Spread of genetically modified (GM) oilseed rape – Relevance for Schleswig-Holstein Land, Germany

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I. Introduction

Commercial cultivation of GM oilseed rape (OSR) will soon be taking place on a large scale. OSR cultivation plays an important role in Schleswig-Holstein (SH). How will transgenes spread in the specific cultivation situation in SH? To what extent will other cultivation systems and land use options be affected?

These and other questions were the reason for developing a range of methods including computer modelling and spacial analysis. The methods aim at a small-scale description of processes involved and a large-scale transfer of results. The work is carried out within the joint research project 'Generic Methods of Investigation and Extrapolation of Oilseed rape Dispersal (*Brassica napus* L.)' (GenEERA) and is funded by the German Ministry of Education and Research (BMBF). A key element is the development of a simulation model that integrates existing knowledge on biological fundamentals and transgene spread over space and time. The development of cultivated, volunteer and feral OSR as well as wild relatives is calculated for typical spacial units covering 1 km². For SH-specific calculations, information on climate, cultivation intensity, management practices and regional cultivation systems are also taken into account. A further element consists of a large-scale spacial analysis which results in a field map of SH which also includes information on land use, ownership and production systems.

II. Results

The model results shown here represent three different aspects of transgene spread.

1.) Effects on the direct neighbourhood and region around GM OSR cultivation

In figure 1 model results of GM OSR contents in the harvest of conventional OSR fields grown in the direct neighbourhood of GM OSR fields are presented. The level of contamination decreases clearly with the size of the conventional OSR field.

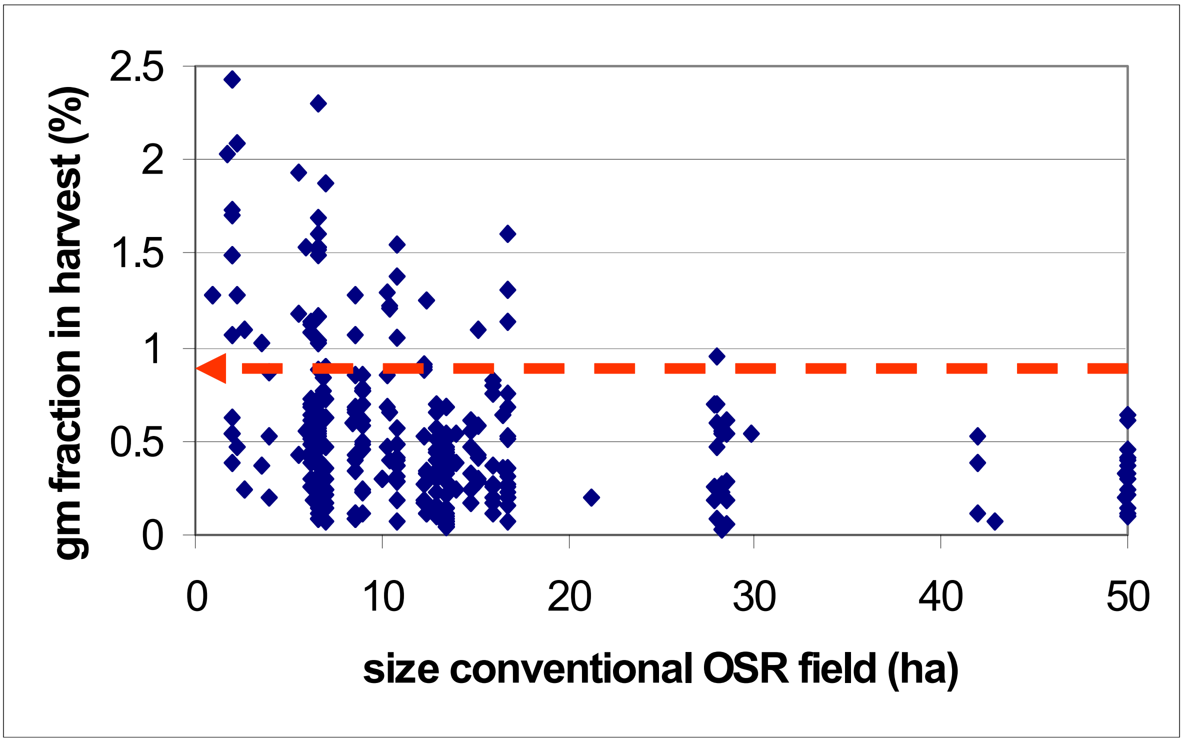

Fig. 1: Model results of GM OSR content in crops of conventional OSR fields (%) in the direct neighbourhood of GM OSR fields in ratio to the size of the conventional OSR field (ha.)

Due to naturally varying self-fertilisation rates and spacial constellations, the results fluctuate considerably. For the field size classes of up to 5 ha., 5 – 10 ha., 10 – 15 ha. and 15 – 30 ha. the threshold value of 0.9% is exceeded with decreasing frequency, i.e. 65%, 21%, 8% and 9% of the model observations. In one of twenty-three observations (i.e. 4%), a GM OSR content of just over 0.9% was even reached for field sizes of 20 – 30 ha. The average values for various size classes fall below the threshold value with the exception of fields of 5 ha. and smaller.

2.) Transgene spread in the course of time

With regard to how quickly the transgenes spread, the seed persistence of OSR is of particular importance. The relevance of this process goes beyond the fact that conventional harvests are affected by previous GM cultivations.

Due to seed persistence in the soil, the spread of OSR in the course of time is another important aspect. Just one GM cultivation can, as shown in Fig. 2, mean that the following conventional cultivations may be subject to labelling for several years. The graph shows the development of the seedbank after just one GM cultivation. The example taken is that of a three-year (one year winter OSR, two years winter corn) and a four-year (winter OSR and three years winter corn) crop rotation.

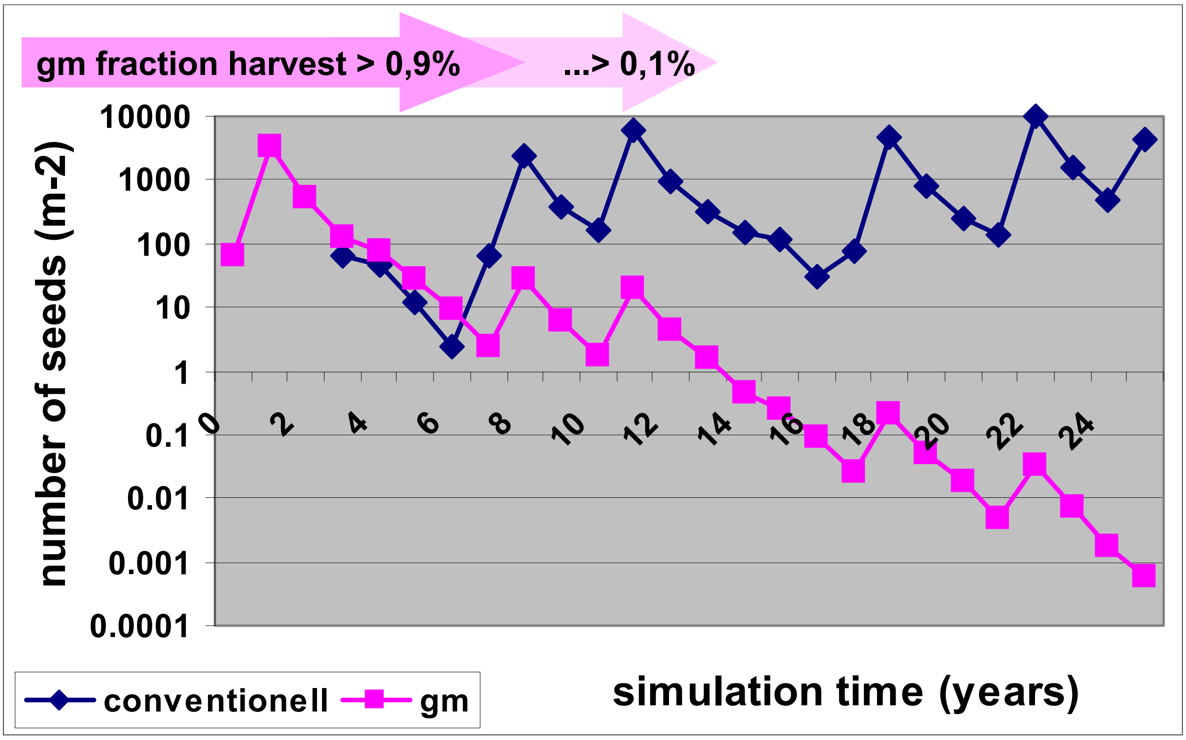

Fig. 2: Example of model result of seed bank (number of seeds m^{-2}) of GM (squares) and conventional OSR (rhombuses) after one cultivation of GM OSR over a simulation period of 25 years. In subsequent conventional OSR cultivations, GM fractions of more than 0.9% or 0.1% in the OSR crop can occur over a certain period (arrow at the top edge of graph).

Refreshment of the GM seedbank – see Fig. 2, simulation years 9, 12, 15, 23 – is the result of the volunteer GM OSR plants in the years in which the cultivation of conventional OSR (sowed every 3rd/4th year) was modelled. This delayed reduction in the GM seedbank extends the period in which the following harvests have to be labelled pursuant to the EU guideline. According to the calculations, the threshold value of 0.9% GM OSR content in the crop yield can be exceeded for up to approx. 8 years (see Fig. 2) and, in extreme cases, for as long as 15 years. The fluctuations arise, for example, from the varying harvest losses or post-harvest management.

3.) Gene stacking

Temporal spread is also a basis for the emergence of multiple transgenes. The creation of multiple transgenes, i.e. plants in which several transgenes are accumulated due to the hybridisation of different transgenic varieties, is important because these plants can appear on open land without having previously been subjected to a risk assessment. There are publications from Canada with examples of the occurrence of oilseed rape plants resistant to several herbicides. We have reconstructed such an example (Hall et al. 2000) in the model. It proves that triple-resistant genotypes can develop within one year if, on three neighbouring fields or field sections, three oilseed rape varieties with different herbicide resistances are grown directly next to one another (here, two GM varieties with glyphosate- or glufosinate-resistance, as well as one conventional imidazolinone-resistant variety).

III. Discussion

The model calculations show that growing GM OSR in the direct neighbourhood of conventional OSR – free of GM plants – is not possible. Only in the case of fields which are much larger than 25 ha. can it more or less safely be excluded that the threshold value of 0.9% for labelling is exceeded. In SH, only 0.23% of the fields are larger than 25 ha. (MUNL 2002). As 73% of the fields are smaller than 3 ha. and 97 % are smaller than 10 ha., this means that agreements are to be reached on which cultivation system is to be used or isolation areas laid down for almost all fields.

This is the case if there is a neighbouring GM cultivation only once. If there should be repeated GM cultivations, the figures for the GM OSR content would be higher. Higher values can be reached over the time as the GM content can accumulate over the years. The high variability of the outcrossing process in itself and the fact that transgenes accumulate over the years, would make it seem advisable to stipulate a regional separation of GM and GM-free OSR cultivation.

Due to the persistence of OSR seeds in the soil, just a one-time GM cultivation can cause problems with the following conventional OSR crops. The temporal spread results, on the one hand, in the GM content in the conventional harvests making labelling necessary for a number of years. On the other hand, the transgenic volunteer plants favour the development of multiple transgenes. Within the areas with GM OSR cultivation, the spacial distances and the varieties selected should therefore be discussed and agreed on in order to prevent the emergence of non approved multiple transgenes.

With the results selected here, it is possible, among other things, to depict the potential effects of threshold values at local and regional level. An area-wide picture is at present being drawn up, taking the complex and indirect spacial and temporal interactions into account, and will be available on conclusion of the project in the spring of 2004. With the methods developed in the GenEERA joint research project and the regional SH study, there are now new fundamentals available for describing the spread of transgenes and for planning the legally prescribed GMO monitoring, extensive effect analyses (life cycle assessment) and cost-benefit analyses of GMO cultivation. For this purpose, further concrete findings and calculations at local and regional level are of fundamental importance.

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V. References

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