POLLEN GRAINS TRANSPORT AND DISPERSION – FIELD EXPERIMENT AND NUMERICAL SIMULATION COMPARISON

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INTRODUCTION

The field experiment and subsequent numerical simulation were initiated because of need on data for coexistence rules and practical guidelines when genetically modified crops will be introduced. There is a serious interest to set up the correct threshold distances between locations with GM plants, close relative plant species, and conventional crops to avoid transgene flow. One possible approach is to use some mathematical model describing the transport and dispersion of particulate matters of the same qualitatively and quantitatively parameters as pollen grains of genetically modified plants.

The knowledge on actual gene flow is very unsatisfactory and data are limited. In addition the existing data vary in a very wide range which is due to the closely restricted conditions of field trials and the great variety of the affecting factors (*Boudry et al.*, 1993, *Delanoy et al.*, 2000, *Lavigne et al*., 2002).

The *Beta* complex in Europe consists genetically diverse forms of the species *Beta vulgaris* L. that occur as crops, wild plants and weeds, all of which are to a degree genetically compatible. Since transgenic sugar beets and conventional cultivars hybridize with wild and weed beets, the monitoring of pollen-mediated gene flow is an important task of biosafety research. Weed beet which descends from both wild-crop hybrids and from crop plants have been allowed to produce and shed seed, both reduces yield of the sugar beet crop and introduces impurity in the harvested tubers, its actual impact in these respects varying greatly with locality in Europe (Saeglitz *et al*., 2000). The wild forms should be preserved, both for their intrinsic value in the maritime flora and as a continuing source of genetic material for plant breeding (*Biancardi et al*., 2005).

MATERIAL AND METHODS

The experiment took part in the sugar beet field located in the NE part of the central Bohemian area in Lustenice (14°57,6032´E, 50°18,0421´N). The data from this experiment are compared with those from numerical simulation. To validate the mathematic model results data from the field experiment are used.

Field trial design

In a field trial, the possibility of crosses between red and weed beet was tested by measuring the frequency of pollinated weed beet plants placed at different distances and directions from a pollen source. As the pollen source, diploid red beets were used that carry a dominant trait – red colour. Four diploid acceptor plants were positioned surrounding a field donor site containing 150 plants. The red beet plants were sown in two 14-days intervals to reach overlapping of flowering period. Bait plants were placed in directions north, west, south, east at distances 1.5, 3, 6, 12, 25, 50, 75 and 100 m from the donor plants. Moreover, in order to reduce the spread of foreign beet pollen in the experimental field, at regular intervals other *Beta* species were removed by hand in a trial. After the harvest at the end of the vegetation

period in September, seeds were dried and later let to germinate. The frequency of gene flow from the red beets was calculated as the percentage of individuals having the red colour of its root, hypokotyl or even stem.

Mathematical modelling approach

Area where the field experiment occurred is almost flat one with very moderate slopes. The difference between the highest point and the lowermost one is approximately about 10 meters. The only obstacles are buildings located far from the place where the experiment took place. These buildings are low and their positions do not affect the flow field with some wake effects. This geometry allowed us to use the dispersion modelling together with some more sophisticated approach.

The standard formula for particulate matter concentration estimation has been used in the dispersion modelling approach. Pollen particles were of two size categories – one for the particles above 20 μm in diameter and the second category for those less than 20 μm in diameter. The first category counted 95 per cent of emitted particles, the rest created the second category. Wind rose for the period when pollination could occur has been created with the Czech Hydrometeorological Institute (CHMI) for this area from the available data. This wind rose is shown on the Figure 1.

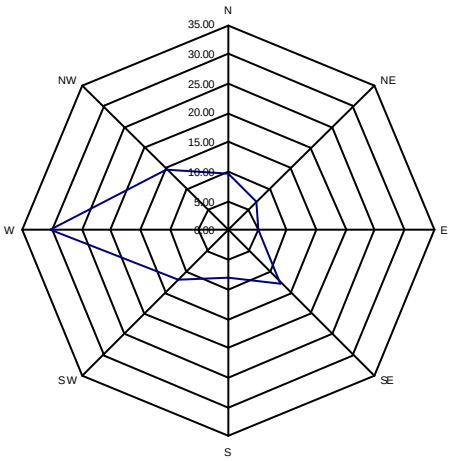


Fig. 1; Wind rose for Lustenice field experiment.

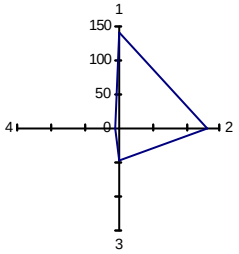
The second approach we would like to use is that based on artificial compressibility method (see, for example, *Drikakis, D. and Rider, W.*, 2004) for the reconstruction of the flow field together with the diffusion–advection equation for the transport and dispersion of pollen grains. Such an approach could be applicable in the areas with more complicated orography and hera it could be tested against the field experiment and the approach based on standard Gaussian dispersion model results.

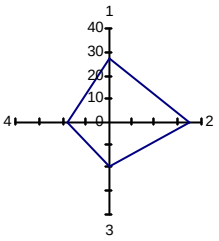
RESULTS

Although the weed beet plants flower for a longer period, there was sufficient overlap to allow crosses between them and red beets.

Comparison of the dispersion modelling results with the experimental data can be seen of the following Figures. On the left figures the experimental results show the absolute number of successful pollination events in a given distance and the right figures show the computed

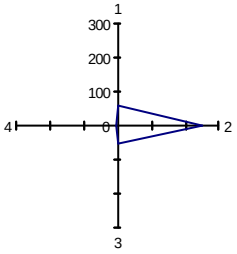
results in per cent. On the Figure 2 the comparison for the distance equal to 6 m from the source is shown. Next Figure 3 shows the same for the distance 12.5 m and the Figure 4 depicts the comparison for the distance 50 m. The model results distribution for far distances display greater symmetry in comparison with experimental data - this effect can be seen also on the Figure 4 for the distance equal to 100 meters from the source.

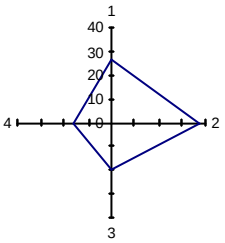




Experimental Data *Computational Results*

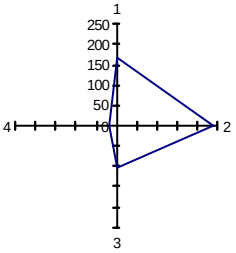
Fig. 2; Distance 6 m from the source in per cent.

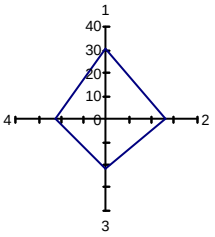




Experimental Data *Computational Results*

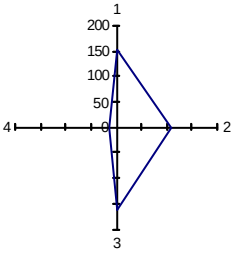
Fig. 3; Distance 12.5 m from the source in per cent.

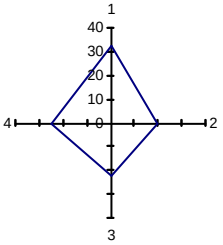




Experimental Data *Computational Results*

Fig. 4; Distance 50 m from the source in per cent.





Experimental Data *Computational Results*

Fig. 5; Distance 100 m from the source in per cent.

Now we are preparing data for the next computational approach that will use the artificial compressibility method. But at this moment results are not available yet.

DISCUSSION AND CONCLUSION

In the beginning of this paragraph it has to be said that there are many uncertainties which can affect the experimental results and they cannot be involved into the computational procedure. The first one can be related with the role of insects in the pollination process. Another one is more general. The wind rose used covers the whole possible pollination period (June and July) but the pollination process cannot be of the same intensity for the whole period. Also the impact of moisture of the pollen grains and their weight could play an important role especially in the changing weight and changes of the sedimentation velocity. All these factors have not been involved into the computation. From the results it is evident overestimated symmetrical distribution especially in the greater distances from the pollen grains source.

In the European Community in seed beet production, the recommended minimum distance from neighboring pollen sources of the genus *Beta* is at least 1000 m (Council Directive 2002/54/EC). The pollen transport over 1000 m distance was much lower than 1%. In the cases of plants, theirs pollen grains are the same qualitative and quantitative parameters as the donor plants, than the 1000 m distance ensures lower threshold of pollination than 1%.

ACKNOWLEDGEMENT

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