ADVISORY COMMITTEE ON RELEASES TO THE ENVIRONMENT

Advice on scientific issues concerning the proposed regime for the coexistence of GM and non-GM crops

Date: 15 September 2004

A. Introduction and background

1. Proposals are currently being developed for a regime to allow the coexistence of GM and non-GM crops, on the assumption that GM crops will be grown commercially in the UK at some point in the future. Government is holding a series of expert workshops over the summer, and will then publish a formal consultation document in the autumn.

2. As set out in the policy statement made by the Secretary of State earlier this year[1], the prime focus of the proposal will be on measures to ensure that farmers growing non-GM crops will be able to produce harvested product that contains less than 0.9% GM material. This product can then be marketed without labelling. Current focus is on oilseed rape, maize, beet and potato and on farm-to-farm coexistence rather than within-farm or in-field coexistence.

3. The general principle behind the measures proposed is to consider the routes whereby GM material may appear in fields where GM seed has not been sown, and to estimate the magnitude of GM presence expected via particular routes. The routes of transfer being considered are:

    - Adventitious presence of GM seed in the non-GM seed sown
    - Cross pollination with a nearby GM crop
    - Cross pollination with nearby populations of GM volunteers or feral crops
    - Cross pollination with nearby populations of crop wild relatives that carry GM constructs through previous crossing with a GM crop
    - Transfer of seed via shared farm machinery

   The aim is to ensure that cross pollination with a nearby GM crop is managed (using isolation distances and/or barrier crops) such that the total amount of GM material in the harvested non-GM crop is below 0.9%.

4. In order to ensure that the measures proposed are on a secure scientific footing, ACRE was asked to consider three issues, as outlined in paragraphs 5-7.

5. *Multiplication of seeds within fields.* The threshold for adventitious presence in non-GM seed represents the minimum GM presence that can be guaranteed in a non-GM crop, if all other routes of entry of GM material are zero. As such these figures represent the baseline starting points for consideration of coexistence measures. However, it is possible that the GM presence in harvested grain from a field sown with seed containing GM seed below the adventitious presence

[1] Text available at http://www.defra.gov.uk/corporate/ministers/statements/mb040309.htm

threshold may actually be higher than the threshold as a result of out-crossing within the field.

6. *Calculation of isolation distances.* The calculation of appropriate isolation distances, either using separation or barrier crops, is central the management of the entry of GM material into non-GM fields through cross pollination. Defra has commissioned the National Institute of Agricultural Botany (NIAB) to carry out a synthesis of the available data on the use of separation distances and barrier crops in order to update their previous work used to set separation distances for the Farm Scale Evaluations

7. *Role of volunteers, feral populations and wild relatives.* Volunteers, feral populations and sexually compatible wild relatives represent routes whereby GM traits present in seed sown in previous years could enter non-GM crops via cross pollination. Given the biology of the crops under consideration, these issues would only seem to be important for oilseed rape. The reasoning for this is that maize does not form volunteers or feral populations, and the harvested material for beet and potato does not result from cross pollination. In the case of oilseed rape volunteers, feral populations and wild relatives could all represent potential reservoirs of GM traits.

B. Advice

8. In considering issues associated with the coexistence of GM and non-GM crops, ACRE's aim is to provide ministers with validation of the scientific principles and approaches underpinning the design of coexistence measures. In particular the Committee stresses the following general points:

    - ACRE does not consider coexistence to be a safety issue. Any GM crops that are given approval for cultivation in the EU will have been through a thorough and careful risk assessment process and will have been deemed to confer no additional risks to human health and the environment compared with their conventional counterparts. There is no reason, on safety grounds, for the segregation of approved GM crops from non-GM crops; coexistence measures are a matter of consumer choice only.

    - In formulating this advice ACRE have been mindful of the thresholds for adventitious presence of GMOs in non-GM material set down in EU legislation. However, the Committee has not considered the appropriateness or otherwise of these thresholds. The thresholds are not related to issues of risk and safety, but relate to consumer choice. As such, the value at which the labelling threshold is set is a matter for political, rather than scientific judgement. The Committee notes that scientific principles are involved in setting other thresholds that follow from the primary labelling threshold (e.g. the thresholds for adventitious presence of GMOs in non-GM seed), and that elements of the following advice may be helpful in setting such thresholds.

Multiplication of seeds within fields

9. The Committee was asked to consider whether adventitious presence of GM material in seeds might lead to a greater presence in harvested seed than in the sown seed as a result of crossing between the GM and non-GM plants within the field. The Committee concludes that there are a number of factors that influence

the relationship between presence in harvested material and the presence in sown seed.

10. A first important consideration is the basis on which the presence of GM material is stated. There are two possible approaches for the description of percentage GM presence in a batch of seed or grain. The first is on a seed number or weight basis – if there are 100 seeds how many of them are GMOs. The second approach is to compare the number copies of GM-specific DNA with the number of copies of a DNA sequence that is found in the non-GM version of the organism. If GM presence is expressed using the second approach then the presence in the harvested grain will always be the same as that in the sown seed, assuming that the GM plants are equally viable and no further GM material enters the field during cultivation.

11. If GM presence is expressed as a percentage of individual seed containing a GM event, it is possible that the proportion of GM grain in harvested grain could be greater than that in the sown seed. This is because pollen from the small number of GM plants could fertilise non-GM plants, leading to the production of seed containing GM events being harvested from non-GM plants. There are two key factors influencing the magnitude of this effect – the genetic state of the GM event, and the extent to which the crop in question is self fertile.

12. In plants containing a single GM event present in the homozygous state, all of the male and female gametes will contain the GM event – this means that that all of the seed on the GM plants will contain the GM event and some seed on the non-GM plants will result from pollination by pollen containing the GM event. However if the GM event is present in the hemizygous state (one copy of the GM event for each pair of haploid genomes), then only half of the female and male gametes from the GM plants will contain the GM event. Other possible states for the GM event (e.g. multiple copies of events that are not genetically linked) will result in different proportions of the gametes containing the GM event.

13. For a crop with no out-crossing, the GM presence in harvested grain will never be more than that in the sown seed, since pollen containing the GM event will not fertilise non-GM plants. For crops with higher rates of out-crossing, the extent to which non-GM plants will be fertilised by pollen containing the GM event increases.

14. A simple calculation taking into account these two factors is outlined in Annex A. The approach illustrated has been used to calculate the factor by which GM presence in harvested grain is likely to increase relative to the presence in sown seed for maize and oilseed rape for a selection of genetic states, and the resulting values are presented in the following table. The figures in bold in this table correspond to those expected for the presence of the GM maize and oilseed rape used in the Farm Scale Evaluations (T25 maize and Ms8xRf3 oilseed rape, respectively).

Genetic state of GM event(s)	Crop species	
	Maize[2]	Oilseed rape[2]
1-event homozygous	1.95	1.1-1.5
2-event unlinked F1 hybrid	1.47	**0.99-1.22**
1-event hemizygous	**0.99**	0.77-0.87

15. This analysis reveals that the relationship between adventitious GM presence in seed sown and GM presence in harvested yield needs to be considered on a case by case basis. The issue is simplified by describing GM presence relative to the number of host genomes present, in which case the GM presence in harvested yield is the same as that present in seed sown for all species and all combinations of GM events.

Calculation of isolation distances

16. ACRE has considered the approach being used by NIAB in making recommendations to Defra concerning the relationship between distance and cross-pollination frequency. In considering the analysis of NIAB, the Committee is concerned primarily with assessing the validity of the approach taken. The Committee does not recommend particular separation distances in this advice, as these will depend on, among other things, the overall approach being taken to coexistence and the thresholds that are set for the adventitious presence of GM seed in non-GM seed.

17. The Committee considers the approach being taken by NIAB is fit for purpose. While the Committee notes that the analysis emphasised uncertainties that may possibly be rare, this is a reasonable approach in the provision of separations distances that are likely to deliver the required thresholds of GM presence in a robust and reproducible manner. It is clear from the analysis that a range of factors, including field size and shape, topographical features and crop variety, will influence the extent of cross pollination.

18. The Committee notes that the data on cross pollination that were collected during the Farm Scale Evaluations of GM herbicide tolerant crops are a valuable source of information in the setting of separation distances for maize and oilseed rape. However, it is important to recall the design of these experiments, where cross pollination into adjacent stands of non-GM crops was investigated, rather than pollen movement through ‘bare-ground’ separation zones.

19. For oilseed rape, the Committee considers that there are sufficient data for the construction of robust recommendations. An exception to this is perhaps cross pollination into partially male-sterile recipient crops (varietal associations), where fewer data are available. However, this is not a major limitation since the area sown to varieties of this type in the UK is low.

[2] Maize is assumed to be 95% out-crossing, while for oilseed rape values for a range of out-crossing rates (10-50%) are given. These are based on figures from http://www.agrsci.dk/gmcc-03/Co_exist_rapport.pdf.

20. For forage maize, the Committee also considers that sufficient data are available to make robust recommendations. Difficulties arise where the recipient crop is sweetcorn – in this case individual cobs are sold, so additional separation or other measures might be required in order to ensure that cobs harvested from plants at the edge of the field will be below the required threshold[3]. Potential solutions to this issue include the use of discard rows at the edge of sweetcorn fields or the careful choice of varieties to ensure that the sweetcorn maize does not flower at the same time as nearby GM forage maize.

21. In drawing up separation distances it is important to consider the extent to which the introduction of GM events into a non-GM crop may be diluted by the presence of large amounts of non-GM material. This occurs at field level, but also at the level of the whole farm. If, for example, oilseed rape is cultivated on a number of fields on a farm only one of which is near to a field where GM oilseed rape has been grown, the GM presence in the bulked grain from across the whole farm may be well below required thresholds for GM presence even if the crop from an individual field is above the threshold. It will be important to specify the level at which thresholds are being enforced, as this may influence the scale of measures adopted.

Role of volunteers, feral populations and wild relatives

22. ACRE considered the extent to which volunteers, feral populations and wild relatives may act as reservoirs for GM events through time. The Committee does not consider that this is an issue of any significance for maize, since the crop does not produce volunteers or establish feral populations and there are no wild relatives. For oilseed rape the only potential issue relates to volunteers. The extent to which oilseed rape volunteers persist is the topic of current Defra-funded research, the results of which will provide further information on this issue. However, normal agricultural management practices are likely to maintain volunteer populations below levels that would contribute significantly to pollen transfer into nearby non-GM fields.

[3] See previous advice on maize separation distances available at http://www.defra.gov.uk/environment/acre/advice/pdf/acre_advice28.pdf

Annex A

The following calculation assumes that GM and non-GM plants set equal numbers of seed and produce equal numbers of pollen grain. The spatial arrangement of the plants is not taken into account, so that all plants are assumed to be cross pollinated by a mixture of pollen derived from the whole field. GM presence in seed is taken to be described on a seed basis.

If:

Proportion of sown seed containing a GM event = α (i.e. the adventitious presence is 100α % on a seed basis)
Proportion of fertilization due to out-crossing = β
Proportion of the male and female gametes derived from GM plants that contain a GM event = γ

Proportion of out-crossing pollen that contains GM event = $\alpha\gamma$

Proportion of harvested grain that contains the GM event from GM plants:

female contribution:	$\alpha\gamma$
male contribution (selfing):	$\alpha(1-\gamma)(1-\beta)\gamma$
male contribution (out-crossing):	$\alpha(1-\gamma)\beta\alpha\gamma$

Proportion of harvested grain that contains the GM event from non-GM plants:

male out-crossing only:	$(1-\alpha)\beta\alpha\gamma$

Therefore the total proportion is α times the following factor:

$$
\begin{aligned}
&\gamma + (1-\gamma)(1-\beta)\gamma + (1-\gamma)\beta\alpha\gamma + (1-\alpha)\beta\gamma \\
&= \gamma + \gamma - \gamma^2 - \gamma\beta + \beta\gamma^2 + \alpha\beta\gamma - \alpha\beta\gamma^2 + \beta\gamma - \alpha\beta\gamma \\
&= 2\gamma - \gamma^2 + \beta\gamma^2 - \alpha\beta\gamma^2 \\
&= \gamma(2 - \gamma + \beta\gamma - \alpha\beta\gamma) \\
&= \gamma(2 - \gamma(1 - \beta + \alpha\beta)) \\
&= \gamma(2 - \gamma(1 - \beta(1 - \alpha)))
\end{aligned}
$$

Since α is small $1-\alpha$ is close to 1, so the factor is approximately:

$$\gamma(2 - \gamma(1 - \beta))$$

Thus for a fully out-crossing crop which is homozygous for the GM trait, the seed harvested from the field will contain double the GM presence of the seed sown.