DARCOFenews

Newsletter from Danish Research Centre for Organic Farming • June 2004 • No. 2

Articles in this issue

Wind dispersal of genetically modified pollen from oilseed rape and rye fields

By **C. Geels**, **P. Løfstrøm**, **L. M. Frohn**, **J. Brandt** and **G. Kjellsson**, National Environmental Institute, Denmark

The increasing use of genetically modified plants (GMP) has opened up for a discussion about the problems related to the co-existence of GM and non-GM crops and especially the consequences for organic farming. One of the objectives of DARCOF project **TOPRO** (Tool for protection against contamination by GMO) has been to develop specific modelling tools, which can be used for the prediction of dispersal of GM pollen under different conditions and for investigating measures to limit the GM dispersal to organic fields.

Dispersal of pollen

The focus has been on wind dispersal of pollen from winter oilseed rape (*Brassica napus*) and winter rye (*Secale cereale*), which are wind-pollinated crops. Insect pollination is also important for many types of crops (including oilseed rape), but the precise importance of wind versus insect pollination is often not well determined. In order to assess the potential risk for gene flow among crops, it is therefore important to increase our knowledge about the biological and physical processes driving the pollen dispersal for a given crop.

In this study a dispersion model is used to investigate the potential for wind dispersal of GM pollen and quantify the ratio between the concentration of GM and non-GM pollen over a given field. Over a non-GM field this ratio can be assumed to be proportional with the GM pollination and hence with the probability of unintended GM content in the crop (i.e., adventitious presence). In the following the applied model is described and examples of the results and future applications are presented.

A new pollen model

The OML-DEP model is based on the Operational Meteorological Air Quality Model, which has been developed and improved throughout the years at the National Environmental Institute in Denmark (Berkowicz et al., 1986; Olesen et al., 1992). The OML model is a modern Gaussian plume model suitable for detailed studies of dispersion of tracers in the atmosphere within 20 to 30 km from the source. The newly developed pollen version of OML-DEP now includes:

- the emission of pollen from area sources (e.g., cultivated fields)
- the subsequent dispersion of pollen in the atmosphere due to the wind and the turbulent mixing processes in the lowest part of the atmosphere

Simulating root growth

Nature conceptions, management and cross-compliance in organic farming

Wind dispersal of genetically modified pollen from oilseed rape and rye fields

Brief news

Front

- the removal of pollen due to both gravitational settling and dry deposition.

Temporal and regional variation in pollen dispersal

The model needs an input of meteorological parameters, which in the current study is obtained from the meteorological model Eta (Nickovic et al. 1998; Brandt et al. 2001). Currently the OML-DEP pollen model simulations have been performed for five pollen seasons in the period 1999 to 2003. Thereby the possible variations in the pollen dispersal as a function of the year to year variations in the meteorological data can be analysed.

In order to study a similar effect of regional differences, the model simulations have been carried out for three locations in Denmark (Tange, Øster Højst and Lille Valby) for the five seasons included. Information on, e.g., the temporal variation of the emission of oilseed rape and rye pollen as well as on the settling velocity was found in the literature.

Model estimates of the spatial distribution of oilseed rape pollen at the three locations and for the five seasons indicate that the dispersal of pollen varies significantly due to the temporal and regional differences in the meteorological conditions. The dominating wind direction has a large impact on both the concentration level and the spatial distribution of pollen, but also the variations of the turbulent conditions in the atmospheric boundary layer (ABL) are seen to be important for the dispersion. The ABL is defined as the lowest part of the atmosphere where eddies (turbulence) are formed due to convection and friction at the surface. Turbulence can then lead to an effective mixing of pollen in the ABL depending on the local heating, the wind speed and the roughness of the surface. The potential for wind dispersal will therefore vary on both short and long time scales depending on local conditions, which all in all makes a general assessment of the probability for pollen dispersal more complicated.

Varying the size and distance between fields

Model simulations for different field sizes and distances between GM and non-GM fields have been carried out. The results are displayed as a group of curves of the percentage GM pollen over a non-GM field.

In the example for oilseed rape **(figure 1)** the GM percentage is calculated for the dominating westerly wind direction at Tange in the 2001 summer season (hence illustrating a worst case scenario). The curves can be used as a simple additive tool to estimate the risk of GM spreading during the planning or managing of, e.g., an organic field for co-existence in an area with GM crops or vice versa.

If, for example, a GM content less than 1% is required in the pollen over a 4 ha organic field, the distance to a 16 ha GM field should be at least 600 m. In case of a smaller GM field of 4 ha, a separation distance of 250 m is required. In the occurrence of several GM fields in the area this estimate is simply repeated for each field and then added to get the total GM contribution over the organic field.

Generally the model results indicate that the separation distance between fields is the most efficient parameter for minimising the amount of GM pollen over a non-GM field. Regarding the size of the fields the results show that for distances larger than 400 m the size of the GM (donor) field is more important than the size of the receiving non-GM field. Overall, a small GM field will lead to a small GM content in the pollen over a large organic field, while the potential for GM dispersal is larger when small organic fields are located in an area with large GM fields.

The equations shown in **figure 1** can be used to estimate the GM percentage (Y) at larger distances (X). In the case of an organic field of 4 ha and a large (16 ha) GM field, the GM contribution can be estimated to be about 0.15% at a separation distance of 3000 m.

Detailed scenario calculations for a test area in Denmark

The OML-DEP model has also been applied for more detailed scenario simulations for a test region in Bjerringbro-Hvorslev in Denmark. Based on information on the distribution of crop types and field sizes (from Tolstrup et al., 2003), these simulations give a view of the importance of the distribution of oilseed rape fields in the landscape with both GM and non-GM crops.

Similar model calculations have been done for rye where two scenarios of basic (250 m) and extended (1000 m) separation distances have been included, see **figure 2A** and **figure 2B**. Here a 50% GMP scenario is assumed (50% GM and 50% non-GM rye) with 10% rye cultivation out of the 65% of this area used for agricultural purposes (Tolstrup et al., 2003; Dalgaard & Kristensen, 2003). It is assumed that the percentage of GM pollen in the atmosphere above the non-GM fields reflects the maximum GM contribution to the final crop (worst case).

The results indicate that the rye crops in the non-GM fields will have a lower GM content than the proposed EU limit in conventional cross-fertilised seed (0,3%) and food (0,9%). As seen in **figure 2A** and **figure 2B** this is true for both separation distances. However, the lower detection limit of 0.1% which may apply to organic crops is potentially exceeded in case of a separation distance of 250 m

Generally these model simulations support that applying a separation distance between GM and non-GM fields is the best method to limit the spread of GM to non-GM crops. The distribution of the fields within the landscape and the dominating wind direction in the region are, however, also important parameters for the total dispersal of pollen and hence for the spread of GM.

The more detailed model simulation with OML-DEP is only possible if information on the local distribution of fields and crop types as well as meteorological data is available. Thereby, the OML-DEP model can be used to investigate the potential for GM spreading by pollen in a specific region with a specific composition of crops. By including local meteorological information covering several years this method gives a more detailed view of the potential for GM dispersal in a given area than the more general additive approach described above. This method can for example be used before release and cultivation of GM crops to study the effect of special separation distances in specific regions in Denmark or other countries based on the local conditions.

References

Berkowicz, R., H. R. Olesen & K. B. Gislason (1986): The Danish Gaussian air pollution model (OML): Description, Test and sensitivity analysis in view of regulatory applications. In: Air pollution Modelling and its applications, pp. 453-481, NATO-CCMS, vol. 10, Plenum Press, New York.

Brandt, J., J. H. Christensen, L. M. Frohn, F. Palmgren, R. Berkowicz & Z. Zlatev (2001): Operational air pollution forecasts from European to local scale, Atm. Env., Sup. No. 1, pp. S91-S98.

Dalgaard, T. & I. T. Kristensen (2003): Udbredelsen af udvalgte afgrøder i Dansk landbrug 2002. Notat vedrørende dyrkning af genetisk modificerede afgrøder, Danmarks JordbrugsForskning, 31s.

Nickovic, S., D. Mihailovic, B. Rajkovic & A. Papadopoulos (1998): The Weather Forecasting System SKIRON, Vol. II, Description of the model, Athens June, 1998, pp. 228.

Olesen H. R., P. Løfstrøm, R. Berkowicz & A. B. Jensen (1992): An improved dispersion models for regulatory use - the OML Model. In: Air pollution

Modelling and its applications, pp. 29-38, Plenum Press, New York.

Tolstrup, K., Andersen, S.B., Boelt, B., Buus, M., Gylling, M., Holm, P.B., Kjellsson, G., Pedersen, S., Østergård, H., & Mikkelsen, S.A. (2003): **Report from the Danish Working Group on the co-existence of genetically modified crops with conventional and organic crops**, DIAS report Plant Production no. 94. Danish Institute of Agricultural Sciences., Tjele.