8.2. **QUANTIFYING AERIAL DISPERSAL OF POLLEN IN RELATION TO OUTCROSSING IN MAIZE**

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## 1. INTRODUCTION

The extensive adoption of GM crops has led to considerable controversy over the potential unwanted movement of genetic traits in the environment. Gene flow in maize can occur via seed or pollen dispersal. Dispersal via seeds can be controlled with care in handling and segregation. Pollen dispersal, on the other hand, is a biophysical process that occurs in the environment and is thus less easily managed, so that detailed understanding of pollen dispersal is important.

Maize pollen concentrations initially decrease rapidly with distance from a source, and conventional wisdom has been that there is little biological impact beyond a few hundred meters from a source. However, this is not necessarily so, since after an initial rapid decrease, pollen concentrations decrease relatively slowly with distance due to the action of atmospheric turbulence (Aylor 2003a, Aylor et al. 2003). The consequent long-extending tail has important implications for gene flow in the environment, especially from extensive source areas.

Our overall objective is to develop a quantitative model for the escape from the crop canopy, the short- and long-range dispersal, and the off-site deposition of *Zea mays* pollen that can be used to assess the importance of pollen deposition at various transport distances on the basis of gene flow and biological impact on non-target species.

## 2. MEASURED POLLEN CONCENTRATIONS

Aerial concentrations of *Zea mays* pollen grains, $C$ (grains m$^{-3}$), were measured above a 26-ha cornfield using Rotorod samplers at heights of 3, 5, and 9 m above ground level (AGL) and using remotely-piloted vehicles (RPVs) at heights of 30 to 60 m AGL. Crop height during the measurements was ~ 2.5 m.

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The RPVs are radio controlled airplanes (2.4 m wing-span) equipped with pollen traps that can be opened and closed remotely during the flight (Shields and Testa 1999, Aylor et al. 2003). Two pollen traps (one on each side of the fuselage, with each sampling ca. 7 m$^3$ (7,000 L) per minute) were operated during each sampling period. The trapping surface in each sampler was the greased underside of a standard 100-mm Petri plate.

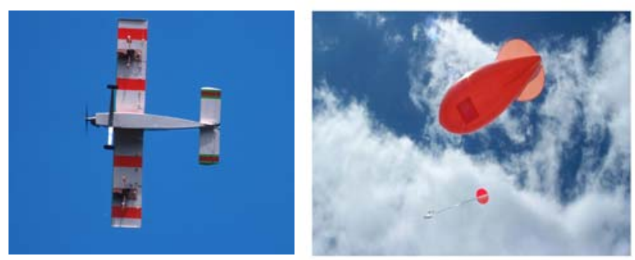

Fig. 1. a) RPV sampling maize pollen aloft. b) Tethersonde wind profiler.

Each RPV carried aloft a data logger with sensors to measure altitude and airspeed. An on-board GPS unit provided the position of the RPV, ground speed, and altitude (GPS based) every 2 to 3 seconds. Data recording was initiated on the opening of the samplers and was concluded when the samplers closed. GPS information was used to plot flight paths and altitudes during each sampling period. Sampling flight paths were perpendicular to the mean wind (determined from simultaneous wind profiles measured using a tethersonde wind profiling system (Vaisala Inc.). Time-average crosswind integrated pollen concentrations were calculated from the pollen samples.

The average maize pollen concentrations, determined from 29 measured profiles, were 254, 83, 17, 3.3, and 1.8 grains m$^{-3}$ at heights of 3, 5, 9, 30, and 60 m AGL, respectively.

## 3. MODELED POLLEN CONCENTRATIONS

We compared the observed pollen concentrations with results from a 2-D Lagrangian stochastic (LS) model (Aylor and Flesch 2001). Wind profiles required by the model were calculated using Monin-Obukov similarity, where the friction velocity, $u_*$ (m $s^{-1}$), and the Monin-Obukov length, *L* (m), were derived from 3-D sonic anemometer and tethersonde data. The value for the settling speed of maize pollen used in the model was 0.28 m $s^{-1}$ (Aylor 2002).

Overall, the LS model predicted well the observed concentrations (within the expected uncertainty). Most of the cases in which the model over- or under-predicted concentrations aloft were associated with highly unstable atmospheric conditions, where the use of Monin-Obukov similarity theory is questionable at heights of 60 m AGL. To account for this, we are currently developing a coupled canopy surface layer/ convective-boundary-layer model, described in the last section.

## 4. POLLEN VIABILITY

The ability of pollen to survive exposure in the atmosphere is critical for evaluating the impact of xenic (adventitious) pollen on seed purity. Using an *in vitro* method, we found maize pollen can survive in the atmosphere for more than 3 hr. A pollen dehydration model was derived that can predict pollen viability *vs.* exposure time (Aylor 2003a, Aylor 2004). Preliminary *in vivo* germination measurements (studies currently in progress) indicate that maize pollen can survive to germinate and penetrate the silk trichomes after even longer exposures to drying than indicated by the *in vitro* studies. Therefore, pollen survival does not appear to be a major limitation to outcrossing for distances up to several km.

## 5. OUTLOOK

The LS model results agree generally with the observations at 9, 30 and 60 m AGL but tend to underpredict the observations at 3 and 5 m AGL. This lack of agreement at the two lowest heights may have been due to variation in pollen shed across the field. We intend to quantify this variation using aerial photography. This will also allow us to address the affect on outcrossing of variation in time of flowering across the field, which can have a large effect on seed purity.

To extend our model predictions above the surface layer, we are developing a combined surface layer/convective boundary layer model. The model will have two main components:

1) a crop canopy and surface layer (CCSL) model, which focuses on pollen transport in inhomogeneous turbulence and on the details of pollen escape and deposition in the canopy,

2) a convective boundary layer transport (CBLT) model based on Luhar (2002), which focuses on pollen transport by the larger scale convective motions of the atmosphere.

These two LS models will be coupled together and run as a single predictive model by matching pollen fluxes at the interface between them which involves a straightforward matching of *u* and *w* wind component PDFs at the interface.

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