2.4

MEASURED AIRBORNE CONCENTRATION AND DEPOSITION RATE OF MAIZE POLLEN (*ZEA MAYS* L.) DOWNWIND OF AN EXPERIMENTAL FIELD

Benjamin Loubet[1 *], Nathalie Jarosz[1], Brigitte Durand[1], Xavier Foueillassar[2] and Laurent Huber[1]
[1] National Institute of Agronomic Research (INRA), France
[2] Association Générale de Producteurs de Maïs (AGPM), France

1. INTRODUCTION

There has been increasing interest recently in dispersion of maize pollen in the environment. One interesting approach that has been developed consists in statistical models calibrated with measured contamination of a target field from a genetically traceable source field (Lavigne *et al.*, 1998). However this approach is limited to the environmental conditions encountered during the experiment. An alternative approach consists in developing process-based models, such as presented in Aylor *et al.* (2001). However, there are few measurements of pollen airborne concentration to validate such models (Raynor, 1972). In this study we present experimental measurements of airborne concentration and deposition downwind of a maize field, together with standard micrometeorological measurements.

2. MATERIAL AND METHODS

The experiment took place near Paris in 2000. The experimental set-up consisted in a 20 m x 20 m maize field surrounded by a 50 m width band of bare soil (Figure 1). The maize was 2.3 m height and the tassels extended between 2.2 and 2.5 m height. The pollen production was estimated with plastic bags placed on the tassels, and changed every morning. The dynamics of the pollen emission was followed with a Burkard placed just above the tassels. Standard micrometeorological measurements (wind speed and direction, air temperature and humidity, net radiation, wetness duration) were made at 4.1 m height above the ground in the experimental field. Three ultrasonic anemometers (Gill, R2) were placed near the experimental field, in the band of bare soil, and above the surrounding maize field to estimate representative values of the friction velocity (u_*) and Monin-Obukhov length (L). Two mass balance mast were placed at x = 3 m and x = 10 m. They provided measurements of airborne pollen concentration with rotorods (McCartney and Lacey, 1991) and cup wind speed at 5 heights between z = 0.25 m and z = 4.0 m. Here, x is the downwind distance to the field, and z is the height above the ground. Small cups filled with a saline solution were placed at x = 1, 2, 3, 4, 8, 10, 16 and 32 m to estimate ground deposition of pollen. The mass balance and deposition measurements were made over periods of roughly 2 hours.

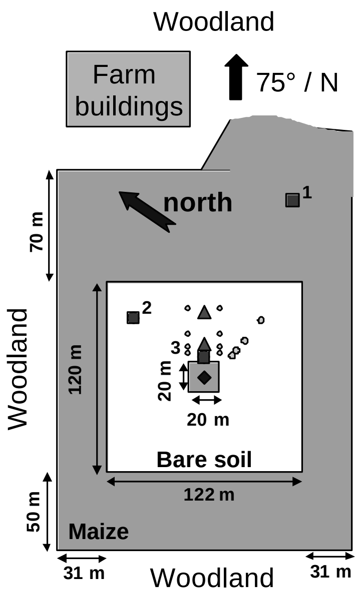

Figure 1. Experimental site. (■) Sonic anemometers, (◆) meteorological mast and continuous measurement of airborne concentration, (▲) mass balance masts, and (❍) deposition plates.

* Corresponding author address:
Benjamin Loubet, INRA, UMR–EGC,
78850 Thiverval-Grignon, France.
e-mail: Benjamin.Loubet@grignon.inra.fr.

3. RESULTS

The meteorological conditions were wet on the first half of the experiment (RH ≥ 60%) and became dryer on the second half (RH ~30% at midday). The flowering period lasted 14 days, and the maximum pollen production was 2 10^6 grains day^{-1} plant^{-1}, which corresponded to 7 10^9 grains day^{-1} for the field. The pollen emissions started increasing when the air became dryer. Emissions generally started at around 8h00 UT and lasted until 15h00 UT, with a maximum between 10h00 and 12h00 UT.

Figure 2 shows three vertical profiles of pollen concentration as measured with the rotorods at x = 3 m and x = 10 m. The concentration at these distances varied between 1 and 210 grains m^{-3} and the vertical profiles at x = 3 m generally showed a maximum at z = 2 m height, whereas at x = 10 m, the maximum was rather below z = 1 m, highlighting the decrease of the mean plume height.

The horizontal fluxes of pollen grains (F_x), estimated with the mass balance technique, were much greater at x = 3 m than at x = 10 m. These fluxes ranged from 5 to 175 grains m^{-1} s^{-1}. The integrated horizontal flux of pollen passing through the mast at x = 3 m ranged from 5×10^5 to 2×10^7 grains m^{-1} day^{-1} which is an order

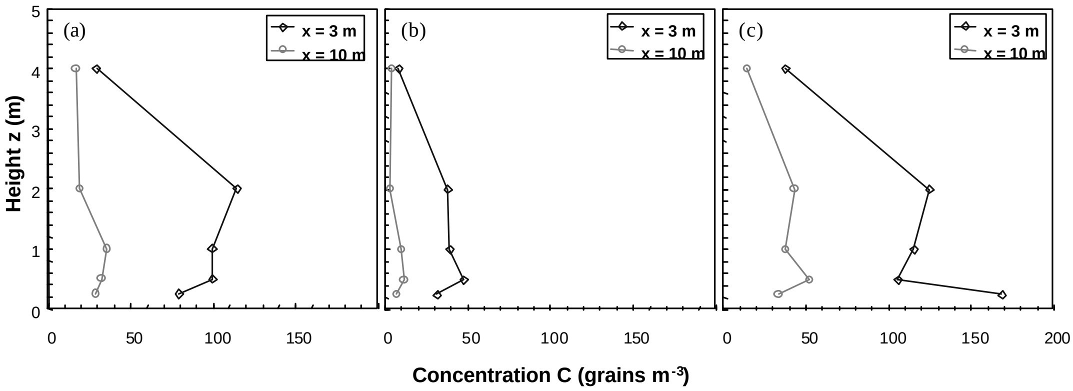

Figure 2. Vertical profiles of pollen concentration measured at x = 3 m and x = 10 m downwind of the source field with rotorods. Three typical runs are shown.

of magnitude smaller than the pollen production per meter width.

Figure 3 shows the deposition rates measured with cups located at the ground for three typical runs. It ranged between 10 and 150 grains $m^{-2} s^{-1}$ between x = 1 and 3 m, and between 3 and 10 grains $m^{-2} s^{-1}$ at x = 32 m. The maximum deposition rate was always observed between x = 1 and x = 3 m.

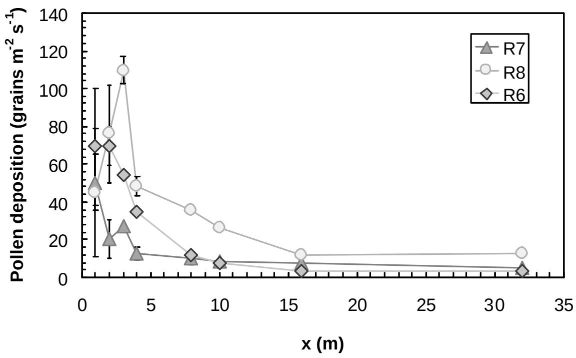

Figure 3. Deposition fluxes of maize pollen as a function of the downwind distance from the field (x), as measured with cups placed at the ground, in three typical runs. Error bars show the standard deviation over the two cups.

4. DISCUSSION

4.1. Dynamics of pollen emissions. The measured daily pattern of pollen concentration using the Burkard showed that the dynamics of pollen emissions was reproducible. The vapour pressure deficit and the canopy wetness the micrometeorological parameters that were best correlated with the dynamics of pollen emissions. However, the small number of measurements does not allow for definitive conclusions.

4.2. Comparison of the mass balance and cups estimates of the deposition rate. The deposition rate of pollen between x = 3 and x = 10 m was estimated as the difference between the mass balance integrated fluxes at these locations. The deposition estimated as such was roughly 20% smaller than the deposition measured with the cups, which suggests that the mass balance technique underestimates the deposition flux (although the fluxes above the mast are not known). Reasons for that underestimation might be linked with the intensity of the turbulent components of the horizontal fluxes (e.g., Leuning *et al.*, 1985).

4.3. Pollen deposition compared to production. The cumulated deposition between x = 0 and 32 m ranged between 100 and 1000 grains $m^{-1} s^{-1}$. These deposition rates measured over 2 hours can not be directly compared with the pollen production, which was estimated on a daily basis. However, the numbers are consistent in the sense that the pollen production of the field divided by the width of the field is of the same order as the deposition rate

5. CONCLUSIONS

A similar experiment has been made in 2001, during 4 weeks, where about 40 runs have been recorded. These new data will be used to better understand the links between the pollen emissions and the micrometeorological conditions. A model such as presented in Aylor *et al.* (2001), will be validated against these data, and will be used to better estimate the fraction of pollen grains deposited locally, as well as to study the turbulent components of the horizontal flux of pollen.

REFERENCES

Aylor, D. E., and Flesch, T. K., 2001: Estimating spore release rates using a Lagrangian Stochastic simulation model. *J. App. Meteorol.*, **40**, 1196-1208.

Lavigne, C., Klein, E. K., Vallée, P., Pierre, J., Godelle, B., Renard, M., 1998 : A pollen dispersal experiment with transgenic oilseed rape. Estimation of the average pollen dispersal of an individual plant within a field. *Theoretical and Applied Genetics*, **96**, 886-896.

Leuning, R., Freney, J. R., Denmead, O. T., and Simpson, J. R., 1985: A sampler for measuring atmospheric ammonia flux. *Atmos. Environ.*, **19**, 1117-1124.

McCartney, H. A., and Lacey, M. E., 1991: Wind dispersal models of pollen from crops of oilseed rape (*Brassica napus* L.). *J. Aerosol Sci.*, **22**, 467-477.

Raynor, G. S., Ogden, E. C., Haynes, J. V., 1972: Dispersion and deposition of corn pollen from experimental sources. *Agronomy Journal*, **64**, 420-427.