Frequency and intensity of guttation events in different crops in Germany

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Background: In crops of economic relevance and some common weeds in Germany, several glasshouse and field trials were conducted at the JKI and cooperating research partners (DWD, IfZ, BDP and UFOP) from 2009 to 2011. Aim of the investigations was to analyze the guttation frequency of these crops, to document climatic conditions that trigger guttation and to describe the quality and quantity of guttation events (e.g. size/number of drops).

Results: Guttation occurred in all crops mainly at young growth stages. Only maize, cucumber, oilseed rape and potato produced guttation droplets until emergence of inflorescence. The excreted amount of fluid was comparable for maize and oilseed rape but considerably lower for sugar beet and barley. In field situation guttation occurred frequently in more than one plant species in parallel when it was not dry or too windy or frosty.

Conclusion: Monocotyledonous crops and weeds showed a higher guttation frequency than most dicotyledonous crops. Maize showed large guttation drops even under low relative air humidity, whereas guttation drops in sugar beets were much smaller and only observed under very high humidity conditions (>90%). Other dicotyledonous crops, such as oilseed rape and potato, showed a much higher guttation frequency than sugar beets.

Keywords: guttation, honey bees, pesticides, crops, weeds

Introduction

Guttation describes an event at which xylem fluid is excreted as droplets along the edges or tips of plant leaves[1] and was presumably first described in 1672 by Abraham Munting and in 1887 mentioned as guttation in the literature by Burgerstein[2]. Since the beginning of the 20th century, it was reported in a wide range of plants e.g. 1925 by Lippmann[3] and therefore considered as a general phenomenon. For a deeper understanding of guttation it is important to recall that plants need to maintain a certain level of water and nutrient transport between the roots and the leaves. This is done by passive mechanisms acting at a declining gradient such as transpiration. However, under climatic conditions that are not suitable for transpiration, e.g. under a relative humidity over 75%[4] close to the leaf surface, guttation may occur. These climatic prerequisites often occur at night or in the early morning. They are the same also for triggering the formation of dew drops[5]. The guttation fluid is excreted via hydathodes. They vary in their anatomical set up. Plants display two basic forms of hydathodes: active and passive. Active hydathodes operate with special epithem cells, whereas in passive hydathodes guttation is a result of root pressure[6]. The composition of the guttation fluid may vary slightly depending on its excretion way (passive and/or active hydathodes) and the growth stage of the plant or leaf[7,8]. Even though the general occurrence of guttation has been well described in literature, no data are available which compare the occurrence, frequency and intensity (size/number of guttation drops, number of guttating plants) of guttation between crops of economic relevance in Germany. To address this question several greenhouse and field trials were conducted by the Julius Kühn-Institut, in cooperation with research partners (DWD, IfZ, BDP and UFOP) from 2009 to 2012.

Experimental methods

A total of eleven important widely-grown crops (e.g. oilseed rape, maize, sugar beet) and twenty-one common weeds like e.g. *Poa annua* were examined in greenhouse or field trials (tab.1). The frequency and intensity of guttation of different crops and weeds in greenhouse trials were compared under the same climatic conditions. In field situation, several areas within the field border (covered with weedy plants) adjacent to the crop field or in neighbouring field crops (preferably cereals) were investigated and compared to the observed field in parallel. The observations started at early plant emergence and ended at the growth stage when guttation ceased. In the glasshouse daily assessments were conducted. Assessments of guttation frequency and intensity in the field trials were carried out daily or in some cases only under climatic conditions suitable for guttation on pre-selected days (e.g. high air humidity, low wind speed, occurrence of dew). At each assessment the climatic conditions (relative air humidity, air and soil temperature), the growth stage of the crop plants using the BBCH scale[9] and the presence of guttation or dew drops were recorded. However, in the field trials, additional climatic information like sky cover, soil humidity was assessed. The size of guttation drops was determined only in glasshouse trials. For this the guttation drops of each plant were counted and balanced on a filter paper.

Tab. 1 List of all investigated widely-grown crops and common weeds.

			Assessment	
Crop	**Greenhouse**	**Field**	**Daily**	**Pre-selected**
Maize	x	x	x	x
Barley	x	x	x	x
Wheat	x	x	x	x
Oilseed rape	x	x	x	x
Cucumber	x	x	x	
Potato	x	x	x	x
Sunflower	x		x	
Sugar beet	x	x	x	x
Onion	x	x	x	
Carrot	x	x	x	
Pea		x	x	
Weeds*	x	x	x	x

**Alopecurus myosuroides, Apera spica-venti, Avena fatua, Chenopodium album, Cirsium arvense, Echinochloa crus-galli, Elytrigia repens, Fallopia convolvulus, Fumaria officinalis, Galium aparine, Lamium amplexicaule, Lamium purpureum, Matricaria recutita, Mercurialis annua, Poa annua, Polygonum aviculare, Solanum nigrum, Stellaria media, Thlaspi arvense, Tripleurospermum perforatum, Viola arvensis*

Results

The different crops required different relative air humidity conditions before any guttation occurred in the greenhouse. Maize started to guttate at a relative humidity of 80%, the other crop species needed a humidity of at least 90% before guttation started. Above 90% humidity maize and cereals showed guttation in greenhouse (90-100% of observation days) nearly daily, whereas at the same conditions oilseed rape and potato guttated often (~60% of observation days) and sugar beet only rarely (20-30%). Similar results were recorded in field situation. In a field situation with several crops and weeds guttation occurred frequently when it was not dry or too windy or frosty, most of the time in more than one plant species in parallel (fig. 1). However, in the field in contrast to greenhouse even under climatic conditions suitable for guttation, guttation was observed on at most 50 % of

preselected observation days for any crop (tab. 1). For weeds similarly as for crops guttation was mainly more frequent for monocotyledon species compared to dicotyledonous ones.

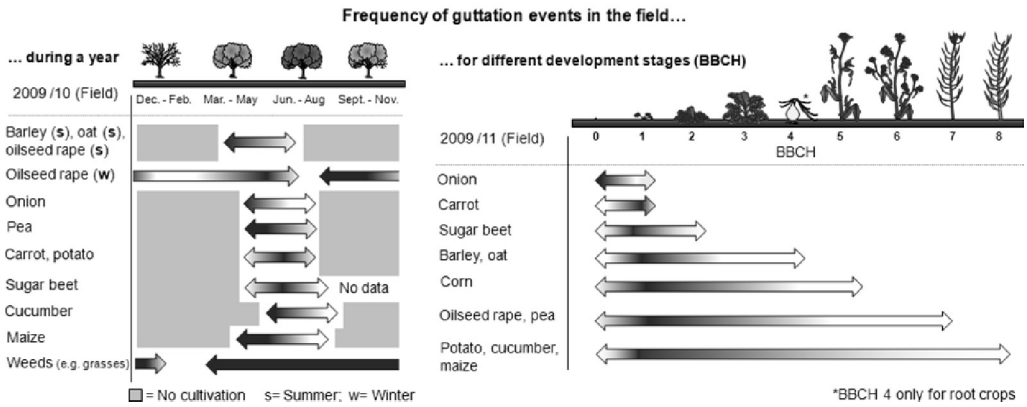

Fig. 1 Frequency of guttation events in the field based on several field studies.

For the majority of crops, guttation can be observed in greenhouse and field studies from the emergence of the seedling until the end of the leave development. Only maize, cucumber, oilseed rape and potato produced guttation droplets until the emergence of inflorescence (fig. 1). During this period the number of guttation drops increased depending on the number of leafs. Maize showed large guttation drops even under low relative air humidity, whereas guttation drops in sugar beets were much smaller and only observed under very high humidity conditions (>90%). However, oilseed rape plants produce very many small drops at a medium to high frequency and in summary more guttation liquid than maize plants with few large drops at a high frequency (tab. 2).

Tab. 2 Amount of guttation fluid of various crops in greenhouse studies, average values of all assessments (BBCH 10-19).

Crop		Oilseed rape	Potato	Maize	Barley	Sugar beet
Number of drops/plant	Mean	37	15,9	3,7	7,4	3,5
	SD	15,6	10,6	0,8	2,6	1,4
Weight of one drop [g]	Mean	0,0022	0,0042	0,0215	0,0021	0,0038
	SD	0,0008	0,0027	0,0077	0,0008	0,0066
Amount of liquid [g]	Mean	0,0814	0,06678	0,07955	0,01554	0,0133
	SD	0,01248	0,02862	0,00616	0,00208	0,00924

Taking the greenhouse results on the amount of excreted guttation fluid and the greenhouse and field studies on the occurrence of guttation into account, a classification of the intensity of guttation was created for different crops (fig. 2).

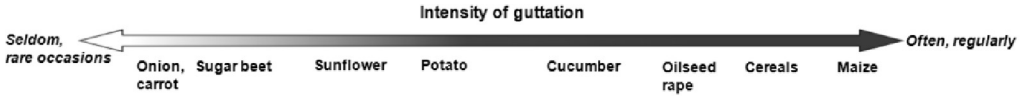

Fig. 2 Classification of the intensity of guttation of various plants based on several greenhouse and field studies.

Conclusions

A valid prognosis of the climatic conditions triggering guttation for a specific widely-grown crop is not possible yet. Even under climatic conditions suitable for guttation, guttation was only observed on 50 % of preselected observation days in investigated fields. However, during most of the year guttation occurs frequently in several crops or weeds and then usually also in many individual plants in parallel. The frequency of guttation however is particularly high in early growth stages of the crops and some plants show guttation more frequently than others. In general, monocotyledonous crops such as maize and cereals showed a higher guttation frequency than dicotyledonous crops such as sugar beets. However, some dicotyledonous crops such as oilseed rape and potato guttate more frequently. Similar results were recorded for some weeds.

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