Water collection by honey bees – How far will foragers fly to use water sources like guttation drops? A first distance trial using cereals and oilseed rape

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Abstract

Background: Depending on the location, various water sources may be available for bee colonies. These sources can be permanent, such as ponds, or incidental like dew or guttation droplets. The aim of the experiment was to investigate whether bees prefer guttation drops as a water source compared to dew or rain drops. Furthermore it was analysed if bees use these water sources up to a distance of 50m from their hives.

Results: During the experiment 147 bees were observed scanning the surface of the plants without landing, 13 bees took up guttation fluid and 36 bees collected dew or rain drops. Few bees were observed collecting guttation fluid at 50m from their hives but most in close proximity of the hives. Furthermore, in some dead bees residues of the seed treatment were detected (imazalil: 0.0011 µg/bee – 0.329 µg/bee; LD50= 35.1 µg/bee).

Conclusion: In the majority of observations, bees were spotted scanning the leaf area of the plants. Only single bees were observed that actually took up water from plant leaves. It seems these bees did not distinguish between dew, rain or guttation droplets. The majority of water collecting or bees resting on plants were observed in the close proximity of their hives.

Keywords: guttation fluid, pesticides, seed treatment, honeybee, water source, distance

Introduction

The water demand of a bee hive is highly variable throughout the year[1]. In spring, the collected water is required primarily to dilute the stored honey whereas in summer it is necessary for temperature and humidity regulation[2]. Throughout the whole year water is required for the preparation of larval food and supply of minerals[3]. Contrary to nectar and pollen, water is not stored in the bee hive and therefore has to be collected when needed[4]. In most cases the colony´s water need is met by collection of fresh nectar or water condensed within the beehive[5]. If needed specialized bees, the water foragers, collect water from various water sources like ponds and ditches or from the surface of plants[6]. Experiments in a desert have shown that water foragers were able to fly up to 2 km to find water sources[7] but in general long distance flights are avoided for energetic reasons[8, 9]. Therefore, one of the potential water sources used by honey bees could be guttation drops from plants in the surrounding of their hives. Guttation describes an event at which xylem fluid is excreted as droplets along the edges or tips of plant leaves[10]. The guttation fluid predominantly contains inorganic substances in lower concentrations compared to plant fluids[11]. Recent studies on several seed treated crops showed that also systemic active substances from the seed coating can be found in the droplets[12]. While most seed treatments contain only fungicides that are not toxic to bees, many insecticidal active ingredients like e.g. neonicotinoids are highly toxic for bees. Insecticidal seed coatings, on the other hand, have been considered as harmless for bees up to now because no direct contact and no relevant exposure of bees to the active substance were assumed[13]. However, it was first shown in some experiments conducted in Germany[14] and Italy[15] in 2009 that systemic substances from the seed treatment were excreted via the guttation fluid in concentrations relevant for honey bees. Considering these results and the fact that most crops grown in Germany have the ability to show guttation[16], the question arises whether guttation drops of insecticidal seed treated crops can

constitute a relevant route of exposure for bees. To address the potential risk from guttation in realistic field conditions, several factors determining the potential exposure have to be considered. Therefore, the aim of this experiment was to obtain more information on water collecting behaviour of honeybees and to investigate if and at which distance guttation drops may used as a water source for honey bees.

Experimental methods

The experiment was conducted from 10th of April until 09th of May 2010 and was set up on one organically and one conventionally managed field near Ahlum (Lower Saxony, Germany). The distance between both fields was 300m. The experimental fields consisted of two plots; one planted with cereals and one adjacent plot with oilseed rape (fig.1) . In the organically managed variant the seeds were untreated. In the conventional variant the cereal seeds were treated with a fungicide (Zardex G®: 20 g/l imazalil, 5 g/l cyproconazol), the winter oilseed rape seed was treated with an insecticide (Elado®: 10 g/kg clothianidin). In both variants the bee hives were placed in the cereal plot with a distance of 0m (field border), 10m, 20m, 30m and 50m to the adjacent oilseed rape field and a distance of 50m from each other. On each field a total of three small bee colonies (one-room, 'Zander') and two *full size colonies* (two-rooms, 'Zander') were set up, the full sized at 0 and 50m and the small sized at 10, 20 and 30m. The hive entrance of all bee colonies pointed towards the oilseed rape plot. All colonies had an oviparous one year old queen.

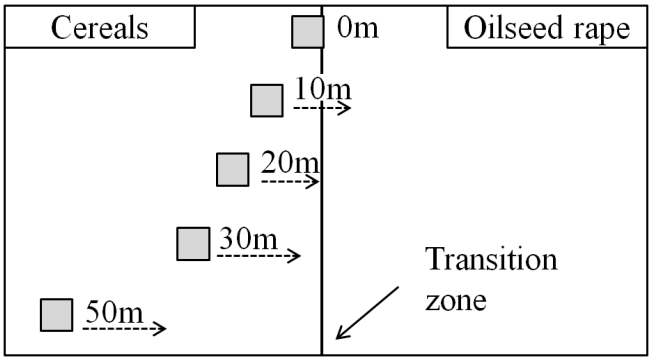

Fig. 1 Experimental field

The observations were conducted several times daily until no more guttation droplets were visible. If no guttation was present, the observation was conducted only once.

During every assessment the climatic conditions (relative air humidity, air and soil temperature), the growth stage of the crop plants using the BBCH monograph[17] and the presence of guttation, rain or dew drops was recorded. With beginning of daily bee flight, the flight activity at the entrance of the hive and behaviour observations on honey bees interacting with plants started. The observations of behaviour were conducted at two fixed observation lines and one observation point. Two of them were located at 0 - 5m distance from the bee hives at the entrance and at the back side. The third observation point was about 1 m^2 large, located at the field border and half grown with cereals and oilseed rape (transition zone). The distance of this point to the hives was depending on the location of the hives 0 to 50m. Each observation of behaviour lasted five minutes. In addition, four times in the course of the study the population development of the beehives was assessed by using the Liebefelder method[18] and the bee mortality every day using modified Gary-traps[19]. After completion of the field experiment residue analysis of dead bees from the Gary-traps was conducted.

Results

The development stage of the cereals at the beginning of the experiment was BBCH 29 (end of tillering), that of oilseed rape was BBCH 53 (inflorescence emergence). The experiment was terminated at flowering of the oilseed rape crop (BBCH 65). During this period both crops often showed guttation drops. In the cereals, guttation was observed more frequently than in oil seed rape (fig. 2).

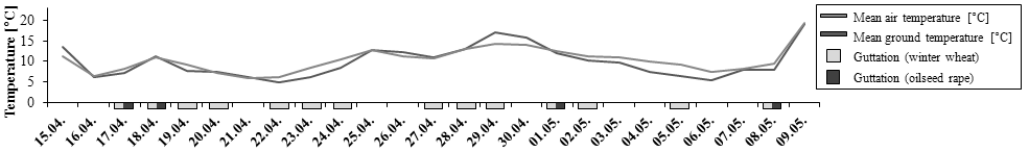

Fig. 2 Course of temperature and guttation events in the experimental fields.

A total of 38 bees were observed searching or collecting nectar within the assessment areas. These were not considered in the following figures and evaluations. The majority of bees, interacting with plants, were observed adjacent to the bee hive (fig. 3, left). In the transition zone between the cereal and oil seed rape a smaller number, approximately about 15 % of the total number was observed. With increasing distance from the bee hives, fewer bees were observed (fig. 3, right).

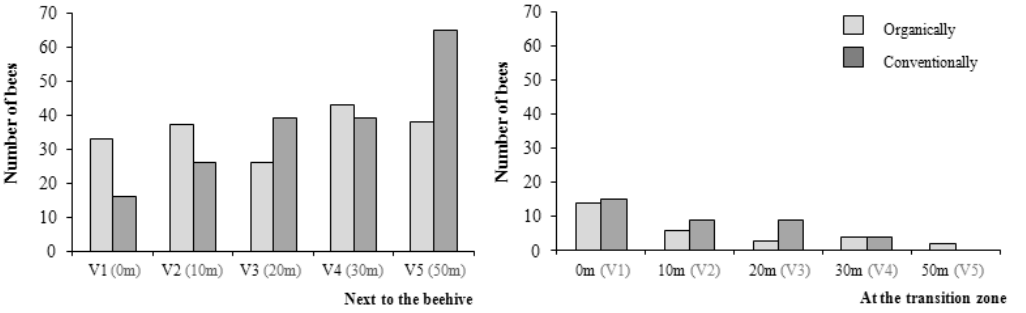

Fig. 3 Number of bees at the observation points (left part = two 1 - 5m lines next the beehive, right part = 1 m^2 point at the transition zone with 0m, 10m, 20m, 30m or 50m distance to the beehive).

In the majority of cases, bees were spotted resting or scanning the leaf area (fig. 4). There was no significant difference in the number of bees that took up guttation, dew or rain drops. At a distance of 50 m from the bee hive in the transition zone of the plots only two bees were observed that took up guttation fluid.

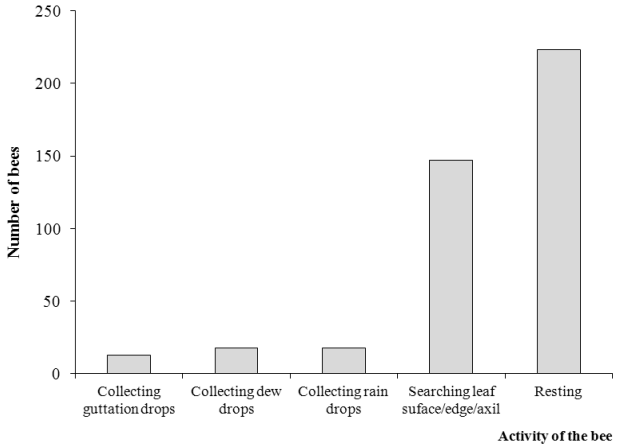

Fig. 4 Overview of the activity of all observed bees irrespective of the observation point.

No adverse effect on the development of bee colonies was detected. The development on both fields was at a similar level. Also the mortality of both the organically and the conventionally managed fields was at a comparable level (fig. 5).

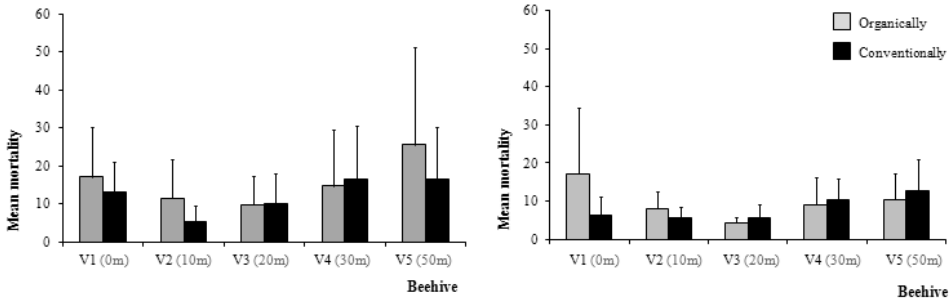

Fig. 5 Mean bee mortality of days without (left part, n= 14) and with (right part, n = 9) guttation in any crop.

No residues of clothianidin, which may have originated from the treated oil seed rape in the conventional variant, were found in dead bees. However, in some samples, residues of the fungicide imazalil (0,0011 µg/bee - 0,329 µg/bee, LD50= 35,1 µg/bee) from the seeds of the conventional cereal plot were detected.

Conclusions

Bees used water from the surface of plants, the edge of leaves and also the leaf axial water as a water source. They did not distinguish between dew, rain and guttation droplets but were often observed scanning the leaf edges. Therefore, it seems that bees are capable of learning where guttation water droplets can be found. The findings of the fungicide in some dead bees from the conventionally managed variant indicated that they took up guttation fluid. With increasing distance from the bee hives less bees interacting with plants were observed. Although most bees were observed adjacent to the bee hive, some were found collecting guttation fluid up to a distance of 50m. In this experiment

no adverse effects on the development of the bee colonies was observed. The development and mortality of all bee colonies independent of the seed treatment used was at a comparable level.

Acknowledgements

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References

1. Nitschmann J, Hüsing JO, Lexikon der Bienenkunde. *Tosa Verlag*, Leibzig (1987).
2. Winston ML, The biology of the honey bee. *Harvard University Press Cambridge*, Massachusetts London (1987).
3. Piscitelli A, Über die Bevorzugung mineralstoffhaltiger Lösungen gegenüber reinem Wasser durch die Honigbiene. *Zeitschrift für vergleichende Physiologie* **42**: 501-524 (1959).
4. Lindauer M, Temperaturregulation und Wasserhaushalt im Bienenstaat. *Zeitschrift für vergleichende Physiologie* **36**: 391-432 (1954).
5. Kuehnholz S, Seeley TD, The control of water collection in honey bee colonies. *Behavioural Ecology and Sociobiology* **41**: 407-422 (1997).
6. Seeley TD, Honigbienen: Im Mikrokosmos des Bienenstocks. *Birkäuser Verlag*, Basel (1997).
7. Visscher PK, Crailsheim K, Sherman G, How do honey bees (*Apis mellifera*) fuel their water foraging flight? *Journal of Insect Physiology*, **42** (11-12): 1089-1094 (1996).
8. Harrison JF, Roberts SP, Flight respiration and energetic. *Annual Review of Physiology*, **62**: 179-205 (2000).
9. Woyciechowski M, Risk of water collecting in honeybee (*Apis mellifera*) workers (Hymenoptera Apidae). *Sociobiology*, **50**: 1059-1068 (2007).
10. Bresinsky A, Neuhaus G, Körner C, Sonnewald U and JW Kadereit, Strassburger - Lehrbuch der Botanik. *Spektrum Akademischer Verlag*, pp. 310 (2001).
11. Ehrhardt JF, Untersuchungen über Hydathoden. Technische Universität München, Institut für Botanik und Mikrobiologie, Dissertation (1978).
12. Schenke D, Joachimsmeier I, Pistorius J, Heimbach U, Pesticides in guttation droplets following seed treatment - field studies. SETAC North America 32nd Annual meeting Boston, Abstract book: 124 (2011).
13. Bundesamt für Verbraucherschutz und Lebensmittelsicherheit (BVL), Kodeliste für Kennzeichnungen und sonstige Auflagen zum PSM-Verzeichnis (accessed 20.12.2011).
14. Wallner K, Guttation: Tropfen, die es in sich haben. *Deutsches Bienen-Journal* **4**: 18-19 (2009).
15. Girolami V, Mazzon L, Squartini A, Mori N, Marzaro M, Di Bernardo A, Greatti M, Giorio C and Tapparo A, Translocation of neonicotinoid insecticides from coated seeds to seedling guttation drops: A novel way of intoxication for bees. *J. Econ. Entomol*. **102**: 1808-1815 (2009).
16. Joachimsmeier I, Pistorius J, Heimbach U, Schenke D, Zwerger P, Kirchner W, Details on occurrence and frequency of guttation in different crops in Germany. ICPBR Wageningen, 11th Symposium Hazards of Pesticides to Bees, 2.-4.11.2011, this issue.
17. BBCH Monograph, Growth Stages of Mono- and Dicotyledonous Plants, 2nd Edition (Meier U, Ed.). Federal Biological Research Centre for Agriculture and Forestry, Berlin and Braunschweig, Germany (2001).
18. Imdorf A, Buehlmann G, Gerig L., Kilchenmann V. and Wille H, Überprüfung der Schätzmethode zur Ermittlung der Brutoberfläche und der Anzahl Arbeiterinnen in freifliegenden Bienenvölkern. *Apidologie* **2**: 137–146 (1987).
19. Gary NE and Lorenzen K, Improved trap to recover dead and abnormal honey bees (Hymenoptera Apidae) from hives. *Environmental Entomology* **13**: 718–723 (1984).