ICPBR-Working Group Risks posed by dusts: overview of the area and recommendations

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DOI: 10.5073/jka.2012.437.055

Abstract

Background: In 2008 the poisoning of about 12000 bee colonies was reported from Germany. These poisonings were caused by the drift of dust particles containing the insecticidal substance clothianidin following the seeding of maize seeds, inadequately treated with the insecticide Poncho Pro.

Results: Investigations were done on the dust load contained in seed packages of different crops, on the experimental abrasion of dust from treated seeds using the Heubach-Dustmeter as well as on the actual dust drift during the sowing operation of treated seeds with different machinery under field conditions. Resistance to abrasion of treated seeds and subsequent dust drift during sowing operations differ significantly between crops, coating recipes and facilities. Furthermore dust drift depends on particle size, sowing technology as well as on environmental conditions (e.g. wind speed, soil humidity).

Conclusions: The drift of dust from treated seeds may pose a risk to honeybees, which needs to be appropriately considered within the authorization process of pesticides. The total quantity of abraded dust as well as the actual emission of dust during the sowing operation can be significantly reduced by technical means (e.g. coating recipe and facility equipment, deflector technology) and by additional mitigation measures (e.g. maximum wind speed).

Keywords; honeybee, poisoning, risk, seed treatment, dust, drift

1. Introduction

In 2008 the poisoning of about 12000 colonies of honeybees was reported by German beekeepers in parts of South-West Germany. According to the findings of investigations immediately initiated, these poisonings were caused by the insecticidal substance clothianidin following the seeding of maize treated with the insecticide Poncho Pro[1,2,3]. Extreme exposure of honeybees to clothianidin was caused by

- bad seed dressing quality (high quantities of dust within seed bags, low resistance of the treated seeds to abrasion, high concentration of active substance within the dust),
- massive emission of dust by seeders (especially vacuum-pneumatic seeders with air outlet at the top/to the side),
- sowing at a time of full flowering of adjacent areas (e.g. oil seed rape, fruit orchards, dandelion; high numbers of contaminated borders on landscape level in the South of Germany),
- strong wind during time of drilling.

The risk assessments and management actions taken subsequently by the German authorities were illustrated by the Federal Office of Consumer Protection and Food Safety (BVL) on the 10th

International Symposium of the ICPBR-Bee Protection Group in Bucharest in 2008. All uses of neonicotinoid pesticides for the treatment of seeds were re-assessed and authorisations of pesticides for maize seeds were immediately suspended in Germany.[4] In Italy and France, scientists deduced from a spatial and temporal correlation between spring mortality of bees and the sowing of maize seed dressed with imidacloprid, thiamethoxam or clothianidin a causal connection between both of these factors.[5,6] Due to the numerous reports of bee poisonings in a number of Member States of the European Union over nearly one decade, the Commission Directive 2010/21/EU was adopted in the year 2010.[7] In this Directive the basic conditions for seed treatments with some neonicotinoids and fipronil concerning seed treatment, seeding technique and risk labeling are stipulated. Based on the analysis of available data (Fent G, 2011, unpublished) it was concluded that during the sowing of pesticide dressed seeds, abraded dust particles are emitted into the environment, including adjacent off-crop areas and effects on non target species, especially honeybees, cannot generally be excluded. In the current paper the data available so far are discussed and recommendations for the authorization of seed dressings are suggested.

2. Results

2.1 Sources of dust

Data on the dust load contained in seed packages of different crops, on the experimental abrasion of dust using the Heubach-Dustmeter [8,9] as well as on the actual dust drift under field conditions have been presented by the Julius Kühn-Institut (JKI) as well as by the plant protection industry, e.g. at the 'European Workshop on Seed Protection', on the 10th and 11th May 2011, in Paris (Heimbach U and Stähler M, 2011, unpublished; Heimbach U et al., 2011a, unpublished, Kubiak R et al., 2011, unpublished) and in the course of a *webinar* on 'Risks for honeybees by using insecticide treated seeds' organized by the US EPA, on 27th July 2011 (Heimbach U et al., 2011b, unpublished Pistorius J et al., 2011b, unpublished).

2.1.1 Free dust from seed bags

The JKI analyzed the amount of free dust from seed bags of several crops (Table 1).

Tab. 1 Amount of free dust from seed bags of several crops (Heimbach U and Stähler M, 2011, unpublished)

CROP/Year of treatment	Target drilling rate of seeds[a] (kg or No. ha^{-1})	Fine-grained dust[b] < 0.5 mm (g ha^{-1})	Coarse-grained dust[b] > 0.5 mm (g ha^{-1})	N
Cereals 2009				
Barley	180	11.3 (31)[a]	46.0 (116)	30
Wheat	250	9.5 (28)	6.7 (19.2)	31
Rye	150	5.1 (24)	6.6 (32.9)	23
Maize	100000			
2008		4.5 (25.6)	6.1 (47.3)	82
2009		1.99 (5.8)	3.5 (12.1)	45
OSR	700000			
2007		0.81 (4.72)	-	22
2008		0.27 (0.88)	-	24
Sugar-beet 2008	100000	0.035 (0.125)	-	22

[a] Cereals given in kg ha^{-1}; [b] Amounts given in mean (max) g ha^{-1} normalized for target drilling rates of 1 ha

The findings, normalized for 1 hectare, indicated that seed bags of different crops contained very different total amounts of dust. Seed bags of cereals contained more dust than maize, oil seed rape

(OSR) or sugar-beet. The maximum mean amount of fine-grained dust of barley seed bags was more than 300 times higher than the amount of fine-grained dust of sugar-beet bags. Additionally the results for maize and OSR show lower amounts of dust in 2009 compared to 2008, indicating first improvements of the seed dressing quality.

Sieving of dust from maize seed bags showed a great variation of particle sizes. These varied over a broad scale, the smallest smaller than 80 microns, the biggest ones over 500 microns.

2.1.2 Resistance of treated seeds to abrasion

Further investigations of the JKI using the Heubach-Dustmeter revealed that the resistance of treated seeds to abrasion can be regarded as a key factor for the amount of dust potentially contained in the seed packages (Table 2). Sugar-beet turned out to show the best resistance to abrasion, followed by OSR, maize and cereals.

Tab. 2 Resistance of treated seeds to abrasion using the Heubach-Dustmeter for several crops (Heimbach U et al., 2011a, unpublished)

CROP/Year of treatment	Target drilling rate of seeds[a] (kg or No. ha^{-1})	Heubach-value[b] (g ha^{-1})	N
Barley 2009-2010	180	2.25	51
Wheat 2009-2010	250	2.84	131
Rye 2009-2010	150	0.86	37
Maize		1.11 (4.15)	53
2008		0.42 (0.91)	81
2009	100000	0.33 (0.66)	43
2010		0.18 (0.4)	34
2011			
OSR 2009-2010	700000	0.08	212
Sugar-beet 2009	100000	0.03	22

[a] Cereals given in kg ha^{-1}; [b] Amounts given in mean (max) g ha^{-1} normalized for target drilling rates of 1 ha

Further to these findings the JKI showed that concentrations of the active substances may vary between treatment facilities, supposedly depending of the individual treatment procedures, recipes (especially additives, stickers) and the implementation of effective dedusting equipment. As part of a quality improvement initiative of the German professional treatment facilities for maize, the resistance of the treated seeds to abrasion was significantly improved, showing mean normalized Heubach-values of 1.11 g ha^{-1} in 2008 compared to 0.18 g ha^{-1} in 2011. This optimization is also reflected in the maximum normalized Heubach-values for maize seeds that were reduced by about 90 % from 4.15 g ha^{-1} in 2008 to 0.4 g ha^{-1} in 2011.

2.2 Drift of dust - Exposure assessment

According to a literature study prepared at the University of Essen (Höke S and Burghardt W, 1997, unpublished) drift of soilborne particles of different nature into adjacent areas increased, if wind speed exceeded 5 m s^{-1}. Furthermore the size and shape of particles affect the potential of drift with respect to distance and duration. While particles of 1000 down to 70 microns creep, jump and roll over short distances of 1 to 1000 meters, particles of less than 70 microns may be subject to suspension and are spread over longer distances. The knowledge about the size and transport dynamics of dust particles from treated seeds is currently insufficient and therefore needs further consideration.

2.2.1 Studies on dust drift from treated seeds and subsequent ground deposition

Experimental data on dust drift have been presented by the Julius Kühn-Institut (JKI) as well as by the plant protection industry e.g. on the European Workshop on Seed Protection, 10th and 11th May 2011, in Paris (Heimbach U and Stähler M, 2011, unpublished; Heimbach U et al., 2011a, unpublished, Kubiak et al., 2011, unpublished).

In the latest comprehensive compilation of dust drift data, the available data for ground deposition following seeding of maize, cereals, OSR and sugar-beet were analysed (Fent G, 2011, unpublished). The analysed data base comprised experimental data from field studies carried out in Germany, Italy and France until 2009. Studies were carried out mainly on behalf of companies of the plant protection industry (i.e. BASF, Bayer CropScience, Syngenta Agro) and the JKI. The data quality requirements applied to the studies available ensured sowing was carried out according to agricultural practice and wind speed was below 5 m sec^{-1}, LOQ and LOD were reported and analytical performance of deposits was state of the art. Applying these criteria, the results of in total 115 field experiments were selected for further scrutiny. Further it was assumed that both dust transport and deposition (dispersal and quantity of active substance retrieved in the collectors) is not product specific and therefore the active substance can be used as a dust drift tracer. However, no analytical data were reported on the concentration of active substances within the dust prior to the drift experiments, e.g. from abrasion tests. A typical study design to investigate the drift of dust particles is given in Figure 1.

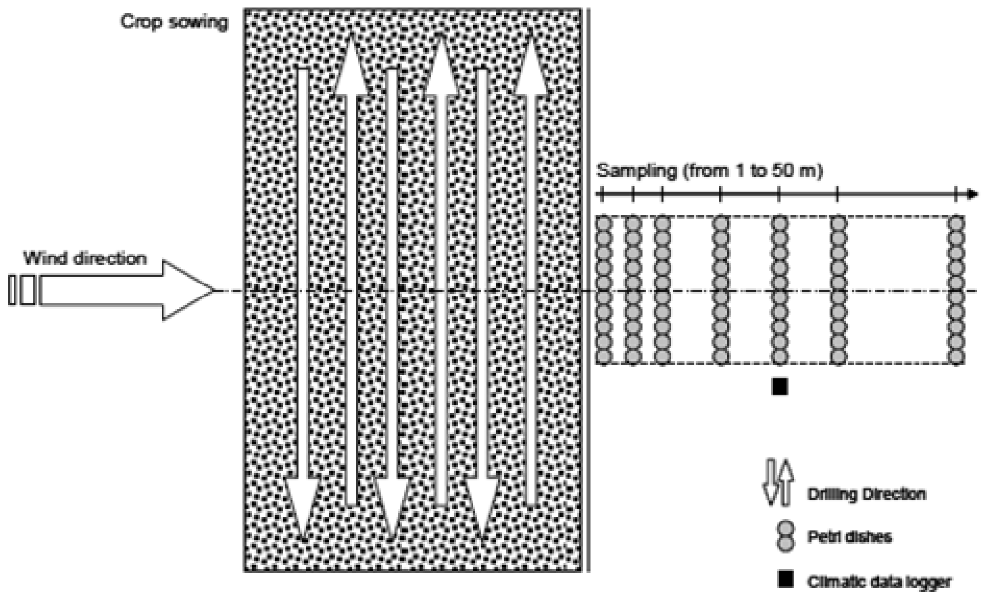

Fig. 1 Typical study design to investigate the drift of dust particles (Fent G, 2011, unpublished)

According to the findings of the JKI (Heimbach U and Stähler M, 2011, unpublished), sugar-beet pills were obviously very resistant to abrasion (Heubach-value of 0.03 g per 100000 seeds). This fact was approved by the analysis of dust drift for sugar-beet seeding, which showed dust drift values below the LOQ, with a few exceptions of single sampler-values only (Fent G, 2011, unpublished). It was concluded that ground dust deposition caused by mechanical seeding of pesticide coated sugar-beet pills is negligible.

The JKI also investigated ground deposition rates of dusts collected in Petri dishes adjacent to a drilled area with seed treated barley (Heubach-value 2.1 g per 180 kg seeds) in 2008, using a mechanical and a pneumatic driller.[9] The mean deposits were about 0.14 % and 0.16 % of the field rate at 1 m to the edge of the field. For dust drift from several cereal seed drilling experiments the 90th percentile of the off-crop ground deposition data for pneumatic sowing technique was about 0.1 % of the field rate applied at the edge of the field (Fent G, 2011, unpublished). Deposition of dust resulting from mechanical seeding was lower compared to pneumatic seeding.

For OSR, the mean ground deposition measured with Petri dishes, which were placed on the open ground at 1 m distance to the edge of the drilled field was found to be about 0.2 % of the field rate applied (Heimbach U et al., 2011a, unpublished). However, no information was given concerning the Heubach-value. The 90th percentile for the off-crop ground deposition following pneumatic drilling of OSR was about 0.1 % (of the field rate applied) at the edge of the field (Fent G, 2011, unpublished). The dust deposition from mechanical seeding technique was significantly lower compared to pneumatic seeding technique.

The ground deposition for maize sown in 2009, using deflector technique in combination with batches of low quality seeds of 2008 (Heubach-value of 2.12 g per 100000 seeds) was up to about 0.5 % of the field rate applied at 1 m to the edge of the field (Heimbach U et al., 2011a, unpublished). When seeds of a higher quality were used (i.e. Heubach-value of 0.86 g per 100000 seeds) and the concentration of the active substance in the dust was reduced at the same time, ground deposition was reduced to about < 0.1 % of the field rate at 1 m to the edge of the field. The JKI also found different concentrations of the active substance in fractions of different particle size. These findings demonstrated a trend towards higher concentrations the smaller the fractions were (Heimbach U and Stähler M, 2011, unpublished). Further it was demonstrated that seeds treated with different treatment rates (in terms of g active substance per 100000 seeds) may generate dust with similar concentrations of active substance and lower treatment rates may even produce higher ground deposits and hence higher exposure than higher treatment rates (Heimbach U et al., 2011b, unpublished). It must therefore be concluded, that the treatment rate alone might have an uncertain impact on the deposition of actives in downwind drift samples, because the concentration between different samples of dust can vary. However, data also showed that within the same treatment facility using the same treatment procedure, concentrations of actives within the dust may correlate with the field application rate. The 90th percentile following the drilling of maize seeds (Heubach-values of < 0.75 g per 100000 seeds) by using deflected, vacuum-pneumatic drilling technique, was extrapolated to be about 0.13 % (of the field rate applied) at the edge of the field (Fent G, 2011, unpublished).

2.2.2 Studies on dust drift from treated seeds and subsequent deposition on vegetation

According to the findings of the JKI, deposits on adjacent flowering crops were higher than on ground level (Heimbach U et al., 2011a, unpublished). Accordingly it was questioned whether ground deposition data could reliably predict exposure of non-target arthropods (e.g. honeybees) to dust on vertical structures adjacent to the field (e.g. hedges or neighbouring flowering crops). Based on the studies available the ground deposition of dust was compared to the amount of dust that was collected by a vertical sampler (i.e. wetted gauze netting) (Neumann P et al., 2011, unpublished). The ratio of vertical deposition divided by horizontal deposition was up to 12.4 (90th percentile: 9.5) with no crop-specific pattern. A field study on maize conducted in 2010 by the JKI showed that deposition data at 0.15 m distance downwind in neighbouring OSR exceeded ground deposition in Petri dishes at 1 m distance by a factor 8.9 (Heimbach U et al., 2011a, unpublished). These data suggest the need to implement an extrapolation factor in the risk assessment in order to cover exposure of bees to dusts on vegetation adjacent to a particular field, if ground deposition data are used for the exposure assessment.

2.2.3 Effects of dust drift on honeybees

The JKI complemented its studies on the quality of treated seeds from different origins with additional investigations on dust drift during sowing, with special emphasis on the exposure of honeybees in adjacent vegetation and at very short distances (Heimbach U et al., 2011a, 2011b, unpublished). The seeds employed for this investigation had a Heubach-value of 0.86 g per 100000 seeds and a concentration of 11 % of clothianidin was determined. Seeding was conducted at an average wind speed of 2.3 m s^{-1} using deflection technique. At the same time the JKI investigated the effects of dust drift from the seeding operation of the treated maize seeds on honeybees in a field test (Pistorius J et al., 2011a, unpublished). The honeybee colonies of the treatment group were located directly adjacent to the maize sowing area, at the edge of a flowering OSR field, which ensured that the honeybees were foraging on the flowering OSR during and after the sowing operation. Honeybee mortality in the treatment group increased to about 200 dead bees per colony at the day of seeding and to about 250 dead bees at day 1 and 4 after seeding. The control colonies, placed at flowering OSR at the upwind border of the sowing area of the maize field, still showed a slight increase of honey bee mortalities (about 50 to 100 per colony day^{-1}), the remote controls at about 800 m distance to the sowing area of the treatment maize showed normal mortalities (about less than 50 per colony day^{-1}). Even though the deposits found in Petri dishes at 1 m distance were quantified below the supposed $NOEC_{field}$ for honeybees for the active substance used, honeybee mortality indicated a higher exposure starting at the day of sowing. The findings reported underline the need to implement an extrapolation factor in the risk assessment in order to cover exposure of honeybees to dusts on vegetation directly adjacent to fields, if ground deposition data are used for the exposure assessment. Furthermore the findings demonstrated that both the quality of seeds and the seeding technique needs to be improved.

2.2.4 Studies on the technical means for a reduction of drift

The JKI documented for pneumatic (vacuum) maize seeding machines a reduction of the emission of contaminated dusts on ground level by about 90 % by reconstructing the vents in the way that the waste air is discharged onto or into the soil (i.e. deflector technique) (Rautmann D et al., 2011, unpublished). The JKI holds a list of suitable drift reducing equipment.

3. Discussion and conclusions

3.1 Discussion

Studies of the JKI clearly demonstrated that the quantity of dust in seed bags and concentration of active substance within the dust may differ depending on seed quality, crop type, treatment rate, treatment recipe, particle size and even the facility where the treatment had been performed (Heimbach U et al., 2011a, unpublished). For the interpretation and standardization of the available data on drift this means that the ground deposition given as relative proportion of the field application rate (e.g. g active substance per 100000 seeds) is only acceptable if the quality of seeds (e.g. classified by the Heubach-value) and the concentration of the active substance within the dust are known and considered sufficiently representative. Furthermore, knowledge on the particle sizes is still lacking. It is therefore considered necessary to appropriately account for the remaining uncertainties, if the currently available drift data (e.g. Fent G, 2011, unpublished) are used for authorization purposes, e.g. by applying additional extrapolation factors. For mechanical seeding of sugar-beet, OSR and cereals the companies of the plant protection industry (Neumann P et al., 2011, unpublished) concluded that dust ground deposition seems to be negligible. However, while this assumption may be supported based on the data reported by JKI for sugar-beet, it is not supported for OSR and cereals (Heimbach U and Stähler M, 2011, unpublished, Heimbach U et al., 2011a, unpublished).

3.2 General conclusions

In general from the data available it can be concluded that dust drift from sowing treated seeds is a common phenomenon along with the deposition of dust particles on soil and on plant surfaces. Resistance to abrasion of treated seeds and the subsequent dust drift during the sowing operation differs significantly between crops, coating recipes and facilities and so do concentrations of active substances. Potentially depending on their size dust particles are filtered out by and may cumulate on neighbouring vegetation or deposit on bare ground (Heimbach U et al., 2011a, unpublished) but may also fly long distances (Höke S and Burghardt W, 1997, unpublished). The drift of dust depends on the type of seeder and environmental conditions (e.g. particle size, wind speed, adjacent vegetation, soil humidity). Maximum ground deposition of dust drift is usually found at the edge of the field. Measurements on plants or on vertically mounted sampling devices show up to about 12 times higher deposits than measurements in Petri dishes on ground level (Neumann P et al., 2011, unpublished). In fact the findings indicate that for seeding operations of some crops, e.g. cereals, maize and OSR, treated with compounds highly toxic for honeybees, e.g. some neonicotinoids and fipronil, best seed treatment techniques with respect to effective dedusting measures (i.e. reducing free dust within the seed bags) and increased resistance of treated seeds to abrasion (i.e. reducing potential of dust generation during packaging to seeding operations) together with the best seeding techniques (i.e. reducing potential of dust emission e.g. by effective deflectors for maize seeds) need to be established (Pistorius J et al., 2011a, unpublished). For sugar-beet the present coating quality already seem to allow a safe seeding operation.

3.3 Recommendations for risk assessment and risk mitigation

In order to facilitate a scientifically sound risk assessment, the appropriate methods need to be elaborated. Because the commonly used HQ-approach has not been validated for the exposure of honeybees to contaminated dust, the TER approach, commonly used in ecological risk assessments, might be a better alternative. This in turn would create the need for establishing and validating higher tier toxicity studies, e.g. in order to assess the $NOEC_{field}$ in terms of g active substance ha^{-1}, as well as the need to establish a risk assessment paradigm. In principle dust drift should be considered in risk assessment for all actives substances respectively pesticides which are toxic to honeybees and which are applied on seeds or as granules and where the mode of application is suspected to generate the emission of contaminated dust into the environment. The risk assessment should be performed especially for critical GAPs (i.e. intended uses) taking into consideration the type of crop, the field rate, the season of application as well as the mode of application (e.g. type of seeder). However, before a risk assessment can be made, also methods for an appropriate exposure assessment need to be elaborated and agreed (i.e. field testing method for drift), e.g. including 3D extrapolation factors for the exposure of honeybees on plants. For all types of seeds and granules potentially toxic to honeybees, the abrasion resistance should be investigated (e.g. by the Heubach-method) and further investigations regarding the concentration of active substance in the abraded dust should be conducted. Finally, appropriate risk mitigation measures as well as appropriate label phrases need to be worked out. In case risk mitigation measures are mandatory, these should be covered by the exposure assessment. All these aspects should be addressed by the relevant Guidance Document which is currently being prepared, lead-managed by the Netherlands, the potential impact on other non-target organisms included.

Acknowledgements

The authors are grateful especially to the JKI for the provision of results from recent research, some of which have not yet been published.

References

1. Pistorius J, Bischoff G, Glas M, Heimbach U, Trenkle A, Stähler M, Maisanbau und Bienenvergiftungen – Hintergründe und Fakten. *Mitt. Julius Kühn-Institut* **417**: 206 pages (2008).
2. Pistorius J, Bischoff G, Heimbach U, Stähler M, Bee poisoning incidents in Germany in spring 2008 caused by abrasion of active substance from treated seeds during sowing of maize; Hazards of pesticides to bees – 10th International Symposium of the ICPBR-Bee Protection Group. *Julius-Kühn-Archiv* **423**: 118-126 (2009).
3. Nikolakis A, Chapple A, Friessleben R, Neumann P, Schad T, Schmuck R X, Schnier H-F, Schnorbach H-J, Schöning R, Maus C, An effective risk management approach to prevent bee damage due to the emission of abraded seed treatment particles during sowing of seeds treated with bee toxic insecticides; Hazards of pesticides to bees – 10th International Symposium of the ICPBR-Bee Protection Group. *Julius-Kühn-Archiv* **423**: 132-148 (2009).
4. Forster R, Bee poisoning caused by insecticidal seed treatment of maize in Germany in 2008; Hazards of pesticides to bees – 10th International Symposium of the ICPBR-Bee Protection Group. *Julius-Kühn-Archiv* **423**: 126-131 (2009).

5. Bortolotti L, Sabatini A G, Mutinelli F, Astuti M, Lavazza A, Piro R, Tesoriero D, Medrzycki P, Sgolastra F, Porrini C, Spring honeybee losses in Italy; Hazards of pesticides to bees – 10th International Symposium of the ICPBR-Bee Protection Group. *Julius-Kühn-Archiv* **423**: 148-152 (2009).
6. Giffard H and Dupont T, A methodology to assess the impact on bees of dust from coated seeds; Hazards of pesticides to bees – 10th International Symposium of the ICPBR-Bee Protection Group. *Julius-Kühn-Archiv* **423**: 73-75 (2009).
7. Commission Directive 2010/21/EU of 12 March 2010 amending Annex I to Council Directive 91/414/EEC as regards the specific provisions relating to clothianidin, thiamethoxam, fipronil and imidacloprid. *Official Journal of the European Union* **L 65/27,** (2010).
8. Heimbach U, Stähler M, Pistorius J, Die Saatgutbehandlung optimieren. *Rheinische Bauernzeitung* **30**: 13-15 (2011).
9. Heimbach U, Beizung von Getreide. *Getreidemagazin* **3**: 8-11 (2011).

Related literature, unpublished:

Fent G, Non-Target Ground Deposition of Dust Resulting from Sowing Pesticide Treated Seeds - Evaluation and Analysis of Current Experimental Datasets to Establish Dust Deposition Tables. RLP AgroScience GmbH; Institute for AgroEcology / EcoChemistry; 67435 Neustadt; Germany, 75 pages, (2011). *unpublished*.

Heimbach U and Stähler M, Seed quality in different crops regarding dust. Presentation held at the European Workshop on Seed Protection (Use of Coated Seeds and Granules) Definition of Good Practices 10th and 11th May 2011, AgroParisTech-ENGREF, Paris (2011). *unpublished*.

Heimbach U, Pistorius J, Schwabe K, Stähler M, Rautmann D, Schenke D, Georgiadis P-Th, Results of dust drift during sowing. Presentation held at the European Workshop on Seed Protection (Use of Coated Seeds and Granules) Definition of Good Practices 10th and 11th May 2011, AgroParisTech-ENGREF, Paris (2011a). *unpublished*.

Heimbach U, Pistorius J, Schwabe K, Stähler M, Rautmann D, Schenke D, Georgiadis P-Th. Dust drift risks during sowing of pesticide treated seeds. Presentation on the Webinar "Risks for honeybees by using insecticide treated seeds" organized by the US EPA, 27.July 2011, 28 pages (2011b). *unpublished*.

Höke S and Burghardt W, Schadstoffgehalte und -ausbreitung bodenbürtiger Stäube in Stadt- und Industriegebieten - Teil I: Literaturstudie. Universität GH Essen, 159 pages (1997). *unpublished*.

Kubiak R, Fent G, Staffa C, and Neumann P, Non-Target Ground Deposition of Dust Resulting from Sowing Pesticide Treated Seeds - Evaluation and Analysis of Current Experimental Datasets to Establish Dust Deposition Tables. Presentation held at the European Workshop on Seed Protection (Use of Coated Seeds and Granules) Definition of Good Practices 10th and 11th May 2011, AgroParisTech-ENGREF, Paris (2011). *unpublished*.

Neumann P, Spatz R and Jene B, Non-Target Ground Deposition of Dust Released During Sowing of Pesticide Treated Seeds and Proposal for the Extrapolation to Vertical Drift from Ground Deposition Drift Data. A Summary for the ICPBR Work Group on Dust; 7 pages (2011). *unpublished*.

Pistorius J, Heimbach U, Joachimsmeier I, Georgiadis P-Th, Frommberger M, Schwabe K, Stähler M, Schenke D, Dust drift, guttation and the risk for honeybees. 24 pages (2011a). *unpublished*.

Pistorius J, Heimbach U, Schwabe K, Stähler M, Rautmann D, Schenke D, Georgiadis P-Th, Dust drift, Guttation and the risk for honeybees. Presentation on the Webinar "Risks for honeybees by using insecticide treated seeds" organized by the US EPA, 27. July 2011, (2011b). *unpublished*.