Corn Dust Research Consortium (CDRC)

Preliminary Report

- Initial Findings for 2013
- Provisional Recommendations
- Timetable

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FINAL

Reviewed and approved by the CDRC

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Executive Summary

This preliminary report of the Corn Dust Research Consortium (CDRC), a multi-stakeholder initiative formed to fund research with the goal of reducing honey bee exposure to dust emitted during treated-seed corn planting, is based on the work of three research teams, led separately by Dr. Reed Johnson of Ohio State University; Dr. Mary Harris of Iowa State University; and Dr. Art Schaafsma, University of Guelph (on behalf of the Grain Farmers of Ontario). It is hoped that the preliminary results and provisional recommendations of the CDRC will inform best practices for the 2014 planting season. Additional research in subsequent seasons will be needed to replicate and substantiate the findings and provisional recommendations.

Two research questions were addressed by CDRC-funded research. The first question sought to develop a greater understanding of the use by honey bees of floral resources in and around corn fields during spring planting. The three research teams took their own approaches regarding this question, incorporating the landscape features, differences in grower practices, and the timing of the planting that varied according to location. Despite these differences, consistencies were observed with respect to honey bee foraging during planting.

The second research question evaluated the effectiveness of a new product developed by Bayer CropScience, *i.e*., Bayer Fluency Agent (BFA), in comparison to standard lubricants (talc and graphite) on deposition levels of pesticide dust in and around fields when commercially available neonicotinoid-treated corn seed products are planted. This question was studied only by the research team led by Dr. Schaafsma.

With respect to the foraging question, the research found that across all three sites honey bees collected pollen largely from trees and woody plants (apple, hawthorn, willow, maple, *etc*.) during the time of corn planting. A second finding indicated that the highest levels of insecticide residue primarily occurred during the two-week period of peak corn planting. It will be important to replicate this work to ensure that these two findings occur consistently and not just during the 2013 planting season.

In assessing the effect of the alternative lubricant, BFA, as a replacement for talc or graphite to separate corn seeds in the pneumatic planters, the CDRC tests showed that when the BFA lubricant was used, total dust and pesticide load in the dust were reduced while pesticide concentration was increased, when compared to the use of conventional lubricants. Further research is needed to determine the overall effectiveness of Bayer's new lubricant in both reducing dust and dust-borne pesticide.

The CDRC is awaiting final data from one part of the Guelph research. The Guelph researchers received funding from other sources and had a wide spectrum of assessments they conducted. It will be important to have all data in hand to test provisional recommendations and to affirm the results of 2013.

The goal of the CDRC is to be as helpful as possible in influencing the practices of all stakeholders with respect to the 2014 growing season; therefore, several

practical solutions that the research highlighted are offered as provisional recommendations (see page 23). All provisional recommendations are based on one year's data and in some cases, small sample sizes; all will require further testing in the coming year.

Several steps will need to be taken to achieve a reduction in exposure of honey bees to neonicotinoids used to treat seeds. Many contributions toward this goal are needed from every sector involved in this situation – farmers, beekeepers, pesticide and lubricant manufacturers, equipment manufacturers, seed dealers, government agencies and regulators, extension agents, agricultural and commodity organizations, and agricultural media all need to become involved.

The CDRC process involved collaborative oversight of practical research through multiple institutions. It has been complex but extremely rewarding. All stakeholders have shared the responsibility for transparency, open deliberation, and unbiased assessment throughout 2013. They will now begin the tasks of follow-up evaluation, information dissemination, and adaptive management in 2014.

Introduction and background

Honey bees living near corn fields can have multiple routes of exposure to pesticides. Exposure may be by contact (dust, soil), by ingestion (pollen/nectar/water), or a combination of these exposure routes. The focus of this discussion is exposure via dust from the planting of treated corn seeds.

Corn planting throughout the U.S. and Canada typically occurs from late April to early May when the fields are sufficiently dry to enter with equipment. Corn seeds currently in use by farmers are frequently treated with pesticide(s). Under humid conditions, treated seeds may become sticky and require a lubricant/fluency agent to move effectively through pneumatic planting equipment; talc and/or graphite are frequently used as seed flow lubricants in the larger pneumatic planters to ensure uniform seed drop. Abrasion of treated seed coatings can result in particles containing pesticide residues mixing with the fluency agents to produce a contaminated “dust” (aka fugitive dust), which can be released by the air exhaust system during planting or subsequent cleaning of the equipment. This “dust” has the potential to be deposited on soil, water, and flowers within and adjacent to corn fields where foraging honey bees, and other pollinators, may be exposed to the pesticide(s).

In 2008, a large number of honey bee colonies in Germany were affected by the drift of dust generated through the abrasion of treated seed during planting. Since that time there has been concern regarding the extent to which one class of pesticides, *i.e*., neonicotinoid insecticides, can move off-site and represent a route of exposure for bees foraging in the vicinity of fields where neonicotinoid-treated seeds have been planted. Although the incident in Germany was attributed to a combination of factors (*i.e*., lack of a suitable sticking agent for the pesticide on the seed, seeding equipment that vents upward, dry windy conditions and an abundance of oilseed rape (canola) in full bloom immediately adjacent to the fields being planted), subsequent research (Krupke et al. 2012; Tapparo et al. 2012) has indicated that fugitive dust may still represent a route of exposure even where suitable sticking agents are used and seeding equipment vents downward.

The Corn Dust Research Consortium

The Corn Dust Research Consortium (CDRC) was formed in early 2013 at the request of the Pollinator Partnership, which provides administrative oversight to the CDRC, to explore potential exposure routes of honey bees to seed treatment dust as well as potential options to mitigate exposure. The CDRC secured the funding for and conducted the oversight of research into two specific corn dust/honey bee interactions:

> Question 1) What are the flowering resources available to and used by honey bees in and around corn fields during planting?
>
> Question 2) What is the efficacy of a newly proposed fluency agent relative to talc and/or graphite in reducing the abrasion of treated seed coatings within planters during planting and the subsequent levels of pesticide-contaminated dust released into the environment?

The goal of the consortium in addressing these two questions is to utilize data from research conducted in three North American locations during the 2013 planting season to develop best practice guidance for the 2014 corn planting season, thereby reducing potential exposure of honey bees to fugitive dust during planting.

It was clear from the beginning that the CDRC could not address all aspects of pollinator exposure, and given limited resources and time, the decision was made to be focused in our efforts. The sampling was focused solely on the potential exposure to honey bees with respect to corn planting. No other species or other crops were considered by CDRC-funded studies.

Nearly a dozen stakeholder groups that comprise the CDRC invested their time and resources to ensure that the research was conducted and presented in the most un-biased, open, and useful form. The participating stakeholders represent interests from various aspects of this situation and include members from:

- American Beekeeping Federation
- American Seed Trade Association
- American Honey Producers Association
- Association of Equipment Manufacturers
- Bayer CropScience
- Canadian Honey Council
- Farm Equipment Manufacturers Association
- National Corn Growers Association
- Pollinator Partnership
- Syngenta
- University of Maryland

In addition, reviews of protocols and study results have been provided by the U.S. Department of Agriculture's Agricultural Research Service (USDA ARS), Health Canada's Pest Management Regulatory Agency (PMRA), and the U.S. Environmental Protection Agency's Office of Pesticide Programs (EPA OPP).

The CDRC research was not formed with the intent to address all questions related to potential exposure to a specific class of insecticides, *i.e.* neonicotinoids and their interaction and/or potential effects on honey bees or all pollinators. In fact, the CDRC research is NOT intended as:

1. An endorsement of seed treatment, neonicotinoids, or any practice
2. A program with a preconceived outcome
3. A study involving any pollinator other than honey bees
4. An examination of Colony Collapse Disorder (CCD)
5. Applicable to any other crop until tested
6. An examination of all potential routes of exposure
7. An examination of potential additive, synergistic or antagonistic relationships between multiple pesticides (*e.g*., insecticides and fungicides)

The CDRC seeks to be a credible source of information about a very limited segment of pesticide-pollinator interactions. Our initial timeline was presented at the EPA/USDA Pollinator Summit meeting in Crystal City, VA on Tuesday, March 5, 2013. That projected timetable was:

- March 5 – March 8, 2013 – Evaluate proposals
- March 12, 2013 – Deliberations based on proposals
- March 15, 2013 – Award grants
- April-May 2013 – Spring corn planting
- August 1, 2013 – Progress report due
- December 1, 2013 – 1st year final report due from researchers to CDRC
- January-February, 2014 – determine possible improvements in corn planting best practices in time for dissemination before spring planting 2014

What follows is a summary of the approaches used by each of the three research institutions for Question 1 and the approach to Question 2 used by one institution, *i.e*., University of Guelph. It should be noted that researchers at each of the three institutions took their own approach to the questions. Their methods and their observations are not identical, nor were they intended to be. The variety of landscape features and differences in grower practices, as well as the timing of the planting, varied according to location. Despite these differences, consistencies were observed, particularly with respect to honey bee foraging during planting. These are noted in the results section (page 16). Several questions still remain (see page 22), especially since we have only have data from one year. These questions and the limits of the data influence the preliminary recommendations (page 23) that are identified as either having come directly from the results of the CDRC study or from common understandings or suggestions supported by other work.

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Iowa State University

Methods

Research cooperators and protocols

Cooperating farmers were located in northwestern Iowa providing eight sites. Among these sites both pneumatic (4) and finger-type (4) planters were employed, and no-till (5), strip-till (1) and conventional (2) cultivation were used. Neonicotinoid treated seeds were planted at 6 no-till sites (4 sites using pneumatic planters and 2 sites using finger-type planters), and untreated seeds were planted with finger-type planters at the remaining 2 sites (these sites were under conventional cultivation). Planter make, model, serial number, seed treatment, planting date and herbicide application date for each site were noted.

Hive description and placement

On April 30, 2 bee hives were positioned at each site along the field margin and were fitted with external pollen traps to sample pollen from foraging bees prior to and following planting. Each hive consisted of two 10-frame brood boxes containing a queen, brood, approximately 20,000 workers, honey stores, and a feeding reservoir.

Pollen collection protocol

Betterbee® Anatomic Pollen Traps were externally mounted to the entrance of hives 1 week (May 1) before initial pollen sampling effort to allow the bees to habituate to the presence of the device (figure 2). To collect pollen, traps were closed for 24 hours per sampling effort (forcing returning foragers to enter the hive through the trap mesh which removes ~50% of collected pollen pellets from the bees' corbiculae). In addition, pollen samples were collected from plant species in flower at each site at the time of hive pollen collection.

Sampling frequency

Planting dates varied among cooperators between April 29 (site 3) and May 20 (site 6). Flowering plant pollen and bee-collected pollen sampling was completed during the following 24hour time periods:

6-7 May	(pre-planting)	
13-14 May	(post planting)	week 1
17-18 May		week 2
2-3 June		week 4
18-19 June		week 6

Bee-collected pollen sampling was to commence one week prior to planting and continue at one-week intervals for 6 weeks. However, due to the highly variable weather and planting schedules among cooperators, we were unable to sample at site 3 prior to planting. Inclement weather precluded sampling at regular weekly intervals following planting; however, we were able to sample at 1, 2, 4, and 6 weeks after planting. Two additional collections were completed at 13 and 17 weeks post planting.

Pollen identification protocol

Pollen pellets from traps were transferred to glass scintillation vials and placed on ice in the field. All pollen was stored at -7^{o}C when not being utilized for identification, to prevent contamination and fungal growth. Pellets were sorted by color and representatives selected randomly from the sorted pollen for imaging.

Slides were made from plant pollen (our reference library) and representative bee-collected pollen samples and photographed in the ISU Light Microscopy imaging facility. All pollen grains were stained with potassium iodide solution and photographed at 40x magnification, and each representative slide of bee-collected pollen was photographed at a minimum of 4 random locations on the slide.

Pollen images were compared to the images of our reference pollen library, which allowed identifications for most pollen types. Further refined identifications were made using collection date, available plant phenology data, location of plants in bloom, color of pollen pellet and comparison to other pollen micrographs. It should be noted that 100% certainty in pollen identification is not possible without electron microscopy.

Toxicological analyses

Samples for pesticide residue analysis were sent to the USDA Materials Analysis Laboratory in Gastonia, NC.

Hive maintenance

Each hive was inspected monthly to determine if queens were present and brood production was ongoing. Only one super was required and placed on top of the brood boxes of each hive. Honey production levels during the season did not require additional supers. All hives were given supplemental feed (corn syrup solution) to allow build-up of adequate stores of honey for overwintering. The Iowa Department of Agriculture and Land Stewardship State Apiarist inspected each hive in late September - early October. One hive (Hive 14) was determined to have only drones and was expected to be lost, and another hive (Hive 6) was missing a queen. The other 14 hives were all queen-right with sufficient honey stores to overwinter.

Ohio State University

Methods and experimental setup

In late April 2013, just prior to corn planting, three apiaries 15 – 34 km apart were set up in areas dominated by field crops in central Ohio. Six honey bee colonies were placed in each apiary, including two new colonies started from packages of bees, two small nucleus colonies, and two large overwintered colonies. Drop-zone dead-bee traps (100L x 50W x 14Dcm; or 40"L x 20"W x 5.5"D) were placed in front of four colonies at each site, and dead bees were collected and counted twice per week.

The overwintered and nucleus colonies were each fitted with a pollen trap (Sundance I) that could be turned on to sample corbicular pollen from returning foragers or turned off to allow pollen into the colony for the bees' sustenance. Pollen traps were emptied and turned on and off on a semiweekly cycle, alternating between colonies, so that pollen was always sampled from two colonies at each site. Corbicular pollen collected at each site on each collection date was weighed, then pooled for further analysis.

Concurrently, observational floral surveys were conducted on a weekly basis to determine the diversity and phenology of floral resources in the study area. Voucher specimens and pollen were collected during floral surveys to build a reference collection for pollen identification. Collection of dead bees and pollen continued through June 11, at which point essentially all corn had been planted in Ohio. At this point 3 of the 18 colonies, one at each site, were either dead or weakened to a point where colony failure was considered imminent

.

Data about the corn planters used by cooperating landowners at each site were collected. Intense local planting of corn occurred between May 3 and May 9, after which rain stalled planting for several days. Planting resumed May 12 and was completed by May 16. According to the USDA National Agricultural Statistics Survey (NASS) Crop Progress Report, statewide cumulative corn planting in Ohio was at 7% on May 5, 46% on May 12 and 74% on May 19 (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1048).

The total landscape of each apiary site was defined as the area contained within a 3-km radius centered on the location of our hives. We quantified the composition of each landscape according to the following categories using a combination of aerial photo analysis and visual ground-truthing: corn, other crops, non-crop fields, tree canopy, residential lots, and margins (including field margins and roadsides). All three sites were dominated by corn and soybean cultivation. Other crops, primarily wheat and alfalfa, occupied the small remainder of cultivated field area. Non-crop landscape elements included uncultivated fields (grazing pasture, fallow agricultural fields, and grassland patches), small forest tracts, scattered residential lots, and marginal strips (field margins and roadsides).

On May 2, immediately before the start of corn planting, the sites were visually assessed for the abundance of bee-attractive blooms in all accessible fields. Each field was assigned a qualitative bloom level of 0-2: 0 = virtually no blooms, 1 = scarce blooms and 2 = abundant blooms. Qualitative floral surveys of non-crop areas were also conducted about twice per week during the period of corn planting. All accessible fields were reclassified on July 4 by crop type, after crops had sufficiently matured to be readily identified. Digital landscape analysis and visualization were performed using Quantum Geographic Information Systems (QGIS) software (QGIS Development Team, version 1.8).

University of Guelph

Methods

Nine farms (2 fields per farm = 18 fields) and 9 bee yards located in 5 key corn growing counties of southwestern Ontario, Canada, were selected for this study. Activities from April to late June 2013 focused on weekly (to Week 6 post-planting) field surveys and sample collection of flowering resources, and pollinators within the field and bordering landscape. Bee yards also were surveyed prior to planting and weekly following planting to Week 6 to collect pollen and dead bees.

Dust generated from pneumatic (negative vacuum) corn planters using either a conventional or novel seed lubricant – Bayer's Fluency Agent (BFA; Bayer CropScience Inc.) was collected during planting using a new vacuum cleaner filtering bag attached to one of the planter's exhaust manifolds, and by sticky dust traps on towers placed along the downwind side of the field during planting. Immediately after planting, whole blossoms of the most common potential forage plant, determined in the study to be dandelions, were collected for residue analysis from the downwind side of the field. All samples collected for residue analysis were placed in coolers with freezer packs for transport back to the lab where they were then stored in a -20^{o}C freezer.

To determine what resources honey bees near experimental field sites were foraging on and whether neonicotinoid residues were transported into the hives via collected pollen, two bee hives per bee yard were equipped with pollen traps one week prior to planting. Pollen samples were collected at regular 24 hr (or at 48 hr if weather conditions were poor for foraging) intervals; 1 week prior to planting, 2 and 6 days after planting and weekly for 6 weeks after planting. Pollen was collected, frozen, and representative samples were sent to the University of Guelph for preparation and then to Johanne Parent (Rimouski, Quebec) for plant species identification.

Note: The experiments were designed as separate objectives. The test of lubricant and dust drift, while near bee yards, was not designed to allow testing of any direct impacts on bees in these bee yards.

Corn fields and apiaries

<u>Question 1</u>

Originally, 10 farms and 10 apiaries located in 5 key corn-growing counties of southwestern Ontario, Canada were identified for this study. However, one apiary experienced high levels of unexpected overwintering bee loss and was removed from the study along with the associated farm/corn fields prior to study initiation. Each farm (2 fields per farm) was paired with an apiary that was within 3 km (majority being less than 2 km) of both fields. Fields ranged from 20 to 100 ha in size. During planting, farmers used negative vacuum air corn planters that were 16 to 24 rows wide. One field was planted using standard lubricant (talc, graphite or a combination talc/graphite product), while the paired field was planted using the BFA. All 18 fields were planted within a ten-day period between May 6 and May 16, 2013, with two fields (Fields 1A and 1B) replanted on May 26, 2013 due to poor emergence.

Vegetation in bloom was surveyed weekly in and around the 18 corn fields from April 29 to June 28, 2013. Field perimeters were divided into 4 sides, with additional zones added based on the landscape and vegetation. Photos of blooming plants, trees and shrubs in the different zones were captured using iCroptrak™ software (Cogent3D Inc.) for the Apple iPad, and geo-referenced. The plant species and their spatial densities were identified and categorized.

At each of the 9 apiaries, 4 hives were used for the study, 2 hives were fitted with an Anel-Standard pollen trap (39 x 15 x 10.5cm; Athens, Greece. www.anel.gr. All 4 hives also were fitted with drop-zone dead bee traps (100L x 50W x 14Dcm; or 40"L x 20"W x 5.5"D).

Pollen traps were engaged at ca.16:00 h on the day previous to the specified pollen collection date. Pollen samples were then collected from the sites no later than ca. 16:00 h on the day of pollen collection. When weather conditions were not ideal for bee foraging (*i.e*., cooler temps or significant rain), pollen traps were left engaged for an additional 24 h. There were 8 sampling dates: the first within a week prior to planting, then on Days 2 and 6 post-planting, then weekly - during weeks 2, 3, 4, 5 and 6 post-planting. The pollen types and proportion were identified by Johanne Parent, Rimouski, Quebec.

Lubricant comparison

Question 2

This portion of the study was conducted on the 9 farms described earlier. Each farm had two fields. Each field pair used the same seed treatment product and rate, planting equipment and settings. During planting, one field per grower was planted using the seed lubricant (talc or graphite or combination product of talc/graphite) they normally used, at the rate the grower was accustomed to using (which was not necessarily at the rate recommended by the planter manufacturer), while the other field was planted using the new BFA at the recommended 1/8 cup per unit of seed (1 unit = 1 bushel or 80,000 seeds).

Both fields of each cooperator were planted with the same seed (*i.e*., same hybrid from the same source, treated with the same seed treatment by the same method). Planter seed hoppers were emptied and the air-flow system operated until no dust was observed escaping (about 5 to 10 min) before a new seed batch and its lubricant were introduced. After the seed was loaded and the lubricant applied, the cooperator planted the headlands of the fields, and the 100-m area along which the dust traps were installed. After two full rounds of planting during the test portion, a sampling bag was installed on one exhaust port for one full round of planting. The sample bag, a new vacuum cleaner filter bag

(Electrolux® CB, #635. 53.5 x 37 x 16cm), was fixed and sealed over one outlet of the planter's exhaust manifold using a metal hose clamp and duct tape. The distance per pass was recorded. The dust collected was normalized to a standard 100-m distance and a single row (also called planter unit) to standardize the planter and field pass distance. Field 2A was planted with seed and lubricant that were placed in the planter the previous night, and the planter remained in the field. Due to concerns with humidity overnight which may have affected dust escaping and lubricant performance, we removed the paired data of Fields 2A and 2B during statistical analyses.

The team tested the hypothesis that the quantity of dust escaping from vacuum planter manifolds when using a conventional seed lubricant is similar to that escaping from the same planter when using the BFA. The Statistical Analysis System (SAS®; SAS Institute, Cary, NC) procedure PROC MIXED model was used with lubricant as a fixed effect and location as a random effect. Dust weight data were subjected to $\log_{10}$ transformation (trans-dust weight) to meet assumptions for normality, and the model tested was: trans dust weight = lubricant. Similarly the team also tested the hypothesis that the neonicotinoid concentration in the dust escaping from vacuum planter manifolds using a conventional seed lubricant is similar to that escaping from the same planters using the BFA and the hypothesis that quantities of neonicotinoid active ingredient (a.i.) escaping from vacuum planter exhaust manifolds using a conventional seed lubricant are similar to those escaping from the same planters using the BFA.

The CDRC is awaiting final data from two aspect of the Guelph research, the data from the prepared field slides (only slides collected from the sample point nearest the test area have been analyzed and reported) and the data from the remaining pollen trap collections (only samples collected during the first three sample periods were analyzed and are reported). All remaining samples are being analyzed and should be available first week of February. These are delayed as the Guelph researchers received funding from other sources and conducted a wide spectrum of assessments, all of which required analyses. It will be important to have all CDRC-related data to go forward in 2014, to test provisional recommendations, and to affirm the results of 2013.

Proprietary data across all research sites

It had been agreed from the beginning that data from each of the three studies would be used by each research team in individual peer-reviewed publications and would be submitted either after this first year of research or after a second year of data collection. These raw data would also be made available on request, but not necessarily before publication in peer-reviewed journals. The results from these studies would be used to develop best practice guidance for the 2014 corn planting season.

What was found – trends and concepts among the three studies

Question 1
Bee-collected pollen

- The majority of pollen collected by honey bees during planting was from trees and shrub species at each of the three study sites. As an example, at the Guelph site, the most abundant pollen types collected from the bee hives during corn planting weeks were Rosaceae (hawthorn, rose, apple etc, 47.0%), *Acer* (maple, 24.8%), *Salix* (willow, 16.7%), Brassicaceae (mustard, 4.2%) and *Taraxacum* (dandelion, 2.4%). Similar trends were found in Ohio (Figure 1) and Iowa (Table 1) below.

Figure 1: Ohio bee-collected pollen (percent by weight)

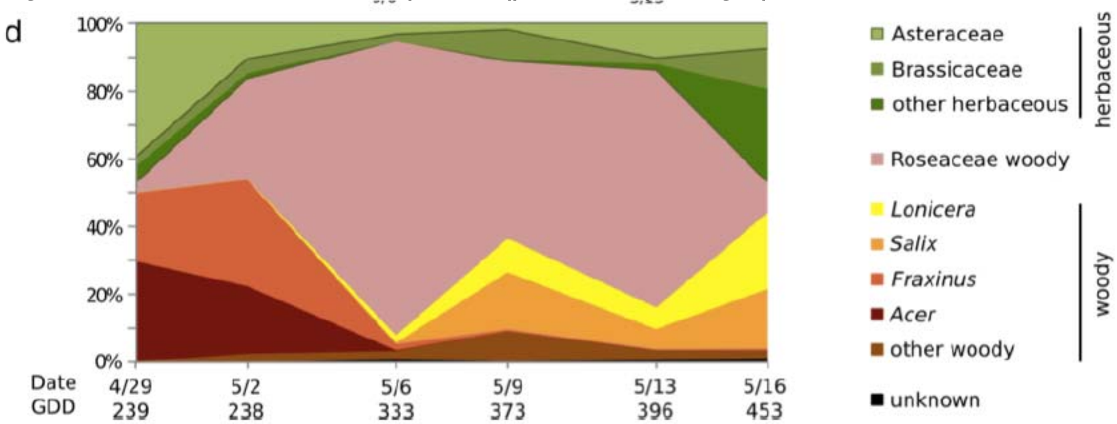

Table 1: Iowa bee-collected pollen (proportion weight of week total)

Plant Species	Sampling Date						
	5/6	**5/13**	**5/17**	**6/2**	**6/18**	**6/23**	**8/27**
Acer spp.	0.29						
Malus domestica	0.12	.0.72	0.49				
Rosa multiflora		0.16					
Taraxacum officinale		0.1					
Forsythia suspensa			0.12				
Salix sp.			0.33				
Oxalis				0.11			
Rudbeckia hirta				0.22			
Syringa vulgaris				0.52	0.36		
Phlox					0.22		
Trifolium sp.					0.23		
Medicago salvia						0.12	
Melilotus sp.						0.66	
Centaurea sp.							0.34
Helianthus sp.							0.10
Solidago spp							0.34
Trifolium repens							0.11

Ohio landscape and bloom observances

Bloom density within cultivated fields was generally very low. At two sites less than 3% of the total field area was classified as having abundant blooms. At the third site, however, approximately 32% of the total field area had abundant blooms. This discrepancy is apparently due to substantial differences in local tilling and herbicide application practices.

Surveys of non-crop areas indicated that in most cases forests, residential lots, and marginal land support the bulk of spring foraging resources for honey bees. This distribution of bee-attractive flora strongly suggests that most honey bee foraging during corn planting season occurs outside of cornfields. This conclusion is corroborated by pollen analysis that identified dandelion, wild mustards, maple, ash, and rosaceous trees--taxa that were observed either primarily or exclusively in residential lots, forest tracts, and marginal land--as the principal pollen sources for our colonies. The significance of these extra-field flora with regard to pesticide exposure should not be overlooked, since many of these critical resources occur in immediate proximity to cornfields, well within the range of drifting seed dust (Biocca *et al*., 2011; Krupke *et al*., 2012). There was, however, one site in our study in which dandelions and wild mustards occurred at moderate to high density within corn fields.

In the course of visualizing the three landscapes that were studied in Ohio, it became apparent that the potential exposure of honey bees to seed treatment insecticides may be dependent on the proximity of foraging habitat to the field being planted. The relative rarity of foraging resources within cornfields and the scarcity of foraging habitat outside cornfields create a discrete pattern of theoretical exposure zones where foraging habitat is located adjacent to or (more rarely) within cornfields. Based on a proposed maximum drift distance of 50 m from the cornfield edge (Biocca, 2011), these theoretical exposure zones would comprise only 4-14% of the total landscape area but 29-40% of the total foraging habitat (taken to be the sum of weedy field, forest, residential, and marginal land).

Pollen contamination

- Neonicotinoid residue levels found on dandelions downwind of the vacuum planters were positively correlated with residue levels in dust emitted from planters; however, few honey bees visited dandelions for pollen.
- Neonicotinoid residues are associated with dust emitted from vacuum planters, and these residues are presumably associated with abrasion of neonicotinoid-treated seed coatings during planting.
- Levels of neonicotinoid residues in bee-collected pollen ranged widely across all sites. See Iowa (Table 2); Ohio (Table 3); and Guelph (Table 4) below.
- In two of our sites, the contamination of pollen was limited to a two-week period during planting. The results from the complete period of sampling from the Guelph study are not yet available. If this observation remains consistent, then it means that the problem of exposure may exist in a discrete timeframe and opens the possibility of controlling the exposure temporally.

Table 2: Iowa bee-collected pollen contamination levels of clothianidin (clo.), thiamethoxam (thia.) and imidacloprid (imid.)

	Sampling Date										
	5/13				**5/17**				**6/2**		
Plant species	Mean (ppb), (no. of samples) and range clo.	Mean (ppb), (no. of samples) and range thia.	No. sam.	Prop. sam. with neo.	Mean (ppb), (no. of samples) and range clo.	Mean (ppb), (no. of samp.) and range thia.	No. sam.	Prop. sam. with neo.	Mean (ppb), (no. of samples) and range imid.	No. sam.	Prop. sam. with neo.
Malus domestica	40.8 (3) 12.0 - 89.3	16.6 (5) 9.7 - 23.6	11	1.00	4.7 (3) 2.9 – 6.0		26	0.23		24	0.08
Rosa multiflora	57.6 (2) 41.2 - 89.3	20.8 (3) 17.9 - 23.7									
Taraxacum officinale		11.3 (1)									
Forsythia suspensa					18.8 (2) 15.3 - 22.3						
Salix sp.					15.5 (1)	6.6 (2) 5.9 – 7.2					
Rudbeckia hirta									26.4 (2) 14.2–38.5		

Table 3: Ohio levels of neonicotinoid residues in unsorted, bulk pollen samples collected between April 23 and May 31, 2013

Site	Date	Clothianidin (ppb)	Thiamethoxam (ppb)	Imidacloprid (ppb)
A	4/23	0	0	0
	4/29	0	0	0
	5/2	0	0	0
	5/6	11.9	5.4	0
	5/9	18.7	4.8	0
	5/13	13.3	4.1	0
	5/16	35.1	8	0
	5/20	3.9	0	0
	5/24	0	0	0
	5/27	6.3	0	0
	5/31	0	0	0
B	4/23	0	0	0
	4/29	0	0	0
	5/2	0	0	0
	5/6	15	8.4	0
	5/9	35.5	9.1	2.6
	5/13	7.4	1.6	0
	5/16	4.8	0	0
	5/20	0	0	0
	5/24	0	2.2	0
	5/27	0	0	0
	5/31	0	0	0
C	4/23	0	0	0
	4/29	0	0	0
	5/2	0	0	0
	5/6	15.7	0	0
	5/9	10.7	0	0
	5/13	24.5	2.7	0
	5/16	6.9	0	0
	5/20	0	0	0
	5/24	0	0	0
	5/27	0	0	0
	5/31	0	0	0

Table 4: Guelph neonicotinoid concentration in bee collected pollen

Bee Yard	**Pre-planting** Neonicotinoid in bee collected pollen (ppb)	**Day 2 of planting** Neonicotinoid in bee collected pollen (ppb)	**Day 6 of planting** Neonicotinoid in bee collected pollen (ppb)
1	1.6	4.6	17.3
2	20.9	6.1	5.9
3	2.9	19.1	ND[1]
4	.0.5	6.1	2.5
5	0.9	4.4	4.3
6	0.3	3.6	6.6
7	48.0	25.5	7.1
8	2.0	16.8	ND[2]
9	5.8	17.8	5.0
Mean	9.2	11.6	7.0
Minimum	0.3	3.6	2.5
Maximum	48.0	25.5	17.3

ND[1]: No neonicotinoid data available. Only 0.1g bee pollen was collected. This quantity was below our LC-MS/MS validation limit.
ND[2]: No data available. No bee pollen was collected due to bad weather conditions.

It should be noted that the focus of the CDRC study was floral routes of exposure, and studies were not designed to differentiate whether the residues were a result of dust released from the exhaust manifolds or from pre-existing residues in soils or from sources outside the study area. The study also did not examine potential adverse effects on bees from exposure to residues.

Question 2: Planter dust emissions

The Guelph research team was the only CDRC group studying the effectiveness of the BFA lubricant. They reported that:

- The BFA (Bayer's alternative lubricant) reduced the amount of dust emitted from vacuum planters compared to conventional lubricants (*i.e.*, talc and/or graphite) by 67.5%.
- The concentration of neonicotinoid residues in the BFA lubricant dust escaping from the vacuum planter was on average 3.7-fold higher than the conventional lubricants.
- The use of BFA at the recommended application rate reduced the quantity of neonicotinoid active ingredient escaping from vacuum planter exhaust by 28% by comparison with the conventional lubricants applied at rates the cooperators were accustomed to using.
- This study compared the BFA fluency powder with what the cooperator used routinely. During this field test, the manufacturer-recommended levels of talc/graphite lubricant (~1 cup per seed unit, defined as 80,000 kernels or 1 bushel) were followed at only one of the 9 test sites. The amount of lubricant in the test was left up to the discretion of the farmer and ranged from 0.06 cup per seed unit to 1.00 cup per seed unit.
- Residues of clothianidin and thiamethoxam were the most frequently detected neonicotinoid residues.

The CDRC is eager to have a second year of data on the comparison of the BFA lubricant to talc and graphite. Also, since only one team made the assessment, CDRC looks to increase the number of research teams assessing this alternative lubricant. Additional teams in the second year will benefit from the experience of the first year. There are several factors in the lubricant report that need to be understood more fully.

The 2013 results for the measurement of exhaust and AI concentration in the lubricants vary widely within the 9 sites. Measurement of planter exhaust is difficult as it requires clean machinery at each measurement and precise collection methods engineered to keep pressure levels constant. Refined methodology is needed so that the exhaust can be measured more consistently.

The evidence and toxicological analysis of dust on the "field panels" will provide data about the concentration as well as the movement of the BFA lubricant vs. talc. The CDRC looks forward to seeing these data.

In applying the research results to practical management steps, the issue of concentration vs. dose can be confusing. With respect to the current study, what is important from a toxicological and risk assessment perspective is the dose applied to the environment and taken up by a species of concern. In pesticide risk assessments the assessor determines the amount of active ingredient applied per unit area, such as pounds per acre or grams per hectare. What matters is the amount of pesticide active ingredient released and deposited per unit area, and that is reduced with the use of the BFA lubricant. The CDRC anticipates that forthcoming field plate data sets will contribute needed data to illuminate this.

Remaining questions

1. What kinds of plantings can be added to corn landscapes that would be timed correctly, attractive enough, and sufficiently removed from the exposure area that could provide forage resources for honey bees and other pollinators?

2. How would the BFA compare to conventional lubricants if they were compared according to the manufacturer's recommended level of lubricant (the current research compared a variety of levels according to the discretion of the farmer)?

3. What impact would removing potentially attractive floral resources in and adjacent to corn fields have on the potential exposure of bees to neonicotinoid residues? What impact would this practice have on the sufficiency and availability of forage for bees over the growing season?

4. Could untested mechanical planter modifications such as foils or deflectors (some of which appear to have had good trials in Europe) have a positive impact in terms of reducing exhaust fan dust generated during planting in North America?

5. Will the implementation of specific drift mitigation measures by the farmer reduce exposure?

6. Contaminated pollen may have a different effect on honey bees than contaminated nectar, and it is unclear how dust may contribute to residues in nectar; how can these differences be taken into account when evaluating ways to reduce exposure routes?

7. How does the implementation of best practices ultimately affect the health of honey bees?

8. Will recommendations from these studies reduce potential honey bee exposure, and what impact will they have on other pollinating species? What impact will they have on floral/forage availability for bees and other pollinators?

9. How will technical solutions that reduce seed treatment insecticide dust emissions and drift distance change the recommended best practices for growers, beekeepers and others?

Provisional recommendations

A simple, “silver bullet” solution is not the result of these data. The CDRC provisional recommendations are based on small sample sizes and data from one year, and therefore all provisional recommendations require further testing in the coming year. However, the original CDRC goal was to be as helpful as possible in influencing the behaviors of all stakeholders with respect to the 2014 growing season; therefore, some practical solutions from the research are highlighted.

Several steps will need to be taken to achieve a reduction in exposure of honey bees to neonicotinoids used to treat seeds. Contributions are needed from every sector involved in this problem – from farmers, beekeepers, pesticide and lubricant manufacturers, equipment manufacturers, seed dealers, government agencies and regulators, extension agents, agricultural and commodity organizations, and agricultural media. **The provisional recommendations in bold are identified as having come directly from the results of the CDRC study.** Other recommendations are supported by work outside the CDRC research program. All recommendations have been vetted with the members of the CDRC; however, within the group there is general agreement that the provisional recommendations are, as stated earlier, based on very limited data. They are presented as a part of a building block approach that will need to be tried and tested, monitored and adaptively managed.

Farmers

- **Use drift-reducing lubricants during planting to reduce dust. This recommendation comes with a caveat; though the CDRC tests showed that when the BFA lubricant was used, total dust and net pesticide load in exhaust emissions were reduced when compared to the use of conventional lubricants, the concentration of pesticide in the exhausted dust appeared to be higher in these tests. This result may be inconsistent with other tests of BFA elsewhere. Further research is needed to determine the extent to which Bayer’s new lubricant consistently reduces net emission of dust-borne pesticide during planting of treated seed.**
- **Follow all precautions to reduce dust and drift, especially with respect to wind and weather conditions during corn planting. As stewards of the land, farmers play a significant role in the health of pollinators by reducing drift during corn planting. All research sites showed that this year during the corn planting window (approximately two weeks) honey bees foraged primarily on the pollen of woody shrubs and trees including apples, crab apples, hawthorns, maples and/or willow. These are important foraging sources to honey bees, particularly when sufficiently distant from the planting area to be unaffected by dust but within the foraging range of the honey bee. Bee-attractive woody pollen sources are**

particularly vulnerable to drift of pesticides in exhausted dust when corn is planted within 50 meters of such forage.

- **Control herbaceous flowers blooming in fields to be planted with corn. This action provides modest benefits to honey bees. Although pesticide residues were detected on cover plants (predominantly dandelions) within seeded fields, the study demonstrated that honey bees did not forage heavily on these plants, but tended to forage on trees and shrubs.**
- Minimize unnecessary use of seed treatment insecticides. Use them only when needed, such as where historic pest infestations are above threshold or high risk factors for pest pressure have been anticipated or determined.
- Follow the principles of Integrated Pest Management.
- Communicate with beekeepers to ensure that they are aware of planting timing and can take appropriate precautions to protect colonies.

Beekeepers

- **Protect supplemental food and water from drift dust.**
- **Position hives away from areas where drift of corn dust can settle on herbaceous or woody plants during planting.** Prevailing wind direction and wind speed may be helpful indicators for placement.
- **Supplement the hive with food to suppress the need for foraging during corn planting, and provide clean water to reduce the need for bees to seek water from sources in and adjacent to corn fields.** However, this recommendation is made with the awareness that bees will often seek out any natural pollen before artificial sources.
- Communicate with producers when you have hives in the area.
- Label hives with your contact information.
- Check hives regularly and report incidents.

Pesticide and lubricant manufacturers

- **Work to reduce movement of corn dust (*e.g*., improved sticking agents, improved fluency agency).**
- **Work to keep all the insecticide on the seed until the seeds are in the ground** (*e.g.*, polymer seed coatings)**.**
- **Work to reduce abrasion potential of treated seed coatings.**
- Ensure the lowest effective labeled rate of neonicotinoid treatment is applied to the seed.
- Offer untreated (fungicide only) seed options.
- Reach out to farmers, and help make them aware of the situation and of the importance of farmers implementing recommended actions to reduce bee exposure.

Equipment manufacturers

- **Ensure that equipment users understand the importance of bee protections and the value of using lower-drift lubricants.**
- Provide mechanical means to reduce the movement of dust from fan exhaust during planting using equipment design principles and verification methods established in internationally recognized standards (ref. ISO 17962 under development).

Seed dealers

- **Support bee health by providing outreach to producers to make wise seed choices and to follow best seed planting practices.**
- Offer untreated seeds as an option for farmers.

Provincial, state and federal government agencies and regulators

- Provide financial and instructional support for maintaining trees and shrubs outside drift areas for bee forage available during planting season.
- Provide guidance for the reduction of attractive herbaceous forage in corn fields.
- Fully fund governmental provisions to ensure that pollinator forage supports can increase and be sustained.
- Encourage application of the lowest effective labeled rate of neonicotinoid treatment on the seed.
- Ensure that both insecticide-treated and fungicide-only seeds are available
- Ensure that IPM practice information is available to the producer.
- Provide a responsive structure for bee-incident reporting. Ensure that incident report procedures are adequately funded and operate in a timely fashion commensurate with the urgency of this situation for honey bees and beekeepers.
- Ensure that seed bag labeling is clear and that growers are aware of the potential risk posed by planter dust.
- Dedicate transportation corridor and rights-of-way plantings to the establishment of pollinator roadsides for habitat.
- Reach out to farmers, and help make them aware of the situation and of the importance of farmers implementing recommended actions to reduce bee exposure.

Extension agents, agricultural and commodity organizations, and agricultural media

- Ensure that IPM practice information is available to the producer.
- Educate the beekeeper in practices that will safeguard bees.
- Educate beekeepers on bee-incident reporting.
- Educate so that label directions are clearly understood.

- Help producers become aware of the situation, and encourage them to adopt recommendations from this report on a timely basis to reduce bee exposure.
- Help agricultural producers, seed dealers and other stakeholders become aware of the situation and encourage them to adopt recommendations from this report to reduce bee exposure.

Next Steps

The CDRC's process of collaborative oversight of practical research through multiple institutions has been complex but extremely rewarding. All stakeholders have shared the responsibility for transparency, open deliberation, and unbiased assessment throughout 2013. They will now begin the tasks of follow-up evaluation, information dissemination, and adaptive management.

Timetable

1. Review and agree on this report (1/29/14)
2. Disseminate this report through a press release and web site posting (1/30/14) http://www.pollinator.org/PDFs/CDRC_PR2014.pdf
3. Determine exact questions to be studied during the 2014 planting season (1/30/14)
4. Prepare RFP and/or solicit research proposals from current research teams (1/30/14) http://www.pollinator.org/PDFs/CDRC_RFP2014.pdf
5. Receive grant applications (2/20/14)
6. Award grants (2/28/14)