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Variation of maize pollen shedding in North Germany and its relevance for GMO-monitoring

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Abstract

Temporal and spatial variation of maize pollen shedding and dispersal was studied near Angermünde, Brandenburg (GER) in 2010 and 2011. The maize pollen concentration in canopy height was measured with high temporal resolution in and outside of maize fields and comparisons were made between maize fields of different flowering behaviour. The results show a high temporal and spatial variation in pollen concentration. Onset of pollen shedding varied between fields in the same region and same year from mid July to the beginning of August. End of pollen shedding varied from mid to late August. The late-flowering fields tended to release pollen more compactly over 2–3 weeks. In contrast, pollen shedding of the early-flowering fields was interrupted several times due to unfavourable weather conditions, leading to pollen-shedding periods extending to over 5 weeks in the region and over 3 weeks even within the same field.

Introduction

Knowledge of the temporal and spatial variation of maize pollen release rates is a critical component for environmental risk assessment and monitoring of GMO (Aylor et al. 2003; Kawashima et al. 2005). Usually for maize pollen shedding a period of 7–14 days is assumed (EFSA 2009). Nevertheless, there is a lack of precise data mainly due to the fact that direct measurements of pollen release rates in the canopy of maize fields are difficult to perform (Viner et al. 2010).

The Hirst-type volumetric spore and pollen sampler (Hirst 1958) has been the standard device for measurements of pollen concentration in the air for many years. The method has been described in detail e.g. by the British Aerobiology Federation (1995). The device works well outside of fields and is usually operated on higher buildings in cities.

Unfortunately the trap cannot be used for measurements of maize pollen concentration inside a field in canopy height, as the vane movement would be obstructed by the nearby plants. Furthermore, the device is sensitive to turbulent wind conditions which are common in the canopy of maize fields (Shaw et al. 1983; van Hout et al. 2008). Especially greater and heavier pollen like maize pollen are no longer captured in a representative way when the direction of inlet and air movement gets out of line (Hinds 1999; Vincent 2007; Hofmann 2007). To overcome these difficulties a new volumetric sampler, the pollen monitor PMO was used allowing to measure maize pollen concentration in the canopy with high temporal resolution.

Fig. 1: The new pollen monitor PMO, a high-volume sampler with omni-directional inlet for continuous measurement of pollen concentration in the air even under turbulent conditions like inside of maize fields in canopy height or close to the field.

Methods

The maize pollen concentration in the air was measured continuously inside and outside of maize fields near Angermünde, Brandenburg (GER), in two consecutive years (2010 and 2011) using the pollen monitor PMO[1] (Fig. 1). The PMO is a high volume sampler with an omni-directional inlet operated with 1,000 l/min. A bye-pass with 10 l/min leads to an impaction unit, for which the Sporewatch[2] was taken oriented with the inlet (2 mm x 14 mm) in line of the airflow inside the tube. The pollen are deposited on a sticky tape (Silkostrip[3]) placed on a rotating drum. The device is regulated electronically and was operated in a 7-day-modus. Inside the field, the height of the inlet was daily adjusted to the height of the pollen releasing tassels in the canopy. The height of the inlet of the samplers outside of the fields was standardized to 1.8 m. The maize pollen

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2 Burkard Scientific Ltd., Uxbridge (GB)
3 Lanzoni s.r.I., Bologna (IT)

deposited on the tape were counted microscopically using the total surface equivalent to an air volume of 14.4 m^3/day. The analysis was done in transverse traverses to get hourly data of maize pollen concentration (British Aerobiology Federation 1995).

In 2010 three pollen monitors were placed inside and outside of a 110-ha maize field (A) (Fig. 2a). One pollen monitor was operated inside the field (#1) and two outside in distances of 10 m (#2) and 180 m (#3). In 2011 three fields with differences in their flowering behavior were monitored (Fig. 2b). One PMO (#4) was situated in an early-flowering field (B) and two PMOs were located in comparably late-flowering fields (#5 in C and #6 in D). Furthermore meteorological data were recorded: In 2010 two 3-dimensional ultrasound-anemometers were placed inside field A (site #1) and outside in 50 m distance. In 2011 the weather data of the nearby station of the DWD at Angermünde were used.

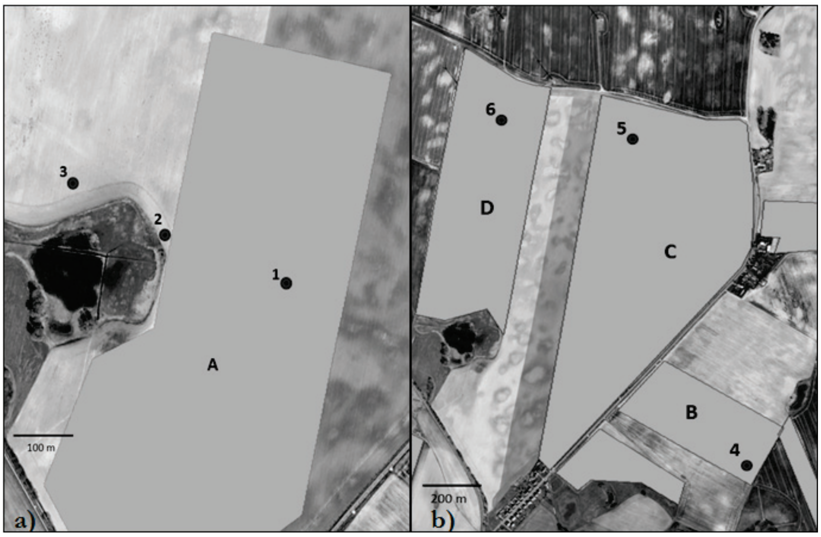

Fig. 2: Measurement sites inside and outside of maize fields near Angermünde, Brandenburg (GER): a) 2010, b) 2011.

Results

Mean daily maize pollen concentrations of field A in 2010 (#1) indicate a compact flowering period starting on August 3rd (Fig. 3) with a main pollen shedding period of 14 days until August 17th, when the pollen release declined to a medium level until the end of measurements on August 22nd. This pattern was reflected by the data of the pollen monitors #2 in 10 m distance and #3 in 180 m distance of the field edge on a respectively lower concentration level. In 2011 pollen measurements in the late-flowering fields C (#5) and D (#6) show a similar pattern of compact pollen shedding lasting from end of July (26th) to mid August (11th) over 2 ½ weeks (Fig. 4). In contrast the early-flowering field B (#4) where the pollen data record started on July 13th reveals a complex pattern of the main pollen shedding period lasting for more than 3 weeks indicating several peaks and interruptions of the pollen release rates due to unfavourable weather conditions. Overall, the results demonstrate that maize pollen shedding may last in a region for more than 5 weeks and even within a single field for over 3 weeks.

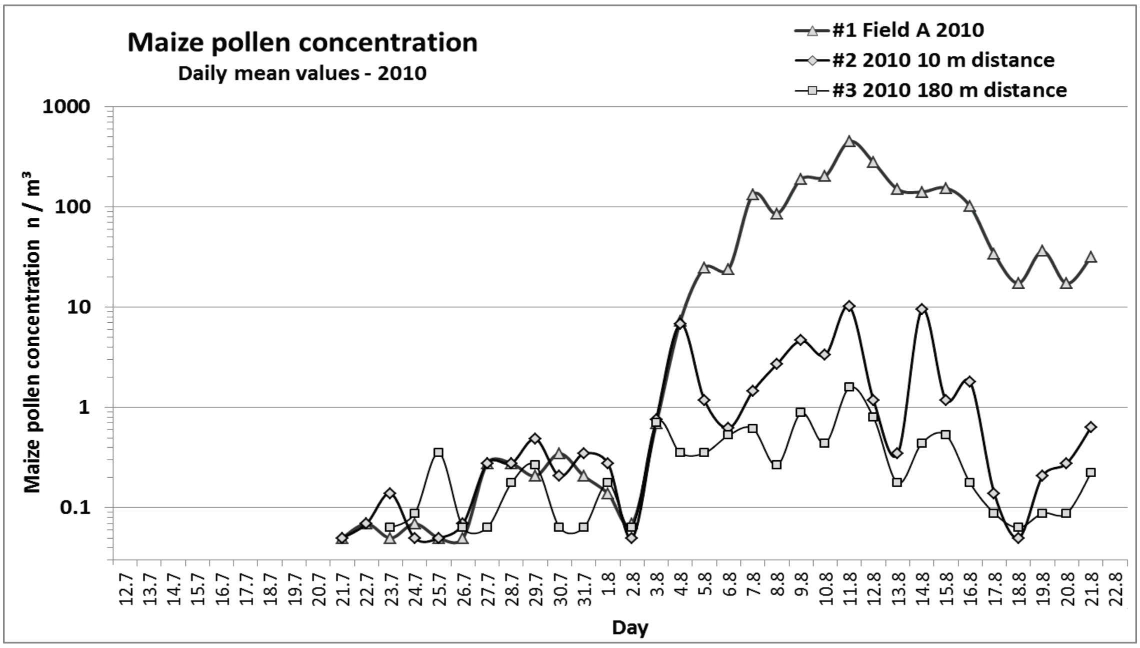

Fig. 3: Daily means of maize pollen concentration inside and outside of a maize field in 2010.

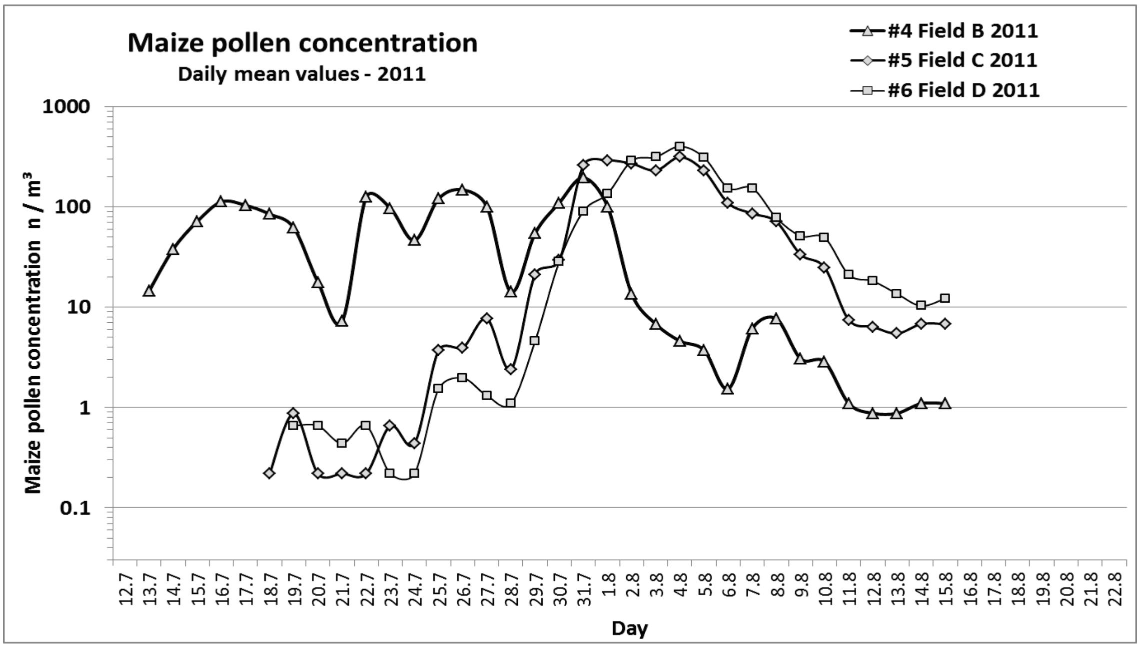

Fig. 4: Daily means of maize pollen concentration inside of maize fields in 2011. B: early-flowering maize field. C+D late-flowering maize fields.

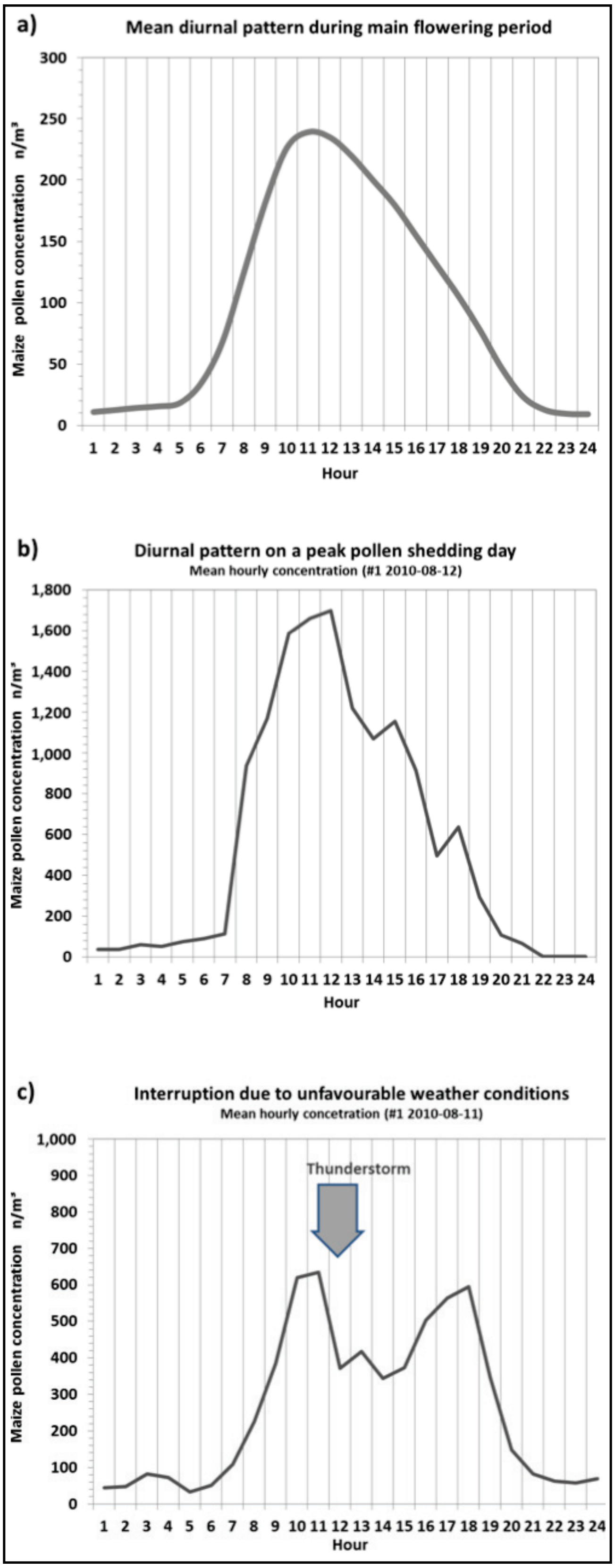

Fig. 5: Diurnal patterns of maize pollen release.

Figure 5a outlines the mean diurnal pattern over the main flowering period as mean hourly concentrations. As described in the literature, the pollen release starts in the early morning and increases rapidly with peak values around midday and declines towards the evening. Maximum pollen concentration on a peak shedding day reached more than 1,700 n/m³ per hour (Fig. 5b). Figure 5c shows the interruption of pollen release due to a thunderstorm. Soon afterward the weather improved and drying winds opened the anthers with a second peak of pollen release in the afternoon. Unfavourable weather conditions could also be identified as the reason for the interruptions in pollen release at the early-flowering field B (#4 in Fig. 4). The analysis of pollen concentration and meteorological data gave no direct correlation to temperature, humidity nor wind speed as single factors, but a positive correlation with turbulence parameters (heat flux density and friction velocity).

Discussion & Conclusions

Our results showed clearly that pollen shedding under the climatic conditions of Northern Germany may last for over 5 weeks in a region and even over 3 weeks within a single field in contrast to a 7–14 day period generally assumed in environmental risk assessment of GMO (EFSA 2009). The detailed data on maize pollen concentration reveals that frequent interruptions of pollen release occur due to unfavourable weather conditions leading to an overall extension of the pollen shedding period. The results are in concordance with earlier reports of long-term measurements of maize pollen concentration in the air at the reference station for rural areas near Ganderkesee, Lower Saxony (GER) over the years 1994 to 2007, where maize pollen could be found frequently in the air over 5–8 weeks (Hofmann et al. 2009). Also Viner et al. (2010) reported records of pollen release rates with more than one peak per day but they could not identify clearly if this was triggered by climatic factors such as temperature. Further analysis of our data on meteorology showed positive correlations of pollen release rates to heat flux density and friction velocity as parameters of turbulence. Turbulence is discussed as a main factor driving pollen release (Boehm et al. 2010).

In respect to environmental risk assessment periods of more than 5 weeks have to be taken into account for maize pollen exposure at least for climatic regions like Northern Germany with temporarily unfavourable weather conditions.

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