Environmental behavior and risk evaluation of neonicotinoids in sugar beet – Fact sheet

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Recently, the EU-commission proposed a ban of neonicotinoids in sugar beet. Growers associations and sugar industry started several activities to oppose. The following fact sheet tries to compile the current status of technical knowledge. It will be continuously carried forward in case substantial and scientifically proofed new facts are available. Therefore, the authors ask for new information to be sent to Nicol Stockfisch[1].

(1) Introduction

In general, the authorisation of active substances of plant protection products and the implementation of bee guidance documents for the authorisation is decided by the European Commission, including decisions on appropriate risk management measures. The task of the European Food Safety Authority (EFSA) is the compilation and evaluation of risk assessment data, which are delivered by the applicants, and the development of GD on demand of COM. Furthermore, the EFSA generates a proposal for the authorisation of active substances. This proposal is discussed for final adoption by COM and European member states in the Standing Committee on Plants, Animals, Food and Feed (SCoPAFF).

(2) New EFSA guidance document on the risk assessment of pesticides on bees

The guidance documents on the risk assessment of pesticides on bees was published by EFSA in 2013. The mandatory requirement of data on laboratory level (Tier 1) is extended by additional tests for honey bees (chronic toxicity adult bees and larval toxicity) and additional organisms (bumble bees and solitary bees). Thus, the workload on tests and evaluation is fourfold compared to the earlier protocol. The evaluation procedure in the bee guidance documents is stepwise. If the trigger values are exceeded on Tier 1-level, additional tests on higher Tier-levels (e.g. field studies) are needed. These field studies are extremely complex and hardly manageable. As the results have to be statistically powerful, in minimum 14 pairs of fields, which are 2 ha in size and separated each by 2 to 3 km distance, are needed for honey bees. No guidelines are described for bumble bees and solitary bees. Some comments from national authorities are that the requirements in detail are not practicable and unrealistic. The combination of sharpened trigger values on Tier 1-level (very conservative), which are validated only for honey bees, and the requirements for higher Tier level experiments (field trials) lead to concerns about realistic options for future authorisation of any pesticides.

An open available sensitivity and impact analysis of the bee guidance documents was reported by Dow AgroSciences, Bayer CropScience and Makhteshim Agan. The analysis evaluated 168 uses resp.151 active substances (1/3 fungicides, 1/3 herbicides and 1/3 insecticides or acaricides).

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Nearly all substances failed the Tier 1-level, thus they have to be investigated on field level if the bee guidance documents get valid. Several national authorities come to similar assumptions, whereas EFSA concluded in an own impact analysis of 61 active substances (16 fungicides, 21 herbicides and 24 insecticides) that 46% of the fungicides, 76% of the herbicides and 71% of the insecticides fail the Tier 1-level. Although the European Commission did not note the bee guidance documents, EFSA follows the guidance documents for risk assessments, e.g. on insecticides. Furthermore, there was no discussion on the guidance documents with the member states in the SCoPAFF. It is likely that the member states will not accept the guidance documents, as it is not practicable.

Key facts

The new guidance document on the risk assessment of pesticides on bees is currently used by EFSA, even if it is not formally noted by the European Commission and not agreed by the member states. Many trigger values in the document are very conservative or not validated. Most active substances of all groups will fail the Tier 1-level and the rules for higher Tier experiments (field trials) are extremely laborious and seem to be not practicable or they are missing for bumble bees and solitary bees. In near future, it can be expected that many active substances cannot be authorized or reauthorized because they do not meet the bee guidance documents requirements.

(3) Current situation in April 2017: EFSA evaluation of neonicotinoids[2]

Peer reviews on neonicotinoids were completed by EFSA in 2016. An excerpt of the studies reads as follows:

- For the uses as seed treatment in sugar beets, the risk from exposure via dust was indicated as low for honey bees, however a high risk to bumble bees and solitary bees was not excluded.
- An exposure via guttation fluids was considered as not the primary route of exposure for bees.
- The risk from exposure to nectar and pollen in treated beets was assessed as low, providing beets are harvested before flowering.
- Concerning flowering weeds, the exposure of honey bees, bumble bees and solitary bees was considered not relevant for beets and other crops, due to the low coverage in field of flowering weeds.
- For all field uses considered in a succeeding crop scenario, a high risk was identified or could at least not be excluded.

[2] EFSA-Journal 2016; Peer review of the pesticide risk assessment (…).14 (11). www.efsa.europa.eu/efsajournal

(4) Neonicotinoids and abrasion from seeds

Key facts

- Mechanical sowing machinery are used in sugar beet cultivation on almost 90 % of the fields in Germany.
- Mechanical sowing and high seed coating quality reduce breaking of pills, abrasion and dust emissions to a minimum.

Possible problem

Abrasion from seeds and breaking of pills can lead to dust emissions during sowing. This dust can include neonicotinoids. Depending on the coating quality, the machinery used and the wind speed during sowing, emissions can result in a deposition of neonicotinoids on the soil surface in the field, in areas adjacent to the field or on flowering plants adjacent to the field. Dust with active compounds deposited on flowering plants can pose a direct risk to pollinators. Additionally, other plants could take up the deposited neonicotinoids from soil and if they flower, they might contaminate pollinators with neonicotinoids.

Risk probability

The best available technology is used to coat sugar beet seed pellets with the active ingredients placed in a layer underneath the outer shell. The outside layer is very resistant to abrasion and therefore the risk for dust emissions during sowing is extremely low. The high seed quality of sugar beet assures that abrasion and dust is far below the threshold values of 50 mg dust/100,000 seeds and less than 60 µg active substance[3]. Broken pills occur with less than 1 %. It is therefore very unlikely.

In addition, the sowing technique influences the development and distribution of dust during drilling. Mechanical sowing machinery reduces dust drift in comparison to pneumatic drilling[4]. In Germany, mechanical sowing machinery has been used for sugar beet cultivation on almost 90 % of the growing area for over 20 years[5]. These circumstances reduce the probability for dust emissions during sugar beet drilling almost to the lowest possible.

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[3] Personal communication, Bayer AG, Division Crop Science

[4] Heimbach et al. 2014: Emission of pesticides during drilling and deposition in adjacent areas. Julius-Kühn-Archiv 444, 68-75.

[5] Buhre et al. 2011: Umfrage zur Produktionstechnik im Zuckerrübenanbau - Sachstand und Trends (1994-2010). Sugar Industry 136, 670-677.

(5) Neonicotinoids and guttation

Key facts

- Guttation in sugar beet occurs rarely and drops are small.
- Guttation drops of sugar beet are very unlikely to serve as water source for bees.

Possible problem

Guttation is a process where plants excrete water droplets (xylem fluid) along the edges or tips of plant leaves. Neonicotinoids are systemic substances and so they are present in all plant organs, also in the xylem fluid. In general, honey bees do not only collect nectar and pollen, but also water. If bees collect guttation fluids from crops treated with neonicotinoids, they might be exposed to high concentrations of active substances.

Risk probability

Guttation in sugar beet occurs rarely. Drops are small and occur only under high humidity of more than 90 %, early in the morning and only during the period of early plant development until canopy closure[6]. Guttation in adjacent vegetation as well as in other crops occurs more frequently[7] and other water sources besides guttation drops might also be available. For these reasons it is unlikely that bees would choose guttation drops of sugar beet as a preferred water source.

[6] Joachimsmeier et al. 2012: Frequency and intensity of guttation events in different crops in Germany. Julius-Kühn-Archiv 437, 87-90.
[7] Personal communication, Ina Patrizia Wirtz, Institut für Bienenschutz, Julius Kühn-Institut (JKI), Bundesforschungs-institut für Kulturpflanzen

(6) Neonicotinoids and flowering weeds and bolters

Key facts

- Control of weeds and bolters is effectively conducted by standard measures during vegetation period.
- Less than 0.5 % of all weeds in sugar beet plots flower.
- The probability for bolting of sugar beet is below 0.05%.

Possible problem

Neonicotinoids applied with seed treatment are not taken up completely by the target crop sugar beet. Residual active compounds remain in the soil close to the seeds. These residues might be taken up by other plants growing in the field like weeds, or will be degraded to other, non-toxic compounds. In the case weeds take up some of the neonicotinoid residues and if they flower, they might be attractive to pollinators like honey bees, bumble bees, solitary bees or others. By this, pollinating insects might become contaminated with neonicotinoids. Flowering weeds can occur on the field or adjacent to the neonicotinoid-treated crop at the field margins.

Sugar beets are biannual plants which are grown annually for sugar production and do not flower during this period. In case they bolt occasionally (producing a stem with flowers) during the first year, they start flowering in the summer, contain neonicotinoids and by this could principally contaminate pollinating insects.

Risk probability

In order to pose a serious risk by flowering weeds to pollinating insects, consecutive events have to take place: weeds must survive or escape herbicide treatment, grow close to the sugar beets, take up neonicotinoid residues from the soil around the seeds, grow to the flowering stage and have to be attractive to pollinating insects. A large study[8] from control plots of herbicide efficacy trials showed clearly, that less than 0.5 % of all weeds in sugar beet plots flower and not all of these are attractive to pollinators. The control plots rather reflect worse case conditions because no mechanical or chemical measures to control weeds were performed. In other spring crops like maize, potatoes and beans only a few of the control plots showed a ground cover above 10 % for flowering weeds.

The probability for bolting varies between fields, refers to specific weather conditions and a specific genetic constitution of the seed material and involves only 0.05 %[9]. Bolters are usually removed by the farmers, which further reduces the probability for attracting pollinating insects.

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[8] Maynard et al. 2015: Weeds in the treated field – a realistic scenario for pollinator risk assessment? Julius-Kühn-Archiv 450, 56-62.

[9] Märländer et al. 2011: Dispersal principles of sugar beet from seed to sugar with particular relation to genetically modified varieties. J. für Kulturpflanzen 63, 349-373.

(7) Neonicotinoids and succeeding crops

Key facts

- Sugar beet are followed by flowering and thus bee attracting crops on less than 15 % of the fields.
- Concentrations of neonicotinoids in the pollen or nectar of succeeding crops attractive to pollinators are very low.

Possible problems

Sugar beet seeds, treated with neonicotinoids can lead to residual active substances in the soil after harvest. These residues might be taken up by succeeding crops, or they might be degraded to non-toxic compounds. In the case succeeding crops take up some neonicotinoid residues and then start to flower, they might be attractive to pollinators like honey bees, bumble bees or others. By this, pollinating insects could become contaminated with neonicotinoids.

Risk probability

In order to pose a serious risk by succeeding crops to pollinating insects, the crop must take up relevant amounts of neonicotinoid residues from the soil, it has to flower and its flowers have to be attractive to pollinators.

In Germany, winter wheat is the dominating crop following sugar beet on 76 % of the fields (farm survey 2010 – 2015)[10]. Other crops grown after sugar beet comprise maize on 9 %, potatoes on 5 % and other cereals on 9 % of the fields. Bees are usually not attracted to flowering wheat[11] or other cereals. Wheat varieties are mostly not open-pollinated or, apart from that, are wind pollinated just like other cereals and grass plants and therefore do not generate flowers attractive to bees.

In model field studies[12], residual concentrations of about 40 µg neonicotinoids/kg of dry soil (ranging between 16 to about 100 µg/kg dry soil) were measured in field soils after long term use of neonicotinoids (more than 5 consecutive growing periods). In reality, there would be only one crop treated with neonicotinoids in a 3- or 4-year rotation in Germany. Subsequently, the untreated crops phacelia, spring oilseed rape and maize were grown on the fields and pollen and nectar of these crops were examined. A significant number (more than 50 %) of samples had concentrations below the quantification limits and concentrations in all other samples were far below the no effect concentrations of 10 to 20 µg/kg for bees, previously agreed by EFSA to be relevant for colony assessment. These results for flowering succeeding crops do not confirm a tangible risk for pollinators. In respect of the enormous dilution effects (sugar beet in crop rotation, soil tillage, degradation processes, dilution during uptake by succeeding crops) a risk cannot be expected.

Investigations in Austria[13] revealed that no neonicotinoids were detected in pollen collected by bees in flowering crops that succeeded field crops treated with neonicotinoids.

[10] Trimpler & Stockfisch 2017: Vielfältige Fruchtfolgegestaltung bei Zuckerrüben. Zuckerrübe 66, Heft 1, 35-37.
[11] USDA 2015: Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen. www.ree.usda.gov
[12] Personal communication, Bayer AG, Division Crop Science
[13] Moosbeckhofer & Mayr 2014: Untersuchungen zur Identifizierung einer Exposition von Honigbienen gegenüber den Wirkstoffen Clothianidin, Thiamethoxam, Imidacloprid und Fipronil unter Feldbedingungen. Gesundheitsreferententagung Wien 2014.

Neonicotinoid residues in soil and guttation water of succeeding crops

Study reports by Bayer

Residues of imidacloprid and its metabolites (imidacloprid-5-hydroxy and imidacloprid-olefin) as well as clothianidin and its metabolites (thiazolylnitroguanidine (TZNG) and thiazolylmethylurea (TZMU) were determined in bee relevant matrices (e.g. in guttation) collected from untreated flowering crops cultivated as succeeding crops after sugar beet.

1. Imidacloprid

Four studies (Ythier 2014a-d) were conducted in France in 2014 on fields with a history of imidacloprid use and as such with natural aged *soil* residues of this active ingredient. Crop history was not specified. Residues of imidacloprid in *soil* before cultivation of untreated crops ranged between 35 and 59 µg/kg dry *soil*. In three of the studies, *guttation* drops were collected from untreated maize and ranged between <LOD* and 5.7 µg/L. In all guttation samples, residues of imidacloprid metabolites were below the limit of quantification (LOQ*) and sometimes even below the limit of detection (LOD*).

In two further studies (Ythier 2014e; Striffler & Ballhaus 2014a), two different concentrations of imidacloprid (high and low, see Tab. 1) in *soil* were established by applying 2 dosages of imidacloprid. In 2013, a low and a high dosage were incorporated in the *soil* followed by cultivation of imidacloprid treated winter wheat or barley with high and low dosages of imidacloprid in seed dressings. Untreated crops (maize, phacelia, mustard) were cultivated in spring 2014, respectively. Imidacloprid in *guttation* of maize ranged between <LOD and 88 µg/L while no differences between the high and low dosed variants could be observed. Imidacloprid in nectar and pollen was highest in mustard with maximum values of 3.9 and 5.1 µg/L, respectively. Traces of imidacloprid metabolites were only measured in single *guttation* and pollen samples.

Tab. 1: Imidacloprid application to create a 'worst case scenario' and imidacloprid residues in soil during plant measurements in succeeding crops.

Study	Variant	Imidacloprid application 2013 [g a.s./ha] (plateau concentration + seed dressing)	Imidacloprid in soil 2014 [µg/kg dry soil]
Ythier 2014e	low	87.3 + 85.8	34 - 82
	high	154 + 118.5	25 -93
Striffler & Bullhaus 2014a	low	95.4 + 63.2	9-18
	high	173.4 + 126.3	16-22

In two further studies (Nikolakis et al. 2011a-b), a worst case scenario with direct application of imidacloprid to the *soil* (126 g a.s./ha) and cultivation of imidacloprid treated winter wheat was established versus an untreated control without imidacloprid in *soil* or seed dressing. After harvesting of winter wheat, untreated oilseed rape was sown. Imidacloprid in *soil* decreased from 34.0 and 45.7 directly after the application of imidacloprid to 15.2 and 18.8 µg a.s./kg dry *soil*, respectively, after a period of 10 month before sowing of oilseed rape in the treated plots.

* Limits of detection (LOD) and quantification (LOQ) for imidacloprid, clothianidin and its metabolites:
Soil: LOQ: 5 µg kg^{-1}; LOD: 2 µg kg^{-1} Guttation: LOQ: 1 µg L^{-1}; LOD: 0.3 µg L^{-1}

2. Clothianidin

Three studies (Jarratt 2014a-c) were conducted in the UK in 2014 on fields with a history of Clothianidin use and as such with natural aged *soil* residues of this active ingredient. Untreated maize and phacelia were sown. Residues of clothianidin in *soil* ranged between 16 and 80 µg/kg dry *soil*. *Guttation* drops were collected only from maize. Clothianidin residues ranged between <LOD and 40.3 µg/L. Residues of clothianidin metabolites ranged between <LOD and 1.9 µg/L for both, TZNG and TZMU.

In two further studies (Ythier 2014f; Striffler & Ballhaus 2014b), two different concentrations of clothianidin (high and low, see Tab. 2) in *soil* were established by applying 2 dosages of clothianidin that were incorporated in the *soil* followed by cultivation of clothianidin treated winter barley with high and low dosages of clothianidin in seed dressings. Untreated crops (maize, phacelia, mustard) were cultivated in spring 2014, respectively. Residues of clothianidin in *guttation* of maize ranged between <LOQ and 547 µg/L, residues of TZNG and TZMU between <LOD and 13 µg/L and <LOD and 92 µg/L, respectively.

Tab. 2: Clothianidin application to create a 'worst case scenario' and clothianidin residues in soil and guttation during plant measurements in succeeding crops.

Study	Variant	clothianidin application 2013 [g a.s./ha] (plateau concentration + seed dressing)	clothianidin in soil 2014 [µg/kg dry soil]	clothianidin in guttation of maize 2014 [µg/L]
Ythier 2014f	low	78.4 + 38.1	25 - 71	4 - 547
	high	212.8 + 134.7	61 - 90	<LOQ - 126
Striffler & Bullhaus 2014b	low	88.8 + 40.4	46 - 52	1 - 73
	high	229.6 + 99.3	67 - 84	3 - 175

A further study (Xu & Dyer 2014) investigated the potential accumulation of clothianidin in *soil* and crop matrices after multiple years of planting clothianidin treated corn and canola seeds. Fifty corn fields in the Midwestern United States and 27 canola fields in Western Canada were sampled in 2012, 2013, and 2014. Clothianidin residues in *soil* were greater than the LOQ (5 ng/g) at 35 of the 50 corn sites, with a 90 th percentile concentration of 13.5 ng/g and an average concentration of 7.0 ng/g. There was no significant accumulation of clothianidin in *soil* from fields with multiple years of clothianidin use. Clothianidin residue in *soil* greater than LOQ (5 ng/g) were measured in 11 of 27 canola sites with an average of 5.7 ng/g and a 90 th percentile concentration of 10.2 ng/g. There was no indication of significant accumulation of clothianidin in *soil* from canola fields with multiple years of clothianidin use -- only 4 of 27 sites had higher residues than the theoretical residue of 6.7 ng/g from one application of clothianidin treated canola seed.

Study reports by Syngenta

3. Thiamethoxam

In 2017, *soil* concentrations were measured in 50 field *soils* in Germany where thiamethoxam treated sugar beets had been grown in 2016. The mean thiamethoxam *soil* residue one year after application (spring 2017) was 2.3 µg/kg, ranging from non-detectable to 7.7 µg/kg (see Tab. 3).

Tab. 3: Soil residues of thiamethoxam and its metabolite CGA322704 (also known as clothianidin) following planting of thiamethoxam treated sugar beet in spring 2016.

TMX product	Results	Soil residues (µg/kg) April 2017		Soil residues (µg/kg) July 2017	
		Thiamethoxam	CGA322704	Thiamethoxam	CGA322704
Cruiser Force (actual application rates: 54-72 g a.s./ha)	Mean[a]	2.3	3.5	1.7	5.2
	SD	1.9	1.8	2.2	2.8
	COV	83.7%	53.0%	130.4%	53.2%
	Maximum	7.7	8.7	13.6	11.3
	Minimum	<LOD	0.54	<LOD	<LOD

TMX = thiamethoxam; SD = standard deviation; COV = coefficient of variance
Thiamethoxam LOQ = 1.0 µg/kg; LOD = 0.3 µg/kg
CGA322704 LOQ = 0.1 µg/kg; LOD = 0.03 µg/kg
[a] Including all samples (n = 50); <LOD considered as 0; <LOQ considered as ½ LOQ

To confirm expected low residues in *soil*, Syngenta has initiated a programme of data generation to understand the potential residues of thiamethoxam and CGA322704 in *soil*, and pollen and nectar in crops grown the year following treated sugar beet. Therefore, three field sites where thiamethoxam treated sugar beet were planted in spring 2016 were located across Germany and Austria. Across all three trials, residues in the *soil* samples taken in the spring 2017 prior to sowing of untreated flowering crops (such as maize) ranged from <LOQ (1.0 µg/kg) to 24 µg/kg *soil* for thiamethoxam and from <LOQ (1.0 µg/kg) to 5.0 µg/kg *soil* for CGA322704. *Guttation* samples from the succeeding crop maize were also collected for residue analysis. The first data are presented in Fig. 1.

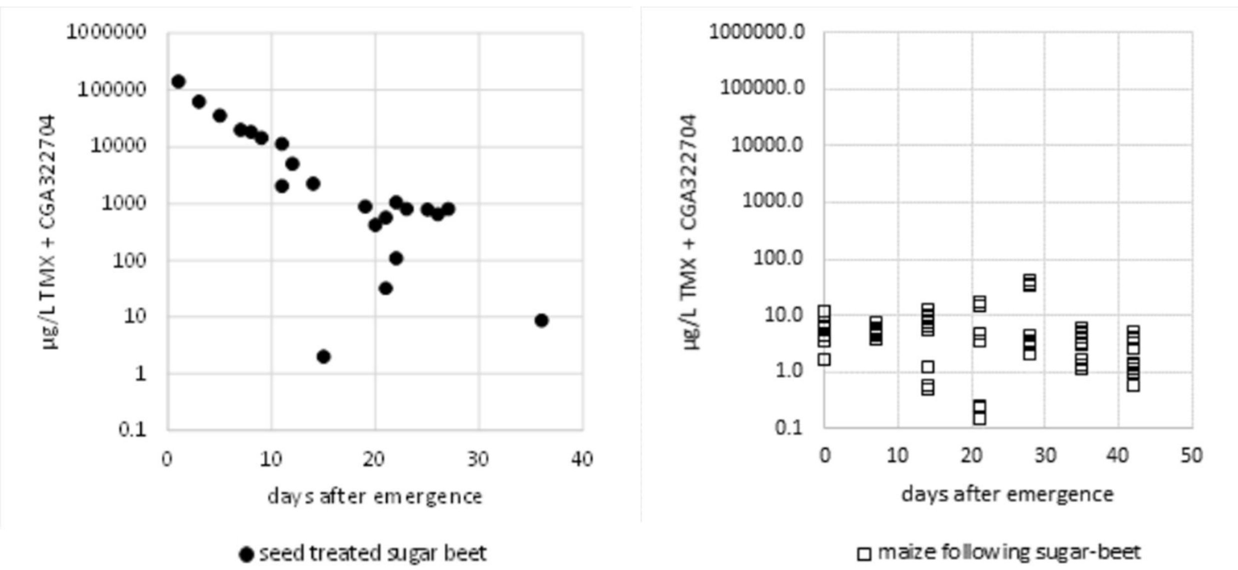

Figure 1: *Thiamethoxam + CGA322704 residues in guttation fluid sampled from thiamethoxam treated sugarbeet and from untreated maize planted as a follow-on crop to treated sugarbeet*