kg, with 9% of values above the NOAEC. The maximum magnitude by which the colony-level NOAEC and LOAEC are exceeded are 4.7X and 1.2X, respectively. Given the magnitude of residues, ≥80% of food resource required by a honey bee colony would need to be collected from treated cucurbit vegetable fields before the resulting exposure is sufficient to exceed both colony level endpoints. Furthermore, the colony-level endpoints are exceeded for 3 days based on mean measured total food residue values. Those residue measurements that exceeded the colony level NOAEC and LOAEC were from two sites in the European study that had measurable residue in pumpkin nectar. With high site-to-site variability, it is possible that exceedances could happen under certain scenarios with many being below the level of concern.

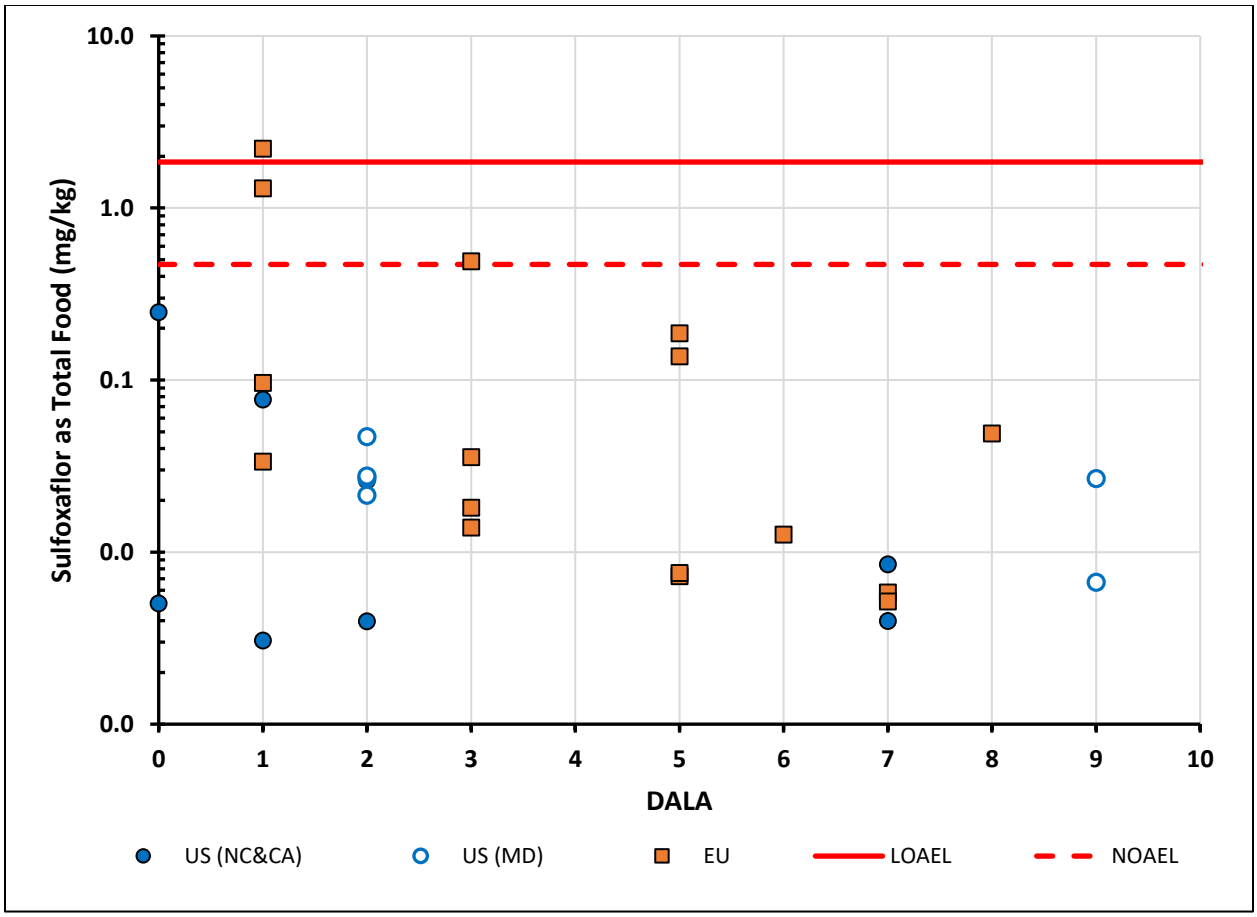


Figure 11-5. Mean daily residues of sulfoxaflor in total food from applications to pumpkin normalized to maximum single application rate (0.071 lb a.i./A).

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), estimates of U.S. bearing acreage of cucurbit vegetable crops include:

- Pumpkins and squash (91,700 acres)
- Watermelon (123,330 acres)
- Cucumber (122,160 acres, fresh and pickles)

Cucurbit vegetable crops are considered attractive to honey bees as a source of nectar and pollen. Available data suggests cucurbits require bee pollination and use managed pollination services (USDA 2017). Members of the cucurbit vegetable crop group are typically associated with a long bloom duration (*e.g.,* 6 weeks or longer) and some varieties exhibit indeterminant blooming. These considerations of crop acreage, bloom duration, and crop attractiveness

suggest that the potential exposure of bees to sulfoxaflor could extend over significant spatial and temporal scales. However, the relatively short persistence of sulfoxaflor in pollen and nectar is expected to reduce the duration of exposure of bees to considerably less than the bloom duration of cucurbit vegetables.

Persistence (DT_{50}/ Residue decline)

A total of 3 DT_{50} values could be reliably determined from two residue studies with pumpkin for estimating the rate of residue declines in pollen and nectar for cucurbit vegetables (**Table 11-19.)**. The DT_{50} values were similar in pollen and nectar (approximately 1 day). The DT_{90} values approximated 3.5 days or less. These DT_{50} values indicate that repeated application of sulfoxaflor would not lead to additional accumulation in pollen and nectar (*e.g.,* no or negligible carry over) with the proposed minimum 7-d retreatment interval.

Table 11-19. DT50 values for sulfoxaflor in cucurbit vegetable matrices by study.

Crop (Region)	DT_{50} Values	DT_{90} Values	MRID
Nectar from Flowers			
Pumpkin (North Carolina)	1.1	3.6	50355202
Nectar from Bees			
Pumpkin (Germany, France)	0.79	2.6	50444403
Pollen from Bees			
Pumpkin (Germany, France)	1.0	3.5	50444403

Source: Appendix M

Other Considerations and Uncertainties

The Tier II risk assessment for cucurbit vegetables assumes that the residue profile in pumpkins is representative of that for other cucurbit vegetable crops. In addition, the proposed labels do not preclude applications to cucurbit vegetables during bloom. Therefore, honey bees could be exposed to sulfoxaflor via oral and direct contact exposure. Risk from contact exposure was described in **Section 11.5**. Additionally, there was an open literature study available for applications of sulfoxaflor to cucumber. Cheng et al. (2018) published a Tier II tunnel study conducted on cucumber in China. Cheng et al. reported similar results in the tunnel study on cucumber as in the previously described tunnel studies submitted by the registrant. Significant increases in mortality was observed immediately after sulfoxaflor application for up to three days with no observed effects to colony health, such as number of adults, number of brood, or food stores. Colonies were observed for 10 days in the tunnel and 14 days after removal from the tunnel. There were several limitations in this study that limited its used in this assessment. First, there was no information on residues in cucumber pollen and nectar. The hives were not

monitored for possible long term effects (over multiple months). Also, the raw data was not available to confirm results, or hive effects. Therefore, the results from this study are used qualitatively in this assessment.

The spatial representation of the residue data is broad (3 sites in the US, 4 sites in Europe), but variability in residues among sites is relatively high soon after application (> 100X). This site-to-site variability suggests the magnitude of sulfoxaflor residues in pollen and nectar are dependent on site or plant-growth characteristics. Since only two out of seven sites had sulfoxaflor concentrations in total food above the colony level NOAEC and LOAEC, site-specific factors appear to affect the risk conclusions. Maximum residues were below the colony level NOAEC 3 days after application suggesting a short window of exposure after pesticide application.

As described earlier and in **Appendix L**, residues in pollen are assumed to represent 1/20th (5%) of the colony-level exposure as compared to nectar. This assumption is based on the different bioenergetics and consumption of pollen and nectar by honey bee colonies and is associated with some uncertainty. With the pumpkin data, residues in pollen were not usually greater than those in nectar. Pollen consumption in the hive can vary over the year and life stage of a bee therefore, increased pollen consumption can have a large effect on exposure to sulfoxaflor. Given that an upper-bound estimate of pollen utilization by hives is 25% that of nectar, the Tier II risk determination for cucurbit vegetables is comparable even with potential variation in pollen exposure of honey bee colonies.

A beekeeper in Dunklin County, MO reported an incident in 2014 where from June through August, crops (including watermelon) were treated with pesticides, including sulfoxaflor as well as others. The beekeeper reported that over 1,000 hives were affected by the pesticide use, which is listed as "incapacitation". There is no information on how many other pesticides may have been used, or data confirming that pesticide exposure actually occurred (*e.g.,* measured residues of pesticides in bees or the hive). Given the limited information associated with this incident report and the apparent application of multiple pesticides, linking these reported effects to sulfoxaflor is not possible.

11.6.7 Citrus Fruits (Crop Group 10)

Sulfoxaflor is being proposed for foliar applications to citrus fruits (Crop Group 10) which includes orange, lemon, grapefruit, lime, tangerine, tangelo, kumquat, citron, mandarin among other crops and hybrids thereof. The proposed application rate is 0.09 lb a.i./A applied up to 3 times per year with a minimum interval of 14 days between. The proposed labels permit only one foliar application from 3 days before bloom through petal fall.

Based on multiple lines of evidence, a potential for colony-level risk to honey bees is indicated with the proposed foliar application of sulfoxaflor to citrus. However, the relatively sparse temporal and spatial representation of the available citrus residue data, including the lack of pollen residue data availability, introduces some uncertainty into this risk conclusion with respect to the magnitude risk among different sites and the duration of risk. A summary of the lines of evidence considered in assessing colony-level risks to honey bees from the propose citrus use is shown in **Table 11-20.**. A discussion of these lines of evidence follows this table.

Table 11-20. Lines of evidence considered in characterizing colony level risks to honey bees from foliar application of sulfoxaflor to citrus fruits.

Residue Exceedance Attribute [(1)]	**NOAEC**	**LOAEC**
Frequency: Number daily mean residue values > NOAEC & LOAEC	4/12	1/12
Duration: Number of days > NOAEC & LOAEC	15	5
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	5.8 (17%)	1.5 (67%)
Additional Lines of Evidence	**Description**	
Crop Attractiveness [(2)] **& Bloom Duration**	Highly attractive (nectar and pollen); long bloom duration (many varieties exhibit indeterminate bloom)	
Managed Pollinators	Generally not required, although commercial beekeepers may use citrus for honey production	
Persistence (DT_{50}/ Residue decline)	Sparse temporal coverage of residue data considered too limited to enable reliable estimates of DT_{50}s. Qualitatively, residues decline relatively rapidly after first measurement.	
Ecological Incidents	None reported, however duration of past use on citrus is relatively limited	
Other Considerations	Four citrus crops are represented by residue data. However, residue data are limited in their temporal and spatial representation. Residues in pollen were not measured and therefore were estimated. Field portion of the citrus study was non-GLP.	
Tier II Risk Conclusion	**Risk**	

[(1)] Residue data: Citrus (MRID 50256403; supplemental)
[(2)] Based on USDA 2017

Residue Profile in Pollen and Nectar

One residue study was submitted that quantified concentrations of sulfoxaflor in 4 citrus fruit crops (lemon, grapefruit, orange and mandarin) grown at two sites in California (MRID 50256403; supplemental). While agronomic practices with mandarin (*i.e.,* tenting during bloom) are expected to prevent oral exposure of bees to sulfoxaflor on the treated field, the mandarin residue data are used here as a surrogate for other citrus crops that are not represented *(e.g.,* tangerines, lime). Residues in nectar of each crop were measured after a single foliar application of 0.036 lb a.i./A made at 3 different times: pre-bloom, during bloom

and post bloom during fall. Nectar samples (hand collected) were taken 2 to 4 times during bloom and consisted of 1-6 replicates each. Residues in pollen were not measured. However, residues of sulfoxaflor measured in pollen from other tree crops (apple, peach) tend to be much higher than those measured in tree crop nectar. Therefore, concentrations in pollen were estimated by multiplying nectar concentration by a factor of 84. This factor was derived from a regression relationship between pollen and nectar residues in other tree crops (**Appendix F)**.

Daily average residues of sulfoxaflor in citrus pollen and nectar (expressed as total food equivalence) from the aforementioned residue study are shown in **Figure 11-6.** These residue data indicate that the colony-level NOAEC of 0.47 mg a.i./kg is exceeded for at least 15 days by a maximum magnitude of 6X. At this maximum residue concentration, a honey bee colony would need to consume at least 17% of their diet from the treated field(s) to achieve an exposure equivalent to the colony-level NOAEC. The colony-level LOAEC of 1.85 mg a.i./kg is exceeded by 1.5X slightly for a period of at least 5 days. Colonies would need to obtain a much larger fraction of their diet from the treated field to receive an exposure equivalent to the LOAEC (67%).

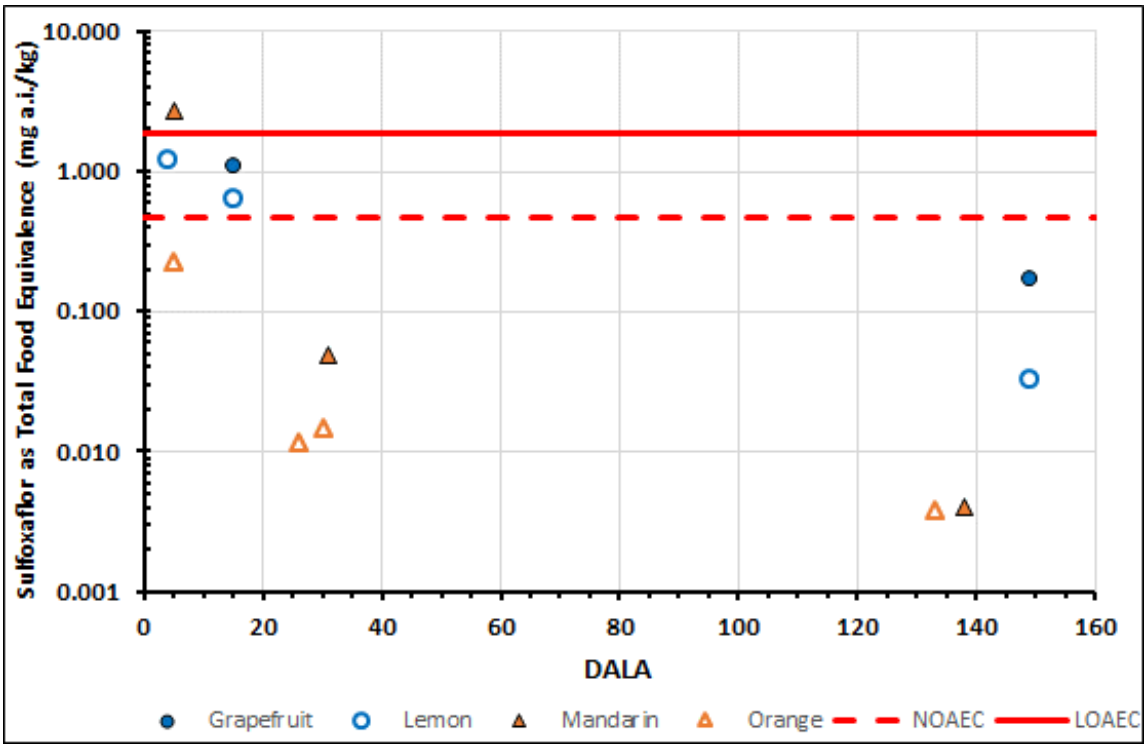


Figure 11-6. Mean daily concentration of sulfoxaflor in citrus (expressed as total food equivalents) normalized to the maximum single application rate of 0.09 lb a.i./A.

Importantly, since the first measurement of sulfoxaflor residues occurred on days 4-5, higher concentrations are expected immediately after application (*i.e.,* days 0-4). Exceedances of the

colony-level NOAEC occur for 3 of the 4 crops represented: mandarin, lemon and grapefruit and with trials conducted at both sites in California. This suggests that the residue profile is not unique to a single crop (or a single site) and is generally representative among citrus fruit crops. It is noted that the residue data for citrus fruits have limitations in their spatial representation (only 2 sites in one state) in addition to the sparse temporal coverage discussed earlier.

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), estimates of U.S. bearing acreage of citrus fruit crops include:

- oranges (613,000 acres),
- lemons/limes (55,000 acres), and
- tangerines, mandarins, clementines (52,100 acres).

Citrus fruit crops are considered highly attractive to honey bees as a source of nectar and pollen. Most citrus fruit crops do not require managed pollination services, although some (*e.g.,* oranges) are known to be used by commercial beekeepers as a valued source of nectar for honey production (USDA 2017). Members of the citrus fruit crop group are typically associated with a long bloom duration (*e.g.,* 6 weeks or longer) and some varieties exhibit indeterminant blooming. Notably, agronomic practices involving mandarin cultivation include tenting during bloom to prevent insect-induced pollination. Therefore, the potential for oral exposure of bees via treated mandarin is considered low.

With the exception of mandarins, these considerations of crop acreage, bloom duration, and crop attractiveness suggest that the potential exposure of bees to sulfoxaflor could extend over significant spatial and temporal scales. However, the relatively short persistence of sulfoxaflor in pollen and nectar is expected to reduce the duration of exposure of bees to considerably less than the bloom duration of citrus fruits.

Persistence (DT_{50}/ Residue decline)

Due to the sparse temporal representation of the residue data for citrus fruits, reliable estimates of the DT_{50} could not be determined. Qualitatively, however, it appears that residue concentrations decline relatively rapidly after their initial measurement.

Other Considerations and Uncertainties

The Tier II risk assessment for citrus fruits assumes that the residue profiles in orange, lemon, grapefruit and mandarin are representative of that for other citrus crops. The proposed level

for citrus fruits permits just one application between 3 days prior to bloom through petal fall (all other applications must be made outside this pre-bloom/bloom period which limits additional exposure and risk). With the possible exception of grapefruit (only 2 residue measurements available), the residue profile for sulfoxaflor on citrus fruits suggests that approximately 3 weeks may be needed between application and bloom to ensure residue values in total food equivalence are below the colony-level NOAEC of 0.47 mg a.i./kg. Limitations in the residue data for citrus fruits that introduce uncertainty into the risk conclusions include:

- estimation of residues in pollen due to lack of pollen data
- limited temporal resolution (long time periods between sampling)
- limited spatial representation (only 2 sites in one region were included).

With respect to pollen, the estimated residues in pollen contribute approximately 80% of the residue values expressed as total food equivalence (nectar + pollen/20). Examination of nectar only residues for citrus fruits (**Figure 11-7**) indicates the colony level NOAEC is exceeded marginally only for mandarin on day 5 after application (0.53 mg a.i./kg nectar). Therefore, much of the NOAEC exceedances for total food equivalence rests on the estimation of pollen residues from nectar, which was derived using a central tendency factor of 84. The ratio of sulfoxaflor residues in citrus pollen to that in nectar was highly variable (25^{th} to 75^{th} percentile = 14 – 157, **Appendix F**).

The temporal resolution of the citrus residue data is limited by relatively large gaps in sampling events (*e.g.,* 3 weeks to several months) for most crops sampled. This introduces uncertainty in the estimated time that residues exceed the colony-level NOAEC and LOAEC. Spatially, these residue data come from two locations in California. Since multiple factors associated with study location may affect the magnitude of residues in pollen and nectar (*e.g.,* weather, soil properties, plant transpiration/growth rates and region-specific agronomic practices), USEPA (2016) recommends a minimum of 3 sites be included in pollen and nectar residue studies which are considered representative of the regions where the crop is grown. Therefore, results from the citrus residue study may underrepresent the variation in pollen and nectar residues associated with these spatially-associated factors.

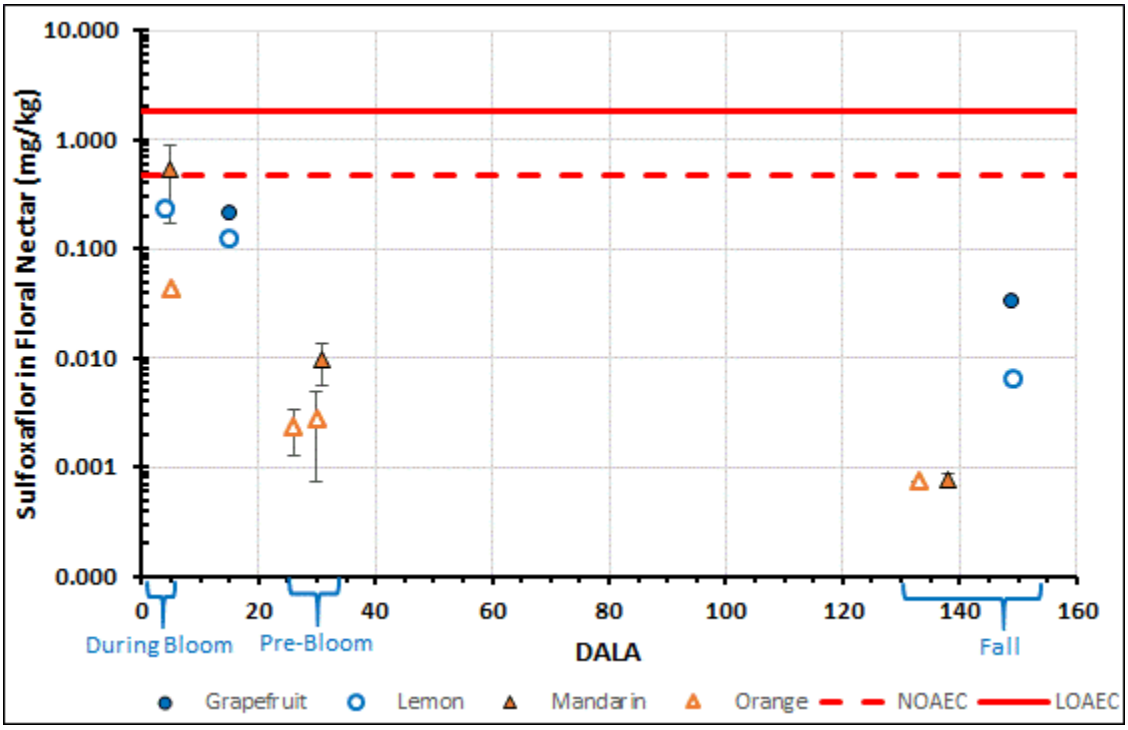


Figure 11-7. Mean daily concentration of sulfoxaflor in citrus nectar normalized to the maximum single application rate of 0.09 lb a.i./A (error bars = 95% confidence limits).

11.6.8 Pome Fruits (Crop Group 11)

Sulfoxaflor is being proposed for foliar applications to apple and pear (pome fruit, crop group 11) of 0.09 lb a.i./A applied up to 3 times per year with a minimum interval of 7 days. The proposed labels do not allow application from 3 days before bloom through petal fall (*i.e.,* no applications during bloom). Based on the submitted residue data for pome fruit in combination with this bloom restriction, a low potential for colony-level effects is indicated with the proposed use on pome fruit. A summary of the lines of evidence considered in assessing colony-level risks to honey bees from the proposed pome fruit use is shown in **Table 11-21.**. A discussion of these lines of evidence follows this table.

Table 11-21. Lines of evidence table for pome fruit crops.

Residue Exceedance Attribute [1]	NOAEC	LOAEC
Frequency: Number daily mean residue values > NOAEC & LOAEC	0/9 *	0/9 *
Duration: Number of days > NOAEC & LOAEC	0 *	0 *
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	0.35X (N.C.) *	0.09X (N.C.) *
Additional Lines of Evidence	**Information**	

Crop Attractiveness [2] & Bloom Duration	Highly attractive (nectar and pollen); blooms from one to several weeks
Managed Pollinators	Required
DT 50 / Residue decline	Rapid decline (mean DT_{50} in nectar and pollen = 0.6 d & 1.0 d, respectively)
Ecological Incidents	None reported
Other Considerations	3-day pre-bloom restriction results in residues that are below the colony-level NOAEC. Collection of single composite samples in sites in two regions may limit incorporation of spatial variability in the residue profile.
Tier II Risk Conclusion	**Low Risk**

[1] Residue data: Apple (MRID 50444405)

*Exceedances are based on residue values $\geq$ 3 Days After Last Application (DALA to reflect proposed application restrictions on the label

[2] Based on USDA 2017;

N.C. = not calculated because > 100% of the treated diet would be needed to reach the NOAEC

Residue Profile in Pollen and Nectar

One residue study was submitted that quantified concentrations of sulfoxaflor in pollen and nectar of apple trees grown in four field trials in Southern Germany and Southern France during 2016 (MRID 50444405). In each trial, a single foliar application of sulfoxaflor (GF-2626) was applied at a nominal rate of 0.043 lb a.i./A to apple trees during bloom. Prior to application, mesh tunnels were arranged around the trees and two honey bee colonies brought into the tunnel for collection of pollen (via pollen traps) and nectar (via honey stomach) for residue analysis. Single composite samples were collected at multiple times after application (1-7 days after application). Additional details on the pome fruit residue study are provided in **Appendix F.**

Daily average residues of sulfoxaflor in apple pollen and nectar (expressed as total food equivalence and normalized to the maximum application rate of 0.09 lb a.i./A) from this residue study are shown in **Figure 11-8**. These data indicate that the colony level NOAEC of 0.47 mg a.i./kg sucrose is exceeded by a maximum of 2X only on day 1 after application. However, the proposed label precludes applications within 3 days of bloom through petal fall and thereby prevents bees from being exposed to these higher residues (as indicated by the shaded box). Sulfoxaflor residues expressed as total food equivalents measured 3 Days After Last Application (DALA) and beyond are all below the colony-level NOAEC by a factor of 3 or greater and below the LOAEC by a factor of 10 or greater. With one exception, average daily residue values among sites are within a factor of 5.

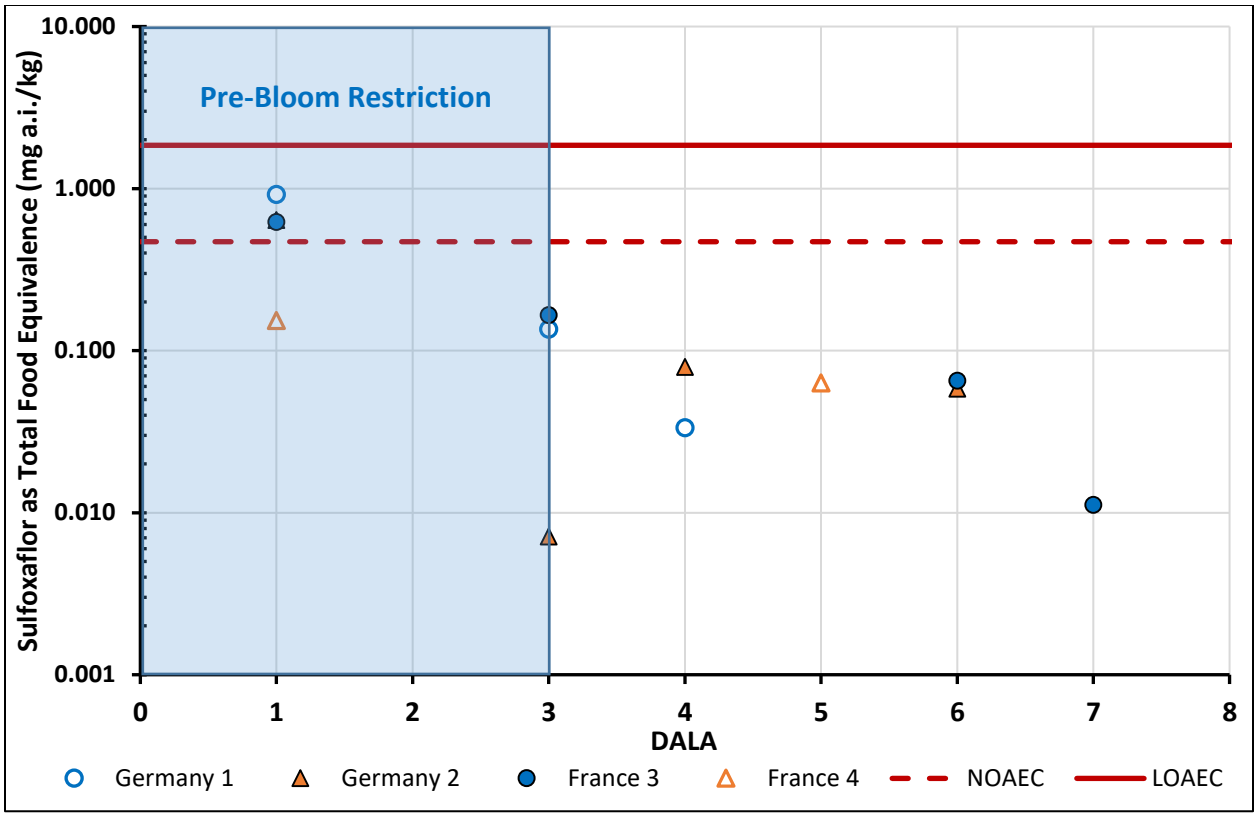


Figure 11-8. Mean daily concentration of sulfoxaflor in apple pollen and nectar (expressed as total food equivalents) normalized to the maximum single application rate of 0.09 lb a.i./A. Shaded box represents the proposed 3-day pre-bloom restriction.

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), approximately 328,000 acres of apples and 54,000 acres of pears were grown in the US. Both apples and pears produce pollen and nectar that is considered attractive or highly attractive to honey bees. Furthermore, both crops require the use of managed pollination services via honey bees. The estimated bloom duration of pome fruit ranges from one to several weeks. These considerations of crop acreage, bloom duration, crop attractiveness and the use of managed pollination services suggest that the potential exposure of bees to sulfoxaflor could extend over significant spatial scales. Importantly, however, the proposed label restrictions on pre-bloom and at-bloom applications are expected to reduce the magnitude of exposure to levels well below those that would lead to colony-level effects.

Persistence / DT_{50}

As seen in other crops, sulfoxaflor residues in apple pollen and nectar show a relatively rapid decline over time (mean DT_{50} in bee-collected nectar and pollen = 1.1 and 0.6, respectively; **Appendix M**). These DT_{50} values indicate that repeated application of sulfoxaflor would not lead to additional accumulation in pollen and nectar (*e.g.,* no or negligible carry over). Therefore, results from the submitted apple residue study (which involved a single application) are considered representative of the proposed use pattern which allows for multiple pre-bloom and post-bloom applications.

Other Considerations and Uncertainties

The Tier II risk assessment for pome fruit assumes that the residue profile in apples is representative of that for other pome fruits. The submitted residue data used to support the Tier II pome fruit assessment reflects 4 residue trials conducted in 2016 across 2 regions/sites of Europe with 3 varieties of apples. According to USEPA 2016b (which was being drafted at the time of this study), at least 3 different sites arrayed across different regions of the growing area are considered desirable for pollen and nectar residue studies. Therefore, the submitted residue study for apples can be considered to have 1 fewer site/region than ideally desired. In addition, residue data reflect a single composite sample while USEPA (2016) recommends a minimum of 3 sample replicates be included. While the submitted residue study may somewhat underrepresent the desired number of sites, the preclusion of sulfoxaflor application 3 days prior to bloom and through petal fall appears to reduce sulfoxaflor residues by an order of magnitude and reduces exposure of bees to below the colony-level NOAEC and LOAEC.

Another consideration in the pome fruit Tier II risk characterization is the extent to which pollen residues influence the risk determination. As described earlier and in **Section 11.6.1** and in **Appendix L**, residues in pollen are assumed to represent $1/20^{th}$ (5%) of the colony-level exposure represented by nectar. This assumption is based on the different bioenergetics and consumption of pollen and nectar by honey bee colonies and is associated with some uncertainty. To evaluate the sensitivity of the risk estimation to this assumption, the contribution of pollen relative to nectar required to exceed the NOAEC were calculated using the apple residue data (DALA 3 and later). This sensitivity analysis indicates that pollen residues would have to contribute from 1/3 to more than 40X that of nectar in order for the colony-level NOAEC of 0.47 mg a.i./kg to be exceeded. Given that an upper bound estimate of pollen utilization by hives is ¼ that of nectar, the Tier II risk determination for pome fruit does not appear sensitive to potential variation in pollen exposure of honey bee colonies.

11.6.9 Stone Fruits (Crop Group 12)

Sulfoxaflor is being proposed for foliar applications to stone fruit, including peach, plum, cherry, prune, apricot and nectarine of 0.09 lb a.i./A applied up to 3 times per year with a minimum interval of 7 days. The proposed labels do not allow application from 3 days before bloom through petal fall (*i.e.,* no applications during bloom). Based on the submitted residue data for stone fruit in combination with this 3-day bloom restriction, a potential for colony-level effects is indicated with the proposed use on stone fruit. A summary of the lines of evidence considered in assessing colony-level risks to honey bees from the propose stone fruit use is shown in **Table 11-22.** A discussion of these lines of evidence follows this table.

Table 11-22. Lines of evidence table for stone fruit crops.

Residue Exceedance Attribute [(1)]	**NOAEC**	**LOAEC**
Frequency: Number daily mean residue values > NOAEC & LOAEC	4/9*	2/9*
Duration: Number of days > NOAEC & LOAEC	4*	1*
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	4.9X (20%)*	1.3X (80%)*
Additional Lines of Evidence	**Information**	
Crop Attractiveness [(2)] & Bloom Duration	Attractive to highly attractive (pollen & nectar); bloom duration approximately 1-3 weeks	
Managed Pollinators	Required	
DT 50 / Residue decline	Mean DT_{50} = 1.6 days (pollen) and 2.5 days (nectar)	
Ecological Incidents	None reported	
Other Considerations	Residue data are from a single site; may under-estimate spatial variability in the residue profile	
Tier II Risk Conclusion	**Risk**	

[(1)] Residue data: Peach (MRID 50355203)
*Exceedances are based on residue values $\geq$ 3 DALA to reflect proposed application restrictions on the label
[(2)] Based on USDA 2017

Residue Profile in Pollen and Nectar

One residue study was submitted that quantified sulfoxaflor residues in pollen and nectar of peach trees (*Prunus persica*) grown in Hart, Michigan (MRID 50355203). One field trial was conducted involving 5 plots (~80 mature peach trees/plot) that received one foliar application of Closer® SC (GF-2032) at a nominal rate of 0.09 lb ai/A. The plots differed in their growth stage at application, ranging from pre-bloom through mid-bloom: BBCH 09 in plot 1; BBCH 54 in plot 2; BBCH[16] 61 in plot 3; BBCH 62 on plot 4; and BBCH 65 in plot 5. Single composite samples

[16] BBCH (**B**iologische **B**undesanstalt, Bundessortenamt und **CH**emische Industrie) is a commonly used phenological scale of plant growth and developmental stages.

of whole flower, nectar, and pollen were collected directly from plants between 0 and 10 days after application (DAA) to quantify sulfoxaflor decline in each matrix in each plot. Additional details on the stone fruit residue study are provided in **Appendix F.**

Daily residues of sulfoxaflor in peach pollen and nectar (expressed as total food equivalence) from this residue study are shown in **Figure 11-9**. These data indicate that the colony level NOAEC of 0.47 mg a.i./kg sucrose is exceeded by a maximum of 30X on the day of application (day 0). This day 0 residue value in total food equivalence is driven mostly by an exceptionally high value measured for pollen (269 mg ai/kg). However, the proposed label precludes applications within 3 days of bloom through petal fall and thereby prevents bees from being exposed to these higher residues (as indicated by the shaded box). Sulfoxaflor residues expressed as total food equivalents measured 3 DALA and beyond still exceed the colony-level NOAEC and LOAEC by up to a factor of 4.9X and 1.3X, respectively. These maximum values were measured on day 4 after application. Residues of sulfoxaflor exceed the colony-level NOAEC and LOAEC at 7 and 4 days after application. These data suggest the 3-day pre-bloom restriction does not reduce residues in total food equivalence to levels below the colony-level NOAEC.

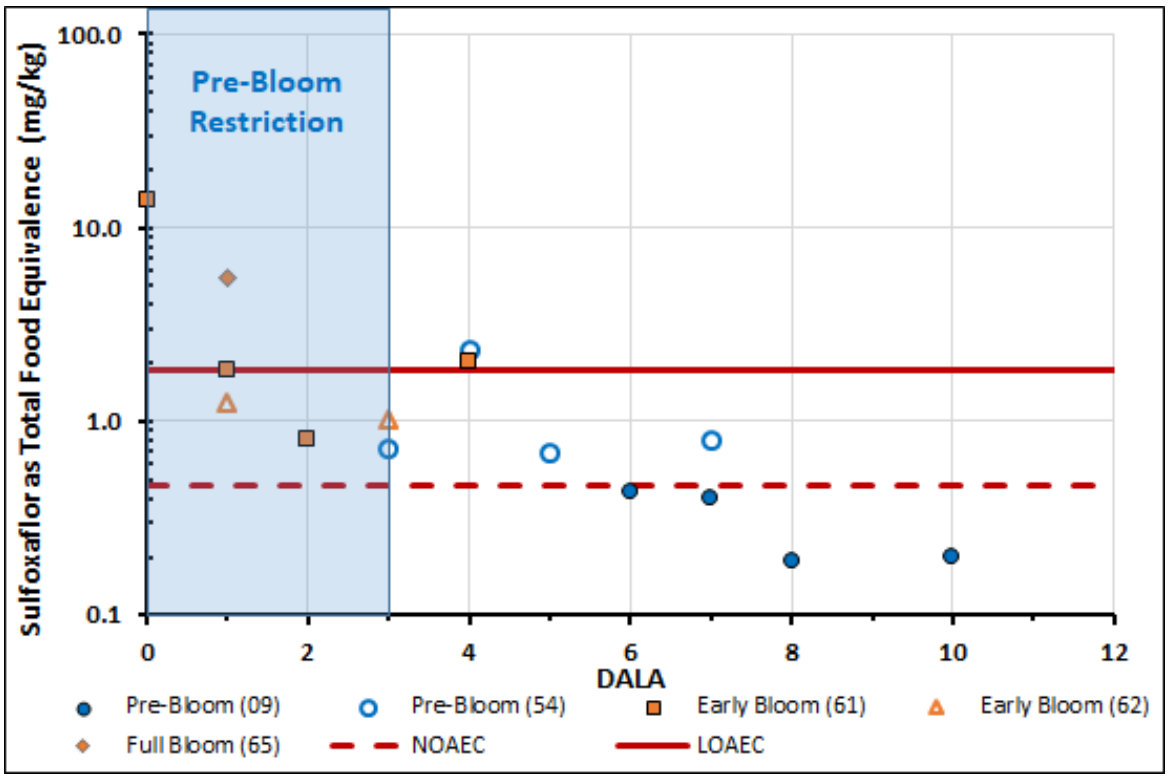


Figure 11-9. Mean daily concentration of sulfoxaflor in peach pollen and nectar (expressed as total food equivalents) normalized to the maximum single application rate of 0.09 lb a.i./A. Shaded box represents the proposed 3-day pre-bloom restriction.

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), the estimated U.S. bearing acreage of stone fruit include:

- peaches (112,880)
- cherry (86,790)
- plum (82,780)
- nectarine (26,400
- apricot (12,150).

Stone fruit produce pollen and nectar that is considered attractive or highly attractive to honey bees. Furthermore, stone fruit crops require the use of managed pollination services via honey bees. The estimated bloom duration of stone fruit ranges from 1-3 weeks. These considerations of crop acreage, bloom duration, crop attractiveness and the use of managed pollination services suggest that the potential exposure of bees to sulfoxaflor could extend over significant spatial scales. Although, the proposed label restrictions on pre-bloom and at-bloom

applications are expected to reduce the magnitude of sulfoxaflor residues, exceedance of the colony level NOAEC is still indicated 7 days after application.

Persistence / DT_{50}

A total of 4 DT_{50} values could be reliably determined from one residue study with peach for estimating the rate of residue decline in stone fruit pollen and nectar (**Appendix M**). As seen in other crops, sulfoxaflor residues in peach pollen and nectar show a relatively rapid decline over time. For nectar sampled from flowers, a DT_{50} of 1.3 days was determined with applications during bloom and a DT_{50} of 3.7 days was determined with applications made prior to bloom. Similar DT_{50} values are seen with pollen (0.6 and 2.5 days from applications made during and prior to bloom, respectively. The basis for the somewhat longer DT_{50} values associated with pre-bloom applications is not known, although the difference in the pre-bloom and during-bloom DT_{50} values is with the range of uncertainty of the DT_{50} estimates. -Given the proposed bloom restriction, these relatively short DT_{50} values indicate that repeated application of sulfoxaflor prior to bloom would be unlikely to result in accumulation in pollen and nectar (*e.g.,* no or negligible carry over). Therefore, results from the submitted peach residue study (which involved a single application) are considered representative of the proposed use pattern which allows for multiple pre-bloom and post-bloom applications.

Other Considerations

The Tier II risk assessment for stone fruits assumes that the residue profile in peach is representative of that for other stone fruits. The submitted residue data to support the proposed stone fruit use reflects 5 residue trials conducted at one site in 2016 with 1 variety of peach. According to USEPA 2016b (which was being drafted at the time of this study), at least 3 different sites arrayed across the growing area are considered desirable for pollen and nectar residue studies. Therefore, the submitted residue study for peaches does not capture the range of geographical variability where sulfoxaflor applications may be made to stone fruit. Therefore, the submitted residue study on peach may underrepresent variation in sulfoxaflor residues in pollen and nectar expected among sites and samples. The preclusion of sulfoxaflor application 3 days prior to bloom and through petal fall appears to reduce residue values relative to applications during bloom and will limit exposure on the treated field via direct contact. However, this pre-bloom restriction is not sufficient to reduce residue levels to below the colony-level NOAEC. A pre-bloom exclusion of at least 7 days would be needed to reduce residues to levels below the colony-level NOAEC.

Another consideration in the stone fruit Tier II risk characterization is the extent to which pollen residues influence the risk determination. As described earlier and in **Section 11.6.1 and in Appendix L**, residues in pollen are assumed to represent $1/20^{th}$ (5%) of the colony-level exposure represented by nectar. This assumption is based on the different bioenergetics and

consumption of pollen and nectar by honey bee colonies and is associated with some uncertainty. With the peach residue data, pollen residues constituted a majority of the estimated total food residues, even though they are divided by a factor of 20. This finding reflects the high residues of sulfoxaflor measured in pollen relative to nectar in this study. To evaluate the sensitivity of the risk estimation to this assumption, the contribution of pollen relative to nectar required to exceed the NOAEC were calculated using the peach residue data (3 DALA and later). This sensitivity analysis indicates that pollen residues would have to contribute less than 1/30th to 1/300th of that for nectar in the majority of cases in order to reduce exposure to at or below the colony-level NOAEC of 0.47 mg a.i./kg. Therefore, even if pollen were to contribute a very small fraction to the total food exposure of honey bees, a potential colony-level risk would be indicated.

11.6.10 Small Fruits and Berries, Grape, and Strawberry (Crop Group 13)

The berries crop group includes, among other members, blackberry, blueberry, and raspberry. This crop group also includes group 13-07 (small fruit and berries group), which itself encompasses 8 subgroups that contain other crops such as blueberry, cranberry, and grape. Sulfoxaflor is proposed for use on crop group 13-07 (except strawberries), as well as grape and strawberry separately. For foliar applications, single maximum application rate is 0.071 lb a.i./A for strawberry and 0.090 lb a.i./A for the other berries. All proposed uses on berries allow for three to four applications per year. For foliar applications to the small fruit group as a whole, the proposed label language does not allow application from three days prior to bloom until petal fall. Strawberries do not have label language restricting applications near or during bloom. Residue data from studies on strawberry were used as a surrogate for the whole small fruits crop group. The small fruits crop group has a wide range of plants and using strawberry as the representative for the whole group is uncertain. Based on the submitted residue data for strawberry a potential for colony-level effects is indicated with the proposed use on small fruits and strawberry.

This section describes the lines of evidence associated with the assessment of risks of sulfoxaflor to honey bee colonies from foliar applications to berry and small fruit crops as summarized in **Table 11-23.**

Table 11-23. Lines of evidence for berries and small fruit and strawberry.

Line of evidence	Small fruit and berry		Strawberry		Grape	
Residue Exceedance Attribute [(1)]	**NOAEC**	**LOAEC**	**NOAEC**	**LOAEC**	**NOAEC**	**LOAEC**
Frequency: Number daily mean residue values > NOAEC & LOAEC	2/26*	1/26*	13/26	8/26	1/26*	0/26*
Duration: Number of days > NOAEC & LOAEC	3*	2*	5	5	3*	0*

Line of evidence	Small fruit and berry		Strawberry		Grape	
Residue Exceedance Attribute [1]	**NOAEC**	**LOAEC**	**NOAEC**	**LOAEC**	**NOAEC**	**LOAEC**
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	8.8X* (11%)	2.2X* (45%)	49X (2%)	12X (8%)	1.1X* (88%)	NC
Additional Lines of Evidence	**Information**					
Crop Attractiveness [2] **& Spatial Scale**	Highly attractive (nectar and pollen); variable timing for bloom, some indeterminate					
Managed Pollinators	Required for some					
DT_{50} / Residue decline	0.5-2.6 d (nectar); 0.5-1.0 d (pollen)					
Ecological Incidents	None					
Other Considerations	Residues (total food) exceed the NOAEC for 5 of 6 sites for strawberry (no bloom restrictions) and 2 of 6 sites for berries/small fruit (with bloom restrictions). Residues in nectar only exceed colony-level NOAEC at multiple sites.					
Tier II Risk Conclusion	**Risk**					

[1] Residue data: strawberry (MRID 50444404); strawberry (MRID 50444402)

[2] Based on USDA 2017;

*Exceedances are based on residue values $\geq$ 3 DALA to reflect proposed application restrictions on the label

Grape is pollen only

NC is not calculated because > 100% of the treated diet would be needed to reach the LOAEC

Residue Profile in Pollen and Nectar

Available residue data for foliar applications of sulfoxaflor to the berry group are shown in Figure 11-14. Mean daily residues of sulfoxaflor in total food from applications to alfalfa corrected to maximum single application rate (0.090 lb a.i./A).**Figure 11-10**. Residue values are normalized to the maximum single application registered for sulfoxaflor across the low growing berry subgroup (*i.e.,* 0.09 lb a.i./A). The first study preformed in the US contained one site in Florida and one site in California (MRID 50444402). This study had two applications of 0.071 lb a.i./A with residue sampling of nectar and pollen from flowers after the second application. Residues in nectar and pollen were highest immediately after application and decreased with time to below the detection limit. In a second study (MRID 50444404), strawberries grown at two sites in Germany and two in France were sprayed with one application of sulfoxaflor at 0.021 lb a.i./A inside a tunnel setup. Bumble bees were used to collect the nectar and pollen samples after application for residue analysis. Residues, again, were highest immediately after application and declined with time until below the limit of detection.

As discussed previously Tier II tunnel studies showed immediate mortality effects at every application rate tested with effects diminishing within 1-3 days. Therefore, label language restricting application during bloom for berries (except strawberry) will mitigate effects from contact exposure on the treated field.

For an oral route of exposure, residues in nectar and pollen (expressed as total food) are compared against Tier II CFS endpoints (**Figure 11-10**). Without consideration of the 3-day pre-bloom restriction, mean measured residues as total food equivalence from foliar applications of sulfoxaflor to berry and small fruit crops range from 0.015 to 23 mg a.i./kg, with 50% of values above the NOAEC. However, when considering that applications are precluded within 3 days prior to and during bloom, mean measured residues of sulfoxaflor expressed as total food equivalents range from 0.015 to 4.4 mg a.i./kg, with the maximum value exceeding the colony-level NOAEC and LOAEC by 8.8X and 2.2X, respectively. At this maximum residue level, the colony level NOAEC would be exceeded if 11% of the diet came from the treated berry field. Furthermore, the colony-level endpoints are exceeded for 3 days beyond the 3-d pre-bloom restriction based on mean measured total food residue values.

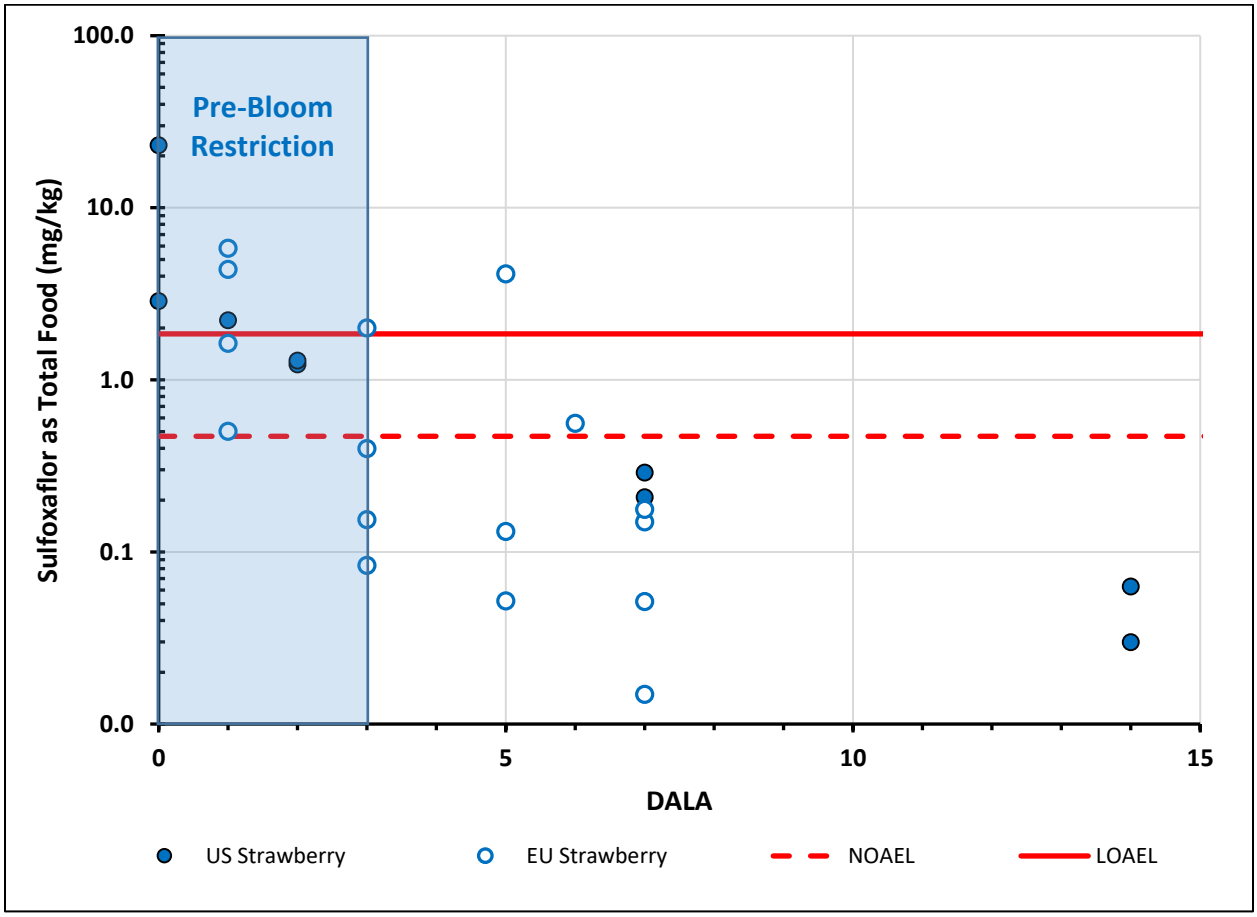


Figure 11-10. Mean daily residues of sulfoxaflor in total food from applications to strawberry normalized to maximum single application rate for small fruits and berries (0.090 lb a.i./A) with a 3-day pre-bloom application interval.

Measured residues from all sites exceed colony NOAEC after application to strawberries. Based on the measured residue data for berries, a 3-day pre-bloom interval can reduce exposure but not exclude the potential for colony-level risk for honey bees foraging on treated small fruit/berry fields.

Grapes are also in the berries and small fruits group; however, they only produce pollen. Shown below in **Figure 11-11** are the pollen residue values converted to nectar equivalence (pollen concentration /20; **Appendix L**) from applications to strawberries. With the previously described 3-day pre-bloom restriction, there is one value above the colony level NOAEC and none are above the LOAEC for pollen.

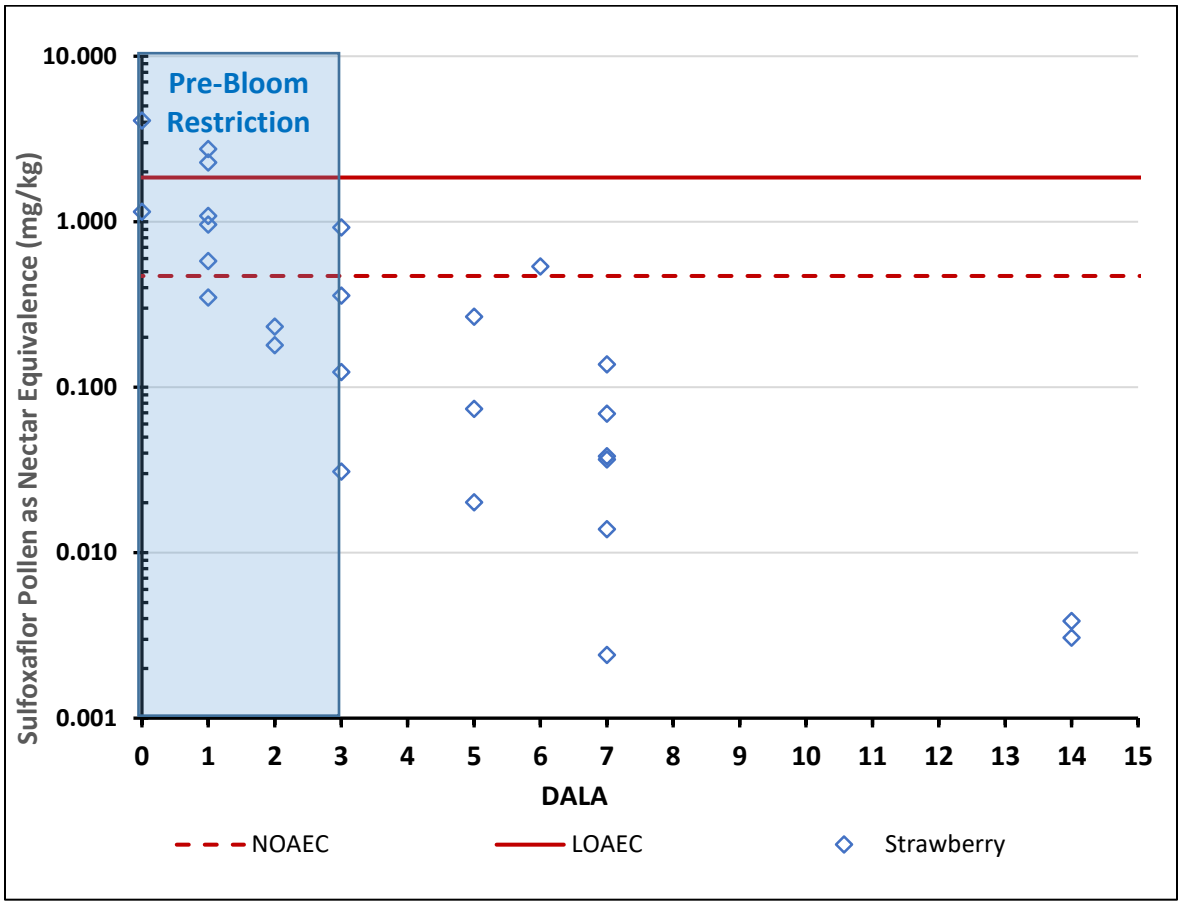


Figure 11-11. Mean daily residues of sulfoxaflor in pollen (expressed as nectar equivalence) from applications to strawberry corrected to maximum single application rate for grape (0.090 lb a.i./A) with a 3-day pre-bloom application interval.

Available residue data for foliar applications of sulfoxaflor to strawberries are again shown in Figure 11-14. Mean daily residues of sulfoxaflor in total food from applications to alfalfa corrected to maximum single application rate (0.090 lb a.i./A).**Figure 11-12**. This data differs

than that of other small fruits because residue values are normalized to the maximum single application rate specific to strawberries of 0.071 lb a.i./A. Furthermore, there is no pre-bloom or during bloom application restriction for strawberries. Despite the lower application rate of strawberries (0.071 lb a.i./A) relative to other berries/small fruit (0.09 lb a.i./A), risk conclusions do not differ appreciably among the crops.

Mean measured total food residues from foliar applications of sulfoxaflor to strawberries range from 0.018 to 18 mg a.i./kg, with 42% of values above the NOAEC. The maximum magnitude by which the colony-level NOAEC and LOAEC are by mean measured residue values are 39X and 10X, respectively. The colony-level endpoints are exceeded for 5 days based on mean measured total food residue values for 5 of the 6 sites included in the residue studies. Five out of six sites tested had measured residue concentrations above the colony NOAEC after application (**Appendix F**). Without a pre-bloom interval and restriction of applications during bloom, there is a potential for colony-level risk to honey bees from exposure to sulfoxaflor on strawberries.

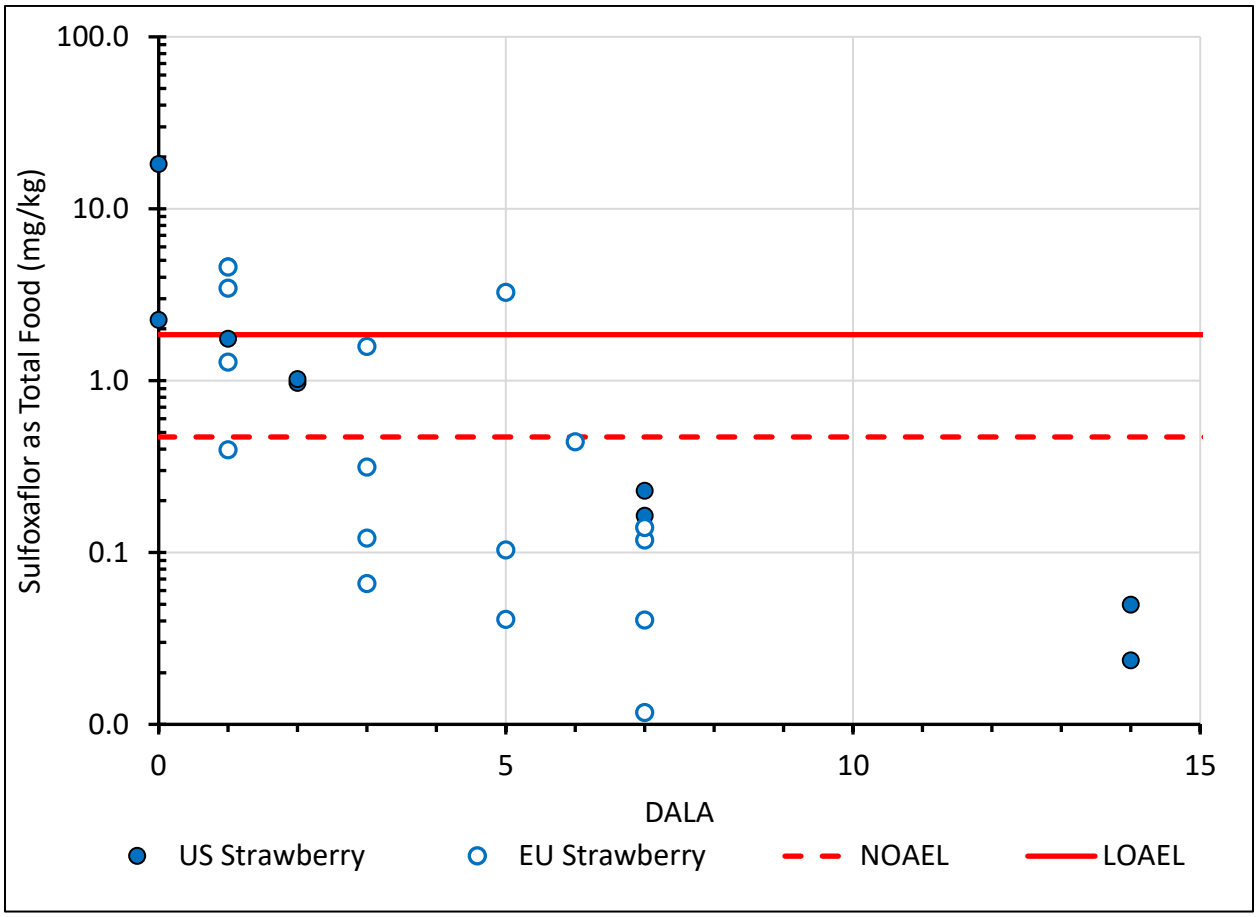


Figure 11-12. Mean daily residues of sulfoxaflor in total food from applications to strawberry corrected to maximum single application rate (0.071 lb a.i./A).

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), estimates of U.S. bearing acreage of small fruit and berries crops include:

- Blueberries (77,700 acres)
- Cranberry (40,300 acres)
- Grapes (40,300 acres)
- Raspberry (17,300 acres)
- Strawberry (58,190 acres)

Small fruit crops are considered attractive to honey bees as a source of nectar and pollen. While grapes do not produce nectar, their pollen is noted to be attractive to honey bees. According to USDA (2017), blueberries, cranberries and raspberries require bee pollination and use managed sources of pollination. Although, bee pollination of strawberry is not considered essential, it may be used to compliment wind pollination. Similarly, grapes are wind pollinated and therefore do not require honey bee pollination. Members of the berry crop group are typically associated with a long bloom duration (*e.g.,* 6 weeks or longer) and various species bloom at different times throughout the year.

Persistence (DT_{50}/ Residue decline)

A total of 5 DT_{50} values were calculated for pollen and nectar matrices from two studies of sulfoxaflor applications to strawberry (**Table 11-24.)**. Among both matrices, DT_{50} values varied from 0.5 to 2.6 days, indicating relatively rapid decline of sulfoxaflor in bee-relevant matrices. These DT_{50} values indicate that repeated application of sulfoxaflor would not lead to additional accumulation in pollen and nectar (*e.g.,* no or negligible carry over) with the proposed minimum 7-d retreatment interval.

Table 11-24. DT_{50} and DT_{90} values for sulfoxaflor in strawberry matrices by study region.

Crop (Region)	DT_{50} Values	DT_{90} Values	MRID
Nectar from Flowers			
Strawberry (Florida) (California)	 2.6 0.5	 8.6 1.7	50444402
Pollen from Flowers			
Strawberry (Florida) (California)	 0.88 0.51	 2.9 1.7	50444402

Crop (Region)	DT_{50} Values	DT_{90} Values	MRID
Pollen from Bees			
Strawberry (France, Germany)	1.0	3.4	50444404

Source: Appendix M

Other Considerations

The Tier II risk assessment for berries and small fruits assumes that the residue profile in strawberry is representative of that for other berries and small fruits. As discussed previously, this assumption introduces uncertainty given the diverse physiology of members of this crop group and their associated agronomic practices. However, the relatively short persistence of sulfoxaflor in pollen and nectar is expected to reduce the duration of exposure of bees to less than the bloom duration of small fruits and berries. Furthermore, while the residue data are limited to one crop within this crop group, they represent applications to 6 different sites which strengthens the geographic representation of the residue data and risk conclusions. The restriction of application during bloom for other small fruits and berries is expected to reduce the exposure duration further.

As described earlier and in **Appendix L**, residues in pollen are assumed to represent 1/20th (5%) of the colony-level exposure as compared to nectar. This assumption is based on the different bioenergetics and consumption of pollen and nectar by honey bee colonies and is associated with some uncertainty. With the strawberry data, residues in pollen were 10x higher than in nectar. Pollen consumption in the hive can vary over the year and life stage of a bee therefore, variation in pollen consumption can have affect exposure of a honey bee colony to sulfoxaflor. However, even based on residues in nectar alone from the US and European studies, the colony-level NOAEC and LOAEC would be exceeded for up to 5 days for the proposed uses on strawberry. Therefore, even though there is uncertainty associated with converting residues in pollen to nectar equivalence to estimate total food exposure, these data indicate the Tier II risk conclusions are not sensitive to this uncertainty.

11.6.11 Cereal Grains (Crop Group 15)

For cereal grain crops, sulfoxaflor is proposed at a maximum application rate of 0.047 lb a.i./A and a minimum interval of 14 days. According to USDA (2017), corn, sorghum, millet, and teosinte are the only members of the proposed cereal grain crops that are attractive to honey bees for pollen only. These crops are mostly wind pollinated but bees can visit during pollen shedding depending on the availability of alternate forage resources. Residue data from a study on buckwheat was used as a surrogate for the pollen attractive cereal grain group. Based on the submitted residue data for buckwheat pollen, no residues exceeded the colony-level

effects endpoints for honey bees. A summary of the lines of evidence considered in assessing colony-level risks to honey bees from the proposed use is shown in **Table 11-25.**Table 11-20.. A discussion of these lines of evidence follows this table.

Table 11-25. Lines of Evidence table for attractive cereal grains.

Residue Exceedance Attribute [1]	**NOAEC**	**LOAEC**
Frequency: Number daily mean residue values > NOAEC & LOAEC	0/15	0/15
Duration: Number of days > NOAEC & LOAEC	NA	NA
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	NC	NC
Additional Lines of Evidence	**Information**	
Crop Attractiveness [2] **& Bloom Duration**	Attractive to honey bees (pollen only)	
Managed Pollinators	Not used	
DT_{50} / Residue decline	Mean DT_{50}: 1.2 d (bee nectar)); 2.7 d (trapped pollen)	
Ecological Incidents	None	
Other Considerations	Crop mostly wind pollinated but honey bees may collect pollen depending on availability of other forage resources. Residue data reflect a single site which may underestimate regional differences in residues.	
Tier II Risk Conclusion	**Low Risk**	

[1] Residue data: buckwheat (MRID 50604601);
[2] Based on USDA 2017

Residue Profile in Pollen and Nectar

Available residue data for foliar applications of sulfoxaflor to corn, sorghum, millet, and teosinte is represented by applications to buckwheat and shown in **Figure 11-13.** The residue study on buckwheat (MRID 50604601) was a semi-field tunnel study with 6 replicate tents at 3 application rates. In the study, nectar and pollen samples were collected by foragers for residue analysis. For these crops, only the residues in pollen were used to assess risk to bees.

Mean measured residues in pollen (expressed as nectar equivalence, **Appendix L**) from foliar applications of sulfoxaflor to buckwheat range from <0.01 to 0.07 mg a.i./kg, with no values above the colony-level NOAEC. Residue values are generally an order of magnitude below the NOAEC and LOAEC.

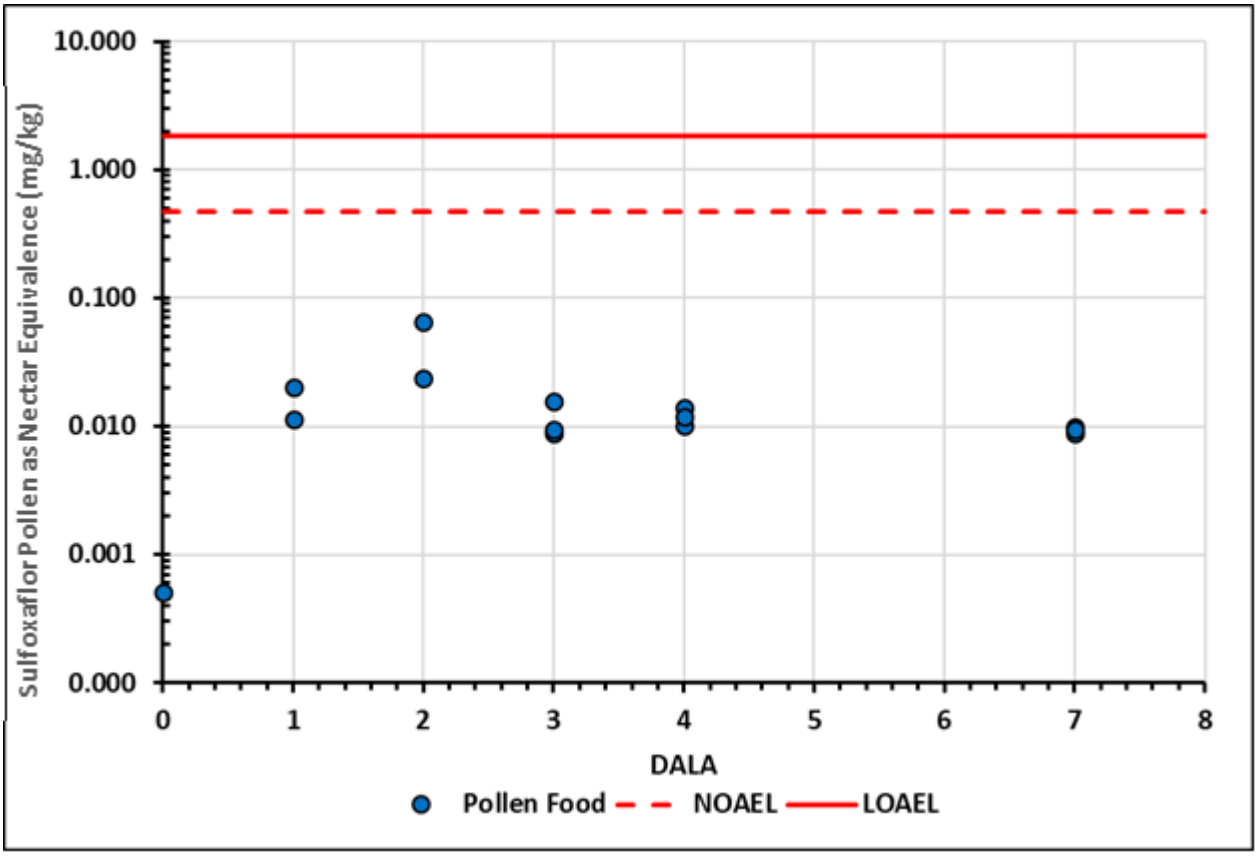


Figure 11-13. Mean daily residues of sulfoxaflor in pollen as nectar equivalence from applications to buckwheat corrected to maximum single application rate (0.047 lb a.i./A).

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), estimates of U.S. bearing acreage of attractive cereal grains are:

- Corn (87,668,000 acres)
- Sorghum (6,910,000 acres)

Corn and sorghum are wind pollinated but can be visited during pollen shedding by honey bees, particularly in times were other more preferred forage resources are limited. Corn pollen shedding is a heavy, short-lived event so the exposure duration for a given field would be relatively short, but the potential spatial scale of exposure could be extensive given the large acreage associated with cereal grains Sorghum has a flower stalk that starts blooming at one end, with flowers progressing along the stalk until completed. During this time bees can collect pollen from the plant. No notes on number of acers or additional crop growth and harvest information is available for millet, and teosinte in the USDA document.

Persistence (DT_{50}/ Residue decline)

Two semi-field tunnel studies were submitted with buckwheat that included measurement of sulfoxaflor in bee-relevant matrices (MRID 50494501 conducted in North Carolina and 50604601 conducted in Kansas). However, residue data were suitable for DT_{50} calculation only from the Kansas study (MRID 50604601; **Appendix H**). In this study, separate trials (tunnels) were evaluated with three different foliar spray application rates during bloom (0.023, 0.071, and 0.089 lb a.i./A). Since only one composite replicate was collected during each sampling event, the individual trial data are considered insufficient for reliable DT_{50} calculation due to lack of variability within a sampling event. Therefore, these data were normalized to the peak concentration within each trial and combined for DT_{50} determination. Among both matrices, DT_{50} values varied from 1.2 days (nectar) to 2.7 days (pollen), indicating relatively rapid decline of sulfoxaflor in bee-relevant matrices (**Table 11-26.**). These DT_{50} values indicate that repeated application of sulfoxaflor would not lead to additional accumulation in pollen and nectar (*e.g.,* no or negligible carry over) with the proposed minimum 7-d retreatment interval.

Table 11-26. DT_{50} and DT_{90} values for sulfoxaflor in buckwheat matrices

Crop (Region)	DT_{50} Values	DT_{90} Values	MRID
Nectar from Bees			
Buckwheat (Kansas)	1.2	4.0	50604601
Pollen from Traps			
Buckwheat (Kansas)	2.7	8.8	50604601

Other Considerations

The Tier II risk assessment for cereal grains assumes that the residue profile in buckwheat is representative of that for other attractive cereal grains (corn, sorghum). Although buckwheat is a cereal grain crop it produces both pollen and nectar. There is uncertainty in using this species to extrapolate to pollen only producing crops. Considerations of crop acreage, agronomic practice, and crop attractiveness suggest that the potential exposure of bees to sulfoxaflor could extend over large spatial scales. However, the relatively short persistence of sulfoxaflor in pollen is expected to reduce the duration of exposure of bees. Furthermore, the buckwheat residue data reflect one study site (Stillwell, KS), which likely does not capture potential variation in residues among sites with different climate, soil or other relevant regional differences.

As described earlier and in **Appendix L**, residues in pollen are assumed to represent $1/20^{th}$ (5%) of the colony-level exposure as compared to nectar. This assumption is based on the different bioenergetics and consumption of pollen and nectar by honey bee colonies and is associated with some uncertainty. As corn, sorghum, millet, and teosinte are pollen only producers this

total food conversion is important to consider. However, when considering a nectar conversion factor of 4 (upper bound estimate of consumption as demonstrated in **Appendix L**) there are still no exceedances of the colony level NOAEC or LOAEC.

11.6.12 Non-grass animal feeds (Crop Group 18)

The non-grass animal feed crop group includes many crops. Sulfoxaflor is proposed for foliar use on alfalfa, alfalfa grown for seed, velvet bean and vetch. For these applications, the single maximum application rate is proposed as 0.090 lb a.i./A, with three applications allowed per year. The label also proposes no more than two applications per cutting. No restrictions on applications made prior to or during bloom are indicated on the proposed labels. According to USDA (2017), alfalfa requires bee pollination for seed production only. Residue data from a study on alfalfa was used as a surrogate for the whole non-grass animal feed group. Based on the submitted residue data for alfalfa, a potential for colony-level effects is indicated with the proposed use on non-grass animal feed. A summary of the lines of evidence considered in assessing colony-level risks to honey bees from the proposed use is shown in **Table 11-27.**Table 11-20.. A discussion of these lines of evidence follows this table.

Table 11-27. Lines of Evidence table for non-grass animal feeds (alfalfa, velvet bean, vetch).

Residue Exceedance Attribute [1]	**NOAEC**	**LOAEC**
Frequency: Number daily mean residue values > NOAEC & LOAEC	7/10	4/10
Duration: Number of days > NOAEC & LOAEC	7	2
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	48X (2%)	12X (8%)
Additional Lines of Evidence	**Information**	
Crop Attractiveness [2] **& Bloom Duration**	Attractive to honey bees (pollen and nectar)	
Managed Pollinators	Used for crops grown for seed.	
DT_{50} / Residue decline	Mean DT_{50}: 1.3 d (flower pollen); 8 d (flower nectar)	
Ecological Incidents	None	
Other Considerations	Earlier cuts (harvests) typically occurring prior to bloom and later cuts being harvested up to 25% bloom. Residue data represent 2 sites in 2 growing regions in the US.	
Tier II Risk Conclusion	**Risk**	

[1] Residue data: alfalfa (MRID 50444401); [2] Based on USDA 2017

Residue Profile in Pollen and Nectar

For foliar applications to non-grass animal feeds, proposed label language requires a 48-hr notification of beekeepers within 1 mile. Available residue data for foliar applications of sulfoxaflor to alfalfa is shown in Figure 11-14. Mean daily residues of sulfoxaflor in total food from applications to alfalfa corrected to maximum single application rate (0.090 lb a.i./A).**Figure**

11-14. The residue study on alfalfa (MRID 50444401) had two application sites, North Carolina and California. While application rates were the same between the two sites (0.09 lb a.i./A) California residues were consistently higher by approximately 1 order of magnitude compared to those measured in North Carolina despite having a slightly longer interval time between applications (10 vs 7 days, respectively).

Mean measured residues (expressed as total food) from foliar applications of sulfoxaflor to alfalfa range from <0.01 to 22.7 mg a.i./kg, with 70% of values above the NOAEC. The maximum magnitude by which the colony-level NOAEC and LOAEC are exceeded by mean measured residue values are 48X and 12X, respectively. At this maximum residue level, the resulting exposure is sufficient to exceed both colony level endpoints if ≥8% of food resource required by a colony is collected from treated alfalfa fields. The colony-level NOAEC is exceeded for at least 7 days based on mean measured residue values.

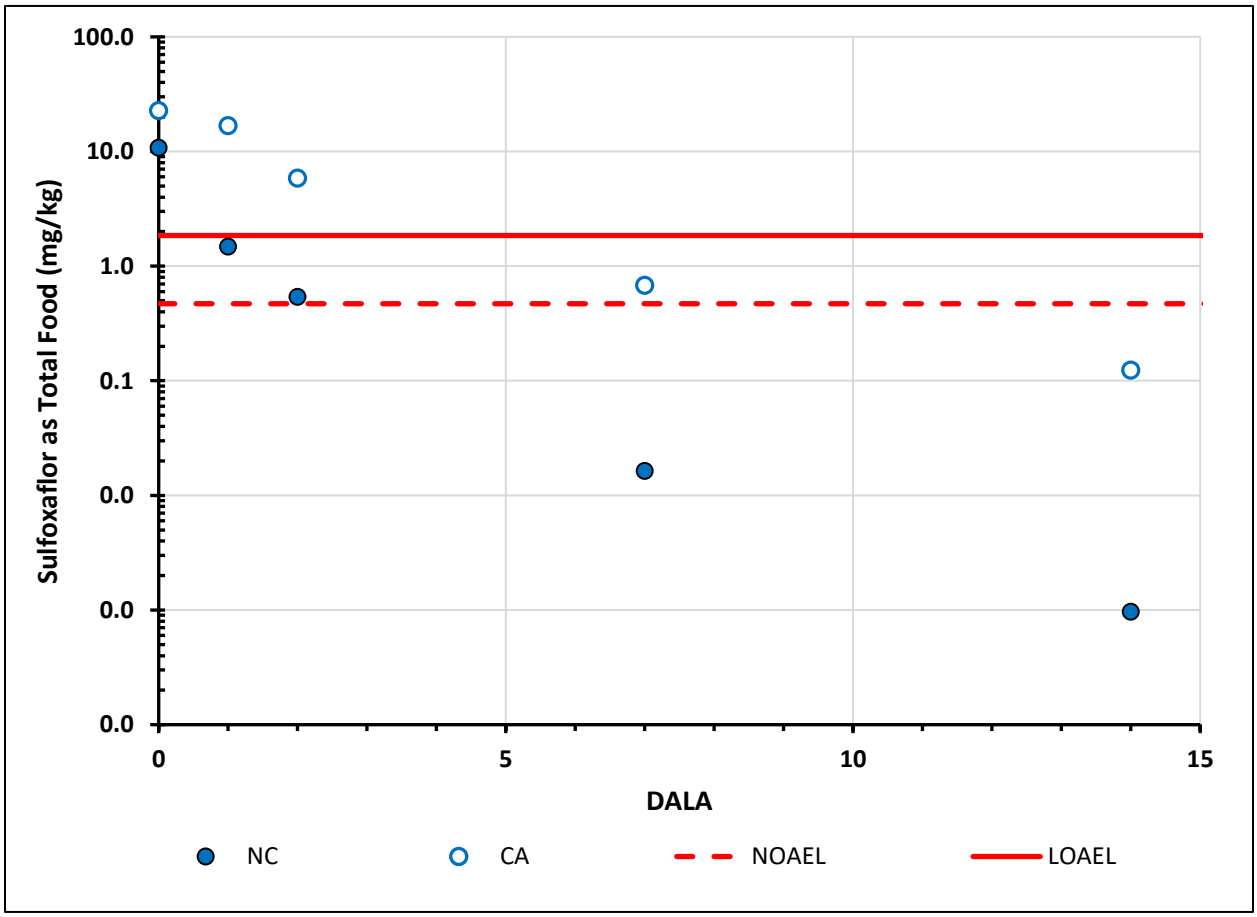


Figure 11-14. Mean daily residues of sulfoxaflor in total food from applications to alfalfa corrected to maximum single application rate (0.090 lb a.i./A).

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), estimates of U.S. bearing acreage of non-grass animal feed crops include:

- Alfalfa (17,763,000 acres, seed production 6,600 acres)
- Vetch (3,441 acres)

Alfalfa and vetch crops are considered highly attractive to honey bees as a source of nectar and pollen. Alfalfa requires bee pollination and uses managed pollinator services for seed production only. The timing of harvest relative to bloom varies by agronomic practice, with earlier cuts typically occurring prior to bloom and later cuts being harvested up to 25% bloom (USDA 2017). Vetch also requires bee pollination but does not typically use managed pollinators.

Persistence (DT_{50}/ Residue decline)

A total of 4 DT_{50} values were calculated for pollen and nectar matrices from one study of sulfoxaflor applications to alfalfa in the U.S. (**Table 11-28.)**. Among both matrices, DT_{50} values varied from 0.3 to 2.3 days, indicating relatively rapid decline of sulfoxaflor in bee-relevant matrices. Somewhat longer DT_{50} values are observed in the California trials compared to North Carolina (about 2-3X). The corresponding DT_{90} values are 8 days or less. These DT_{50} values indicate that repeated application of sulfoxaflor would not lead to additional accumulation in pollen and nectar (*e.g.,* no or negligible carry over) with the proposed minimum 7-d retreatment interval.

Table 11-28. DT_{50} and DT_{90} values for sulfoxaflor in alfalfa matrices by study region.

Crop (Region)	DT_{50} Values	DT_{90} Values	MRID
Nectar from Flowers			
Alfalfa (North Carolina) (California)	 0.37 1.2	 1.2 4.1	50444401
Pollen from Flowers			
Alfalfa (North Carolina) (California)	 0.26 2.3	 0.87 7.7	50444401

Other Considerations

The Tier II risk assessment for non-grass animal feed assumes that the residue profile in alfalfa is representative of that for other members of this crop group. Considerations of crop acreage, agronomic practice, and crop attractiveness suggest that the potential exposure of honey bees to sulfoxaflor could extend over large spatial scales. However, the relatively short persistence of sulfoxaflor in pollen and nectar is expected to reduce the duration of exposure of honey bees. It is noted that the residue data for alfalfa reflect two different sites among different regions (California and North Carolina). A minimum of 3 sites distributed across different regions where the crop is grown is recommended for conducting field residue trials with pollen and nectar (USEPA 2016b). Therefore, these residue data may underestimate the variation in residue values related to geographic differences among growing regions. With respect to alfalfa grown for forage, agronomic practices result in early cuttings being conducted prior to bloom which would greatly reduce exposure of bees to sulfoxaflor.

As described earlier and in **Appendix L**, residues in pollen are assumed to represent 1/20th (5%) of the colony-level exposure as compared to nectar. This assumption is based on the different bioenergetics and consumption of pollen and nectar by honey bee colonies and is associated with some uncertainty. However, even based on residues in nectar alone, the colony-level NOAEC and LOAEC would be exceeded for at least 2 days for the proposed uses on alfalfa and other non-grass animal feeds. Therefore, even though there is uncertainty associated with converting residues in pollen to nectar equivalence to estimate total food exposure, these data indicate the Tier II risk conclusions are not sensitive to this uncertainty.

11.6.13 Oilseed (Crop Group 20)

Within the oilseed crop group, sulfoxaflor is proposed for application to cotton and the canola (20A) subgroup. Sulfoxaflor is proposed for foliar use with a single maximum application rate of 0.023 and 0.071 lb a.i./A, respectively. The label also proposes a 3-day pre-bloom through petal fall restriction on application of sulfoxaflor for the canola group but no bloom restrictions are proposed for applications to cotton.

This section describes the lines of evidence associated with the assessment of risks of sulfoxaflor to honey bee colonies from foliar applications oilseed crops. Two residue studies on canola and one on cotton are available. These residue data indicate that residues in pollen and nectar do not exceed colony level NOAEC and LOAEC at current proposed application rates **(Table 11-29.)**.

Table 11-29. Lines of evidence table for oilseed crops (cotton, canola).

Residue Exceedance Attribute (1)	NOAEC	LOAEC
Frequency: Number daily mean residue values > NOAEC & LOAEC	0/64	0/64
Duration: Number of days > NOAEC & LOAEC	0	0

Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	0.8X (N.C.)	0.2X (N.C.)
Additional Lines of Evidence	**Information**	
Crop Attractiveness [2] & Spatial scale	Cotton: Attractive (floral nectar); Potentially attractive (extrafloral nectar); Not attractive (pollen); Canola: Highly Attractive (nectar and pollen); Long bloom duration (indeterminant bloom)	
Managed Pollinators	Not Required for cotton but used for honey production by some commercial beekeepers; Canola requires bee pollination and uses managed pollinators.	
DT_{50} / Residue decline	Cotton mean: 1.3 d (bee nectar) Canola mean: 1.5 d (nectar); Sunflower: 0.5 d (pollen)	
Ecological Incidents	None	
Other Considerations	Canola had similar residues in nectar and pollen, therefore large increases in hive pollen consumption would be needed to have an impact on in hive exposure.	
Tier II Risk Conclusion	**Low Risk**	

[1] Residue data: canola (MRID 50444406); canola (MRID 50355204); cotton (MRID 48755606)
[2] Based on USDA 2017
N.C. = not calculated because > 100% of the treated diet would be needed to reach the NOAEC

Residue Profile in Pollen and Nectar

For foliar applications to cotton, the proposed label language includes advisory language that suggests a 48-hr notification of beekeepers within 1 mile. For applications to the canola group, the proposed label language includes a restriction from 3 days prior to bloom until petal fall. Available residue data for foliar applications of sulfoxaflor to canola is shown in **Figure 11-15**. There are two residue studies on canola, one in the United States (MRID 50355204) and one in Europe (MRID 50444401) each with multiple application rates. When adjusted or application rate the two studies with six different locations have very similar residue concentrations. The data is more variable later in the time series as the residues approach the limit of quantification for sulfoxaflor.

Mean measured residues (expressed as total food) from foliar applications of sulfoxaflor to canola range from <0.01 to 0.36 mg a.i./kg, with no values above the NOAEC. A 3-day pre-bloom interval is currently proposed for uses on canola varieties and available residue data suggest that this will further reduce sulfoxaflor exposure potential.

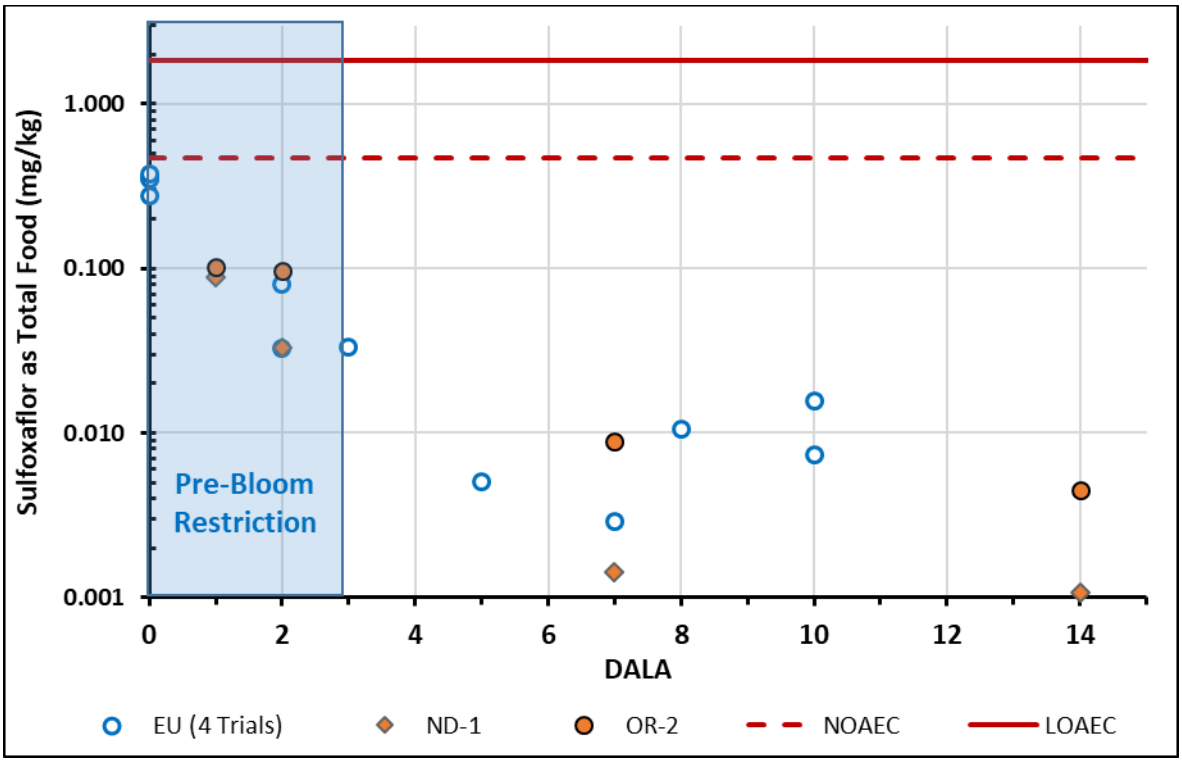


Figure 11-15. Mean daily residues of sulfoxaflor in total food from applications to canola corrected to maximum single application rate (0.023 lb a.i./A).

In the available residue study for cotton (MRID 48755606) two applications were tested with residue measurements following each application at one site in California. The second application happed on day 5 after the first application and is apparent by the spike in sulfoxaflor concentration as seen in **Figure 11-16**. The magnitude of sulfoxaflor in total food is not higher after the second application than the first leading to the conclusion that this chemical does not accumulate in plant tissues. Additionally, similar residue decline rates are observed for each application. Mean measured residues in nectar from foliar applications of sulfoxaflor to cotton range from <0.01 to 0.28 mg a.i./kg, with no values above the NOAEC. Even with no restrictions in relation to bloom, there is low risk from sulfoxaflor exposure.

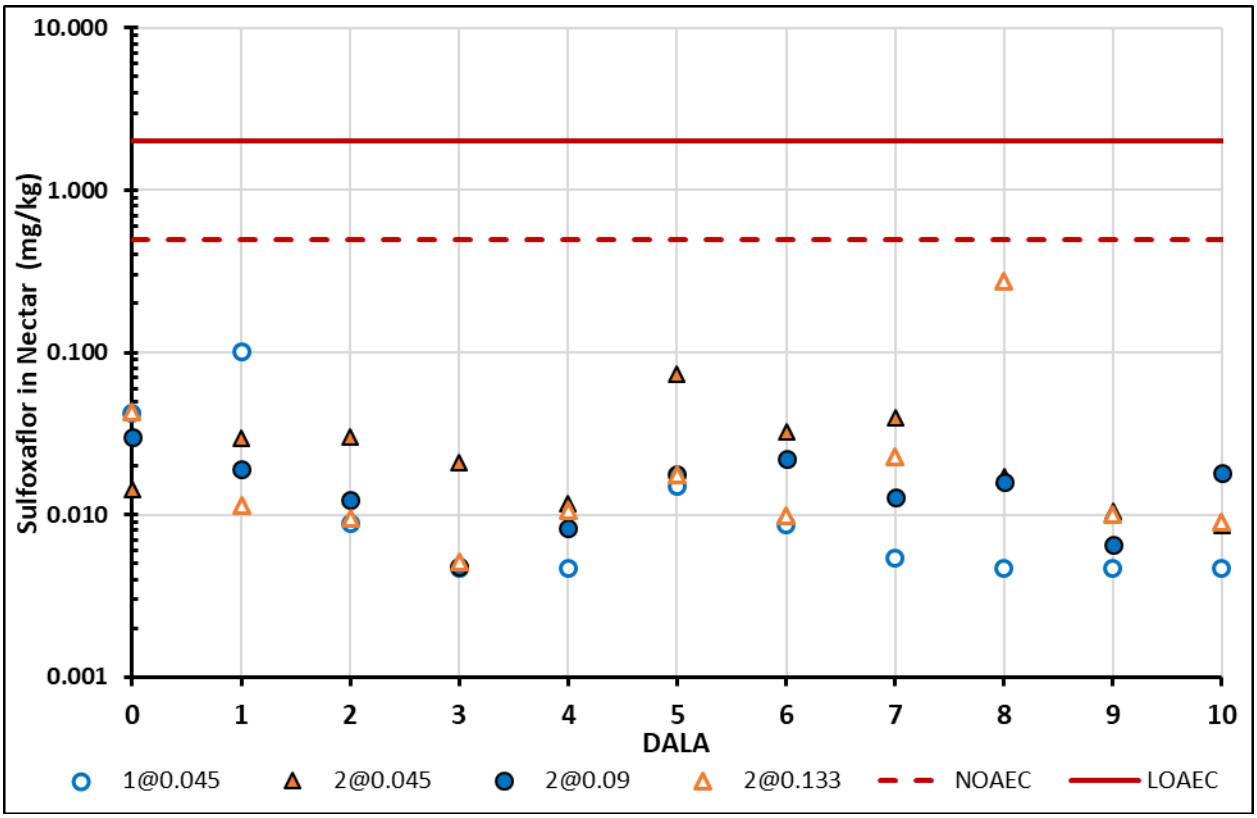


Figure 11-16. Mean daily residues of sulfoxaflor in nectar from applications to cotton corrected to maximum single application rate (0.071 lb a.i./A).

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), estimates of U.S. bearing acreage of oilseed crops include:

- Canola (1,266,200 acres)
- Mustard seed (43,400 acres)
- Cotton (7,664,400 acres)

Crops in the oilseed group are considered highly attractive to honey bees as a source of nectar and pollen. Cotton however is attractive only for nectar. Cotton is known to have extra floral nectaries that produce nectar for long periods of time. The available data did not measure these extra floral nectaries leaving an uncertainty in our analysis. Both cotton and canola have very high crop acreage in the US with bloom duration lasting between 4 and 5 weeks.

Persistence (DT_{50}/ Residue decline)

A total of 6 DT_{50} values were calculated for pollen and nectar matrices from 3 studies of sulfoxaflor applications to 3 oilseed crops (**Table 11-30.).** As seen with the analysis of dissipation rates with other crops, the DT_{50} values are short *(i.e*., 2 days or less) regardless of crop, matrix or region of study. The corresponding DT_{90} values are 7 days or less. These DT_{50} values indicate that repeated application of sulfoxaflor would not lead to additional accumulation in pollen and nectar (*e.g.,* no or negligible carry over) with the proposed minimum 5-d retreatment interval for cotton.

Table 11-30. DT_{50} and DT_{90} values for sulfoxaflor in oilseed crop matrices by study region.

Crop (Region)	DT_{50} Values	DT_{90} Values	MRID
Nectar from Bees			
Cotton (California)	1.6 1.5 0.8	5.1 5.1 2.7	48755606
Canola (Germany)	1.0	3.4	50444406
Nectar from Flowers			
Canola (Oregon)	2.0	6.7	50355204
Pollen from Flowers			
Sunflower (Kansas)	0.51	1.7	50355201

Source: Appendix M

Other Considerations

With sulfoxaflor, residue data are available for both members of the oilseed crop group for which applications are proposed (canola, cotton). With canola, residue data reflect measurements made at 4 sites in Germany and 2 sites in 2 different regions of the US. Therefore, the spatial representation of the canola data is considered reasonable, according to USEPA (2016). With cotton, data are available for only 1 site in California. Thus, some underestimation of the spatial variability in cotton residue values is considered likely.

As described earlier and in **Appendix L**, residues in pollen are assumed to represent $1/20^{th}$ (5%) of the colony-level exposure as compared to nectar. This assumption is based on the different bioenergetics and consumption of pollen and nectar by honey bee colonies and is associated with some uncertainty. With the canola data, residues in pollen were not usually greater than those in nectar. Pollen consumption in the hive can vary over the year and life stage of a bee therefore, increased pollen consumption can have a large effect on exposure to sulfoxaflor. Given that an upper bound estimate of pollen utilization by hives is 25% that of nectar, the tier

II risk determination for canola is comparable even with potential variation in pollen exposure of honey bee colonies. In contrast, cotton pollen is not considered attractive to honey bees and risk is determined based on residue concentrations in nectar only.

11.6.14 Other Orchard Crops (Tree nuts and pistachio, Tree farms and plantations, Home orchards, Woody Ornamentals, and Avocado, Pineapple, and Cacao)

This section describes tree crops that do not have residue data available within their respective crop group. In these cases, crop data for the closest surrogates, based on broad plant characteristics (*i.e.,* woody/tree crops) are be used to characterize risk. Since ornamental plants may be woody or herbaceous, woody ornamentals (*e.g.,* trees, bushes) are included in this group for risk estimation. Data from citrus, pome, and stone fruit are be used as a surrogate for other orchard crops including tree nuts, tree farms, and tropical fruit (avocado and pineapple). Sulfoxaflor is proposed for foliar applications on these other crops with a single maximum application rate is 0.090 lb a.i./A.

According to USDA (2017), some tree nuts and avocados require bee pollination and use managed sources of pollination. Although, bee pollination of tree farms is dependent on the species of tree it is possible for some of these species to be attractive to honey bees.

Based on the submitted residue data for citrus, apple, and peach a potential for colony-level effects is indicated with the proposed use on tree nuts, tree farms, home orchards, ornamentals and avocado, pineapple, and cacao. A summary of the lines of evidence considered in assessing colony-level risks to honey bees from the proposed use on other orchard crops and ornamentals is shown in **Table 11-31.**Table 11-20. A discussion of these lines of evidence follows this table. Residue studies previously described from citrus, pome, and stone fruit were used as surrogates for applications to these other orchard crops.

Table 11-31. Lines of evidence table for other orchard crops (tree nuts, tropical fruits, tree farms, home orchards, ornamentals).

Residue Exceedance Attribute	NOAEC	LOAEC
Frequency: Number daily mean residue values > NOAEC & LOAEC	19/41	6/41
Duration: Number of days > NOAEC & LOAEC	15	5
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	29X (N.C.)	7.4X (N.C.)
Additional Lines of Evidence	**Information**	
Crop Attractiveness [(1)] & Bloom Duration	Attractive (nectar and pollen); extremely variable depending on species	
Managed Pollinators	Required for some	
DT_{50} / Residue decline	DT_{50} values range from 0.6 to 2.5 days (pollen) and from 1.1 to 3.7 days (nectar) based on pome and stone fruit	

Ecological Incidents	None
Other Considerations	Using other orchard crops as a surrogate introduces uncertainty into the assessment of risk.
Tier II Risk Conclusion	**Risk**

(1) Based on USDA 2017

N.C. = not calculated because > 100% of the treated diet would be needed to reach the NOAEC

Residue Profile in Pollen and Nectar

For foliar applications to other orchard crops, the proposed label language does not allow application from three days prior to bloom until petal fall, for tree farms as well as the tree nut crop group. Additionally, these groups include bee advisory language suggesting a 48-hour notification of beekeepers within 1 mile and limit application timing when managed bees and native pollinators are least active (before 7 am; after 7 pm; temperature <55 ^{o}F). There is no bee specific language for avocados or pineapple.

Available residue data for foliar applications of sulfoxaflor to these other orchard crops is shown in **Figure 11-17.** This includes the combined information from citrus, pome, and stone fruit residue studies. For citrus, residues in pollen were not measured and were estimated as described previously in **Section 11.6.7.** The blue box represents a three-day pre-bloom interval for tree farms and tree nut crops. Residue values are normalized to the maximum single application registered for sulfoxaflor across the orchard group (i.e., 0.09 lb a.i./A).

For an oral route of exposure residues in nectar and pollen, expressed as total food, are compared against the Tier II CFS endpoint. Mean measured total food residues from foliar applications of sulfoxaflor to all orchard crops <0.01 to 14 mg a.i./kg, with 46% of values above the NOAEC. The maximum magnitude by which the colony-level NOAEC and LOAEC are exceeded are 29X and 7.4X, respectively. Furthermore, the colony-level endpoints are exceeded for at least 15 days based on mean measured total food residue values. While the 3-day pre-bloom interval would reduce exposures to honey bees it is not sufficient to exclude risk. For those orchard crops that do not preclude applications from 3 days prior to bloom and during bloom, colony level endpoints are exceeded from data on all surrogate crops.

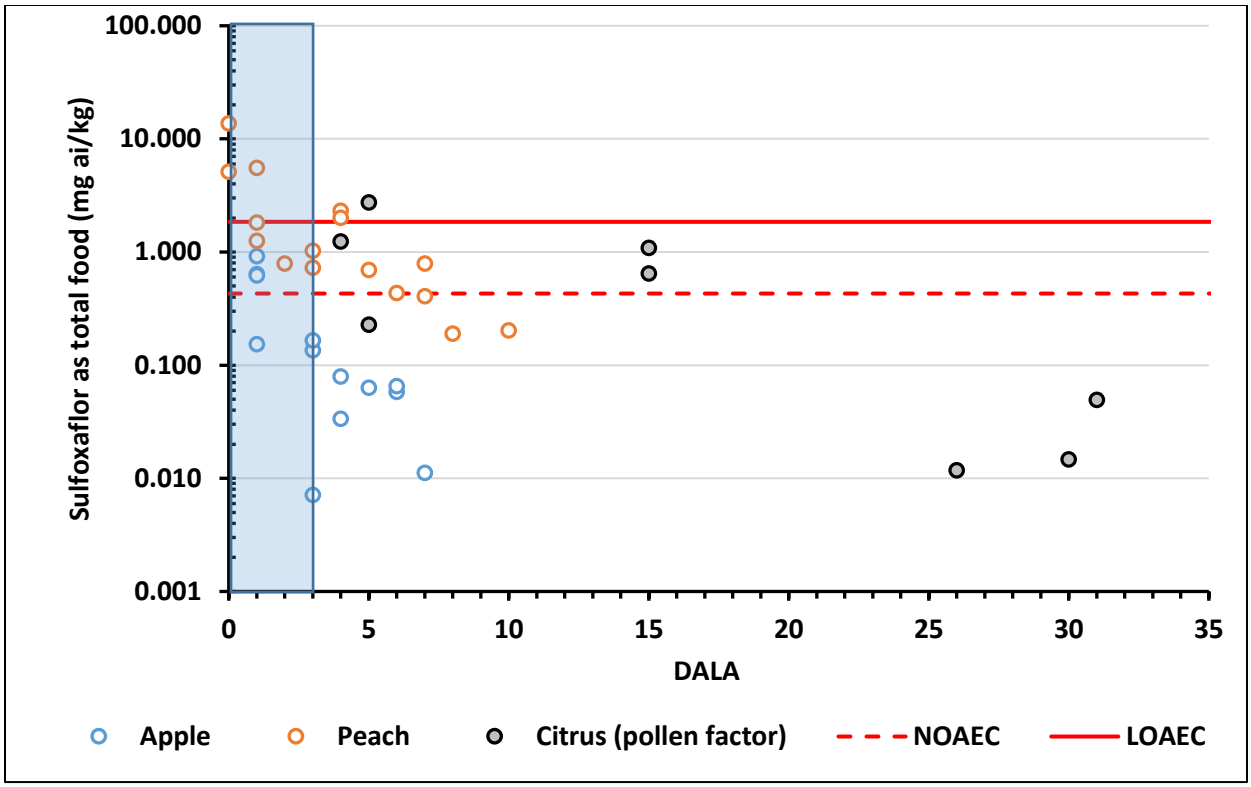


Figure 11-17. Measured residues in pollen and nectar from all orchard crops corrected to max single application rate (0.090 lb a.i./A).

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), estimates of U.S. bearing acreage of other orchard crops include:

- Almonds (780,000 acres)
- Walnuts (245,000 acres)
- Pistachio (178,000 acres)
- Hazelnuts (29,00 acres)
- Chestnuts (3,784 acres)
- Avocado (59,950 acres)

Tree nut crops are variable in their attractiveness to bees as well as the necessity of managed pollinators. Almonds, for example, are considered very attractive and managed pollinators are crucial to the success of the crop. In contrast, walnuts are only attractive to honey bees for pollen collection and are mostly wind pollinated. Avocados are attractive to honey bees and managed pollinators are often used.

There is uncertainty associated with the attractiveness of pineapple and tree farms. Based on USDA (2017), No data are available to estimate the attractiveness of pineapples to honey bees, however many other tropical fruits are considered attractive. Similarly, no information is available on the attractiveness of cacao to honey bees. The proposed label has use for sulfoxaflor on tree farms which can contain a wide variety of species. It is known that some species of non-fruit trees are attractive and require bee pollination. Therefore, in the absence of information, it is presumed that pineapple and at least some tree species cultivated in tree farms are attractive to honey bees.

Persistence (DT_{50}/ Residue decline)

Based on DT_{50} values from other orchard crops (pome and stone fruits), the persistence of sulfoxaflor in other orchard crops is expected to be short (*e.g.,* $DT_{50} < 4$ days).

Other Considerations

The Tier II risk assessment for other orchard crops assumes that the residue profiles in citrus, pome and stone fruit are representative of that for other members of this category of crops. Uncertainty is introduced in this risk characterization due to the use of residue data for these surrogate crops. There is also uncertainty regarding the attractiveness of some crops in this category, as discussed previously, in addition to lack of pollen residue data for citrus. When considering data from all available orchard crops (apple and peach in addition to citrus), the residue data represent 6 crops distributed among 6 sites and 4 regions including Europe and the U.S. Thus, the spatial representation of the available residue data used to support the Tier II risk characterization is considered reasonably strong.

11.6.15 Other Herbaceous Crops (Attractive Root and Tubers, Fruiting Vegetables, Legumes, Ornamentals)

This section describes herbaceous crops that do not have residue data available within their respective crop groups (attractive root and tubers, fruiting vegetables, legumes, herbaceous ornamentals). In these cases, crop data for the closest surrogates, based on broad plant characteristics (*i.e.,* herbaceous crops) are be used to characterize risk. Specifically, sulfoxaflor residue data from all other herbaceous crops (alfalfa, canola, cotton, pumpkin, strawberry, *Phacelia*, and sunflower) are used as surrogates for other herbaceous crops including attractive root and tubers, legumes, fruiting vegetables, and herbaceous ornamentals. Sulfoxaflor is proposed for foliar applications on these crops with a variety of maximum single application rates. No restrictions are indicated on the proposed labels with respect to timing of application relative to the bloom period, indicating a potential for contact and oral exposure of bees.

a. Crops at a rate of 0.071 lbs a.i/A

Several crops are proposed with a maximum single application rate of 0.071 lb a.i./A, these include legumes, fruiting vegetables, and potatoes. According to USDA (2017), only sweet potato is attractive to honey bees within the potato group. Of the attractive fruiting vegetables, some are attractive for nectar and pollen (okra and roselle), while others are only attractive for pollen (peppers and chillies). Bee pollination is required for sweet potatoes (for breeding purposes only), chillies and peppers (usually bumble bee), and for some bean crops (not soybean).

Based on the submitted residue data for other herbaceous crops, a potential for colony-level effects is indicated with the proposed uses on legumes, fruiting vegetables (okra, roselle), and sweet potato that produce honey bee attractive nectar and pollen. In the absence of crop-specific residue data, pollen and nectar residue data from other herbaceous crops were used as surrogates (after adjusting to application rate of 0.071 lb a.i./A). The lines of evidence supporting the assessment of risks of sulfoxaflor to honey bee colonies from foliar applications to legumes, fruiting vegetables (okra, roselle, peppers, and chillies), and sweet potato (pollen and nectar producing) are shown in **Table 11-32.**

Table 11-32. Lines of evidence table for other herbaceous crops normalized to 0.071 lb a.i/A proposed for legumes, fruiting vegetables (okra, roselle, others) and sweet potato.

Line of evidence	**Legumes, sweet potato[2], okra, roselle**		**Chillies and peppers[3]**	
Residue Exceedance Attribute	**NOAEC**	**LOAEC**	**NOAEC**	**LOAEC**
Frequency: Number daily mean residue values > NOAEC & LOAEC	26/166	11/166	10/166	4/166
Duration: Number of days > NOAEC & LOAEC	7	5	3	1
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	39X (3%)	10X (10%)	6.9X (15%)	1.7X (57%)
Additional Lines of Evidence	**Information**			
Crop Attractiveness [1] & Bloom Duration	Nectar and pollen, bloom duration variable or not available		Pollen only, bloom duration variable or not available	
Managed Pollinators	Some legumes and fruiting vegetables; others for breeding purposes only		Bumble bee pollination	
DT_{50} / Residue decline	22 DT_{50} values in nectar and pollen matrices range from 0.3 to 2.6 days			
Ecological Incidents	None			
Other Considerations	NOAEC is exceeded for 5 of the 7 herbaceous crops with residue data			
Tier II Risk Conclusion	**Risk**		**Risk**	

[1] Based on USDA 2017

[2] Legumes, sweet potato, okra and roselle produce attractive nectar and pollen; Sweet potato is the only attractive member of the root and tuber potato subgroups 1C and 1D
[3] Chillies and peppers are pollen only producers

Residue Profile in Pollen and Nectar

Available residue data for foliar applications of sulfoxaflor to this group are shown in Figure 11-14. Mean daily residues of sulfoxaflor in total food from applications to alfalfa corrected to maximum single application rate (0.090 lb a.i./A).**Figure 11-18**. For an oral route of exposure, residues in nectar and pollen, expressed as total food, are compared against the Tier II CFS endpoint. Mean measured total food residues from foliar applications of sulfoxaflor to from <0.01 to 18 mg a.i./kg, with 16% of values above the NOAEC. The maximum magnitude by which the colony-level NOAEC and LOAEC are exceeded are 39X and 10X, respectively. At this maximum level, a honey bee colony would have to obtain 3% and 10% of its diet from the treated field for the colony-level NOAEC and LOAEC to be exceeded, respectively. The colony NOAEC is exceeded for 5 of the 7 herbaceous crops with residue data which suggests that risk conclusions are less dependent on which surrogate crop is chosen to represent the other herbaceous crops. Furthermore, the colony-level endpoints are exceeded for 7 days based on mean measured total food residue values. With respect to the contribution of pollen to the risk determination, a comparison of residues in nectar only indicates exceedance of the colony-level NOAEC with 4 of the 7 crops with similar magnitude, duration and frequency of exceedance as when pollen residues were included. Therefore, the risk characterization does not depend on the assumed contribution of pollen to the total food residues.

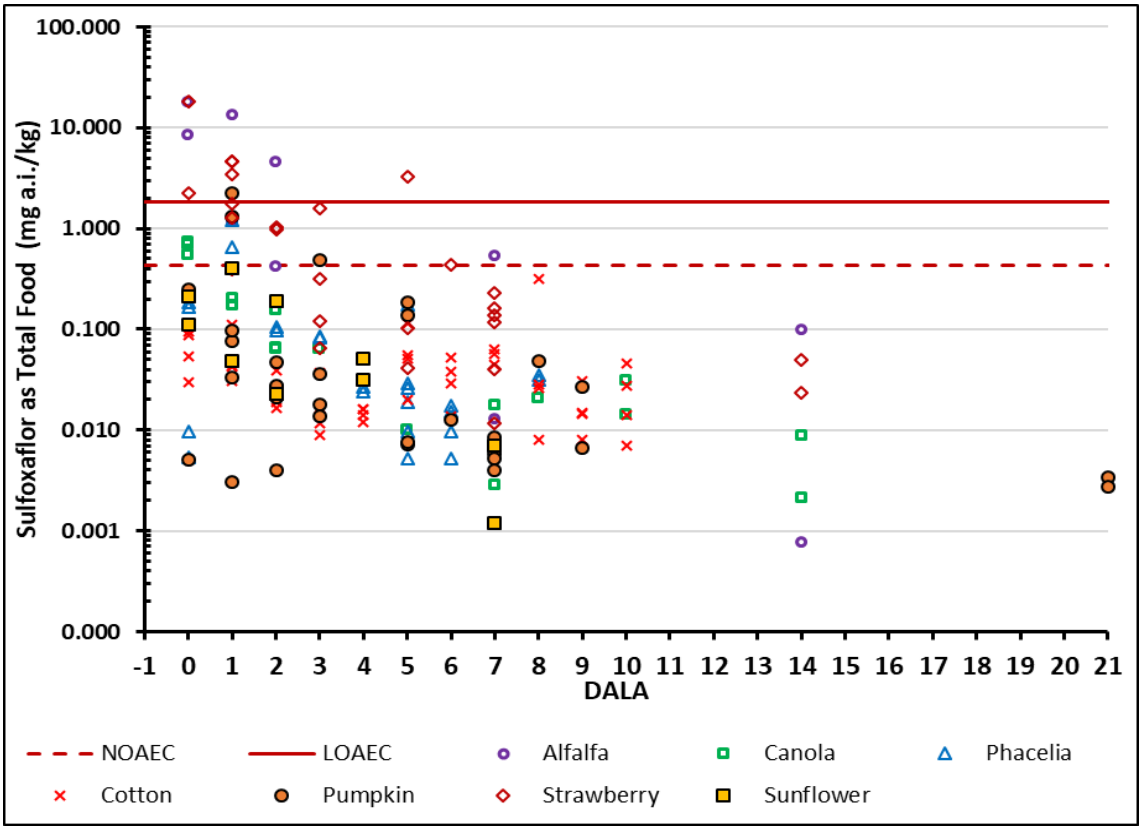


Figure 11-18. Sulfoxaflor residues measured in herbaceous crops (expressed as total food) scaled to the application rate of 0.071 lb a.i./A for legumes and fruiting vegetables (okra, roselle) and sweet potato.

Pollen Only Producing Fruiting Vegetables

Certain fruiting vegetable crops produce pollen only that is attractive to honey bees (chillies and peppers). Since crop-specific residue data are lacking for this group, residue data from all other herbaceous crops are used as a surrogate to characterize colony-level risk. Accordingly, residue values were normalized to the maximum single application rate for these crops (*i.e.,* 0.071 lb a.i./A) and converted to a total food (nectar) equivalence (pollen concentration/ 20).

Among the herbaceous crops, mean measured total food residues (*i.e.,* pollen converted to nectar equivalence) from foliar applications of sulfoxaflor to alfalfa and strawberry exceed the colony level NOAEC and LOAEC, while those for 5 other crops do not (cotton, pumpkin, canola, sunflower, *Phacelia*; **Figure 11-19)**. For strawberry, total food residues range from <0.01 to 3.2 mg a.i./kg, with 6% of values above the NOAEC. The maximum magnitude by which the colony-level NOAEC and LOAEC are exceeded are 6.9X and 1.7X, respectively. At these maximum residue values, colonies would be exposed at the NOAEC and LOAEC if they obtained 15% and

57% of their diet on the treated field, respectively. The colony-level endpoints are exceeded for 3 days based on mean measured total food residue values.

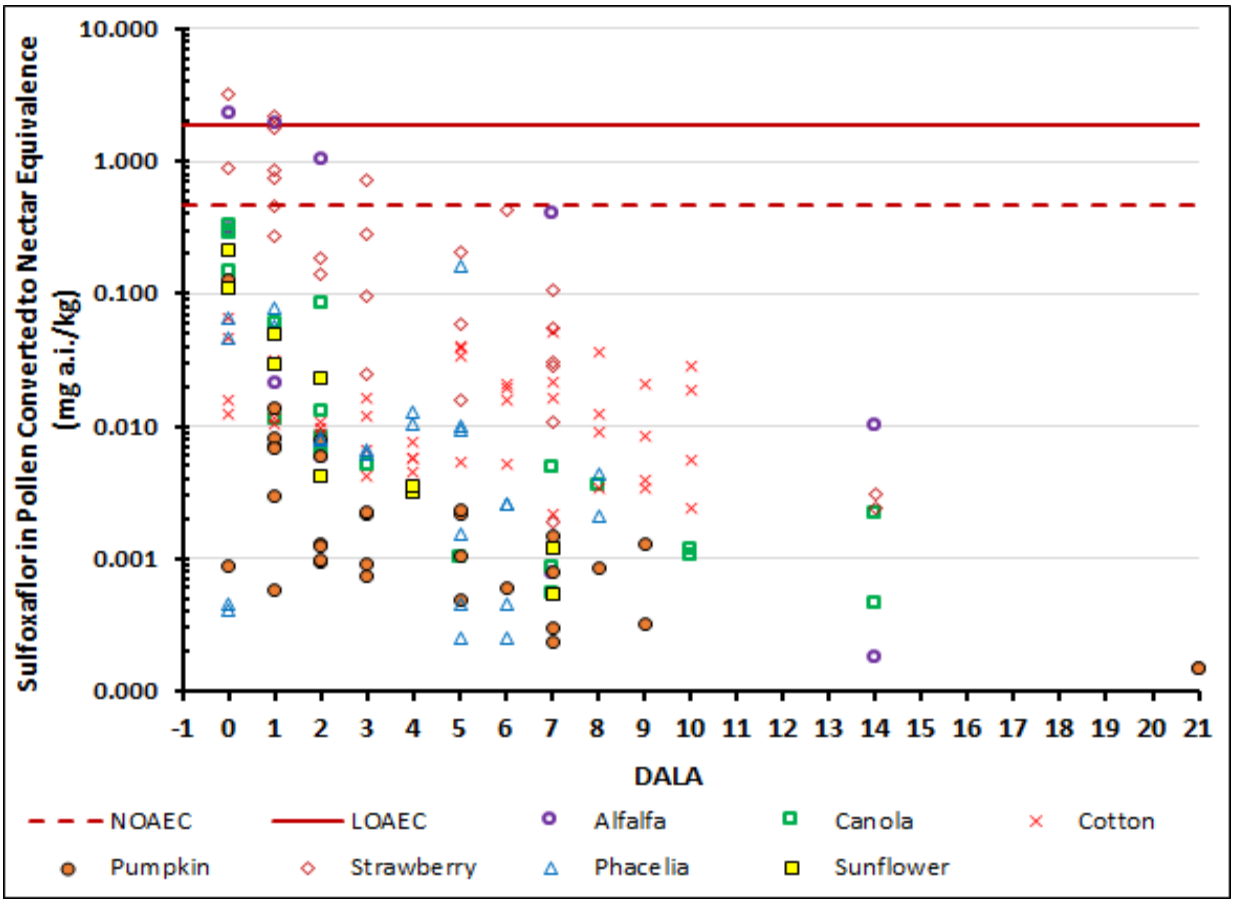


Figure 11-19. Sulfoxaflor residues measured in pollen (expressed as nectar equivalence) of herbaceous crops scaled to the application rate of 0.071 lb ai/A for chillies and peppers.

Attractiveness and Spatial Scale

According to 2012 Agricultural Census data summarized in USDA (2017), estimates of U.S. bearing acreage of the previous crops include:

- Potato sub-group: Sweet potato (113,200 acres)
- Legume crop group: Soybean (75,869,000 acres); Fava beans (1,311,300 acres); Peas (797, 000 acres); Chick pea (213,600 acres); Snap beans (77,200 acres); Cow peas (39,100 acres)
- Fruiting vegetable crop group: Chillies and peppers (71,200 acres); Okra (2,377 acres)

In the potato crop group, only sweet potato is attractive to honey bees as a source of nectar and pollen. Of the fruiting vegetable crop group, chillies and peppers are pollen attractive, but require pollinators, while okra and roselle are nectar and pollen attractive but do not require pollinators. Many legume crops are attractive to honey bees as a source of nectar and pollen, while a few select crops (fava beens, cow peas) are known to require bee pollination (USDA 2017). Combined legume crops have a large special scale of potential exposure.

These considerations of crop acreage and attractiveness suggest that the potential exposure of bees to sulfoxaflor could extend over significant spatial and temporal scales. However, the relatively short persistence of sulfoxaflor in pollen and nectar is expected to reduce the duration of exposure of bees.

b. Crops at a rate of 0.090 lbs a.i/A

Finally, root and tuber crops (other than potatoes) are proposed for a maximum single application rate of 0.090 lb a.i./A. According to USDA (2017), only some root and tuber crops are attractive or are not harvested before bloom. These crops include Jerusalem artichoke, edible burdock, dasheen, horseradish, and turmeric. Since crop-specific residue data are lacking for this group, residue data from all other herbaceous crops are used as a surrogate to characterize colony-level risk. Accordingly, residue values were normalized to the maximum single application rate for these crops (*i.e.,* 0.09 lb a.i./A) and converted to a total food equivalence (nectar + pollen concentration/20).

Based on the submitted residue data for other herbaceous crops a potential for colony-level effects is indicated with the proposed maximum single application rate of 0.09 lb a.i./A on attractive root and tuber crops. This section describes the lines of evidence associated with the assessment of risks of sulfoxaflor to honey bee colonies from foliar applications to attractive roots and tuber vegetables as summarized in **Table 11-33.**.

Table 11-33. Lines of evidence table for other herbaceous crops normalized to 0.090 lbs a.i/A for attractive root and tubers[2] (Jerusalem artichoke, edible burdock, dasheen, horseradish, turmeric).

Residue Exceedance Attribute	NOAEC	LOAEC
Frequency: Number daily mean residue values > NOAEC & LOAEC	30/166	13/166
Duration: Number of days > NOAEC & LOAEC	7	5
Magnitude: Ratio of Max to NOAEC & LOAEC (% of diet required to reach NOAEC & LOAEC)	49X (N.C.) (2%)	12X (N.C.) (8%)
Additional Lines of Evidence	**Information**	
Crop Attractiveness [1] & Bloom Duration	Pollen and nectar (bloom duration information not available)	
Managed Pollinators	Only when used for seed production	

Residue Exceedance Attribute	NOAEC	LOAEC
DT50 / Residue decline	22 DT_{50} values in nectar and pollen matrices range from 0.3 to 2.6 days	
Ecological Incidents	None	
Other Considerations	6 of 7 herbaceous crops had residues exceeding the NOAEC	
Tier II Risk Conclusion	**Risk**	

[1] Based on USDA 2017

[2] Attractive members of the root and tuber subgroups 1A and 1B

N.C. = not calculated because > 100% of the treated diet would be needed to reach the NOAEC

Residue Profile in Pollen and Nectar

Available residue data for foliar applications of sulfoxaflor to attractive root and tuber crops are shown in **Figure 11-20**. For an oral route of exposure residues in nectar and pollen, expressed as total food, are compared against the Tier II CFS endpoint. Mean measured total food residues from foliar applications of sulfoxaflor range from <0.01 to 23 mg a.i./kg, with 18% of values above the NOAEC. The maximum magnitude by which the colony-level NOAEC and LOAEC are exceeded are 49X and 12X, respectively. At these maximum residue values, colonies would be exposed at the NOAEC and LOAEC if they obtained 2% and 8% of their diet on the treated field, respectively. The colony NOAEC is exceeded for 6 of the 7 herbaceous crops with residue data which suggests that risk conclusions are less dependent on which surrogate crop is chosen to represent the other herbaceous crops Furthermore, the colony-level endpoints are exceeded for 7 days based on mean measured total food residue values. With respect to the contribution of pollen to the risk determination, a comparison of residues in nectar only indicates exceedance of the colony-level NOAEC with 6 of the 7 crops with similar magnitude, duration and frequency of exceedance as when pollen residues were included. Therefore, the risk characterization does not depend on the assumed contribution of pollen to the total food residues.

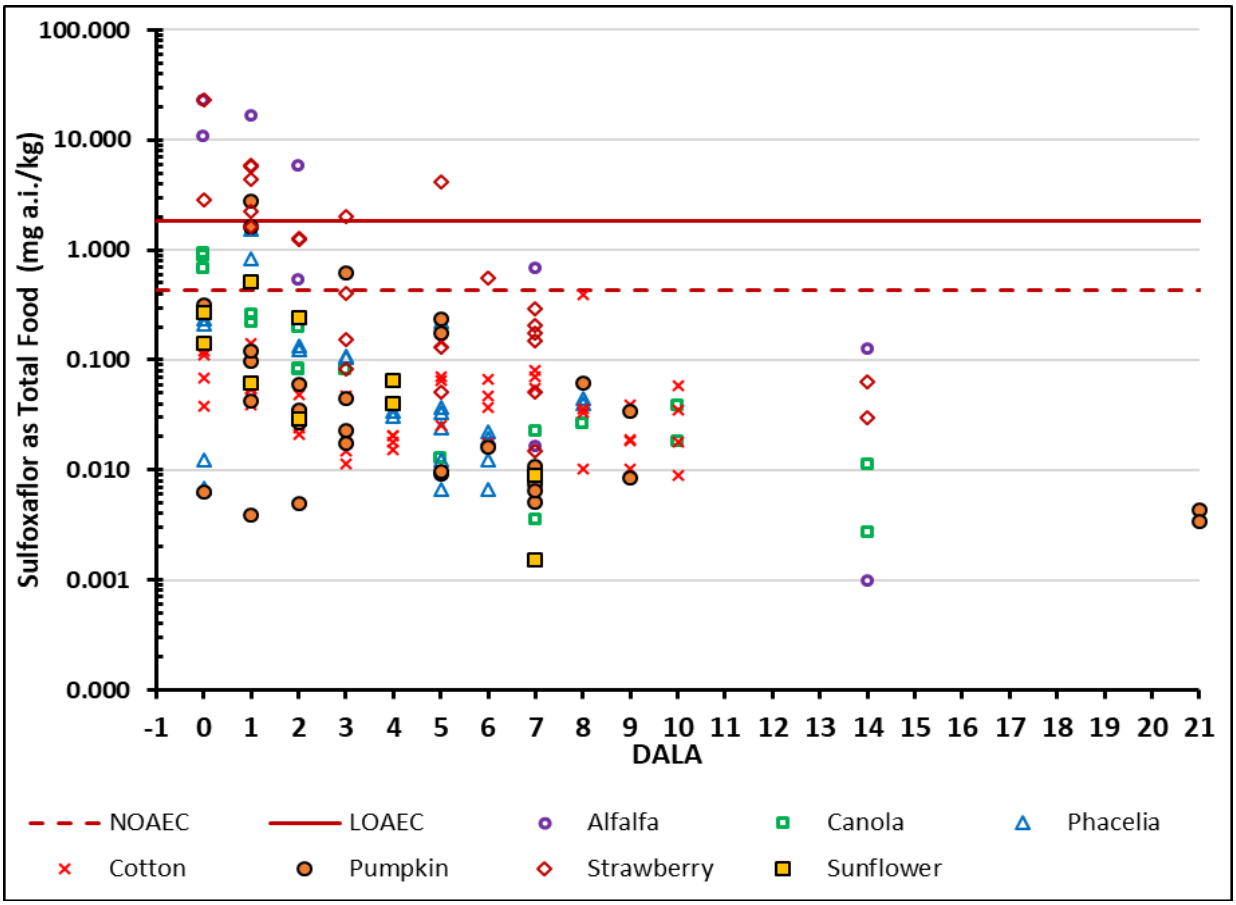


Figure 11-20. Sulfoxaflor residues measured in herbaceous crops (expressed as total food) scaled to the application rate of 0.09 lb a.i./A for attractive root and tubers.

Attractiveness and Spatial Scale

Attractive root and tuber crops (subgroup 1A and 1B) are considered minor crops and not represented with acreage estimates in USDA 2017. Additionally, acers of other root and tuber crops used for seed production is also low.

Other Considerations

The Tier II risk assessment for other herbaceous crops assumes that the residue profiles in alfalfa, canola, phacelia, cotton, pumpkin, strawberry and sunflower are representative of that for other members of this category of crops. Uncertainty is introduced in this risk characterization due to the use of residue data for these surrogate crops. When considering data from all available herbaceous crops, the residue data represent 7 crops distributed among 6 sites and 4 regions including Europe and the U.S. Thus, the spatial representation of the available residue data used to support the Tier II risk characterization is considered reasonably

strong. Additionally, the more crops that have residue values above the colony level NOAEC and LOAEC lead more evidence to the risk picture in this surrogacy method.

11.7 Tier III Effects Assessment

A Tier III (full field) study has not been submitted with sulfoxaflor and the registrant has requested a waiver for this study per 40 CFR Part 158.630 (MRID 50688001). Currently, Tier III full field studies are requested in a limited number of situations to address specific uncertainties or hypotheses not resolved with lower tier assessments. In response to the submitted waiver request, the Agency considered the following:

1. The recent development of EPA's risk assessment guidance for bees (USEPA 2014; 2016), which includes additional study recommendations not considered in the 40 CFR 158.630;
2. The utility of the current suite of Tier II colony-level effects and exposure studies for assessing risks of sulfoxaflor to bees; and
3. The expected utility of one or more Tier III full field studies and their likelihood to materially change the risk assessment conclusions.

In its review of these considerations, the Agency granted the requested waiver for a Tier III full field study for the proposed uses of sulfoxaflor (D453063). In granting this waiver, the Agency believes the existing suite of semi-field (Tier II) effects and exposure studies enables it to conduct a comprehensive and appropriately conservative assessment of the potential risks of sulfoxaflor to bees. Furthermore, given the limitations and high degree of specificity associated with full field (Tier III) studies *(i.e.,* limited ability to extrapolate results across locations), the Agency believes that submission of a Tier III full field study per the 850.3040 guidelines would have a low potential for altering its risk assessment conclusions and subsequent registration decision. Secondarily, EFED notes that the conditional requirements for the Tier III full field study (850.3040) codified in 40 CFR Part 158.630 do not fully reflect the current state of science supporting the assessment of pesticide risks to bees. Based on guidance developed subsequent to the 40 CFR 158.630 conditional data requirements, EFED now, in most cases, recommends the Tier III (full field) study (*i.e.,* the 850.3040) be required under a much narrower set of circumstances rather than any time a potential for colony-level effects is identified. Such circumstances include addressing highly specific assessment hypotheses and uncertainties that are identified and not able to be addressed from lower tier testing.

11.8 Risks to Non-*Apis* Bee

Consistent with the Agency's 2014 risk assessment guidance for bees, the preliminary risk assessment of agricultural uses of sulfoxaflor focuses on the honey bee, *A. mellifera*. This *Apis*-centric focus reflects two important considerations: 1) honey bees are widely recognized as the

most important managed pollinator in most regions of the world from both a commercial and ecological perspective;[17] and 2) standardized test methods for evaluating exposure and effects of chemicals in a regulatory context are much more developed with the honey bee compared to non-*Apis* bees (USEPA *et al.* 2014; USEPA 2012[18]), although recent progress has been made on test method development for bumble bees[19]. Nonetheless, within North America alone, there are an estimated 4,000 species of bees (Michener 2007) and this number rises to more than 20,000 worldwide (Fischer and Moriarty 2014). Several species of non-*Apis* bees are commercially managed for their pollination services, including bumble bees (*Bombus spp.)*, leaf cutting bees (*Megachile rotundata*), alkali bees (*Nomia melanderi*), and blue orchard bees (*Osmia lignaria)*, and the Japanese horn-faced bee (*O. cornifrons*). Importantly, a growing body of information indicates native bees (in addition to other insect pollinators such as flies, moths, butterflies, beetles, wasps, and ants) play an important role in crop and native plant pollination, besides their overall ecological importance via maintaining biological diversity. Although the current risk assessment process for bees does not include a formal process that is specific to non-*Apis* bees, available data related to the potential exposure of non-*Apis* bees to sulfoxaflor and subsequent effects are summarized here in relation to the previously described risk assessment for the honey bee.

11.8.1 Exposure Considerations

Several aspects of the biology and ecology of non-*Apis* bees lead to important differences in the route and extent to which they may be exposed to pesticides compared to honey bees. These aspects have been reviewed previously (EFSA 2012, Fisher and Moriarty 2014; Boyle et al., 2019) and are summarized here briefly. Specifically, many non-*Apis* bees are smaller in size and thus, would in theory receive a higher dose on a contact exposure basis (*i.e*., greater surface area to volume ratio) via intercepting droplets of sprayed pesticide. Most non-*Apis* bees are solitary nesting species[20] and therefore, loss of a single nesting adult would have a much greater consequence on reproduction (at least for that nest) compared to the loss of a single adult foraging honey bee from a colony. Furthermore, the foraging range of non-*Apis* bees tends to be much smaller than that of honey bees. As a consequence, non-*Apis* bees that occupy areas adjacent to treated fields may be exposed to pesticides at a higher proportion of

[17] According to Tautz, J. (2008), approximately 80% of the world's flowing plants are pollinated by insects and 85% of these by honey bees. In all, the list of flowering plants pollinated by honey bees includes 170,000 species.
[18] USEPA. 2012. White Paper in Support of the Proposed Risk Assessment Process for Bees. Submitted to the FIFRA Scientific Advisory Panel for Review and Comment September 11 – 14, 2012Office of Pesticide Programs, Environmental Fate and Effects Division, Environmental Protection Agency, Washington DC; Environmental Assessment Directorate, Pest Management Regulatory Agency, Health Canada, Ottawa, CN; California Department of Pesticide Regulation.
[19] Compilation of results of the ICPPR non-Apis working group with a special focus on the bumble bee acute oral and contact toxicity ring test 2014 ICPPR Non-Apis Working Group. Available at: http://pub.jki.bund.de/index.php/JKA/article/view/5352
[20] Colonies of the social non-*Apis* bees (*e.g*., bumble bees and stingless bees) tend to be smaller than honey bees.

their foraging area compared to honey bees, which can forage over long distances (~7 km) in which they are more likely to encounter untreated forage areas. For ground nesting bees, exposure via direct contact with soil may be a major route of exposure unlike that for the honey bee (Boyle et al. 2019). Soil and leaf material are known to be used extensively by some non-*Apis* bees for nest construction, which may lead to different types of exposures (*e.g.,* contact exposure with contaminated residues on treated foliage).

To investigate the extent to which exposure estimates for honey bees may serve as a surrogate for non-*Apis* bees, comparisons were made in the daily consumptions rates of pollen and nectar available from the literature as compiled by EFSA (2012). Although there are a number of uncertainties associated with these consumption estimates, the data in **Table 11-34.** and **Table 11-35.** suggest that proposed food consumption rate for adult honey bee workers (292 mg/bee/day) is similar to that for adult bumble bee (210-402 mg/bee/day) and is greater than that of adult female European mason bee and alfalfa leaf cutting bees (45-193 and 110-165 mg/bee/day, respectively). Food consumption rates estimated for 5-day old honey bee larvae (120 mg/bee/day) are greater than rates for larvae of the other non-*Apis* bees (7.8-83 mg/bee/day). These data suggest that the Tier I exposure assessment conducted for oral ingestion of imidacloprid by adult honey bees would be representative (and generally protective) for adults of these non-*Apis* bee species. Similarly, Boyle et al. (2019) also concluded that current information indicates the honey bee is a reasonably appropriate surrogate for non-*Apis* bees with respect to exposure via consumption of nectar and pollen. One caveat to this conclusion is that honey bee larvae are fed processed pollen and nectar continuously in the form of bee bread whereas larvae of bumble bees and other non-*Apis* bees consume pollen and nectar directly from a single mass provision which may lead to differential exposure relative to *Apis* larvae.

Table 11-34. Comparison of oral exposure to pollen and nectar for adult *Apis* and Non-*Apis* bees[1].

Species	Nectar consumption rate (mg/bee/day)*	Pollen consumption rate (mg/bee/day)	Total food consumption rate (mg/bee/day)
Honey bee worker *(A. mellifera)*	**292**	**0.04**	**292**
Bumble bee *(Bombus spp.)*	183-372	27-30	210-402
European mason bee *(Osmia cornuta)*	45-193	N/A	45-193
Alfalfa leaf-cutting bee (*Megachile rotundata*)	110-165	N/A	110-165

[1]From EFSA (2012); N/A = not applicable

Table 11-35. Comparison of oral exposure to pollen and nectar for larval *Apis* and Non-*Apis* bees[1].

Species	Male/ female	Nectar consumption rate (mg/bee/day) *	Pollen consumption rate (mg/bee/day) *	Total food consumption rate (mg/bee/day)
Honey bee *(A. mellifera)*	Female	117	2.7	120
Bumble bee *(Bombus spp.)*	unknown	60	22-23	82-83
European mason bee *(Osmia cornuta)*	Female	1.8	16.3	18
	Male	1.1	9.5	11
Alfalfa leaf-cutting bee (*Megachile rotundata*)	Female	6.2	3.1	9.3
	Male	5.2	2.6	7.8

[1] From EFSA (2012); * = from stored provisions

As discussed previously, non-*Apis* bees are expected to have contact exposure to pesticides via soil and plant material used for nest construction. For the European mason bee, contact exposure to mud by adult females has been estimated at 200 – 400 mg/bee/day. Similarly, contact exposure of alfalfa leaf cutting bees has been estimated at 173 mg/bee/day. Due to the limitations in available data, the current risk assessment process for honey bee does not address exposure via soil and foliar contact exposure which are likely more important for some non-*Apis* bees.

Another important aspect to consider regarding the potential exposure of non-*Apis* bees to sulfoxaflor is the extent to which they are attracted to agricultural crops to which it is registered for use. Based on a recent compilation of crop attractiveness ratings for *Apis* and non-*Apis* bees (USDA 2017), bumble bees are classified as being as (or more) attracted to the crops registered for sulfoxaflor use as honey bees. For certain crops (*e.g.,* tomatoes, blueberries), bumble bees are commercially managed to provide pollination services (although tomato pollination primarily occurs in greenhouses).

11.8.2 Toxicity Considerations

Since risk is a function of both exposure and sensitivity to a chemical, the available information on relative toxicity of sulfoxaflor to Apis and non-Apis bees is summarized in this section.

a. Tier I (Organism) Level

Tier I (organism level) toxicity data for *Apis* and non-*Apis* bees are compared for evaluating the relative sensitivity of *Apis* and non-*Apis* bees to sulfoxaflor. Details of the studies from which these data were obtained are described earlier in **Section 11.2**. Based on these data, the overall range of acute contact toxicity is summarized below in **Table 11-36.** for *Apis* and non-*Apis* bees.

Table 11-36. Comparison of sulfoxaflor acute toxicity to *Apis* and non-*Apis* bees.

Species	Formulation	Acute LD_{50} (µg a.i./bee)	n	MRID (Classification)
Acute Contact Toxicity				
Honey bee *(A. mellifera)*	TGAI	**0.379**	1	47832102 (acceptable)
Honey bee *(A. mellifera)*	TEP (GF 2032 SC) TEP (GF 2372-WG)	0.13 0.224	2	47832419 (acceptable) 47832511 (acceptable)
Bumble bee (*Bombus terrestris)*	TEP (GF 2032 SC)	7.55	1	47832418 (supplemental)
Acute Oral Toxicity				
Honey bee *(A. mellifera)*	TGAI	**0.146**	1	47832103 (acceptable)
Honey bee *(A. mellifera)*	TEP (GF 2032 SC)	0.0515	1	47832417 (acceptable)
Bumble bee (*Bombus terrestris)*	TEP (GF 2032 SC)	0.027	1	47832418 (supplemental)

Value in **bold** indicates the LD_{50} used in to assess risks to the honey bee.

On an acute contact toxicity basis, available data for the TEF (GF 2032-SC) is approximately 60X more toxic to honey bees compared to bumble bees (e.g., LD_{50} = 0.13 vs 7.55 µg a.i./bee for honey bee and bumble bee, respectively). This greater sensitivity of honey bee vs. bumble bee may be related to differences in body size, which has been suggested by some researchers (for review, see Boyle et al., 2019). Thus for at least one species of bumble bee (*B. terrestris*), the acute contact toxicity of sulfoxaflor to honey bees appears to be highly protective. On an acute oral basis, sulfoxaflor TEP GF 2032 SC appears to be similarly toxic (within 2X) to the honey bee and bumble bee (0.0515 vs 0.027 µg a.i./bee, respectively), suggesting that the honey bee is a reasonable surrogate for toxicity to *B. terrestris*. Since there are many species of non-*Apis* bees that have yet to be tested with sulfoxaflor (and/or have suitable test methods developed for regulatory use), the difference in sensitivity to sulfoxaflor relative to the honey bee is not known.

b. Tier II (Colony Level)

Data concerning the effects of sulfoxaflor on non-*Apis* social bees are available for the bumble bee (*B. terrestris*) from one registrant study (Tänzler and Eichler 2017; MRID 50845101) and one open literature study (Siviter et al., 2018). Results from each of these studies is described below.

Tänzler and Eichler 2017 (MRID 50845101)

In this registrant-submitted study, the effects of formulated sulfoxaflor (GF-2626: 125 g/L) on bumblebees (*Bombus terrestris*) was tested using tomato plants in single greenhouse (6015 m^2) which was divided into 14 sections. These sections included:

- 4 untreated control sections;
- 4 treated sections with sulfoxaflor at 24 g a.i./ha/m canopy height (= 0.023 lb a.i./A based on 1.1 m plant height at Day 0);
- 4 treated sections with formulated imidacloprid (Kohinor 200 SL; 20% as) used as a reference toxicant at 2,000 g a.i./ha/m canopy height (= 1.96 lb a.i./A based on 1.1 m plant height at Day 0); and
- 2 sections used for residue monitoring, where 1 was treated with sulfoxaflor at 0.023 lb a.i./A without bumblebees and the other was untreated.

Each section within the control, sulfoxaflor and imidacloprid groups contained a single bumble bee colony; whereas, the two sections used for residue monitoring each contained two colonies. Colonies were placed in their respective section 4 days in advance of application; colonies in the control and sulfoxaflor treatments were closed the evening in advance of application and remained so until the morning of 1 DAT; whereas colonies in the imidacloprid treatment remained open. Applications of sulfoxaflor or imidacloprid were made at full bloom; whereas controls were untreated. In the residue monitoring sections, samples were collected of pollen collected by foraging bumblebees at 1 day after treatment (DAT) and of tomato flowers at 0, 1, 3 and 8 DAT. Biological measures included: mortality inside the colony and at the colony entrance from -2DAT through 27DAT, foraging activity (measured in terms of bite marks on flowers) from -2DAT through 27DAT and colony weight from -4DAT through 27DAT.

Prior to exposure, mortality was not significantly different ($p>0.05$) among control, sulfoxaflor and imidacloprid-treated colonies (mean mortality = 0.9, 1.5 and 1.3 bees, respectively, $p>0.05$). Following application (1 – 27 DAT), mortality from sulfoxaflor-treated colonies (55 dead bees total, 1.4 dead bees/colony/d) was not significantly different from controls (83 dead bees total, 2.1 dead bees/colony/d). However, mean total mortality per day in the imidacloprid treatment was 23.1 bees/colony/day and was significantly ($p<0.05$) higher than controls, thus indicating the ability to detect treatment related differences with the reference toxicant.

Qualitatively, foraging activity of bees in the sulfoxaflor-treated colonies were similar compared to controls (both falling within categories 2 – 3); however, based on bite marks, bees from the sulfoxaflor-treated colonies were more active in terms of the number of visits (bite marks) to a flower. The study authors noted that closing the control and sulfoxaflor colonies until 1 DAT did not appear to have any detrimental effect on the vitality or foraging activity of the bees. Bees from the imidacloprid-treated colonies had foraging categories between 0 – 2 where 0 indicated no bite marks; however, it is important to note that unlike control and sulfoxaflor

sections were bees were closed within their colonies during until 1 DAT, the imidacloprid was applied as bees were actively foraging on 0 DAT.

Prior to exposure, colony weights at -4DAT averaged 764 g, 771 g and 753 g in the control, sulfoxaflor and imidacloprid groups, and there were no statistical differences from controls. Following treatments, there were no statistical differences in colony weight between controls and sulfoxaflor-treated colonies. At 27 DAT mean weight of control colonies was 823 g while mean weight of sulfoxaflor-treated colonies was 824 g ($p>0.05$). The imidacloprid treated colonies averaged 743 g at the end of the study was significantly lower ($p<0.05$) than the control colonies.

No residues of sulfoxaflor were detected in control samples above the limit of quantification (LOQ=10 µg/kg in flowers and pollen). For sulfoxaflor-treated colonies, 1.36 mg a.i./kg was detected in bee-collected pollen. At 0, 1, 3 and 8 DAT, residues in flowers were 0.59, 0.15, and 0.017 mg a.i./kg, respectively, indicating a rapid decline over time. This non-guideline study is considered scientifically sound and but is classified as supplemental (qualitative) due to several limitations in the study design and execution. The main limitations included: 1) no analytical verification of application solutions, 2) controls were not treated but should have been treated with uncontaminated water to account for the effect of spraying, and 3) imidacloprid colonies were not closed during application while controls and sulfoxaflor were closed.

Siviter et al. 2018

In this study, Siviter et al. (2018) examined the effects of a 0.005 mg a.i./L sulfoxaflor in sucrose solution fed to nascent bumblebee colonies (*B. terrestris*) were reared from wild-caught queens. The exposure portion of this study lasted 2 weeks in a laboratory setting followed by a 4-week post exposure monitoring phase and involved 27 paired control and treated colonies at the Royal Holloway University of London campus. Endpoints evaluated included the number of workers, colony mass, worker mortality, relative size of pollen loads, queen survival, number of males and new queens produced, presence of worker and gyne larvae, and the number of pollen and nectar pots.

The study authors report no statistical difference in the quantity of diet consumed between control and sulfoxaflor-treated colonies. The authors report that between 2–3 weeks after exposure, there were detectable differences in the number of workers between control and sulfoxaflor-treated colonies. Treated and control colonies were equally likely to produce male reproductives, but treated colonies produced significantly fewer males in total, where the differences became apparent from approximately 9 weeks onward. There was no difference in the dry weight of males from sulfoxaflor-treated and control colonies, which the study authors indicated could not be used to explain the “differential investment in reproductive biomas”. According to the study authors, neither treated nor control colonies produced an abundance of

queens, but control colonies produced more gynes than treated (*i.e*., 36 new gynes from 3/26 control colonies while no new gynes were produced by any of the 25 treated colonies). The study authors indicate that there were no differences in timing of reproductive onset, queen longevity, and colony survival between sulfoxaflor-treated and control colonies. The daytime foraging censuses revealed no significant differences in the relative number of bees returning to control and sulfoxaflor-treated; there was also no statistical difference between sulfoxaflor-treated and controls in the proportion of workers returning with pollen from Week 8 onwards. The authors state that effects of sulfoxaflor on reproductive out were mediated by the early drop in worker numbers that began 2 – 3 weeks after exposure.

The study authors conclude that chronic exposure to sulfoxaflor as levels consistent with post-spray exposure concentrations resulted in "severe" sublethal effects on bumble bee colonies. Effects included significant reduction in reproductive offspring and hypothesize that direct or indirect effects of sulfoxaflor on a small cohort of the bees may have a cumulative long-term consequence of colony fitness.

However, this study is classified as "invalid" and is not considered appropriate for use in regulatory risk assessment. The primary reasons for invaliding this study include:

- High incident of disease in wild-caught queens (of the 332 wild queens captured, only 52 or 16% could actually be used in the study be due to excessive disease and poor reproductive performance). This high incidence of disease and poor reproductive performance may be indicative of other stressors not measured on the queens which raises questions as to the suitability of these queens for use in toxicity testing;
- Age differences among wild-caught queens spanned approximately 1 month. This may have affected variability in reproductive performance of colonies;
- The sites of study did not appear to be controlled in terms of public access nor were environmental conditions provided at the monitoring sites;
- Test material purity was not specified and concentrations were not verified analytically in feeding solutions;
- Poor reproductive performance in controls (only 3/26 colonies produced new queens) suggest that colonies were not healthy or experienced undue stress during testing; and
- The source of pollen used for feeding was not specified nor were pesticide residues evaluated for potential contamination of the food source.

Comparison to Tier II (Colony-Level Effects): *Apis* and *Bombus*

A comparison of the colony-level effects for honey bees and bumble bees could only be done with the Tier II tunnel exposures with *A. mellifera and B. terrestris* (Tänzler and Eichler 2017, MRID 50845101) since the study by Siviter et al. (2018) is considered invalid for regulatory use. For honey bees, combined oral and contact exposure to a single spray application of 0.021-

0.023 lb a.i./A during foraging resulted in short term (< 3 days) increases in worker mortality and reductions in flight intensity but no sustained impacts on brood development or colony strength; **Table 11-14.**; (MRID 50494501 & 50444501). Colonies of *B. terrestris* exposed to spray applications of 0.023 lb a.i./A on tomato showed no significant increase in mortality, hive weight or foraging activity (Tänzler and Eichler 2017, MRID 50845101). However, it is noted that the bumble bee hives were closed during application which likely reduced their contact exposure compared to the honey bees in the aforementioned Tier II tunnel studies. Therefore, it is difficult to establish firm conclusions regarding the relative sensitivity of honey bee colonies vs. bumble bee colonies to sulfoxaflor based on the available information.

12 Conclusions

Given the uses of sulfoxaflor and sulfoxaflor's environmental fate properties, there is a likelihood of exposure of sulfoxaflor to non-target terrestrial and/or aquatic organisms. However, the potential for acute or chronic risk to fish and aquatic invertebrates is determined to be low, as acute and chronic RQ values do not exceed the respective acute and chronic LOCs of 0.5 and 1. The potential for risk to aquatic and terrestrial plants is also determined to low, as RQ values do not exceed the LOC (1) for aquatic and terrestrial plants.

A potential for acute risk to birds is identified. Specifically, acute, dose-based RQ values calculated using a refined foliar dissipation half-life of 12.3 may exceed the LOC of 0.5 for one avian dietary category and size class at the highest application rate. This risk finding is uncertain because the acute toxicity endpoint used to derive the avian RQ values represents a "non-definitive" endpoint and is based on a threshold for treatment-related increases in regurgitation. Acute and chronic diet-based RQ values do not exceed applicable LOCs for birds.

A potential for chronic risk to mammals is identified. Specifically, chronic dose-based RQ values up to 3.8 were determined using a refined DT_{50} and exceed the LOC of 1 for at least one mammalian dietary category and size class across all uses. For some crops, information from residue-decline trials indicates relatively short half-lives (e.g., a few days), particularly on foliage. For these crops, there is uncertainty regarding whether the relatively short duration of exposure expected in the field would elicit similar reproductive effects as the chronic, 2-generation study with the rat where animals are fed treated diets continuously.

Regarding risks to bees, the following proposed uses of sulfoxaflor are considered to result in low risk to honey bees because they are either not attractive or are harvested prior to bloom:

- Brassica, Leafy, and Bulb vegetables, Barley, Oats, Rye, Teff, Triticale, Wheat, Rice, Commercial Turfgrass, and Conifer/Christmas tree

For proposed uses on honey-bee attractive crops, a potential for acute and chronic risk to honey bees (and non-*Apis* bees for which the honey bee serves as a surrogate) is identified based on Tier I assessment results. Refined Tier I acute and chronic oral RQ values exceed the acute and chronic LOCs for at least one honey bee caste and life stage with all proposed uses with an exposure potential identified for honey bees. Acute contact risks are indicated at the Tier I level (RQ = 0.6 to 1.1) for uses with application rates of 0.047 and higher.

At the Tier II level, results from semi-field tunnel studies indicate risk from combined contact and oral exposure of honey bees are short-lived (3 days or less based on increased worker mortality) when applied during foraging at application rates ranging from 0.02 to 0.07 lb a.i./A. At the highest application rate (0.09 lb a.i./A), elevated mortality rates of forager bees are indicated up to 8 days after application. Importantly, these studies indicate that these short-term effects did not result in longer-term effects on colony strength and brood development, which addresses multiple uncertainties associated with previous assessments.

Also at the Tier II level, a low potential for colony-level risk associated with oral exposure to sulfoxaflor is indicated:

- Pome fruit, Cotton, Canola, and Corn, Sorghum, Millet, and Teosinte

Despite disallowing applications from 3 days prior to bloom until after petal fall, the following proposed uses of sulfoxaflor suggest a potential for colony-level risk resulting from oral exposure:

- Stone fruit, Small fruit, Tree nuts and pistachio, Tree farms or plantations, Home orchards, vineyards, or tree fruits

Furthermore, a potential for colony-level risk is indicated for the following uses which allow one or more applications during bloom:

- Citrus, Strawberry, Animal feeds, Cucurbit and Fruiting vegetables, Root and Tuber, Avocado (Cacao & Pineapple), Legumes, and Ornamentals

It is noted that there is a potential for repeated applications of sulfoxaflor to honey-bee attractive crops during or near bloom to result in combined oral exposures that exceed the 10-d exposure duration of the colony feeding study upon which the Tier II oral risk assessment is based. Such crops where repeated applications may be made during bloom include cucurbits, strawberry, alfalfa (when not harvested before bloom), pineapple, avocado, cacao, attractive fruiting vegetables, attractive root and tubers, and legumes. In addition, honey bee colonies used to pollinate multiple crops in succession could potentially become exposed to sulfoxaflor for combined time periods lasting longer than 10 days. Therefore, it is possible that colony-level

effects could occur at lower dietary concentrations for exposures substantially longer than the 10-d exposure used to establish the current NOAEC of 0.47 mg a.i./kg. The 42-d colony feeding study suggests that long term exposures of honey bee colonies result in a similar NOAEC of 0.43 mg a.i./kg in sucrose solution (MRID 50849601). However, there is uncertainty in this study due to variable exposures encountered with the feeding solutions. If honey bee colonies were to become exposed to sulfoxaflor for periods lasting substantially longer than 10 days and such longer exposures led to greater sensitivity of colonies, there is a potential for the oral Tier II risk assessments results to underestimate colony-level risk to honey bees.

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48755603	Stempniewicz, A. (2012) XDE-208: Chronic Toxicity Effects to Honeybee larvae (Apis mellifera L.) Under Laboratory Conditions (in vitro). Project Number: 120536/B/OCR, 20110132. Unpublished study prepared by Innovative Environmental Services (IES), Ltd. 78p.
48755604	Schmitzer, S. (2011a). Study on the Effect of GF-2626 on Honey Bees and their Brood (Apis mellifera L.) under Semi-Field Conditions - Tunnel Test. Dow Study ID 101599
48755605	Schmitzer, S. (2011b). Study on the Effect of GF-2626 on Honey Bees and their Brood (Apis mellifera L.) under Semi-Field Conditions - Tunnel Test. Dow Study ID 80755
Schmitzer 2011c	Toxicity Testing of GF-2626 on Honey Bees (Apis mellifera L.) under Semi-Field Conditions - Tunnel Test - DAS Study Number: 101602
48755606	Ythier, E. (2012) Sulfoxaflor: A Semi-field Study in Cotton Treated with GF-2372 (Sulfoxaflor 50% WP) to Determine Residues in Matrices Relevant to Exposure of Honeybees and Honey Bee Brood, to Enable Estimation of Exposure of a Typical Honey Bee Colony. Field Phase Conducted in San Joaquin Valley (California, USA). Project Number: 110603/OCR, 14SRUS11C6. Unpublished study prepared by Syntech Research France. 443p.

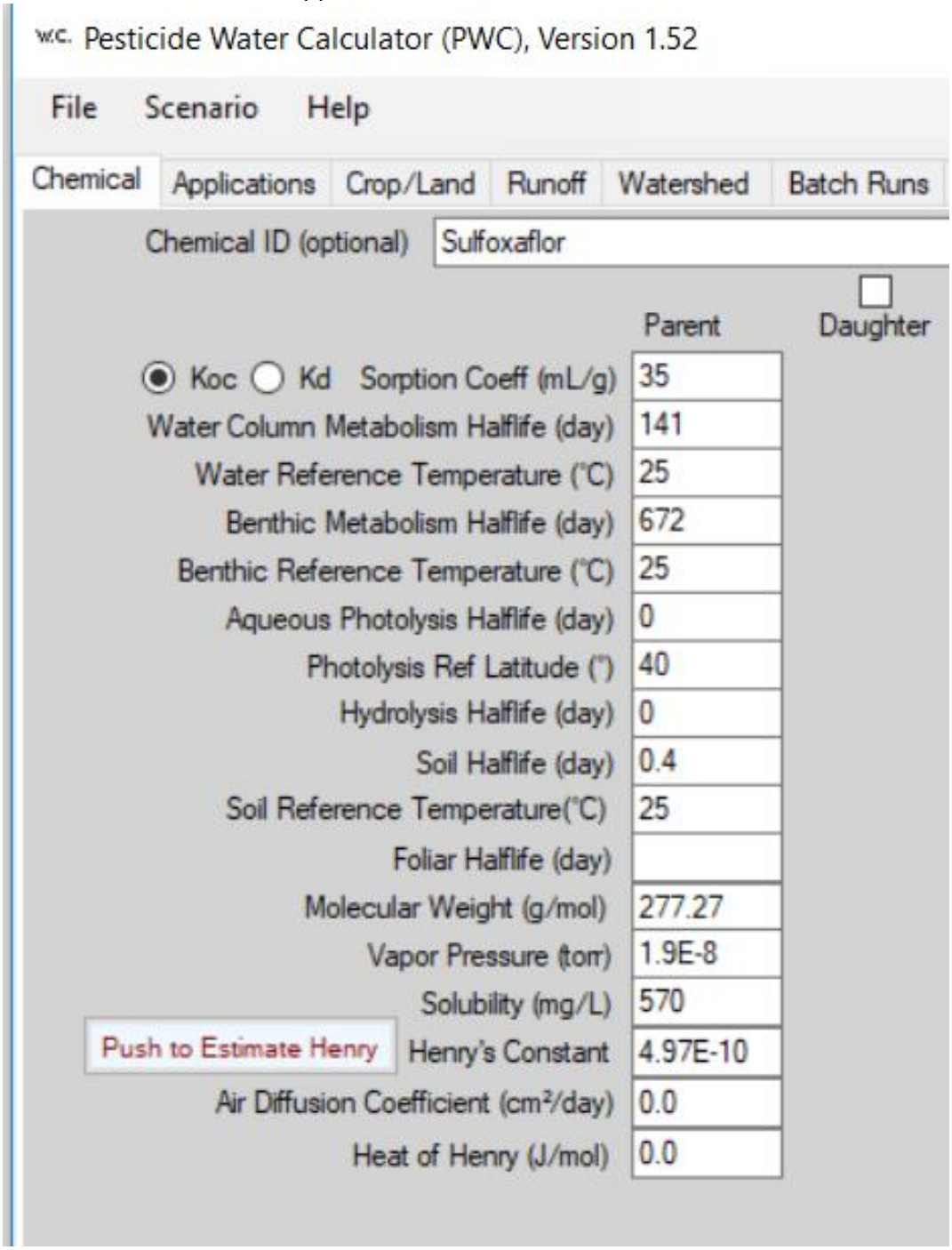
MRID	Study
50024601	Leonard, J.; Moore, S. (2016) Sulfoxaflor: A Laboratory Study to Determine the Chronic Oral Toxicity to the Adult Worker Honey Bee Apis mellifera L. (Hymenoptera: Apidae): Final Report. Project Number: 160359, 014SRUS16C062, 10002528/000/80726/0001. Unpublished study prepared by SynTech Research Laboratory Services, LLC. 156p.
50024602	Leonard, J.; Moore, S. (2016) Sulfoxaflor: A Laboratory Study to Determine the Toxicity by combined Dermal and Dietary Exposure to Larvae and Pupae of the Honey Bee Apis mellifera L. (Hymenoptera: Apidae): Final Report. Project Number: 160358, 014SRUS16C063, 10002528/000/80712/0001. Unpublished study prepared by SynTech Research Laboratory Services, LLC. 148p.
50166901	Verge, E. (2017) Sulfoxaflor-Assessment of Effects on the Adult Honey Bee, Apis mellifera L., in a 10 Day Chronic Feeding Test under Laboratory Conditions: Final Report. Project Number: 160519. Unpublished study prepared by Eurofins Agroscience Services EcoChem GmbH. 90p.
50256403	Bonetti, C. (2016) Evaluate Sulfoxaflor Residues within Nectar at Different Application Periods: Final Report. Project Number: 141091, S15/00896. Unpublished study prepared by Eurofins Lancaster Laboratories. 147p.
50256404	Howerton, J. (2017) GF-2032: Effects and Determination of Residues on Honeybee (Apis mellifera L.) Adults and Brood in Semi-Field Test Conditions. Project Number: 160521, 014SRFR15C08. Unpublished study prepared by SynTech Research Laboratory Services, LLC. 66p.
50355201	Howerton, H.; Gilson, L. (2017) Residues of Sulfoxaflor in Sunflower Nectar and Pollen after Foliar Application with GF-2372: Final Report. Project Number: 150537, 014SRUS15C116, S15/04734. Unpublished study prepared by SynTech Research Laboratory Services, LLC. 147p.
50355202	Louque, R. (2017) Magnitude of Residues of Sulfoxaflor in Nectar, Pollen, and Whole Plants Following Foliar Application of GF-2032 to Pumpkin. Project Number: 160362, 14050/4113, 10002528/002/61010/0008. Unpublished study prepared by Smithers Viscient. 360p.
50355203	Louque, R. (2017) Magnitude of Residues of Sulfoxaflor in Nectar, Pollen, and Whole Flowers Following Foliar Application of GF-2032 to Peach Trees. Project Number: 160581, 14050/4121, 10002528/002/61010/0010. Unpublished study prepared by Smithers Viscient. 343p.
50355204	Louqeu, R. (2017) Magnitude of Residues of Sulfoxaflor in Nectar, Pollen, and Whole Plants Following Foliar Application of GF-2032 to Canola. Project Number: 160365, 14050/4118, 10002528/002/61010/0003. Unpublished study prepared by Smithers Viscient. 353p.
50444401	Belshay, T. (2017) Magnitude of Residues of Sulfoxaflor in Nectar, Pollen, and Whole Plants Following Foliar Application of GF-2372 to Alfalfa. Project Number: 160364, 14050/4117, 10002528/002/61010/0004. Unpublished study prepared by Smithers Viscient. 383p.
50444402	Belshay, T. (2017) Magnitude of Residues of Sulfoxaflor in Nectar, Pollen, and Whole Plants Following Foliar Application of GF-2032 to Strawberries. Project Number:

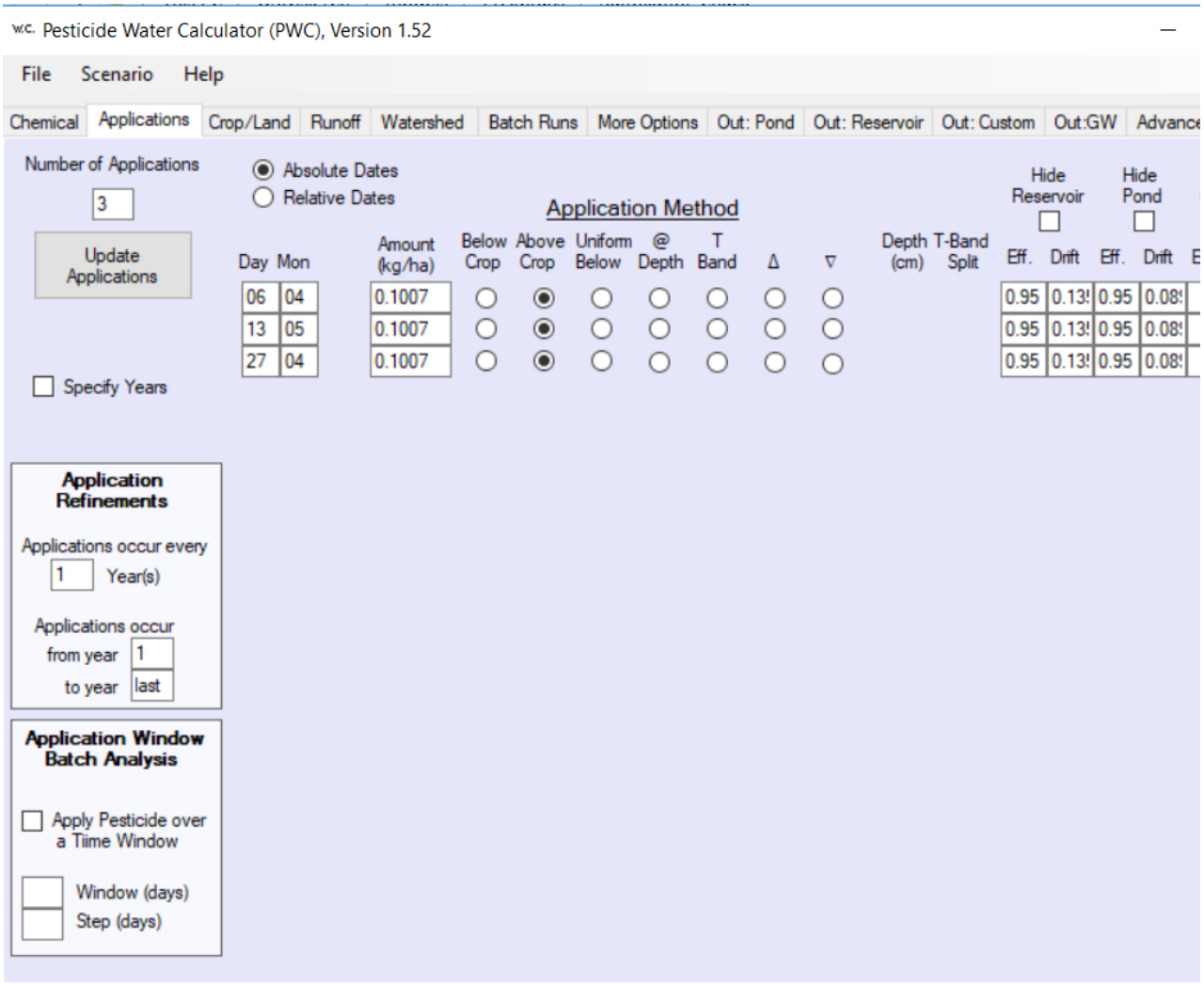
MRID	Study
	160363, 14050/4116, 10002528/002/61010/0006. Unpublished study prepared by Smithers Viscient. 356p.
50444403	Appeltauer, A. (2017) Determination of Residues of Sulfoxaflor in Nectar and Pollen of Pumpkin after One Application of GF-2626 in a Semi-Field Residue Study with Honeybees (Apis mellifera L.) in Central and Southern Europe 2016. Project Number: 160354, S16/00596. Unpublished study prepared by Eurofins Agroscience Services EcoChem GmbH. 159p.
50444404	Appeltauer, A. (2017) Determination of Residues of Sulfoxaflor in Nectar and Pollen of Strawberry Plants after One Application of GF-2626 in a Semi-Field Residue Study with Bumblebees Bombus terrestris L in Central and Southern Europe 2016. Project Number: 160355, S16/00602. Unpublished study prepared by Eurofins Agroscience Services EcoChem GmbH. 162p.
50444405	Appeltauer, A. (2017) Determination of Residues of Sulfoxaflor in Nectar and Pollen of Apple after One Application of GF-2626 in a Semi-Field Residue Study with Honeybees Apis mellifera L in Central and Southern Europe 2016. Project Number: 160356, S16/00603. Unpublished study prepared by Eurofins Agroscience Services EcoChem GmbH. 178p.
50444406	Appeltauer, A. (2017) Determination of Residues of Sulfoxaflor in Nectar and Pollen of Winter Oil Seed Rape after One Application of GF-2372 in a Semi-Field Residue Study with Honeybees Apis mellifera L in Germany 2016. Project Number: 160357, S16/00604. Unpublished study prepared by Eurofins Agroscience Services EcoChem GmbH. 162p.
50444501	Renz, D. (2017) GF-2626 (Sulfoxaflor): Brood Development of the Honey Bee (Apis mellifera L.) in a Semi-Field Tunnel Study in *Phacelia tanacetifola* in Germany 2016: Final Report. Project Number: DAS/150677, S16/01353, 10001643/000/80755/0013. Unpublished study prepared by Eurofins Agroscience Services EcoChem GmbH. 558p.
50444502	Szczesniak, B. (2017) GF-2626 (Sulfoxaflor): Brood Development of the Honey Bee (Apis mellifera L.) in a Colony Feeding Test in Germany 2016: Final Report. Project Number: DAS/160352, S16/01455, 10001643/000/80762/0002. Unpublished study prepared by Eurofins Agroscience Services EcoChem GmbH. 699p.
50494501	Louque, J. (2017) GF-2032 (Sulfoxaflor): Assessment of Effects on Development of the Brood and Adult Workers of the Honey Bees (*Apis mellifera*) in a Semi-Field Tunnel Study after One Application on Buckwheat (*F. esculentum*): Final Report. Project Number: 160360, 14050/4114. Unpublished study prepared by Smithers Viscient. 2223p.
50604601	Howerton, J, Gilson, L (2018). GF-2032: Effects and Determination of Residues on Honeybee (Apis mellifera L.) Adults and Brood in Semi-Field Test Conditions. Dow AgroSciences LLC, Lab Report No. 014SRFR15C08
50845101	Tänzler, V, Eichler, M. (2017). GF-2626: Pollination by Bumble Bees (*Bombus terrestris* L.) in Tomato Plants under Semi-Field Conditions - Greenhouse Study. Study ID: 160353. Unpublished study prepared by Ibacon GmbH. 158 pp
50849601	Louque, J. (2017) Sulfoxaflor: Colony Feeding Study Evaluating Chronic Effects of a Treated Sugar Diet on Honey Bee Colony Health under Free Foraging Conditions: Final

MRID	Study
	Report. Project Number: 160361, 14050/4115. Unpublished study prepared by Smithers Viscient. 1130p.
50849501	Gesell, J. (2019). An Experimental Evaluation of 50% Sucrose Dose Solutions Containing Sulfoxaflor. Dow AgroSciences LLC Study ID: 191247. 52 p

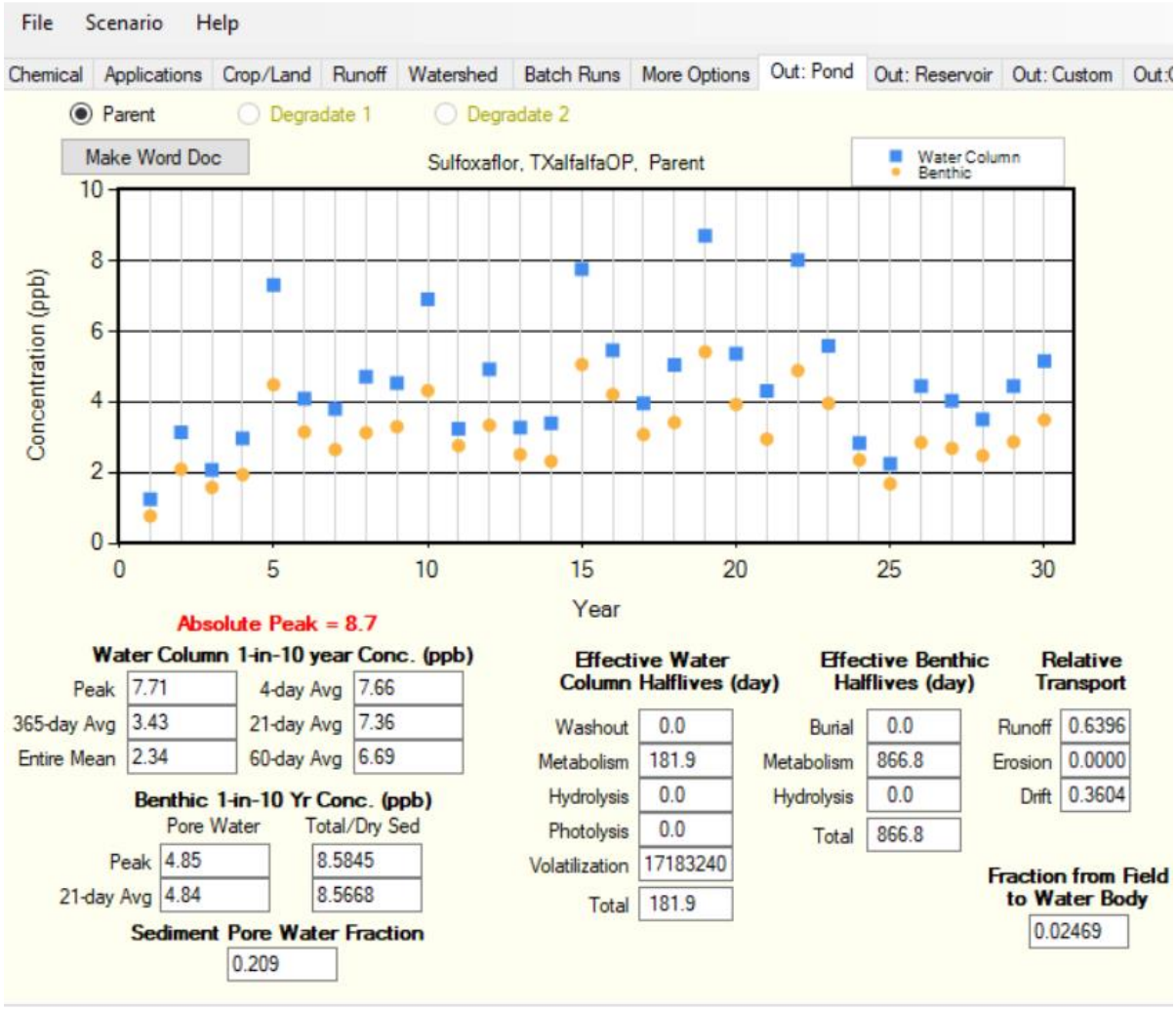
Appendix A. Example Model Runs for Environmental Fate Modeling

Example Run 1: Alfalfa modeling using PWC Version 1.52 and TXalfalfaOP scenario.
INPUTS: Screen Shots for Chemical and Applications

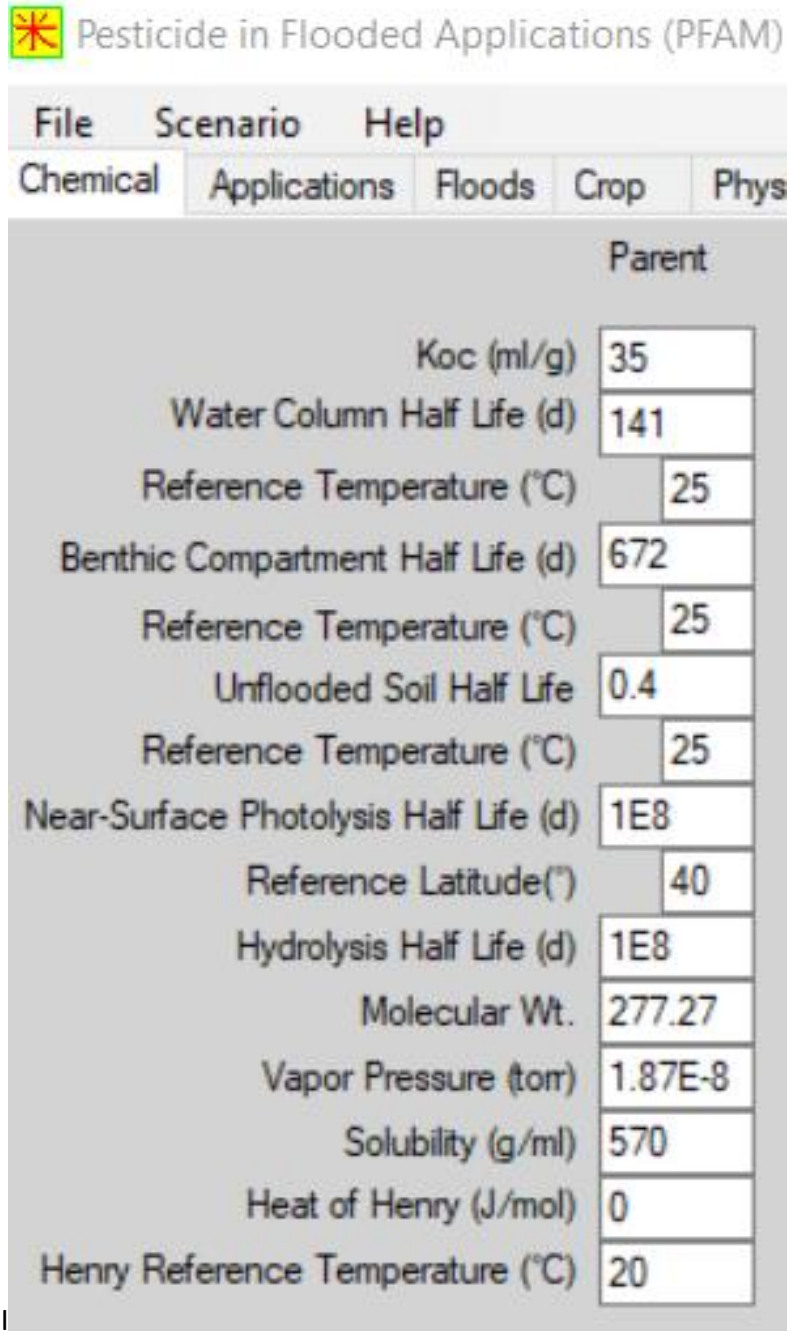


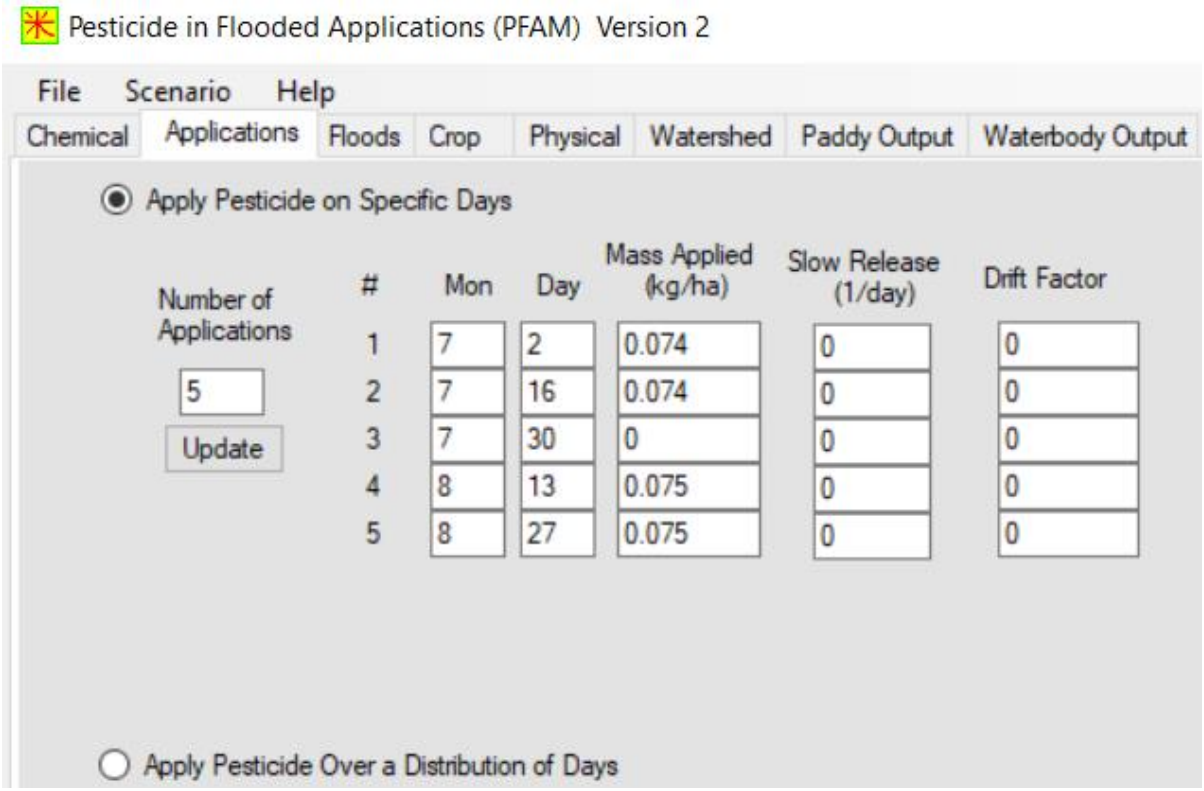

w.c. Pesticide Water Calculator (PWC), Version 1.52
File
Scenario
Help
Chemical
Applications
Crop/Land
Runoff
Watershed
Batch Runs
More Options
Out: Pond
Out: Reservoir
Out: Custom
Out:GW
Advance
Number of Applications
3
Update Applications
Specify Years
Absolute Dates
Relative Dates
Application Method
Day
Mon
Amount (kg/ha)
Below Crop
Above Crop
Uniform Below
@ Depth
T Band
Δ
∇
Depth (cm)
T-Band Split
Hide Reservoir
Hide Pond
Eff.
Drift
Eff.
Drift
06 04 0.1007 0.95 0.95
13 05 0.1007 0.95 0.95
27 04 0.1007 0.95 0.95
Application Refinements
Applications occur every
1
Year(s)
Applications occur
from year
1
to year
last
Application Window Batch Analysis
Apply Pesticide over a Tiime Window
Window (days)
Step (days)

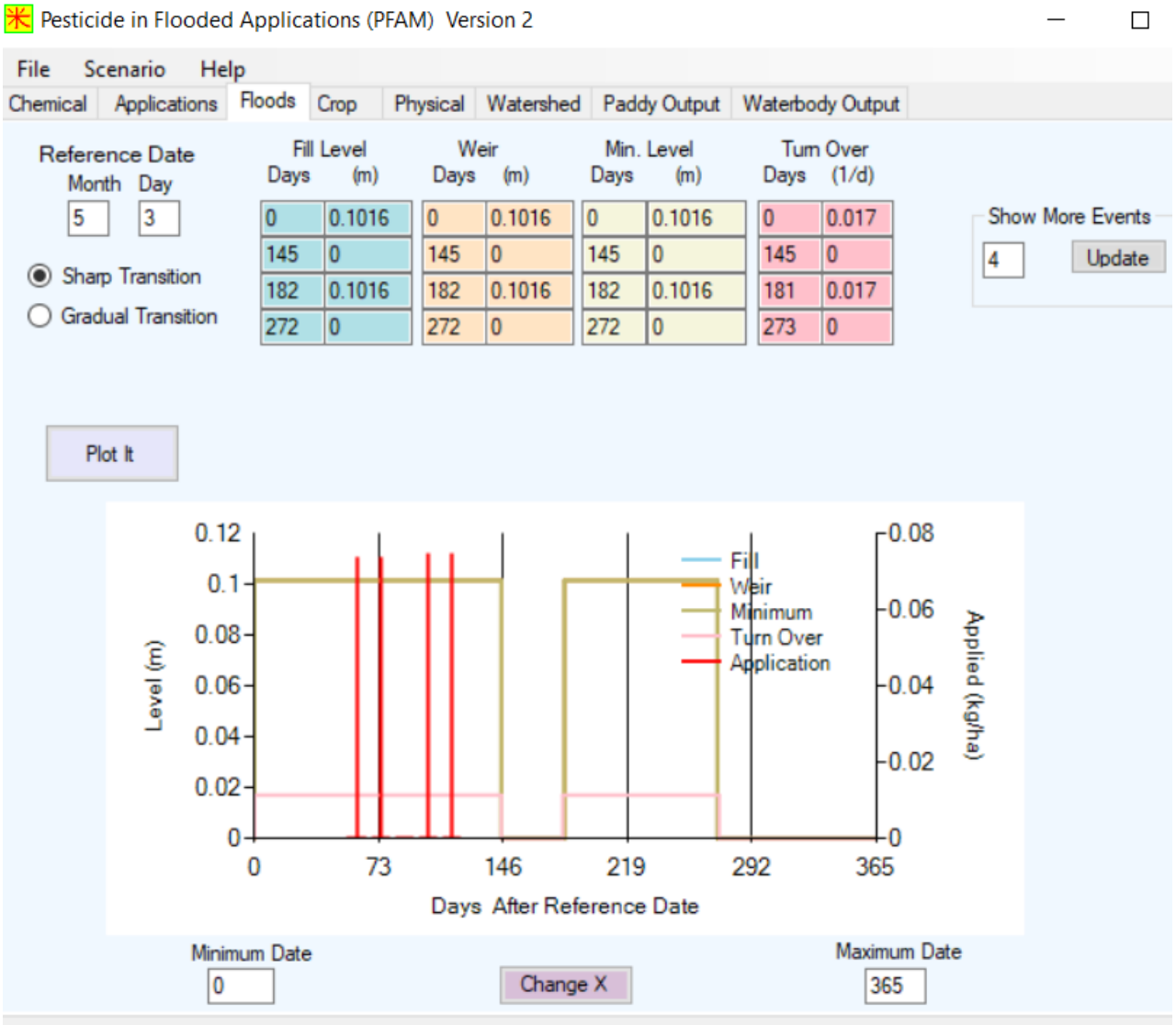
OTPUT: Screen Shot for the 1-in 10 year EEC averages (ppb)



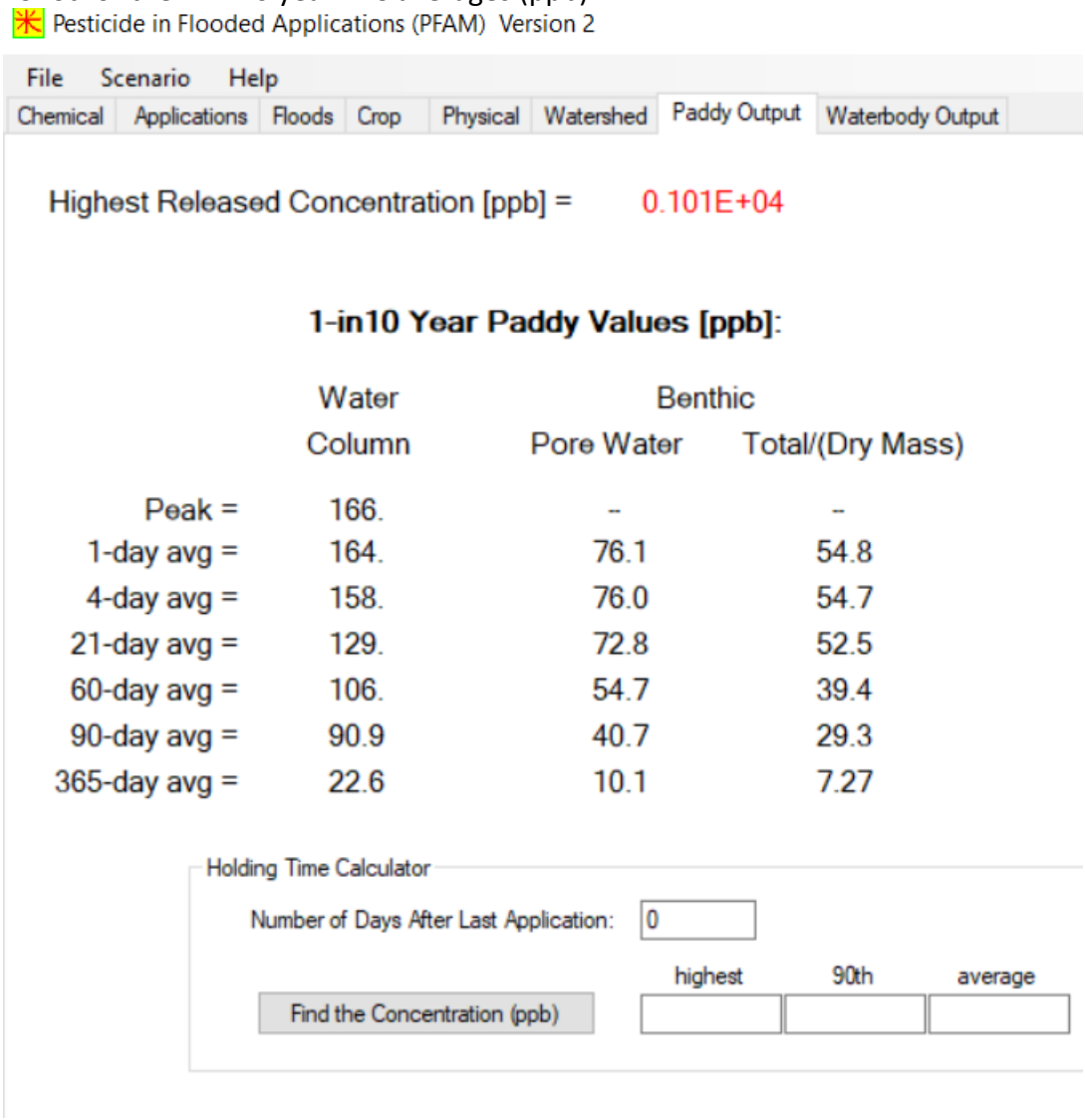
Example Run2: Rice Modeling using PFAM Version 2 and ECO CA Winter scenario
INPUTS: Screen Shots for Chemical; Application; and flood schedule (Flood: 3-May/ drain 25-sep)




Pesticide in Flooded Applications (PFAM) Version 2
File
Scenario
Help
Chemical
Applications
Floods
Crop
Physical
Watershed
Paddy Output
Waterbody Output
Apply Pesticide on Specific Days
Number of Applications
5
Update
Mon Day Mass Applied (kg/ha) Slow Release (1/day) Drift Factor
1 7 2 0.074 0 0
2 7 16 0.074 0 0
3 7 30 0 0 0
4 8 13 0.075 0 0
5 8 27 0.075 0 0
Apply Pesticide Over a Distribution of Days


Pesticide in Flooded Applications (PFAM) Version 2
File
Scenario
Help
Chemical
Applications
Floods
Crop
Physical
Watershed
Paddy Output
Waterbody Output
Reference Date
Month
Day
5
3
Sharp Transition
Gradual Transition
Fill Level
Days
(m)
0
0.1016
145
0
182
0.1016
272
0
Weir
Days
(m)
0
0.1016
145
0
182
0.1016
272
0
Min. Level
Days
(m)
0
0.1016
145
0
182
0.1016
272
0
Turn Over
Days
(1/d)
0
0.017
145
0
181
0.017
273
0
Show More Events
4
Update
Plot It
0.12
0.1
0.08
0.06
0.04
0.02
0
Level (m)
0.08
0.06
0.04
0.02
0
Applied (kg/ha)
Fill
Weir
Minimum
Turn Over
Application
0
73
146
219
292
365
Days After Reference Date
Minimum Date
0
Change X
Maximum Date
365

OTPUT: Screen Shot for the 1-in 10 year EEC averages (ppb)



Appendix B. Example Output for Terrestrial Modeling and Model Parameterization

Example T-REX Upper Bound Kenaga Residues for RQ Calculation

Chemical Name:	Sulfoxaflor	
Use		
Formulation		
Application Rate	0.090	lbs a.i./acre
Half-life	12.3	days
Application Interval	14	days
Maximum # Apps./Year	3	
Length of Simulation	1	year
Variable application rates?	no	

Endpoints			
Avian	Zebra Finch	LD50 (mg/kg-bw)	80.00
	Mallard duck	LC50 (mg/kg-diet)	5620.00
	Mallard duck	NOAEL(mg/kg-bw)	26.00
	Mallard duck	NOAEC (mg/kg-diet)	200.00
Mammals		LD50 (mg/kg-bw)	750.00
		LC50 (mg/kg-diet)	0.00
		NOAEL (mg/kg-bw)	6.07
		NOAEC (mg/kg-diet)	100.00

Dietary-based EECs (ppm)	Kenaga Values
Short Grass	36
Tall Grass	16
Broadleaf plants	20
Fruits/pods/seeds	2.2
Arthropods	14

Avian Results

Avian Class	Body Weight (g)	Ingestion (Fdry) (g bw/day)	Ingestion (Fwet) (g/day)	% body wgt consumed	FI (kg-diet/day)
Small	20	5	23	114	2.28E-02
Mid	100	13	65	65	6.49E-02

Large	1000	58	291	29	2.91E-01
Granivores	20	5	5	25	5.06E-03
	100	13	14	14	1.44E-02
	1000	58	65	6	6.46E-02

Avian Body Weight (g)	Adjusted LD50 (mg/kg-bw)
20	86.37
100	109.95
1000	155.31

Dose-based EECs (mg/kg-bw)	Avian Classes and Body Weights (grams)		
	small	mid	large
	20	100	1000
Short Grass	41	23	10
Tall Grass	19	11	4.8
Broadleaf plants	23	13	5.9
Fruits/pods	2.6	1.5	0.65
Arthropods	16	9.1	4.1
Seeds	0.57	0.32	0.14

Dose-based RQs (Dose-based EEC/adjusted LD50)	Avian Acute RQs Size Class (grams)		
	20	100	1000
Short Grass	0.47	0.21	0.07
Tall Grass	0.22	0.10	0.03
Broadleaf plants	0.27	0.12	0.04
Fruits/pods	0.03	0.01	0.00
Arthropods	0.19	0.08	0.03
Seeds	0.01	0.00	0.00

Dietary-based RQs (Dietary-based EEC/LC50 or NOAEC)	RQs	
	Acute	Chronic
Short Grass	0.01	0.18
Tall Grass	0.00	0.08
Broadleaf plants	0.00	0.10
Fruits/pods/seeds	0.00	0.01
Arthropods	0.00	0.07

Mammalian Results

Mammalian Class	Body Weight	Ingestion (Fdry) (g bwt/day)	Ingestion (Fwet) (g/day)	% body wgt consumed	FI (kg-diet/day)
Herbivores/	15	3	14	95	0.014
	35	5	23	66	0.023

insectivores	1000	31	153	15	0.153
Granivores	15	3	3	21	0.003
	35	5	5	15	0.005
	1000	31	34	3	0.034

Mammalian Class	Body Weight	Adjusted LD50	Adjusted NOAEL
Herbivores/ insectivores	15	10989.15	5.49
	35	8891.40	4.45
	1000	3845.80	1.92
Granivores	15	10989.15	5.49
	35	8891.40	4.45
	1000	3845.80	1.92

Dose-Based EECs (mg/kg-bw)	Mammalian Classes and Body weight (grams)		
	15	35	1000
Short Grass	181.44	125.40	29.07
Tall Grass	83.16	57.48	13.33
Broadleaf plants	102.06	70.54	16.35
Fruits/pods	11.34	7.84	1.82
Arthropods	71.07	49.12	11.39
Seeds	2.52	1.74	0.40

Dose-based RQs (Dose-based EEC/LD50 or NOAEL)	Small mammal 15 grams		Medium mammal 35 grams		Large mammal 1000 grams	
	Acute	Chronic	Acute	Chronic	Acute	Chronic
Short Grass	0.02	33.02	0.01	28.21	0.01	15.12
Tall Grass	0.01	15.14	0.01	12.93	0.00	6.93
Broadleaf plants	0.01	18.58	0.01	15.87	0.00	8.51
Fruits/pods	0.00	2.06	0.00	1.76	0.00	0.95
Arthropods	0.01	12.93	0.01	11.05	0.00	5.92
Seeds	0.00	0.46	0.00	0.39	0.00	0.21

Dietary-based RQs (Dietary-based EEC/LC50 or NOAEC)	Mammal RQs	
	Acute	Chronic
Short Grass	#DIV/0!	3.81
Tall Grass	#DIV/0!	1.74
Broadleaf plants	#DIV/0!	2.14
Fruits/pods/seeds	#DIV/0!	0.24
Arthropods	#DIV/0!	1.49

Derivation of Sulfoxaflor Foliar Dissipation Half Life

For deriving a sulfoxaflor-specific foliar dissipation rate, an abundance of residue-decline data was available from registrant-submitted field residue trials (MRID 48755703). In selecting data sets for calculating the foliar dissipation half-life values, guidelines provided in the T-REX User's Guide was followed. Specifically, residue-decline data sets needed to meet the following criteria in order to be considered for half-life calculation:

1. Day 0 measurement of residues available
2. At least 3 measurement times with residues above the limit of detection
3. R^2 values (ln concentration vs. time) of 0.7 or higher
4. Statistical significance of regression coefficient of 0.1 or lower

Based on these criteria, a total of 44 foliar DT_{50} values were available for sulfoxaflor Individual DT50 values for sulfoxaflor measured in various crops and crop matrices (**Table B-1**). These DT_{50} values consisted of measurements on a variety of crops and plant matrices (*e.g.*, foliage, fruit, seeds, grains and roots. In situations where multiple trials were available within a crop and crop matrix (*e.g.*, multiple values for head lettuce), the DT_{50} values were averaged. The resulting 25 DT_{50} values averaged within a crop matrix are shown in **Table B-2**.

Table B-1. Individual foliar DT_{50} values for sulfoxaflor (source: MRID 48755703)

DT50 (days)	*Cumulative Percentile*	*Crop*	*Matrix*	*DAS Study ID*	*Trial ID*
1.5	2%	Leaf Lettuce	Leaves	80073	80504
1.8	4%	Mustard Greens	Leaves	90129	Trial 1
1.9	7%	Leaf Lettuce	Leaves	101453	CEMS-4690A
2	9%	Head Lettuce	Head	90101	90721
2.1	11%	Radish	Tops	90016	Trial 2
2.2	13%	Head Lettuce	Head	101625	4691A
2.3	16%	Cabbage	Heads	80074	80511
2.3	18%	Cabbage	Heads	80074	80511
2.4	20%	Leaf Lettuce	Leaves	080032-04	CEMS-3939A
2.4	22%	Leaf Lettuce	Leaves	080032-04	CEMS-3939A
2.5	24%	Wheat	Forage	80152	Trial 2
2.7	27%	Head Lettuce	Head	080032-02	3942A
2.7	29%	Head Lettuce	Head	080032-02	3942A
2.9	31%	Cauliflower	Inflorescence	90104	90735
2.9	33%	Cauliflower	Inflorescence	90104	90735
3	36%	Head Lettuce	Head	080032-02	3942C
3.1	38%	Canola	Forage	08008B	80594
3.2	40%	Broccoli	Head/Stems	80074	80509
3.2	42%	Broccoli	Head/Stems	80074	80509
3.2	44%	Broccoli	Head/Stems	80074	80509
3.3	47%	Barley	Straw	80087	80588
3.3	49%	Barley	Straw	80087	80588

DT50 (days)	*Cumulative Percentile*	*Crop*	*Matrix*	*DAS Study ID*	*Trial ID*
3.8	51%	Barley	Forage	80087	80588
3.8	53%	Barley	Forage	80087	80588
4.3	56%	Canola	Forage	90109	90763
4.8	58%	Radish	Roots	90016	Trial 2
5.1	60%	Spinach	Foliage	80013	Trial 2
5.4	62%	Wheat	Straw	80086	80580
6.3	64%	Melon	Fruit	080041-02	3965B
6.4	67%	Canola	Seed	101630	CEMS-4713A
6.4	69%	Canola	Seed	101630	CEMS-4713A
6.6	71%	Tomato	Fruit	80014	2
7.1	73%	Strawberry	Berries	80026	Trial 1
7.1	76%	Strawberry	Berries	80026	Trial 1
7.7	78%	Barley	Grain	80087	80588
8	80%	Pepper	Fruit	90103	90731
8.8	82%	Strawberry	Berries	80089	80577
10.2	84%	Orange	Peel	80093	Trial BR1
11.4	87%	Apricot	Fruit	80085	80566
12.8	89%	Tomato	Fruit	90095	2
23.3	91%	Orange	Fruit	80079	80531
30.2	93%	Orange	Fruit	90035	90741
32.4	96%	Orange	Fruit	80079	80531
40.9	98%	Wheat	Straw	80086	80583

Table B-2. Mean DT50 values for sulfoxaflor measured with various crops and crop matrices

DT50 (days)	*r/n+1*	Crop	Matrix	DAS Study ID	Trial ID
1.8	4%	Mustard Greens	Leaves	90129	Trial 1
2.1	8%	Radish	Tops	90016	Trial 2
2.3	12%	Cabbage	Heads	80074	80511
2.4	15%	Head Lettuce	Head	90101	90721
2.46	19%	Leaf Lettuce	Leaves	80073	80504
2.9	23%	Cauliflower	Inflorescence	90104	90735
2.9	27%	Wheat	Forage	80086	80580
3.2	31%	Broccoli	Head/Stems	80074	80509
3.3	35%	Barley	Straw	80087	80588
3.5	38%	Wheat	Hay	80152	Trial 1
3.7	42%	Canola	Forage	08008B	80594
3.8	46%	Barley	Forage	80087	80588
4	50%	Spinach	Foliage	90102	90726
4.8	54%	Radish	Roots	90016	Trial 2
5.2	58%	Pepper	Fruit	90103	90731
6.3	62%	Melon	Fruit	080041-02	3965B
6.4	65%	Canola	Seed	01630	CEMS-4713A
7.1	69%	Wheat	Grain	80086	80580
7.233333	73%	Tomato	Fruit	80076	80519
7.7	77%	Barley	Grain	80087	80588
7.95	81%	Strawberry	Berries	80089	80577
10.2	85%	Orange	Peel	80093	Trial BR1
11.4	88%	Apricot	Fruit	80085	80566
23.15	92%	Wheat	Straw	80086	80580
28.63333	96%	Orange	Fruit	80079	80531

Appendix C. Listed Species

In November 2013, the EPA, along with the Services and the United States Department of Agriculture (USDA), released a summary of their joint Interim Approaches for assessing risks to endangered and threatened (listed) species from pesticides. The Interim Approaches were developed jointly by the agencies in response to the National Academy of Sciences' (NAS) recommendations and reflect a common approach to risk assessment shared by the agencies as a way of addressing scientific differences between the EPA and the Services. The NAS report[1] outlines recommendations on specific scientific and technical issues related to the development of pesticide risk assessments that EPA and the Services must conduct in connection with their obligations under the ESA and FIFRA.

EPA received considerable public input on the Interim Approaches through stakeholder workshops and from the Pesticide Program Dialogue Committee (PPDC) and State-FIFRA Issues Research and Evaluation Group (SFIREG) meetings. As part of a phased, iterative process for developing the Interim Approaches, the agencies will also consider public comments on the Interim Approaches in connection with the development of upcoming Registration Review decisions. The details of the joint Interim Approaches are contained in the white paper *Interim Approaches for National-Level Pesticide Endangered Species Act (ESA) Assessments Based on the Recommendations of the National Academy of Sciences April 2013 Report*[2], dated November 1, 2013.

Given that the agencies are continuing to develop and work toward implementation of the Interim Approaches to assess the potential risks of pesticides to listed species and their designated critical habitat, this ecological risk assessment for sulfoxaflor does not contain a complete ESA analysis that includes effects determinations for specific listed species or designated critical habitat. Although EPA has not yet completed effects determinations for specific species or habitats, this assessment assumed, for all taxa of non-target wildlife and plants, that listed species and designated critical habitats may be present in the vicinity of the application of sulfoxaflor. This assessment will allow EPA to focus its future evaluations on the types of species where the potential for effects exists once the scientific methods being developed by the agencies have been fully vetted. Once the agencies have fully developed and implemented the scientific methodology for evaluating risks for listed species and their designated critical habitats, these methods will be applied to subsequent analyses for sulfoxaflor as part of completing this registration review.

Appendix D. New Honey bee tier I study summaries

[1] *Assessing Risks to Endangered and Threatened Species from Pesticides.* Available at http://www.nap.edu/catalog.php?record_id=18344

[2] Available at http://www2.epa.gov/endangered-species/assessing-pesticides-under-endangered-species-act#report

Adult Chronic Oral Toxicity

MRID 50024601. Adult honey bees, *Apis mellifera*, (0-2 days post emergence) were exposed to Sulfoxaflor for 10 days in a feeding study at measured concentrations of <0.002 (control), 0.04921, 0.09314, 0.1732, 0.3204, and 0.5751 mg ai/kg diet, corresponding to a mean intake of 0.002157, 0.003493, 0.006467, 0.01160, and 0.01839 µg ai/bee/day. The mean accumulated intake doses were 0.02157, 0.03493, 0.06467, 0.1160, and 0.1839 µg ai/bee.

After 10 days, mortality averaged 0% in the negative control, and ranged from 0% to 23% across all treatment groups. The weight of surviving bees was not determined. Based on the actual intake doses, the 10-day NOAEL and LOAEL values for mortality and food consumption were 0.01160 and 0.01839 µg ai/bee/day, respectively. The LOAEL of 0.01839 µg ai/bee/day corresponds to 23% mortality and 17% reduction in food consumption relative to controls.

The sublethal effects were limited to affected bees in the 0.1732, 0.3204, and 0.5751 mg ai/kg diet groups. Behavioral effects started on day 5 and primarily included disorientation and the bees falling on their backs as they tried to climb the walls of the test cage. The unusual behavior observed in the 0.1732 mg/kg treatment is likely due to the diet preparations on days 7 and 8 being more than 200% of the nominal concentration. Other treatments also had reported deviations from nominal concentrations on days 7 and 8 (187% to 329%). Small but still substantial deviations from nominal (144% to 178%) were also observed on days 3, 4 and 9 for some treatments. Reasonable agreement was observed between measured and nominal concentrations (70%-130%) on the other days of the study, which suggests a dosing error of some kind occurred in the study rather than simply high variation in analytical measurements. This study is classified as supplemental (qualitative) due to the elevated test concentrations which deviated widely from nominal concentrations on selected days during the study.

MRID 50166901. Adult honey bees, Apis mellifera L., were exposed to Isoclast (Sulfoxaflor) for 10 days in a feeding study at mean measured concentrations of 25.4, 51.3, 105, 207, and 433 µg ai/kg diet which were equivalent to dietary doses of 0.78, 1.77, 3.13, 5.39, and 9.98 ng ai/bee/day using information on consumption rates.

After 10 days, mortality was 2.5, 5.0, 2.5, 0, and 0% in the measured 25.4, 51.3, 105, 207, and 433 µg ai/kg diet treatment groups, respectively, as compared to 5% in the negative control. Mean food consumption was significantly reduced by 23% relative to negative controls at the 433 µg ai/kg diet and was not significantly different in any other treatment group. Based on the dietary concentrations, the 10-day NOAEC was 435 µg ai/kg diet based for mortality and 206 µg ai/kg diet based on reduced food consumption. When expressed as dietary doses, the 10-day NOAEL was 9.98 µg ai/bee/day for mortality and 5.39 µg ai/bee/day for reduction in food consumption. No other sublethal effects were observed at any treatment concentration in the study. This study is classified as acceptable.

Larval Chronic Toxicity

MRID 50024602. Individual synchronized honey bee (*Apis mellifera*) larvae (first instar; L1 on Day 1 of the study) were exposed in vitro to sulfoxaflor TGAI (95.6%) from Day 3 to Day 8 of the study. The mean measured dietary concentrations were 0 (negative and solvent control), 0.1656, 0.3316, 0.6816, 1.321, and 2.594 mg ai/kg diet, which corresponded to dietary doses of 0 (negative and solvent control), 0.02620, 0.05286, 0.1086, 0.2120, and 0.4147 µg ai/larva, respectively. All groups consisted of four replicates with 12 larvae/replicate; each larva was contained within a plastic grafting cell that was within a 48-well cell culture plate. After Days 7-8, upon the first observation of a completely consumed diet, the larvae were transferred to pupation plates.

On Day 8, cumulative larval mortality averaged 2 and 0% in the negative and solvent control, respectively, and ranged from 0 to 4% in the treatment groups. On Day 22, pupal mortality averaged 15 and 8% in the negative and solvent control, respectively, and ranged from 10 to 40% in the treatment groups. Emergence averaged 85 and 92% in the negative and solvent controls, respectively, and ranged from 60 to 90% in the treatment groups. Adult live weight averaged 0.0922 and 0.0928 g in the negative and solvent control, respectively, and ranged from 0.0829 to 0.0890 g in the treatment groups.

There were no significant effects on Day 8 and 15 mortality. While mortality at test termination and emergence were affected in this study, the effects were not sufficient to elicit an effect ≥50%.
The NOAEC for Day 22 mortality and adult emergence was 1.321 mg ai/kg (equivalent to 0.2120 µg ai/larva). The LC50 and EC50 values were both >2.594 mg ai/kg diet (equivalent to >0.4147 µg ai/larva). This study is classified as acceptable.

Appendix E. Default BeeRex Example Output

Table 1. User inputs (related to exposure)

Description	Value
Application rate	0.090
Units of app rate	lb a.i./A
Application method	foliar spray

Table 2. Toxicity data

Description	Value (µg a.i./bee)
Adult contact LD50	0.13
Adult oral LD50	0.146
Adult oral NOAEL	0.0054
Larval LD50	0.415
Larval NOAEL	0.212

Table 3. Estimated concentrations in pollen and nectar

Application method	EECs (mg a.i./kg)	EECs (µg a.i./mg)
foliar spray	9.9	0.0099

Table 4. Daily consumption of food, pesticide dose and resulting dietary RQs for all bees

Life stage	Caste or task in hive	Average age (in days)	Jelly (mg/day)	Nectar (mg/day)	Pollen (mg/day)	Total dose (µg a.i./bee)	Acute RQ	Chronic RQ
Larval	Worker	1	1.9	0	0	0.00	0.00	0.00
		2	9.4	0	0	0.00	0.00	0.00
		3	19	0	0	0.00	0.00	0.01
		4	0	60	1.8	0.61	1.47	2.89
		5	0	120	3.6	1.22	2.95	5.77
	Drone	6+	0	130	3.6	1.32	3.19	6.24
	Queen	1	1.9	0	0	0.00	0.00	0.00
		2	9.4	0	0	0.00	0.00	0.00
		3	23	0	0	0.00	0.01	0.01
		4+	141	0	0	0.01	0.03	0.07
Adult	Worker (cell cleaning and capping)	0-10	0	60	6.65	0.66	4.52	122.19
	Worker (nurse bees)	6 to 17	0	140	9.6	1.48	10.14	274.27
	Worker (comb building)	11 to 18	0	60	1.7	0.61	4.18	113.12

	Worker (foraging for pollen)	>18	0	43.5	0.041	0.43	2.95	79.83
	Worker (foraging for nectar)	>18	0	292	0.041	2.89	19.80	535.41
	Worker (maintenance of hive in winter)	0-90	0	29	2	0.31	2.10	56.83
	Drone	>10	0	235	0.0002	2.33	15.93	430.83
	Queen (laying 1500 eggs/day)	Entire life stage	525	0	0	0.05	0.36	9.63

Table 5. Results (highest RQs)

Exposure	Adults	Larvae
Acute contact	1.87	NA
Acute dietary	19.80	2.95
Chronic dietary	535.41	5.77

Appendix F. Honey bee residue study summaries

Previously Reviewed Residue Data

Previously Reviewed Residue Data

For sulfoxaflor, pollen and nectar residue data were described in the previous Section 3 risk assessment (D382619) for multiple studies including:

- a semi-field tunnel study with cotton (MRID 48755606);
- a pumpkin residue trial (MRID 48755601); and,
- two semi-field tunnel studies with *Phacelia* (MRID 48476601 and 48445806).

Maximum reported residues of sulfoxaflor in various plant and hive matrices are shown in **Table** Error! Reference source not found.**F-1** below.

Table F-1. Maximum Measured Residues (mg ai/kg) of Sulfoxaflor in Plant and Hive Materials from Various Field Studies.

Application Rate (lb a.i./A)	Plant Pollen	Plant Nectar	Plant Tissue	Forager Nectar*	Forager Pollen*	Comb Pollen	Comb Larvae	MRID
Cotton (Apps. during bloom, 10-d sampling, in tunnels)								
1 x 0.045	1.26	ns		0.13	0.22	0.03	<0.01	48755606
2 x 0.045	2.54	ns	ns	0.05	0.83	0.04	0.01	
2 x 0.089	6.66	ns	ns	0.07	2.78	1.19	0.03	
2 x 0.134 [c]	2.61	ns	ns	1.01	2.23	0.04	0.08	
Phacelia								
1 x 0.021	ns	ns	0.52[b]	0.05	0.29	ns	ns	48476601
1 x 0.043	ns	ns	1.48[b]	0.09	0.81	ns	ns	
Phacelia								
1 x 0.006	ns	ns		ns	ns	0.06[a]	ns	48445806
1 x 0.012	ns	ns		ns	ns	0.04[a]	ns	
1 x 0.021	ns	ns	1.76[b]	ns	ns	0.61[a]	ns	
1 x 0.045	ns	ns		ns	ns	0.23[a]	ns	
1 x 0.088	ns	ns		ns	ns	1.01[a]	ns	
Pumpkin								
2 x 0.022	0.08	0.03	0.20[b]	ns	ns	ns	ns	48755601
2 x 0.089	0.38	0.03	1.27[b]	ns	ns	ns	ns	

[a] Samples taken 7 days after treatment rather than immediately after treatment
[b] Whole plant samples in study MRID 48476601, flower samples in study MRID 48445806, leaf tissue in study MRID 48755601.
[c] Not considered in the current risk assessment since the single application rate (0.134 lb a.i./A) exceeds the maximum single rate for the proposed Section 3 (0.09 lb a.i./A).
* Used for refining default estimates of oral exposure of bees to sulfoxaflor.
Shaded ("ns" not sampled) cells indicate no data are available for the applicable matrix.

Newly Reviewed Residue Data

Additional studies containing relevant residue data were submitted after the previous Section 3 risk assessment (D382619) including:

- Alfalfa (MRID 50444401)
- Apple (MRID 50444405)
- Buckwheat (residues from tunnel study; MRID 50494501; 50604601)
- Canola (MRID 50444406; 50355204)
- Citrus (MRID 50256403)
- Peach (MRID 50355203)
- *Phacelia* (residues from tunnel study; MRID 50444501)
- Pumpkin (MRID 50355202; 50444403)
- Strawberry (MRID 50444402; 50444404)
- Sunflower (MRID 50355201)

A summary of each study is provided below.

Alfalfa (MRID 50444401). This study was designed to measure the magnitude of residues of sulfoxaflor and its four major metabolites, X11579457, X11719474, X11519540 and X11721061, in alfalfa (*Medicago sativa*) whole plant, nectar and pollen, which represent potential exposure risks to pollinators in the field. Two separate trials were conducted, at locations in North Carolina (Trial 1) and California (Trial 2). Three subplots at each trial location received two foliar applications of Transform® WG at 0.090 lb ai/A/application, based on a maximum seasonal rate of 0.186 lb ai/A, applied in two application timings at the minimum retreatment interval of 7 days. Whole plants were collected from each site prior to treatment, and whole plant and flower samples (for nectar and pollen) were collected from early- through late-bloom for residue analysis (0 through 14 Days After Last Application [DALA]). Samples were collected and analyzed by validated analytical methods to determine the residue concentrations. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2372 (49.4% a.i.)
Crop	Alfalfa
Variety	NA
Sites/Location	2 sites (Hertford, NC and Live Oak, CA)
Application Methods	Commercial boom sprayer
Application Rates (lb ai/A)	0.090 x 2 @ 7 (NC) or 10 (CA) days apart (0.18 total)
Application Timing	NC Site: 1st Appl pre-bloom (BBCH 60-61); 2nd appl during bloom (BBCH 62-63). CA Site: 1st appl pre-bloom (BBCH 60); 2nd appl. during bloom (BBCH 63)
Matrices	Hand collected nectar, pollen, and whole plant
Design	3 replicate plots/site; 2 sites
Sample Timing	0, 1, 2, 7 & 14 DALA; with control whole plant sample -7 or -10 DALA

Study Element	Description
Residue QA/QC	Nectar and pollen spike recoveries near LOQ were occasionally 2X expected result; Recoveries of spikes made 100-1000X the LOQ were within the acceptable range of 70-120%

Results: Concentrations of residues were higher in California relative to North Carolina, and were found at greatest concentrations in pollen, followed by nectar, and then whole plant tissue. Maximum mean concentrations of sulfoxaflor observed at the California trial (0 DALA) were 58.4 mg ai/kg in pollen, 19.8 mg/kg in nectar, and 6.89 mg/kg in whole plant. Maximum mean concentrations of sulfoxaflor at the North Carolina trial (0 DALA) were 7.7 and 10.3 mg ai/kg in pollen and nectar samples, respectively (**Table F-2**). Mean residues sulfoxaflor in nectar and pollen declined by an order of magnitude within 2 days after application at the NC site. Mean sulfoxaflor residues in nectar and pollen declined by 50% or more within 2 days after application at the CA site. By 7 days after application residues in nectar (both sites) and pollen (NC site) were near or below 0.1 mg ai/kg. Residues of sulfoxaflor in pollen remained elevated (10.5 mg ai/kg) at the CA site, but then declined by an order of magnitude 7 days later. Raw data for nectar and pollen are plotted in **Figure F-1** and **Figure F-2**, respectively

Table F-2. Mean residues of sulfoxaflor in hand collected nectar and pollen in alfalfa

DALA	Mean Sulfoxaflor in Nectar (mg ai/kg)		Mean Sulfoxaflor in Pollen (mg ai/kg)	
	NC Site	CA Site	NC Site	CA Site
0	10.3	19.8	7.7	58.4
1	1.5	14.3	0.53	49.9
2	0.53	4.5	0.15	26.8
7	0.02	0.16	0.02	10.5
14	0.001	0.11	0.004	0.26

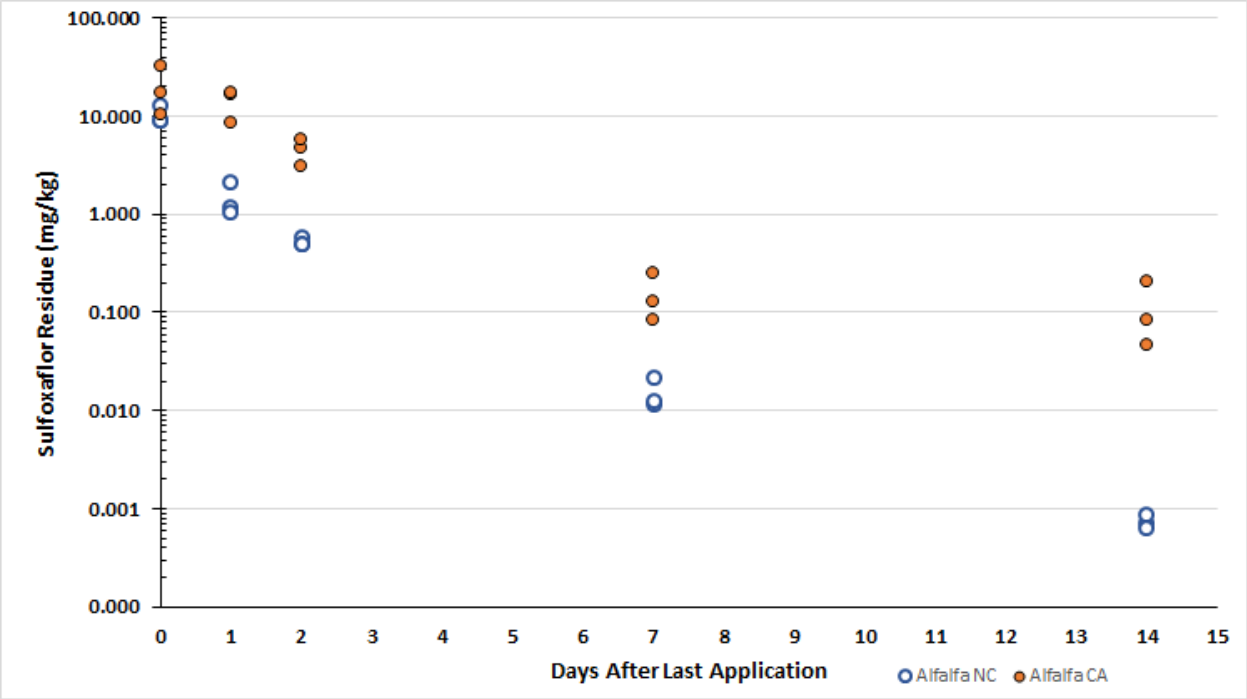


Figure F-1. Residues of sulfoxaflor measured in hand-collected nectar following foliar spray applications of 0.09 lb a.i./A to alfalfa

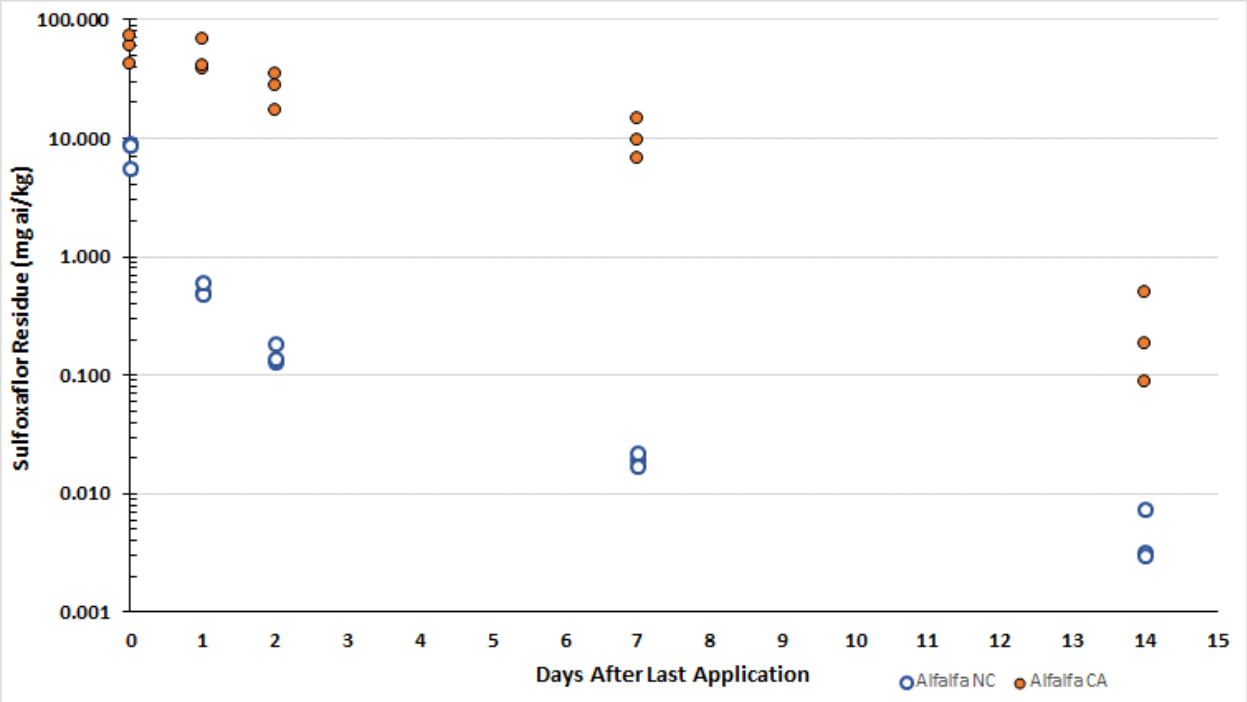


Figure F-2. Residues of sulfoxaflor measured in hand-collected pollen following foliar spray applications 0.09 lb a.i./A to alfalfa

Apple (MRID 50444405). The study objective was to determine sulfoxaflor residue levels in nectar and pollen, collected by forager honey bees, from apple trees after one application of

GF-2626 under confined semi-field conditions. This study was conducted in four separate field trials in Southern Germany and Southern France during 2016. Trials 1 and 2 were located in Southern Germany (Baden- Württembuerg) 59 km apart and Trials 3 and 4 were located in Southern France (Lot et Garonne and Tarn-et-Garonne) 72 km apart. The test item, GF-2626, was applied to apple trees and residues of the active ingredient, sulfoxaflor, was measured in nectar and pollen of apple flowers. The study consisted of one treatment group per trial and one application in the test item treatment group per trial (during flowering), at a target rate of 48 g a.i/ha (nominal). Two commercial honey bee colonies were placed in each tunnel at the beginning of flowering before the application. Bees were used as a sampling device for nectar and pollen only. Single composite samples of forager bees (for analysis of nectar) and pollen traps (for analysis of pollen) were collected once before application and subsequently on 3 to 4 sampling dates after the application. Trial 1 was sampled on -2, 1, 3, and 4 days after application, in trial 2 on -1, 1, 3, 4, and 6 days after application, in trial 3 on 0, 1, 3, 6, and 7 days after application and in trial 4 on 0, 1, 5, and 8 days after application. Samples were collected and analyzed by validated analytical methods to determine the residue concentrations. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2626
Crop	Apple
Variety	Braeburn (Sites 1&2); Canada (Site 3); Granny Smith (Site 4)
Sites/Location	Site 1 (Wössingen, Germany); Site 2 (Katzental, Germany); Site 3 (Feugarolles, France; Site 4 (Meauzac, France)
Application Methods	Sites 1 & 2: Backpack sprayer; Sites 3 & 4 (Mist blower)
Application Rates (lb ai/A)	0.043, 0.041, 0.042, 0.043 (Sites 1-4, respectively), single application
Application Timing	During bloom (BBCH 63-66)
Matrices	Bee-collected nectar (300 bees/sample), Pollen from traps (0.2g/sample)
Design	Tunnels (140-180 m2) with blooming trees + 2 hives with bees used for sampling
Sample Timing	1 before application, 3-4 sampling events after application; single sample composites; -2 to 8 DALA
Residue QA/QC	Nectar and pollen spike recoveries = 85-103%

Results: One application of GF-2626 was applied to apple trees, under confined semi-field conditions, at a nominal application rate of 48.0 g ai/ha and yielded detectable residues of sulfoxaflor in nectar and pollen samples. No residues of sulfoxaflor were detected in nectar and pollen samples at or above the LOD in untreated control samples taken before application in all trials. Overall, residues were greater in pollen than in nectar, and were generally greater in samples collected from the German sites as compared to the sites in southern France (**Figure F-3 and Figure F-4**). Sulfoxaflor residues showed a clear decline in both matrices from the sampling directly after application to the last sampling date. Although some peaks were observed in trials 1 and 4 in nectar samples, these were within the normal range of variations occurring for field residues specimens. Trial 1 yielded the maximum residue values detected in apple tree pollen and nectar with residues of 5.19 mg/kg and 0.181 mg/kg, respectively.

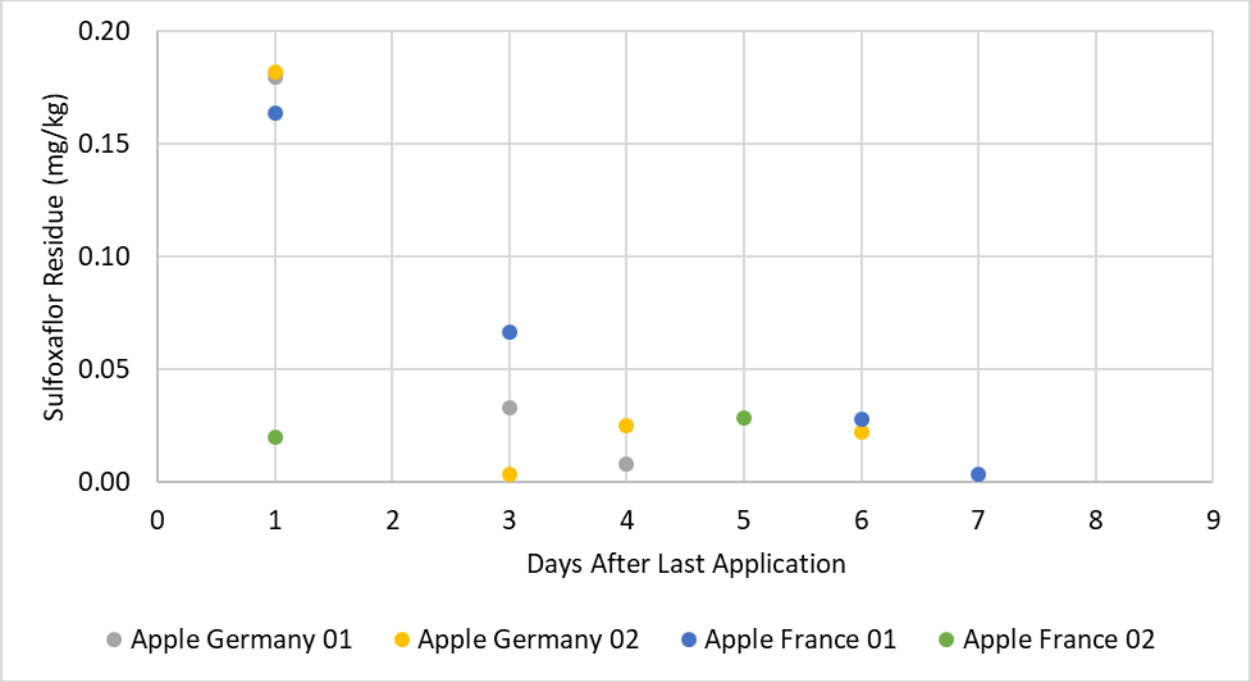


Figure F-3. Mean residues of sulfoxaflor in bee-collected nectar following foliar spray application of 0.04 lb a.i./A to apple trees

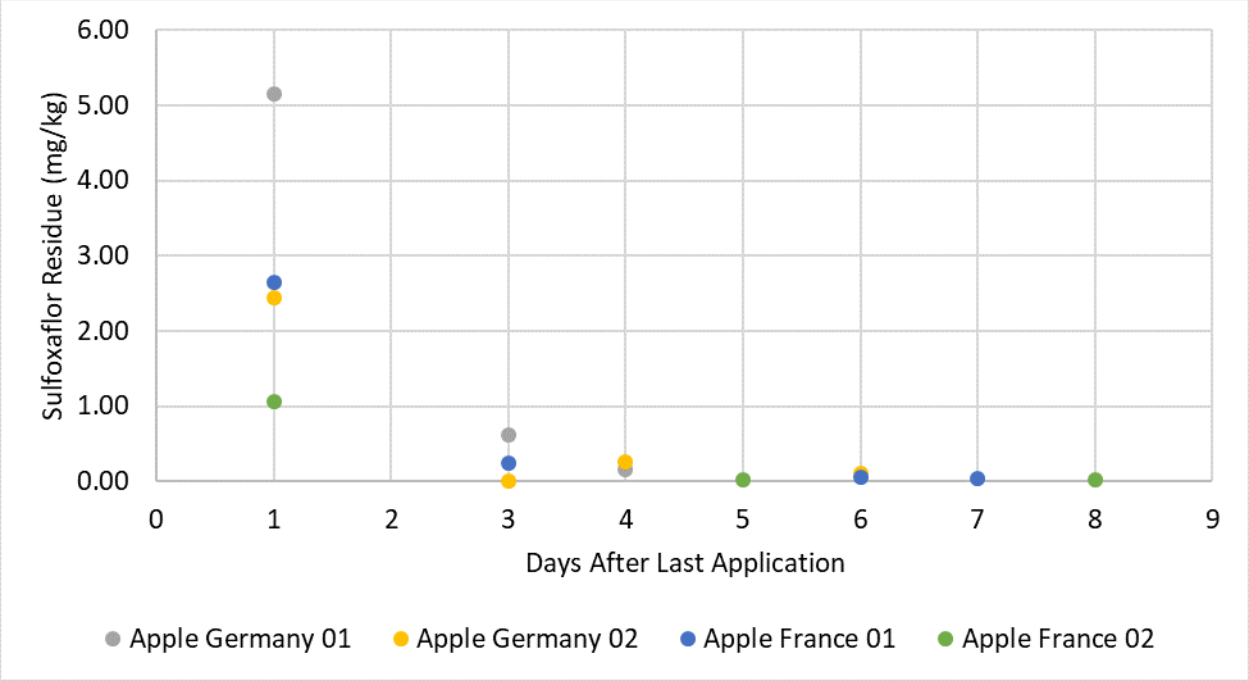


Figure F-4. Mean residues of sulfoxaflor in bee-collected pollen following foliar spray application of 0.04 lb a.i./A to apple trees

Buckwheat (MRID 50494501; 50604601). Two semi-field tunnel studies were submitted which evaluated foliar spray applications to buckwheat in North Carolina and Kansas. Results from the residue portion of these studies are described in **Appendix I.**

Canola (MRID 50444406). The study objective was to determine sulfoxaflor residue levels in nectar and pollen, collected by forager honey bees, from winter oil seed rape after one application of GF-2372 under confined semi-field conditions. Four separate field trials were conducted in Germany during 2016. Trial 1 was located near Stutensee, trial 2 near Pforzheim, trial 3 near Bodelshausen, and trial 4 near Heilbronn, Baden Württemberg. The study consisted of one treatment group per trial: The test group T (1 replicate/tunnel; control samples were taken as pre-sampling from the same tunnel as T before application). There was one application in the test item treatment group per trial (at the beginning of flowering), at a target rate of 24 g ai/ha (nominal). Two honey bee colonies were placed in each tunnel at the beginning of flowering before application. Nectar and pollen samples were collected from forager bees between three and five collection times post application and once before. Trial 1 was sampled on -7, 0, 2, and 10 days post application. Trial 2 was sampled on -1, 0, and 8 days after application. Trial 3 was sampled on -3, 0, 3, 5, and 7 days after application. In trial 4 samples were collected on -1, 0, 2, and 10 days after application. On every sampling day a pooled sample of at least 600 forager bees was collected and divided into two samples (A and R), each containing at least 0.2 g. Samples were collected and analyzed by validated analytical methods to determine the residue concentrations. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2372 (49.4% a.i.)
Crop	Winter oil seed rape (*Gossypium hirsutum*)
Variety	Acala
Sites/Location	4 sites in Southern Germany. Trial 1 (Stutensee), Trial 2 (Pforzheim); Trial 3 (Bodelshausen), Trial 4 (Heilbronn)
Application Methods	Commercial boom sprayer
Application Rates (lb ai/A)	0.043 x1
Application Timing	During bloom (BBCH 62-65)
Matrices	Bee-collected nectar, pollen from traps
Design	1 treatment tunnel/site, 2 hives/tunnel
Sample Timing	Daily from -7 – 10 DALA
Residue QA/QC	Nectar and pollen spike recoveries were 81 ± 8% and 94 ± 8%

Results: One application of GF-2372 was applied to winter oil seed rape, under confined semi-field conditions, at a nominal application rate of 0.043 lb ai/A and yielded detectable residues of sulfoxaflor in nectar and pollen samples. No residues of sulfoxaflor were detected in nectar and pollen samples at or above the LOD in untreated control samples taken before application in all trial. The highest sulfoxaflor residues were detected directly after application on 0 DAA in all trials, with maximum residues of 4.05 mg/kg in pollen (trial 1) and 0.268 mg/kg in nectar (trial 4; **Figures F-5 and F-6**, respectively). There was an evident decline of residues in

both matrices from the sampling directly after application (0DAA1) to the last sampling (7-10DAA1).

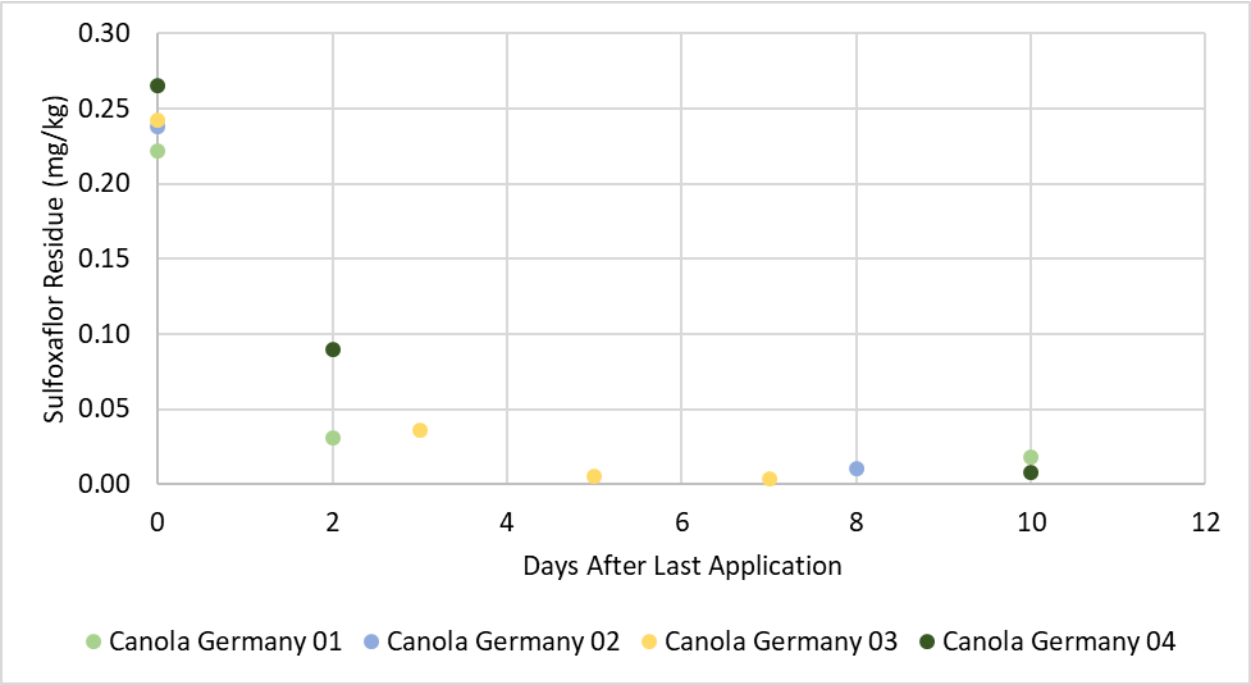


Figure F-5. Mean residues of sulfoxaflor in bee-collected nectar following foliar spray application of 0.043 lb a.i./A to canola.

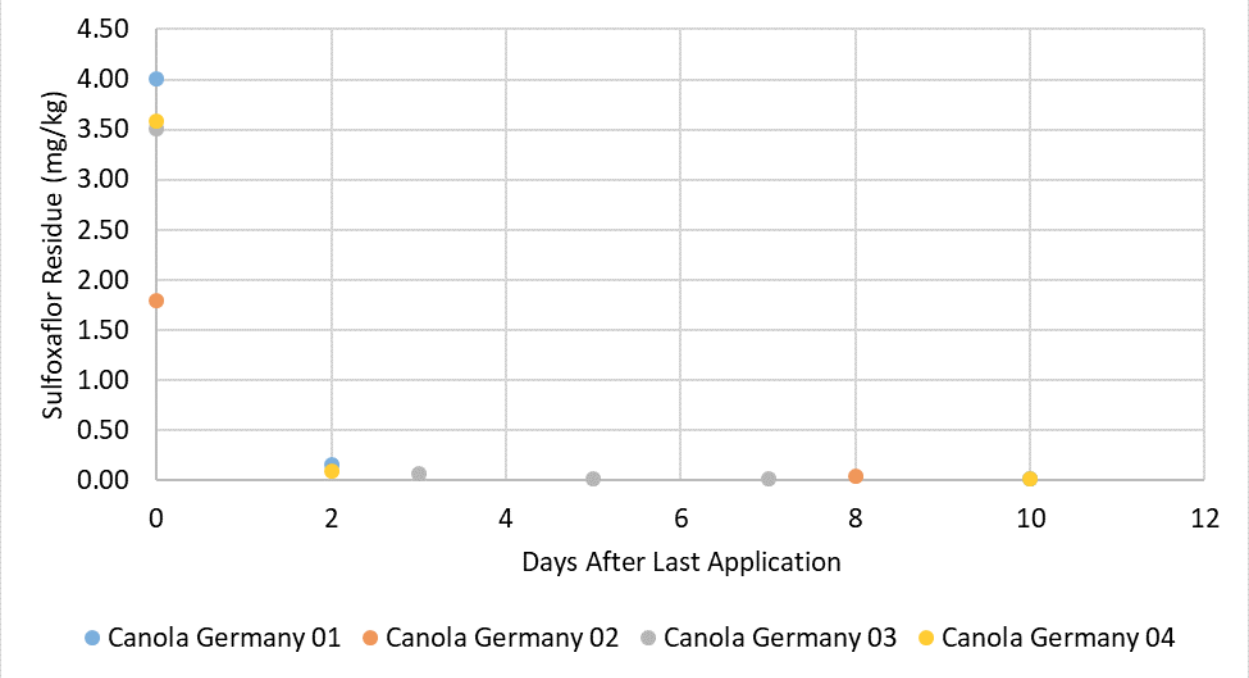


Figure F-6. Mean residues of sulfoxaflor in bee-collected pollen following foliar spray application of 0.043 lb a.i./A to canola.

Canola (MRID 50355204). This study was designed to measure the magnitude of residues of sulfoxaflor and its metabolites (X11579457, X11719474, X11519540, and X11721061) in canola (*Brassica napus*) whole plants, nectar, and pollen, which represent potential exposure risks to pollinators in the field. Two separate trials were conducted, at locations in North Dakota and Oregon. Three subplots at each trial location received two foliar applications (14 days prior to bloom at and BBCH 61 in OR and BBCH 62 in ND) of Transform® WG at a nominal application rate of 0.023 lb ai/A (cumulative application of 0.046 lb ai/A). Whole plant, nectar, and pollen samples were collected -14, 1, 2, 7, and 14 days after last application (DALA) to quantify sulfoxaflor and metabolite decline in each matrix. Samples were collected and analyzed by validated analytical methods to determine the residue concentrations. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2372 (49.4% a.i.)
Crop	Canola
Variety	46H75 (ND) 5525CL (OR)
Sites/Location	2 sites (Northwood, ND & Hood River, OR)
Application Methods	Commercial boom sprayer
Application Rates (lb ai/A)	0.023 x 2 @ 14 days apart (0.046 total)
Application Timing	ND Site: 1st Appl @ ~14 d pre-bloom (BBCH 16); 2nd appl during early bloom (BBCH 62). OR Site: 1st appl @ ~14 d pre-bloom (BBCH 51); 2nd appl. during early bloom (BBCH 61)
Matrices	Hand collected nectar, pollen, whole plant (OR nectar from centrifuged flowers; ND nectar from capillary tubes)
Design	3 replicate plots/site; 2 sites
Sample Timing	-14, 1, 2, 7 & 14 DALA
Residue QA/QC	Nectar and pollen spike recoveries near LOQ were occasionally 2X expected result; Recoveries of spikes made 100-1000X the LOQ were within the acceptable range of 70-120%

Results: One application of GF-2372 was applied to winter oil seed rape, under confined semi-field conditions, at a nominal application rate of 0.023 l a.i./A x 2 (14 days apart) yielded detectable residues of sulfoxaflor in nectar and pollen samples. No residues of sulfoxaflor were detected in nectar and pollen samples at or above the LOD in untreated control samples taken before application in all trial. The highest sulfoxaflor residues were detected directly after application on 0 DAA in all trials, with maximum residues of 4.05 mg/kg in pollen (trial 1) and 0.268 mg/kg in nectar (trial 4; **Figures F-7 and F-8**). There was an evident decline of residues in both matrices from the sampling directly after application (0DAA1) to the last sampling (7-10DAA1).

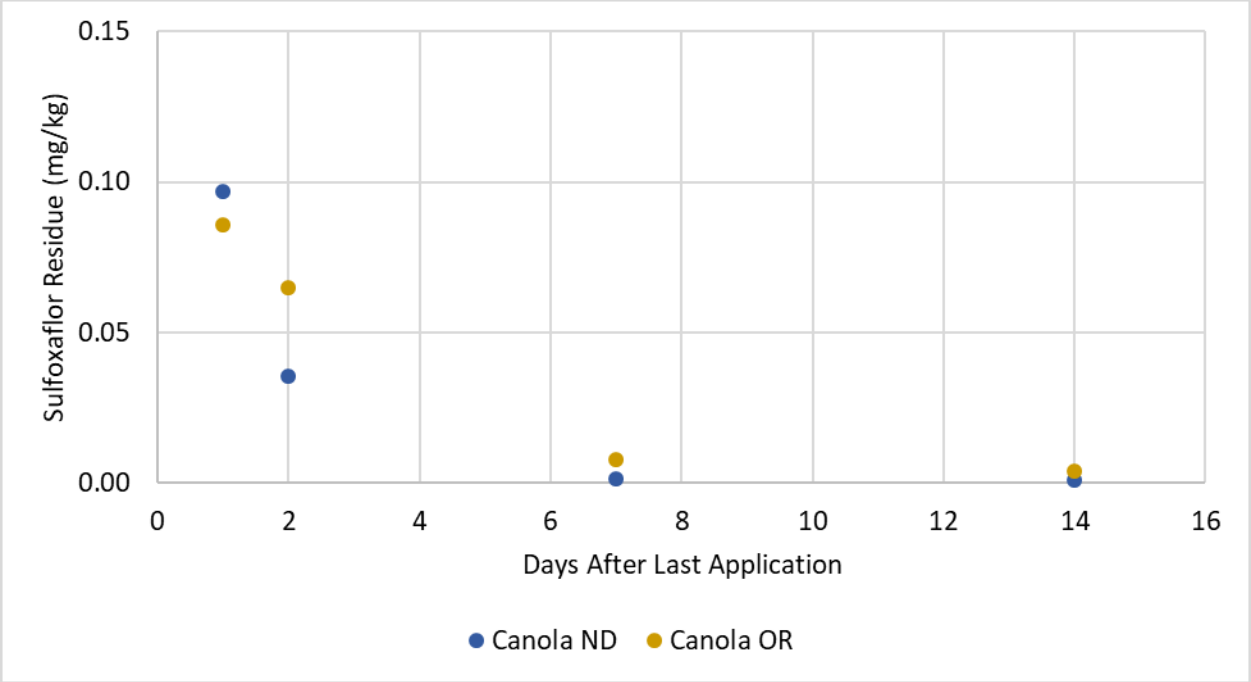


Figure F-7. Mean residues of sulfoxaflor in hand-collected nectar following two foliar spray applications of 0.023 lb a.i./A to canola 14 days apart

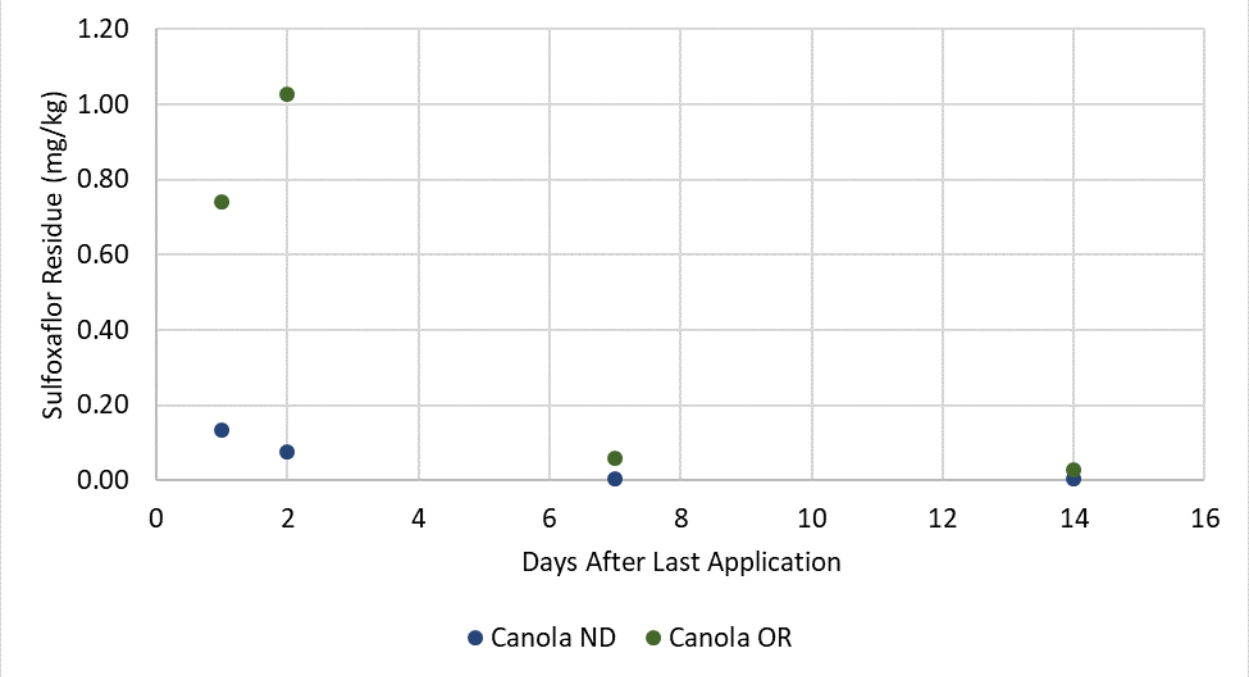


Figure F-8. Mean residues of sulfoxaflor in hand-collected pollen following two foliar spray applications of 0.023 lb a.i./A to canola 14 days apart

Citrus (MRID 50256403). This study was designed to measure the magnitude of residues of sulfoxaflor in nectar following a single application via backpack mist blower at approximately

0.09 lb ai/A (102 g ai/ha) with CLOSER® SC. The test system consisted of plots of established trees with typical commercial cultivars of citrus: mandarin orange, navel orange, lemon, and grapefruit in Riverside and Tulare Counties, California. All trials included one untreated control plot and three treated plots that received a single application of the sulfoxaflor at an estimated fall, pre-bloom, and mid-bloom of flowers. For pre-bloom applications, trees were monitored for the onset of leaf flush and applications were made when flush was well advanced but when few flowers were present and bee foraging had not yet begun. The mid-bloom applications were conducted at 7-10 days after bloom initiation. Nectar samples were collected two times during the bloom period of Spring 2015, characterized as mid-bloom and late-bloom collection, where possible. The limit of detection (LOD) and limit of quantification (LOQ) were 0.3 and 1 µg a.i./kg nectar. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2032 (21.7% a.i.)
Crop	Citrus (lemon, grapefruit, orange, mandarin)
Variety	Lisbon (lemon), star (grapefruit), Old line naval (orange), tango (mandarin)
Sites/Location	Riverside Co, CA (lemon & grapefruit); Tulare Co, CA (orange & mandarin)
Application Methods	Backpack mist blower
Application Rates (lb ai/A)	0.037, single application
Application Timing	Fall, pre-bloom, & mid-bloom
Matrices	Hand-collected nectar from plants (10+ flowers/sample; 400-500 ul)
Design	Control and treated sites, 6 trees/site, 1 site/crop; field portion of study non-GLP
Sample Timing	2 times during bloom where possible
Residue QA/QC	Nectar and pollen spike recoveries = 104-120%

Results: Reported residues of sulfoxaflor in citrus nectar (hand collected from plants) are shown in **Figure F-9**. Mean residues of sulfoxaflor in citrus nectar were greatest for mandarin, followed by grapefruit, lemon and orange. Residues were greatest following applications during bloom, as expected given the shorter time between application and residue sampling. Residues in citrus pollen were not measured during this study, which represents a limitation for use in risk assessment. Furthermore, residues were not measured in nectar from each crop at all time points. This study is classified as supplemental (quantitative) based on nectar residues only.

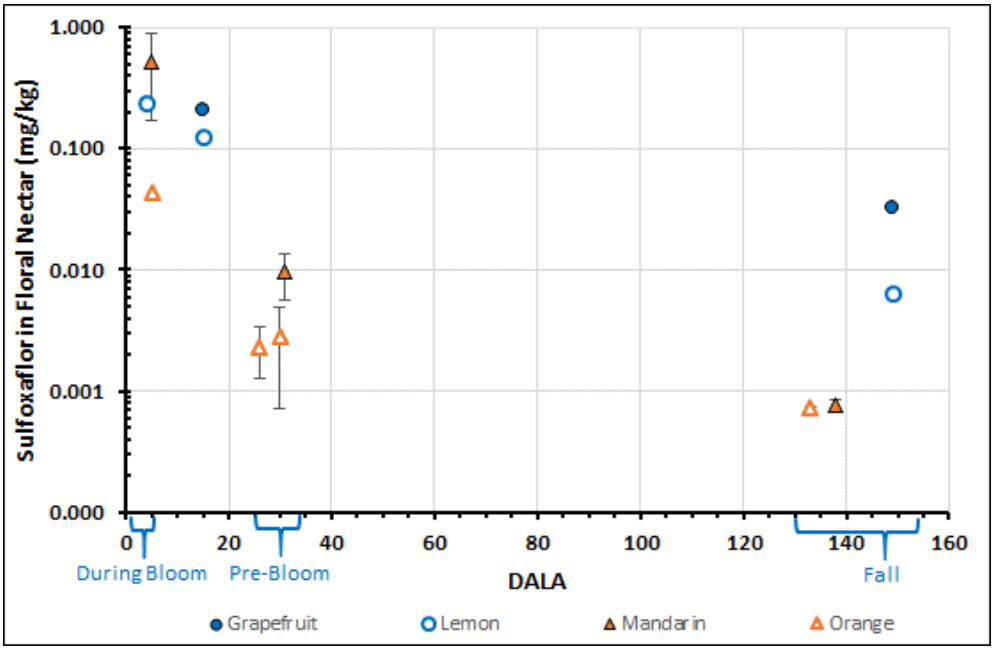


Figure F-9. Sulfoxaflor concentration (µg ai/kg) in citrus nectar following applications of 0.09 lb ai/A during bloom (Trial 1), 10-30 days prior to bloom (Trial 2) and the 130+ days prior to bloom (Trial 3). Error bars = 95% confidence limits.

Relevant descriptive statistics from the citrus residue study are shown in **Table F-3.**

Table F-3 Summary statistics of sulfoxaflor concentrations (µg ai/kg) measured in citrus nectar following 0.09 lb ai/A foliar spray applications.

Citrus Crop	Appl. Timing	Sample DAA	# Reps.	Mean (µg/kg)	Min-Max (µg/kg)	STD (µg/kg)	90th (µg/kg)
Grapefruit	Pre-bloom	11	1	85.4	NA	NA	NA
	Fall	145	1	13.1	NA	NA	NA
Lemon	Mid-bloom	0	1	97	NA	NA	NA
	Pre-bloom	11	1	50.4	NA	NA	NA
	Fall	145	1	2.6	NA	NA	NA
Mandarin	Mid-bloom	5	6	214	52.5 - 510	181	478
	Pre-bloom	31	6	3.9	2.0 – 7.1	2.0	6.6
	Fall	137	6	0.33*	0.2 – 0.5*	0.19	0.63
Orange (Naval)	Mid-bloom	5	6	17.9	2.7 - 46	15.6	43.6
	Pre-bloom	26	5	0.79*	0.2* – 1.5	0.58	1.9
	Pre-bloom	30	6	0.97*	0.5* – 3.3	1.1	1.8
	Fall	133	6	0.15*	0.15*	NA	NA

NA = not applicable; * = concentration below Limit of Detection (LOD=0.3 µg ai/kg) or Limit of Quantification (LOQ=1.0 µg ai/kg). For calculations, reported concentrations <LOD were assumed to be ½ the LOD of 0.3 ppb; reported concentrations between the LOD but <LOQ were assumed to be ½ the LOQ of 1 µg ai/kg

Since sulfoxaflor residues in citrus pollen were not quantified, the relationship between pollen and nectar was investigated for the other residue study crops when paired samples were available (*i.e.,* linear regression results from pollen vs nectar (log transformed) are shown in **Figure F-10** for herbaceous crops and **Figure F-11** for tree crops (apple, peach).

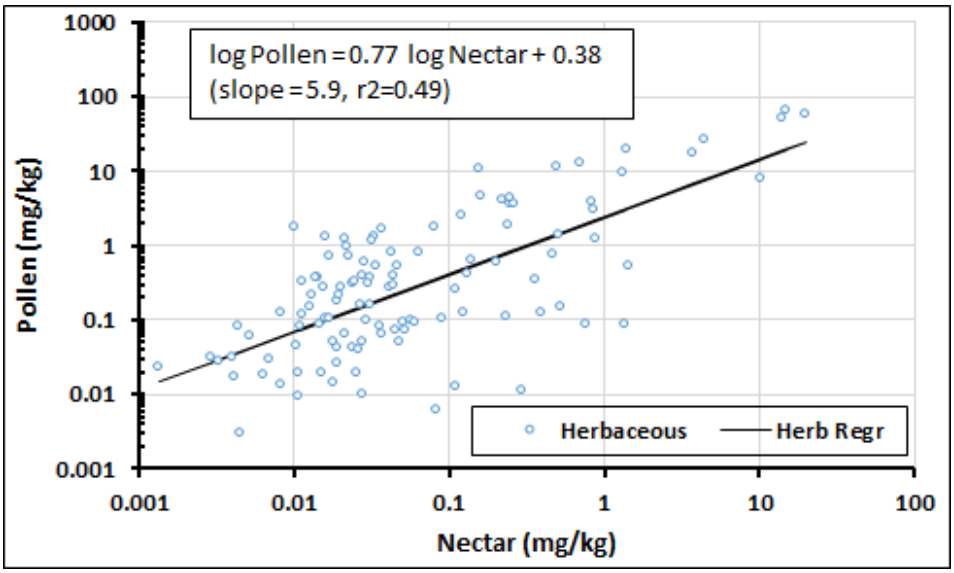


Figure F-10. Mean sulfoxaflor concentrations in pollen vs. nectar from herbaceous crops. Regression conducted on log transformed values (n=113).

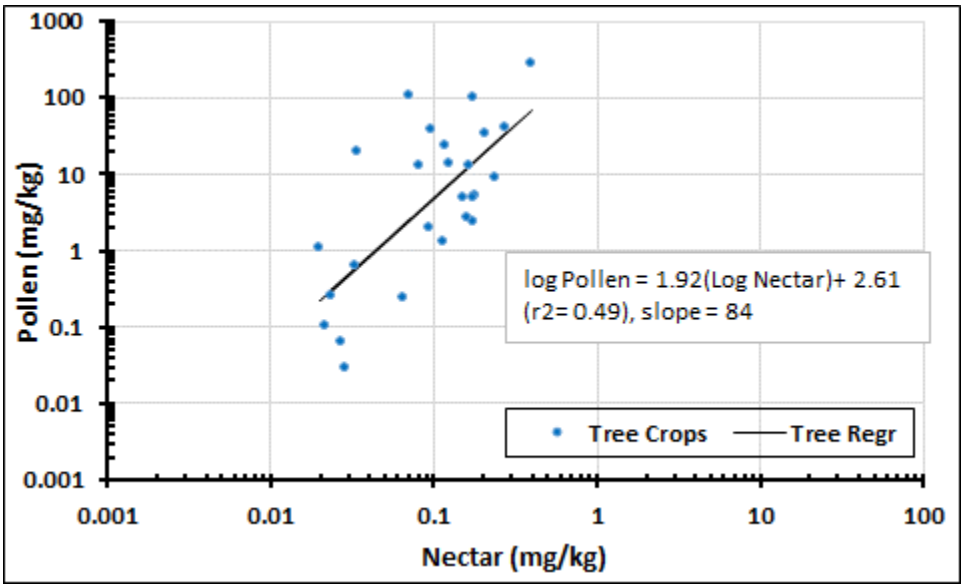


Figure F-11. Mean sulfoxaflor concentrations in pollen vs. nectar from tree crops (apple, peach). Regression conducted on log transformed values (n=26).

It is apparent from these data that the relationship between pollen and nectar associated with tree crops (slope = 84) differs from that for herbaceous crops (slope = 5.9). Notably, however, there are far fewer tree crops represented (2) compared to herbaceous crops (7) and the associated number of comparisons are also fewer (26 vs. 113, respectively). An alternative analysis was conducted on the ratio of sulfoxaflor in pollen and nectar (**Table F-4**). The tree crop residue data are highly skewed as indicated by the large difference between mean and median (50th) values. Based on median values, this alternative analysis still supports the much greater ratio of pollen to nectar for the tree crops compared to herbaceous crops. Therefore, for estimating the concentration of sulfoxaflor in citrus pollen from concentrations citrus nectar, a value of 84 will be used based on the slope of regression relationship shown in **Figure F-11**.

Table F-4. Summary statistics for the ratio of sulfoxaflor in pollen to nectar

Group	Mean	50th	75th	90th	n
Tree Crops	186	34	157	570	26
Herbaceous Crops	12	5.8	15	27	113

Peach (MRID 50355203). This study was designed to measure the magnitude of residues of sulfoxaflor and its metabolites (X11579457, X11719474, X11519540, and X11721061) in peach (*Prunus persica*) whole flowers, nectar, and pollen, which represent potential exposure risks to pollinators in the field. One field trial was conducted in Hart, Michigan. Five plots (~80 mature peach trees/plot) received one foliar application of Closer® SC (GF-2032) at a nominal rate of 0.09 lb ai/A. The plots differed in their growth stage at application, ranging from pre-bloom through mid-bloom: BBCH 09 in plot 1; BBCH 54 in plot 2; BBCH 61 in plot 3; BBCH 62 on plot 4; and BBCH 65 in plot 5. Whole flower, nectar, and pollen samples were collected between 0 and 10 days after application (DAA) to quantify sulfoxaflor and metabolite decline in each matrix in each plot. Samples were collected and analyzed by validated analytical methods to determine the residue concentrations. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2032
Crop	Peach (*Prunus persica*)
Variety	Red Haven (13 yr-old trees, 12-14 ft height)
Sites/Location	Hart, MI
Application Methods	Air Blast, PTO pump
Application Rates (lb ai/A)	0.086-0.091, single application
Application Timing	**Plot 1** (pre-bloom, sprouting, BBCH 09); **Plot 2** (pre-bloom, inflorescence, BBCH 54); **Plot 3** (early bloom, BBCH 61); **Plot 4** (early bloom, BBCH 62); **Plot 5** (full bloom, BBCH 65)
Matrices	Hand-collected nectar, pollen, whole flower
Design	1 site; 5 plots, 10 trees/plot; control sampled 3d prior to treatment; applications made a variable timing pre- and during bloom

Study Element	Description
Sample Timing	2-4 times (early, mid, late bloom); ≥ 0.1 ml nectar; > 0.1 g pollen; > 50 g flower from 8 or more trees
Residue QA/QC	Nectar and pollen spike recoveries = 81-120%

Results: Single foliar applications of sulfoxaflor across different growth stages of peach trees at a nominal application rate of 0.090 lb ai/A – yielded detectable residues of sulfoxaflor in all matrices (**Figures F-12 and F-13**). Recoveries of metabolites were lower and more variable with less consistent patterns compared to the parent material. Sulfoxaflor accounted for the majority of total sulfoxaflor residues (TSR) in all matrices. Mean sulfoxaflor residues were greatest in pollen, followed by whole flowers and nectar. In general, sulfoxaflor residues were greatest in plot 3 (application made at BBCH 61), however, samples were collected immediately after application. In plots 1 and 2, maximum detected sulfoxaflor concentrations were typically detected at the first or second sampling event corresponding to between 3 and 7 days after application (DAA). Sulfoxaflor residues in plot 3 at 3 to 7 DAA were comparable to those in plots 1 and 2, suggesting that recoveries are comparable regardless of growth stage at the time of application.

Pollen- The maximum measured sulfoxaflor concentration was detected in plot 3 (269 mg/kg, 1 DAA). The order of maximum measured concentrations was plot 3 (269 mg/kg, 1 DAA), plot 5 (108 mg/kg, 2 DAA), plot 4 (98.9 mg/kg, 1 DAA), plot 2 (40.4 mg/kg, 2 DAA), and plot 1 (4.76 mg/kg, 7 DAA). All metabolites were detected in pollen collected from all 5 plots. Similar to the parent material, all metabolites had maximum measured concentrations in plot 3 (application made at BBCH 61). The parent material exhibited steady declines following maximum residues levels (1 to 5 DAA). The metabolites X11719474, X11721061, and X11519540 also exhibited declines, whereas the other metabolites had more variable responses over the sampling period.

Nectar- The order of maximum measured sulfoxaflor concentrations was plot 3 (0.398 mg/kg, 0 DAA), plot 2 (0.277 mg/kg, 4 DAA), plots 1 and 4 (0.176 mg/kg,6 and 0 DAA, respectively), and plot 5 (0.0719 mg/kg, 1 DAA). No metabolites were detected in plots 4 or 5, X11719474 was the only metabolite detected in plots 1 and 2, and X11719474 and X11721061 were the only two metabolites were detected in plot 3. Sulfoxaflor was the only analyte that exhibited steady declines following maximum detection during the sampling period.

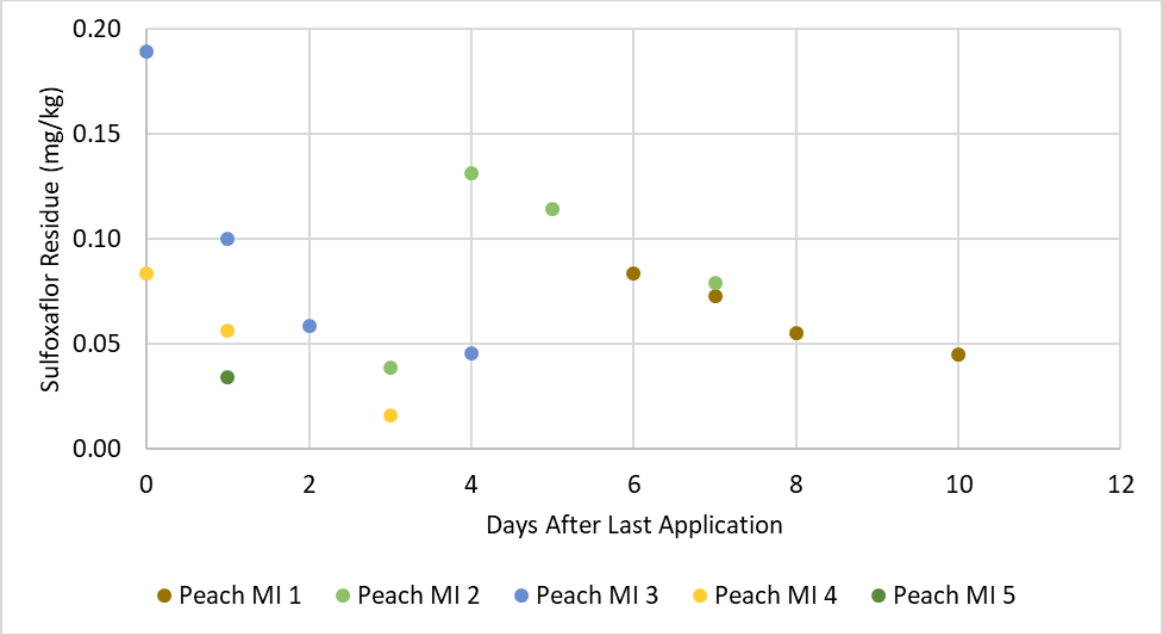


Figure F-12. Mean residues of sulfoxaflor in hand-collected nectar following one foliar spray applications of 0.09 lb a.i./A to peach

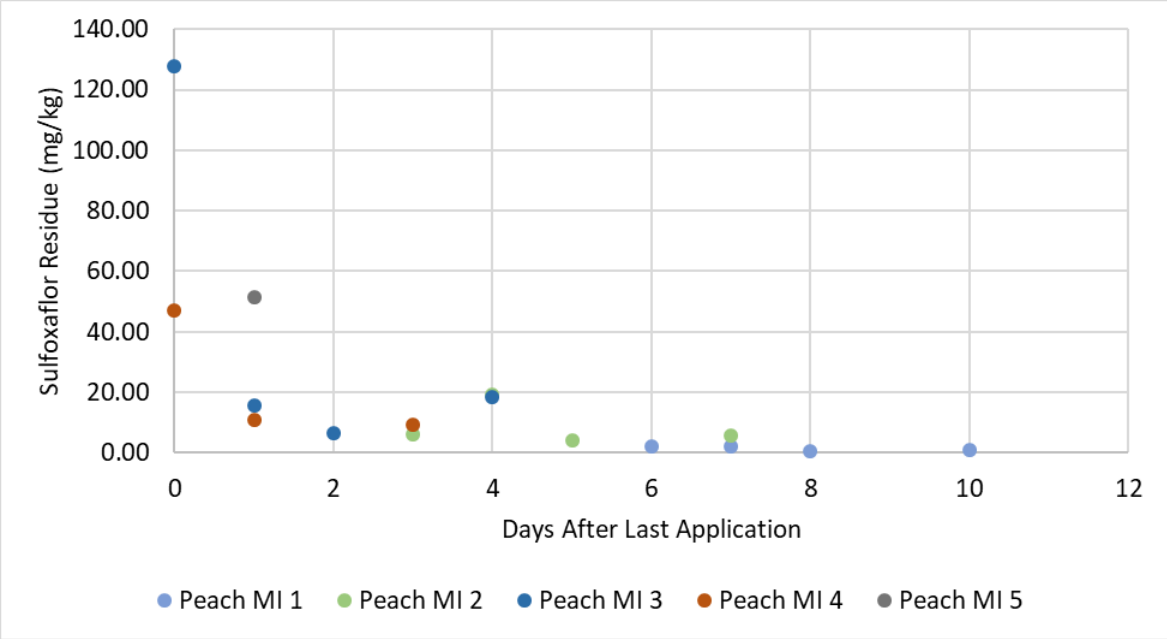


Figure F-13. Mean residues of sulfoxaflor in hand-collected pollen following one foliar spray applications of 0.09 lb a.i./A to peach

Pumpkin (MRID 50355202). This study was designed to measure the magnitude of residues of sulfoxaflor and its metabolites (X11579457, X11719474, X11519540, and X11721061) in pumpkin (*Cucurbita pepo*) whole plants, nectar, and pollen, which represent

potential exposure risks to pollinators in the field. Two separate trials were conducted, at locations in North Carolina and California. Two subplots at each trial location received two foliar applications (8-10 days pre-bloom and at bloom) of Closer® SC at a nominal application rate of 0.070 lb ai/A (cumulative application of 0.140 lb ai/A). Whole plant, nectar, and pollen samples were collected 0, 1, 2, 7, and 21 days after last application (DALA) to quantify sulfoxaflor and metabolite decline in each matrix. Samples were collected and analyzed by validated analytical methods to determine the residue concentrations. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2032 (21.8% a.i.241 g/L)
Crop	Pumpkin
Variety	Progress (NC) and Connecticut (CA)
Sites/Location	2 sites (Belvidere, NC and Zamora, CA)
Application Methods	Commercial backpack sprayer
Application Rates (lb ai/A)	0.071 x 2 @ 7 days apart (0.142 total)
Application Timing	NC Site: 1st Appl @ ~10 d pre-bloom; 2nd appl during bloom (BBCH 62-63). CA Site: 1st appl @ ~8 d pre-bloom; 2nd appl. during early bloom (BBCH 60-61)
Matrices	Hand collected nectar, pollen, whole plant
Design	2 replicate plots/site; 2 sites
Sample Timing	0, 1, 2, 7 & 21 DALA; with control whole plant sample before first application
Residue QA/QC	Nectar and pollen spike recoveries near LOQ for 8 samples had recoveries ranging from 128-911% of nominal; Recoveries of spikes made 100-1000X the LOQ were within the acceptable range of 70-120%

Results. Immediately after application, sulfoxaflor residues in pumpkin nectar and pollen from the NC site were much greater than those measured from the CA site, by approximately two orders of magnitude (**Figures F-14 and F-15**). By two days after the last application, sulfoxaflor residues measured in the NC site declined by two orders of magnitude in pollen and a factor of 5 in nectar. Residues measured from the CA site remained near or below the level of quantitation.

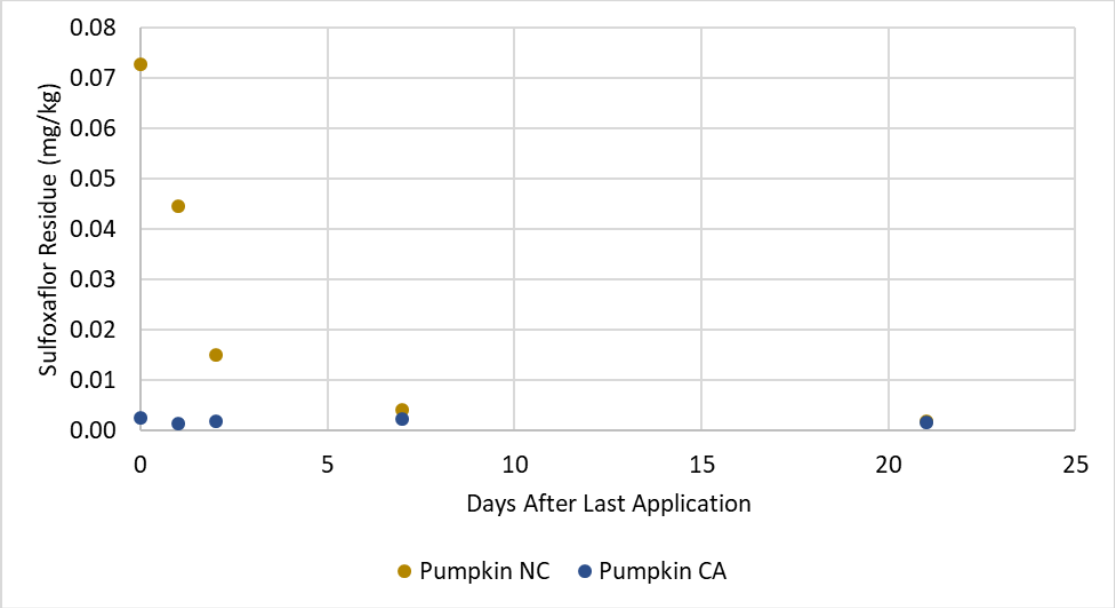


Figure F-14. Mean residues of sulfoxaflor in hand-collected nectar following two foliar spray applications of 0.07 lb a.i./A to pumpkin 7 days apart

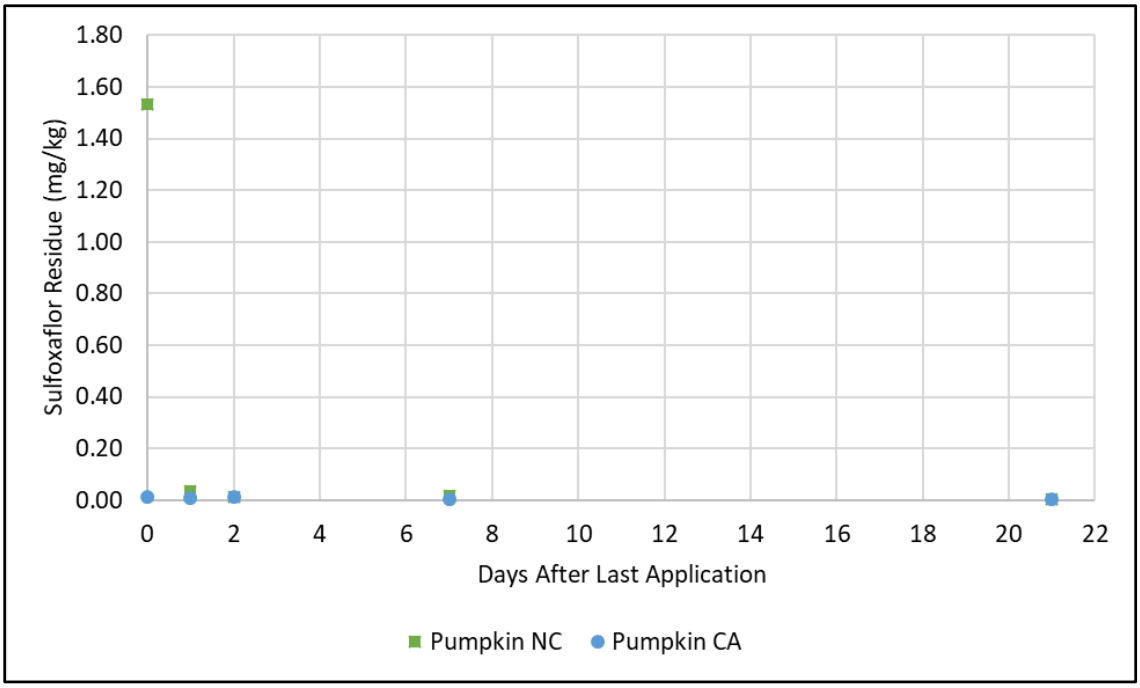


Figure F-15. Mean residues of sulfoxaflor in hand-collected pollen following two foliar spray applications of 0.07 lb a.i./A to pumpkin 7 days apart

Pumpkin (MRID 50444403). This study was conducted to quantify the magnitude and decline of residues of sulfoxaflor in pumpkin (*Cucurbita*) matrices following a single foliar application of the end-use-product GF-2626 at 48 g ai/ha (0.040 lb ai/A) to field plots planted to pumpkin in Southern Germany near Pforzheim (Trial 1) and Bodelshausen (Trial 2) and in Southern France near Lannes (Trial 3) and Fourcés (Trial 4). Each trial location contained

one replicate 200-m^2 treated plot enclosed by a tunnel (*ca.* 5.0 meters wide by 40.0 meters long by 2.5 - 3.5 meters high) covered in plastic/light plastic gauze to ensure good ventilation. A control plot was not included in the study design. Each tunnel contained two commercial honeybee (*Apis mellifera* L.) colonies and one waterer. Colonies were placed in the tunnels at the beginning of flowering before the application, i.e., 12 days (Trial 1), 5 days (Trial 2), 3 days (Trial 3) or 1 day (Trial 4) prior to the first sampling event. The hives in each tunnel were equipped with pollen traps, which were inserted on the hive entrance either on sampling day or on the day before, taking care that all flowers within a tunnel were closed and no pollen from the day before could be collected. Applications were made during flowering, and honeybees were used as the exclusive sampling device for nectar and pollen. Waterers were removed during application. Forager bees for nectar collection and pollen from the pollen traps were collected prior to application, and at 1, 3, 5, and 6-8 DAA. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2626 (11.8% a.i.)
Crop	Pumpkin
Variety	Koshare yellow (Germany) and Potimarron (France)
Sites/Location	4 sites (Pforzheim and Bodelshausen, Germany & Lannes and Fourcès, France)
Application Methods	Commercial boom sprayer
Application Rate (lb ai/A)	0.042 lb ai/A x 1
Application Timing	Germany 1 mid flowering (BBCH69), Germany 2 early flowering (BBCH61), France 1 & 2 early-mid flowering (BBCH65)
Matrices	Honey bee-collected nectar and pollen. Nectar was extracted from bee honey stomachs and pollen from pollen traps outside the hive. /
Design	1 tunnel plot/site; 4 sites. Single composite samples/event
Sample Timing	1, 3, 5 & 6-8 DALA and prior to application
Residue QA/QC	Nectar and pollen spike recoveries were within the acceptable range of 70-120%

Results. Maximum sulfoxaflor residues ranged from 0.0845 mg/kg (France Trial 2) to 0.162 mg/kg (Germany Trial 1) in pollen, and from 0.0119 mg/kg (Germany Trial 1) to 1.36 mg/kg (France Trial 2) in nectar (**Figure F-16 and F-17**). Interestingly, the difference in initial maximum residue values of nectar and pollen was greater among sites within each country compared to between countries. This illustrates the unpredictable nature of residues in plant pollen and nectar as related to trial location. By 3 days after application, residues declined to less than half the values measured on day 1.

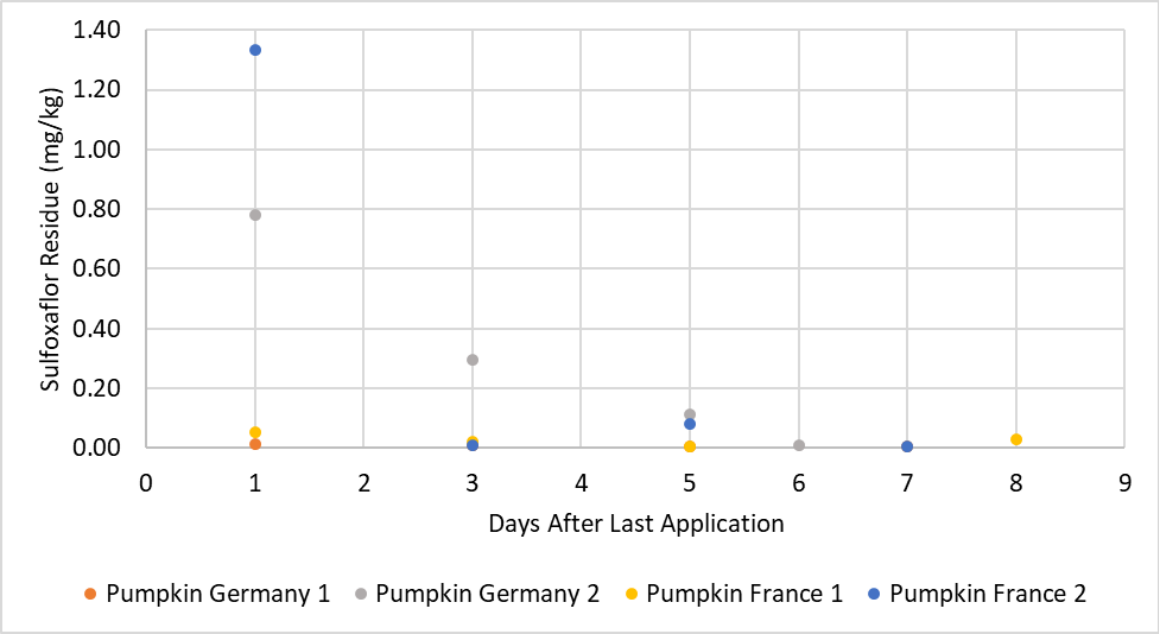


Figure F-16. Residues of sulfoxaflor in bee-collected nectar following one foliar spray application of 0.04 lb a.i./A to pumpkin

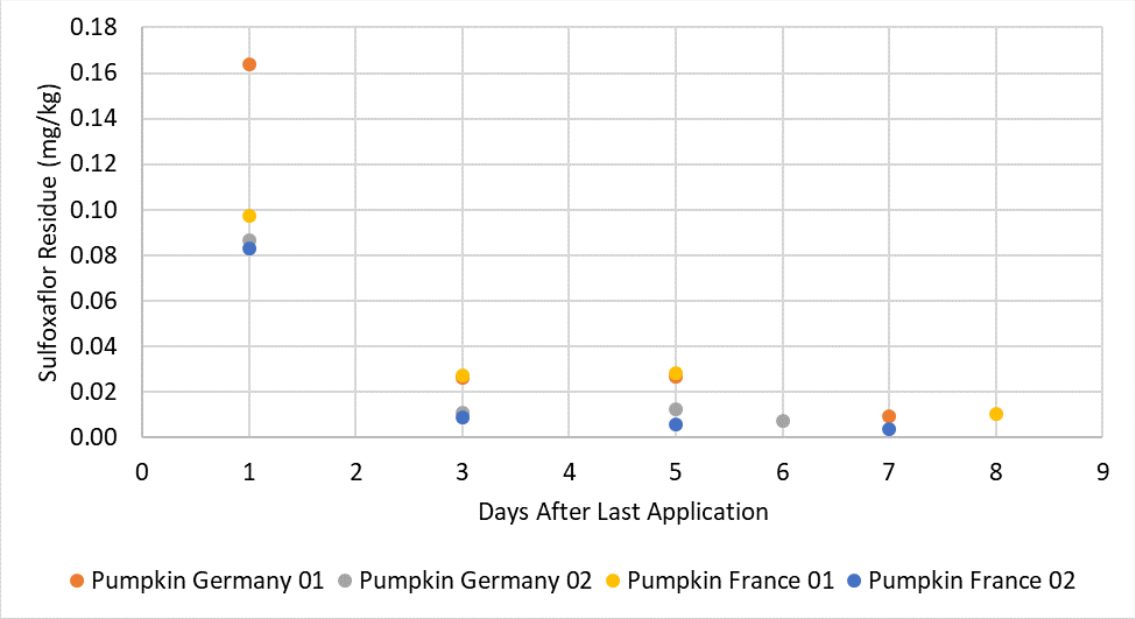


Figure F-17. Residues of sulfoxaflor in bee-collected pollen following one foliar spray application of 0.04 lb a.i./A to pumpkin

Strawberry (MRID 50444402). This study was designed to measure the magnitude of residues of sulfoxaflor and its four major metabolites, X11579457, X11719474, X11519540 and X11721061, in strawberry (*Fragaria l.*) whole plant, nectar and pollen, which represent potential exposure risks to pollinators in the field. Two separate trials were conducted, at locations in Florida (Trial 1) and California (Trial 2). Three subplots at each trial location received two foliar applications of Closer® SC at 0.070 lb ai/A/application, based on a maximum

seasonal rate of 0.140 lb ai/A, applied in two application timings at the minimum retreatment interval of 7 days. Whole plants were collected from each site prior to treatment, and whole plant and flower samples (for nectar and pollen) were collected from early- through late-bloom for residue analysis (0 through 14 DALA). Samples were collected and analyzed by validated analytical methods to determine the residue concentrations. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2032 (21.8% a.i.)
Crop	Strawberry
Variety	Radiance (FL) and Albion (CA)
Sites/Location	2 sites (Dover, FL and Yuba City, CA)
Application Methods	Commercial boom sprayer
Application Rates (lb ai/A)	0.071 x 2 @ 7 days apart (0.142 total)
Application Timing	FL Site: 1st Appl pre-bloom (BBCH 61); 2nd appl during early bloom (BBCH 62). CA Site: 1st appl pre-bloom (BBCH 61); 2nd appl. during early bloom (BBCH 61)
Matrices	Hand collected nectar, pollen, whole plant (nectar from centrifuged flowers)
Design	3 replicate plots/site; 2 sites
Sample Timing	-14 (CA) or -7 (FL), 0, 1, 2, 7 & 14 DALA
Residue QA/QC	Pollen spike recoveries near LOQ were occasionally 1.5X expected result; Recoveries of spikes made 100-1000X the LOQ were within the acceptable range of 70-120%

Results: Two foliar applications to strawberry plants at 0.070 lb ai/A/application (based on a maximum seasonal rate of 0.140 lb ai/A), yielded detectable residues of sulfoxaflor in nectar, pollen and whole plants at both trial sites (**Figures F-18 and F-19**). Maximum mean concentrations of sulfoxaflor observed at the California trial (0 DALA) were 65.3 mg/kg in pollen and 15.2 mg/kg in nectar. Maximum mean concentrations of sulfoxaflor at the Florida trial (0 DALA) were 18.8 in pollen and 1.41 in nectar. Initial concentrations (Day 0) in nectar and pollen measured in the CA site were 10X and 3X greater compared to those from the FL site. By 2 days after the last application, residues of sulfoxaflor in pollen and nectar measured in strawberries at the CA site declined by an order of magnitude, while those from the FL site declined by 2-3X.

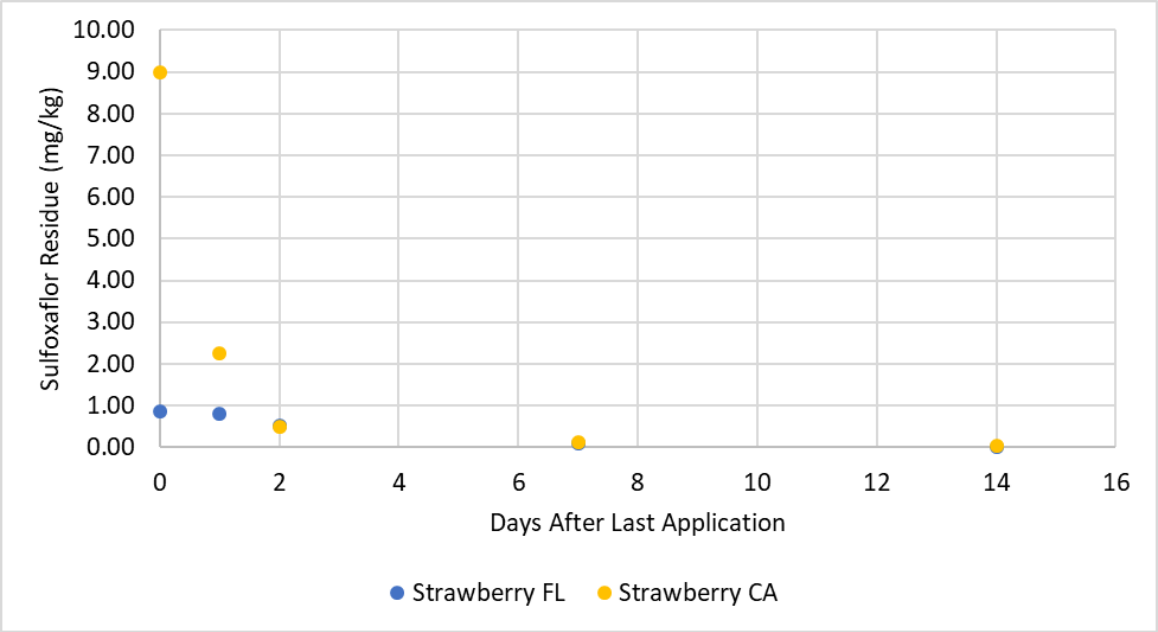


Figure F-18. Mean residues of sulfoxaflor in hand-collected nectar following two foliar spray applications of 0.07 lb a.i./A to strawberry 7 days apart

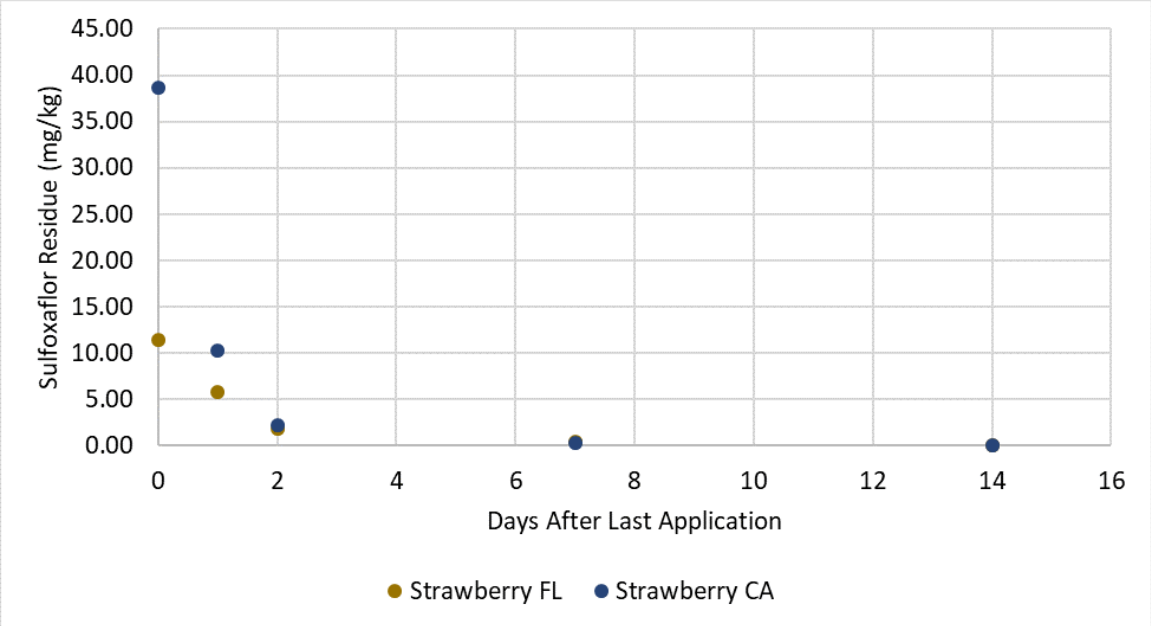


Figure F-19. Mean residues of sulfoxaflor in hand-collected pollen following two foliar spray applications of 0.07 lb a.i./A to strawberry 7 days apart

Strawberry (MRID 50444404). The study objective was to determine sulfoxaflor residue levels in nectar and pollen, collected by forager bumblebees, from strawberry plants after one application of GF-2626 under confined semi-field conditions. This study was conducted in four separate field trials in Southern Germany and Southern France during 2016. Trials 1 and 2 were located in Southern Germany (Baden- Württembuerg) and Trials 3 and 4 were located in

Southern France (Lot-et-Garonne). The test item, GF-2626, was applied to strawberry plants and residues of the active ingredient, sulfoxaflor, was measured in nectar and pollen. The study consisted of one treatment group per trial and one application in the test item treatment group per trial, at a target rate of 24 g a.i/ha (nominal). Six (trials 1 through 3) and four (trial 4) bumblebee colonies were placed in each tunnel at the beginning of flowering, before application. Nectar and pollen samples were collected from forager bees on five dates, once before application and four times post application. Trials 1, 2, and 4 were sampled on days 1, 3, 5, and 7 after application and trial 3 was sampled on days 1, 3, 6, and 7 after applications. Samples were collected and analyzed by validated analytical methods to determine the residue concentrations. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2626 (11.8% a.i.)
Crop	Strawberry
Variety	Clery (Germany 1, France 2), Malvina (Germany 2), Garringuette (France 1)
Sites/Location	2 sites (Wüttembuerg Germany and Lot-et-Garonne France)
Application Methods	Commercial boom sprayer in Germany and a backpack sprayer in France
Application Rates (lb ai/A)	0.021 lb ai/A x 1
Application Timing	All sites applied during growth stage BBCH65
Matrices	Pollinator (bumble bee) collected nectar and pollen.
Design	2 replicate plots/site; 2 sites
Sample Timing	1, 3, 5 & 7 DALA
Residue QA/QC	Nectar and pollen spike recoveries were within the acceptable range of 70-120%

Results: One application of GF-2626 was applied to strawberry plants, under confined semi-field conditions, at a nominal application rate of 24.0 g ai/ha – yielded detectable residues of sulfoxaflor in nectar and pollen samples (**Figures F-20 and F-21**). No resides of sulfoxaflor were detected in nectar and pollen samples at or above the LOD in untreated control samples taken before application in all trials. Overall, pollen and nectar residues were greater in samples collected from the France trials compared to those collected from Germany. Sulfoxaflor residues showed a clear decline in both matrices from the sampling directly after application to the last sampling date. In all four trials, residues were greater in pollen than nectar. Residues in pollen peaked immediately following application and declined throughout the duration of the exposure. Residues in nectar were slightly more variable, with maximum detections occurring immediately following application in Trials 1 through 3 and on the third sampling event in Trial 4. The maximum sulfoxaflor residue values detected in strawberry nectar and pollen were 0.894 mg/kg and 12.7 mg/kg, respectively.

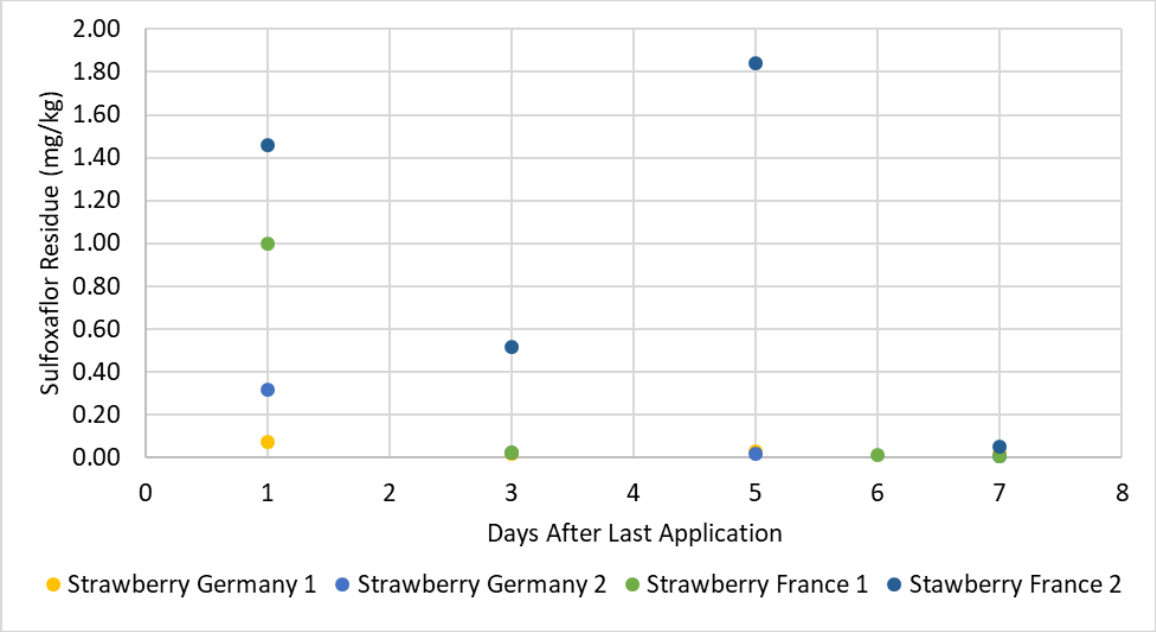


Figure F-20. Residues of sulfoxaflor in bee-collected nectar following one foliar spray application of 0.02 lb a.i./A to strawberry

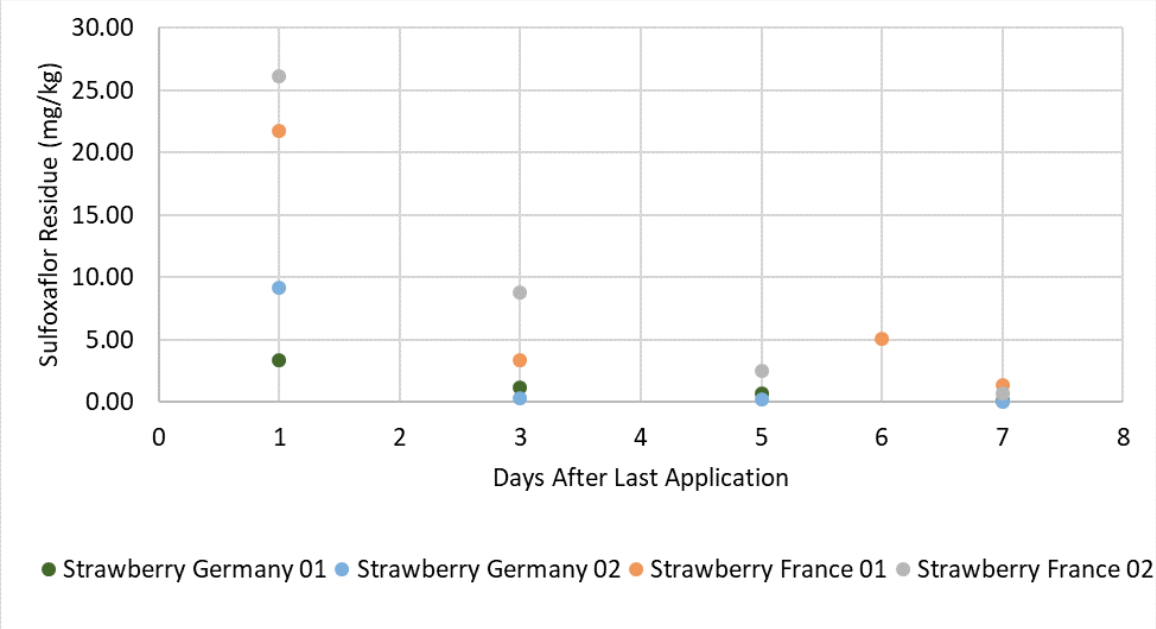


Figure F-21. Residues of sulfoxaflor in bee-collected pollen following one foliar spray application of 0.02 lb a.i./A to strawberry

Sunflower (MRID 50355201). This study was conducted in Stilwell, Kansas and was designed to measure the magnitude of residues of sulfoxaflor in sunflower nectar and pollen, which represent potential exposure risks to pollinators in the field. The trial had two test plots, an untreated plot (Plot 1) and a treatment plot (Plot 2), which received two foliar broadcast

applications of GF-2372 at a nominal application rate of 0.09 lb ai/A. The first application occurred approximately 7 days prior to full bloom. The second application occurred during full bloom, seven days after the first application (DAFA). There were 10 sampling events during the study, five occurred after the first application and the remaining five occurred after the second application of GF-2372. Sampling events occurred on 0DAA, 1DAFA, 2DAFA, 4DAFA, 7DASA, 1DASA, 2DASA, 4DASA, 9DASA, 11DASA, 14DASA (days after second application). During each sampling event a minimum of 12 sunflowers were collected from each plot. Pollen was collected from the sunflowers at each sampling event and nectar was collected from the flowers when available. Samples were collected and analyzed by validated analytical methods to determine the residue concentrations. A summary of the study elements is provided below.

Study Element	Description
Test Substance	GF-2372 (49.4% a.i.)
Crop	Sunflower
Variety	Peredovik
Sites/Location	Stillwell, KS
Application Rates (lb ai/A)	0.090 x 2 @ 7 days apart (0.18 total)
Application Timing	7 days pre-bloom (BBCH61) & 7 days after the 1st in full bloom (BBCH65)
Matrices	Hand-collected nectar and pollen
Design	1 control and 1 treatment plot at 1 site
Sample Timing	0, 1, 2, 4, 7 DAFA + 1, 2, 4, 9, 11, and 14 DASA
Residue QA/QC	Pollen spike recoveries near LOQ were occasionally 2X expected result; Recoveries of spikes made 100-1000X the LOQ were within the acceptable range of 70-120%

Results: Two (7 days prior to bloom and 7 days after the first application at growth stages BBCH 61& 65, respectively) foliar applications of GF-2372 to sunflower plants at a nominal application rate of 0.09 lb ai/A – yielded detectable residues of sulfoxaflor in nectar and pollen samples (**Figures F-22 and F-23**). No sulfoxaflor residues greater than the LOQ were observed in any untreated control samples, with the exception of three nectar control samples with residues of 0.00648, 0.00163, and 0.00281 mg/kg on 1DALA, 4DALA, and 7DALA, respectively. Sulfoxaflor residues in nectar and pollen exhibited a steady decline from following maximum detection. Residues in pollen peaked immediately following the first application (5.34 mg/kg, 0DAFA), whereas residues in nectar peaked following the second application (0.473 mg/kg,

1DALA).

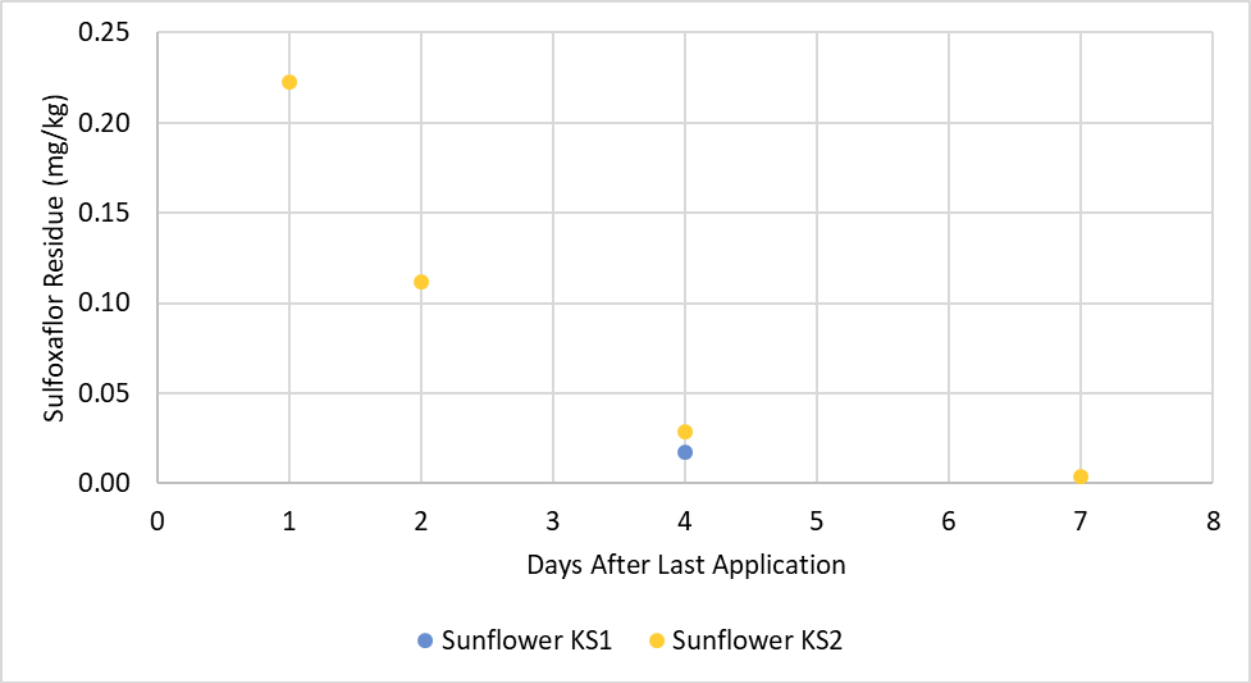


Figure F-22. Mean residues of sulfoxaflor in hand-collected nectar following two foliar spray applications of 0.09 lb a.i./A to sunflower 7 days apart

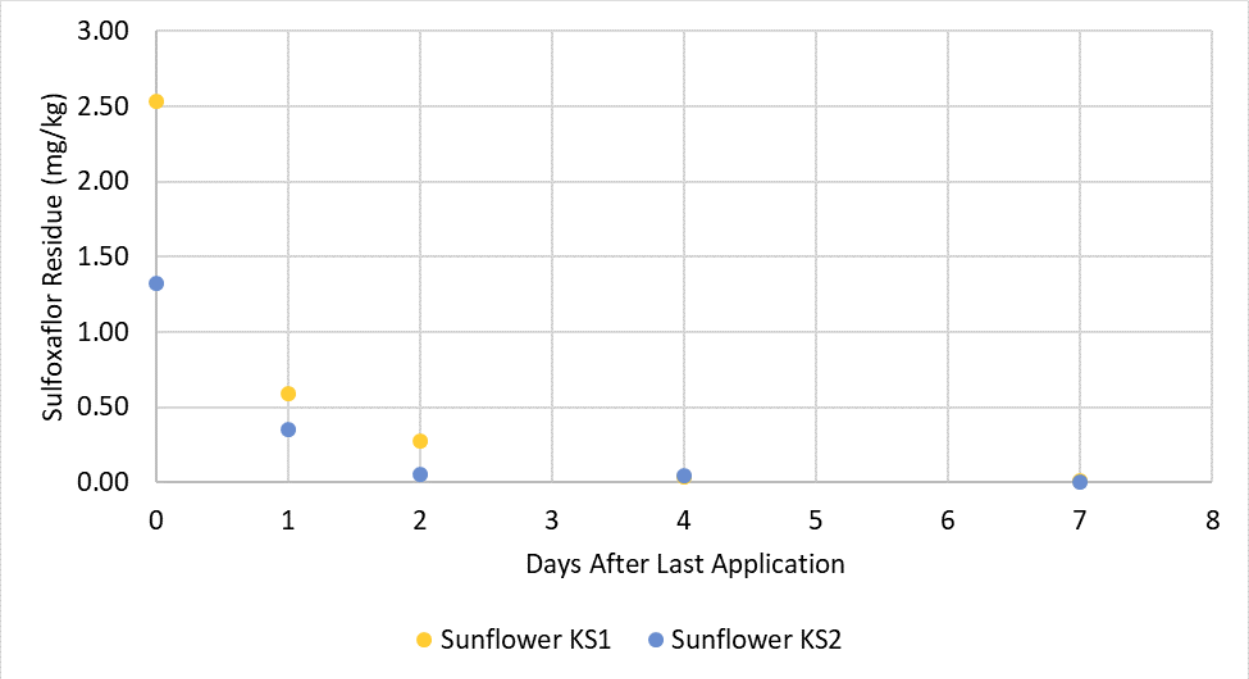


Figure F-22. Mean residues of sulfoxaflor in hand-collected pollen following two foliar spray applications of 0.09 lb a.i./A to sunflower 7 days apart

Appendix G. Refined tier I BeeREX RQ calculation over time

Pumpkin

Refined Tier I oral RQ values for honey bees resulting from use on pumpkins range from 0.01 – **0.44** (adult acute), 0.01 – 0.08 (larval acute), 0.13 – **7.69** (adult chronic), and 0.01 – 0.11 (larval chronic) depending on their caste and function within the hive. These RQ values reflect measured residues of pollen and nectar obtained from foliar applications adjusted to the maximum label rate for cucurbits (MRID 50355202 and 48755601). **Figure 6-10** below shows the adult and larval oral RQs in relation to the LOCs with the totality of the nectar and pollen data available and how it translates into the magnitude, duration and frequency of Tier I LOC exceedances.

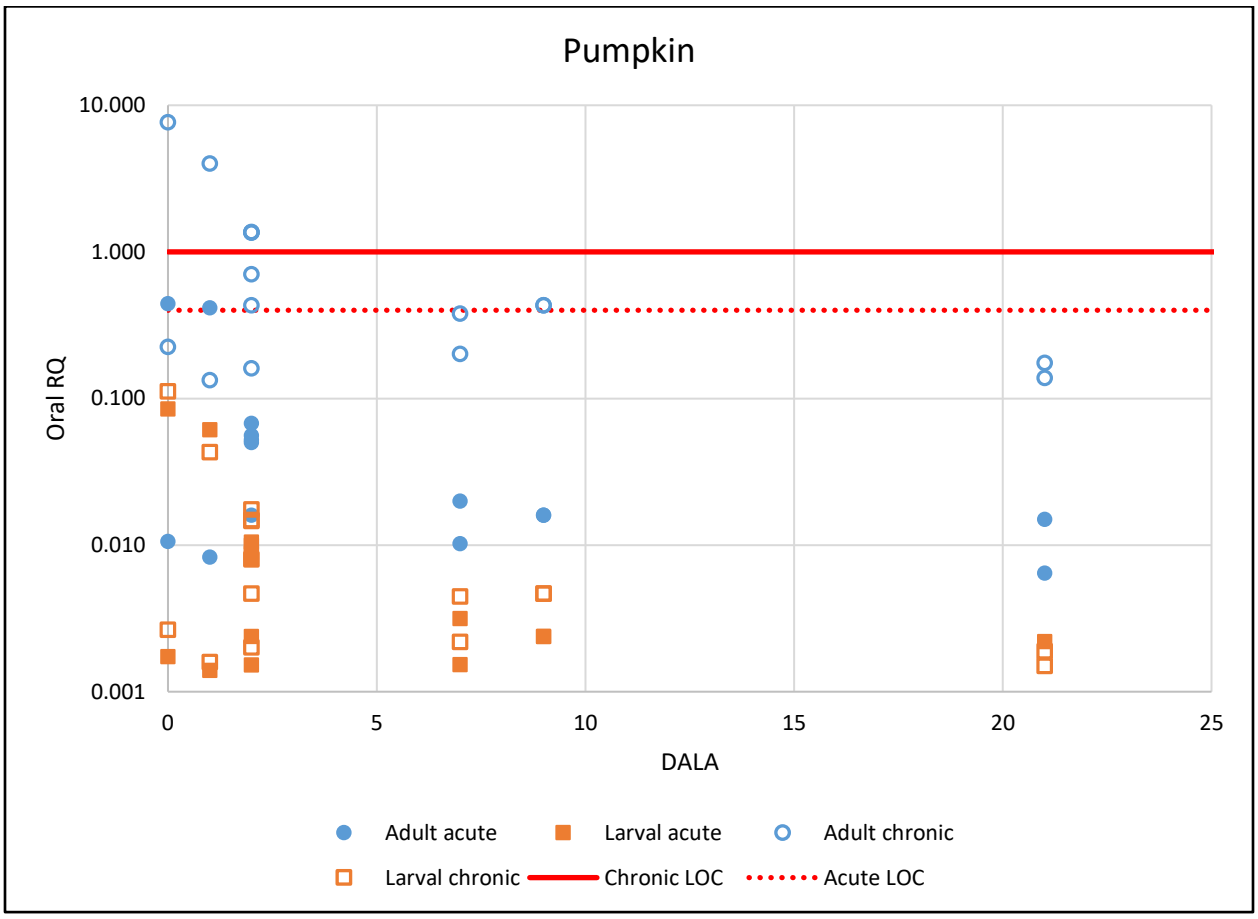


Figure 1. Summary of acute and chronic RQ values using totality of pollen and nectar residue data from foliar-applied pumpkin residue study (MRID 50355202 and 48755601).

Daily oral RQ values were calculated for each life stage/duration. As indicated by **Figure 0.1**, 100% of the refined Tier I acute and chronic RQ values were below the LOC values (0.4 and 1.0, respectively) 9 days following the last application.

Citrus

Refined Tier I oral RQ values for honey bees resulting from use on citrus range from 0.01 – 0.33 (adult acute), 0.01 – 0.05 (larval acute), 0.01 – **11.6** (adult chronic), and 0.01 – 0.12 (larval chronic) depending on their caste and function within the hive. These RQ values reflect measured residues nectar obtained from foliar applications adjusted to the maximum label rate for citrus (MRID 50256403). Figure 6-10 below shows the adult and larval oral RQs in relation to the LOCs with the totality of the nectar and pollen data available and how it translates into the magnitude, duration and frequency of Tier I LOC exceedances.

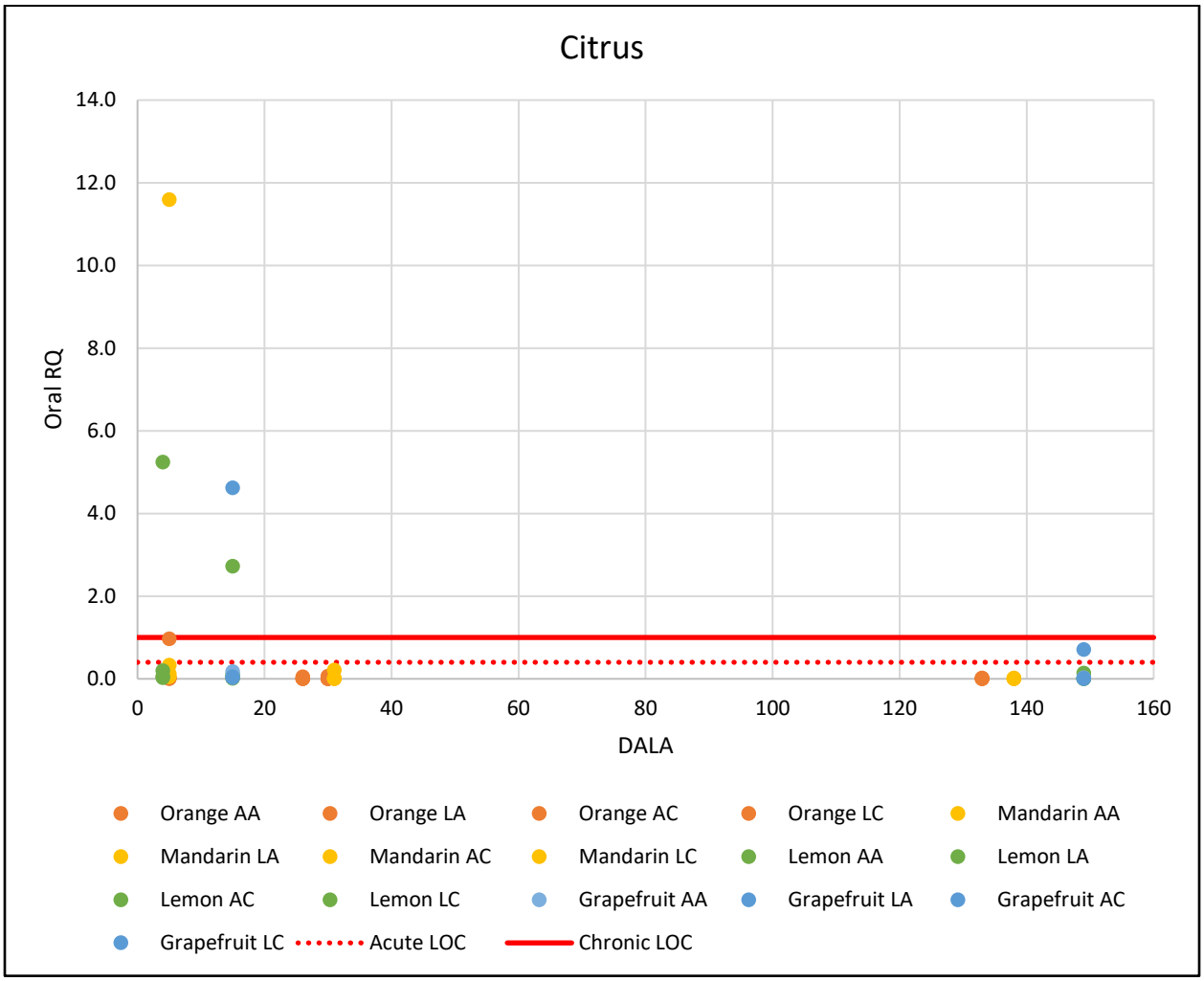


Figure 2. Summary of acute and chronic RQ values using totality of nectar residue data from foliar-applied citrus residue study (MRID 50256403).

Daily oral RQ values were calculated for each life stage/duration. As indicated by **Figure 0.1**, 100% of the refined Tier I acute and chronic RQ values were below the LOC values (0.4 and 1.0, respectively) 15 days following the last application. All RQ exceedances were for adult chronic exposure.

Peach

Refined Tier I oral RQ values for honey bees resulting from use on peach range from 0.20 – **18.1** (adult acute), 0.04 – **2.45** (larval acute), **5.34** – **490** (adult chronic), and 0.09 – **4.79** (larval chronic) depending on their caste and function within the hive. These RQ values reflect measured residues of pollen and nectar obtained from foliar applications adjusted to the maximum label rate for peach (MRID 50355203). Figure 6-10 below shows the adult and larval oral RQs in relation to the LOCs with the totality of the nectar and pollen data available and how it translates into the magnitude, duration and frequency of Tier I LOC exceedances.

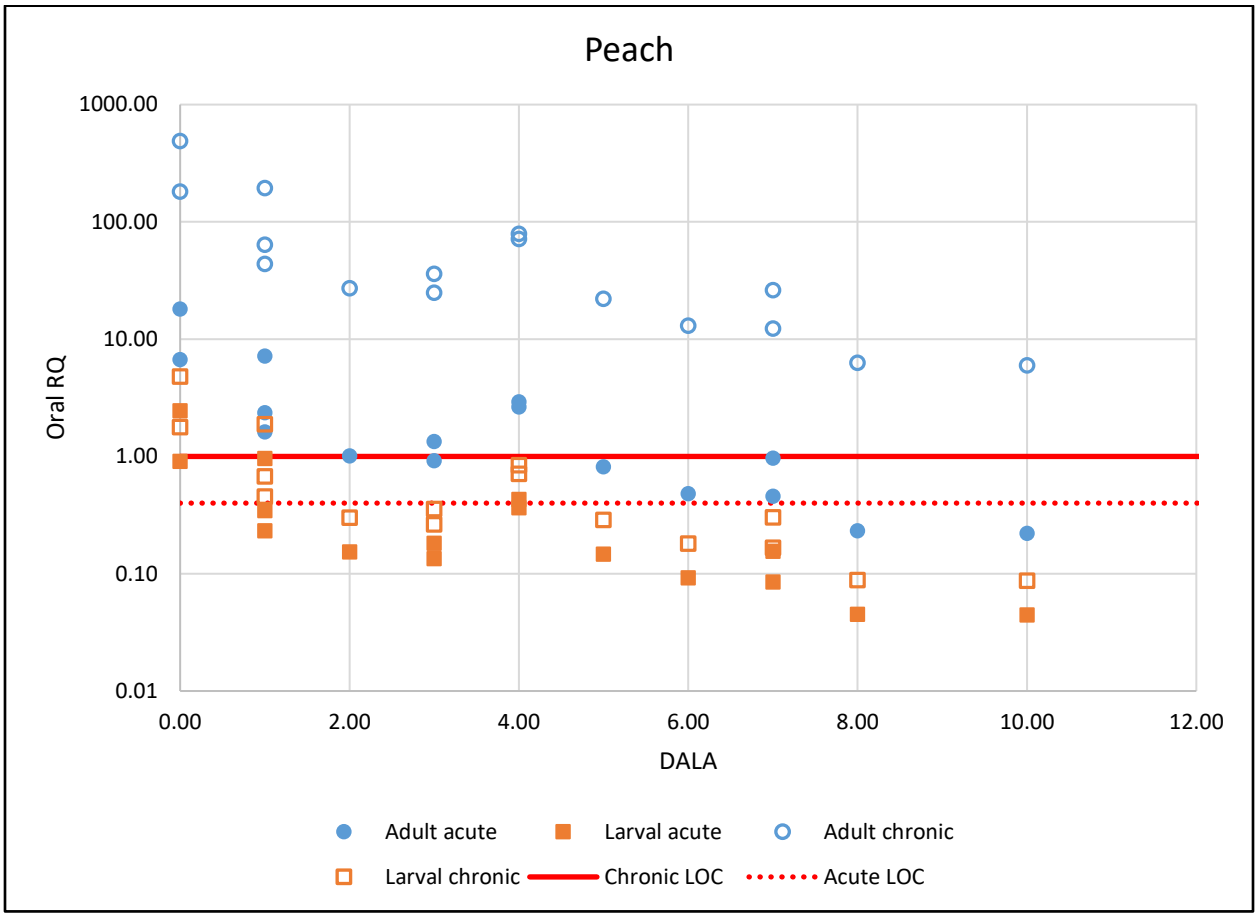


Figure 3. Summary of acute and chronic RQ values using totality of pollen and nectar residue data from foliar-applied peach residue study (MRID 50355203).

Daily oral RQ values were calculated for each life stage/duration. As indicated by **Figure 0.1**, adult and larval acute and larval chronic refined Tier I RQ values were below the LOC values (0.4 and 1.0, respectively) 8 days following the last application. Adult chronic RQs for the duration of the study did not fall below the LOC of 1.0.

Apple

Refined Tier I oral RQ values for honey bees resulting from use on apple range from 0.10 – **0.51** (adult acute), 0.01 – 0.10 (larval acute), 0.03 – **13.9** (adult chronic), and 0.01 – 0.19 (larval chronic) depending on their caste and function within the hive. These RQ values reflect measured residues of pollen and nectar obtained from foliar applications adjusted to the maximum label rate for peach (MRID 50444405). Figure 6-10 below shows the adult and larval oral RQs in relation to the LOCs with the totality of the nectar and pollen data available and how it translates into the magnitude, duration and frequency of Tier I LOC exceedances.

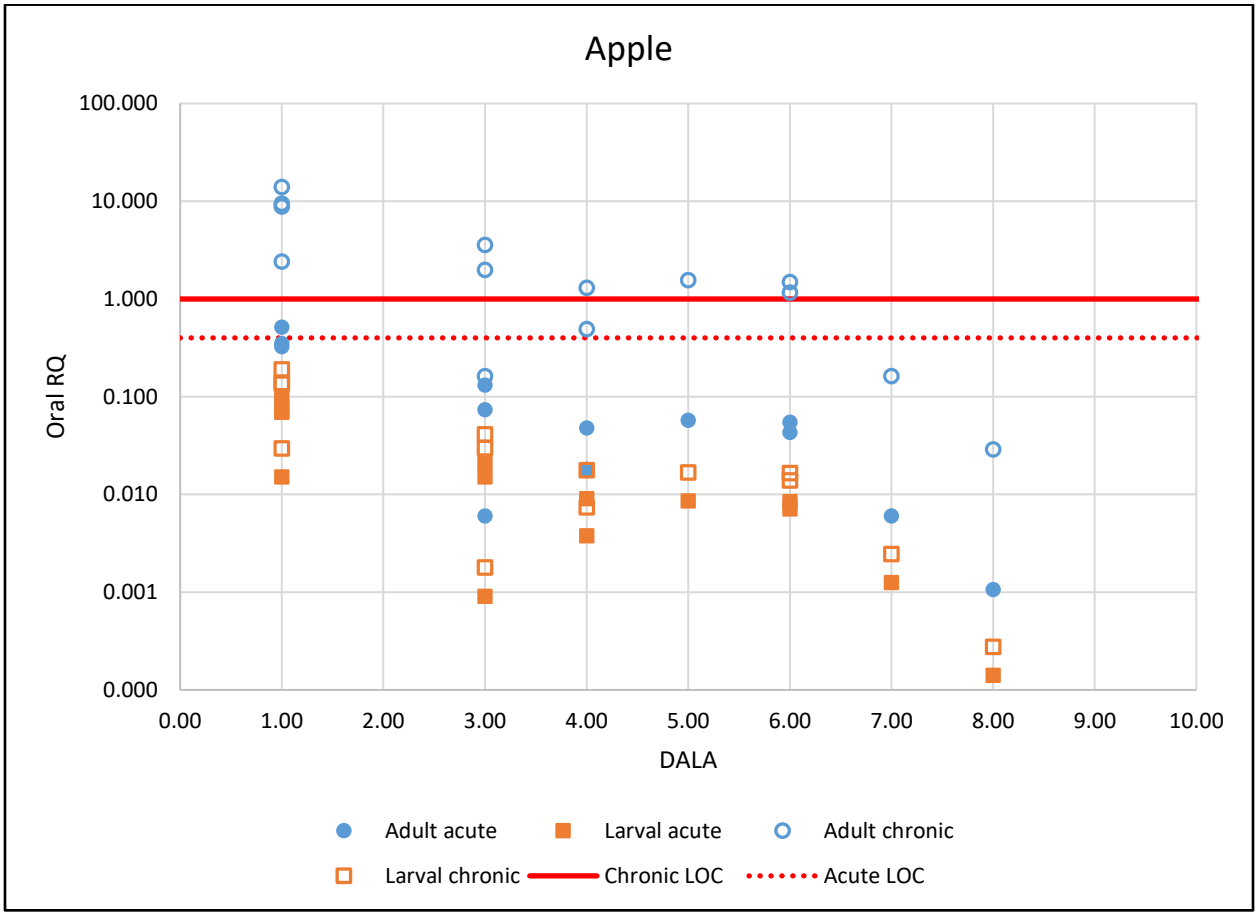


Figure 4. Summary of acute and chronic RQ values using totality of pollen and nectar residue data from foliar-applied apple residue study (MRID 50444405).

Daily oral RQ values were calculated for each life stage/duration. As indicated by **Figure 0.1**, 100% of the refined Tier I acute and chronic RQ values were below the LOC values (0.4 and 1.0, respectively) 7 days following the last application.

Strawberry

Refined Tier I oral RQ values for honey bees resulting from use on strawberry range from 0.01 – **33.6** (adult acute), 0.01 – **5.57** (larval acute), 0.16 – **820** (adult chronic), and 0.01 – **9.69** (larval chronic) depending on their caste and function within the hive. These RQ values reflect measured residues of pollen and nectar obtained from foliar applications adjusted to the maximum label rate for strawberry (MRID 50444404 and 50444402). Figure 6-10 below shows the adult and larval oral RQs in relation to the LOCs with the totality of the nectar and pollen data available and how it translates into the magnitude, duration and frequency of Tier I LOC exceedances.

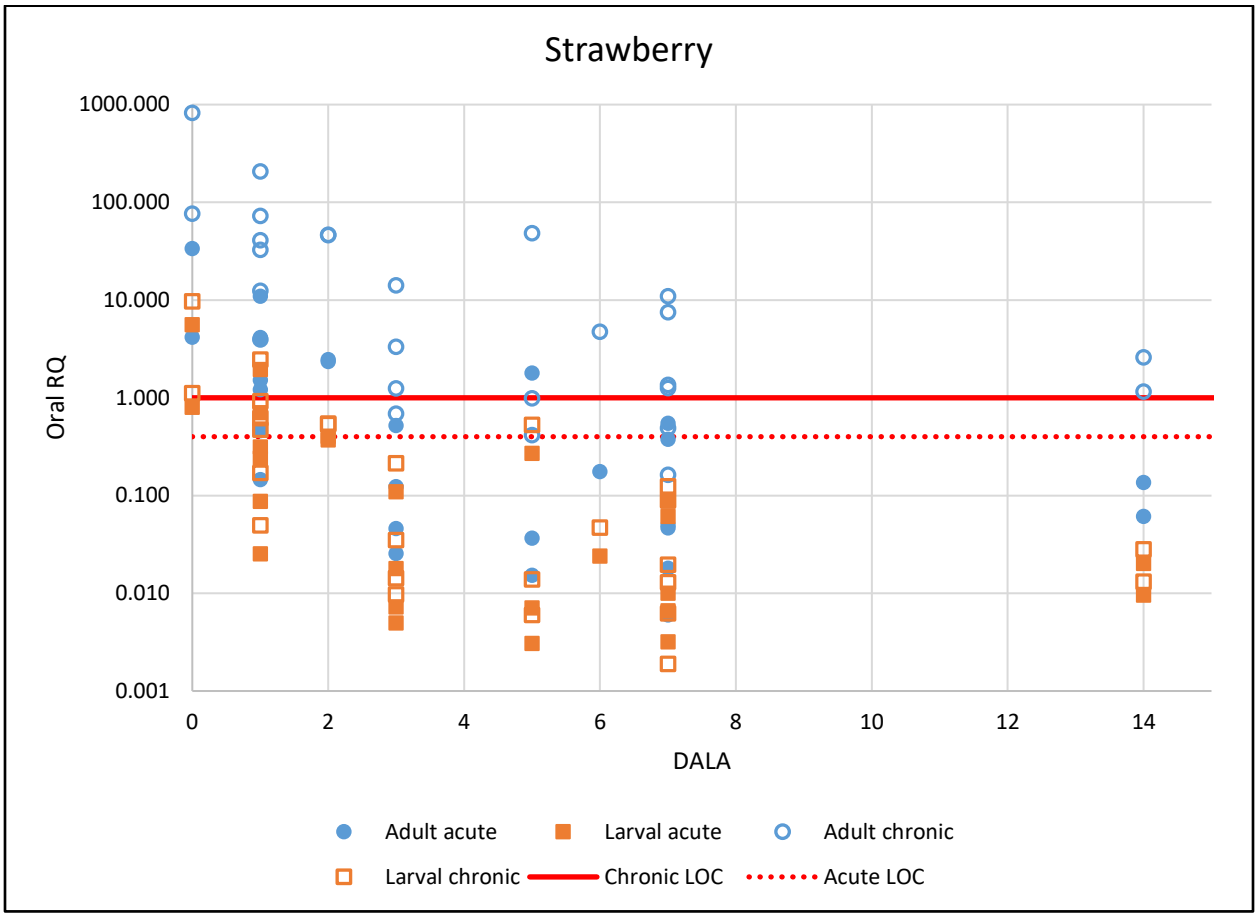


Figure 5. Summary of acute and chronic RQ values using totality of pollen and nectar residue data from foliar-applied strawberry residue study (MRID 50444404 and 50444402).

Daily oral RQ values were calculated for each life stage/duration. As indicated by **Figure 0.1**, adult and larval acute and larval chronic refined Tier I RQ values were below the LOC values (0.4 and 1.0, respectively) 14 days following the last application. Adult chronic RQs for the duration of the study did not fall below the LOC of 1.0.

Alfalfa

Refined Tier I oral RQ values for honey bees resulting from use on alfalfa range from 0.01 – **63.6** (adult acute), 0.01 – **9.83** (larval acute), 0.04 – **1070** (adult chronic), and 0.01 – **12.2** (larval chronic) depending on their caste and function within the hive. These RQ values reflect measured residues of pollen and nectar obtained from foliar applications adjusted to the maximum label rate for alfalfa (MRID 50444401). Figure 6-10 below shows the adult and larval oral RQs in relation to the LOCs with the totality of the nectar and pollen data available and how it translates into the magnitude, duration and frequency of Tier I LOC exceedances.

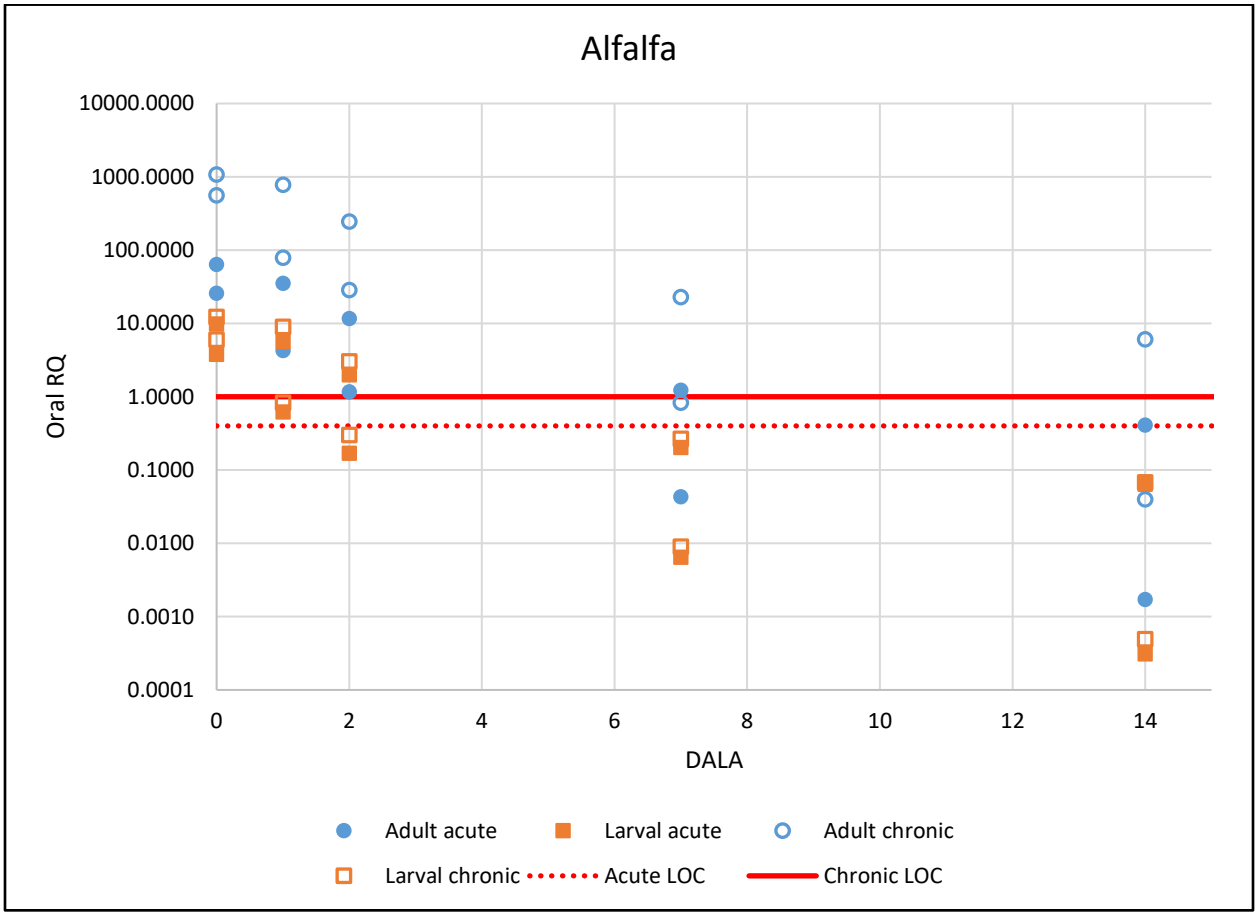


Figure 6. Summary of acute and chronic RQ values using totality of pollen and nectar residue data from foliar-applied alfalfa residue study (MRID 50444401).

Daily oral RQ values were calculated for each life stage/duration. As indicated by Figure 0.1, larval acute and chronic refined Tier I RQ values were below the LOC values (0.4 and 1.0, respectively) 14 days following the last application. Maximum adult acute and chronic RQs for the duration of the study did not fall below the LOC of 1.0.

Cotton

Refined Tier I oral RQ values for honey bees resulting from use on cotton range from 0.01 – 0.25 (adult acute), 0.01 – 0.05 (larval acute), 0.16 – **6.86** (adult chronic), and 0.01 – 0.10 (larval chronic) depending on their caste and function within the hive. One outlier value is excluded from this summary. These RQ values reflect measured residues of pollen and nectar obtained from foliar applications adjusted to the maximum label rate for cotton (MRID 48755606). Figure 14-29 and 14-30 below show the adult and larval oral RQs in relation to the LOCs with the totality of the nectar and pollen data available and how it translates into the magnitude, duration and frequency of Tier I LOC exceedances.

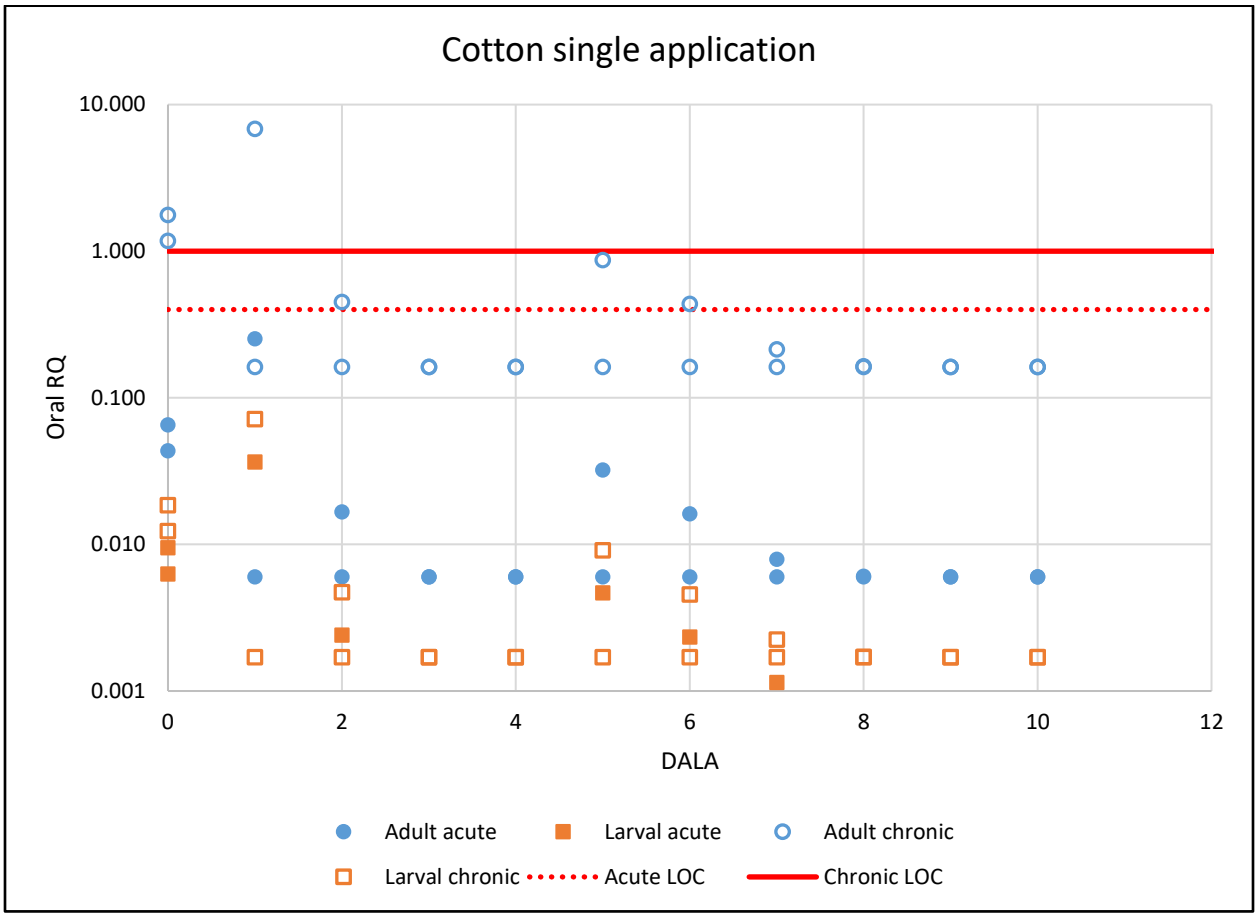


Figure 7. Summary of acute and chronic RQ values using pollen and nectar residue data from foliar-applied cotton residue study with only one application (MRID 48755606).

Daily oral RQ values were calculated for each life stage/duration. As indicated by Figure 14-29, adult and larval acute and larval chronic refined Tier I RQ values were below the LOC values (0.4 and 1.0, respectively) at all timepoints after application. Maximum adult chronic RQs for the study fell below the LOC of 1.0 within 6 days after application.

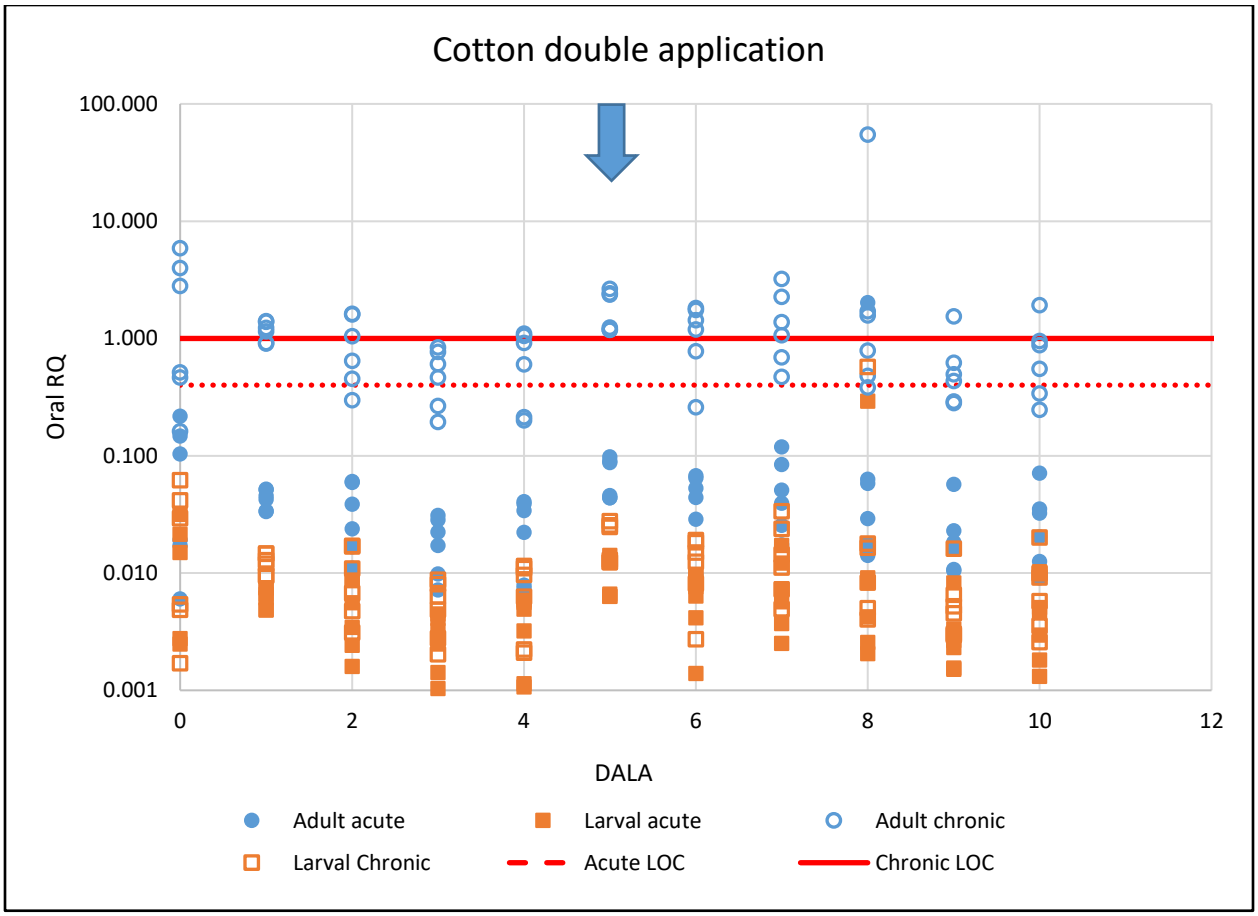


Figure 8. Summary of acute and chronic RQ values using pollen and nectar residue data from foliar-applied cotton residue study with two applications, blue arrow represents day of second application (MRID 48755606).

When considering a multiple application scenario daily oral RQ values were again calculated for each life stage/duration. As indicated by Figure 14-30, adult and larval acute and larval chronic refined Tier I RQ values were below the LOC values (0.4 and 1.0, respectively) at all timepoints after application. Maximum adult chronic RQs for the duration of the study did not fall below the LOC of 1.0. As seen in Figure 14-29 it took up to 6 days after application for RQ values to fall below the LOC and measurements were only taken for 5 days as represented in Figure 14-30.

Canola

Refined Tier I oral RQ values for honey bees resulting from use on canola range from 0.01 – **0.54** (adult acute), 0.01 – 0.11 (larval acute), 0.16 – **14.52** (adult chronic), and 0.01 – 0.21 (larval chronic) depending on their caste and function within the hive. These RQ values reflect measured residues of pollen and nectar obtained from foliar applications adjusted to the maximum label rate for canola (MRID 50355204 and 50444406). Figure 14-31 below show the adult and larval oral RQs in relation to the LOCs with the totality of the nectar and pollen data available and how it translates into the magnitude, duration and frequency of Tier I LOC exceedances.

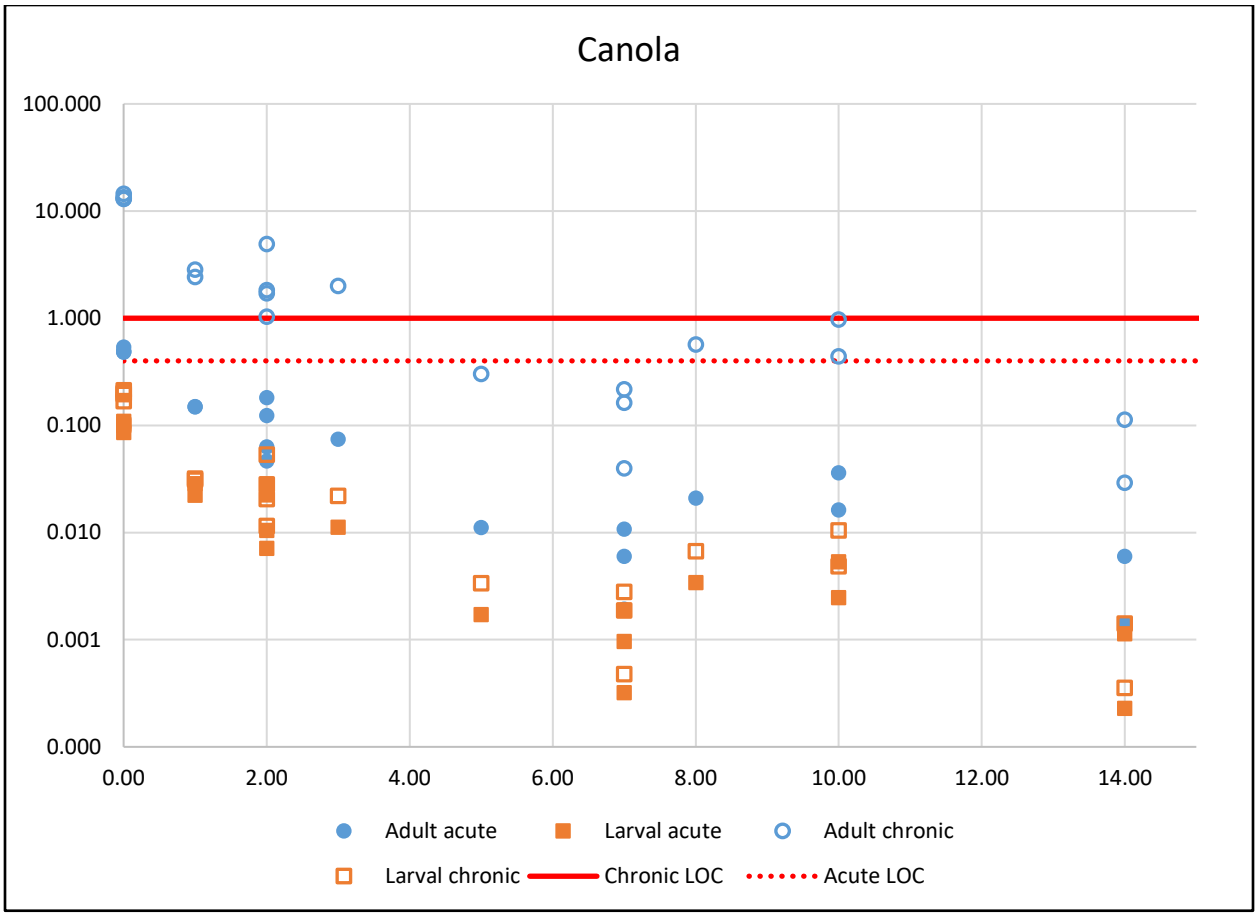


Figure 9. Summary of acute and chronic RQ values using totality of pollen and nectar residue data from foliar-applied canola residue studies (MRID 50355204 and 50444406).

Daily oral RQ values were calculated for each life stage/duration. As indicated by **Figure 14-31**, all larval RQ values were below the associated LOC values (0.4 and 1.0, respectively). While, all of the refined Tier I acute and chronic RQ values were below the LOC 10 days following the last application.

Sunflower

Refined Tier I oral RQ values for honey bees resulting from use on sunflower range from 0.01 – **0.95** (adult acute), 0.01 – 0.14 (larval acute), 0.16 – **25.58** (adult chronic), and 0.01 – 0.28 (larval chronic) depending on their caste and function within the hive. These RQ values reflect measured residues of pollen and nectar obtained from foliar applications to sunflower (MRID 50355201). Figure 14-32 below show the adult and larval oral RQs in relation to the LOCs with the totality of the nectar and pollen data available and how it translates into the magnitude, duration and frequency of Tier I LOC exceedances.

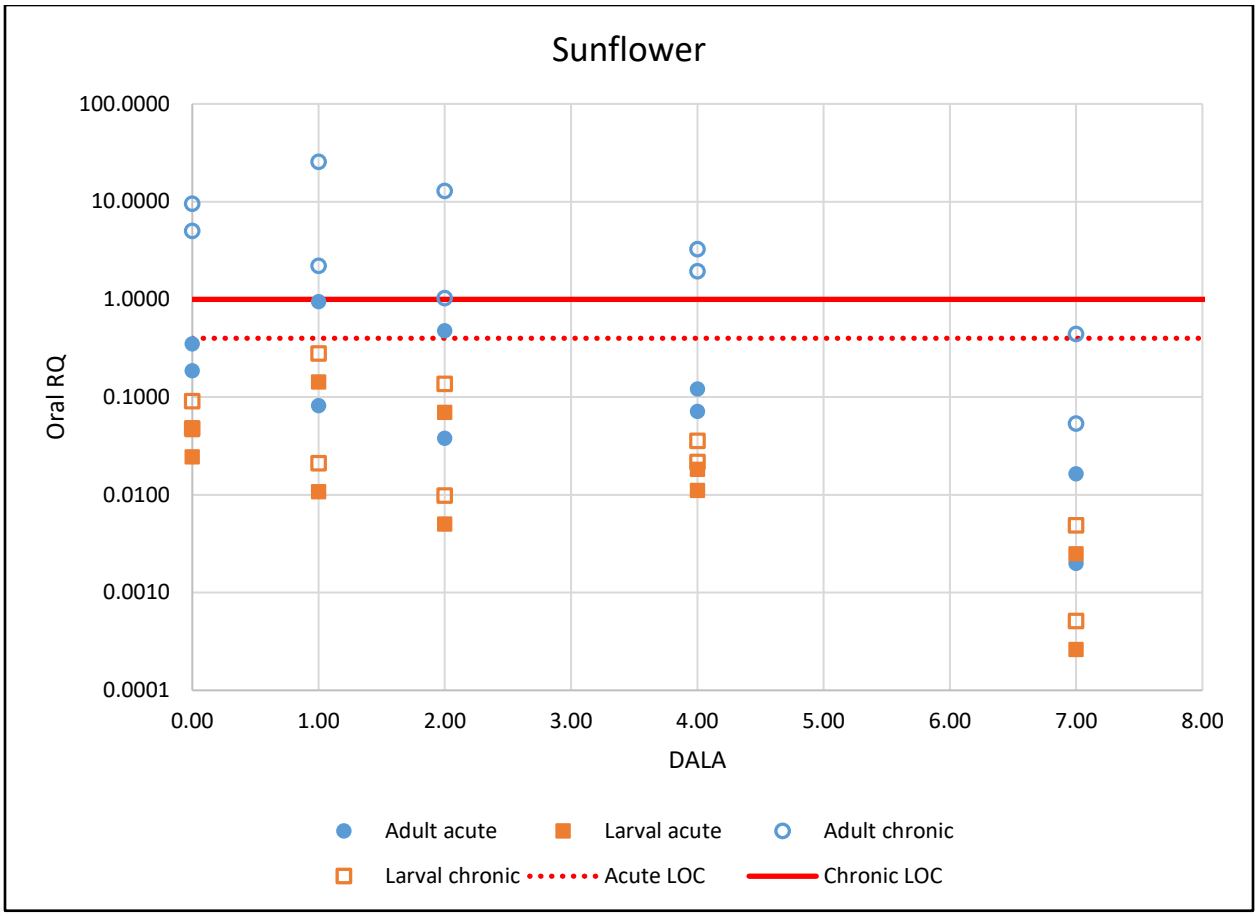


Figure 10. Summary of acute and chronic RQ values using totality of pollen and nectar residue data from foliar-applied sunflower residue studies (MRID 50355201).

Daily oral RQ values were calculated for each life stage/duration. As indicated by **Figure 14-31**, all larval RQ values were below the acute and chronic LOC values (0.4 and 1.0, respectively). While, all refined Tier I acute and chronic RQ values were below the LOC 7 days following the last application.

Appendix H. Previously Reviewed Honey Bee Tier II Tunnel Studies

A total of six Tier II semi-field (tunnel) studies were submitted by the registrant examining the effects of sulfoxaflor on the honey bee at the colony-level. As noted in the previous Section 3 ecological risk assessment (D382619), there are uncertainties associated with the results from these studies, but they are included here for completeness purposes. The salient features and primary risk conclusions associated with each of the six semi-field studies are summarized in **Table H-1**. A discussion of measured effects of sulfoxaflor on various individual and colony-level endpoints is provided below.

Study Design Summary. All six tunnel studies differed substantially in their overall design. For example, Hecht-Rost (2009) used a regression-type design which included five different application rates ranging from 0.006 to 0.088 lb ai/A with one replicate (tunnel) per treatment. Similarly, Ythier (2012) evaluated four different application rates ranging from 0.045 to 0.134 lb ai/A) with one replicate tunnel per treatment. The studies by Schmitzer (2010; 2011a,b,c) used a hypothesis-based test design with fewer treatments but three replicate tunnels per treatment with application rates ranging from 0.004 to 0.043 lb a.i./A. Although this design permitted statistical analysis via hypothesis testing, the high variability in response endpoints combined with the small number of replicates (3) resulted in low statistical power for detecting potential treatment-related effects in the vast majority of comparisons. Therefore, observed differences in mean responses across treatments are also emphasized in addition to statistical differences to determine whether any trends were apparent across treatments/controls.

Regarding the timing of pesticide applications, Schmitzer (2010) evaluated sulfoxaflor applications during and after bee flight, while Schmitzer (2011a,b) evaluated applications prior to bloom in addition to during and after bee flight. Schmitzer (2011c), Ythier (2012), and Hecht-Rost (2009) evaluated applications only during bee flight.

The duration of the observation period post-application also differed widely across studies. Hecht-Rost (2009) and Schmitzer (2010) included no observations after hives were removed from the exposure tunnels. Schmitzer (2011a,b,c) included a 10-d, 17-d and 90-d post tunnel (post-exposure) observation period, respectively. Ythier (2012) evaluated effects after 7 days post exposure.

It is also important to note that the time of year when each study was initiated also differed among the studies. Tests were started in June (for Schmitzer 2011a), July (for Schmitzer 2011b), August (for Hecht-Rost 2009, Schmitzer 2010, and Ythier 2012) and October (for Schmitzer 2011c). Since honey bee colonies typically show strong seasonal increases and declines over the course of spring, summer and fall, the timing of the study can be an important factor to consider when interpreting the results.

Lastly, in terms of the relevance of the foliar applications to the proposed registration of sulfoxaflor in the US, it is noted that all but the Ythier (2012) study used application rates that

were substantially below the maximum proposed application rate in the US (*i.e.,* below single rate of 0.133 lb ai/A and the yearly maximum rate of 0.266 lb ai/A).

Forager Mortality. Five of the semi-field studies summarized in **Table H-1** included measures of forager bee mortality determined from observations of dead bees collected away the hive and from dead bee traps at the hive entrances during the period of confinement in the tunnels. In general, the mortality pattern of adult forager bees was similar across the five tunnel studies. A spike in mortality up to 20 times that of control hives was observed on the day of pesticide application (0 day after application; 0DAA). Subsequent to 0DAA, forager bee mortality declined sharply and recovered to levels similar to control hives within 3 days, sometimes less. For studies that included identical application rates during and after bee flight (Schmitzer 2010; 2011a,b), the magnitude of forager bee mortality was generally greater when pesticide was applied during bee flight compared to after bee flight, likely reflecting the combined effect of exposure via direct contact and via contact and/or ingestion residues on plants. The lack of sustained mortality of adult foragers following pesticide applications at rates from 3-67% of the maximum single rate proposed in the US suggests that the direct effects of sulfoxaflor on foraging bees (*i.e*., those effects resulting from exposure from direct contact with spray droplets and residues on plants) are relatively short-lived. However, the potential for indirect effects of short-term loss of foragers on brood development and colony strength over the longer-term (e.g., through pre-mature recruitment of hive bees into the forager work force) at maximum US application rates has not been quantified. Although Ythier (2012) used the maximum single and seasonal application rates, they did not quantify the effects of sulfoxaflor on forager bee mortality since this study was intended to measure sulfoxaflor residues in plant tissues, not biological effects.

In the context of toxicity from dried residues on plants, the lack of sustained mortality to forager bees from residues applied after bee flight is consistent with the results from the foliar residue toxicity study (MRID-47832512) which showed ≤15% mortality after exposure to aged foliar residues from 4 hours to 24 hours.

Forager Flight Activity. The effect of sulfoxaflor on forager bee flight activity generally reduced the activity immediately following pesticide application. Hecht-Rost (2009), Schmitzer (2010) and Schmitzer (2011a, b) all reported reductions in flight activity up to 5 times lower than controls on 0DAA. By 3DAA, however, flight activity was similar to control levels in these studies. No obvious treatment-related effects on flight activity were reported by Schmitzer (2011c); however, the application rates used were very low relative to the proposed maximum US rate (3-16% of the maximum proposed rate). Overall, these results suggest that at rates from 3-67% of the maximum single rate proposed in the US, the direct effects of sulfoxaflor on flight activity of foraging bees (*i.e*., those effects resulting from exposure from direct contact with spray droplets and residues on plants) are relatively short-lived. The effects of sulfoxaflor on the flight activity of foraging bees at maximum application rates proposed in the US have not been quantified.

Behavior Abnormalities. Similar to adult forager mortality and flight activity, the occurrence of behavior abnormalities (*e.g.* uncoordinated movement, spasms or an intensive cleaning behavior) was short-lived at the studied application rates (3-67% of US maximum). The frequency of these behavioral abnormalities was relatively low and they were not sustained beyond 2 days after pesticide application.

Brood Development. The suitability of the submitted semi-field studies for quantifying the effects of sulfoxaflor on developing honey bee brood is very limited, even when they are considered apart from limitations associated with the use of low application rates. Hecht-Rost (2009) and Schmitzer (2010) evaluated brood after only 7 and 9 days exposure, which is far short of the recommended duration of semi-field studies by OECD Guideline 75. A longer post-exposure evaluation time is necessary in order to evaluate the effects over an entire honey bee brood cycle (21 days for workers). Furthermore, these two studies also held bees in tunnels for much longer than recommended prior to exposure (8-11 days vs. 2-3 days recommended by OECD Guideline 75), which may have confounded interpretation of brood development results as colony bees may have experienced undue stress from prolonged confinement of hives in the tunnel. Schmitzer (2011c) included a long post-exposure observation period (3 months); however, the study was initiated in late October and brood development and colony-strength were already in a state of significant decline due to the late season in which the study was conducted. This uncertainty is supported by the lack of discernible effects on brood at 14DAA by either reference toxicant (dimethoate or fenoxycarb) used in the study. Ythier (2012) evaluated brood pattern at 10DAA and 17DAA (close to an entire brood cycle), but did not include a control treatment in order to make appropriate comparisons. It is noted, however, that this study was not designed to provide a comprehensive evaluation of biological effects; rather it was designed to quantify sulfoxaflor residues in various plant matrices. Although pre- and post-application assessments of brood can be compared (**Table H-1.**), it is not possible to distinguish the effects of tunnel confinement from those of sulfoxaflor on brood development based on pre- and post-exposure comparisons alone. Adverse effects resulting from tunnel confinement in the cotton study by Ythier (2012) is considered possible (if not likely) because cotton pollen is known to be a sub-optimal source of pollen to honey bees (Vaissiere *et al.*, 1994) and bees were not able to maintain sufficient pollen stores over the course of the tunnel exposure.

Apart from their low applications rates (16-32% of the proposed US maximum), the two studies with the most suitable design for evaluating the effects of sulfoxaflor on honey bee brood are Schmitzer (2011a,b). Both studies included adequate post-application observation periods (20-53 days), used three replicates/treatment, and tracked the development of a defined cohort of marked brood over time (rather than overall brood pattern on the comb). By following the development of individual brood, two indices of brood development were derived (*i.e.*, brood termination index and brood compensation index) according to OECD Guideline 75. The brood termination index is simply the proportion of brood that fails to develop fully through emergence. The brood compensation index is a reflection of the average of the five

development stages achieved by the brood cohort (with 1 = egg, 2 = young larvae, 3 = old larvae, 4 = pupae, 5= empty cell [emerged] or cell re-filled with egg/larva).

In both studies, Schmitzer (2011a,b) reported a high average brood termination rate in control hives of 56% and 65%, respectively. This means that over half the brood in control hives failed to emerge and transition to adult bees. Although no specific acceptability criteria have been defined by OECD for this index in controls, these values exceed brood termination rates of controls reported by an inter-laboratory study supporting the development of OECD Guideline 75 (Schur *et al*., 2003). Notably, Schur *et al.* reported that brood termination rate in control hives varied from 8% to 43% in a ring-test of five trials of the OECD 75 tunnel study design. The authors attributed the high brood termination rates (32-43%) in three trials to poor weather conditions that occurred during the studies. In a recent review of historical control data for brood termination rate, Pistorius *et al*., (2011) correlated increases in control brood termination rate with lateness in the season of test initiation and smaller available forage area in the tunnels. Regardless of the source of the high brood termination rate in the control treatments from Schmitzer (2011a,b), it likely reflects stress on the bees caused by the study design and creates substantial uncertainty as to the ability to detect the potential effects of sulfoxaflor on developing brood. A large increase in brood termination rate (98-100%) was observed for the reference toxicant (fenoxycarb) for these two studies, which indicates that despite the high larval mortality in control hives, a major catastrophic impact on brood could be detected. Importantly, the application rates of fenoxycarb (300 g ai/ha or about 2X the maximum single application rate identified in the US) are specifically intended to cause catastrophic impacts on developing brood in order to demonstrate that the study design was sufficient to detect effects on brood. Although the effects of sulfoxaflor applications on brood development are uncertain due to high mortality of larvae in controls, these results suggest that the overall effects were less than the catastrophic losses experienced by the colonies exposed to the reference toxicant.

The results from the brood compensation index indicated no obvious or statistical differences in treatments compared to controls by 22DAA and 21DAA for Schmitzer (2011a,b), respectively. The average brood compensation rate in control and sulfoxaflor-treated hives ranged from 3.0 to 4.2. This indicates that on average, honey bee broods were able to reach an older larval or pupal stage. Therefore, these results suggest that the high brood termination rate discussed previously occurred principally at the latter stages of brood development. Since the brood compensation and termination indices are related, the uncertainty associated with high brood termination rate in controls also impacts the interpretation of the brood compensation index responses. In both studies, a large reduction in brood compensation index (1.7-1.9) indicates the effects of the reference toxicant (fenoxycarb) were discernible in this study.

Taken as a whole and in consideration of their respective limitations, the results from the six tunnel studies are unable to conclusively demonstrate whether sulfoxaflor applications adversely impact brood development, even at the lower application rates used.

Colony Strength. Measures of colony strength (number of bees occupying the combs) were available from 5 of the 6 tunnel studies submitted (**Table H-1**). Assessment relative to concurrent control hives was possible in 3 studies (one study had no concurrent control and the other had compromised controls). In general, effects of sulfoxaflor on colony strength were slight or not apparent with the three studies with controls (Schmitzer 2011a,b,c). A 15-28% reduction in mean colony strength was apparent through most of the exposure period for the treatment with the two highest application rates (0.043 lb ai/A pre-bloom and after flight). However, a similar study conducted by the same authors (Schmitzer 2011b) found no obvious difference in colony strength with 0.043 lb ai/A applied pre-bloom. Similarly, Schmitzer (2011c) found no obvious difference in colony strength of treatments compared to controls by 14DAA. However, it should be noted that application rates used in this study were very low (3-16% of US maximum) and it was conducted late in the season as colonies were in a natural state of decline in terms of brood production.

When colony strength is evaluated by comparing pre- and post-application measurements within a sulfoxaflor treatment, no treatment-related difference is apparent in the study by Hecht-Rost (2009) measured at 7DAA or Ythier (2012) measured at 10 days after first application (10DAFA and 17DAFA. The similarity in colony strength measurements taken pre- and post application within and among all treatments reported for the cotton study (Ythier 2012) implies that conditions of the sulfoxaflor treatments did not result in an obvious decline in mean colony strength by 17DAFA, even at the maximum US application rate of 2 x 0.134 lb ai/A. Although lack of a current control and limited observation period precludes definitive conclusions regarding the effect of sulfoxaflor on colony strength in this study, these results suggest that major impacts on honey bee colony strength are not apparent with sulfoxaflor applications at the maximum US application rate, at least over the short term (*e.g.,* 17DAFA).

Overall Conclusions from Tier II Assessment. Results from the Tier II semi-field studies suggest that at the application rates used (3-67% of US maximum), the direct effects of sulfoxaflor on adult forager bee mortality, flight activity and the occurrence of behavioral abnormalities is relatively short-lived, lasting 3 days or less. Direct effects are considered those that result directly from interception of spray droplets or dermal contact with and ingestion of foliar residues. The direct effect of sulfoxaflor on these measures at the maximum application rate in the US is presently not known. The effect of sulfoxaflor on brood development is considered inconclusive due to the aforementioned limitations associated with these studies. When compared to controls, the effect of sulfoxaflor on colony strength applied at 3-32% of the US maximum proposed rate was either not apparent or modest at most (based on one study). Sulfoxaflor applied to cotton foliage up to the maximum rate proposed in the US did not result in an observable decline in mean colony strength by 17DAFA when compared to colonies assessed 3 days prior to application. Additional data would be needed to determine the potential effects of sulfoxaflor applications on brood development and long-term colony health at the maximum application rates proposed in the US. Such data would include one or more Tier II semi-field tunnel studies conducted according to OECD 75 guidance. It is further noted that the high variability in sulfoxaflor residues from the cotton residue study and the nature of

the cotton flowering introduces uncertainty in the extrapolation of these residue results to other crops. Therefore, additional data on the nature and magnitude of sulfoxaflor residues in one or more pollinator-attractive crops would be needed to address this source of uncertainty.

Table H-1. Summary of Tier II colony-level studies conducted with sulfoxaflor

Study Attribute	Results Summary					
	1. Hecht-Rost (2009) MRID-48445806	**2. Schmitzer (2010)** MRID 48445807	**3. Schmitzer (2011a)** MRID 48755604	**4. Schmitzer (2011b)** MRID 48755605	**5. Schmitzer (2011c) (no MRID)**	**6. Ythier 2012** MRID 48755606
Application Timing & Rate	**During flight: 0.006-0.088 lb ai/A** (6-99 g ai/ha)	**During flight: 0.021-0.043 lb ai/A** (24 & 48 g ai/ha) **After flight:** 0.043 lb ai/A (48 g ai/ha)	**Pre bloom: 0.043 lb ai/A** (48 g ai/ha) **After flight: 0.021-0.043 lb ai/A** (24 & 48 g ai/ha) **During flight: 0.021 lb ai/A** (24 g ai/ha)	**Pre bloom: 0.043 lb ai/A** (48 g ai/ha) **After flight: 0.021 lb ai/A** (24 g ai/ha) **During flight: 0.021 lb ai/A** (24 g ai/ha)	**During flight: 0.004, 0.007, 0.021 lb ai/A** (4, 8, 24 g ai/ha)	**During flight**: **0.045 lb ai/A x 1** (50 g ai/ha x 1) **0.045 lb ai/A x 2** (50 g ai/ha x 2) **0.089 lb ai/A x 2** (100 g ai/ha x 2) **0.134 lb ai/A x 2** (150 g ai/ha x 2)
No. Reps. / Treatment	1	3	3	3	3	1
% of US Max. Single Appl. Rate	4-67%	16-32%	16-32%	16-32%	3-16%	34-100%
Crop	*Phacelia*	*Phacelia*	*Phacelia*	*Phacelia*	*Phacelia*	Cotton
Exposure Pathways Assessed	Direct contact, dermal, oral	Direct contact, dermal, oral	**During flight:** Direct contact, dermal, oral **Pre-bloom, after flight:** dermal, oral	**During flight:** Direct contact, dermal, oral **Pre-bloom, after flight:** dermal, oral	Direct contact, dermal, oral	Direct contact, dermal, oral
Exposure Duration, Month of Study Initiation	**In-Tunnel Exposure:** (pre-application) **11d** (post-application) **7d** **Post Tunnel Obs.: 0d** August	**In-Tunnel Exposure:** (pre-application) **8d** (post-application) **9d** **Post Tunnel Obs.: 0d** August	**In-Tunnel Exposure:** (pre-application, after & during flight) **3d** (pre-application, pre-bloom) **0d** (post-application, after & during flight) **7d** (post-application, pre-bloom) **10d** **Post Tunnel Obs.: 20d**	**In-Tunnel Exposure:** (pre-application, after & during flight) **10d** (pre-application, pre-bloom) **0d** (post-application, after & during flight) **7d** (post-application, pre-bloom) **17d** **Post Tunnel Obs.: 53d**	**In-Tunnel Exposure:** (pre-application) **8d** (post-application) **7d** **Post Tunnel Obs.: 90d (colony survival)** October	**In-Tunnel Exposure:** (pre-application) 3**d** (post-application) **10d** **Post Tunnel Obs.: 7d** August-September

Study Attribute	Results Summary					
	1. Hecht-Rost (2009) MRID-48445806	**2. Schmitzer (2010)** MRID 48445807	**3. Schmitzer (2011a)** MRID 48755604	**4. Schmitzer (2011b)** MRID 48755605	**5. Schmitzer (2011c) (no MRID)**	**6. Ythier 2012** MRID 48755606
			June	July		
Forager Mortality	**Day 0**: up to 7X increase (treatment dependent) **Day 3-7**: ≈ control levels;	**Day 0**: Up to 20X increase **Day 3-7**: ≈ control levels	**Day 0-1**: up to 8X increase in mortality **Days 2-7**: treat ≈ controls **Days 8-27 (post tunnel):** treat ≈ controls	**Day 0**: up to 3X ↑ **Days1-7:** no consistent difference vs. controls**	**Day 0:** up to 4X ↑; **Day 1-7:** treatments ≈ controls	Not assessed
Flight Intensity	**Day 0**: up to 5X decrease (dose-dependent) **Day 3-7**: Dose-independent decrease	**Day 0**: up to 2X decrease **Days 1-7**: treatment ≈ controls	Some reduction seen (during and after bee flight), but recovery to control levels by D2-4	**Day 0:** some (<50%) reduction vs. controls **Day 1-7:** treatment ≈ controls	No obvious treatment related effects on foraging activity, but late season may have confounded results	Not assessed
Forager Behavior	Light intoxication symptoms (D0AA only**)**	Some behavioral abnormalities ≤ 2DAA	Some behavior abnormalities observed on 0DAA in 1 treatment, none thereafter	No behavioral abnormalities observed at any treatment	Some behavior abnormalities observed on 0DAA in 24 g ai/ha, none thereafter	Not assessed
Brood Development	**Treat vs. Control:** Inconclusive **Pre vs. Post Appl.:** - Dose-dependent ↓in % Larvae - Dose-dependent. ↓ in % capped brood	**Treat vs. Control:** - no statistical or obvious difference @ 9DAA; **Pre vs. Post:** - no statistical or obvious differences; - modest ↓% capped and ↑ % empty cells may reflect emergence	**Treat vs. Control:** **Brood compensation index:** - no statistical or obvious treatment related effects @ 22DAA - **Brood termination rate:** - inconclusive	**Treat vs. Control:** **Brood compensation index:** - no statistical or obvious treatment related effects @ 21DAA - **Brood termination rate:** - inconclusive	**Treat vs. Control:** **Brood pattern:** treat ≈ controls through 14DAA, but late season may have confounded results	No control was included **Pre vs. Post Appl.** **Brood pattern:** - %larvae, %pupae, reduced ~ 2X @ 10DAA; - % pollen ~ 0% @ 10DAA - %nectar ≥ pre-appl. levels - % adult bees within 20% of pre-appl levels
Colony Strength	**Treat vs. Control:** Inconclusive **Pre vs. Post Appl.:**	Not assessed	**Treat vs. Control:** Up to 15-28% reduction in 48g ai/ha through	**Treat vs. Control:** - treatments ≈ controls up through 60DAA	**Treat vs. Control:** - treatments ≥ controls, but late season may	**Pre vs. Post Appl.** Hive strength similar across treatments

Study Attribute	Results Summary					
	1. Hecht-Rost (2009) MRID-48445806	**2. Schmitzer (2010)** MRID 48445807	**3. Schmitzer (2011a)** MRID 48755604	**4. Schmitzer (2011b)** MRID 48755605	**5. Schmitzer (2011c) (no MRID)**	**6. Ythier 2012** MRID 48755606
	10-25% dose-independent ↓		27DAA (pre bloom) and 15DAA (after flight)		have confounded results - By D90AA, only 1/18 colonies failed (8 g/ha)	before and after application
Study Limitations*	1. *Varroa* infestation in controls 2. Long pre-exposure period in tunnels (11d) 3. High variability among colonies prior to exposure 4. Short observation period (7d) 5. 1 rep/treatment 6. Low % larvae in controls (7DAA)	1. Long pre-exposure period in tunnels (8d) 2. Short observation period (9d) 3. High overall variability within treatments (n=3) 4. No colony strength measurements	1. Poor control performance re: brood termination rate (56%) 2. High overall variability within treatments (n=3)	1. Poor control performance re: brood termination rate (65%) 2. Long pre-exposure period in tunnels (10d) 3. high overall variability within treatments (n=3)	1. All colonies in steep decline in brood condition due to late season (Oct). rendering the ability to detect treatment effects uncertain	1. No concurrent control was included for interpreting biological effects*** 2. one replicate / treatment 3. short observation period (17d)
Reference Toxicant Effects	**Dimethoate (400g/ha);** - similar brood pattern as controls (except % larvae) - colony strength similar to treatments; - sustained ↑in # dead bees; -sustained ↓flight intensity	**Dimethoate (600g/ha);** - similar brood pattern as controls - sustained ↑in # dead bees; -sustained ↓flight intensity	**Fenoxycarb (300g /ha)** - **Brood compensation:** sustained ↓ vs. controls over 22DAA - **Brood termination:** major impact (98%) - c**olony strength:** generally sustained reduction vs. controls	**Fenoxycarb (300g /ha & Dimethoate 600g/ha:** - c**olony strength:** generally sustained ↓ - **brood compensation:** sustained ↓ - **Brood termination:** major impact (98-100%)	**Dimethoate (600g/ha), Thiamethoxam (50g /ha)**: - Brood pattern: similar to controls through 14DAA	Not assessed

***** Except for Ythier (2012), these limitations are in addition to the use of application rates below the proposed U.S. maximum single rate of 0.133 lb ai/A

** 1 of 3 tunnel replicates at 48 g ai/ha showed increased mortality over days 1-7AA, but it is uncertain if this is treatment related.

*** this study was designed to assess residues of sulfoxaflor in plant and hive matrices, not biological effects.

Appendix I. Newly Submitted Honey Bee Tier II Tunnel Study Summaries

New Tier II Tunnel Studies

Louque, J (2017; MRID 50494501).

This semi-field tunnel study was conducted to determine the effects of GF-2032 (nominally a 252 g a.i./L) SC formulation containing the insecticide sulfoxaflor on the honeybee, *Apis mellifera* L. This study included three treatment groups of the test item GF2032 applied at nominal rates of 0.09, 0.071, and 0.023 lb a.i./A in separated tunnels. A fourth group (tunnel) treated with tap water served as control. Two reference items were also tested. Dimethoate was applied at a rate of 0.1 L/ha and 1 L/ha (nominal). Novaluron was applied at a rate of 0.0778 lb a.i./A (nominal). All applications were conducted during daily bee-flight and water supply was moved out of the tunnels until the end of application to avoid direct contamination. The effect of the test item was examined on bee colonies in tunnels (approx. 120 m^2) placed on plots with buckwheat *(Fagopyrum esculentum).* The crops were in BBCH growth stage 62-64, ground cover was 80-100%, and the crops were reported to be in fair/good health.

Adult bee mortality was determined daily by counting dead bees in drop-zone dead bee traps and on linen strips. Dead bees were differentiated between adult worker bees, males, freshly emerged bees, pupae, and larvae during each assessment. Foraging activity was recorded within areas of 1 m^3 at three different locations in each tunnel. At each assessment interval, the number of bees foraging on flowering buckwheat were counted for approximately 15 seconds at each location. Simultaneously, behavior of bees around the hives and in the crop was being observed.

Colony condition assessments were conducted once before exposure, once during exposure, and three times post-exposure. Colony strength (no. of adult bees) and comb area containing capped pupae were quantified. Additively, colonies were examined for any bee diseases at each assessment according to standard beekeeping practices. Bee brood developmental status in individual marked comb cells was captured at specified intervals with digital photography and quantified using image processing software Honeybee Complete©. Termination rates were determined for each colony separately and the mean value per treatment group was calculated. Brood index and Brood compensation index was calculated for each assessment day and colony.

Residue samplings on various honey bee and plant matrices were conducted during the study using two replicates for T1, T2, T3, and C for sampling. Whole buckwheat plants and bee bread samples were collected once before exposure, once on the day of exposure, and seven times after exposure. Bee bread samples were collected as available, once before exposure, once during exposure, and seven times after exposure. Nectar and larvae were collected once before exposure, once on the day of exposure, and eight times after exposure.

Adult Mortality. Adult foraging bees exposed to GF-2032 at rates of 0.090, 0.071, and 0.023 lb a.i./A (during flight) exhibited a statistically-significant increases in mortality of up to 8X the rate observed in controls on the day of application. This increase in mean daily worker bee mortality was short lived, however, having returned to not significantly different from controls by 1DAA (for the 0.071, and 0.023 lb a.i./A treatments) and 3DAA (for the 0.090 lb a.i./A treatment). No statistically significant increases in daily mortality rates were detected after 4DAA.

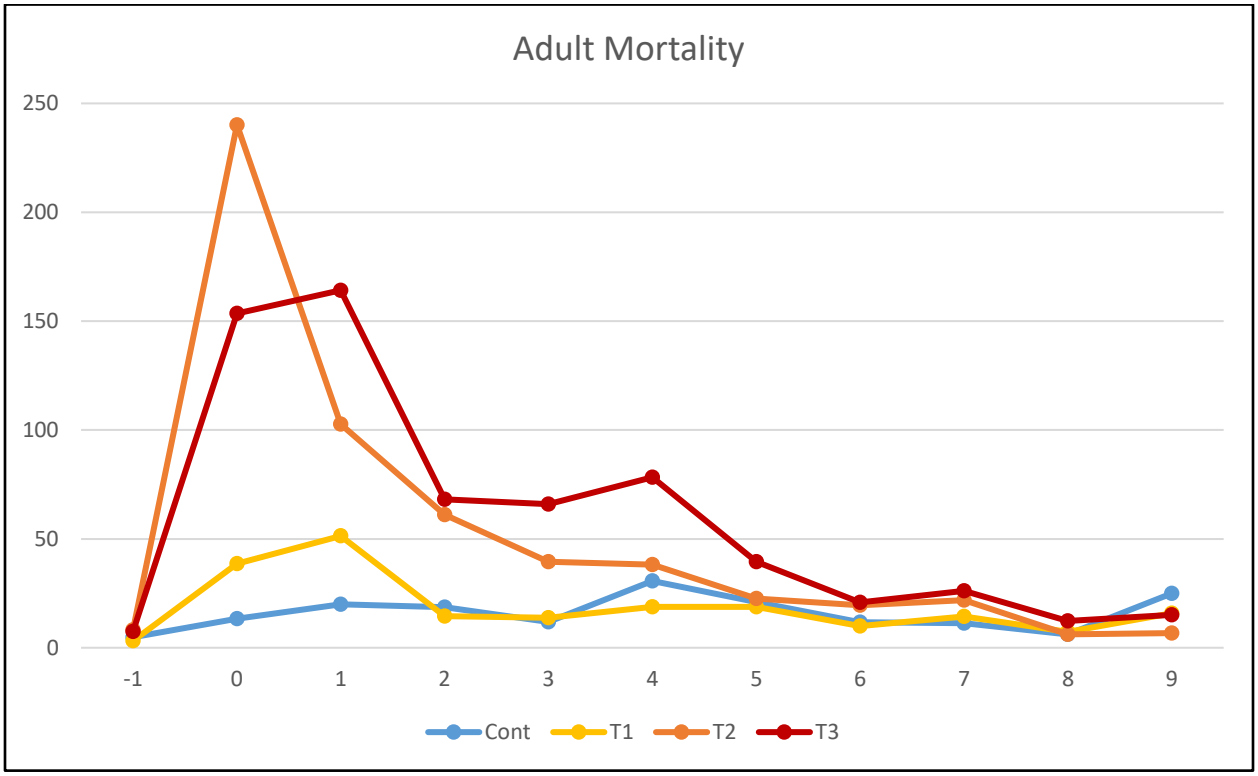


Figure I-1. Mean mortality of adult bees per day.

Foraging Activity. There were slight decreases in flight intensity in the treatment groups as compared to the control during the exposure period, but the largest decreases in any treatment group was a 2-fold decrease as compared to the control. This endpoint was highly variable within the same group over time, fluctuating up and down in a manner likely attributable to chance alone and not due to treatment.

Colony Strength. The effect of sulfoxaflor on colony strength is difficult to interpret due to large variation between hives. There were no sustained effects to colony strength at any timepoint. There were no obvious dose-dependent trends in colony strength apparent among hives. Pollen stores were significantly different from control at 8DAA and 66DAA. These differences were not sustained in between these timepoints.

Brood Condition. There were not enough eggs in all colonies to perform a 300-egg assessment for the 1st cohort. As indicated by the brood termination rate, most eggs did not

move forward in development past the first stages. It is known that poor brood performance is a common issue with tunnel tests and work is being done to optimize the test design by (ICPPR). Cohort 2 was marked later and all but one colony, had recovered from the tunnels effects enough to have sufficient eggs for marking. Overall, the control and all treatments were similar across endpoints. Control variation was wide and limited the ability to pick up any statistical differences between the control and treatments.

Residues. Residues of sulfoxaflor up to 0.03 mg/kg were detected in hive nectar in the 0.071 and 0.09 lb a.i./A treatment groups and showed decline over time after the peak at 10DAA. Residues for in-hive bee bread were only detected at 0.09 lb a.i./A at 7DAA at 0.24 mg/kg.

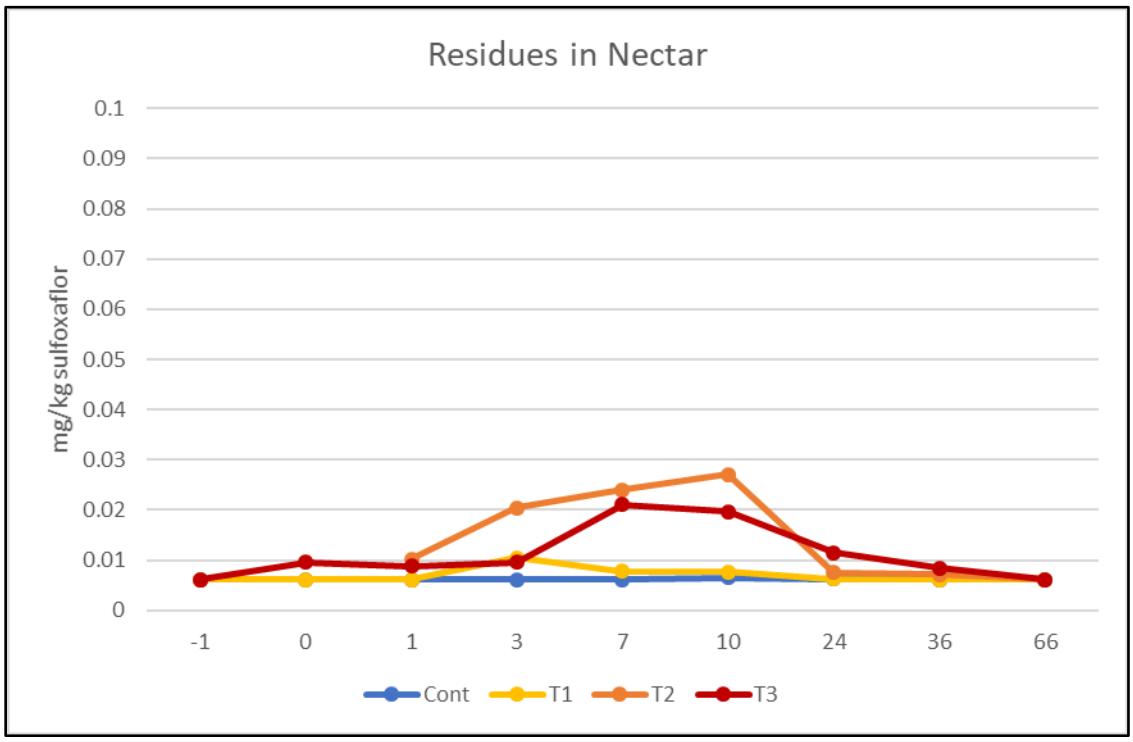


Figure I-2. Sulfoxaflor residues from in hive nectar per day.

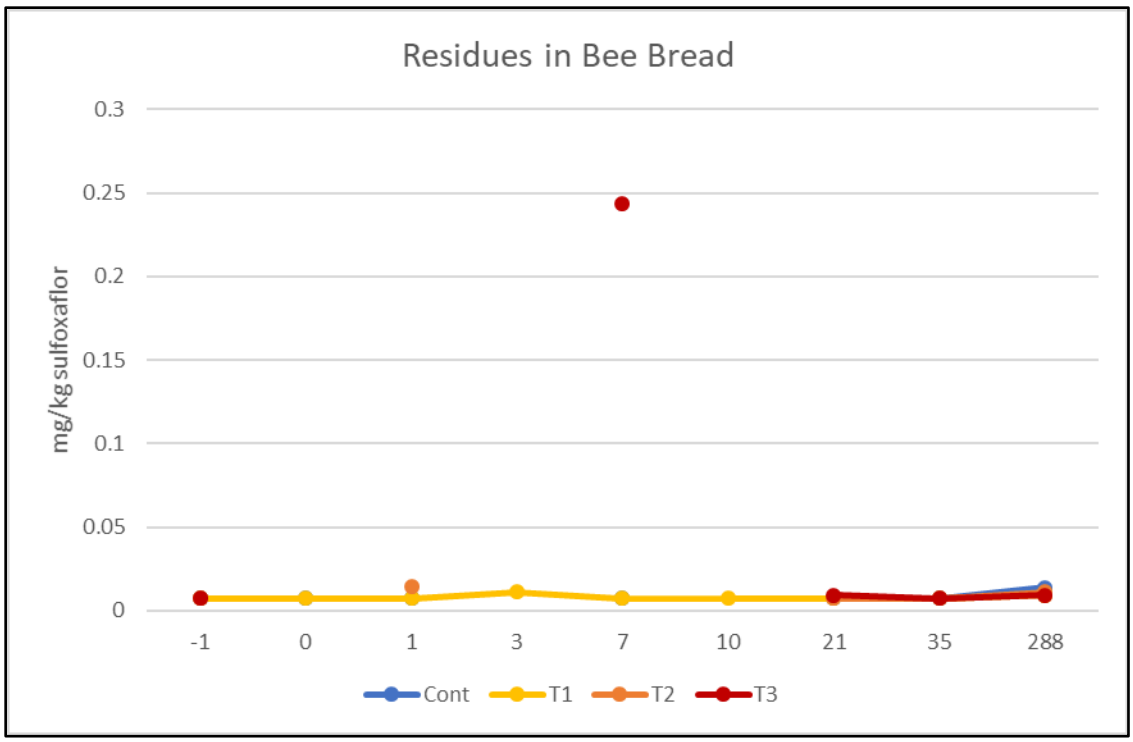


Figure I-3. Sulfoxaflor residues from in hive bee bread per day.

Overwintering. The majority of colonies were lost in the late winter, which was attributed to temperature swings. With 50% mortality in the controls; 17% mortality in T1; and 83% mortality in both T2 and T3. High control mortality confounds the interpretation of impact of sulfoxaflor treatment on overwintering success.

Conclusions. Although this study had several strengths, it also had limitations that limits the use in pollinator risk assessment. Even though the maximum application rate tested (0.090 lb a.i./A) is the maximum single application rate on the US label it does not reach the maximum yearly rate. Mortality was significantly affected but other hive matrices did not show sustained effects at any treatment level. In hive residues showed that sulfoxaflor does enter the hive in a dose dependent manner and declined over time within 10 days.

In the context of available field studies involving honey bees, this study contains some strengths including:

- Inclusion of multiple colony-level endpoints reflecting hive condition, brood development, and nectar/pollen availability.
- Quantification of exposure to sulfoxaflor and metabolites in hive matrices (uncapped nectar, honey, bee bread)
- Sulfoxaflor was quantified in the solutions used to treat the crops for the exposure.

A number of limitations were noted, including:

- Relatively low number of replicates (n = 6) for each treatment and controls.
- Sulfoxaflor was detected in matrices of several control groups.
- Only one application method was tested.
- Not all colonies had enough eggs which led to a weaker brood analysis.
- Pupal samples were inadvertently analyzed instead of larval samples.
- Colony size was not equalized, and most hives did not meet the population criteria listed in the protocol.

Howerton, JH and LM Gilson (2018; MRID 50604601)

This semi-field tunnel study was conducted to determine the effects of GF-2032 (nominally a 252 g a.i./L) SC formulation containing the insecticide sulfoxaflor on the honeybee, *Apis mellifera* L. This study included three treatment groups of the test item GF2032 applied at nominal rates of 0.09, 0.071, and 0.023 lb a.i./A in separated tunnels. A fourth group (tunnel) treated with water served as control. Two reference items were also tested. The first reference group was treated with Dimethoate at an actual rate of 0.055 lb ai/acre, while the second was treated with Rimon at an actual rate of 0.079 lb ai/acre. All applications were conducted during daily bee-flight to ensure contact exposure occurred. The hive bodies were covered with cardboard during application to prevent contamination of the hive exterior, while permitting foraging bees to enter and leave the hive. The water buckets were also removed during application to prevent contamination. After application the covers were removed, and the buckets replaced. The effect of the test item was examined on bee colonies in tunnels (approx. 120 m^2) placed on plots with buckwheat *(Fagopyrum esculentum).*

Adult bee mortality was determined based on dead bees (adults, larvae, and pupae) observed in bee traps and on sheets lining the ground in the tunnels. At the time of the assessment, dead bees and debris were removed from the traps and sheets. Foraging bees and bees in flight were counted over a 15 second interval inside three marked areas in each tunnel (measured 1 x 1 m). Photographs were taken to try to determine variation of crop coverage from tunnel to tunnel. The number of flowers in the photos were counted. Simultaneously, behavior of bees around the hives and in the crop was being observed.

Colony health assessments were performed by visual inspection of each hive.
Abnormal behavior, disease, and the presence of a queen, eggs, and/or queen cells were recorded. Quantitative estimates were made for the percentage of bee coverage, empty space, nectar/honey, pollen, capped brood, and open brood. The total bee hive population was estimated by multiplying the mean % coverage for all frames by the maximum coverage of bees possible on a frame side by the total number of frames. The number of cells containing honey/nectar, pollen, capped brood, or open brood was calculated using an equation that considered the total % frame side coverage and the total number of cells occupying one frame side. Bee brood developmental status in individual marked comb cells was captured at specified intervals with digital photography and quantified using image processing software Honeybee Complete©. Termination rates were determined for each colony separately and the mean value per treatment group was calculated. Brood index and Brood compensation index was

calculated for each assessment day and colony.

Residue samplings on various honey bee and plant matrices were conducted during the study over seven sampling events during full bloom (-1, 0, 1, 2, 3, 4, and 7 DAA). Pollen loads from forager bees were collected using pollen traps set up on the hives the evening before each sampling event. The traps were emptied by the end of bee flight each sampling day, and pollen was transferred to amber glass vials using forceps. Forager bees were collected as they returned to the hive using nets, then the bees were transferred to jars containing dry ice and stored frozen until honey stomach processing could be completed. Honey stomachs were removed in the laboratory and stored in autosampler vials (2-ml), which were then placed into an amber glass vial. Whole plants were sampled from at least 12 areas of the plot by pulling them from the ground, and attached roots were removed before double-bagging the plant samples.

Adult Mortality. Adult foraging bees exposed to GF-2032 at rates of 0.090, 0.071, and 0.023 lb a.i./A (during flight) exhibited a statistically-significant increases in mortality of up to 20X the rate observed in controls on the day of application. This increase in mean daily worker bee mortality was short lived, however, having returned to not significantly different from controls by 2DAA (for the 0.023 lb a.i./A treatments) and 3DAA (for the 0.071 and 0.090 lb a.i./A treatment). Significant spikes in mortality were seen in the 0.071 treatment level until the end of observation 9DAA.

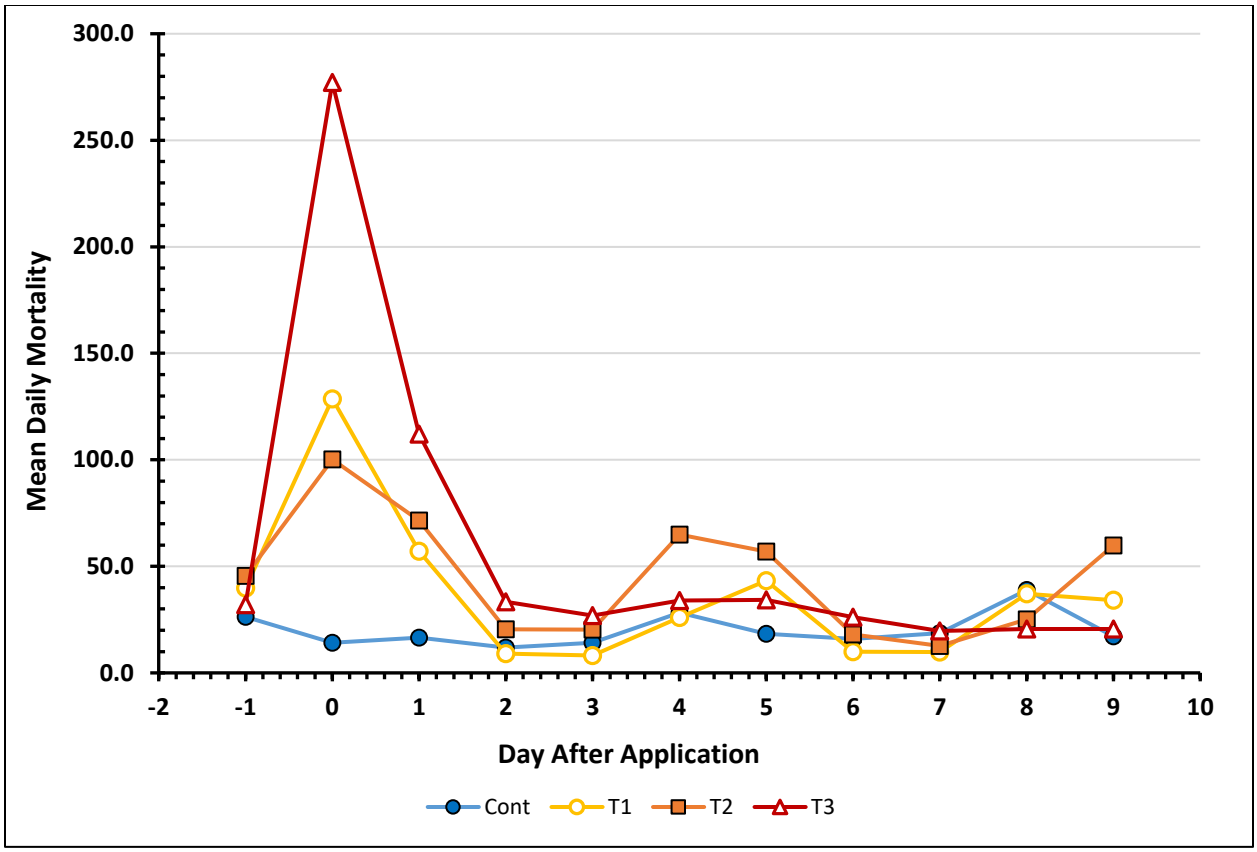


Figure I-4. Mean number of dead adult bees per day.

Foraging Activity. There were significant decreases in flight intensity in the treatment groups as compared to the control during the entire exposure period. This endpoint was highly variable within the same group over time, fluctuating up and down in a manner likely attributable to chance.

Colony Strength. The effect of sulfoxaflor on colony strength is difficult to interpret due to large variation between hives. There were no sustained effects to colony strength at any timepoint. There were no obvious dose-dependent trends in colony strength apparent among hives. Honey stores were significantly different from control at 43DAA. Number of brood was significantly different from controls for the 0.023 treatment level at 26DAA, for the 0.071 treatment level in the Fall, and for the 0.090 treatment level at 8DAA. These differences were not sustained between these timepoints or constant between treatment levels.

Brood Condition. The brood and compensation indices for eggs were reduced in the highest application group in the first brood cycle. The brood and compensation indices for young larvae were reduced in the lowest and highest application group in the first brood cycle. The brood and compensation indices for old larvae were reduced in the lowest application group in the first brood cycle. The termination rate for eggs, young larvae, and old larvae was increased in all treated groups in the first brood cycle.

The brood index, compensation index, and termination rate for eggs, young larvae, and old larvae appeared unaffected by treatment in the second brood cycle.

Residues. Residues of sulfoxaflor up to 2.37 mg/kg were detected in bee collected nectar in the 0.09 lb a.i./A treatment group and showed decline over time after the peak at 2DAA. Residues in nectar were less in the 0.071 and 0.023 treatment groups but followed the same decline trend. Residues of sulfoxaflor in bee collected pollen up to 2.48 mg/kg were detected in the 0.09 lb a.i./A treatment group and declined over time after the peak at 2DAA. In both pollen and nectar 7 days was not enough for residues to drop below the limit of detection for sulfoxaflor.

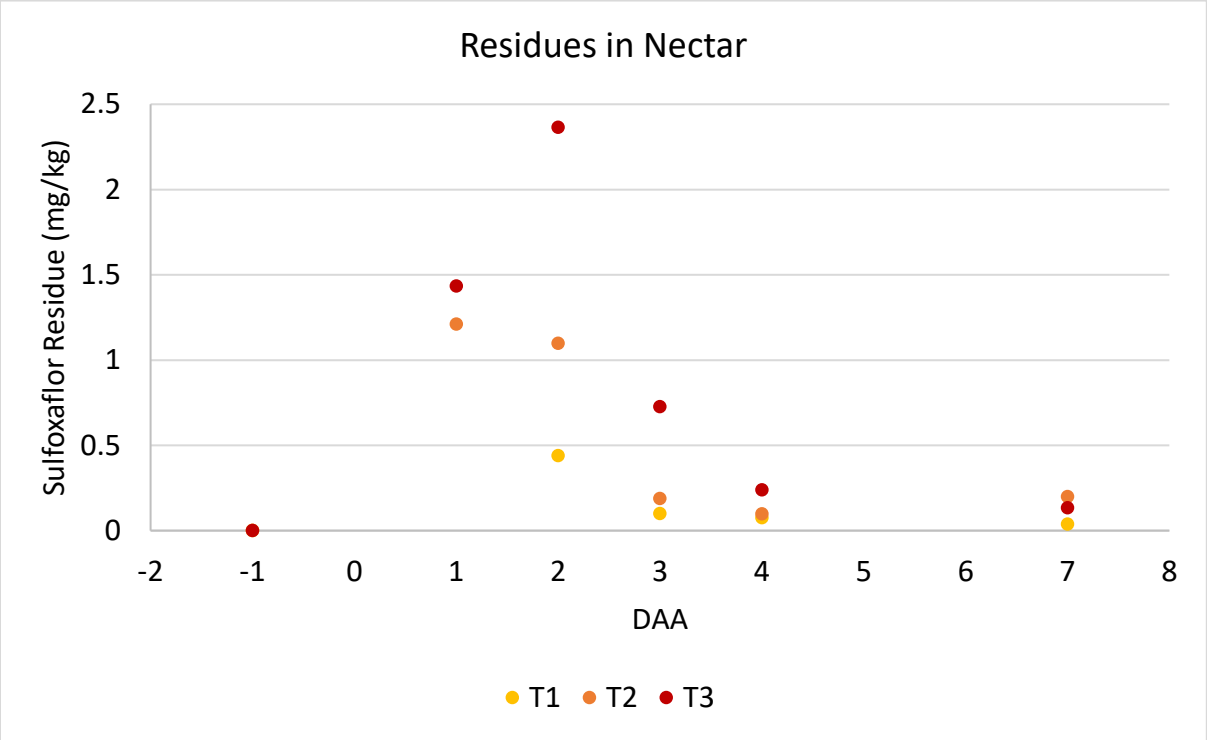


Figure I-5. Sulfoxaflor residues from bee collected nectar per day after application.

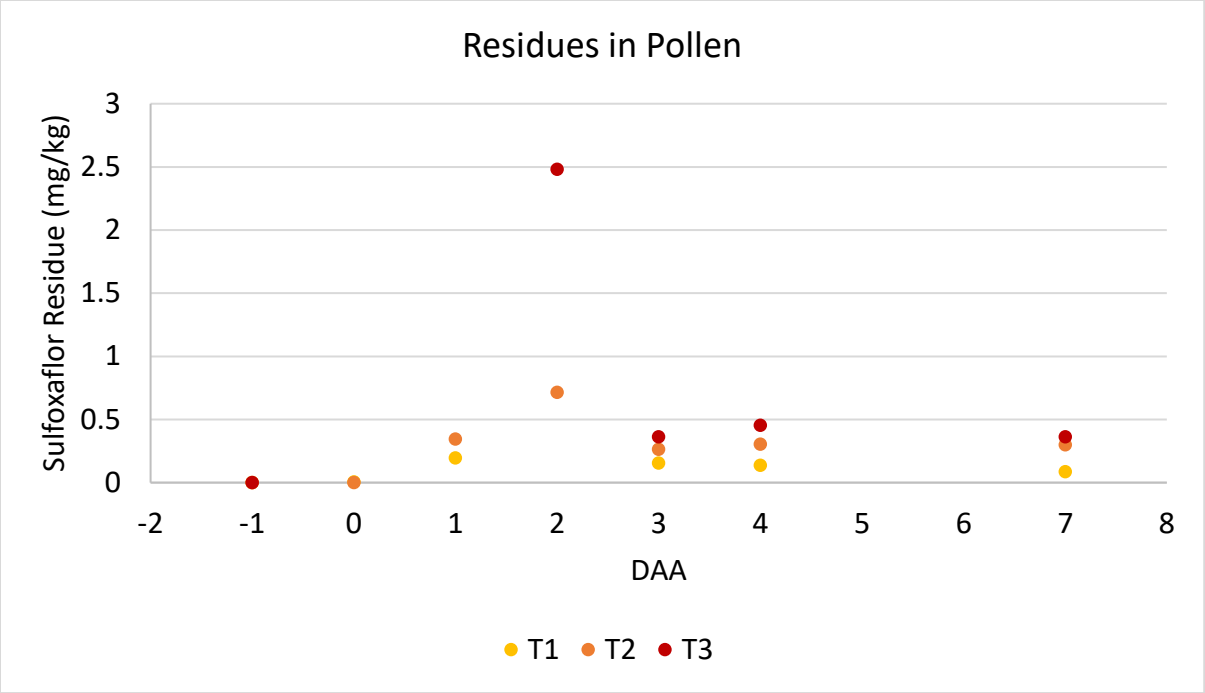


Figure I-6. Sulfoxaflor residues from bee collected per day after application.

Overwintering. The majority of colonies were lost in the late winter. With 63% mortality in the controls; 67% mortality in T1; 83% mortality in T2 and 50% mortality in T3. High control mortality confounds the interpretation of impact of sulfoxaflor treatment on overwintering success.

Conclusions. Although this study had several strengths, it also had limitations that limits the use in pollinator risk assessment. Even though the maximum application rate tested (0.090 lb a.i./A) is the maximum single application rate on the US label it does not reach the maximum yearly rate. Adult bee mortality and foraging behavior was significantly affected but other hive matrices did not show sustained effects at any treatment level. Bee collected nectar and pollen showed dose dependent concentrations of sulfoxaflor with measurable residues remaining 7 days after application.

In the context of available field studies involving honey bees, this study contains some strengths including:

- Inclusion of multiple colony-level endpoints reflecting hive condition, brood development, and nectar/pollen availability.
- Quantification of exposure to sulfoxaflor and metabolites in plant matrices (nectar and pollen)
- Sulfoxaflor was quantified in the solutions used to treat the crops for exposure.

A number of limitations were noted, including:

- Relatively low number of replicates (n = 6) for each treatment and controls.
- Poor overwintering survival in the controls prevented the use of that endpoint.

Renz, D (2017; MRID 50444501).

This semi-field tunnel study was conducted to determine the effects of GF-2626 (nominally a 125 g a.i./L) formulation containing the insecticide sulfoxaflor on the honeybee, *Apis mellifera* L. This study included two treatment groups of the test item GF2626 applied at nominal rates of 24, and 48 g a.i./ha in separated tunnels. A third group (tunnel) treated with tap water served as control. Two reference items were also tested. Perfekthion (dimethoate) was applied at a rate of 400 g a.i./ha (nominal) and Insegar (fenoxycarb) was applied at a rate of 300 g a.i./ha (nominal). All applications were conducted during daily bee-flight as bees were actively foraging (≥10 honey bees/ m^2 per treatment group). Each water supply was moved out of the tunnels until the end of application to avoid direct contamination. The effect of the test item was examined on bee colonies in tunnels (approx. 100 m^2) placed on plots with flowering plants *(Phacelia tanacetifolia).* The crops were in BBCH growth stage 63-64.

Mortality was determined daily by counting the number of dead honey bees in the dead bee traps in front of the hives, on the bottom drawer inside the hives and on the linen sheets which were spread out in the tunnels. The bee colonies were removed from tunnel tents on 8DAA and brought to a monitoring site for further mortality assessments up to 40DAA. The dead bees found were differentiated into adult worker bees, pupae, and larvae during each assessment, and the exact number of each was recorded. For foraging activity assessments, the bees were observed daily the before application, on the day of application, and once daily up to 7DAA. At each assessment time, the number of bees that were both foraging on flowers in the assessments areas or flying over the crop were counted on three foraging assessment areas of 1 m^2 per tunnel for one minute. Behavior during the study was assessed daily at the same time as mortality and foraging activity.

The colony condition assessments were conducted before application, 3 days after application, and 10 times at the monitoring site on, and at the end of overwintering. The colony condition assessments determined colony strength (number of bees), presence of a healthy queen, comb areas containing brood (eggs, larvae, and capped cells), and comb areas with food stores (pollen, nectar, and honey). The development of the bee brood was assessed in individually marked brood cells over two independent brood cycles. The selected combs were uniquely identified. The fixed brood areas were photographed during each brood stage assessment (photographic assessments) and the digital photos were transferred to a computer for analysis (Hive Analyzer® software. The brood index, compensation index, and brood termination rate were determined from the marked brood cells.

Multiple matrices were sampled for residue analysis. Forager bees were sampled from hive entrances once before and three times after application. Whole *Phacelia* plants were sampled

from the same hive entrances twice before application, on the day of application, and six times after application. Pollen from pollen traps were sampled from hive entrances once before and six times after application. The grid of the pollen trap was inserted during time of honeybee foraging activity and kept in place for approximately 4 hours. Pollen from combs was sampled with a pollen extractor and nectar from combs with a syringe on 7DAA2.

Adult Mortality. Adult foraging bees exposed to GF-2626 at rates of 24 and 48 g a.i./ha (during flight) exhibited a statistically-significant increases in mortality of up to 5.5X the rate observed in controls on the day of application. This increase in mean daily worker bee mortality was short lived, however, having returned to not significantly increased 1DAA (for the 24 and 48 g a.i./ha treatments). No statistically significant increases in daily mortality rates were detected after 0DAA.

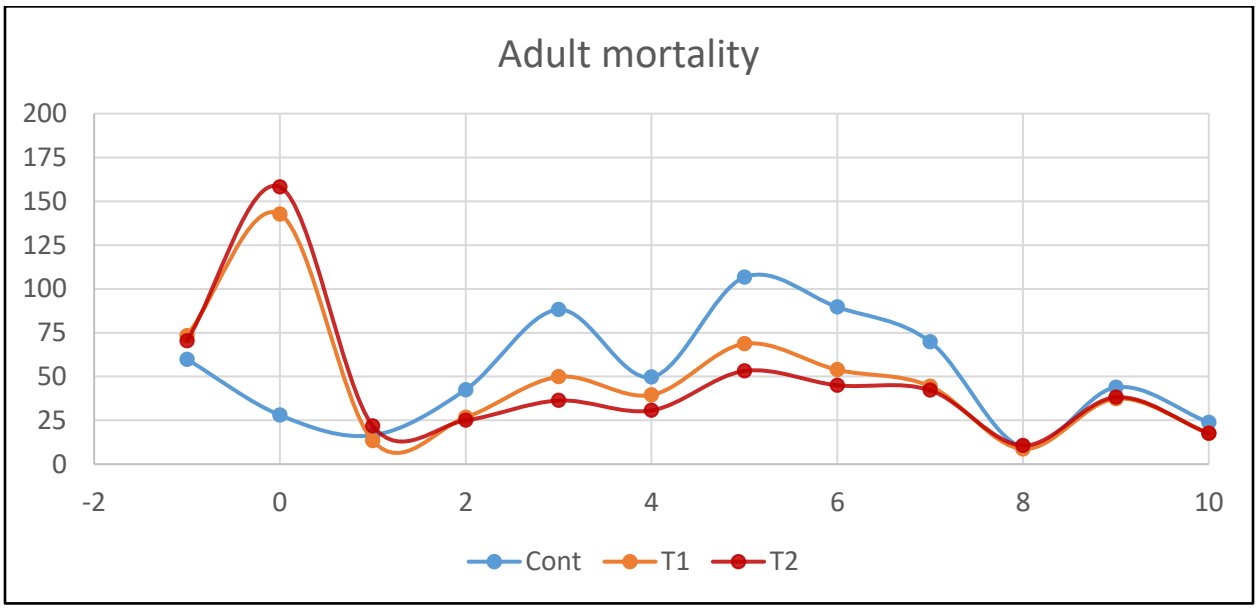


Figure I-7. Mortality of adult bees per day.

Foraging Intensity. Application of GF-2032 led to a reduction of foraging activity of bees on the day of application. However, immediately prior to application foraging activity was significantly reduced in both treatment groups. Relative to control bees, mean foraging intensity on 0DAA was reduced by 50% in the 24 and 48 g a.i./ha treatment groups. For the remainder of the test, mean forage intensity of bees was decreased in both treatment groups but should be interpreted with caution as flight activity was reduced before application at similar levels.

Behavioral Effects. On the day following application for treatment 1, there were 86 bees with locomotion issues, 24 cramping bees, and 2 flying without landing bees. For treatment 2, there were 51 bees with locomotion problems, 4 trembling, and 39 cramping. During the further exposure period (1DAA2 to 7DAA2) there were 12 bees exhibiting abnormal behavior. When compared to the control, treatments 1 and 2 generally resulted in more

abnormal behaviors and can be said to influence the behavior of worker bees, but these effects diminished rapidly.

Colony Strength. The effect of sulfoxaflor on colony strength is difficult to interpret due to large variation between hives. There were no sustained effects to colony strength at any timepoint. There were no obvious dose-dependent trends in colony strength apparent among hives. Number of cells with eggs was significantly different from control at 20DAA. While number of cells with larvae was significantly different from control at 35DAA and 69DAA. These differences were not sustained in between these timepoints.

Brood Condition. Brood indices, compensation indices, and termination rates of eggs, young larvae and old larvae in T1 and T2 of the first and second brood cycle were not significantly different from the control.

Residues. Residues of sulfoxaflor in nectar collected by bees peaked the day of application (0.35mg/kg) and declined with application rate and over time until no longer detected at day 3DAA. Residues in bee collected pollen up to 1 mg/kg were detected the day of application and declined with application rate and over time until day 7DAA. Residues in plants (max of 0.56 mg/kg on 0DAA) declined steadily in the 24 and 48 g ai/ha treated plots to about 0.02 mg/kg by 7DAA.

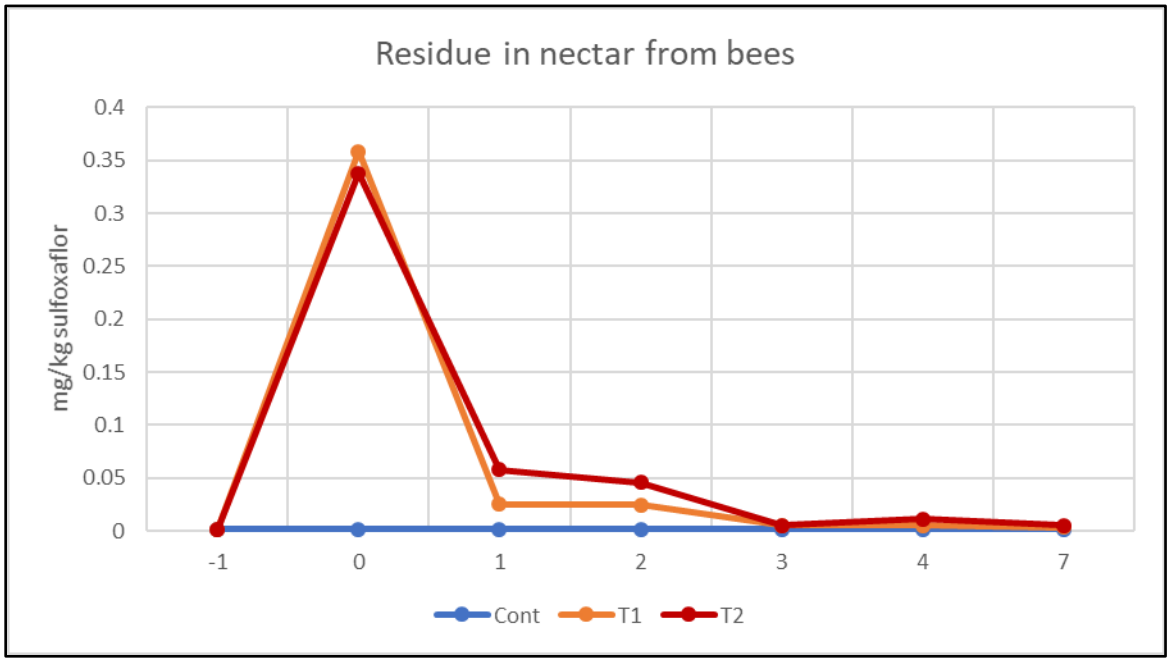


Figure I-8. Sulfoxaflor residues in bee nectaries per day.

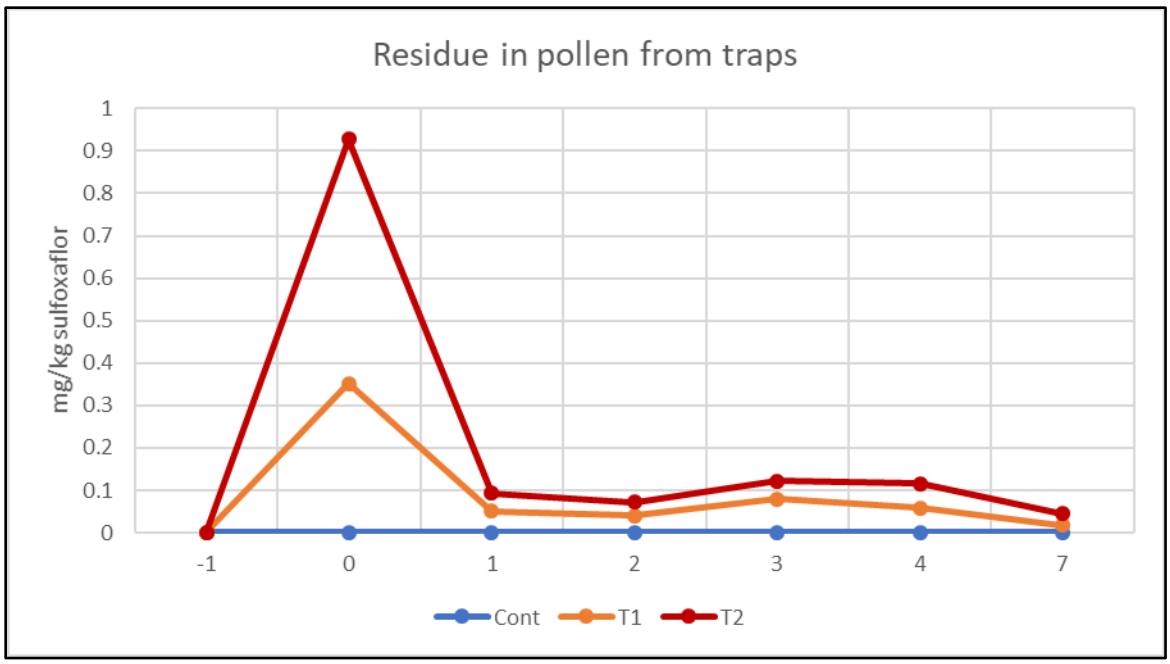


Figure I-9. Sulfoxaflor residues in pollen collected from traps per day.

Overwintering. All hives from this study survived overwintering with no effects observed at any treatment level.

Conclusions. Although this study had several strengths, it also had several limitations that limits the use in pollinator risk assessment. Specifically, the maximum application rate tested (48 g ai/ha) was less than half the proposed single maximum rate on the US label (100 g ai/ha). Mortality was significantly impacted with treatment, along with observations of behavioral effects and decreased flight intensity. These impacts did not last more than 1 day after application. There were no observable differences between control and treatment hives for colony strength or brood condition during the study. In hive residues followed an increasing trend with higher application rates and declined in the hive within 7 days.

In the context of available field studies involving honey bees, this study contains some strengths including:

- Inclusion of multiple colony-level endpoints reflecting hive condition, brood development, and nectar/pollen availability.
- Quantification of exposure to sulfoxaflor in hive and plant matrices (pollen from traps, pollen and nectar from combs, nectar from foraging bees, Phacelia plants, and brood comb larvae and pupae).
- Detailed QA/QC results regarding quantification of sulfoxaflor residues in various matrices.

A number of limitations were noted, including:

- Relatively low number of replicates in the treatment and control groups (n = 6).
- Only one application method was tested to determine magnitude and decline kinetics of residues in the various matrices.
- Transit and storage stability of the residue samples were not assessed.

Appendix J. European Colony Feeding Study (Szczesniak (2017; MRID 50444502)

Executive Summary

The effects of the sulfoxaflor formulated end-use product Closer (GF 2626; 12% a.i.) was evaluated in a honey bee (*Apis mellifera*) colony feeding study. Colonies were provided 200 mL of diets containing untreated 50% sucrose (control) or sucrose diets at 0.02, 0.1, 0.5, 2, or 4 mg ai/kg each day for 10 consecutive days. Six colonies were used in each treatment group; five of the colonies were used for biological measurements and one colony was used for monitoring residues. Two additional treatments (each with 3 colonies) received diets containing reference toxicants dimethoate or fenoxycarb). Study colonies ranged in size from 7849 to 9,945 adult bees. Following the 10-day exposure phase of the study, the colonies were monitored through the spring of the following year (*i.e*., overwintering). Colony condition assessments (CCAs were conducted twice before the exposure phase, 12 times after the exposure phase and once after overwintering. Bee mortality was evaluated daily from 4 days before feeding (4 DFB) to 44 days after feeding (44 DAF). Two complete honey bee brood (egg → larvae → pupae) cycles were evaluated: brood cycle 1 from 1 DBF to 20 DAF and brood cycle 2 from 15 DAF to 43 DAF during which time brood development indices were measured.

The lowest observed adverse effect concentration (LOAEC) in this study is based on sustained and statistically significant ($p<0.05$) differences (reductions) relative to controls in the number of adults bees and brood; increased worker and larval mortality during Weeks 1 and 2 after the 10-day exposure period; reductions in colony weight; and, reduced honey stores after overwintering in colonies exposed to sulfoxaflor at nominal dietary concentrations of 2 mg ai/kg (measured 1.85 mg ai/kg). The no observed adverse effect concentration (NOAEC) is 0.5 mg ai/kg (measured 0.47 mg ai/kg). Although this study is classified as supplemental, it is considered scientifically sound and may be used quantitatively in risk assessment. Its supplemental (quantitative) classification stems from not providing food provisions equally across the course of the study (and among colonies) and verification of dietary concentrations only once during the exposure phase of the study.

Study Design

Szczesniak (2017; MRID 50444502) conducted a honey bee (*A. mellifera carnica L.*) colony feeding study using either untreated 50% sucrose solution or sucrose solution spiked with the formulated sulfoxaflor end-use product (Closer™; GF-2626; 12% active ingredient [a.i.]) at nominal sulfoxaflor dietary concentrations of 0.02, 0.1, 0.5, 2 and 4 mg ai/kg diet. Six colonies were tested in each group[21] in which mg ai/kg 5 colonies were used for biological measurements and 1 was used for chemical (sulfoxaflor residue) measurements. Two additional treatments (3 colonies each) were included to test two reference toxicants (*i.e*., dimethoate, fenoxycarb). Therefore, the study consisted of a total of 42 colonies. Each of the 42 colonies

[21] treatments are also reported as C, T1, T2, T3, T4, and T5, respectively

were obtained from a commercial supplier and contained sister queens, with 5-10 combs of brood, 3-10 combs of honey and 7,670 to 9,945 adult bees each. The study author reported that hives were free from signs of the fungal disease nosemosis (*Nosema spp*) and the parasitic varroa mite (*Varroa destructor*) or other bee diseases. All hives were arranged non-randomly at a single site located in Baden-Württemberg, Germany on April 26, 2016 (33 days prior to test initiation) for acclimation (**Figure J-1**). The study is reported to have been conducted according to Good Laboratory Practice (GLP) standards established under FIFRA and OECD.

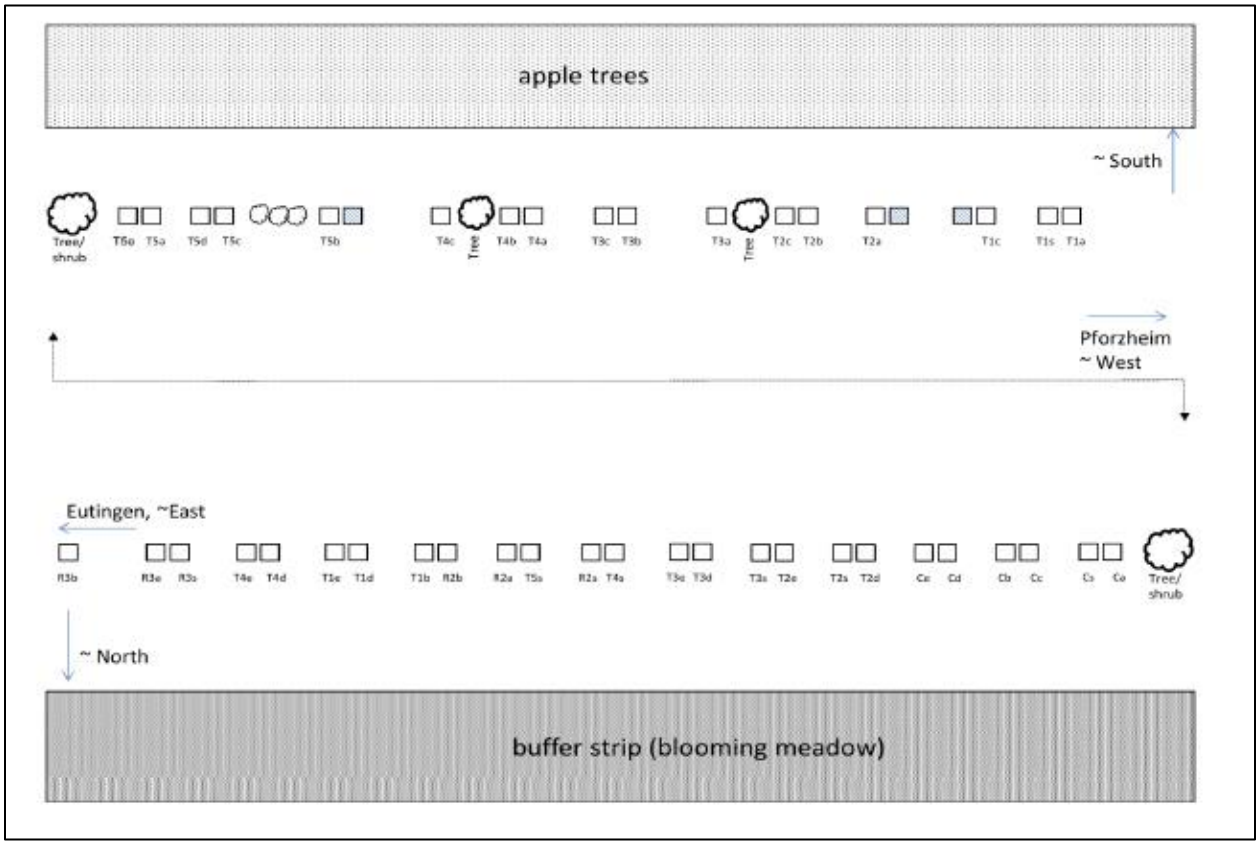


Figure J-1. Diagram of the sulfoxaflor colony feeding study site showing locations of honey bee (*Apis mellifera*) hives

Exposure, Biological and Chemical Monitoring

Each colony was fed 200 mL of spiked 50% sucrose solution daily beginning on May 29, 2016 and continuing for a total of 10 days. Sucrose solutions were freshly prepared daily, and samples were taken for analytical verification at 3 days after feeding (DAF) began. The quantity of sucrose solution consumed each day was recorded. After 10 days, supplemental feeding with sucrose was provided to the colonies on 5 occasions until overwintering in accordance with local beekeeping practices. The first supplemental feeding consisted of "food comb" (mixture of honey and nectar from combs) was provided to most (but not all) colonies 16 DAF due to a lack of flowering crops close to the study site. During the remaining 4 supplemental feedings, all colonies were fed with Apiinvert™ (a commercial mixture of sucrose, glucose and fructose) at

the following rates: 2.5 kg/colony (25 DAF); 4 kg/colony (50 DAF); 5 kg/colony (72 DAF); and size-dependent rations on 100 DAF just prior to overwintering. Hives were treated with formic acid for *Varroa* mite control on July 22 (54 DAF) and August 22 (85 DAF).
Biological and chemical measurements were taken prior to and after the initiation of feeding, in accordance with **Table J-1.**

Table J-1. Biological and chemical measurements of honey bee (*Apis mellifera*) colonies in colony feeding study of sulfoxaflor.

Measurement	Description	Timing
Colony condition assessment (CCA)	Photographic assessment of brood, food stores, adult bees	2 CCAs before feeding; 12 CCAs post-feeding, 1 CCA post-wintering
Mortality & behavior	Counts of dead adults, larvae and pupae via dead bee traps and on bottom of hive; visual observation of bees.	Daily from 4 DBF to 44 DAF
Hive weight	Daily measurement of hive weight @ 11:30 am.	5 DBF to 299 DAF
Brood index, Brood compensation index, Brood termination rate	Monitoring of development of 200 brood cells/hive beginning at egg, young larval and old larval stages.	Brood cycle #1: 1 DBF – 20 DAF Brood cycle #2: 15 DAF-43 DAF
Sucrose consumption	Measurement of remaining test solution.	Daily, 0 DAF to 10 DAF
Temperature, humidity, precipitation	Daily	5 DBF through 299 DAF
Varroa	Counts of *Varroa* mites collected on hive traps.	Oct 24, 2016
Analysis of sucrose solutions	Measurement of sulfoxaflor in feeding solutions.	3 DAF
Residue in hives	Residues in nectar, pollen, bees, honey, worker jelly.	2 DBF, 11, 19, 47 DAF

CCA= colony condition assessment; DAF=days after feeding; DBF= days before feeding.

Study Results

A summary of the study results is provided in **Table J-2**.

Table J-2. Summary of biological and chemical results for honey bee colonies fed sulfoxaflor for 10 days (MRID 50444502)

Study Attribute	Results Summary [(1)]
Test Substance	GF-2626
Timing/Location	2016-17, Baden-Wurttenberg, Germany
Exposure period & Concentration	10 days continuous feeding • 0, 0.02, 0.10, 0.50, 2.0, and 4.0 mg ai/kg (Nominal) • < DL, 0.018, 0.094, 0.47, 1.85, 3.78 mg ai/kg (Measured) • (90%-95% of nominal)
No. Reps. / Treatment	5 (+1 for residue)

Study Attribute	Results Summary [(1)]
Feeding Timing	200 mL sucrose/day/colony, renewed daily
Colonies	42 colonies (sister queens) with 7670 to 9945 adults, 5-10 brood combs, 3-10 honey combs; established 33 days before test initiation
Sucrose Consumption	55% ↓ in daily mean consumption @ 4 mg ai/kg relative to controls. No significant reduction in consumption @ 0.02 – 2 mg ai/kg treatments.
Residues in Hive Matrices	Dose-dependent increase in most hive matrices at 11 DAF**, steep decline by 19 DAF** (except pupae), concentrations **~ LOQ by 45 DAF**. Peak concentrations in nectar > worker jelly> larvae ~ pupae >> pollen
Residue Spike Recovery	90%-101% among various hive matrices & feeding solution
Adult Bee Mortality	• **Before Feeding:** 21-30 dead bees/d all treatments *(NS)* • **During Feeding**: **3X ↑ @ 4 mg ai/kg *(S)*** • **1 Wk. Post Feeding: 4X ↑ @ 4 mg ai/kg** (122 dead bees/d; *NS*); 0.02-2 mg ai/kg = 33-45 dead bees/d, *(NS)* • **2 Wk. Post Feeding: 12X ↑ @ 4 mg ai/kg** (238 dead bees/d; ***S***); **6X ↑@ 2 mg ai/kg** (128 dead bees/d; *NS*); 0.02-0.5 mg ai/kg *(NS)* • **3-5 Wk. Post Feeding:** Mortality rates were similar among treatments *(NS)*
Larval and Pupal Bee Mortality	• **Before Feeding:** similar mortality rates all treatments (0.3-0.8 dead bees/d; *NS*) • **During Feeding: 7X ↑ @ 4 mg ai/kg *(S)*** • **1 Wk. Post Feeding: 40X ↑@ 4 mg ai/kg** (12.7 dead bees/d; ***S***); **22X ↑ @ 2 mg ai/kg** (6.8 dead bees/d; ***S***); 0.02-0.5 mg ai/kg = 0.5-0.6 dead bee/d; *NS*) • **2 Wk. Post Feeding: 275X↑ @ 4 mg ai/kg** (56 dead bees/d; ***S***); **580X ↑ @ 2 mg ai/kg** (157 dead bees/d; ***S***); **13X ↑ @ 0.5 mg ai/kg** (2.6 dead bees/d; *NS*); 0.02-0.1 mg ai/kg = 0.9 dead bees/d ***(S** only at 0.02 mg ai/kg)* • **3-4 Wk. Post Feeding:** 4 mg ai/kg (5.5 dead bees/d; ***NS***); 2 mg ai/kg (2.8 dead bees/d; ***S***) 0.02-0.5 mg ai/kg (0.2-0.9 dead bees/d; ***S** only @ 0.02 mg ai/kg in wk 4*) • **5 Wk. Post Feeding:** similar low loss rates at all treatments (0.1-0.3 dead bees/d; *NS*)
Abnormal Behavior	Relatively high number of behavioral abnormalities @ 2 and 4 mg ai/kg (cramping, locomotion problems, and inactive bees). Abnormalities @ 0.02-0.5 mg ai/kg are similar to controls
Colony Strength (Adults)	• **2 & 4 mg ai/kg:** sustained treatment related reductions in # adults @ 9 CCA 5-11 (34-76%; ***S***) • **0.1 & 0.5 mg ai/kg:** slight/sporadic reduction in # adults @ CCA 5-11 (3-25%; *NS*) • **0.02 mg ai/kg:** significant reductions at CCA 6, 9-11 ***(S***); poor hive strength in one hive prior to exposure; not considered treatment related
Brood Strength	• **2 & 4 mg ai/kg:** sustained treatment related reductions in total brood (4 to 8 CCAs; 44%-69%; ***S***); Significant reductions in # eggs, larvae, pupae at multiple CCAs ***(S)*** • **0.02-0.5 mg ai/kg**: slight reductions to slight increases total brood, # eggs, larvae, pupae (usually < 15%; *NS*); Significant reduction at CCA5 @ 0.02 mg ai/kg not considered treatment related
Brood Termination Rate	• **4 mg ai/kg** (1st brood cycle): Significant increase in mean brood termination (30%-50%; ***S***) monitored from eggs. Small (<20%) to no increase when monitored from older life stages. No significant increase *(NS*) in brood termination rate for the second brood cycle.

Study Attribute	Results Summary [1]
	• **<u>0.02-2 mg ai/kg:</u>** No significant increase *(NS)* for 1st or 2nd brood cycles monitored from eggs
Brood Index	• **<u>4 mg ai/kg</u>** (1st brood cycle): Significant decrease in mean brood index ***(S)*** monitored from eggs. No significant decrease in brood index for the second brood cycle monitored from eggs. • **<u>0.02-2 mg ai/kg:</u>** No significant decrease *(NS)* for 1st or 2nd brood cycles monitored from eggs
Brood Compensation Rate	• **<u>4 mg ai/kg</u>** (1st brood cycle): Significant decrease in mean brood index (S) monitored from eggs. • **<u>0.02-2 mg ai/kg:</u>** No significant decrease *(NS)* for 1st or 2nd brood cycles monitored from eggs
Food Stores	• **<u>Pollen:</u>** large reduction at multiple CCAs @ 4 mg ai/kg (70%-100%; ***S***); sporadic and small reductions noted @ 0.1 mg ai/kg, but highly inconsistent concentration response pattern. • **<u>Honey:</u>** 30%-70% reduction @ 2 and 4 mg ai/kg during CCA 6 - CCA 15 (***S*** @ CCA8). Smaller reductions @ 0.02-0.5 mg ai/kg, inconsistent concentration-response relationship *(NS)*
Hive Weight	• **<u>2-4 mg ai/kg</u>:** sustained reductions in hive weight (20-25%; ***S***) • **<u>0.02-0.5 mg ai/kg</u>**: smaller reductions (~0-15%; NS) with inconsistent concentration response relationship
Varroa	• No treatment related effects on infestation indicated; non-standard method of monitoring
Overwintering Success and Condition	• **<u>4 mg ai/kg:</u>** 60% overwintering success (2/5 colonies collapsed); Reduced honey stores ***(S)*** • **<u>0-2 mg ai/kg:</u>** 100% overwintering success; Reduced honey stores @ 2 mg ai/kg ***(S)***; significant reduction in pupae and eggs @ 0.02 mg ai/kg not considered treatment related. No other significant effects on brood or food stores.
Overall NOAEC & LOAEC	• **NOAEC = 0.5 mg ai/kg (0.47 mg ai/kg measured)** • **LOAEC = 2 mg ai/kg (1.85 mg ai/kg measured)**
Study Limitations*	1. Relatively low number of replicates (5), resulting in low statistical power 2. All colonies located at a single site (no site-to-site variability) 3. Inconsistent supplemental feeding on 16 DAF 4. Non-random placement of hives 5. Feeding solutions analyzed only once
Reference Toxicant Effects	**<u>Dimethoate (0.86 mg ai/kg);</u>** - similar brood pattern as controls - no sig diff in # dead bees; -slight transient effects **<u>Fenoxycarb (171 mg ai/kg);</u>** - effect on brood pattern - sustained ↑in # dead bees; -effects on total brood and certain stages

[1] S=significantly different from controls ($p<0.05$), NS= not significantly different from controls ($p>0.05$)

Sucrose Consumption

Colonies were fed a total of 2,000 mL of 50% sucrose solution over the 10-day feeding (exposure) period (*i.e*., 200 ml/d). Control colonies consumed on average 97% of the sucrose solution each day while colonies receiving 0.02, 0.1, 0.5 and 2 mg ai/kg sulfoxaflor consumed between 90% and 97% of the feeding solution each day and there were no statistically significant differences in the volume of diet consumed between control and sulfoxaflor-treated colonies (**Table J-3**). However, colonies fed sulfoxaflor at 4 mg/L diet consumed on average significantly ($p<0.05$) less (43% reduction) of the feeding solution relative to controls.

Table J-3. Mean, minimum (Min), and maximum (Max) Consumption (in milliliters per colony per day; mL/hive/day) of sucrose feeding solutions by control and sulfoxaflor exposed honey bee (*Apis mellifera*) colonies during 10-day exposure period.

Treatment (mg ai/kg, nominal)	Mean (mL/hive/day)	Min (mL/hive/day)	Max (ml/hive/day)
Control	194.9	174.7	200
0.02 mg ai/kg	195.3	186.5	200
0.1 mg ai/kg	189.5	160.3	200
0.5 mg ai/kg	180.5	172.1	188.4
2 mg ai/kg	185.9	177.2	199.2
4 mg ai/kg	**86.9***	54	112.2

* significantly reduced relative to controls, $P<0.01$; Mann Whitney test

Residues in Hive Matrices

Single samples of hive matrices (*i.e*., nectar, pollen, worker jelly) and hive bees (larvae, pupae) were analyzed for sulfoxaflor on -2 (before dosing), 11, 19 and 45 DAF **(Figures J-2 and J-3**). Although the extent of residue sampling was limited (*i.e.,* no replicates and only 4 sampling events), some distinct temporal patterns emerge in the residue profiles. With the exception of residues in pupae (**Figure J-3**), sulfoxaflor residues in the other hive matrices sampled peak on DAF 11 (*i.e*., one day after the end of exposure phase of the study) and declined by factors of ~ 6 to 8-fold by DAF 19. Sulfoxaflor residues measured in pupae peaked on DAF 19. By DAF 45, sulfoxaflor residues in all matrices sampled declined to levels near or below the limits of quantitation (LOQ). These data suggest that sulfoxaflor persistence in hive matrices is ~ 30 days or less following 10 days continuous exposure. This time period is on the order of a single brood cycle (21 days).

The highest peak residues measured were in hive nectar (up to 1.5 mg ai/kg), followed by worker jelly (up to 0.8 mg ai/kg; **Figure J-2**), larvae (0.28 mg ai/kg), and pupae (0.15 - 0.2 mg ai/kg; **Figure J-3**), and pollen (0.06 mg ai/kg; **Figure J-2**). Except for pupae, the highest residues measured where in colonies treated with 2 mg ai/kg; whereas, for pupae, the highest residues were detected in colonies treated with 4 mg ai/kg. Peak residue concentrations in hive nectar are approximately 50% of the sulfoxaflor concentration in the sucrose feeding solution which may reflect degradation and/or dilution with uncontaminated nectar sources. Peak concentrations of sulfoxaflor in worker jelly are about 25% of those in the sucrose feeding solution. This further reduction in residue concentrations relative to stored nectar may reflect additional degradation and/or dilution during bees' production of worker jelly.

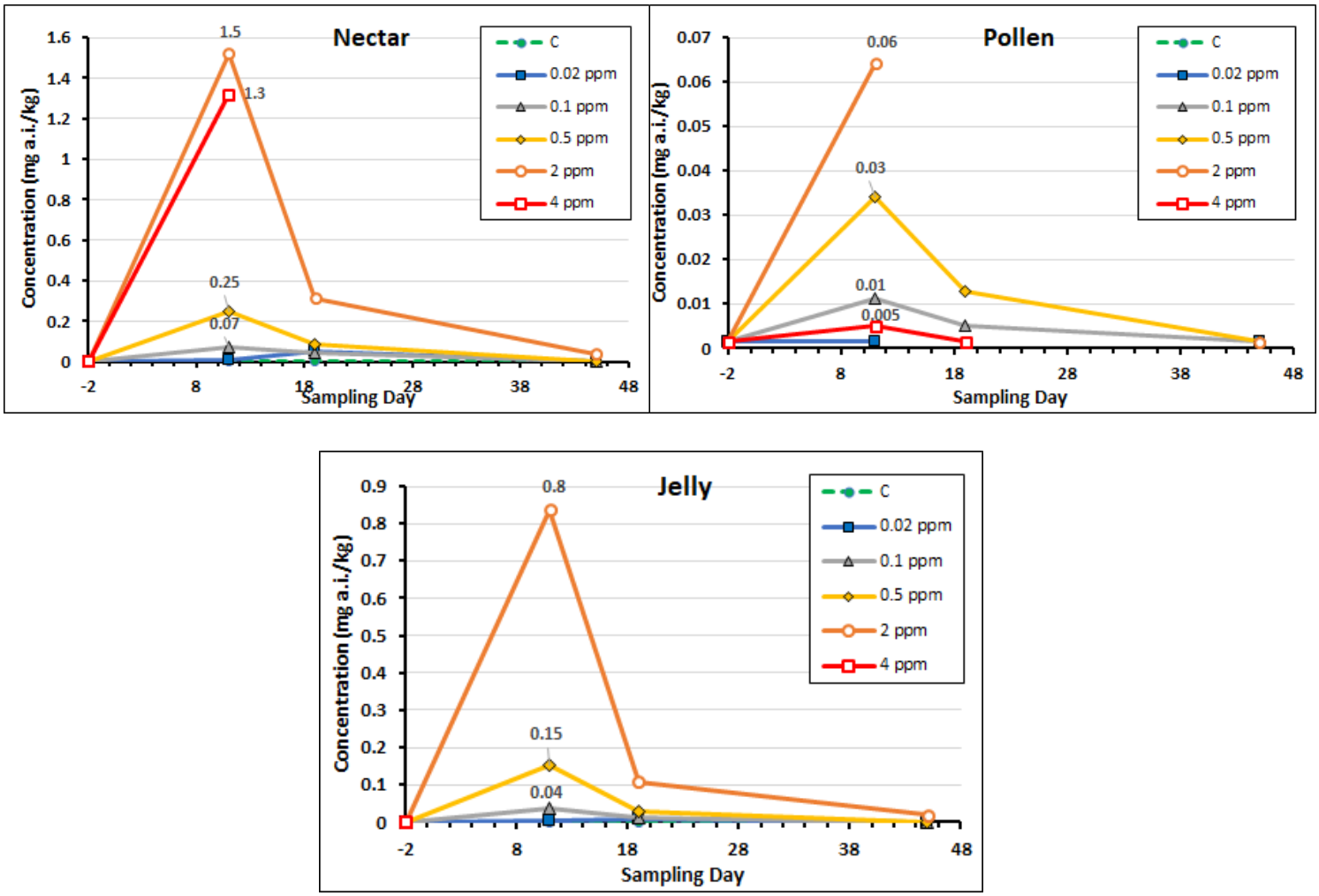


Figure J-2. Sulfoxaflor concentrations (in parts per million = mg ai/kg) measured in nectar, pollen and worker jelly from the monitoring honey bee (*Apis mellifera*) hives from sampling day -2 through 48 days after feeding.

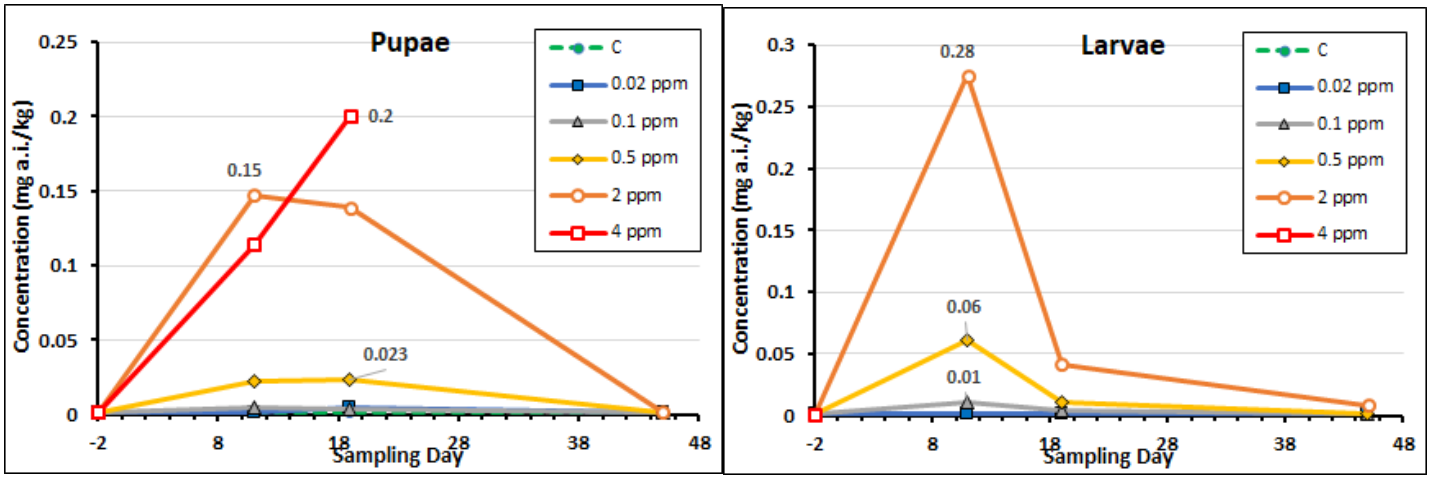


Figure J-3. Sulfoxaflor concentrations (in parts per million = mg ai/kg) measured in honey bee (*Apis mellifera*) larvae and pupae from the monitoring hives from sampling day -2 through 48 days after feeding

Adult and Brood Mortality

Mortality of adult and larval/pupal bees was monitored daily from -4 DAF through 44 DAF during the study. Mortality results, summarized on a weekly basis for adults and brood (i.e., larvae and pupae) are shown in **Tables J-4** and **J-5**, respectively. **Figure J-4** depicts daily mean mortality for adults and larvae for each of the study groups. The pattern of mortality measured for adult and immature bees was similar to controls in the lowest three treatments (0.02, 0.1 and 0.5 mg ai/kg; **Figure J-4**), with weekly means of adult mortality typically ranging between 15 and 35 bees/day. According to the study authors, the periodic spikes in adult bee mortality observed in these three treatments on Days 12, 17 and 22 did not appear treatment related, as they also occurred in the controls and may reflect low ambient temperatures (*i.e.*, 8-9° C) measured during these days. When summarized on a weekly basis, adult worker mortality was not statistically significant different from controls for the colonies treated with sulfoxaflor at 0.02, 0.1 and 0.5 mg ai/kg. Increased, but not statistically-significant, mortality of adult bees in the 0.5 mg ai/kg treatment on Days 32-33 was due to a single colony (rep C) and was not manifest at 2 and 4 mg ai/kg.

In contrast to the lower three sulfoxaflor treatments (*i.e.,* 0.02, 0.1, and 0.5), adult bee mortality measured in colonies fed sulfoxaflor at 2 mg ai/kg and 4 mg ai/kg increased relative to controls up through 2-weeks post feeding (**Figure J-4, Table J-4**). For example, statistically-significant ($p<0.05$) increases in mean adult bee mortality (*i.e.*, 49.1 bees/d) during the 10-d feeding period occurred in the 4 mg ai/kg treatment relative to controls (15.4 bees/day). Mean adult bee mortality remained elevated in the 4 mg ai/kg treatment during Week 1 post-feeding (122 bees/day) although it was not statistically significant, and in post-exposure Week 2 (238 bees/day) in which the mortality was significantly ($p<0.05$) different than controls. By Week 3,

mean mortality of adults fed 4 mg ai/kg sulfoxaflor was similar (and not significantly different) from controls. Elevated mortality of adult bees fed 2 mg ai/kg sulfoxaflor was evident only during Weeks 1 and 2 post-feeding (44.8 and 128 bees/day) the differences from controls were not statistically significant.

Table J-4. Mean (± Standard Deviation) and total mortality of adult honey bees (*Apis mellifera*) recorded before, during and after feeding either untreated (Control) or sulfoxaflor-spiked sucrose solutions for 10 days.

Treatment	Before Feeding			During Feeding			Post Feeding Wk 1			Post-Feeding Wk 2		
	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total
Control	22.7	*18.1*	453	15.4	*11.7*	669	34.6	*28.4*	1211	19.5	*15.8*	684
0.02	21.3	*8.1*	426	12.2	*10.6*	762	32.8	*28.8*	1147	25.1	*20.5*	878
0.10	26.2	*20.5*	524	13.9	*13.9*	815	34.3	*37.6*	1199	20.1	*18.5*	703
0.50	22.5	*14.0*	449	14.8	*10.9*	1168	35.8	*45.1*	1252	21.9	*18.0*	767
2.0	23.8	*12.5*	476	21.2	*40.0*	2699	44.8	*52.6*	1569	128	*89.2*	4468
4.0	29.5	*17.6*	589	**49.1***	*35.0*	669	122	*205*	4269	**238***	*160.6*	8324

Treatment	Post Feeding Wk 3			Post Feeding Wk 4			Post Feeding Wk 5			Table Notes:
	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total	
Control	21.0	*12.1*	734	18.9	*10.3*	660	17.8	*9.2*	534	* = significant ($p<0.05$) increase relative to controls.
0.02	16.9	*11.7*	590	19.2	*10.2*	673	22.8	*11.9*	684	
0.10	18.6	*21.1*	650	14.7	*10.2*	515	14.1	*9.0*	422	
0.5	17.4	*9.6*	608	45.6	*99.2*	1595	14.2	*11.6*	426	Total = total dead bees among the 5 replicate hives during the observation period
2.0	23.9	*26.6*	836	14.8	*7.8*	519	14.4	*13.3*	431	
4.0	29.4	*21.0*	1028	15.7	*10.9*	550	12.4	*10.1*	373	

* = significantly different from controls ($p<0.05$, Wilcox Test)

No statistically-significant difference was detected in mean larvae/pupae mortality in the lower 3 sulfoxaflor treatments (*i.e.*, 0.02, 0.1, and 0.5) relative to controls, except for 0.02 mg ai/kg during Weeks 2 (0.9 bees/day) and 4 (0.5 bees/day) (**Table J-5**). These slight but statistically-significant increases in immature bee mortality at 0.02 mg ai/kg are not considered by the study author to biologically significant nor treatment-related. Colonies fed 2 mg ai/kg sulfoxaflor showed statistically-significant increases in immature bee mortality during Weeks 1 through 4 post-feeding, with daily means of 6.8, 157, 2.8 and 1.2 bees/day, in post-exposure Weeks 1, 2, 3 and 4, respectively (**Table J-5**). Mean daily mortality in immature bees in post-exposure Week 2 in the 2 mg ai/kg treatment (157 bees/day) was about 3X greater than those in the 4 mg ai/kg treatment (55 bees/day) during the same week.

Table J-5. Mean (± Standard Deviation) and total mortality of larval and pupal honey bees (*Apis mellifera*) recorded before, during and after feeding either untreated (Control) or sulfoxaflor-spiked sucrose solutions for 10 days.

Treatment (mg ai/kg)	Before Feeding			During Feeding			Post Feeding Wk 1			Post Feeding Wk 2		
	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total
Control	0.3	0.7	5	0.2	0.5	12	0.3	1.1	12	0.2	0.5	7
0.02	0.7	2.5	13	0.3	0.8	19	0.6	0.9	21	**0.9***	1.2	30
0.10	0.3	0.6	6	0.1	0.4	7	0.5	1.2	19	0.9	1.7	31
0..50	0.5	0.9	9	0.5	1.6	30	0.6	1.1	21	2.6	5.6	92
2.0	0.9	1.4	18	0.8	2.1	43	**6.8***	11.0	237	**157***	265	5488
4.0	0.8	1.1	15	**1.4***	2.1	75	**12.7***	21.9	444	**55.5***	101	1942

Treatment (mg ai/kg)	Post Feeding Wk 3			Post Feeding Wk 4			Post Feeding Wk 5			Table Notes:
	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total	Daily Mean	*SD*	Total	
Control	0.1	0.3	3	0.1	0.2	2	0.3	0.7	9	* = significant (p<0.05) increase relative to controls. Total = total dead larvae + pupae among the 5 replicate hives during the observation period
0.02	0.3	0.5	9	**0.5***	0.8	18	0.3	0.6	8	
0.10	0.2	0.6	7	0.3	1.4	12	0.1	0.3	4	
0.50	0.9	2.1	32	0.8	1.9	28	0.2	0.9	6	
2.0	**2.8***	5.1	97	**1.2***	2.4	41	0.1	0.3	3	
4.0	5.5	13.8	191	**1.7***	3.8	61	0.3	0.8	9	

* = significantly different from controls (p<0.05, Wilcoxon Test)

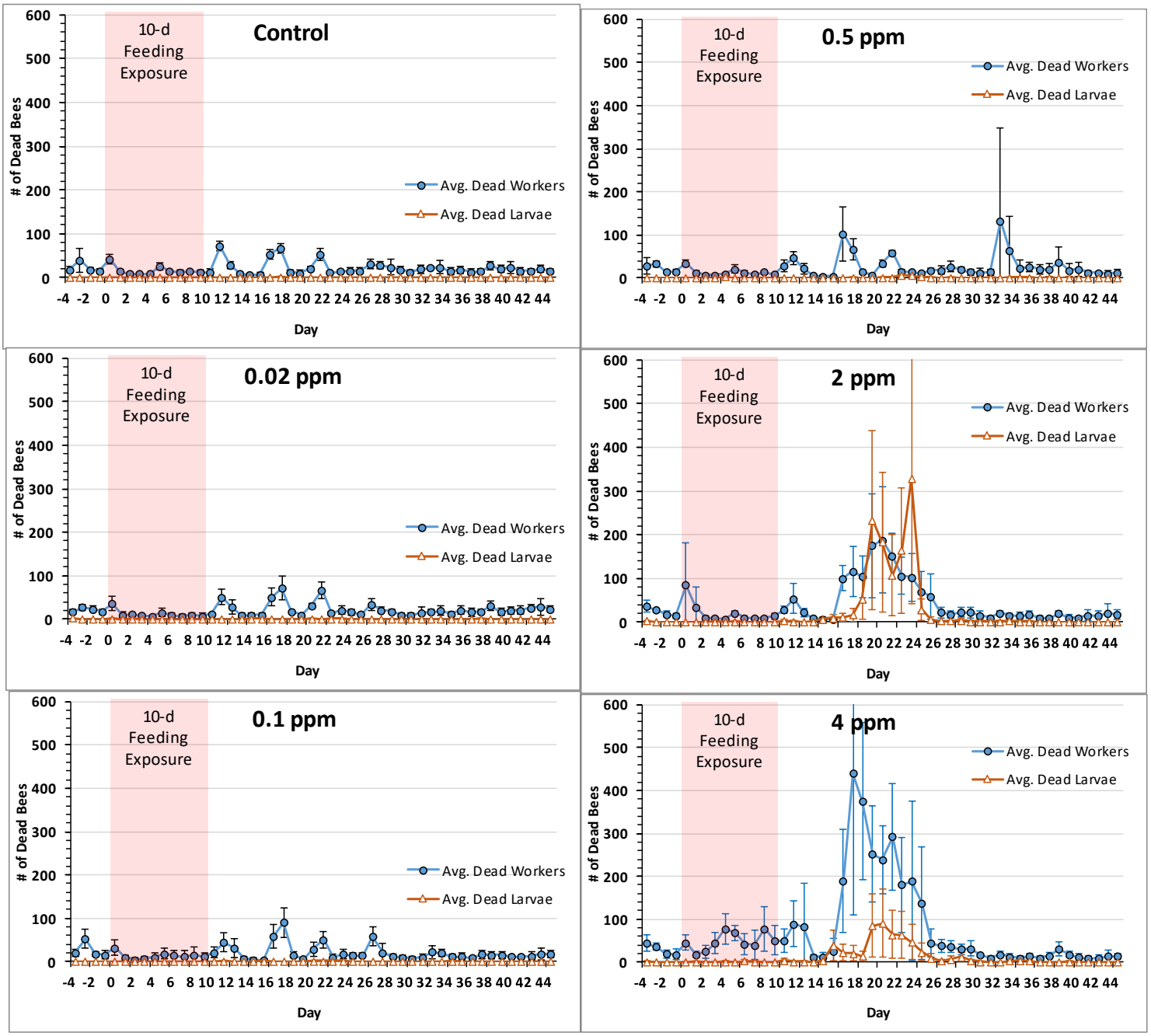
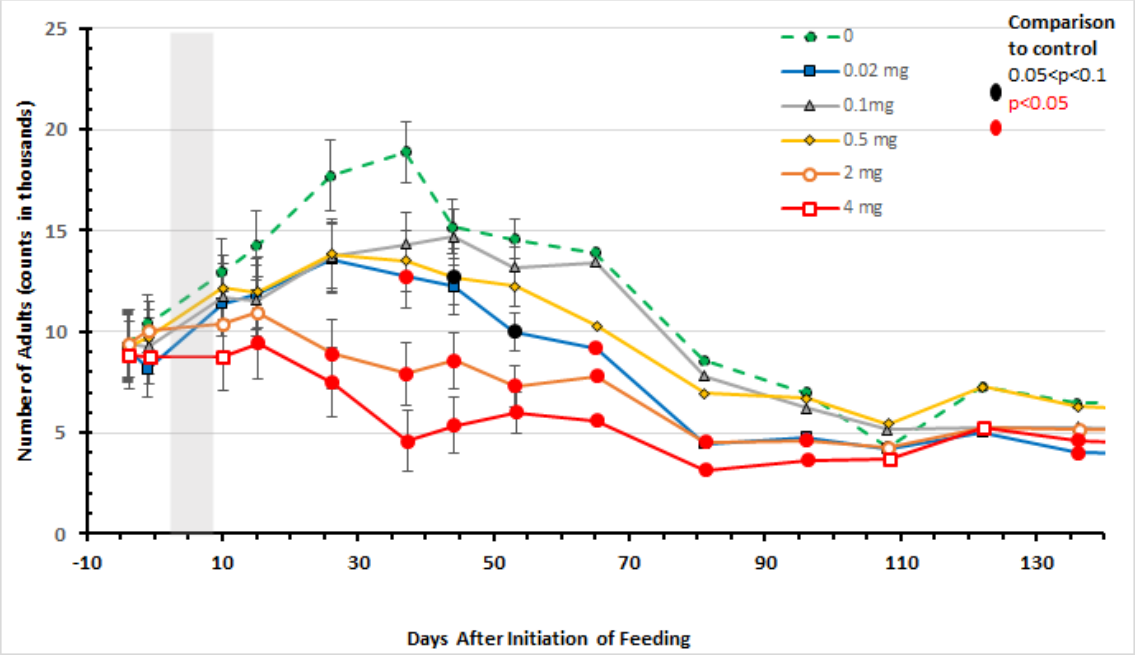


Figure J-4. Mean daily mortality of adult and larval honey bees (*Apis mellifera*) exposed to either control or sulfoxaflor-treated feeding solutions across study days. The 10-day exposure period is highlighted in pink. Error bars reflect 95% confidence limits (ppm=parts per million; mg ai/kg).

Colony Strength and Total Brood

Results from the measurement of colony strength (*i.e.*, total number of adult bees) and total brood in control and sulfoxaflor-treated colonies are shown in **Figure J-5.** As depicted in **Figure J-5**, colonies fed sulfoxaflor at 2 mg ai/kg or 4 mg ai/kg had statistically significant ($p<0.05$) differences (reductions) relative to controls in the numbers of adult bees and total brood (*i.e.*, eggs, larvae, pupae) following exposure and lasting for most of the monitoring period prior to overwintering. Numbers of adult bees fed 2 and 4 mg ai/kg did not display a spring build up (increase) like control colonies and those colonies exposed to sulfoxaflor at 0.02-0.5 mg ai/kg. No statistically-significant differences in total brood were observed in colonies fed sulfoxaflor at 0.02-0.5 mg ai/kg relative to controls. With the number of adult bees, colonies fed sulfoxaflor at 0.5 mg ai/kg exhibited a difference (reduction) that approached statistically significant ($p <0.1$) relative to controls only at colony condition assessment (CCA) 7, and no statistically-significant reductions were observed in colonies fed 0.1 mg ai/kg sulfoxaflor.

The mean number of adult bees in colonies fed sulfoxaflor at 0.02 mg ai/kg was significantly reduced ($p<0.05$) relative to controls on multiple CCAs following exposure (**Figure J-5**, top panel). This finding is unexpected given the general lack of significant differences in adult bees at test concentrations 5X and 25X higher (*i.e.*, 0.1 and 0.5 mg ai/kg).



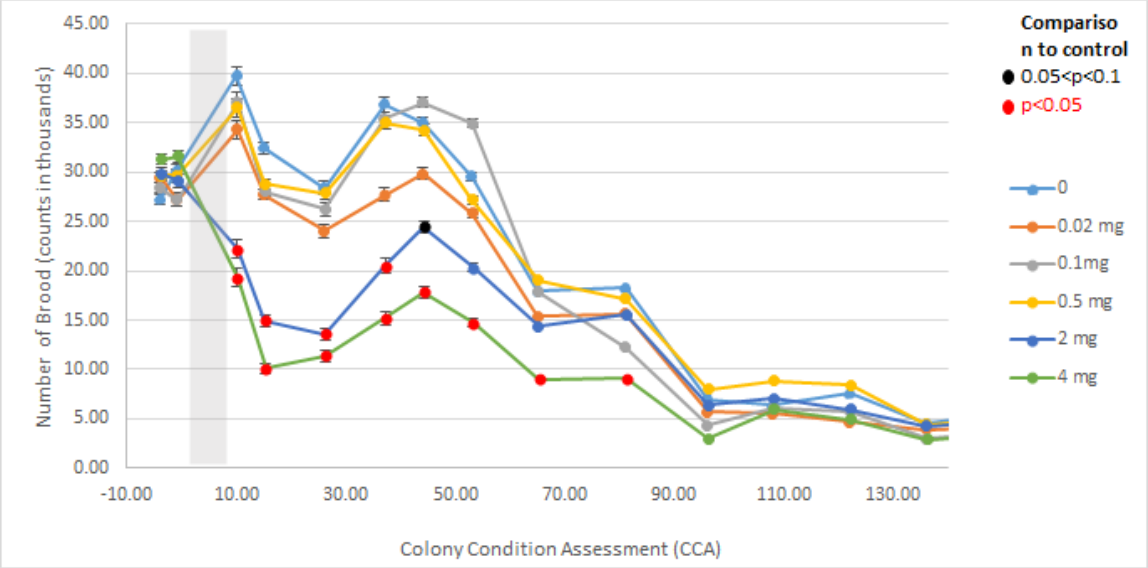


Figure J-5. Mean (std. error) of adults (top) and brood (bottom) among sulfoxaflor-treated and control colonies over duration of study. Grey bar reflects the timing of the 10-d feeding period.

According to the study report, data for individual colonies in the 0.02 mg ai/kg treatment indicates that replicate C had less than 50% of adult bees just prior to exposure compared to the other 4 colonies (**Figure J-6, bottom panel**). Numbers of adult bees in this colony continued to be low throughout the subsequent 8 CCAs. Furthermore, one colony in the controls (A) contained relatively large numbers of adults throughout the CCAs. With only 5 colonies per treatment, the results from a single colony can have a relatively large impact on statistical results, which may be the case in the comparison of colonies in the 0.02 mg ai/kg treatment to controls.

A second line of evidence is that no biologically or sustained statistically-significant increase in mortality of adult or larval bees occurred in colonies fed 0.02 mg ai/kg sulfoxaflor relative to controls from DAF -4 through DAF 44, as described previously.

A third line of evidence is that food provisions (pollen, nectar) and brood development (described in subsequent sections) were not significantly different than controls in the 0.02 mg ai/kg treatment and were only consistently affected in the 2 and 4 mg ai/kg treatments.

Fourthly, residues measured in hive matrices of colonies fed sulfoxaflor at 0.02 mg ai/kg were 1-2 orders of magnitude below the chronic no-observed effect concentration (NOAEC) for adult bees fed sulfoxaflor in the Tier 1 laboratory test (NOAEC = 0.32 mg ai/kg; LOAEC = 0.58 mg ai/kg). Therefore, direct effects on adult bees fed 0.02 mg ai/kg would not be expected based on the levels of sulfoxaflor measured in the feeding solution or hive matrices.

Finally, colonies fed 0.02 mg ai/kg had levels of *Varroa* mite that were below the commonly accepted threshold of concern (3 mites/100 bees). Therefore, these of evidence suggest that effects on adult numbers observed at 0.02 mg ai/kg are not likely to be treatment related.

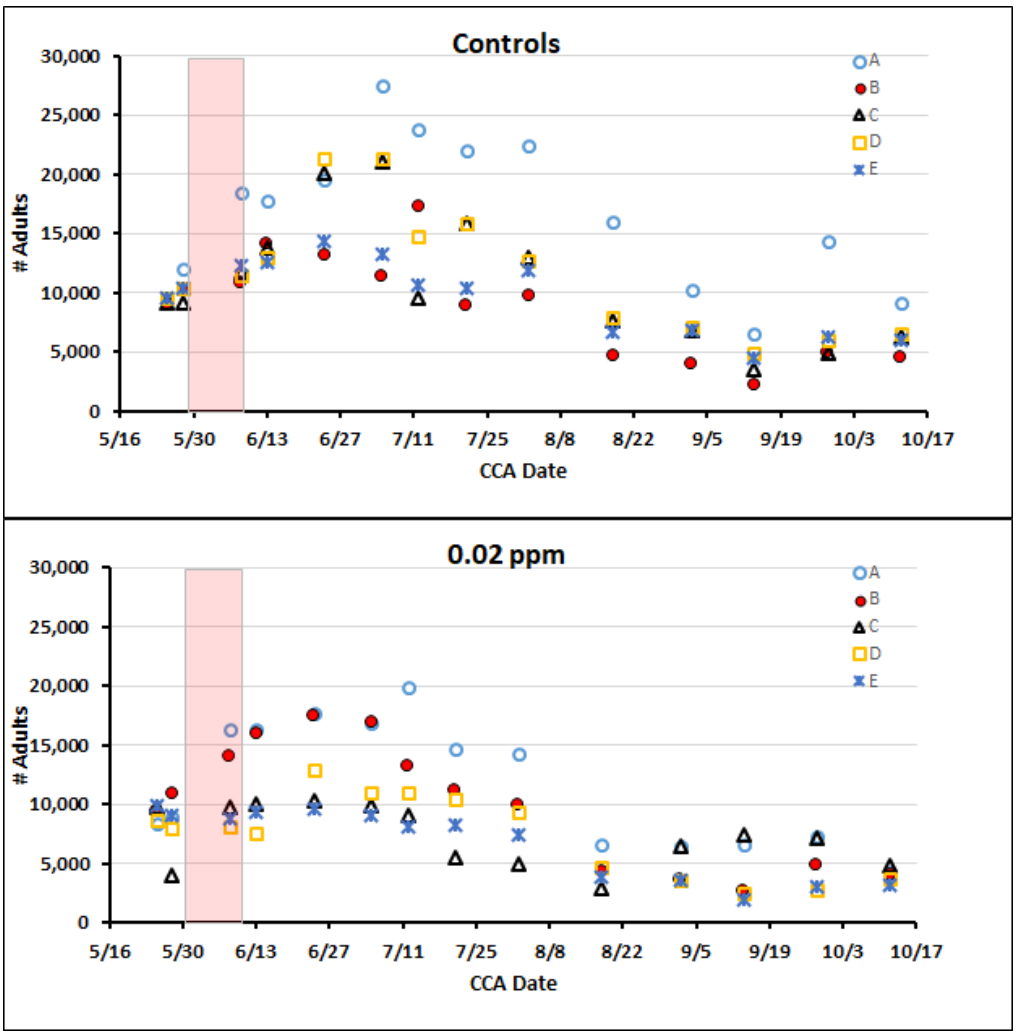


Figure J-6. Total numbers of adult honey bees (*Apis mellifera*) from each of the 5 replicate (A – E) control (top) and sulfoxaflor 0.02 mg ai/kg (ppm)-treated (bottom) colonies over the colony condition assessment (CCA dates).

Brood Life Stages

With respect to individual life stages of brood, significant ($p < 0.05$) differences (reductions) were detected in the number of eggs, larvae and pupae in the highest two sulfoxaflor treatments (*i.e.*, 2 and 4 mg ai/kg) relative to controls except for larvae from one CCA in the 0.02 mg ai/kg treatment (**Figure J-7**). These findings are consistent with results of overall bee brood mortality described in the preceding section.

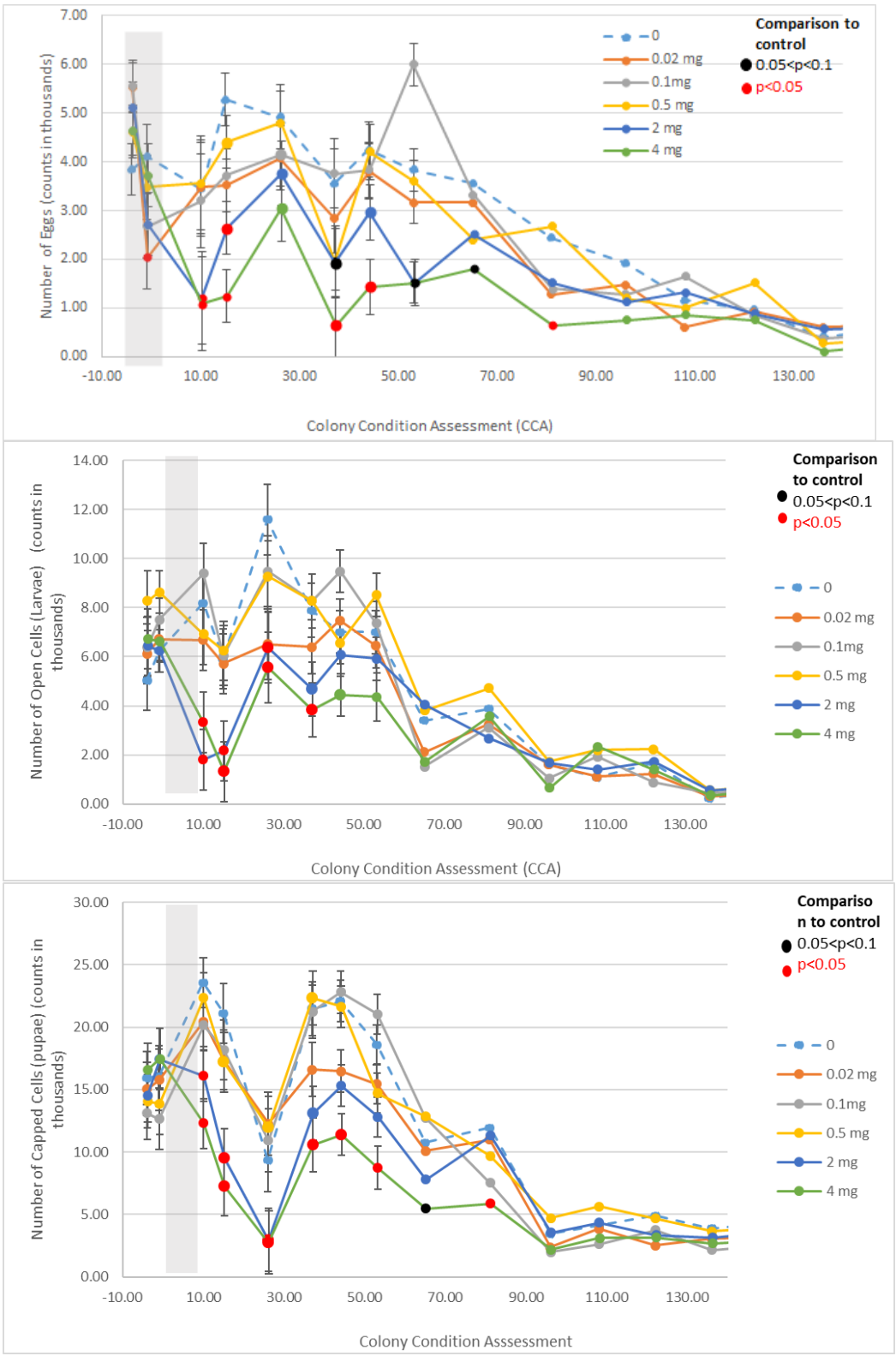


Figure J-7. Mean numbers of honey bee (*Apis mellifera*) eggs (top), uncapped cells (larvae; middle) and capped cells (pupae; bottom) in control and sulfoxaflor-treated colonies across colony condition assessments conducted over duration of colony feeding study. Gray bar depicts 10-day exposure phase of the study).

Food Provisions

All colonies (including controls) show an overall decline in the numbers of cells containing pollen during the two CCAs after feeding (**Figure J-8**). This decline is then followed by a steady increase in pollen stores over the next 4 CCAs followed by a second gradual decline. The mean number of cells containing pollen was significantly ($p < 0.05$) different (reduced) in hives fed sulfoxaflor at 4 mg ai/kg relative to controls during multiple CCAs. However, beyond this treatment a consistent concentration-response pattern is not indicated. At two CCAs, the number of pollen cells is significantly ($p<0.05$) different (reduced) from controls in hives fed sulfoxaflor at 0.1 mg ai/kg, but not those fed 0.5 mg ai/kg. Pollen provisions in hives fed sulfoxaflor at 2 mg ai/kg were significantly ($p<0.05$) different (reduced) compared to controls only at 1 CCA while no significant differences were detected from controls in hives fed sulfoxaflor at 0.02 and 0.5 mg ai/kg at any CCA.

A gradual increase is seen in the number of cells containing honey following feeding in controls and sulfoxaflor-treated hives over the duration of the CCA measurements. According to the study authors, the "peaks" in honey stores following dosing likely reflected the supplemental feeding during the experiment at 16, 25, 50, 72 and 100 DAF. Statistically significant ($p<0.05$) differences in honey stores relative to controls were only detected at the 2 and 4 mg ai/kg treatments for one CCA.

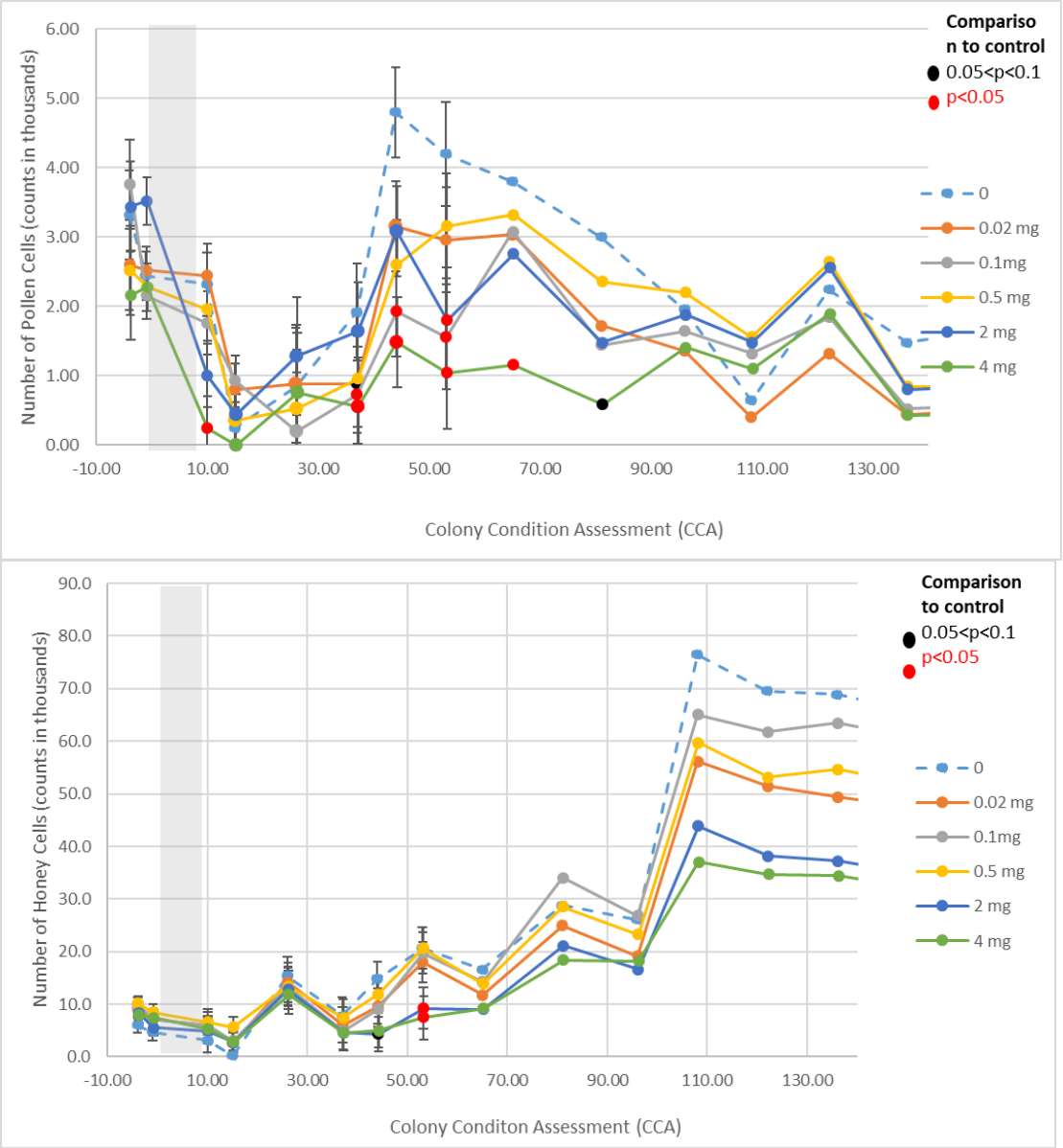


Figure J-8. Mean number of cells containing pollen (top panel) and honey (bottom) from control and sulfoxaflor-treated honey bee (*Apis mellifera*) colonies across colony condition assessments conducted over duration of colony feeding study. Gray bar depicts 10-day exposure phase of the study).

Brood Indices

The brood index a measure of the development of brood to the expected life stage and is calculated based on the following ordinal ranking of the life stage present by monitoring a cohort of 200 eggs over a 21-d brood cycle:

- 0 = empty cell
- 1= egg

- 2= young larvae
- 3= old larvae
- 4= pupae
- 5= successful hatch

The **Brood Index** is calculated by assigning the above rankings to each cell at selected time intervals over a brood cycle and calculating the average ranking of 200 tracked cells. If the expected brood stage is not present in a cell, it is assigned a "0". The **Brood Compensation Index** is similar to the Brood Index, but if the queen replaces brood in a cell that failed to develop with a new egg, a "1" is assigned to that cell rather than a "0" and its development is tracked and ranked along with the rest of the brood. In this way, the Brood Compensation Index accounts for the ability of the queen to replace brood that fail to develop properly. Consequently, the Brood Compensation Index will be greater than the Brood Index to the extent that the queen replaces failed brood with new eggs and these eggs continue to develop. The **Brood Termination Rate** is simply a measure of the percentage of cells containing brood that did not develop to the expected stage.

Results from the Brood Index, Brood Compensation Index and Brood Termination Rates of control and sulfoxaflor-treated colonies are summarized in **Figure J-9** for brood tracked from the egg stage through pupation among two different brood cycles. The first brood cycle was monitoring from 1 day before feeding (DBF) to 22 days after feeding (DAF). For the first brood cycle, the Brood Index is significantly ($p < 0.05$, Dunnett's test) different (reduced) relative to controls at 5, 10, 16 and 21 DAF in colonies treated with sulfoxaflor at 4 mg ai/kg. Identical results are seen with the Brood Compensation Index (*i.e.*, statistically significant effects only at the highest treatment), except at 16 DAF where no statistically-significant reductions occur. With the Brood Termination Rate, significant ($p<0.05$) differences (increases) from controls increases are seen in the 4 mg ai/kg treatment at 5, 10, 16, and 21 DAF.

The second brood cycle was monitored from 15 DAF through 37 DAF (22 days). For the second brood cycle, no statistically-significant differences were detected in any sulfoxaflor treatment relative to controls. These data suggest that the impacts on brood development (either direct or indirect) detected in the first brood cycle occurred during and shortly after colonies were fed sulfoxaflor-treated sucrose were transient and did not extend into the second brood cycle.

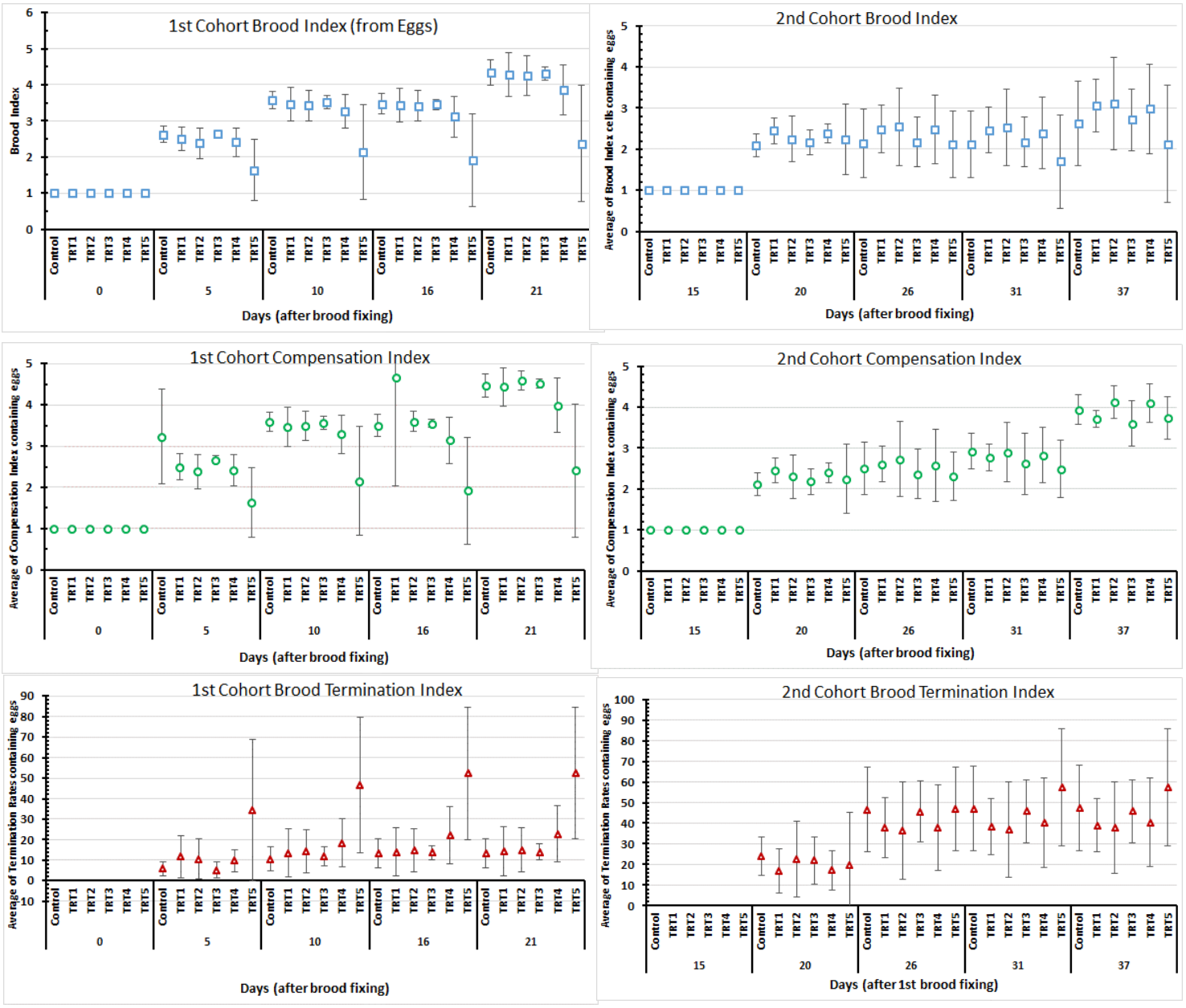


Figure J-9. Brood index, brood compensation index, and brood termination rate for controls and sulfoxaflor-treated honey bee (*Apis mellifera*) colonies. Sulfoxaflor TRT1=0.02; TRT2=0.1; TRT3= 0.5; TRT4=2 and TRT5=4 mg ai/kg.

Hive Weight

The weight of each of the colonies was recorded daily over the duration of the study (except during winter). Results of the mean colony weight for control and sulfoxaflor-treated colonies are depicted in **Figure J-10.** Significant ($p < 0.05$) differences (reductions) in weight of colonies treated with sulfoxaflor occurred at 2 and 4 mg ai/kg, relative to controls, shortly after the 10-day dosing period ended (*i.e.*, starting at DAF 22 for the 2 mg ai/kg treatment and at DAF 16 for the 4 mg ai/kg treatment). The colongy weight continued to be significantly different until DAF 66 for colonies traeated with sulfoxaflor at 2 mg ai/kg and until DAF 75 for colonies treated with 4 mg ai/kg with brief reductions shortly thereafter. Beginning near DAF 100, statistically-significant ($p<0.05$) differences (reductions) in hive weight were detected in the 2 and 4 mg ai/kg treatments and continued until DAF 136. A statistically significant ($p<0.05$) differences (reductions) in hive weight were also detected in the 0.02 mg ai/kg treatment from DAF 133-136; however, for reasons highlighted earlier, this reduciton is not considered likely to be treatment related.

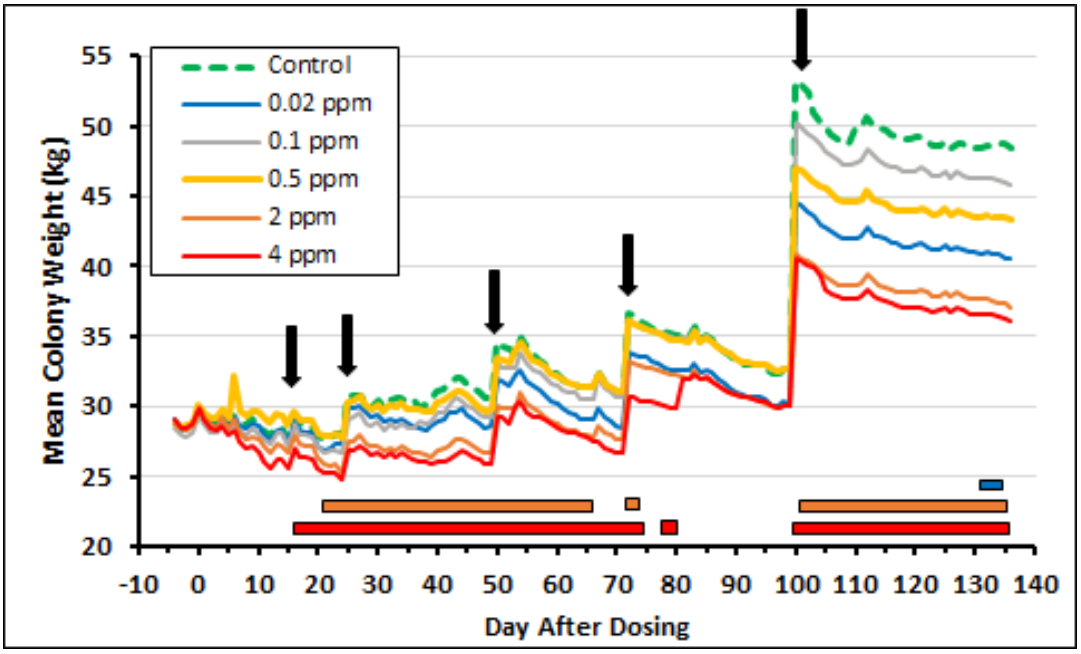


Figure J-10. Mean weigh of control and sulfoxaflor-treated honey bee (*Apis mellifera*) colonies. Black arrows indicate days were hives received supplemental feeding. Horizontal bars indicate days in which colony weight was significantly reduced relative to controls (coded according to treatment color; ppm = parts per million equivalent to mg ai/kg).

It is noted here that supplemental feeding of hives on DAF 16 was not uniform among all colonies within sulfoxaflor treatment groups other than contros. Specifically, the study authors report that "food comb" (weight unspecified) was fed to "most colonies" on DAF 16 due to the small amount of food reserves remaining in the hives and lack of flowering plants near the site. Closer inspection of the report indicates that following colonies received this supplemental feeding on DAF 16:

- Controls (all hives)
- 0.02 mg ai/kg (hives b, c, d, e)
- 0.1 mg ai/kg (hives b, c, d, e)
- 0.5 mg ai/kg (hives b, d, e)
- 2 mg ai/kg (hives b, c, d, e)
- 4 mg ai/kg (hives a, c, d, e)

No explanation was provided for this lack of uniformity in hive feeding on DAF 16. Supplemental feeding on the other time periods was uniform across hives within and among treatments.

Varroa

The presence of Varroa mites was monitored once during the fall (October24th) after the exposure period. Hives were monitored by recording the number of mites falling on the bottom of each hive on to sticky traps for seven days. This method is considered a less accurate technique for monitoring the rate of mite infestation of bees compared to other methods (*e.g.,* sampling bees directly via sugar shake method). The number of mites/hive/day recorded for each hive is shown in **Figure J-11**. These data indicate no obvious treatment-related effect on infestation by *V. destructor*. Although the overall infestation rate appears low, the methodology used differs from that typically used to measure mite infestation in which the number of mites per 100 bees is determined. Therefore, these results are not necessarily comparable to typical counts of *Varroa* mite infestation.

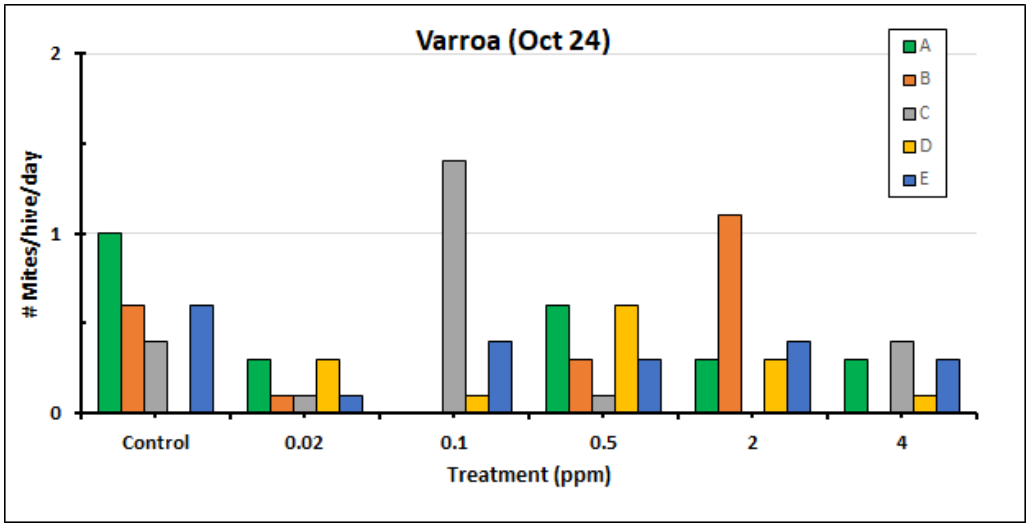


Figure J-11. Counts of varroa mites (*Varroa destructor*) in each of the control and sulfoxaflor-treated honey bee colonies in autumn (October 24) prior to overwintering.

Overwintering Success and Condition

All five hives in the control and the sulfoxaflor treatments of 0.02, 0.1, 0.5 and 2 mg ai/kg survived overwintering; whereas, two colonies failed in the 4 mg ai/kg treatment (1 prior to overwintering at 81 DAF and 1 after overwintering on DAF 299). Statistics were not conducted on overwintering success due to the low number of replicate hives (5).

Measures of colony condition (*i.e*., overall number of adults, eggs, larvae, pupae, pollen and honey) on the only CCA conducted after overwintering are shown in **Figure J-12**. The number of adult bees was significantly ($p<0.05$) different from controls in colonies fed sulfoxaflor at 0.02, 0.1, 0.5, 4 mg ai/kg sulfoxaflor ($p<0.05$) and was approaching statistical significance ($p<0.1$) in colonies fed 2 mg ai/kg sulfoxaflor. However, the study authors considered this measurement as invalid because of the influence of increasing temperatures during the CCA measurement. Specifically, CCAs were conducted in the order of increasing test concentrations (controls first, then 0.02, 0.1, 0.5, 2 and 4 mg ai/kg). During this time, the ambient temperature initially was below 10°C where adult bee foraging would be sporadic (*i.e*., most of the bees would be in the hive). With subsequent measurements, temperatures increased above 10°C which resulted in more adult bees leaving the hives and actively foraging. Honey bees are known to avoid foraging when temperatures drop below 10°C. Therefore, the lower numbers of adult bees with increasing test concentrations is confounded by the differential foraging activity of bees during their measurement after overwintering.

Statistically significant ($p<0.05$) differences (reduction) in the mean number of eggs and pupae in the colonies were only detected in the 0.02 mg ai/kg treatment (**Figure J-12**). Given the complete lack of concentration-response relationship, the study authors did not consider this reduction to be treatment related. No statistically significant differences were detected in the number of cells containing larvae or pollen in any sulfoxaflor treatment relative to controls. However, honey stores were significantly ($p<0.05$) different (reduced) compared to controls for colonies treated with sulfoxaflor at 2 and 4 mg ai/kg (**Figure J-12**).

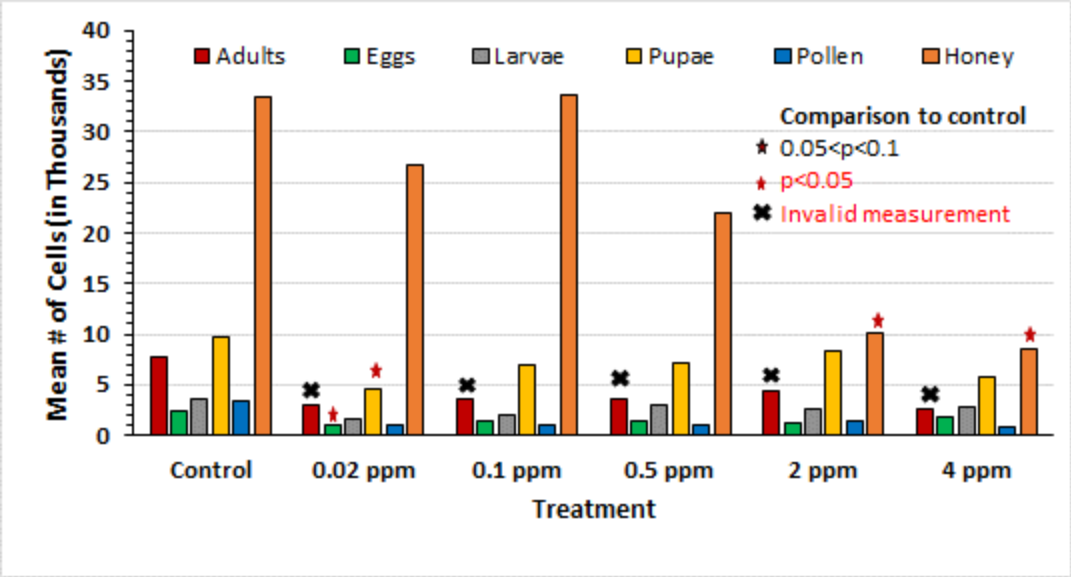


Figure J-12. Colony condition assessment of control and sulfoxaflor-treated hives on DAF 299 after overwintering

Study Strengths, Limitations and Classification

The following strengths and limitations are noted for this study in the context of assessing colony-level risks of oral sulfoxaflor exposures to honey bees.

Strengths:

- Measurement of multiple, colony-level effects which facilitates more holistic interpretation of the results;
- Measurement of residues in hives and in feeding solutions; and
- Long-term of monitoring of endpoints over time.

Limitations:

- Relatively low number of biological replicates (5) compared to other colony feeding studies results in reduced statistical power and greater influence of a single hive on overall results;
- Potential variability with respect to geographic location was not included since all hives were located at a single site;
- Hives were non-randomly placed at the study site, which could introduce bias in the results;
- Food provisions not provided equally to all hives on DAF 100; and,
- Measurement of sulfoxaflor residues in feeding solutions was done only once during the study, and
- Storage and transit stability of residue samples were not determined.

In considering these strengths and limitations, this study is classified as supplemental, but it is considered appropriate for quantitative use in risk assessment.

Study Conclusions (NOAEC, LOAEC)

The most sensitive endpoints from this colony-level feeding study are:

NOAEC = 0.5 mg ai/kg (0.47 mg ai/kg measured)
LOAEC = 2 mg ai/kg (1.85 mg ai/kg measured)

The LOAEC from this study is based on the occurrence of sustained (and statistically-significant) colony-level effects in hives fed 2 mg ai/kg sulfoxaflor in sucrose. These effects include:

- Reductions in number of adults and brood
- Increases in worker and larval mortality during weeks 1 and 2 after feeding
- Reduction in colony weight
- Reduced honey stores after overwintering

The NOAEC and LOAEC are expressed as nominal concentrations since the analytical results of the feeding solutions were close to nominal (*e.g.,* 0.47 and 1.85 mg ai/kg, respectively) but only a single sample was taken to confirm exposure concentrations.

Appendix K. US Colony Feeding Study (Louque 2017; MRID 50849601)

Executive Summary

In a honey bee (*Apis mellifera* L.) colony feeding study, the effects of technical grade sulfoxaflor (95.6% active ingredient) were evaluated. Colonies were exposed to either control (untreated; 24 colonies) or sulfoxaflor-treated (12 colonies) diets of 50% sucrose for 6 consecutive weeks where fresh diet (2 liters) was provided twice per week; sulfoxaflor treatments were at nominal dietary concentration of 0.017, 0.085, 0.17, 0.43, 1.0 mg/kg-sucrose. Residues of sulfoxaflor and its primary degradates were monitored in honey, uncapped nectar and bee bread (honey + pollen) over the course of the study. Colony condition assessments (CCA) were conducting during the exposure and monitoring phases of the study and included evaluations of food reserves, the number of adult bees and the number of pupae.

The NOAEC from the study is the nominal treatment of 0.43 mg ai/kg (nominal); the LOAEC is 1.0 mg ai/kg (nominal) and is based on the occurrence of sustained (and statistically-significant; $p<0.05$) colony-level effects which include:

- Reduced number of comb cells containing bee bread (39%-52% reduction relative to controls), which is an indication of reduced foraging ability;
- Reduced number of comb cells with pupae (16-29% reduction relative to controls) indicating effects on brood development; and,
- Reduced hive weight (40%-50% reduction relative to controls) during and after the exposure period.

However, due to the highly variable nature of analytical measurements of sulfoxaflor in feeding solutions (particularly at the highest 3 treatments), actual exposure of individual colonies during the dosing period are likely to be variable. Therefore, this study is considered supplemental and suitable only for qualitative use in risk assessment (*i.e.,* as an additional line of evidence but not for making risk determinations).

Study Design

The technical registrant (Corteva Agroscicences) submitted a honey bee (*Apis mellifera* L.) colony feeding study (Louque 2017; MRID 50849601) in which bees were fed either untreated sucrose solution or sucrose solutions spiked with sulfoxaflor (TGAI, 95.6% a.i.). The study was conducted according to Good Laboratory Practice (GLP) standards established under both FIFRA and OECD. A total of 96 colonies were used in this study which consisted of 12 apiaries. At each of the 12 sites, 1 colony was tested at each treatment level (*i.e*., 0.017, 0.085, 0.17, 0.43, 1.0 mg/kg-sucrose[22]), 2 colonies were used as untreated controls, and 1 additional colony was used for chemical residue and pollen palynology (floral source) monitoring. Colonies were initiated using packaged bees were obtained from a commercial supplier and contained sister queens

[22] treatments are 0.02, 0.1, 0.2, 0.5, 1.2 mg ai/L on a volume basis.

and which were placed in 10-frame hives with new foundation. Prior to exposure, hives were culled such that those in the study contained all stages of brood (*i.e*., eggs, larvae, pupae), a queen, adequate food stores and had no visible signs of the fungal disease Nosemosis *(Nosema spp)* or the parasitic varroa mite (*Varroa destructor*). Prior to placing at the study sites, hives were blocked by colony strength (*i.e.*, overall number of adults), with site A having the strongest hives, followed by site B and so on. All hives were arranged at each site June 14th, 2016 with hive entrances facing outward as shown in (**Figure K-1**).

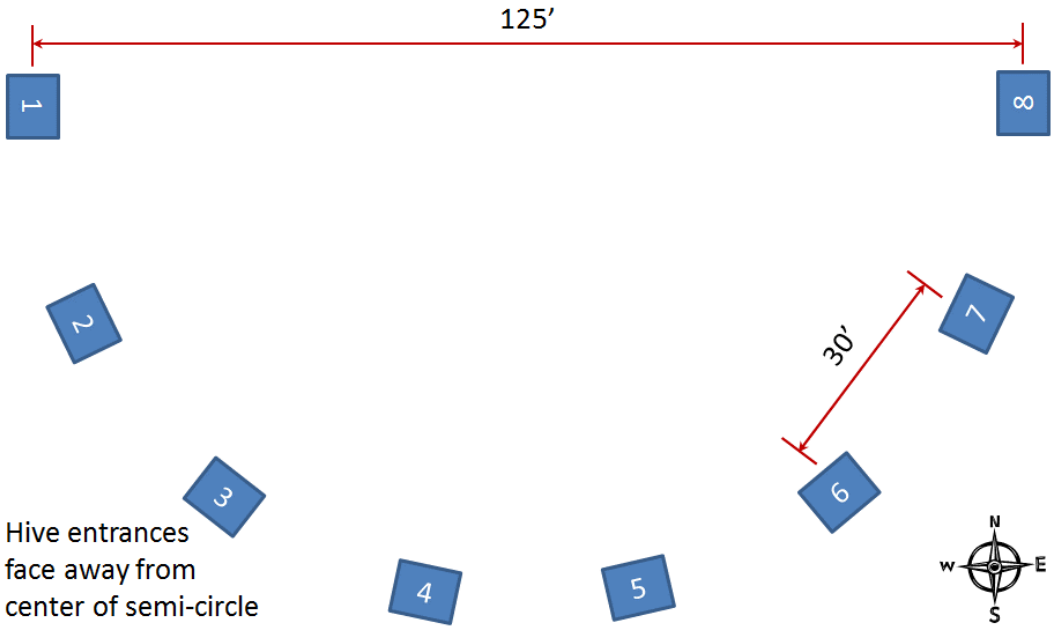


Figure K-1 Diagram of the honey bee (*Apis mellifera*) colony feeding study site showing locations of hives at each study site.

Each apiary site had approximately 10 acres of blooming buckwheat prior to exposure (beginning June 1) and just after exposure (beginning August 15th). After the exposure phase, hives were moved to two apiary sites (1 mile apart) for further monitoring through overwintering.

Exposure, Biological and Chemical Monitoring

Freshly treated sugar syrup was prepared twice weekly for 42 days of the exposure phase of the study; diets consisted of a volume of 2000 mL sucrose/feeding event beginning July 11 and ending Aug 19, 2016. Appropriate aliquots of sulfoxaflor TGAI stock solution were added to their respective treatment in the morning just before the diets were placed into the colonies. When adding new diet to the hives, the previous feeding's diet was removed from the in-hive feeder and its weight determined to the nearest 1 gram.

Colonies were removed from the exposure sites on the night of September 7th, 2016, after the fifth colony condition assessment (CCA 5) was completed and transported to either of two monitoring sites near the Pollinator Research Facility. Supplemental feeding (2 L of 50% sucrose

solution) was provided 5 times in October (10/3, 10/6, 10/10, 10/21, 10/28) during the monitoring phase of the study; 3 times in November and (11/4, 11/11, 11/18) and once in December (12/1). In addition, supplemental feeding of pollen substitute was provided once in mid-November (11/11) and once in mid-December (12/15). Miticide treatment (*i.e*., thymol) was provided on September 16 and October 4, 2016 to all colonies based on best beekeeping practice mite thresholds.

Numerous biological and chemical measurements were taken prior to and after the initiation of feeding, in accordance with **Table K-1.**

Table K-1. Biological and chemical measurements of honey bee (*Apis mellifera*) colonies used in colony feeding study with sulfoxaflor technical grade active ingredient.

Measurement	Description	Timing
Colony condition assessment (CCA)	Photographic assessment of brood (pupae only), food stores, adults	3 CCAs before feeding, 4 CCAs post feeding, 2 CCAs post wintering
Abnormal behavior	Visual observation of abnormal behaviors, disease	Each CCA
Hive weight	Hourly measurements	Prior to exposure – end of study
Sucrose consumption	Measurement of remaining test solution	Prior to each renewal
Temperature, humidity, precipitation	Daily	5 days before feeding (DBF) through 299 days after feeding (DAF)
Varroa & Nosema Sampling	Counts of *Varroa* mites & *Nosema spp.* from sampled bees	CCA 3, 5, 7, 9
Analysis of sucrose solutions	Measurement of sulfoxaflor in feeding solutions	Weeks 1, 3 and 5
Hive residues	Bee-collected pollen (Pollen traps) and bee bread (pollen + honey), uncapped nectar, honey	Wk 1, 2, 6, 15, 37, 42 Wk 3, 5, 15, 42

Study Results

A summary of the study results is provided in **Table K-2**. A brief discussion of each of the study endpoints follows **Table K- 2**.

Table K-2. Summary of biological and chemical results for honey bee (*Apis mellifera*) colonies fed sulfoxaflor in diet for 42 days (MRID 50648901)

Study Attribute	Results Summary (1)
Test Substance	Sulfoxaflor (95.6%)
Timing/Location	2016-17, Belvidere, NC; 12 sites
Exposure period & Concentration	**42 days continuous feeding** • 0, 0.017, 0.085, 0.17, 0.43, 1.0 mg ai/kg (Nominal) • Week 0: <DL, 0.013, 0.073, 0.14, 0.36, 0.90 mg ai/kg (Meas.= 77%-90% nominal) • Week 3: <DL, 0.019, 0.054, 0.06, 0.018, 0.28 mg ai/kg (Meas. = 4%-110% nominal) • Week 5: <DL, 0.017, 0.084, 0.15, 0.11, 0.19 mg ai/kg (Meas. = 20%-100% nominal)

Study Attribute	Results Summary [1]		
No. Reps. / Treatment	12 (treatments); 24 (controls); 1 (residue/monitoring)		
Feeding Timing	2000 mL sucrose/colony 2X each week for 6 weeks (42L total)		
Colonies	96 colonies (sister queens) established 8 weeks prior to test initiation with 10 combs and all brood stages/food provisions present. 6,200-7,800 adults at CCA3		
Sucrose Consumption	Overall mean consumption @ 0.43 and 1.0 mg/kg significantly reduced to 83% and 63% of controls, respectively. No significant reduction in consumption @ 0.017- 0.17 mg/kg treatments.		
Residues in Hive Matrices	Dose-dependent increase in quantity in the number of cells containing nectar/honey and bee bread stores during dosing (weeks 3 and 5) and after dosing (week 11). Sulfoxaflor concentrations in nectar were ~5-10X higher than those in bee bread. By week 11 (6 weeks after dosing ended) residues in honey declined to approximately 25%-40% of peak residues measured during the exposure phase. After overwintering (week 42), sulfoxaflor in honey was detected mostly in the highest 3 treatments (15-25% of peak), while in bee bread, it was detected in only 1 sample.		
Residue Spike Recovery: mean (range)	**Bee Bread:** **@LOQ:** 99% (92-122%) **@LOQ x 1000:** 74% (50-109%)* * 5/12 recoveries < 70%	**Nectar:** **@LOQ:** 109% (90-947%)* **@LOQ x 1000:** 83% (60-112%)** * 5/18 samples > 120% ** 3/18 samples < 70%	**Honey:** **@LOQ:** 102% (62-148%)* **@LOQ x 1000:** 104% (79-122%) * 3/8 recoveries < 70% or > 120%
	Sucrose: Mean = 90-100% (19/20 recoveries within 70-120%)		
Bee Bread (pollen + honey) Provisions	• **1.0 mg ai/kg:** Significant reductions (39% & 52%) @ CCA6 & CCA7 (P<0.05) • **0.43 mg ai/kg:** 24% reduction at CCA7 (0.05< p <0.1) • **0.017-0.17 mg ai/kg:** similar or higher than controls		
Colony Strength (# Adults)	• **1.0 mg ai/kg:** Significant reductions (25%) @ CCA7 only (0.05< p <0.1) • **0.017-0.43 mg ai/kg:** similar or higher than controls at all CCAs		
# Pupae	• **1.0 mg ai/kg:** Significant reductions @ CCA4 (16%) and CCA6 (29%; 0.05< p <0.1) • **0.017-0.43 mg ai/kg:** similar or higher than controls at all CCAs, except for apparent non-treatment related reduction in hives fed 0.017 mg ai/kg at CCA6 (49%) and CCA7 (66%; p<0.05)		
Hive Weight	• **1.0 mg ai/kg:** Sustained reductions in hive weight (40-50%), statistically significant @ CCA7 • **0.017-0.43 mg ai/kg:** weights generally +/- 20% of controls		
Varroa & Nosema	• No consistent or obvious treatment-related effects on mite loads or *Nosema* infection indicated		
Overwintering Success and Condition	• **Controls:** 25% colony loss by Dec 2016; 67% total colony loss after overwintering (16/24 colonies collapsed). Lower number of adults (~5,500) prior to overwintering is a likely factor in hive loss. • **0.017-0.43 mg ai/kg:** 17%-50% loss by Dec 2016; 25%-75% total colony loss after overwintering (3/12 to 9/12 colonies failed). Lower number of adults (< 7,000) prior to overwintering is a likely factor in hive loss.		
Overall NOAEC & LOAEC	• **NOAEC = 0.43 mg ai/kg (nominal)** • **LOAEC = 1.0 mg ai/kg (nominal)**		

Study Attribute	Results Summary [(1)]
Study Strengths	1. High number of replication (n=24 for controls; 12 for treatments) for increased statistical power. 2. 6-wk exposure duration reflects "high end" exposure scenario of hives. 3. Long-term monitoring of hives beyond overwintering. 4. 12 different sites included, with stratified randomized block design. 5. Low-level of cross-contamination detected in control hives.
Study Limitations*	1. Uncertainty in the delivered exposures to hives at least on weeks 3 and 5. 2. Did not monitor all stages of brood (*e.g.,* eggs, larvae) or honey stores. 3. High control colony loss after overwintering in controls (67%) invalidates overwintering portion of the study. Low number of adults in hives prior to overwintering may have contributed to high frequency of colony loss. 4. Analytical recovery of residues in hive matrices at various spiked concentrations exceeded generally accepted range of 70%-120%.
Study Classification	**Supplemental (qualitative).** This study is not considered appropriate for quantitative use in risk assessment. However, portions of the study (prior to overwintering) may be used qualitatively as an additional line of evidence on the potential effects of sulfoxaflor on honey bee colonies.

Exposure Verification

Results from diet treatment level verification samples taken of the sucrose feeding solutions on Weeks 0, 3 and 5 are depicted in **Figure K-2** and summarized in **Table K-3.** On Week 0 (the first week of dosing), measured sulfoxaflor concentrations in the sucrose feeding solutions were between 95% and 110% of nominal concentrations, indicating that the intended dietary exposures were achieved. However, on Weeks 3 and 5, measured concentrations were consistently lower than nominal concentrations at the highest two treatments (5%-31% of nominal at 0.43 mg ai/kg; 24%-35% of nominal at 1.0 mg ai/kg). On Week 3, measured concentrations in the 0.17 mg ai/kg treatment were also 44% of nominal, but were 100% of nominal at Week 5.

The study authors suggested that incomplete mixing of the sulfoxaflor stock solutions in the feeding solution containers contributed to the poor percent of nominal results in Weeks 3 and 5, in part because the time between stock solution addition and sampling was shorter (~ 5 minutes on Weeks 3 and 5 vs. ~ 1 hour on Week 0) than what took place at Week 0. A follow up study (MRID 50849501) was conducted to replicate the preparation, mixing and transport of feeding solutions from this CFS. The mixing study demonstrated incomplete mixing of sulfoxaflor in sucrose feeding solutions up to 3 hours after preparation in the highest two test concentrations. It is thought that the heterogeneous distribution of sulfoxaflor was feeding solutions was caused by differing densities of the 50% sucrose and stock solutions. Regardless, these results suggest that individual honey bee colonies fed the highest test concentrations (which correspond to the NOAEC and LOAEC), likely experienced highly variable exposures over time. Therefore, the extent to which hives were exposed to the appropriate concentrations of sulfoxaflor in feeding solutions, particularly at the two highest concentrations, is considered uncertain with respect to measured concentrations in the diet. Based on concentrations in

uncapped nectar, there is evidence to support that the colonies, on average, were exposed to increasing concentrations of sulfoxaflor (**Figure K-3**).

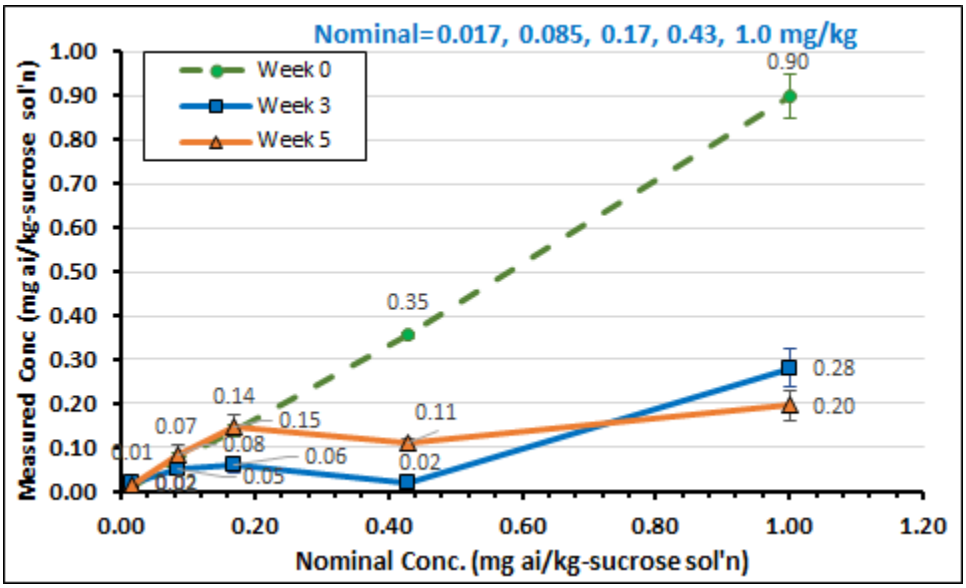


Figure K-2. Measured vs. nominal concentrations of sulfoxaflor in rate verification samples of sucrose feeding solutions

Table K-3. Results from rate verification samples of sulfoxaflor measured in sucrose feeding solutions

Week	Treatment Mean-Measured Concentration in mg ai/kg (% Nominal)				
	0.017	**0.085**	**0.17**	**0.43**	**1.0**
0	0.013 (77%)	0.073 (86%)	0.14 (83%)	0.355 (82%)	0.90 (9%0)
3	0.019 (114%)	0.054 (63%)	0.060 (36%)	0.018 (4%)	0.281 (28%)
5	0.017 (102%)	0.084 (99%)	0.149 (88%)	0.109 (25%)	0.195 (20%)

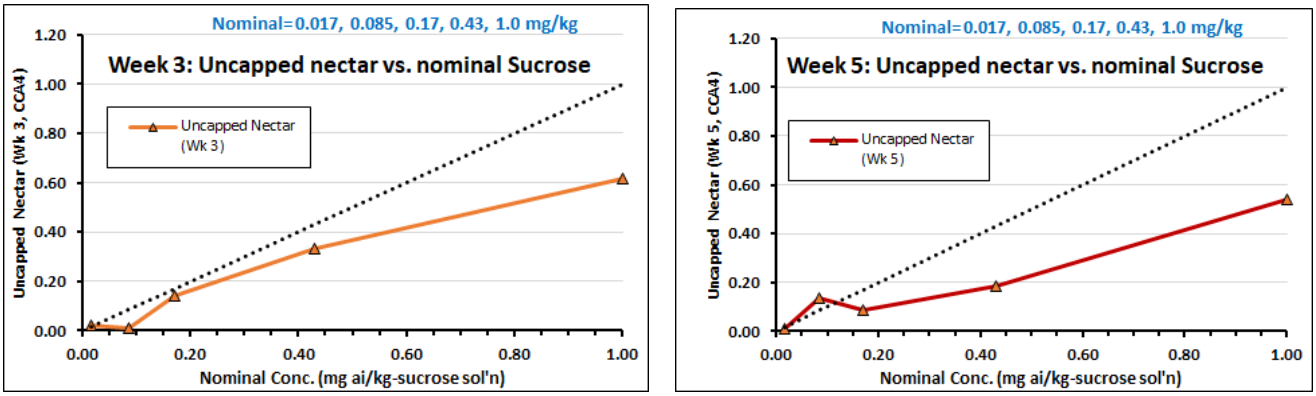


Figure K-3. Comparison of sulfoxaflor residues in uncapped nectar to nominal dietary concentrations on Weeks 3 and 5. Dotted line represents 1:1 ratio.

Sucrose Removal, Consumption and/or Storage

Colonies were fed a total of 2,000 ml of 50% sucrose solution twice weekly over the 42-d exposure phase of the study. Control colonies removed, consumed, and/or stored on average 89% of the diet over the entire feeding period while colonies receiving sulfoxaflor at 0.017, 0.085, and 0.17 mg ai/kg diet consumed[23] between 89% and 93% % of the diet and were not significantly different from controls (**Table K-4**). However, colonies fed sulfoxaflor at 0.43 and 1.0 mg ai/kg diet consumed on average 83% and 63% of the diet, respectively, both of which are significantly different (*i.e*., reduced) relative to controls. Relative to control hives, significant ($p<0.05$) reductions in diet consumption in hives fed sulfoxaflor at 1.0 mg ai/kg occurred from Day 4 through Day 21, while hives fed 0.43 mg ai/kg showed significant ($p<0.05$) reductions only on Day 8 **(Figure K-4).**

Table K-4. Consumption of sucrose solutions by control and sulfoxaflor exposed colonies

Treatment (mg ai/kg)	Mean Consumption (ml/feeding)	STD (ml/feeding)	% Consumed
Control	1780	415	89%
0.017	1791	376	90%
0.085	1870	280	93%
0.17	1809	426	90%
0.43	1669*	405	83%
1.0	1266*	604	63%

* significantly reduced relative to controls ($p<0.05$, Mann Whitney/Wilcoxon Ranked Sum Test; MRID 50648901)

[23] Hereafter, sucrose consumption refers to the volume of sucrose removed, consumed and/or stored by the colonies. It is not known how much sucrose was consumed relative to the amount stored.

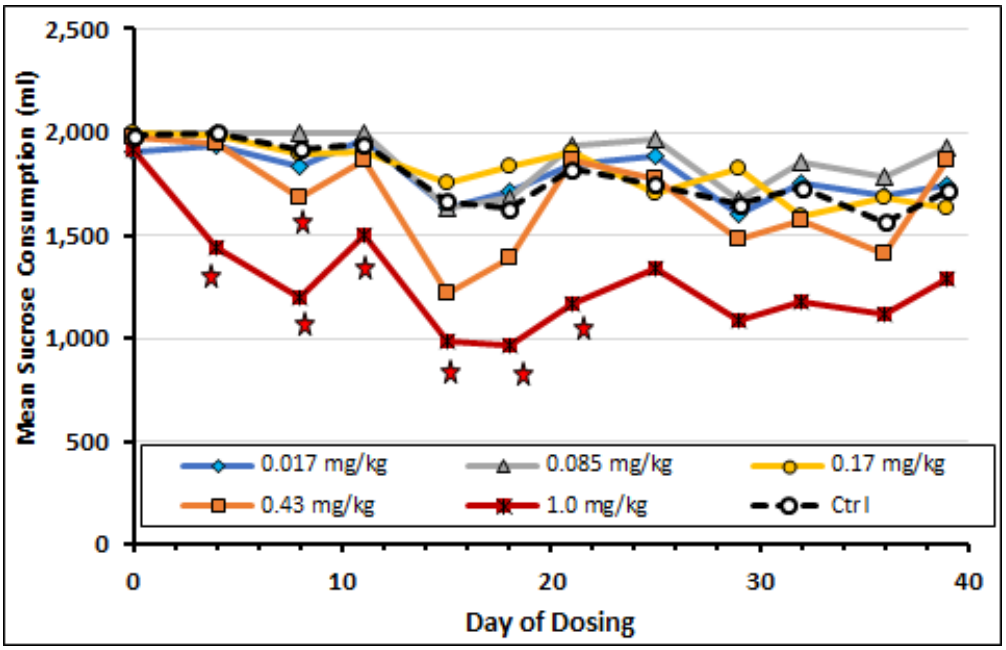


Figure K-4. Consumption of sucrose diet by control and sulfoxaflor-exposed colonies after each feeding (stars = statistically significant differences relative to control (p <0.05; Mann Whitney/Wilcox test; MRID 50648901)

Residues in Hive Matrices

Samples of hive matrices from the majority of hives were analyzed for sulfoxaflor and associated metabolites[24] at 4 CCAs during the study (**Figure K-5**). Residues in uncapped nectar were measured at CCA4 and CCA5 (*i.e.*, Weeks 3 and 5, during the exposure phase) while residues in honey were measured at CCA7 (i.e., Week 11 during the monitoring phase, but prior to overwintering) and at CCA9 (i.e., during the monitoring phase, but after overwintering). Residues in bee bread were measured at each of these four time points. In general, sulfoxaflor residues in the hive matrices correlated in a dose-dependent manner with nominal concentrations in feeding solutions. High variability was evident among individual residue samples on a given sampling day, which may reflect heterogeneity in the distribution of in these matrices (i.e., capped nectar vs honey vs bee bread) in the combs. This variability is not unexpected since bees used in the study were free to forage on sugar (nectar) sources outside the hive which would presumably not be contaminated with sulfoxaflor.

Uncapped Nectar/Honey: On Week 3, mean residues of sulfoxaflor in uncapped nectar ranged from 0.02 – 0.62 mg ai/kg in all treatments except the 0.085 mg ai/kg treatment. These mean residues reflect 60%-110% of the nominal concentration in feeding solution (**Figure K-5, top panel**), and suggest that some dissipation or dilution of sulfoxaflor with uncontaminated sources of nectar had been occurring. The mean concentration of sulfoxaflor in uncapped

[24] The metabolites of sulfoxaflor are not considered part of the stressor of concern due to low occurrence and/or low toxicity relative to parent sulfoxaflor.

nectar from hives fed 0.085 mg ai/kg was only 0.002 mg ai/kg on Week 3 (2% of nominal feeding concentration) and was detected in just 1 of 9 samples taken. The reason for the low detection in uncapped nectar in this treatment is not apparent. On Week 5, mean sulfoxaflor residues in uncapped nectar showed slight declines in all but the 0.085 mg ai/kg treatment (range: 0.01-0.54 mg ai/kg) which reflect 40% to 60% of the nominal concentration in feeding solutions. In the 0.085 mg ai/kg treatment, one high value (0.85 mg ai/kg) resulted a mean concentration of 0.14 mg ai/kg in uncapped nectar which was 1.6X higher than that of the nominal concentration in feeding solution. On Week 11 (~ 6 weeks after the cessation of dosing), mean sulfoxaflor residues in honey (range: 0.02-0.26 mg ai/kg) typically declined to 30% - 50% of those measured in uncapped nectar during Week 3. Following overwintering, sulfoxaflor residues in honey were below levels of detection in the lower 2 treatments in all but one sample. Mean residue values in the 3 highest treatments ranged from 0.01 to 0.06 mg ai/kg or 6-8% of the nominal concentration in diet. Notably, sulfoxaflor in control hive matrices were detected at a low frequency (8/68 samples for nectar/honey and at low levels (<0.04 mg ai/kg), thus suggesting that cross contamination of controls by foraging bees feeding on spiked sucrose solutions was minimal. When detected, concentration of the primary degradate (X11719474) averaged just 14% of parent sulfoxaflor concentrations and the other 3 degradates were rarely detected.

Bee Bread. Generally, mean sulfoxaflor residues in bee bread were approximately 5-10X lower than those measured in nectar and honey (**Figure K-5, bottom panel**). This finding likely reflects the smaller contribution of nectar (as spiked sucrose solution) to the bee bread matrix compared to pollen, which would not be contaminated. Sulfoxaflor was not detected above levels of quantitation (LOQ=0.01 mg ai/kg) in the lowest treatment (fed 0.017 mg ai/kg) at any sampling time. During the exposure period, mean residues of sulfoxaflor in bee bread from the highest 4 treatments ranged between 0.02-0.07 mg ai/kg during Week 3 and between 0.01 to 0.09 mg ai/kg during Week 5. By Week 11, (i.e., during the monitoring phase at ~ 6 weeks after the cessation of dosing), mean residues of sulfoxaflor on the highest 4 treatments were detected above levels of quantitation only 50% of the time, with overall means falling to about 1/3 those measured on Weeks 3 and 5. Sulfoxaflor was detected only once in bee bread from controls, indicating minimal cross contamination by foraging bees. The primary degradate (X11719474) was detected primarily in the 3 highest treatments during Weeks 3 and 5, averaging about 60% of parent sulfoxaflor concentrations when both were detected.

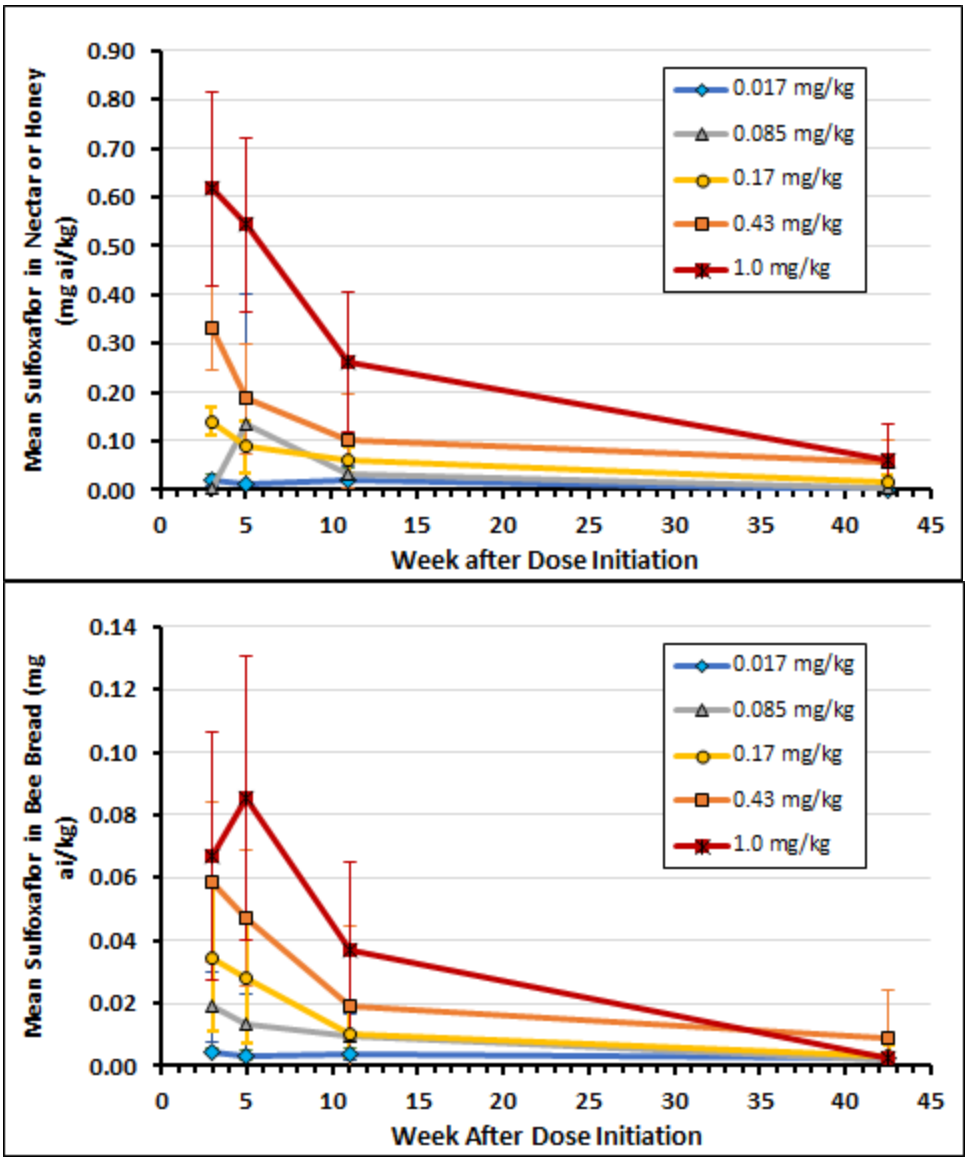


Figure K-5. Concentrations of sulfoxaflor measured in nectar/honey (top panel) and bee bread (bottom panel) across weeks after dosing (error bars = 1 STD; MRID 50648901).

Food Provisions

With control hives, mean bee bread provisions (measured as the number of cells on the comb containing bee bread) declined from about 2,700 cells at CCA3 (late June) to 1,100 cells at CCA4 (early August; **Figure K-6). Attachment 1** contains a tabular summary of mean number of cells containing bee bread. This was followed by a rapid increase to 3,800 cells at CCA5 (late August) and stable levels from CCA6 (late September) to CCA7 (late October). In treated colonies, the mean number of cells containing bee bread showed a similar pattern over time among as the control colonies. Bee bread provisions were reduced in colonies fed 1.0 mg ai/kg sulfoxaflor from CCA4 through CCA7, but reductions were only statistically significant ($P < 0.05$) at CCA6 (39% reduction) and CCA7 (52% reduction). Colonies fed the second highest concentration

(0.43 mg ai/kg) showed a 24% reduction in the mean number of cells containing bee bread only at CCA7 but this was only statistically significant at (p <0.1. Data from the last two CCAs after overwintering (CCA8 in March 2017 and CCA9 in April 2017) were excluded from the analysis due to the high magnitude of colony failure which occurred prior to these CCAs and the potential for biasing results towards those relatively few (presumably healthier) hives which survived.

The study authors did not report any information on honey stores during the study.

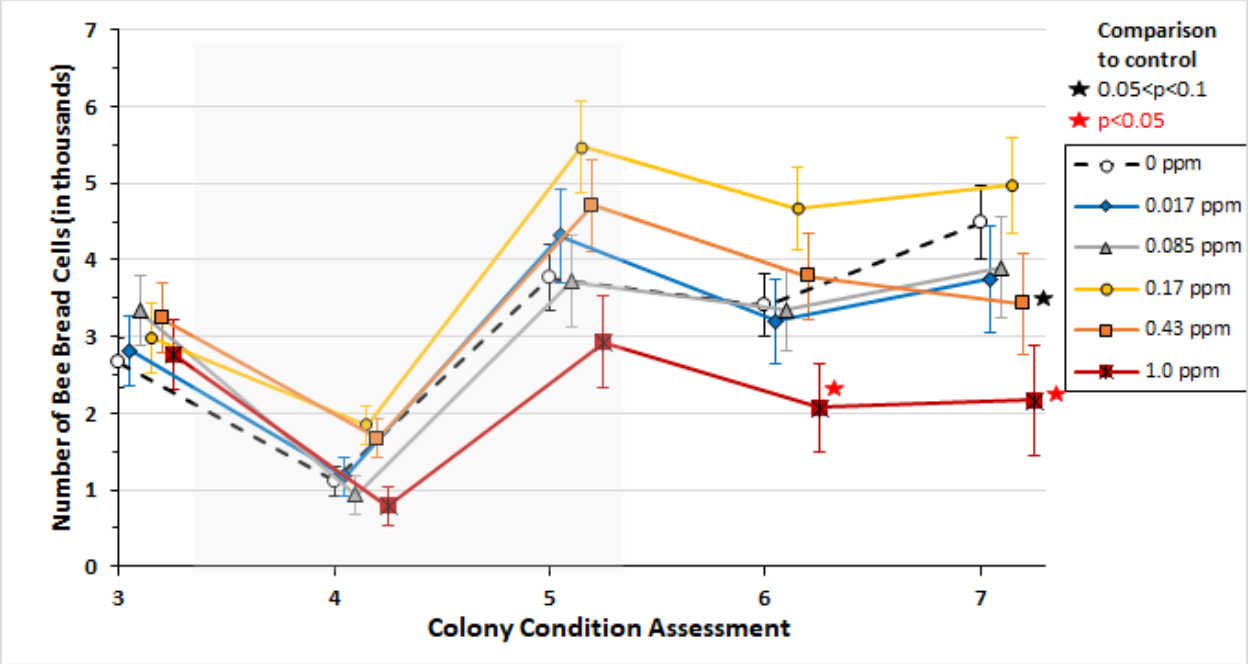


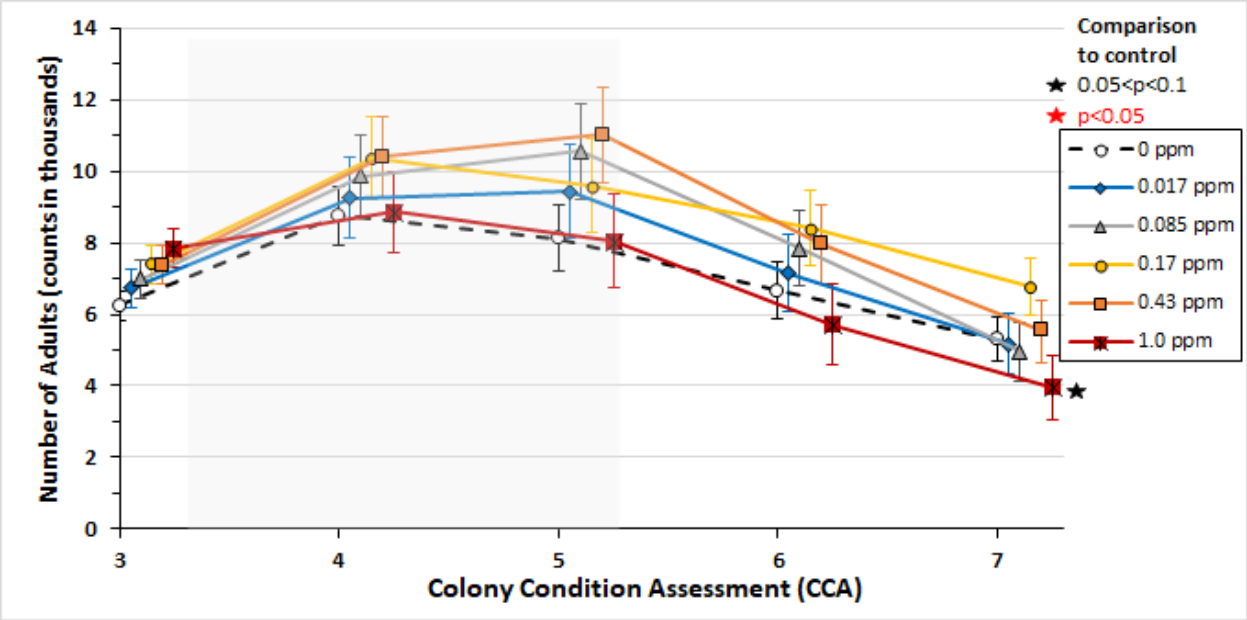
Figure K-6. Mean number of cells containing bee bread (pollen) from control and sulfoxaflor-treated colonies across weeks after dosing (gray box = sucrose feeding period; MRID 50648901).

Colony Strength and Pupae

Results from the measurement of colony strength (adult bees) and number of pupae (capped brood) from control and treated colonies are shown in **Figure K-7** for CCA3 through CCA7; **Attachment 1** contains tabular summaries of mean numbers of adults and pupae. Notably, data from CCA8 and CCA9 were excluded from the analysis because of the high frequency of colony failure (>50%) in controls and all but one sulfoxaflor treatment. The mean number of adult bees just prior to dosing (CCA3) was similar among control and sulfoxaflor treatment hives (6,200 – 7,800/hive). In control hives, the mean number of adult bees[25] increased by 40% from 6,200 at CCA3 to 8,800 at CCA4. At each successive CCA, the mean number of adults in controls hives decreased relative to the previous CCA (-7% at CCA5, -18% at CCA6, and -21% at CCA7). Declines in hive strength at CCA6 (late September) and CCA7 (late October) are expected

[25] Means for adults and pupae calculated as least square means according to the SAS repeated measures analysis.

as hives prepare for overwintering and reduce the production of brood and discard males (drones). For sulfoxaflor-treated colonies, the mean number of adults followed a similar temporal trend as observed for controls. In general, hives fed sulfoxaflor at 0.017-0.43 mg ai/kg showed increased hive strength relative to controls by 10-25% at CCA4 through CCA6. Colonies fed sulfoxaflor at 1.0 mg ai/kg sucrose showed similar hive strength as controls at CCA4 and CCA5, but mean hive strength was reduced by 14% at CCA6 and 25% at CCA7, the latter was only statistically significant between a p-value of 0.05-0.1 (SAS, repeated measures ANOVA).



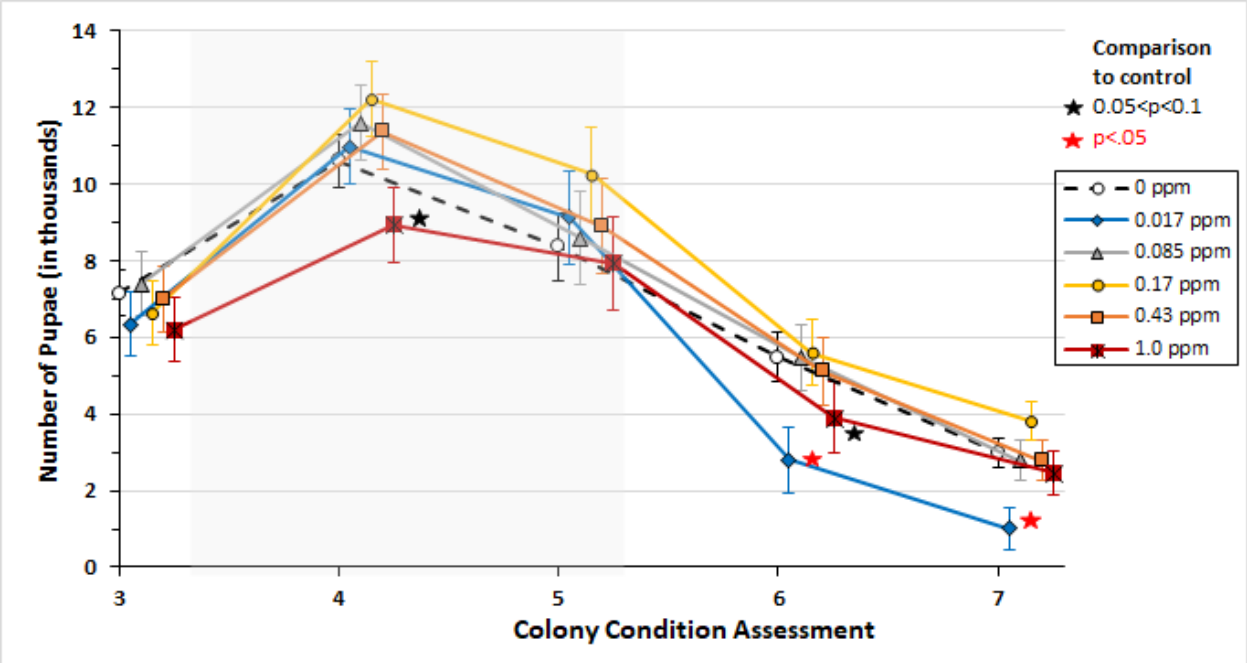


Figure K-7. Mean (std. error) number of adults (top panel) and pupae (bottom panel) among sulfoxaflor treated and control colonies (MRID 50648901) across Colony Condition Assessments. Grey box reflects the timing of the 42-d feeding period.

Mean number of pupae increased from CCA3 to CCA4 followed by declines at the subsequent CCAs in controls and sulfoxaflor-treated hives (**Figure 5)**. The mean number of pupae just prior to dosing (CCA3) was similar among control and treatment hives (6,200 – 7,400/hive). In control hives, the mean number of pupae increased by 50% with 7,100 at CCA3 to 10,600 at CCA4. At each successive CCA, the mean number of pupae in controls hives decreased relative to the previous CCA (-21% at CCA5, -34% at CCA6, and -46% at CCA7). Declines in pupae at CCA6 (late September) and CCA7 (late October) are expected as hives prepare for overwintering and reduce the production of brood. For sulfoxaflor fed colonies, the mean number of pupae followed a similar temporal trend as observed for controls. Relative to controls hives fed 1.0 mg ai/kg showed an overall decrease in mean number of pupae from 5-30% at CCAs 4 through 7. These reductions were not statistically significant ($0.05 < p < 0.1$; SAS, repeated measures ANOVA) at CCA4 and CCA6. Except for hives fed 0.017 mg ai/kg at CCA6 and CCA7, no other significant reductions in pupae were observed. The significant reductions in pupae observed for 0.017 mg ai/kg are not considered treatment related given the lack of concentration-response relationship and lack of corresponding impacts on other colony endpoints (bee bread, adults).

Hive Weight

The weight of each colony was recorded hourly over the duration of the study (except during breif periods of scale failure). The hive weight was based on the midnight measurement (when foragers would likely be in the hive. Results of the mean colony weight for control and sulfoxalfor-treated colonies are shown in **Figure K-8.** According to the study authors, significant

reductions in colony weight relative to controls only occurred with hives fed 1.0 mg ai/kg during CCA7 (~105 days after initiation of expousre). While variability in hive weights within a treatment apparently reduced the abiltiy to detect statistically significant effects, the sustained 40-50% reduction in mean hive weight for hives fed 1.0 mg ai/kg is considered to be biologically signficant, and is consistent with reductions in bee bread and pupae recorded in this treatment. Relative to controls, mean weight of hives from the lower 4 treatments were generally ±20% of controls. Importantly, data beyond CCA7 (105 days after exposure) are considered subject to potential bias due to the elevated frequency of colony failure in control and sulfoxaflor-treated hives.

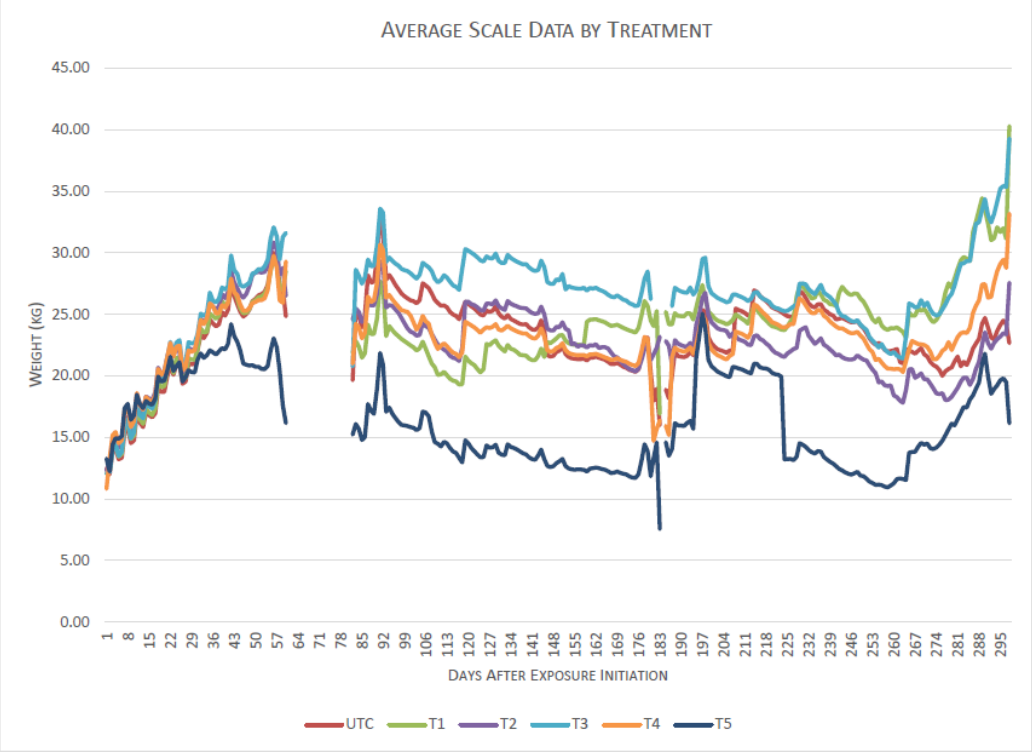


Figure K-8. Mean weight of control and sulfoxaflor-treated honey bee colonies across days after initiation of exposure.

Varroa

The occurrence of *Varroa* mite was determined at CCA3, 5, 7 and 9. Hive bee samples were collected at each of these assessment periods. Bees were washed in alcohol to remove mites and the number of mites per 100 bees was calculated. Miticide (*i.e.*, thymol) was applied to all study hives once before and after CCA6. No obvious treatment-related influence on mite loads was detected **(Table K-5**). Relatively few hives contained mite loads above the recognized threshold of concern of 3/100 bees. A total of 7 control hives failed as of CCA7. Mean mite loads for failed and living control hives at CCA7 were 0.64 and 0.44 mites/100 bees at CCA3, respectively, and 2.0 and 1.4 mites/100 bees at CCA5.

Table K-5. Counts of *Varroa* mites (Varroa destructor) in each of the control and sulfoxaflor-treated hives.

Group	Average	StdDev	Max	# >3	n
Control					
CCA3	0.61	0.75	3.17	1	24
CCA5	1.45	1.84	7.37	3	19
CCA7	0.61	0.76	2.65	0	17
CCA9	0.66	0.64	1.64	0	8
0.017 mg/kg					
CCA3	0.27	0.27	0.85	0	11
CCA5	0.49	0.56	1.47	0	11
CCA7	0.29	0.26	0.48	0	3
CCA9	1.17	1.67	3.1	1	3
0.085 mg/kg					
CCA3	0.30	0.18	0.6	0	12
CCA5	1.62	1.49	4.76	2	9
CCA7	1.01	1.22	2.94	0	8
CCA9	0.80	1.06	2.51	0	5
0.17 mg/kg					
CCA3	0.27	0.26	0.8	0	12
CCA5	0.95	1.64	5.33	1	10
CCA7	0.48	0.56	1.87	0	10
CCA9	1.11	1.77	5.47	1	9
0.43 mg/kg					
CCA3	0.27	0.36	1.03	0	12
CCA5	0.41	0.40	1.04	0	8
CCA7	0.26	0.46	1.33	0	9
CCA9	0.69	1.10	2.79	0	6
1.0 mg/kg					
CCA3	0.44	0.60	2.26	0	12
CCA5	1.29	1.06	3.85	1	10
CCA7	0.30	0.25	0.53	0	4
CCA9	0.21	0.24	0.47	0	3

Nosema

Results from the measurement of *Nosema* spores at 3 CCAs are shown in **Table K-6**. Older bees were collected from the outer frames and frozen. Honey bee abdomens were processed for spore counts. Results from CCA9 should be interpreted with caution as they typically reflect 50% or fewer remaining hives after overwintering. No obvious trend with sulfoxaflor treatment and nosema count was detected. The higher value of Nosema at CCA5 in the highest sulfoxaflor treatment appears to result from a single extremely large count for one hive (18,000,000 spores).

Table K-6. Counts of Nosema (*Nosema spp.*) spores for control and sulfoxaflor-treated hives.

Group	Average	Max	n
Control			
CCA5	121,316	1,250,000	19
CCA7	252,941	2,150,000	17
CCA9	31,250	50,000	8
0.017 mg/kg			
CCA5	245,455	950,000	11
CCA7	516,667	850,000	3
CCA9	0	0	3
0.085 mg/kg			
CCA5	416,667	1,800,000	9
CCA7	44,375	300,000	8
CCA9	8,333	50,000	6
0.17 mg/kg			
CCA5	170,000	550,000	10
CCA7	10,000	50,000	10
CCA9	133,333	1,150,000	9
0.43 mg/kg			
CCA5	733,333	3,150,000	9
CCA7	233,333	1,350,000	9
CCA9	66,667	200,000	6
1.0 mg/kg			
CCA5	2,026,556	18,000,000	9
CCA7	275,000	700,000	4
CCA9	116,667	350,000	3

Overwintering Success

Results from the overall colony success are reported in **Figure K-9** in terms of the percent of colonies that experienced failure (defined as lack of adult bees in the hive). Prior to overwintering in Dec 2016, about 30% or fewer hives failed, except for the lowest treatment where 50% of the hives failed. After overwintering, an additional 10% ot 40% of hives failed, resulting in a total colony failure ranging from 25% to 75% (all but one treatment had 50% or greater loss). The reason for this poor overwintering success is not understood. However, one possibility is the relatively low number of bees (mean = 3,900 – 6,800 bees) present in the hives immediately prior to overwintering, which is generally considered a factor influencing the risk of colony failure due to the inability to thermoregulate and/or gather sufficient food reserves. No treatment-related pattern is evident with the colony failure before or after overwintering.

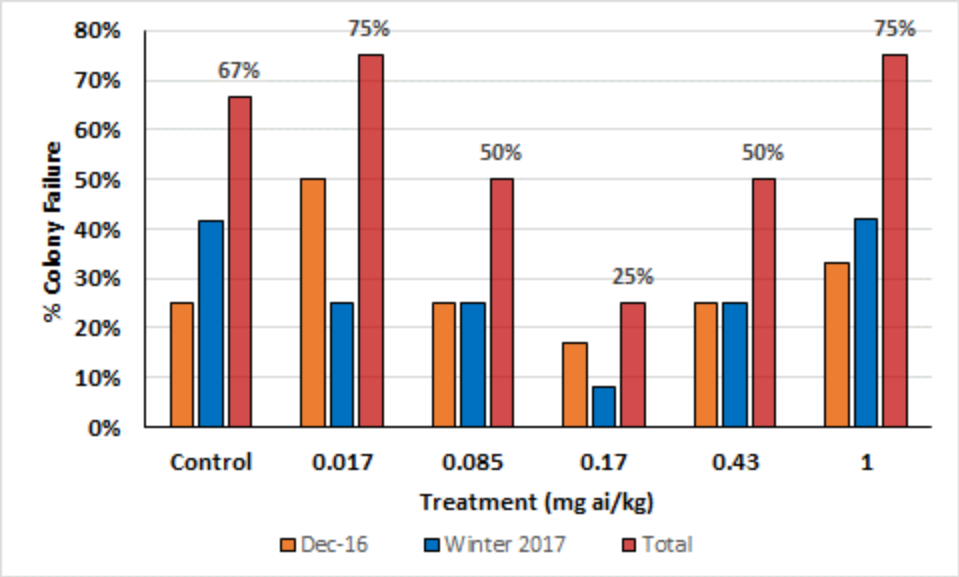


Figure K-9. Occurrence of colony failure in control and sulfoxaflor-treated hives before, during and after overwintering

Study Strengths, Limitations and Classification

The following strengths and limitations are noted for this study in the context of assessing colony-level risks of dietary sulfoxaflor exposures for honey bees.

Strengths:

- A large number of replicates was used in the study (n=24 for controls; 12 for treatments) which enabled improved statistical power;
- Long-term monitoring was conducted on hives (2 time points beyond overwintering);
- The 6-wk duration of continuous exposure to the test substance is considered representative of "high end" conditions that hives could encounter under real world conditions (e.g., repeated applications over time during bloom);
- 12 different sites were included which enabled variability due to colony strength and spatial differences in foraging resources and other factors to be incorporated into study results; and,
- A low-level of cross-contamination was detected in control hives

Limitations:

- There is significant uncertainty in the delivered exposures to hives at least on Weeks 3 and 5 (where concentrations were documented) and possibly other weeks where concentrations were not documented);
- Study authors did not monitor all stages of brood (*e.g.*, eggs, larvae) or honey stores;
- The high frequency of colony loss after overwintering in controls (67%) invalidates overwintering portion of the study. Low number of adults in hives prior to overwintering may have contributed to high frequency of colony loss; and,

- Analytical recovery of residues in hive matrices at various spiked concentrations exceeded generally accepted range of 70%-120%.

Study Conclusions (NOAEC, LOAEC)

The most sensitive endpoints from this colony-level feeding study are:

NOAEC = 0.43 mg ai/kg-sucrose (nominal)
LOAEC = 1.0 mg ai/kg-sucrose (nominal)

The LOAEC from this study is based on the occurrence of sustained (and statistically-significant) colony-level effects in hives fed 1.0 mg ai/kg-sucrose. These effects include:

- Reduced number of comb cells containing bee bread (39%-52% reduction relative to controls), which is an indication of reduced foraging ability;
- Reduced number of comb cells with pupae (16-29% reduction relative to controls) indicating effects on brood development; and,
- Reduced hive weight (40%-50% reduction relative to controls) during and after the exposure period.

However, due to the highly variable nature of analytical measurements of sulfoxaflor in feeding solutions (particularly at the highest 3 treatments), actual exposure of individual colonies during the dosing period are likely to be variable. Therefore, this study is considered supplemental and suitable only for qualitative use in risk assessment (*i.e.,* as an additional line of evidence but not for making risk determinations).

Attachment 1: Summary Statistics for Colony Condition Assessment Endpoints (MRID 50648901)

Table 1-1. Mean and standard deviation in the number of adults measured at colony condition assessments (CCA) 3 through CCA7

	Mean Number of Adults[1] *(STD)*					
CCA	**Control**	**0.017 ppm**	**0.085 ppm**	**0.17 ppm**	**0.43 ppm**	**1 ppm**
CCA 3	6,235	6,726	6,980	7,389	7,386	7,837
	(2,057)	*(1,251)*	*(2,077)*	*(1,246)*	*(1,863)*	*(1,986)*
CCA 4	8,757	9,258	9,873	10,368	10,397	8,873
	(3,419)	*(3,193)*	*(4,656)*	*(3,117)*	*(3,433)*	*(5,224)*
CCA 5	8,131	9,443	10,552	9,581	11,010	8,050
	(4,152)	*(3,873)*	*(4,702)*	*(4,954)*	*(5,206)*	*(4,677)*
CCA 6	6,848	7,169	7,840	8,403	8,082	5,664
	(3,095)	*(3,808)*	*(4,416)*	*(3,380)*	*(3,262)*	*(3,222)*
CCA 7	5,512	5,193	5,298	6,797	5,607	**3,747***
	(2,631)	*(3,205)*	*(2,458)*	*(3,092)*	*(2,213)*	*(1,811)*
# hives @ CCA7	19	9	10	11	10	8

* significantly reduced relative to control (repeated measures ANOVA, p<0.1)

[1] arithmetic means differ slightly from least square means used in repeated measures ANOVA when treatments vary in sample sizes (# of hives). ppm = parts per million (mg/L).

Table 1-2. Mean and standard deviation in the number of cells with pupae measured at colony condition assessments (CCA) 3 through CCA7.

	Mean Number of Pupae[1] (*STD*)					
CCA	**Control**	**0.017 ppm**	**0.085 ppm**	**0.17 ppm**	**0.43 ppm**	**1 ppm**
CCA 3	7141	6335	7397	6632	6995	6185
	(2567)	*(3419)*	*(2469)*	*(1941)*	*(2820)*	*(2993)*
CCA 4	10599	10968	11579	12220	11381	**8944***
	(3899)	*(3427)*	*(4041)*	*(2724)*	*(1969)*	*(3920)*
CCA 5	8356	9122	8584	10252	8900	7934
	(4671)	*(4771)*	*(5161)*	*(3503)*	*(3605)*	*(3214)*
CCA 6	5689	**2804****	5468	5605	5203	**4078***
	(2591)	*(3025)*	*(4166)*	*(2769)*	*(2594)*	*(2165)*
CCA 7	3123	**986****	2894	3875	2836	2563
	(1401)	*(1183)*	*(1946)*	*(2221)*	*(1601)*	*(1504)*
# hives @ CCA7	19	9	10	11	10	8

* significantly reduced relative to control (repeated measures ANOVA, p<0.1)

** significantly reduced relative to control (repeated measures ANOVA, p<0.05)

[1] arithmetic means differ slightly from least square means used in repeated measures ANOVA when treatments vary in sample sizes (# of hives). ppm = parts per million (mg/L)

Table 1-3. Mean and standard deviation in the number of cells with bee bread measured colony condition assessments (CCA) 3 through CCA7.

	Mean Number of Cells with Bee Bread[1] (*STD*)					
CCA	**Control**	**0.017 ppm**	**0.085 ppm**	**0.17 ppm**	**0.43 ppm**	**1 ppm**
CCA 3	2659	2816	3333	2985	3241	2773
	(1248)	*(1313)*	*(1571)*	*(1388)*	*(1726)*	*(1040)*
CCA 4	1112	1180	940	1850	1669	794
	(816)	*(839)*	*(815)*	*(704)*	*(1352)*	*(644)*
CCA 5	3765	4314	3719	5480	4709	2928
	(1985)	*(1339)*	*(1173)*	*(3110)*	*(2398)*	*(1832)*
CCA 6	3442	3158	3341	4671	3830	**2007****
	(1958}	*(1550)*	*(1772)*	*(2987)*	*(1831)*	*(903)*
CCA 7	4634	3824	3882	5122	**3322***	**2065****
	(2140)	*(1519)*	*(2715)*	*(3011)*	*(1348)*	*(1457)*
# hives @ CCA7	19	9	10	11	10	8

* significantly reduced relative to control (repeated measures ANOVA, $p<0.1$)

** significantly reduced relative to control (repeated measures ANOVA, $p<0.05$)

[1] arithmetic means differ slightly from least square means used in repeated measures ANOVA when treatments vary in sample sizes (# of hives). ppm = parts per million (mg/L)

Appendix L. Tier II Method For Assessing Combined Nectar And Pollen Exposure To Honey Bee Colonies

1. Background

Honey bees consume a mixture of nectar (as honey) and pollen (fresh or stored as bee bread, which is a combination of pollen and honey). Individual worker bees consume different amounts of the two matrices at different times in their lives. For example, young adult nurse bees consume an average of 9.6 mg of pollen per day and 140 mg nectar per day while older bees foraging for nectar consume essentially no pollen and 290 mg nectar per day (USEPA 2015). As adult worker bees age and their tasks in the hive change, their nutritional requirements and corresponding nectar and pollen consumption rates change. With the example of nurse and nectar forager bees, nurse bees require more pollen so that they can produce jelly (which is rich in protein and lipids) to feed larvae and the queen, while forager bees primarily consume nectar (which is rich in sugar) to fuel their foraging flights. The amount of nectar and pollen consumed by the colony on any given day is a function of how many individual larvae and adult worker bees of each task are present in the hive. Other castes (*i.e.,* queen and drones) represent a relatively small proportion of the number of individuals in a hive (Winston 1987) and so do not contribute substantially to the total amount of food consumed by the hive.

Available exposure studies for sulfoxaflor indicate that concentrations are generally greater in pollen compared to nectar of treated crops. Refined Tier I risk quotients (RQs) that were calculated using residue data for pollen and nectar indicate potential risk to various castes of honey bees. In conducting a Tier II assessment, it is necessary to compare colony-level toxicity endpoints to the available residue data; however, this is complicated somewhat by the nature of the available toxicity data. Specifically, the available Tier II colony feeding study (CFS) involves exposures to colonies via spiked sucrose (a surrogate for nectar). Since residue data show that exposures may occur simultaneously through both nectar and pollen, there is a need to understand effects resulting from exposures through both matrices simultaneously and in a currency relevant to the CFS.

The purpose of this analysis is to determine how to assess colony-level exposure to sulfoxaflor residues in nectar and pollen combined (referred to as “total food”). This method considers the amount of each matrix consumed by honey bees (on a daily basis).

2. Method Description

2.1 Total nectar equivalent approach

The method for assessing exposure and potential risks to honey bee colonies involves estimating the total exposure of the colony to the pesticide through food ($C_{total\text{-}t}$; ng a.i./g; **Equation 1**). The total nectar equivalent ($C_{total\text{-}t}$) is the sum of the concentration in nectar (at a given time), *i.e.*, $C_{nectar\text{-}t}$ (ng a.i./g), and the concentration in pollen at the same time, *i.e.*, $C_{pollen\text{-}t}$

(ng a.i./g). The concentration in pollen is adjusted by a weighting factor that accounts for the relative difference in dose compared to nectar. The strength of this approach is that it integrates exposure from nectar and pollen, both of which are consumed on a daily basis by honey bee colonies. The section below discusses the derivation of the weighting factor for adjusting pollen to nectar-equivalents.

Equation 1. $C_{total-t} = C_{nectar-t} + \frac{C_{pollen-t}}{factor}$

2.2. Derivation of weighting factor for pollen

In order to determine the relative amounts of pollen and nectar consumed by bees in a colony on a given day, food consumption rates for individual worker bees from BeeREX were used (**Table 1**). The number of individual bees (adults and larvae) counted in the control hives of the registrant CFS (MRID 50849601) were multiplied by the food consumption rates. The colonies included in these studies were full sized, containing over six thousand adult (in hive) worker bees. This study was used to allow for consideration of representative numbers of worker larvae and adults present in a hive. In this approach, the following assumptions were made in how to break out the individuals observed to match the different caste/task groups of bees in BeeREX:

- The total number of larvae are equally distributed among the different developmental stages of the larval instars (workers).
- The total number of adult bees counted at each timepoint in the CFS are
    - in-hive bees
    - equally distributed among the 3 types of in-hive bees (*i.e.,* cell cleaners, nurses, comb builders, food handlers)
- The total number of foragers is:
    - Under-estimated as the number of adult bees enumerated does not account for those that are actively foraging); and.
    - equals ¼ of the number of in hive bees (van Der Steen 2015)
        - Represented by: ¾ nectar, ¼ pollen foragers (because bees typically forage for pollen only in the morning; whereas, bees may forage for nectar all day (Fewell and Winston 1996).
- Since the CFSs were conducted in summer, it was assumed that no winter bees were present.
- Given that queens consume no pollen or nectar, consumption by queens is not considered.
- When drones are present, they are much fewer in number compared to adult workers.
    - It was assumed that consumption by drones would be negligible; therefore, the number of drones is assumed to be 0.

Table 1. Nectar and pollen consumption rates by caste and task (from BeeREX) and assumptions for converting measurements from Colony Feeding Study (CFS) to number of individuals relevant to BeeREX larval and adult castes/tasks.

Life stage	Caste or task in hive	Average age (d)	Nectar consumed (mg/d)	Pollen consumed (mg/d)	Number of individuals/X[a]
Larval	Worker	1	0	0	total larvae/5
		2	0	0	total larvae/5
		3	0	0	total larvae/5
		4	60	1.8	total larvae/5
		5	120	3.6	total larvae/5
	Drone	6+	130	3.6	0[c]
	Queen	1	0	0	0[b]
		2	0	0	0[b]
		3	0	0	0[b]
		4+	0	0	0[b]
Adult	Worker (cell cleaning and capping)	0-10	60	6.65	Total adults/3
	Worker (brood and queen tending, nurse bees)	6 to 17	140	9.6	Total adults/3
	Worker (comb building, cleaning and food handling)	11 to 18	60	1.7	Total adults/3
	Worker (foraging for pollen)	>18	43.5	0.041	((Total adults)/4)*1/4
	Worker (foraging for nectar)	>18	292	0.041	((Total adults)/4)*3/4
	Worker (maintenance of hive in winter)	0-90	29	2	0[d]
	Drone	>10	235	0.0002	0[c]
	Queen (laying 1500 eggs/day)	Entire life stage	0	0	0[b]

[a] Denominator distributes the number of individuals equally across ages (column 3) for each respective hive caste/task (column 2).
[b] Queen does not consume pollen and/or nectar directly but rather royal jelly; therefore, her contribution to total colony pollen/nectar consumption is negligible; therefore, value set to zero.
[c] Number of drones considered low in comparison to worker is considered negligible therefore, value set to zero.
[d] Since CFSs were carried out in summer, it is assumed that no winter bees are present.

Using these calculations, a colony of approximately 15 thousand bees (adults and larvae combined) consumes approximately 0.045 kg of pollen and 1.16 kg of nectar a day. When considering the numbers of bees from multiple colony condition assessments (CCAs) from the CFS for sulfoxaflor (MRID 50849601), colonies consumed 25.6x less pollen compared to nectar. **Table 2** includes an example of the calculations, using the number of bees observed in CCA 3 of the CFS.

Table 2. Example calculation of amount of nectar and pollen consumed by hive (based on number of larvae and adults observed at CCA3 of sulfoxaflor CFS, MRID 50849601**).**

Life stage (Task in hive)	Average age (d)	Amount of food consumed by an individual (mg/d)		Number of bees	Total (mg) consumed by colony*	
		Nectar	Pollen		Nectar	Pollen
Larvae	1	0	0	1,428	0	0
	2	0	0	1,428	0	0
	3	0	0	1,428	0	0
	4	60	1.8	1,428	85,692	2,571
	5	120	3.6	1,428	171,384	5,142
Adult Worker (cell cleaning and capping)	0-10	60	6.65	2,078	124,700	13,821
Adult Worker (brood and queen tending, nurse bees)	6 to 17	140	9.6	2,078	290,967	19,952
Adult Worker (comb building, cleaning and food handling)	11 to 18	60	1.7	2,078	124,700	3,533
Adult Worker (foraging for pollen)	>18	43.5	0.041	390	16,951	16
Adult Worker (foraging for nectar)	>18	292	0.041	1,169	341,366	48
			Total	14,935	1,155,760	45,082

*Calculated by multiplying the amount of nectar or pollen consumed by an individual by the number of individuals. Separate calculations carried out for pollen and nectar.

The observation that honey bee colonies consume less pollen compared to nectar is supported by Seely (1985), who estimated the amount of pollen and nectar that honey bee colonies consume in a given year. For “unmanaged” hives in new England, colonies consumed 20 kg of pollen and 160 kg of nectar (60 kg honey). This is roughly a factor of 8x less pollen consumed compared to nectar over an entire year. van der Steen (2015) estimated that a colony needs 125 kg nectar and 15-30 kg pollen per year. This is 4-8 x less pollen on an annual basis consumed compared to nectar. This supports the analysis discussed above using the BeeREX food consumption values in that it demonstrates that more nectar is consumed in a year compared to pollen. There is uncertainty in relying on this value for setting the weighting factor because it includes an entire year time period. Over the course of a year, summer and winter bees consume different amounts of pollen and nectar (USEPA 2015). For the current assessment, consumption rates and resulting exposures to summer bees are most relevant.

When considering the information discussed above on relative consumption rates by colonies of nectar and pollen, pollen weighting factors appear to range 4-25x.

3. Summary

As discussed above, honey bee colonies consume more nectar than pollen on a daily basis. The available information indicates that the difference in contribution of colony's dose from pollen ranges 4x-25x less than that of nectar. Therefore, for the Tier II analysis, exposure ($C_{total\text{-}t}$) to honey bee colonies will be bounded by applying concentration data for pollen ($C_{pollen\text{-}t}$) and nectar ($C_{nectar\text{-}t}$) to **Equations 2 and 3,** which represent the upper and lower bound of exposure, respectively.

Equation 2. $C_{total-t} = C_{nectar-t} + \frac{C_{pollen-t}}{25}$ (lower bound)

Equation 3. $C_{total-t} = C_{nectar-t} + \frac{C_{pollen-t}}{4}$ (upper bound)

Appendix M. Summary of Sulfoxaflor DT_{50} and DT_{90} values Determined in Pollen and Nectar

Methods. For estimation of DT_{50} and DT_{90} values of sulfoxaflor in pollen and nectar, kinetic evaluation of sulfoxaflor residues data was conducted using the Computer Assisted Kinetic Evaluation (CAKE) software, version 3.3. Due to the relatively small number of sampling events over time and replication within a sampling event, DT_{50} and DT_{90} values were estimated using the single first order model (SFO) to avoid overparameterization of the data sets with higher order models. Estimation of DT_{50} and DT_{90} values was done on an individual trial basis whenever possible and when replicate samples were measured within a sampling event. Prior to estimating DT_{50} and DT_{90} values, residue trial data sets were screened to ensure that sufficient data were available to produce reliable estimates (*e.g.,* replicate values above the LOQ for 4 or more sampling events with appropriate spacing between sampling events). In several residue studies, replicate samples were not collected within a sampling event (usually for bee-collected matrices). In these cases, trials were combined within a study site or region in order to incorporate variability within each sampling event into the estimates of DT_{50} and DT_{90} values. In some situations, this necessitated normalizing residue data to a common application rate assuming proportionality between application rate and residue concentrations.

The reliability of DT_{50} and DT_{90} values was evaluated based on several statistical attributes of the SFO model fit:

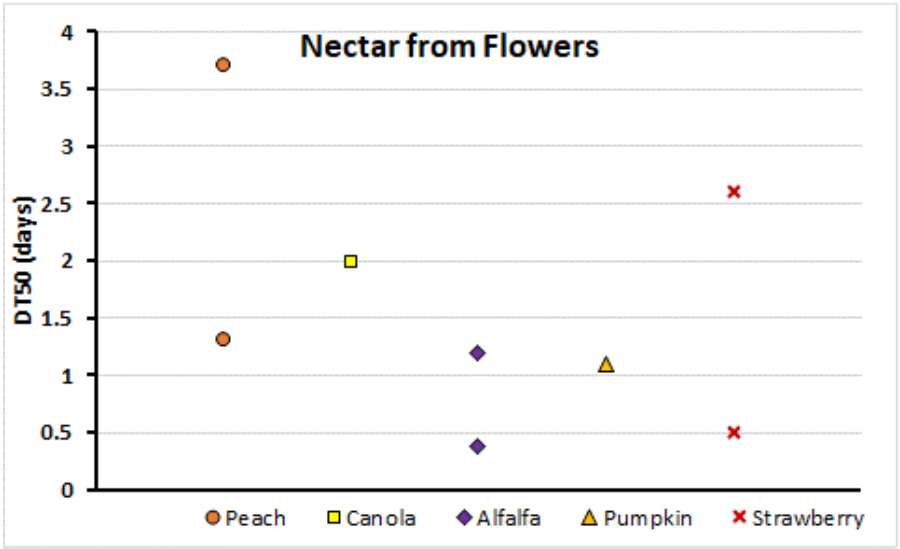
- statistical significance of the dissipation rate constant (k);
- correlation coefficient (r^2);
- 90^{th} percentile confidence limits around 'k'.

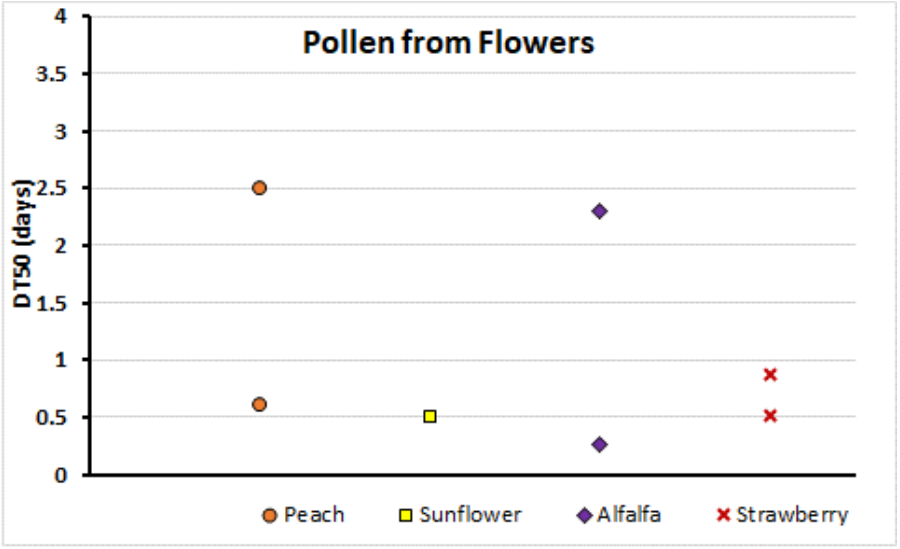
Due to the large degree of variability associated with pollen and nectar residue data with other pesticides,[26] the following criteria were used to determine acceptability of DT_{50} estimates from this analysis:

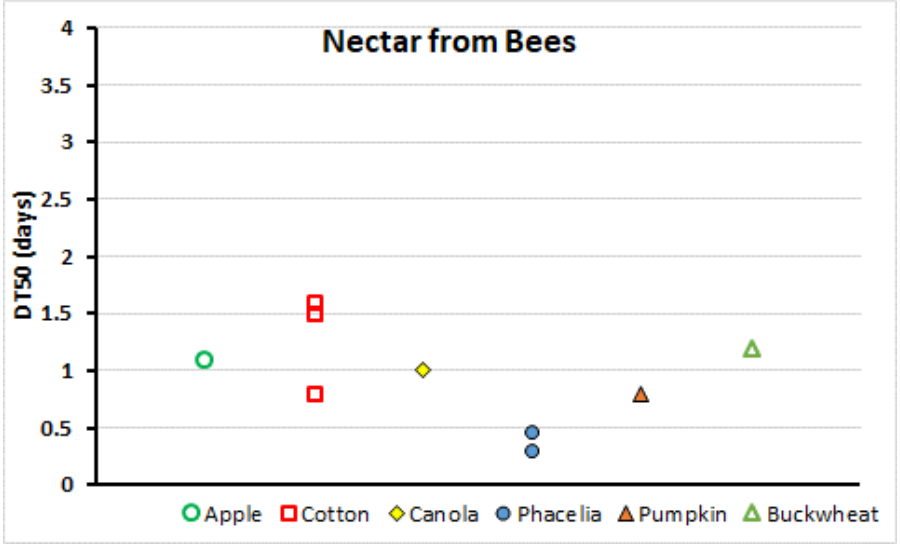
- p values for 'k' of 0.1 or less;
- r^2 of 0.25 or greater; and
- 90^{th} percentile C.L. of 'k' which did not overlap zero.

Results from the kinetic analysis of sulfoxaflor pollen and nectar data are shown in **Figure M-1** and **Table M-1.**

[26] The range residue values among replicates can vary by up to an order of magnitude (Sappington et al., 2018; https://doi.org/10.5073/jka.2018.462.000)







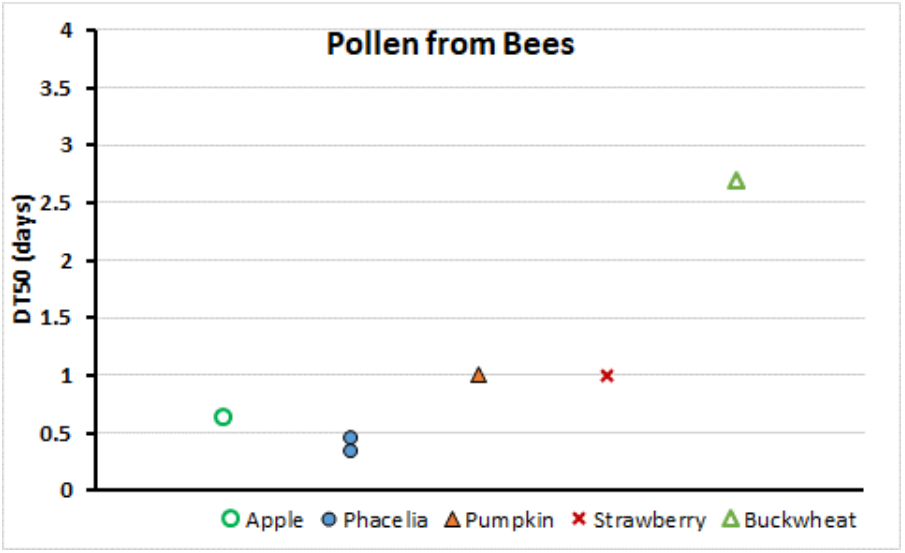


Figure M-1. Summary of sulfoxaflor DT50 values by matrix and crop

Table M-1. Summary of kinetic analysis of sulfoxaflor residue data for pollen and nectar

Crop Group (Crop) MRID	Appl Timing (Trial Info)	Matrix	DT_{50} (d)	DT_{90} (d)	K (90% CI) (1/d)	P Value	r^2	χ^2	Notes
Pome (Apple) 50444405	During bloom (1 x 0.04 lb ai/A, n=13, D1-D7)	Nectar (bee)	1.1	3.8	0.61 (0.15-1.06)	0.02	0.62	21%	Combined trials, large residuals on D1 due to one outlier
		Pollen (bee)	0.64	2.1	1.08 (-0.24-2.41)	0.08	0.69	7.3%	Combined trials, large residuals on D1
Stone (Peach) 50355203	During bloom (1 x 0.09 lb ai/A, n=9, D0-D4)	Nectar (flower)	1.3	4.2	0.55 (0.05-1.06)	0.04	0.54	21%	Combined trials, large residuals on D0 & D1
	Pre-Bloom (1 x 0.09 lb ai/A, n=7, D4-D10)		3.7	12.2	0.19 (0.16-0.21)	$1E^{-5}$	0.98	3.7%	Combined trials, 1 outlier on D3 removed.
	During bloom (1 x 0.09 lb ai/A, n=9, D0-D4)	Pollen (flower)	0.60	2.0	1.2 (0.03-2.3)	0.05	0.62	23%	Combined trials, large residuals on D0 & D1
	Pre-Bloom (1 x 0.09 lb ai/A, n=8, D3-D10)		2.5	8.2	0.28 (-0.10-0.67)	0.10	0.36	70%	Combined trials, Large residuals on D3 & D4
Citrus (Grapefruit, Mandarin, Lemon, Orange) 50256403	Pre-Bloom & During bloom (1 x 0.04 lb ai/A, D4-D149)	Nectar (flower)	N/C	N/C	N/C	N/C	N/C	N/C	Study design insufficient to enable reliable determination of DT_{50} values
Oilseed (Cotton) 48755606	During bloom (1 x 0.045 lb ai/A)	Nectar (bee)	N/C	N/C	N/C	N/C	N/C	N/C	Too few residue values above LOD to determine a reliable DT_{50}
	During bloom (2 x 0.045 lb ai/A, Appl. #1, n=10, D0-D4)		N/C	N/C	N/C	0.35	0.03	28%	Poor model fit; residues variable and non-monotonic over time
	During bloom (2 x 0.045 lb ai/A, Appl. #2, n=10, D5-D10)		1.6	5.1	0.45 (0.23-066)	0.002	0.71	19%	Residue values following 2nd application, 2 reps/sampling event
	During bloom (2 x 0.089 lb ai/A, Appl. #1, n=10, D0-D4)		1.5	5.1	0.45 (-0.08-0.99)	0.08	0.31	9.9%	Large residual on D0; residue values following 1st application, 2 reps/sampling event
	During bloom (2 x 0.089 lb ai/A, Appl. #2, n=10, D5-D10)		N/C	N/C	N/C	0.20	0.07	22%	Poor model fit; residues variable and non-monotonic over time

Crop Group (Crop) MRID	Appl Timing (Trial Info)	Matrix	DT_{50} (d)	DT_{90} (d)	K (90% CI) (1/d)	P Value	r^2	χ^2	Notes
	During bloom (2 x 0.133 lb ai/A, Appl. #1, n=10, D0-D4)		0.80	2.7	0.89 (0.29-1.5)	0.01	0.69	26%	Large residual on D0; residue values following 1st application, 2 reps/sampling event
	During bloom (2 x 0.133 lb ai/A, Appl. #2, n=10, D5-D10)		N/C	N/C	N/C	0.5	0.01	>100%	Poor model fit; residues variable and non-monotonic over time
Oilseed (Canola) 50444406	During bloom (1 x 0.04 lb ai/A n=12, D0-D10; Germany)	Nectar (bee)	1.0	3.4	0.68 (0.52-0.84)	$8E^{-6}$	0.98	9.7%	Combined data from 4 trials
		Pollen (bee)	N/C	N/C	N/C	0.14	0.90	3.6%	Combined data from 4 trials; rapid decline is clearly indicated by D2; lack of D1 data = poor estimates
Oilseed (Canola) 50355204	Pre- & during bloom (2 x 0.023 lb ai/A, n=12, D1-D14, ND trial)	Nectar (flower)	N/C	N/C	N/C	N/C	N/C	N/C	Insufficient data above the LOQ to calculate a reliable DT_{50}
		Pollen (flower)	N/C	N/C	N/C	N/C	N/C	N/C	Insufficient data above the LOD to calculate a reliable DT_{50}
	Pre- & during bloom (2 x 0.023 lb ai/A, n=12, D1-D14, OR trial)	Nectar (flower)	2.0	6.7	0.35 (0.05-0.64)	0.03	0.75	5.8%	Oregon trial, 3 reps/event
		Pollen (flower)	N/C	N/C	N/C	0.21	0.27	34%	High variability among reps on D1 and D2
Oilseed (Sunflower) 50355201	Pre & during bloom (1 or 2 x 0.09 lb ai/A, 2 trials, n=5/trial, KS)	Nectar (flower)	N/C	N/C	N/C	N/C	N/C	N/C	Insufficient number of samples taken to calculate a reliable DT_{50}
		Pollen (flower)	0.51	1.7	1.4 (0.60-2.1)	0.005	0.87	3.7%	1 rep/event; 2 trials combined.
Non-Grass Animal Feed (Alfalfa) 50444401	Pre- & during bloom (2 x 0.09 lb ai/A, N=12, D0-D14, NC trial	Nectar (flower)	0.37	1.2	1.9 (1.3-2.5)	$3E^{-5}$	0.96	4.5%	3 reps/event
		Pollen (flower)	0.26	0.87	2.7 (1.3-4.0)	0.002	0.95	2.4	3 reps/event
	Pre- & during bloom (2 x 0.09 lb ai/A, N=12, D0-D14, CA trial	Nectar (flower)	1.2	4.1	0.56 (0.23-0.89)	0.005	0.74	16%	3 reps/event, large residuals on D0
		Pollen (flower)	2.3	7.7	0.30 (0.16-0.44)	0.001	0.83	11%	3 reps/event
Cereal Grains (Buckwheat) 50494501	During bloom (1 x 0.023 lb ai/A, n=14, D0-D66)	Nectar (bee)	N/C	N/C	N/C	N/C	N/C	N/C	Insufficient data above the LOQ to calculate a reliable DT_{50}
	During bloom (1 x 0.071 lb ai/A, n=13, D0-D66)		N/C	N/C	N/C	0.19	0.15	58%	Poor model fit, high variability among replicates, 2 reps/event
	During bloom (1 x 0.09 lb ai/A, n=13, D0-D66)		N/C	N/C	N/C	0.12	0.30	50%	Poor model fit, high variability among replicates, 2 reps/event

Crop Group (Crop) MRID	Appl Timing (Trial Info)	Matrix	DT_{50} (d)	DT_{90} (d)	K (90% CI) (1/d)	P Value	r^2	χ^2	Notes
Cereal Grains (Buckwheat) 50604601	During bloom (1 x 0.023; 1 x 0.071; 1 x 0.09 lb ai/A; D0-D66)	Nectar (bee)	1.2	4.0	0.57 (0.35-0.79)	$4E^{-4}$	0.78	31%	1 rep/event. Data normalized to trial-specific peak then combined across trials for DT_{50} determination
		Pollen (bee)	2.7	8.8	0.26 (0.09-0.43)	0.009	0.50	17%	
N/A (*Phacelia*) 48476601	During bloom (1 x 0.023 lb ai/A; 2 trials, D0-D6)	Nectar (bee) Pollen (bee)	N/C	N/C	N/C	N/C	N/C	N/C	Insufficient data above the LOQ to calculate a reliable DT_{50}
	During bloom (1 x 0.043 lb ai/A; 2 trials, D0-D6)	Nectar (bee) Pollen (bee)	N/C	N/C	N/C	N/C	N/C	N/C	Insufficient data above the LOQ to calculate a reliable DT_{50}
N/A (*Phacelia*) 50444501	During bloom (1 x 0.022 lb ai/A; n=12, D1-D8)	Nectar (bee)	0.29	0.95	2.4 (1.9-3.0)	$9E^{-6}$	0.99	11%	2 reps/event
		Pollen (bee)	0.45	1.5	1.6 (0.80-2.3)	0.002	0.93	34%	2 reps/event
	During bloom (1 x 0.043 lb ai/A; n=12, D1-D8)	Nectar (bee)	0.45	1.5	1.5 (1.2-1.8)	$2E^{-6}$	0.98	15%	2 reps/event
		Pollen (bee)	0.33	1.1	2.1 (1.1-3.1)	0.002	0.99	26%	2 reps/event
Cucurbit (Pumpkin) 50355202	During bloom (1 x 0.071 lb ai/A, n=15, D1-D21, NC Trial)	Nectar (flower)	1.1	3.6	0.64 (0.01-1.3)	0.05	0.47	11%	3 reps/event, high variability on D1 among reps
		Pollen (flower)	N/C	N/C	N/C	0.30	0.69	2%	3 reps/event; rapid decline by D1, flat near or below LOD up to D21
	During bloom (1 x 0.071 lb ai/A, n=15, D1-D21, CA Trial)	Nectar (flower)	N/C	N/C	N/C	0.25	0.04	16%	Poor model fit, high variability among replicates, 3 reps/event
		Pollen (flower)	N/C	N/C	N/C	N/C	N/C	N/C	Insufficient data above the LOQ to calculate a reliable DT_{50}
Cucurbit (Pumpkin) 50444403	During bloom (1 x 0.04 lb ai/A, n=12, D1-D7, 3 Trials)	Nectar (bee)	0.79	2.6	0.88 (-0.32-2.1)	0.10	0.52	11%	Combined trials (1 Fr., 2 Germ.), 1 rep/event, high variability on D1
		Pollen (bee)	1.0	3.5	0.67 (0.32-1.0)	0.002	0.69	22%	Combined trials (2 Fr., 1 Germ.); 1 rep/event
Small Fruits/Berry (Strawberry) 50444404	During bloom (1 x 0.022 lb ai/A, n=16, D1-D7, 4 Trials)	Nectar (bee)	N/C	N/C	N/C	N/C	N/C	N/C	1 rep/event; Insufficient data above the LOQ to calculate a reliable DT_{50}
		Pollen (bee)	1.0	3.4	0.67 (0.11-1.2)	0.03	0.56	33%	1 rep/event; combined data from 4 trials
Small Fruits/Berry (Strawberry) 50444402	Pre- & during bloom (2 x 0.074 lb ai/A, n=15, D1-D14, FL Trial)	Nectar (flower)	2.6	8.6	0.27 (0.12-0.42)	0.004	0.78	11%	3 reps/event, FL trial
		Pollen (flower)	0.88	2.9	0.79 (0.02-1.6)	0.05	0.47	8%	3 reps/event. FL trial, outlying value on D0

Crop Group (Crop) MRID	Appl Timing (Trial Info)	Matrix	DT_{50} (d)	DT_{90} (d)	K (90% CI) (1/d)	P Value	r^2	χ^2	Notes
	Pre- & during bloom (2 x 0.072 lb ai/A, n=15, D1-D14, CA Trial)	Nectar (flower)	0.50	1.7	1.4 (11-1.7)	$5E^{-7}$	0.97	2%	3 reps/event, CA trial
		Pollen (flower)	0.51	1.7	1.3 (0.76-1.9)	$7E^{-4}$	0.86	2%	3 reps/event, CA trial